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Volume 2 of 4

SPACE COMMUNICATIONS: THEORY AND APPLICATIONS

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Volume 2: Coding and Detection Theory

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NASA SP-7022(02)
Volume 2 of 4

SPACE COMMUNICATIONS: THEORY AND APPLICATIONS

A BIBLIOGRAPHY

Volume 2: Coding and Detection Theory

An extensive collection of annotated references to reports, journal articles, and books published during the period 1958–1963.

Compiled by
Dr. Richard F. Filipowsky and
Louise C. Bickford

Scientific and Technical Information Division JUNE 1965
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INTRODUCTION

Space Communications: Theory and Applications is a four-volume bibliography compiled by the Federal Systems Division, IBM under contract to the National Aeronautics and Space Administration. It contains an extensive listing of references to reports, articles, and books on several subjects directly pertinent to the field of space communications. The compilers have endeavored to provide maximum coverage of the literature for the period 1958 through 1963. However, references to publications of unusual significance that appeared before 1958, as well as a limited number of 1964 references, have also been included. The bibliography has been prepared primarily for use by communications specialists engaged in technical activities related to the aerospace program. Each of the four volumes is complete in its coverage of specific subjects and is being published separately.

Volumes 1, 2, and 3 are devoted primarily to a theoretical consideration of their subject matter but, when appropriate, references pertaining to applications are also included. Volume 4 contains references to four important and timely applications of space communications. The NASA Special Publication numbers and the particular subjects of each volume are as follows:

NASA SP-7022(01)	Volume 1	Modulation and Channels
NASA SP-7022(02)	Volume 2	Coding and Detection Theory
NASA SP-7022(03)	Volume 3A	Information Processing
	3B	Advanced Techniques
NASA SP-7022(04)	Volume 4A	Communications Satellites
	4B	Instrumented Satellites
	4C	Deep Space Applications
	4D	Manned Space Flight Applications

Each volume contains a Table of Contents for that particular volume and a separate Table of Contents for the complete set of four. For additional reference aid, a subject index is included in each volume. A listing of abbreviations (established by Science Abstracts, Section B, Electrical Engineering Abstracts, London) of widely used journals and periodicals is included in each volume, for the purpose of identifying source documents.

Arrangement of references in the bibliographic listing is based on subjects in accordance with the Table of Contents. Under each specific topic, references are divided into "Principal Publications" and "Related Publications." Within each of these categories, references are listed in chronological order and, when further separation is necessary, by individual author. Each citation to a reference is accompanied by an annotation if the title of the reference is not sufficiently informative. Whenever possible, annotations included in this bibliography have been extracted from the original reference or from its abstract.

For additional information concerning the structure and function of the Table of Contents, and for a detailed description of the arrangement of references, the user is referred to the "User's Guide" which follows this Introduction.

AVAILABILITY OF DOCUMENTS

References cited in this bibliography are available for examination in the designated issues of the original journals. Copies of particular issues may be borrowed from libraries maintaining sets of these journals. In some instances, reprints may be obtained by writing to the editorial office of the journal.

Copies of NASA SP-7022 (02), the second volume of Space Communications: Theory and Applications, can be obtained from NASA (Code ATSS-A), without charge, by NASA offices and contractors, U. S. Government agencies and their contractors, and organizations that are working in direct support of NASA programs.

Other organizations and individuals can purchase copies of NASA SP-7022 (02) from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

USERS GUIDE

The Table of Contents for each volume best illustrates the general structure of the volume and the arrangement of its contents. The main subject is synonymous with the subtitle of the volume and is designated by the number 1, 2, 3 or 4. Each volume or subject (1) is divided into divisions (1.0, 1.1, 1.2, etc.), sections (1.10, 1.11, 1.12, etc.) and finally, into subdivisions (1.110, 1.111, 1.112, etc.).

Arrangement of references and other text under the four categories is as follows:

Subject 1: A general description of the contents of the entire volume which briefly identifies all important subtopics.

Division 1.1: A more detailed statement of content is usually presented with emphasis on the fundamental aspects of the topics to be considered. Specific references to related sections and subdivisions are included.

Section 1.10: An explanatory note is provided, when appropriate, to describe a single topic covered in detail in the following subdivisions.

Subdivision 1.100: This is the most limiting level of categorization and will normally contain a complete compilation of information on a specific topic. It opens with a statement that identifies the types of references Included and the types that are Not Included. Cross-reference instructions follow and refer only to those related sections or subdivisions that appear in the same volume. Finally, all citations and annotations appear in this category, divided into two groups: Principal Publication and Related Publications. The last digit of the subdivision number has special significance in the listing of pertinent references. For example, if the complete category number is 1.111, the final "1" signifies that references pertaining to the fundamental and theoretical aspects of the subject appear under it. If the last digit is "7" or "8", the references which appear under it will pertain to specific applications related to the topic under discussion. Similarly, testing and simulation references are denoted when the last digit is "9". The user may note that all of the final digits in a category are not used in the bibliography. This apparent omission does not mean that divisions, sections, or subdivisions are missing but that pertinent references have not been identified at this time. However, the unused numbers have been assigned and if relevant references appear in the future, they can be incorporated in a supplementary or revised issue of the bibliography.

The index for each volume is constructed on a two-tier basis, i.e., a major subject or technical expression and those supporting expressions that are directly associated with the major subject. A special effort has been made to retain the original terminology of authors in the index. New terms and translations of foreign terms, as used by individual authors, have been mixed with older and more familiar expressions and are included in the index in proper alphabetical order.

Duplicate entries to the same reference will be found occasionally within a subdivision. The user will note that both entries are included because different sources are identified and the repetition may provide more convenient access to the document. Defense Documentation Center (DDC, formerly ASTIA) documents are designated AD, followed by six digits. NASA documents are designated N62 (or N63, N64) followed by five digits. AIAA documents are designated A62 (or A63, A64) followed by five digits.

Titles of foreign language citations have been translated into English.

ABBREVIATIONS OF PRIMARY SOURCE DOCUMENTS

AIEE - American Institute of Electrical Engineers
Conf. - Conference
Conv. - Convention
Engng. - Engineering
IEE - Institution of Electrical Engineers
IEEE - Institute of Electrical and Electronic Engineers
Inst. - Institute
Instn. - Institution
Internat. - International
IRE - Institute of Radio Engineers
J. - Journal
Nat. - National
Proc. - Proceedings
Rec. - Record
Symp. - Symposium
Trans. - Transactions

Ann. Radioelect. - Annales de Radioelectricite
Arch. Elekt. Ubertragung - Archiv der Elektrischen Ubertragung
Avtomat. i Telemekh. - Avtomatika i Telemekhanika
Bell Syst. Tech. J. - Bell Systems Technical Journal
Elektron. Rundschau - Elektronische Rundschau
IRE Trans. Comp. Parts - IRE Transactions Component Parts
IRE Trans. Commun. Syst. - IRE Transactions Communications Systems
IRE Trans. Electronic Comp. - IRE Transactions Electronic Components
IRE Trans. Inform. Th. - IRE Transactions Information Theory
IRE Trans. Microwave Th. Tech. - IRE Transactions Microwave Theory and Techniques
IBM J. Res. Developm. - IBM Journal of Research and Development
J. Appl. Phys. - Journal of Applied Physics
JPL Res. Summ. - JPL Research Summary
JPL Space Progr. Summ. - JPL Space Program Summary
Nachrichtentech. Z. - Nachrichtentechnische Zeitschrift
Proc. Electronic Comp. Conf. - Proceedings Electronic Computer Conference
Radio Engng. - Radio Engineering
RCA Rev. - RCA Review
Rec. Nat. Commun. Symp. - Record National Communications Symposium
Rev. Sci. Instrum. - Review of Scientific Instruments
Telecomm. Radio Engng. - Telecommunications and Radio Engineering

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SUBJECT 2

CODING AND DETECTION THEORY

The second volume in this series of space communications bibliographies is a continuation of the first volume, which contains references to literature on modulation methods and on channel characteristics.

The term CODING, in its most general interpretation, comprises all intentional efforts to modify, in accordance with well defined mathematical rules, the information carrying signals of a communications link for the purpose of improving the transmission quality and efficiency. MULTIPLEXING is a collective name for all methods which can be used to combine signals from several information sources and to transmit them over the same communications facility. Decoding and demultiplexing are the converse operations at the receiving side, which are necessary for securing the reproduction of the information carrying signals in their original form.

DETECTION or demodulation is the converse operation of modulation. Optimum detection systems, however, have the additional task of separating the received signals in an optimum way from disturbances and distortions. This operation is also called signal extraction or, loosely, signal processing. In digital transmission systems it is not unusual to call the detection process a decision operation, though a distinction is frequently made between these two terms.

The first division of this volume contains the analytical fundamentals for all coding operations and contains also reviews of special applications of coding. The next three divisions specialize in one application of coding, the information compression of the output of information sources. Alternate terms for this subject are information compaction or redundancy reduction.

Division 2.2 contains the general background material for such operations and any references to discrete data compaction.

Division 2.3 deals with the information compression of one dimensional analog signals such as speech and music.

Division 2.4 extends this subject of information compression to operations on multi-dimensional sources, with concentration on picture compaction.

Multiplexing is the subject of two divisions. The multiplexing of physical communications channels, usually called lines or circuits, is referenced in division 2.5. The multiplexing of communications links or of messages arriving from different sources involves a number of novel approaches, with RADAS (Random Access Discrete Address Systems) being most likely the most prominent one. A separate division (2.6) contains these references.

Division 2.7 deals with protective coding, i.e., with the application of coding methods for the detection and correction of errors in digital communications systems.

Detection theory is concentrated in division 2.8 which also contains selected references on detection and search methods for radar systems. The close relationship of such problems to communications detection problems warrants their inclusion.

The last division (2.9) is reserved for controlled communications methods. By this term one may understand any combinations of modulations, coding, multiplexing and detection methods which can be controlled, usually automatically. Such efforts result in more adaptive communications systems, which are better equipped to match the wide variations of channel characteristics. Feedback communications systems, also called loop systems, or two-way linked systems are an important class of such controlled communications systems.

Volume two of this series excludes, in general, references to hardware, i.e., to special circuits, components and equipment. Descriptions of complete space communications systems will be referenced in volume 4.

The time period from which references have been selected for this volume (1958 - 1963) is the same as for volume one. The source material used was also selected on the same basis as the material of first volume.

DIVISION 2.1
FUNDAMENTALS OF CODING

The Morse code and the various codes for teletype systems are the oldest applications of coding in electrical communications. Since 1940 engineers have been using coding operations for improving the transmission quality of communications facilities. Pulse code modulation and the general interest in digital operations led to an evolution of a mathematically well-founded coding theory. Many of the key publications in this area originated prior to 1958 and the reader will find references to them in books and surveys quoted in subdivision 2.101.

The years since 1958 brought a further intensification of many efforts to apply coding in practical communications systems. The principal field of application is still protective coding, which will be discussed in division 2.7. Another field of coding may be designated as compactive coding or redundancy reducing coding and the divisions 2.2 to 2.4 deal with this aspect. It is now clear that a general coding theory is emerging and that applications in many other fields have met with initial success. In this division we concentrate on fundamentals and on a number of special codes, which cannot be classified as compactive nor as protective codes.

The section 2.11 is devoted to general problems of coding theory. There will be some duplication with other subdivisions in this book, as it is not clear at this time which branches of coding theory have such general character and which branches will merely be required for some restricted classes of codes. The lack of a generally accepted terminology is another difficulty in attempts to classify the literature on coding. The reader is advised to make frequent use of the alphabetical index and of the terms included at the beginning of each subdivision.

Section 2.12 deals with binary group codes, which were originally developed as protective codes but which have also found successful applications in ranging, in coherent communications systems such as coded carriers and for synchronization.

Section 2.13 reports the beginning of an extension of the well-established binary coding techniques to communications systems with more than two elementary waveforms. These higher order coding investigations are also useful in orthogonal communications systems, which use more than two binary sequences as elementary information carriers (See volume 1, subdivision 1.314).

Still further in the future are the so-called analog codes (Section 2.14). These codes apply mathematical transformations, other than modulation , to continuous waveforms for the purpose of increasing transmission efficiency and quality; interest in this field is just starting.

Section 2.18 contains references to a number of special purpose codes, which include, for example, telegraphic codes, but also unclassified references to security codes. Some publications mentioned in this section will also be quoted in the subdivisions which are related to their particular coding structure. The subdivision on nonrandom error detecting codes (2.184) may be of special interest as it refers to recent efforts to apply coding techniques for the improvement of equipment reliability, in particular to failure tracing and self-repair methods.

Section 2.10
Introduction to Coding

2.101: Books and Surveys on Coding

Included: Coding and decoding operations research; Papers combining many different subjects of coding.

Not Included: Books on information theory (1).

Cross References: Books on error correction coding (2.700).

Principal Publications:

CODING THEORY AND ITS APPLICATIONS TO COMMUNICATIONS SYSTEMS
L. Baumert, et al., JPL Technical Rept. 32-67, March 31, 1961.

TRANSMISSION OF INFORMATION - A STATISTICAL THEORY OF COMMUNICATIONS
R. M. Fano, New York, John Wiley and Sons, Inc., 1961, 389 p.

A textbook with strong emphasis on coding in various forms.

CODING AND DECODING OPERATIONS RESEARCH. RESEARCH. VOLUME II
M. Mitchell, et al., Advanced Electronics Center, General Electric Co., Ithaca, N. Y., Final rept., (AFCRL-8, vol. 2), vol. 2, 14 Jan. 1961. 1v., AD 257 420.

AN INTRODUCTION TO INFORMATION THEORY
F.M. Reza, New York, McGraw Hill Book Co., Inc., 1961, 496 p.

Contains an extensive review on many aspects of coding in communications. . . . Many references to earlier publications.

MATHEMATICAL STUDY OF CODING TECHNIQUES AND OF MINIMIZATION PROBLEMS FOR SWITCHING CIRCUITRY
Parle Mathematical Labs., Inc., Carlisle, Mass., AFCRL-317, April 1961, 42 p., AD 263 945.

The ten scientific reports and twenty two technical memoranda dealing with Boolean formulas and minimization problems and coding theory are summarized. A bibliography on reliability is presented.

GROUP THEORY IN ELECTRICAL ENGINEERING
R. M. Bevensee, Arch. Elekt. Uebertragung, vol. 16, Sept. 1962, p. 449/459.

. . . reviews the applications of group theory to various problems in electrical engineering. . . . deriving the normal modes of a symmetric lumped network. The transformation properties simplify certain lengthy switching operations. With the theory we generate the normal modes of a microwave circulator. Slepian's group alphabets for the noisy binary symmetric channel are reviewed. Finally we study the fields in several microwave structures. . . .

THE RATE OF INFORMATION TRANSMISSION THROUGH SYMMETRIC CHANNELS
L. F. Borodin, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (Trans. no. FTD-TT-62-878, from Sto Let so Dyna Rozhdeniya A. S. Popova, Yubileynaya Sessiya, Izdatel'stvo Akademii Nauk SSSR, p. 57/73, 1960) 10 Sept. 1962, 27 p., incl. illus., 9 refs., AD 286 603.

. . . A graphical method is given for determining the optimum value of the probability of symbol erasure (in the sense of the maximum traffic capacity of a channel). . . . It is shown that the optimum code of an erase channel in the presence of a sufficiently large number of symbols in a code combination allows information to be transmitted through an erase channel with a previously assigned uncertainty and rate, close to the traffic capacity of the channel. A method is indicated for setting up codes which have properties close to those of the optimum code of an erase channel, and also codes in which all combinations differ from one another exactly by d = a to the m-1 positions.

A METHOD OF CODING MESSAGES BY STATISTICAL CODE
V. A. Garmash, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (Trans. no. FTD-TT-62-1637 from Soviet Patent No. 147024 (646826/26), 10 Dec. 1959), 22 Jan. 1962, 4 p., AD 298 219.

INFORMATION THEORY, AN ASTIA REPORT BIBLIOGRAPHY
H. W. Miles, Armed Services Technical Information Agency, Washington, D. C., 1 Jan. 1962, 35 p., AD 269 800.

. . . References are included for documents catalogued by ASTIA from 1953 through 1 January, 1962 . . . channel, capacity, coding, communication systems, and theory, data transmission systems, and computer design.

INFORMATION THEORY AND CODING
N. Abramson, New York, McGraw Hill Book Co., Inc., 1963, 201 p.

The interest of this book is in the relevance of the theory to the real world . . . in a wide number of fields. Easy to read. Covers the developments of the last 15 years in many aspects of coding. Historical notes and additional references make the book very valuable.

EXPECTED ERROR LENGTH AND PROBABILITY OF LOSS OF SYNCHRONISM OF CERTAIN ERGODIC CODES
S. P. Morse, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., 10 April 1963, 30 p., AD 418 419.

. . . Several ergodic codes are compared with respect to both expected error length and probability of loss of synchronism due to channel errors as a function of compressibility . . . source bits are then passed into a coder which, by use of a neat input code, creates words from the source bits and, by use of output code, decomposes the words into channel bits. Both input and output codes are unitary (i.e., no word begins another word) but the output code need not be neat. The combination of an input and an output code is called a coding scheme. Two schemes using the same input and output codes but differing in the number of code words "n" are said to belong to the same code scheme family. This paper deals with a comparison of different code families . . . Hamming output codes are discussed and compared to the codes listed with respect to expected error length.

CODING THEORY
W. W. Peterson, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 223/229, 120 references.

This is part of a "Report on Progress in Information Theory in the USA 1960-1963", edited by L. A. Zadeh.

STATISTICAL CODING IN TELEMECHANICS
R. R. Vasil'yev, et al., Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, AD 412 241.

A HANDBOOK ON COMMUNICATION CODES. PART I. PERMUTATION CODES AND CODED-CHARACTER SETS
ITT Communication Systems, Inc., Paramus, N. J., Rept. no. 64TR364, 31 Jan. 1964, 1v., AD 433 200.

Related Publications:

PROGRESS IN INFORMATION THEORY IN THE USA, 1957-1960
P. Elias, et al., IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 128/144.

TRANSMISSION OF STATISTICAL INFORMATION
E. C. Posner, JPL Res. Summ., vol. 1, no. 36-12, Oct. Nov. 1961, p. 76/78.

CODING THEOREMS OF INFORMATION (Volume 31 of "Ergebnisse der Mathematik und ihrer Grenzgebiete, N. F.")
J. Wolfowitz, Berlin-Gottingen-Heidelberg; Springer-Verlag, Englewood Cliffs, N. J., Prentice-Hall, 1961, 125 p.

CODING THEOREMS OF INFORMATION THEORY
J. Wolfowitz, Englewood Cliffs, N. J., Prentice-Hall, Inc., 1962, 124 p.

The author is concerned with information theory in the narrow sense, i.e., the proof of Shannon's fundamental coding theorem and its converse for a wide variety of channel models. The book is strictly a formal mathematical development; there is no discussion of applications or of the construction of error-correcting codes. . . .

2.102: Introductions to Coding

Included: Spectrum conservation through coding; Coding in special space communications applications; Comparison of communications systems with and without coding.

Not Included: Pulse code modulation (1).

Cross References: Introductions to error correction encoding (2.700); Comparison of digital transmission systems with and without protective coding (2.712).

Principal Publications:

NOTATION AND CHARACTERISTICS OF TWO-LEVEL CODES
G. Birkel, Jr., IRE Trans. Telem. Remote Contr., vol. TRC-3, no. 1, no. 7.1, April 1957.

Notations signifying various permutations of 2-level (binary) aggregates permit the tailoring of digital codes to fit particular hardware applications. Definitions of terms and permutation properties are followed by coding techniques and some applications.

EARTH SATELLITE TELEMETRY CODING SYSTEM
R. W. Rochelle, Elect, Engng., vol. 76, Dec. 1957, p. 1062.

COMMUNICATIONS SATELLITES
L. J. Carter, (editor), (British Interplanetary Society, Symposium on Communications Satellites, London, England, May 12, 1961), New York, Academic Press, Inc., 1962, 202 p., A63-12455.

. . . Specific topics covered include channel dropping, coding and decoding, . . .

KODIERUNG VON NACHRICHTEN (Coding of Messages) (In German)
P. Fey, Nachrichtentechnik, vol. 11, no. 11, Nov. 1961, p. 484/487.

CODING THEORY
R. M. Goldstein, et al., JPL Res. Summ., vol. 1, no. 36-12, Oct. Nov. 1961, p. 66/72.

ELEMENTS OF ENCODING
F. M. Reza, Rome Air Development Center, Griffiss Air Force Base, N. Y., (RADC TN 61-3), Feb. 1961, 57 p., AD 253 442.

The common terms of encoding such as source, efficiency, redundancy and decipherability are defined in this report. A criterion is given for uniquely decipherable codes. Shannon-Fano, Huffman, Gilbert-Moore, Elias and Hamming error correcting codes are discussed. . . .

CRITERIA FOR SELECTING A DIGITAL CODE
C. H. Wolff, Control Engng, vol. 4, April 1962, p. 128/130.

Care in code selection during system design can pay off greatly in operating reliability of digital systems . . .

DISCUSSION: MODULATION OR CODING
G. P. Divnogortsev, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 7, July 1963, p. 71/72.

It is known . . . that "modulation is a process having as its purpose the translation of the spectrum of a low-frequency signal into the high-frequency range so that the signal can be transmitted by radio facilities" . . . a number of papers have recently appeared . . . which, with very little foundation and quite unnecessarily, attribute the concept of modulation to processes having nothing in common with translation of a signal spectrum.

For example, there have appeared such terms as phase-difference modulation (PDM), relative phase modulation (RPM), relative frequency modulation (RFM) and relative amplitude modulation (RAM). . . . these modulation systems . . . are but addition of signal coding equipment at the input and output of the old systems. . . .

Related Publications:

SIGNAL PROCESSING IN THE TIROS INSTRUMENTATION SYSTEM
M. H. Mesner, IRE Trans. Nat. Symp. Space, no. 4-1, Sept. 1960, p. 1/21.

The various signals . . . are processed in the space-borne satellite and in the remaining portion of the system on the ground. The telemetry channel, video channel, command channel, and the attitude, spin data, and sun angle information transfer channel, comprise the signal chains of the satellite system. . . .

INFORMATION HANDLING AND PROCESSING IN LARGE COMMUNICATION SYSTEMS
W. F. Luebbert, Stanford Electronics Labs., (Technical rept. no. 099-1), 11 July 1960, AD 243 676.

. . . It is demonstrated that communications systems can be viewed as information processing systems with rather different characteristics from conventional one-location data processors, and that both communications and conventional systems can be viewed as special cases of a more general type of system. Von Neumann's concept of interchangeability of program and data in computers can be extended to interchangeability of system and user information in communications systems. The result would be entirely new dimensions for planning and techniques for overcoming some of the most severe limitations of current communications systems.

BASIC ISSUES OF SPECTRUM CONSERVATION
D. G. Fink, IRE Internat. Conv. Rec., pt. 5, vol. 10, March 1962, p. 221/222.

. . . the book . . . by Fred Lack, called "Radio Spectrum Conservation". . . . was written by members of JTAC and by consultants and experts in the field of propagation and spectrum management. . . . I was amazed and somewhat appalled to find that most of the problems which have been mentioned in this book, and which many of us felt something would be done about in the ten years after it was published, remain with us almost unattacked—let alone solved. . . .

CODED DIGITAL COMMUNICATIONS: INFORMATION TRANSFER, NOT ENERGY TRANSFER
P. Rosen, et al., Space/Aeronautics, vol. 39, Feb. 1963, p. 95, 97, 99, 101, A63-12127.

. . . the suitability of algebraic and sequential coding is considered. . . .

Section 2.11

2.110: Coding Theory in General

Included: Penny weighting problems; Lossless symbol coding; General coding theorems; Theory of code construction; Polynomial codes in general; Groups of collineations on codes; Rook domains; Sizes of code dictionaries in general; Sum-free sets; Replicating triangles; Replicating polygons; Rank and nullity; Pyramid-packing; Error distributing codes; Uniform finite memory codes; Ergodic codes; Perfect maps.

Not Included: Models of communications channels (1); Information theory in general (1).

Cross References: Cyclic codes for error correction (2.740); Fully decodeable code word sets (2.211); Unique decipherability of codes (2.211); Comma free codes (2.211); Hadamard matrices (2.120); Complementary series (2.120); Block codes (2.730); Unitary codes (2.211); Modular geometric shapes (2.260).

Principal Publications:

CODING THEOREM FOR FINITE-STATE CHANNELS
R. G. Gallager, Mass. Inst. Tech., Quart. Prog. Rept., April 1958, p. 94/99.

NOTES ON THE PENNY-WEIGHTING PROBLEMS, LOSSLESS SYMBOL CODING WITH NONPRIMES, ETC
M. J. Golay, IRE Trans. Inform. Th., vol. IT-4, Sept. 1958, p. 103/109.

A NOTE ON A RESULT IN THE THEORY OF CODE CONSTRUCTION
R. C. Bose, et al., Information and Control, vol. 2, no. 2, Feb. 1959, p. 183/194.

. . . establishes a connection between Hadamard Matrices . . . and the maximal binary codes . . . such that the Hamming distance between any two sequences is greater than or equal to d.

DIAGRAMMATIC METHODS OF CODE CONSTRUCTION
R. C. Clark, Commun. and Electronics, Jan. 1959, p. 817/823.

LOSSLESS SYMBOL CODING WITH NONPRIMES
J. Cocke, IRE Trans. Inform. Th., vol. IT-5, March 1958, p. 33/34.

POLYNOMIAL CODES OVER CERTAIN FINITE FIELDS
I. S. Reed, et al., J. Soc. Indust. Applied Math., vol. 8, no. 2, June 1960, p. 300/304.

A NOTE ON RANK AND NULLITY IN CODING THEORY
L. Calabi, Inform. Control, vol. 4, no. 4, Dec. 1961, p. 359/363.

The notions of "rank" and "nullity" are introduced into coding theory as possible new tools. Various results demonstrate their relevance and suggest their potential utility. . . .

THE SIZES OF CERTAIN CODE DICTIONARIES
S. W. Golomb, JPL Res. Summary, no. 36-13, Dec./Jan. 1961, p. 23/24.

The cells of a hyper-chessboard of size n^k are to be colored in a maximum number of colors w (k,n) such that a rook placed anywhere will cover (attack or occupy) at least one cell of each color.

SUM-FREE SETS
E. C. Posner, et al., JPL Res. Summ., vol. 1, no. 36-10, June/July 1961, p. 16/17.

A set S of integers is called sum-free if x, y in S imply x + y not in S.

THE SIZES OF CERTAIN CODE DICTIONARIES (Continued)
J. Franklin, et al., JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 316/333.

In RS 36-13, p. 23, and RS 36-14, p. 46, the following formulation of a general problem in coding theory was considered: The cells of a hyperchessboard of size n^k (a k-dimensional vector space over an n-element set) are to be colored in a maximum number of colors w (k,n) such that a rook placed anywhere will cover (attack or occupy) at least one cell of each color. . . . result will now be established.

THE SIZES OF CERTAIN CODE DICTIONARIES
S. W. Golomb, et al., JPL Res. Summ., no. 36-14, Feb./March 1962, p. 46/48.

. . . Several new results will be discussed . . .

MORE MODULAR GEOMETRIC SHAPES
S. W. Golomb, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 146/150.

. . . problem of cutting plane figures into four "replicas," congruent to one another and similar to the original.

ROOK DOMAINS AND GENERALIZED HAMMING CODES
A. W. Hales, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 33/34.

CUBES WITH ZEROS AND ONES
A. W. Hales, JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 35/36.

. . . the following problem, relating to coding over an n-symbol alphabet, was discussed: The cells of a hyperchessboard of dimension k and edge length n are to be colored in a maximum number of colors w (k,n) such that a rook placed anywhere will attack or occupy at least one cell of each color.

STUDY ON APPLICATION OF CODING THEORY
A. E. Laemmel, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., Semi-annaul rept no. 5, 1 July - 30 Dec. 1962, Rept no. PIBMRI-895-5-63, 15 Feb. 1963, 34 p., 18 refs, AD 401 924.

. . . theory of digital codes and finite state machines. . . . problems of ergodicity . . . synthesis of sequential machines to economically solve tasks which are essentially nonsequential.

GENERALIZED CODING AND UNIFORM FINITE MEMORY CODES
T. J. Wagner, Electronics Research Lab., U. of Calif., Berkeley, 26 Dec. 1962, 35 p., AD 408 706.

A general framework for encoding and decoding is presented which includes block coding. The key concept used with the generalized codes is that of decoding rate . . . Uniform finite memory codes are defined from the general framework . . . is defined for these codes but what its value is remains an open question . . .

GROUPS OF COLLINEATIONS ON CODES
R. E. Block, JPL Space Progr. Summ., vol. 4, no. 37-25, Dec./Jan. 1963, p. 158/160.

. . . some results are given on a type of code equivalence, namely, on collineations. By a collineation of a (not necessarily linear) code, or in fact of any matrix M, is meant a pair of permutations p, , such that performing on the the columns permutes code words (rows of M) according to p. A group G of collineations of M will be considered.

CUBES OF NON-NEGATIVE INTEGERS
H. Fredericksen, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 144/145.

A problem which occurs in connection with providing an upper bound to the size of optimal colorings in the theory of error-distributing codes (RS 36-13, p. 23/24; RS 36-14, p. 46/48) is the following . . . This note presents some further contributions, but does not solve the problem.

UPPER BOUNDS FOR FIXED-WEIGHT CODES OF SPECIFIED MINIMUM DISTANCE (Correspondence)
C. V. Freiman, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 246/248.

ROOK DOMAINS, LATIN SQUARES, AFFINE PLANES, AND ERROR-DISTRIBUTING CODES
S. W. Golomb, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 196/208.

A problem originally suggested in the context of genetic coding leads naturally to the concept of rook packing and error-distributing codes. It is shown how various concepts in the theory of Latin squares, and also in coding theory, are best expressed in the form of questions about the placing of rooks on k-dimensional hyperchessboards of side n. . . . the concept of error-distributing code . . . was first suggested in the context of genetic coding. These codes correspond to the placing of rooks on a hyperchessboard with cells colored, so that a rook placed at any cell will cover a cell of every color. . . .

STILL MORE REPLICATING POLYGONS
S. W. Golomb, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 935/937.

More about rep-4. The 30-deg right triangle has a total of four inequivalent rep-4 dissections . . . The first of these is the standard rep-4 dissection of a triangle; the second is the alternative dissection for right triangles; while the remaining two work only for the 30-deg right triangle.

COLLINEATIONS IN A PLANE OF ORDER 10
M. Hall, Jr., et al., JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 137/144.

. . . This article considers the problem of the existence of projective planes of order 10 with a special property—the possession of a nontrivial collineation.

ASSIGNMENT OF NUMBERS TO VERTICES
J. H. Lindsey, II, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 145/149.

In SPS 37-17, Vol. IV, pp. 69/71, L. Harper discussed the following problem. Given a cube in n-dimensions, how shall the integers from 0 to $2^n - 1$ be assigned to the vertices of this n-cube in such a way as to minimize the sum, over all neighboring pairs of vertices, of the absolute value of the difference of the numbers assigned to each vertex? . . . The proper generalizations of Harper's result are proved in this paper. Harper's theorem shall also be reproved below in such a way as to make the proof of the present extension easier.

EXPECTED ERROR LENGTH AND PROBABILITY OF LOSS OF SYNCHRONISM OF CERTAIN ERGODIC CODES
S. P. Morse, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., 10 April 1963, 30 p., AD 418 419.

. . . Several ergodic codes are compared with respect to both expected error length and probability of loss of synchronism due to channel errors as a function of compressibility . . . source bits are then passed into a coder which, by use of a neat input code, creates words from the source bits and, by use of output code, decomposes the words into channel bits. Both input and output codes are unitary (i.e., no word begins another word) but the output code need not be neat. The combination of an input and an output code is called a coding scheme. Two schemes using the same input and output codes but differing in the number of code words "n" are said to belong to the same code scheme family. This paper deals with a comparison of different code familes . . . Hamming output codes are discussed and compared to the codes listed with respect to expected error length.

REPLICATING TRIANGLES
E. C. Posner, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 97/98.

. . . prove . . . result on replicating triangles, as a supplement to the preceding article by Golomb.

GENERATION OF OPTIMAL CODES BY A "PYRAMID-PACKING" ARGUMENT (Correspondence)
J. Ziv, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 253/255.

Related Publications:

PHILOSOPHY OF PCM
C. F. Shannon, et al., Proc. IRE, vol. 11, no. 36, Nov. 1948, p. 1324/1331.

COMMUNICATIONS IN THE PRESENCE OF NOISE
C. E. Shannon, Proc. IRE, no. 37, Jan. 1949, p. 10/22.

ERROR-CORRECTING CODES—A LINEAR PROGRAMMING APPROACH
E. J. McCluskey, Jr., Bell Syst. Tech. J., vol. 38, no. 6, Nov. 1959, p. 1485/1512.

THE CONSTRUCTION OF MISSILE GUIDANCE CODES RESISTANT TO RANDOM INTERFERENCE
A. R. Eckler, Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 973/994.

. . . no general methods exist for finding . . . those codes in which the longest command is as short as possible. This paper presents certain lower bounds, together with a few empirically derived codes approaching these lower bounds. The relationship between these codes and the well-known error-correcting binary codes of information theory is discussed in an appendix. . . .

MEASURE, LEBESGUE INTEGRALS, AND HILBERT SPACE
A. N. KOIMOGOROV AND S. V. FOMIN, New York Academic Press, 1961, 147 p.

Very clear presentation of the fundamentals of measure theory. Can be useful in coding theory, in channel theory, and in many other applications. Very good presentation of the abstract Hilbert Space. Will be useful in signal theory.

DIE BILDABTASTUNG ALS TRANSFORMATION DER ZWEIDIMENSIONALEN BILDSYSTEM-CHARAKTERISTIK IN EINE EINDIMENSIONALE FUNKTION (Picture Scanning Methods as Functional Transforms) (In German)
F. Arp, Arch. Elekt. Uebertragung, vol. 17, May 1963, p. 207/216, 20 refs.

The process of image scanning can be associated with a transfer coefficient that links the two-dimensional system properties of optical and electron-optical imaging with the unidimensional system factor of the electric transmission channel. The errors of two-dimensional imaging, to the extent they are stationary, can thus be transformed into the equivalent of the image amplifier. . . .

ERROR-CORRECTING CODES: AN AXIOMATIC APPROACH
E. F. Assmus, Jr., et al., Inform. Control, vol. 6, no. 4, Dec. 1963, p. 315/330.

This paper emphasizes that coordinates of an error-correcting code are functions. We have incorporated certain ideas already present in the literature into an axiomatic treatment of error-correcting codes. . . .

A THEOREM ON THE DISTRIBUTION OF WEIGHTS IN A SYSTEMATIC CODE
J. MacWilliams, Bell Syst. Tech. J., vol. 42, no. 1, Jan. 1963, p. 79/94.

A systematic code of word length n is a subspace of the vector space of all possible rows of n symbols chosen from a finite field. The weight of a vector is the number of its nonzero coordinates; clearly any given code contains a certain finite number of vectors of each weight from zero to n. This set of integers is called the spectrum of the code, and very little is known about, although it appears to be important both mathematically and as a practical means of evaluating the error-detect-properties of the code.

In this paper it is shown that the spectrum of a systematic code determines uniquely the spectrum of its dual code (the orthogonal vector space). . . .

ON THE MINIMAL REALIZATION OF ALL LINEARLY SEPARABLE SETS OF N DIMENSIONS (Technical Report: Applied Mathematics),
E. S. Whitmore, Lockheed Missiles and Space Co., Sunnyvale, Calif., March 1962, 35 p., refs, N63-16473.

Section 2.12

2.120: Binary Group Codes in General

Included: Complementary series; Autocorrelation of binary codes in general; Optimum finite group codes; Code rings; Maximum weight group codes; Coset codes; Products of binary group codes in general; Binary group codes with pre-assigned weights; Minimum distance codes in general; Hadamard matrices; Constant distance codes.

Not Included: Equipment for the generation of codes; Shift registers.

Cross References: Binary group codes for error correction (2.730); Polynomial codes for error correction (2.740); Autocorrelation of PN codes (2.121); Military codes (2.211); Jump-shift register codes (2.758); Noncyclic codes for error correction (2.752); Cyclic codes for error correction (2.740); Products of ranging codes (2.123).

Principal Publications:

A NOTE ON UPPER BOUNDS FOR MINIMUM DISTANCE CODES
D. D. Joshi, Information and Control, vol. 3, Sept. 1958, p. 289/295.

LINEAR TRANSFORMATIONS OF BINARY CODES
N. I. Matiukhin, Automat. Remote Control, vol. 19, Aug. 1958, p. 759/770.

OPTIMUM FINITE GROUP CODES
J. E. Storer, et al., Proc. of IRE, vol. 46, Sept. 1958, p. 1649.

GROUP CODE EQUIVALENCE AND OPTIMUM CODES
A. B. Fontaine, et al., IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 60/70.

A RING MODEL FOR THE STUDY OF MULTIPLICATION FOR COMPLEMENT CODES
H. L. Garner, IRE Trans. Electronic Comput., vol. EC-8, March 1959, p. 25/31.

CODE RINGS AS A METHOD OF REPRESENTING CODE SETS
A. N. Radchenko, Automat. Remote Control, vol. 20, July 1959, p. 945/951.

. . . for the shortening of the writing of sets of code combinations by excluding from the constituents of various codes the repeated combinations of terms of less than the full (maximum) length. An analysis is made of the conditions for the existence of such shortened forms of representing code sets, called code rings, and the existence of various types of code rings is proved. . . .

FURTHER THEORY OF GROUP CODES
D. Slepian, Paper from IRE-URSI Joint Meeting - Oct. 19-21, 1959, San Diego, Calif.

EXPERIMENTAL AUTOCORRELATION OF BINARY CODES
D. F. DeLong, MIT Lincoln Laboratory, Oct. 1960.

MAXIMUM-WEIGHT GROUP CODES FOR THE BALANCED M-ARY CHANNEL
C. W. Helstrom, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 550/555.

BINARY CODES WITH SPECIFIED MINIMUM DISTANCE
M. Plotkin, IRE Trans. Inform. Th., vol. IT-6, no. 4, Sept. 1960, p. 445/450.

SOME FURTHER THEORY OF GROUP CODES
D. Slepian, Bell Syst. Tech. J., vol. 39, no. 5, Sept. 1960, p. 1219/1252.

The notion of equivalence for group is explored is some detail. A dual for a code, and the sum and product of two or more codes, are defined. Properties of these constructs are investigated. Indecomposable codes are defined. . . .

SOME LOWER BOUNDS ON THE NUMBER OF CODE POINTS IN A MINIMUM DISTANCE BINARY CODE. I & II
R. P. Bambah, et al., Inform. Control, vol. 4, no. 4, Dec. 1961, p. 313/319 and p. 320/323.

DISCOVERY OF AN HADAMARD MATRIX OF ORDER 92
J. D. Baumert, et al., JPL Res. Summary, no. 36-11, Aug./Sept. 1961, p. 31.

ON CONSTRUCTING GROUP CODES
R. B. Benerji, Inform. Control, vol. 4, no. 1, March 1961, p. 1/14.

COMPLEMENTARY SERIES
M. J. Golay, IRE Trans. Inform. Th., vol. IT-7, no. 2, April 1961, p. 82/87.

A set of complementary series is defined as a pair of equally long, finite sequences of two kinds of elements which have the property that the number of pairs of like elements with any one given separation in one series is equal to the number of pairs of unlike elements with the same given separation in the other series. . .

INEQUIVALENT HADAMARD MATRICES
S. W. Golomb, et al., JPL Res. Summary, vol. 1, no. 36-9, April/May 1961, p. 28/30.

A Hadamard matrix is a matrix of ones and minus ones whose row (column) vectors are orthogonal. The order of a Hadamard matrix is necessarily 1, 2 or 4t with t = 1, 2, 3, ... Two n X n Hadamard matrices are called equivalent. . . if one can be formed from the other by permutation and complementation. . . of rows and columns. . . .

HADAMARD MATRICES
S. W. Golomb, et al., JPL Res. Summ., vol. 1, no. 36-12, Oct./Nov. 1961, p. 73/76.

. . . Any Array of + and - signs, with an equal number of agreements and disagreements between any pair of rows, is called an "Hadamard matrix" . . . The problem is to discover all the possible Hadamard matrices, or at least to describe the sizes for which such arrays exist.

HADAMARD MATRICES OF ORDER 16
E. C. Posner, et al., JPL Res. Summ., vol. 1, no. 36-10, June/July 1961, p. 21/26.

It has been shown. . . that a normalized Hadamard matrix equivalent to a group matrix is itself a group matrix. This was used to prove that a second Hadamard matrix of order 16 is indeed inequivalent to the group of order 16.

EQUIVALENCE OF CYCLIC SEQUENCES UNDER TRANSFORMERS OF THE AFFINE GROUP
E. C. Posner, et al., JPL Res. Summ., vol. 1, no. 36-10, June/July 1961, p. 17/21.

Cyclic sequences which differ only in time-origin have the same autocorrelation function; some sequences, notably those with two-level autocorrelations, are insensitive to certain permutations of the sequence terms.

. . . transformations of sequences. . . do not change the values which the correlation function assumes, but only the order in which these values appear. It is of interest then to determine the number of sequences which are distinct under such transformations.

HADAMARD MATRICES OF THE WILLIAMSON TYPE
L. Baumert, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 139/140.

. . . been conjectured that Hadamard matrices exist for all. . . values of n. Since an Hadamard matrix of order 2n = 2(4t) can easily be constructed from one of order n, the question of existence for all possible n is reduced to the case where t is odd.

CODES WITH CONSTANT DISTANCE BETWEEN CODE WORDS
R. Block, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 151/152.

In SPS 37-16, Vol. IV, pp. 42/45, affine codes. . . were studied. These codes have the property that the distance between every two distinct words is exactly q. Here a study will be made of the class of codes with this constant distance property.

A CODE SEPARATION PROPERTY (Correspondence)
D. L. Cohn, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 382/383.

. . . comments on a coding property relating to the Hamming distance property. This work was motivated by a search for a selective station calling code. . . .

NOTE ON "COMPLEMENTARY SERIES" (Correspondence)
M. J. Golay, Proc. IRE, vol. 50, Jan. 1962, p. 84.

NOTE ON HADAMARD MATRICES OBTAINED FROM DIFFERENCE SETS
M. Hall, Jr., JPL Space Progr. Summ., vol. 4, no. 37-19, Dec. 1962, p. 140/143.

Hadamard matrices of order n = 4t are known to exist for all values of n = 4t less than 200 except for n = 116, 156, and 188. In this discussion it is shown that no difference set exists which would yield a matrix of any one of the orders 116, 156 or 188. The special methods given here can be generalized to other cases.

A WEIGHT FORMULA FOR GROUP CODES
G. Solomon, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S1/4.

. . . An explicit expression is given for the weights of any group code. . . . The formula is, in general, quite complicated and requires a computer for computation of its explicit form. However, for the new practical codes of a highly algebraic nature (Bose-Chaudhuri, Cyclic, Polynomial, Jump-Shift Register codes which are characterized by simple field parameters and polynomials), the formula emerges more pliable. . . .

HADAMARD MATRICES; A POLYNOMIAL APPROACH
G. Solomon, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 57/60.

. . . an attack is launched via the Mattson-Solomon (ref. 3) polynomials over the roots of unity. This successful approach to block coding is now applied to the above problem, and from this viewpoint some of the old results are reformulated, causing the outstanding problems to become problems on algebraic surfaces over finite fields.

Most of the results concerning polynomials over roots of unity are contained in previous Summaries and published papers (RS 36-12, Vol. I, p. 68/70, Refs. 3, 4). . . .

A NOTE ON THE MEAN SQUARE WEIGHT FOR GROUP CODES
N. Zierler, Inform. Control, vol. 5, no. 1, March 1962, p. 87/89.

HADAMARD MATRICES AND CONSTANT-DISTANCE CODES
R. E. Block, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 156/158.

This article describes a new class of constant-distance binary codes—codes consisting of 0's and 1's such that every two code words differ in the same number of places. The class to be described here has an extra property which could be used in communications systems. This property may be expressed by saying that the code is two-level—there are only two possible values for the number of ones in the words of the code.

. . . JPL work on constant-distance codes has appeared in SPS 37-22, Volume IV, p. 147, 152, 153.

HADAMARD MATRICES AND CONSTANT-DISTANCE CODES, II
R. E. Block, JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 187/188.

In a previous article (SPS 37-23, Vol. IV, p. 156/158. . . the concept of a decomposable constant-distance code was introduced. Here it is proved that decomposable constant-distance codes of Hadamard type exist with $v = 4c^2$ codewords . . .

ON THE WEIGHTS OF THE ELEMENTS OF BINARY GROUP CODES
L. Calabi, et al., Parke Mathematical Labs., Inc., Concord, Mass., Scientific rept. no. 5, AFCRL 63 95, March 1963, 18 p., 8 refs., AD 409 595, N63-17629.

Various necessary and sufficient conditions are given for the existence of binary codes with preassigned weights. . . . Some properties of the weight distribution are deduced.

DECODING RULES FOR CERTAIN PRODUCT CODES
L. Calabi, et al., Parke Mathematical Labs., Inc., Carlisle, Mass., Scientific Report No. 6, (AFCRL-63-137), March 1963, 30 p., 6 refs., N63-18357.

. . . performance established, for products of binary group codes of even minimal weight and for Hobbs' codes of any dimension.

ON THE WEIGHT OF THE ELEMENTS OF BINARY GROUP CODES
L. Calabi, et al., Parke Mathematical Labs., Inc., Carlisle, Mass., Report No. 7, (AFCRL-63-105), March 1963, 41 p., 11 refs., N63-17630, AD 407 059.

. . . new upper and lower bounds are obtained which are easy to compute and, in certain regions, better than other known bounds.

ON THE COSET CODES IN ASYMMETRIC CHANNELS (Correspondence)
C. V. Freiman, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 118.

. . . a coset code is formed whenever an n-place binary sequence other than a code word is added to each of the code words of a redundant n-place binary group code. In this communication we shall show that any coset code formed from a close-packed single error-correcting (Hamming) code outperforms that code in any memoryless binary channel of nonzero capacity which is not perfectly symmetric. . . .

METODY PREOBRAZOVANIIA KODOVYKH KOLETS (Methods For Converting Code Rings) (In Russian)
G. F. Ianbykh, Radiotekhnika i Elektronika, vol. 8, Aug. 1963, p. 1301/1311, 12 refs., A63-25286.

Presentation. . . of code rings (periodic symbol sequences). The method makes it possible to obtain, in a number of cases, a code ring with a period equal to the product of two initial code rings. Conditions are formulated for obtaining such a ring when the initial rings are binary sequences. It is shown that the method of converting rings by B-conversion is a particular case of the new method. . . .

M-ARY SIGNALLING AND BALANCED INCOMPLETE BLOCK DESIGNS
A. S. Kobos, Air Force Systems Command. Griffiss AFB, N.Y., Advanced Development Lab., (RADC-TDR-63-256), June 1963, 13 p., 13 refs., N63-19779.

A set of code words obtained by the cycle permutation of binary sequences having autocorrelation functions with only two values is discussed. The relationships of this type of code to solutions of balanced, incomplete block design problems and other mathematical constructs are presented. These codes consist of m words of m binary digits each. . . . Cases in which these codes can be shown to exist are noted, and a list of known codes with lengths less than 100 is provided. The advantages of signaling with this type of code, as compared to orthogonal code words, are discussed.

ON MAXIMUM-WEIGHT CODES (Correspondence)
E. Myravaagnes, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 289/290.

. . . a counter-example to a statement made in papers by Helstrom and Borodin, devoted to maximum-weight group codes. . . .

COMMUNICATION SYSTEMS TECHNIQUE BASED ON FUNDAMENTAL CONCEPTS OF JACQUES HADAMARD
R. G. Segers, Vitro Labs., West Orange, N. J., (RADC-TDR-63-177), June 1963, 79 p., 41 refs., N63-17897.

PROBLEMS OF CYBERNETICS (Selected Articles)
Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 16 Aug. 1963, 49 p., AD 415 169.

Mathematical studies. . . on group code theory, and the application of the Hadamard Matrix to a single problem of coding.

Related Publications:

THE THEORY OF GROUPS
M. Hall, Jr., New York, MacMillan Co., 1959, 420 p.

DESIGN METHODS FOR MAXIMUM MINIMUM-DISTANCE ERROR-CORRECTING CODES
J. E. MacDonald, IBM J. Res. Developm., vol. 4, no. 1, Jan. 1960, p. 43/57.

. . . If a code can be constructed with minimum distance between code points of 2m+ 1, then any number of errors per code word which does not exceed m can be corrected, thus increasing the reliability of transmission above that to be expected with no redundancy in the code.

A NOTE ON A NEW CLASS OF CODES
G. Solomon, Inform. Control, vol. 4, no. 4, Dec. 1961, p. 364/370.

Error correcting codes of all (k, p) group codes (p odd), i. e., linear mappings of k-tuples of zeros and ones into p-tuples of zeros and ones, are viewed as a purely algebraic problem. This problem concerns the zeros of certain polynomials on pth roots of unity. These polynomials are parameterized via elements of subgroups of the smallest field containing the pth roots of unity. We introduce, in addition, the so-called jump-shift register codes. These are ((p+1) /2, p) single error-correcting codes for p, a prime for which 2 has multiplicative order p - 1. These noncyclic codes are placed in a pseudo-cyclic setting and are easily encodable and decodable. . . .

TREE-LIKE STRUCTURE OF BLOCK CODES (Correspondence)
D. M Jones, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 384/385.

WEAK SIGNAL COMMUNICATION TECHNIQUES
Bell Telephone Labs., Inc., Whippany, N. J., Final rept., May 1961/April 1963. July 1963, 96 p., ASD TDR63 525, AD 417 037.

. . . The theoretical results. . . are documented more fully in the interim report (AD 299 219) dated April 1962. That report included. . . determination of group code performance. The present report contains. . . use of binary group codes in the gaussian noise channel . . .

2.121: Theory of PN Sequences of Binary Elements

Included: Pseudo-noise binary sequencies; Linear shift-register generated sequences; Pseudo-random sequences; Autocorrelation function of cyclic binary sequences; Theory on PN sequence generation; Partially correlated binary codes; Generating specified shifts of PN sequences; Cycle-and-add property of PN sequences; Punctured cyclic codes in general; Periodic sequences with specified autocorrelation; Equivalence classes of sequences; Correlation functions of filtered PN sequences; Perfect sequences; Optimal sequences; Minimax sequences; Quasi-PN sequences; Complementary sequences; Self-products of PR sequences; Phase shift pulse codes.

Not Included: Design of sequence generators; Communications systems with binary sequences (1); Ranging systems with binary sequences.

Cross References: Punctured cyclic codes for error correction (2.740); Hadamard matrices (2.120); Multiplexing with quasi-orthogonal binary functions (2.640); Nonbinary PN sequences for error correction (2.760).

Principal Publications:

INTRODUCTION TO LINEAR SHIFT-REGISTER GENERATED SEQUENCES
T.G. Birdsall, et al., Univ. of Mich. Research Institute, Ann Arbor, Electronic Defense Group, Dept. of Electrical Engrg., Tech. Rept. No. 90, Oct. 1958, 112 p.

This report deals with both maximal and non-maximal sequences of linear, shift-register generators. . . . the theory of algebraic polynomials . . . is used to determine the properties of sequences from a given generator. . . . shift-and-add properties of both maximal and non-maximal sequences are discussed. . . .

THE CORRELATION FUNCTIONS OF RANDOM SEQUENCES OF RECTANGULAR PULSES
I.N. Amiantov, et al., Radio Engng., vol. 14, no. 4, 1959, p. 9/25.

PERIODIC SEQUENCES WITH AUTO-CORRELATION PROPERTIES
JPL Res. Summ., vol. 1, no. 36-4, June - July 1960, p. 62/63.

. . . A program has been written for the IBM-704 which computes all of the most general prime implicants . . . consistent with a given partially specified Boolean function. . . .

EXPERIMENTAL DETERMINATION OF CYCLIC BEHAVIOR OF SEQUENCE GENERATORS
JPL Res. Summ. vol. 1, no. 36-4, June - July 1960, p. 63/64.

Consider an M-stage shift register with an appropriate feedback logic to generate a desired periodic sequence. If this period is less than 2^M, there will exist possible starting positions (vectors) for the shift register that do not belong to the desired cycle. The question arises as to whether these vectors will lead into the desired cycle, or perhaps into separate closed cycles. In particular, it is desired to know specifically which, if any, of the 2^M possible vectors do not lead into the desired cycle. This summary describes an experimental method of answering this question. . . .

PARTIALLY CORRELATED BINARY CODES
L.D. Baumert, et al., JPL Res. Summ., no. 36-11, Aug. - Sept. 1961, p. 29/30.

NONEXISTENCE OF CERTAIN PERFECT SEQUENCES
S.W. Golomb, et al., JPL Res. Summ., vol. 1, no. 36-9, May - June 1961, p. 30/31.

This note is intended to stress certain properties of sequences with two-level autocorrelation functions. Such sequences are called perfect. . . .

PHASE SHIFT PULSE CODES WITH GOOD PERIODIC CORRELATION PROPERTIES
R.C. Heimiller, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 254/257.

A method of generating phase shift pulse codes of arbitrarily long length with zero periodic correlation except for the peak for zero shift is presented. . . .

GOLAY'S COMPLEMENTARY SERIES (Correspondence)
J.B. Kruskal, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 273/276.

Golay, in a recent paper, introduced the notion of complementary sequences of 0's and 1's. He states as a result obtained by trial that complementary sequences of length 18 do not exist. We prove this result. . . .

IMPULSE RESPONSE OF LINEAR SYSTEMS USING CORRELATION AND DIRECT MEASUREMENT
B.E. Berson, Rochester U., N.Y., Aug. 1962, 58 p., incl. illus., 17 refs., AD 281 770.

If a pseudo-random noise sequence is used as the input to a linear system, then by suitably correlating the output of the system and a delayed version of the input, the impulse response of the system can be obtained. The effect of the finite size of the sequence autocorrelation function upon the expected results is analytically determined. . . . a simple method of obtaining a delayed sequence. . . . Measurements . . . on low pass rc filters. . . . A polarity-coicidence correlator was used . . .

PHASE SHIFT PULSE CODES WITH GOOD PERIODIC CORRELATION PROPERTIES (Correspondence)
R.L. Frank, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 381/382.

Polyphase codes with "good" periodic correlation properties have recently been described by Heimiller. By "good" is meant that the autocorrelation function of the periodic sequence is everywhere zero except at multiples of the period, where the autocorrelation function has a single maximum. Heimiller describes . . . codes . . . where p is a prime number. Frank, more than 9 years ago, designed identical N sequences without the restriction that N be prime. A recently issued patent describes a synchronizing system utilizing one special property of these codes and references . . . patent applications describing other aspects. Earlier descriptions of polyphase codes are contained in reports having restricted circulation. These reports contain probably the earliest usage of the term "phase-coding" as applied to discrete phase-shift modulation to the carrier of pulse signals. . . .

CORRELATION FUNCTIONS OF FILTERED PN SEQUENCES
C.E. Gilchriest, JPL Space Progr. Summ., vol. 4, no. 37-16, June - July 1962, p. 81/87.

Spacecraft communications systems developed by JPL depend quite heavily on pseudo-noise (PN) synchronization techniques . . . adaption to new systems nearly always uncovers new problems to be solved. Such is the case on the current spacecraft telemetry, command, and ranging systems.

COMPLEMENTARY SEQUENCES OF LENGTH 26 (Correspondence)
S. Jauregui, Jr., IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 323.

In a recent paper Golay suggested the need for an exhaustive search for complementary codes of length 26. Such a search has been completed using a CDC 1604 computer. . . . Dr. Golay informed the author . . . that he had found the complementary pair . . . using a "by hand" technique. . . .

A CONCISE ALGORITHM FOR THE SEQUENCE GENERATION
JPL Res. Summ., no. 36-14, Feb. - March 1962, p. 54/55.

A sequence generator capable of generating all binary sequences of length up to 64 was implemented and reported in RS 36-10, pp. 27-3. Previously, the word detector connections were given by a 2-page table which listed the appropriate connections for obtaining the length of the sequence. A set of instructions and a special work sheet were used to obtain these connections.
The two tables . . . take a long time to prepare and are inconvenient to use; moreover, in the case of longer sequences, the two tables would contain hundreds of pages. Consequently there has been a need for a concise table containing the necessary information.
A single 1-page table, has now been devised which replaces the two tables formerly comprising 16 pages.

FINDING SEQUENCES WITH FAVORABLE AUTOCORRELATION FUNCTIONS
R.C. Titsworth, JPL Res. Summ., no. 36-14, Feb. - March 1962, p. 51/53.

Binary cyclic sequences having certain period of the form 4k-1 possess autocorrelation functions which are ideal, in that the out-of-phase correlation values are all the same and negative. These are the so-called pseudonoise, or two-level autocorrelation, sequences which have been described frequently in the literature . . . These ideal sequences do not exist for every period of the specified form, the first counter-example being period 27. This article describes a search for the best (nearest-to-ideal) sequences of any specified length.

MUTUALLY DISTINGUISHABLE QUASI PN SEQUENCES
D.R. Anderson, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 124/132.

. . . shows how to construct periodic p-ary digital signals which have small out-of-phase autocorrelation and which have small in- and out-of-phase cross-correlation. For each prime p, finite field theory is used to construct families of p-ary signals of period p^m-1 corresponding to each positive integer m. . . .

AN ALGORITHM FOR GENERATING PSEUDO-RANDOM PERMUTATIONS
R. Eisen, Northwestern U., Evanston, Ill. Technological Inst., (ONR-RM-93; AD 431 536), Feb. 1963, 4 p., N64-16864.

An algorithm (suitable for coding on electronic computers) that can be used to generate pseudorandom permutations of any N numbers is presented. A computer code of the algorithm is presented along with an example of its use.

AN INTERESTING DECOMPOSITION PROPERTY FOR THE SELF-PRODUCTS OF RANDOM OR PSEUDORANDOM BINARY SEQUENCES (Correspondence)
W. J. Gill, et a., IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 246/247.

STUDY OF CORRELATION PROPERTIES OF BINARY SEQUENCES
R. Gold, Magnavox Co., Torrance, Calif. Interim rept. no. 1, Rept. no. R692, 15 Oct. 1963-15 Jan. 1964, AD 431 113.

. . . a new and promising approach to the problem of correlation of linear sequences is developed. Families of linear sequences of equal period are generated from a single shift register. . . .

GENERATING SPECIFIED SHIFTS OF PN SEQUENCES
R. Goldstein, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 104/105.

PN sequences have found wide use in recent years in the fields of telemetry, ranging and coding. In such fields, it is often desirable to generate a PN sequence which is shifted ahead (or behind) a reference sequence by a specified (and perhaps variable) amount.

The cycle-and add (Ref. 6) property of PN sequences offers a convenient method of producing the desired delay, as is portrayed in Fig. 15.

M-ARY SIGNALLING AND BALANCED INCOMPLETE BLOCK DESIGNS
A. S. Kobos, Rome Air Development Center, Griffiss Air Force Base, N. Y., Final rept., June 1963, 11 p., RADC TDR 63 256, AD 413 835.

A set of code words obtained by the cyclic permutation of binary sequences having autocorrelation functions with only two values is discussed. The relationships of this type of code to solutions of balanced incomplete block design problems and other mathematical constructs are presented. These codes consist of m words of m binary digits each. A simple m-ary system transmitting through white Gaussian noise is used to discuss error probabilities. . . . The advantages of signalling with this type of code, as compared to orthogonal code words, are discussed.

BINARFOLGEN LINEAR RUCKGEKOPPELTER SCHIEBEREGISTER, ERZEUGUNG, EIGENSCHAFTEN UND ANWENDUNGSBEISPIELE (Binary Effects of Coupled Linear Feedback Shift - Register, Generation, Characteristics and Examples of Application) (In German)
H. H. Leibelt, Nov. 1963, 89 p., refs., Available from Vereinigte Universitats-u, Fachbuchhandlungen, R. Wagner Str. 1, Cologne, W. Germany, (DVL-307), N64-15032.

The characteristics of the binary effects generated by a coupled-feedback linear shift register are discussed. Emphasis is placed on investigations of period length, the correlation function, and the number of effects with maximum-period length.

A GENERAL VIEWPOINT ON SHIFT-REGISTER SEQUENCES
I. S. Reed, RAND Corp., Santa Monica, Calif., Memo. no. RM3874 PR, Oct. 1963, 19 p., AD 420 361.

. . . concentrating on the synthesis of counters able to create extremely long sequences by sequentially modifying the effective connections or operators in the feedback loops. Nonlinear shift-registers are examined from several different points of view, and then the insight so afforded is applied to. . . yield maximal length sequences with a minimum of equipment.

ANALYSIS AND SYNTHESIS OF LINEAR AND NON-LINEAR SHIFT REGISTER GENERATORS
T. A. Roberts, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 390/399, 14 refs.

. . . This paper surveys techniques for the analysis and synthesis of digital counters or sequence generators composed of shift registers with logical feedback. Shift register generators are of interest for two reasons: (1) their ability to generate cyclic code sequences of any periodicity with unique randomness and correlation properties, and (2) their distinct advantages in circuit economies over conventional counter designs for digital computer and control applications.

PUNCTURED CYCLIC CODES
G. Solomon, et al., JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 100/104.

. . . a class of codes which are obtained from maximal length shift register codes by deleting or puncturing certain of their coordinates. The "punctured cyclic codes" thus obtained are shown to be optimum and an encoding and decoding procedure is outlined. In the demonstration of the optimality of these codes, a new group code is derived. This bound is always as good as, and generally

better than, the well-known Plotkin bound (Ref. 4).

CORRELATION PROPERTIES OF CYCLIC SEQUENCES
R. C. Titsworth, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, (NASA CR-51586; JPL-TR-32-388), July 1, 1963, 88 p., 76 refs., N63-23043.

. . . In the unconstrained channel with additive Gaussian noise, where the optimum detector is based on correlation or matched filters, the quality of a code can be expressed as a function of the correlation values between code words. Methods are presented for determining cyclic sequences with given correlation properties. When the amount of equipment in the receiver is limited, matched filtering is no longer the optimal detection scheme. A better system is one which by the use of a Boolean Function, combines several "component" sequences to generate the transmitted signal; the receiver consists of filters matched to each component . . .

OPTIMAL AND MINIMAX SEQUENCES
R. C. Titsworth, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 381/389.

. . . Binary cyclic sequences with 'perfect' 2-level autocorrelation functions have been studied by Golomb, Hall, and others. These sequences are useful in communications because delayed replicas of the sequence are maximally distinguishable from the original, insofar as correlation is involved. . . . These sequences all have periods of the form 4t+3, but this condition alone is not sufficient. In fact, their periods grow relatively sparse as their period becomes large. . . . It is advantageous, because of this scarcity, to seek sequences having arbitrary period, with as near-perfect autocorrelation as possible. It is the purpose of this article to study binary cyclic sequences whose maximum out-of-phase autocorrelation value assumes the minimum value possible for its particular period, and to develop a criterion by which one may know whether a given sequence is optimal from this point of view. . . .

AN UPPER BOUND ON THE NUMBER OF SOLUTIONS TO THE CORRELATION EQUATION
R. C. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 133/136.

cyclic binary (0,1) sequence . . . its autocorrelation function . . . solutions to . . . are not unique. But how many solutions are there—apart from cyclic shifts? An upper bound on the number of such solutions is derived here.

PERIODIC SEQUENCES WITH SPECIFIED AUTOCORRELATION
R. C. Titsworth, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 91/93.

Huffman (Ref. 1) has shown that periodic sequences having a certain type of autocorrelation function can be determined by considering the polynomial whose coefficients are the autocorrelations.

The same technique can be used, with modification, to analyze cyclic sequences whose autocorrelation is specified. There is, however, a straightforward method, involving only elementary concepts, to determine such sequences. . . . factoring the spectral function of the sequence into two conjugate parts each of whose inverse Fourier transforms are real sequences.

BOUNDS ON THE NUMBER OF EQUIVALENCE CLASSES OF SEQUENCES
R. C. Titsworth, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 93.

AMBIGUITY FUNCTIONS OF COMPLEMENTARY SEQUENCES (Correspondence)
R. Turyn, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 46/47.

A pair of binary sequences (x_i), (y_i) will be called complementary if the sum of their (nonperiodic) correlation functions is zero except for zero shift (i.e., is a δ function). . . .

Related Publications:

SERIAL CORRELATION IN THE GENERATION OF PSEUDO-RANDOM NUMBERS
R. R. Coveyou, J. Assn. Computing Machinery, vol. 7, no. 1, Jan. 1960, p. 72/74.

SHIFT REGISTERS GENERATING MAXIMUM-LENGTH SEQUENCES
P. H. Scholefield, Electronic Technol. (GB), vol. 37, no. 10, Oct. 1960, p. 389/394.

Some examples are given of an improved logical arrangement which enables certain maximum-length shift-register sequences to be generated with fewer circuit components than in earlier methods. . . .

GENERAL-PURPOSE SEQUENCE GENERATOR
M. F. Easterling, et al., JPL Res. Summ., vol. 1, no. 36-10, June/July 1961, p. 27/30.

A sequence generator capable of generating all binary sequences of length up to 64 has been implemented. This sequence generator is capable of generating a total of $2^{65}-2$ different sequences. In order to generate any one of the available sequences, a minimum of 6 and a maximum of 22 external connections are needed. . . .

HADAMARD MATRICES OF ORDER 16
E. C. Posner, et al., JPL Res. Summ., vol. 1, no. 36-10, June/July 1961, p. 21/26.

It has been shown. . . that a normalized Hadamard matrix equivalent to a group matrix is itself a group matrix. This was used to prove that a second Hadamard matrix of order 16 is indeed inequivalent to the group of order 16.

HADAMARD MATRICES OF THE WILLIAMSON TYPE
L. Baumert, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 139/140.

. . . been conjectured that Hadamard matrices exist for all. . . values of n. Since an Hadamard matrix of order 2n = 2(4t) can easily be constructed from one of order n, the question of existence for all possible n is reduced to the case where t is odd.

NOTE ON HADAMARD MATRICES OBTAINED FROM DIFFERENCE SETS
M. Hall, Jr., JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 140/143.

Hadamard matrices of order n = 4t are known to exist for all values of n = 4t less than 200 except for n = 116, 156, and 188. In this discussion it is shown that no difference set exists which would yield a matrix of any one of the orders 116, 156 or 188. The special methods given here can be generalized to other cases.

HADAMARD MATRICES: A POLYNOMIAL APPROACH
G. Solomon, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 57/60.

. . . an attack is launched via the Mattson-Solomon (ref. 3) polynomials over the roots of unity. This successful approach to block coding is now applied to the above problem, and from this viewpoint some of the old results are reformulated, causing the outstanding problems to become problems on algebraic surfaces over finite fields.

Most of the results concerning polynomials over roots of unity are contained in previous Summaries and published papers (RS 36-12, Vol. I, p. 68/70, Refs. 3, 4) . . .

HADAMARD MATRICES AND CONSTANT-DISTANCE CODES, II
R. E. Block, JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 187/188.

MAXIMUM DISTANCE Q-NARY CODES
R. C. Singleton, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 116

A Q-nary error-correcting code is a code based on q symbols, rather than on two as in the case of binary codes. These codes have been studied by a number of authors and much of this work is summarized by Peterson. . . . In this paper, the class of codes. . . called maximum-distance separable (M.D.S.) codes . . . were investigated. . .

2.122: Codes with Orthogonal Binary Sequences

Included: Comma-free binary orthogonal sets; Bi-orthogonal code sets of binary sequences; Codes with quasi-orthogonal sequences in communications systems.

Not Included: Communications systems with binary sequences (1); Orthogonal sets of waveforms for communications (1).

Cross References: Comma-free codes for source encoding (2.211); Hadamard matrices (2.120); Legendre synchronization codes (2.124); Polyphase codes (2.130); Multiplexing with orthogonal binary sequences (2.542).

Principal Publications:

TWO PROPERTIES OF PSEUDO-RANDOM SEQUENCES
L. L. Campbell, IRE Trans. Inform. Th., vol. IT-5, March 1959, p. 32.

. . . which may make them useful in certain communication systems.

ORTHOGONAL MATRICES, ERROR-CORRECTING CODES AND LOAD-SHARING MATRIX SWITCHES (Correspondence)
R. T. Chien, IRE Trans. Electronic Comput., vol. EC-8, no. 3, Sept. 1959, p. 400.

CODING LONG SECTION OF BINARY SYMBOLS
V. A. Garmash, Radio Engng., vol. 14, no. 4, 1959, p. 84/87.

. . . in the transmission discrete communications over a noiseless channel a considerably long chain N of symbols may be coded in a sequence of binary numbers in such a way that the average number of binary signs on the initial

symbol of the communication will be approximately equal to the entropy of the initial communication H. . . . a group of chains with a very small probability . . .

ORTHOGONAL CODES
H. F. Harmuth, Proc. Instn. Elect. Engrs. pt. C., London, vol. 107, no. 12, Sept. 1960, p. 242/248.

Code alphabets whose characters can be represented by a finite sequence of digits of value +1 have been extensively investigated. The characters of these binary codes may be considered to be superpositions of orthogonal functions, one for each digit, which are multiplied by +1 or -1. A character of an orthogonal code consists of one function of a set of orthogonal functions multiplied by +1 or -1. . . .

ON CODED PHASE-COHERENT COMMUNICATIONS
A. J. Viterbi, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, (Technical rept. no. 32-25), 15 Aug. 1960, AD 243 735.

. . . This report considers the result of encoding independent equiprobable binary words or sequences of independent binary digits into sets of binary code words. These are transmitted over a channel perturbed by additive white gaussian nouse and detected by correlating them with their stored or locally generated replicas at the receiver. . . .

CODING THEORY AND ITS APPLICATIONS TO COMMUNICATIONS SYSTEMS
L.D. Baumert, et al., Jet Propulsion Lab., CIT, Pasadena, Calif., (Tech. rept. 32-67), 31 March 1961, 84 p., AD 257 752.

A general theory of binary sequences with desirable correlation properties is developed for application to the design of digital communication systems. . . .

THE TRANSFORMATION GROUP OF AN ORTHOGONAL CODE
J. Kohler, JPL Res. Summ., no. 36-13, Dec./Jan. 1961, p. 24/26.

PERMUTATION AND COMPLEMENTATION OF THE COLUMNS OF A CODE. In a previous report (RS 36-12 Vol. 1) the group of permutations on the columns of the Hadamard biorthogonal dictionary, which leaves the dictionary invariant, was determined. The results obtained there are here extended so as to include the operation of interchanging 0 and 1 in any given column of the code. The operations of permuting columns and interchanging 0 and 1 in a given column preserve the error-correcting properties of the code. However, comma freedom may be introduced (or destroyed) by these operations.

ALGORITHMS FOR THE CONSTRUCTION OF CERTAIN BINARY CODES
J. J. Stiffler, JPL Res. Summ., no. 36-13, Dec./Jan. 1961, p. 26/28.

In selecting a code dictionary for the continuous channel, it is sometimes expedient, in the interest of band-width conservation, for example, to choose a sub-optimum dictionary. Such a dictionary might be one in which the maximum cross-correlation between code words is positive, but nevertheless small, while the number of words is considerably greater than that of the transorthogonal dictionary with the same number of binary symbols per word. . . . several methods are presented for systematically constructing binary codes of this type. . . . It is well known that the so-called binary biorthogonal codes can be constructed from orthogonal codes . . . The code dictionary is doubled . . . It will be shown that the biorthogonal code can again be doubled in size . . .

OPTIMUM MESSAGE TRANSMISSION IN A FINITE TIME
S. S. L. Chang, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 215/224.

. . . It is shown that the optimum signals are sequences of binary waveforms resembling a $(2^m - 1, m)$ Slepian group code, the generators of which can be obtained from a modified Reed Code.

An analysis is also made of near-optimum codes which allow some inequality in the distance between code words in signal space. The advantage of these near-optimum codes is that for a small sacrifice in error probability, either the information rate can be substantially increased, or the bandwidth of the system greatly reduced. The details of these systems are given and the results show that a manyfold improvement is obtained. . . .

THE NONEXISTENCE OF COMMA-FREE BINARY ORTHOGONAL SETS OF ORDER 8
M. Hall, et al, JPL Res. Summ., no. 36-14, Feb./March 1962, p. 44/46.

Consider an 8 x 8 array of ones and zeros with the property that the sum (term-by-term addition modulo 2) of any two rows of this array contain exactly four ones.

Such an array is called an orthogonal set. If this set of rows has the additional property that no overlap formed from any two rows is a third row or the complement of a third row, it is called strongly comma-free of index one. This paper shows that no such set exists.

AN INTEGRATED "ERROR-FREE" COMMUNICATION SYSTEM
J. C. Hansen, Philco Corp., Palo Alto, Calif., Tech. note no. WDL-TN62-13, 31 Dec. 1962, 17 p. incl. illus., AD 401 182.

. . . a system is proposed which combines the functions of command, synchronization, range, and range rate on one two-way radio link. . . . employing comma-free words which have been coded for error detection. The coding is such that synchronization obtains the same high degree of reliability as the information. . . . offers relative ease of implementation common to the class of cyclic codes.

ORTHOGONAL CODES AT VERY LOW SIGNAL-TO-NOISE RATIOS
E. C. Posner, JPL Res. Summ., no. 36-14, Feb./ March 1962, p. 36/39.

Here the same problem as in the preceding section is considered, but for orthogonal codes using correlation detection instead of for error-correcting codes using bit-by-bit detection.

ON THE USE OF BINARY ORTHOGONAL SELF-SYNCHRONIZING CODES
J. J. Stiffler, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 153/155.

KODIEREN MIT ORTHOGONALEN FUNKTIONEN. I. GRUNDLAGEN (Coding with Orthogonal Functions. I. Fundamentals) (In German)
H. Harmuth, Arch. Elekt. Uebertragung, vol. 17, Sept. 1963, p. 429/437.

The characters of code alphabets can be represented by the superposition of orthogonal time functions. This representation permits the detection of telegraph signals by cross-correlation with a few sample functions rather than by cross-correlation with many sample characters that can be assembled from these functions. . . . Furthermore, the fundamentals for the computation of the relative error rates due to thermal noise are derived. They will be used in a forthcoming paper to devise alphabets that permit an error-free transmission. Unlike the error-free alphabets devised by Elias they allow to approach arbitrarily well Shannon's limit of the transmission capacity of a communication channel. . . .

KODIEREN MIT ORTHOGONALEN FUNKTIONEN. II. KOMBINATIONS-ALPHABETE UND MINIMUM-ENERGIE-ALPHABETE (Coding with Orthogonal Functions. II. Combinations Alphabets and Minimum Energy Alphabets) (In German)
H. Harmuth, Arch. Elekt. Uebertragung, vol. 17, Nov. 1963, p. 508/518.

SEVERAL CLASSES OF CODES GENERATED FROM ORTHOGONAL FUNCTIONS
P. Hsieh, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 88/91.

. . . utilizing the existing knowledge of discrete error-correcting binary codes . . . The method consists in constructing the transformation matrix . . . that performs the linear transformation by taking the finite set of orthogonal functions into the set of continuous code words. . . . In constructing signals for continuous channels, it is possible to use waveform redundancy to reduce the probability of transmission error. . . . In particular, discrete ternary codes using symbols -1, 0, 1 are constructed to form some classes of continuous codes. . . .

200 Mbit/s PSEUDO RANDOM SEQUENCE GENERATORS FOR VERY WIDE BAND SECURE COMMUNICATION SYSTEMS
R.A. Marolf, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 183/187.

. . . The generators are of the re-fed shift register type, whereby the shift register can easily be expanded by regular transmission lines to generate extremely long sequences. The Pumped Tunnel Diode Transistor Logic (PTDTL) circuit is used in the shift register and feedback logic circuit. Stable operation is ensured by wide tolerances on dc bias and "pump" voltages. . . .

TRANSMISSION OF TELEMETRY DATA BY MEANS OF GROUP CODES
E.V. Mitriaev, (Radiotekhnika i Elektronika, vol. 8, June 1963, p. 923/929 In Russian) Radio Engng. Electronic Phys., vol. 8, June 1963, p. 935/940, Translation, A64 17556.

Discussion of a method of optimum representation of digital data by group code combinations. The method is stated to minimize the mean risk with the power of the loss function $s > 1$ and with uniform probability distribution. Statement of the problem, properties of the group code combination-transformation matrix, the best permutation and its properties, and an example of optimum correlation are considered. . . .

ON THE APPLICATION OF SOME DIGITAL SEQUENCES TO COMMUNICATION
J.K. Wolf, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 422/427.

The effects of filtering a random binary sequence with certain finite memory linear and nonlinear filters are considered. Of interest are the statistical properties of the filtered sequence such as the power spectral density and amplitude distribution function, as well as methods for recovering the original sequence. Applications of these techniques to communication systems are discussed. . . .

Related Publications:

REPRESENTATION AND ANALYSIS OF SIGNALS. PART VII. SIGNAL DETECTION IN A NOISY WORLD
W.M. Huggins, Johns Hopkins U. School of Engineering, Baltimore, Md., (AFCRC TN 601360), 15 Sept. 1960, 82 p., incl. illus., AD 245 887.

. . . The phase-principle of signal detection is generalized to be applicable to signals of arbitrary waveform and it is shown that a particular realization of a phase detector using superlimiters requires about 5 db more S/N than does a conventional matched-filter amplitude detector for the same detection and false-alarm probabilities.

INVESTIGATION OF DIGITAL DATA COMMUNICATION SYSTEMS
J.G. Lawton, Cornell Aeronautical Lab., Inc., Buffalo, N.Y., (Rept. no. UA-1420-S-1), (RADC TR 61-58), 3 Jan 1961, AD 256 584.

. . . performance of several types of Phase Shift Keyed (PSK) systems, as determined by the relationship of the error probability to signal-to-noise coherent, binary and m-state PSK systems, and the effects of frequency offset, cross-talk and thermal noise on the performance of these systems are considered.

A NOTE ON A NEW CLASS OF CODES
G. Solomon, Inform. Control, vol. 4, no. 4, Dec. 1961, p. 364/370.

Error correcting codes of all (k, p) group codes (p odd), i.e., linear mappings of k-tuples of zeros and ones into p-tuples of zeros and ones, are viewed as a purely algebraic problem. This problem concerns the zeros of certain polynomials on pth roots of unity. These polynomials are parametrized via elements of subgroups of the smallest field containing the pth roots of unity. We introduce, in addition, the so-called jump-shift register codes. These are ((p+1)/2, p) single error-correcting codes for p, a prime for which 2 has multiplicative order p - 1. These noncyclic codes are placed in a pseudo-cyclic setting and are easily encodable and decodable. . . .

A NEW MULTIPLEX TECHNIQUE FOR TELEMETRY
A.H. Ballard, Nat. Telem. Conf., May 1962, no. 6-2, p. 1/16.

. . . The name ORTHOMUX (meaning Orthogonal Waveform Multiplexing) has been adopted to describe the new concept. . . . The polynomial waveforms which exhibit this property may be generated in a very simple way by cascading miniature circuit modules fully transistorized in design. . . .

LEGENDRE PCM SYNCHRONIZATION CODES
R.S. Codrington, et al., Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 2.5, 17 refs.

THE GENERATION OF IMPULSE-EQUIVALENT PULSE TRAINS
D.A. Huffman, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S10/16.

The necessary and sufficient conditions for a function to be the autocorrelation function of a waveform consisting of a finite length train of pulses of various amplitudes is derived. The number of pulse trains having a given realizable autocorrelation function is determined. An "impulse-equivalent" pulse train is defined as one that yields, as closely as is theoretically possible, the same autocorrelation function that a single pulse gives. . . .

NOTE ON THE EXISTENCE OF PERFECT MAPS
I.S. Reed, et al., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 10/12.

. . . In determining location in a previously mapped region by map-matching, there arises the question of minimum submap size relative to the size of the complete map of the region for unambiguous determination of position. A lower bound for the size of the submap is obtained for quantized binary maps. . . . The two-dimensional analogy of perfect maps to shift register codes suggests a possible davelopment of planar error-correcting codes and an application to the two-dimensional range-velocity amibiguity problem of radar.

SYNCHRONIZATION METHODS FOR BLOCK CODES
J.J. Stiffler, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 25/34.

Efficient use of block codes to communicate over a telemetry channel is dependent upon the knowledge of the instants, in time, that one code word ends and the succeeding waveform begins. This word synchronization is the subject of concern in this paper. Two . . . techniques . . . The first relies upon the identification of periodically transmitted prefixes, which unavoidably increase the redundancy . . . The second . . . eliminates the need for prefixes entirely and relies instead upon certain properties of the code itself. Both these techniques are investigated more closely as applied to binary orthogonal codes. . . .

RANDOM MULTIPLE ACCESS
H.E. Lanning, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 169/174.

The most obvious means of providing random multiple access to a satellite communication system is through the use of frequency and time division multiplex. . . . methods of assigning channels are not completely satisfactory . . . It is possible to eliminate some of the problems associated with standard frequency and time division multiplex by combining them and using one wideband channel in a signal stacking arrangement. . . . orthogonal signals can be constructed . . . Unfortunately, these codes require inter-channel synchronization and complex address generation. . . . by constructing interference rejecting codes an efficient system of channel utilization could be developed. The generation of these interference rejecting codes is most easily accomplished by utilizing pseudo-

random sequence generators. The resulting signals will be quasiorthogonal and have a cross channel interference level controllable to any arbitrarily low level. . . .

COMMUNICATION SYSTEMS TECHNIQUE BASED ON FUNDAMENTAL CONCEPTS OF JACQUES HADAMARD
R. G. Segers, Vitro Labs., West Orange, N. J., Final Report (April 1962 - March 1963), RADC-TRD-63-177), June 10, 1963, 79 p., 41 refs., N63-17897.

. . . conducted for the purpose of development of advanced communications systems. Chapter I presents a functional analysis approach to the demodulation problem . . . Chapter II concentrates on mathematical considerations . . . to enlarge the domain of the validity of the theory of Chaper I. Chapter III presents communication techniques derivable from incidence matrices of balanced incomplte block-design configurations.

PSEUDO-RANDOM CODING FOR BIT AND WORD SYNCHRONIZATION OF PSK DATA TRANSMISSION SYSTEMS
J. C. Springett, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 410/422, 14 refs.

REDUNDANCY AND COMPLEXITY OF LOGICAL ELEMENTS
S. Winograd, Inform. Control., vol. 6, no. 3, Sept. 1963, p. 177/194.

. . . The complexity of encoders of block codes for transmission of information is defined. . . . establish a connection between the bound on the error correcting ability of a redundant circuit and the bound on the error correcting ability of a block code. . . .

2.123: Ranging Codes

Included: Sequence correlation estimates; Maximality of majority logic; Clock component codes; Acquisition properties of ranging codes; Acquirable codes.

Not Included: Delay lock discriminator; Coder and decoder for ranging systems; Acquisition procedures of ranging systems; Radar systems with ranging codes; Deep space ranging systems (4C); Signal processing for ranging codes (3A).

Cross References: Autocorrelation of PN sequences in general (2.121); Radar detection theory (2.883); Polyphase codes (2.130).

Principal Publications:

A RING MODEL FOR THE STUDY OF MULTIPLICATION FOR COMPLEMENT CODES
H. L. Garner, IRE Trans. Electronic Comput., vol. EC-8, March 1959, p. 25/31.

A CLASS OF ACQUIRABLE RANGING CODES
JPL Res. Summ., vol. 1, no. 36-1, Dec./Jan. 1959-1960, p. 40/42.

. . . The classical approach to determining range by radar is to transmit a pulse; and measure the round-trip time until it returns. . . . When the amount of power in the returning signal sinks below the threshold of detectability, due to increasing range and to power limitations in the transmitter, it is possible to transmit a periodic train of pulses, with some pulse repetition frequency f. Putting a correlator into the receiver facilitates the extraction of pulse position information from the noise, by the simple expedient of time averaging. . . . ambiguity. . . has been introduced. . . more sophisticated ranging procedure must be employed. One solution is to use a pseudo-random sequence of pulses on a periodic time base. . . .

DEEP SPACE RANGE MEASUREMENT
JPL Res. Summ., vol. 1, no. 36-2, Feb./March 1960, p. 26/31.

Acquirable Ranging Codes and Noise. . . . The process of acquiring a ranging code consists of making a series of trial matchings between a locally generated code and the code to be acquired. . . The correctness of a trial match is tested by multiplying the two signals together and averaging the product over a certain period of time. The correlation properties of the codes are such that a reasonable number of trials will assure a correct match between the two codes. . . .

THE EVOLUTION OF RANGING CODES
M. F. Easterling, et al., JPL Res. Summ., vol. 1, no. 360-10, June/July 1961, p. 26/27.

As the technique of ranging has developed through research, analysis, and experiment, there has been a continuous evolution of the ranging codes employed. It is the purpose of this report to summarize briefly this evolution and to present a new type of ranging code that meets the requirements of a transponder ranging system capable of operating over interplanetary distances.

MAXIMALITY OF MAJORITY LOGIC
R. C. Titsworth, et al., JPL Res. Summ., no. 36-11, Aug./Sept. 1961, p. 31/33.

When several binary sequences are combined by an arbitrary Boolean function, the properties of the output sequence have a particularly interesting form when the input sequences all have 2-level autocorrelation, a balance of 0's and 1's, and relatively prime periods. If the function is properly chosen, the characteristics of the output sequence are such that cross-correlations between this output and each input are high whenever the correlation delay is a multiple of the period of the input sequence, and low elsewhere. Such output sequences are thus easy to acquire, since each component can be acquired separately. In this article, it is shown that the best logic from the standpoint of maximum correlation with each component is a majority logic.

CONTINUOUS-WAVE RADAR WITH HIGH RANGE RESOLUTION AND UNAMBIGUOUS VELOCITY DETERMINATION
S. E. Craig, et al., IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 153/161.

. . . An excellent waveform for modulating the transmitter is the pseudorandom code generated by a shift register with multiple feedback paths. . . . It is shown that phase-reversal modulation results in little distortion of the code, while frequency modulation can give rise to false range indications.

ON OPTIMIZING CLOCK-COMPONENT RANGING CODES
R. C. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 91/96.

. . . single-channel ranging receiver. . . The inner loop, or clock-loop, is synchronized to the symbol rate of the incoming code $\alpha$by the presence of a "clock component" in α , and the locally generated code y is slaved to the output of this clock-loop.

Whenever the clock-loop is locked to the clock component of α , the local code y is stepwise synchronized to α (RS 36-2, 36-3, 36-19).

SEQUENCE-CORRELATION ESTIMATES BY PARTIAL SUMMATION
R. C. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 39-40.

. . . It is often advantageous, in the interest of saving time and equipment (if matched filters are used) to estimate the autocorrelation function of the sequence by summing the received sequence terms, multiplied by a delayed replica, for only a fraction of the total period. This article shows that such an estimate is unbiased and that the variance decreases monotonically to zero as more and more terms are admitted into the sum.

AN ACQUIRABLE CODE
E. Weiss, et al., Lincoln Lab., MIT, Lexington, Rept. no. 55G-2, (AFESD TDR 62-105), 9 July 1962, 8 p., 3 refs., AD 281 751.

. . . At the ground one transmits continuously a single sequence of very long period. This is received at the vehicle and retransmitted. Thus, at the ground a corrupted and out-of-phase version of the original sequence is received. By operating on it (usually by correlation techniques) one hopes to determine the phase, and then by measuring the elapsed time to find the distance in question (without sequence). Such a sequence is known as an acquirable code. . . . mathematical procedures. . . for selecting an acquirable code . . .

CODING FOR TRACKING RADAR RANGING
T. C. Bartee, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Technical rept. no. 318, 38 p., AFESD TDR63 104, AD 416 649, N64-14028.

. . . an uninterupted periodic binary sequence of very long period is used to modulate the radar output. The sequence employed has the property that a short segment of the sequence is uniquely associated with its phase or position in the sequence . . . A digital correlation procedure is employed to discriminate against detection errors which occur in the received segments. The expected time required to measure the distance and the probability of computing an an incorrect distance and are presented for various probabilities of detection error . . . logic design. . . required digital circuitry. . . .

GENERATING SPECIFIED SHIFTS OF PN SEQUENCES
R. Goldstein, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 104/105.

PN sequences have found wide use in recent years in the fields of telemetry, ranging and coding. In such fields, it is often desirable to generate a PN sequence which is shifted ahead (or behind) a reference sequence by a specified (and perhaps variable) amount.

The cycle-and add (Ref. 6) property of PN sequences offers a convenient method

of producing the desired delay, as is portrayed in Fig. 15.

BINARFOLGEN LINEAR RUCKGEKOPPELTER SCHIEBEREGISTER, ERZEUGUNG, EIGENSCHAFTEN UND ANWENDUNGSBEISPIELE (Binary Effects of Coupled Linear Feedback Shift-Register, Generation, Characteristics and Examples of Application) (In German)
H. H. Leibelt, Nov. 1963, 89 p., refs., Available from Vereinigte Universitats-u, Fachbuchhandlungen, R. Wagner Str. 1, Cologne, W. Germany, (DVL-307), N64-15032.

The characteristics of the binary effects generated by a coupled-feedback linear shift register are discussed. Emphasis is placed on investigations of period length, the correlation function, and the number of effects with maximum-period length.

HOW CODED-PULSE TECHNIQUES EXTEND RADAR RANGE
T. Sakamoto, et al., Electronics, vol. 36, Nov. 22, 1963, p. 34/37, A64-11294.

Brief description of an experimental long-range coded-pulse radar system which uses a wide transmitted pulse with a low repetition rate, and which increases resolution by phase modulating the transmitted pulse carrier. A pseudo-random sequence is generated with a feedback shift register as a modulating signal. . . .

CORRELATION OF CLOCK COMPONENT CODES
P. Schottler, et al., JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 189/192.

The use of codes derived from pseudonoise (PN) sequences to make precision measurements of range on targets in space is well documented (Refs. 5, 6). Typically, a range code is generated by combining a number of component sequences to produce a sequence which has the required length and correlation properties, and then assigning a unit of time, called one digit period, to each term of the combined sequence.

One important class of ranging codes is that in which one of the components is an alternating sequence of ± 1's (a clock). Sequences of this form are called clock-component sequences, and without loss in generality, the logic function by which they are generated can be separated into the product of the clock and a second combining function. . .

OPTIMAL RANGE CODING
R. C. Titsworth, JPL-TR-32-411; NASA CR-50762; 15 April 1963, 23 p., 9 refs., N63-19205.

. . . analysis of a continuous, coded ranging scheme. By the use of a Boolean function several "component" sequences are encoded into a transmitted signal. The receiver correlates the delayed return signal with different Boolean combinations of delayed replicas of the components to determine separately the time delay of each component sequence. From these delays, the total delay is computed.

AN UPPER BOUND ON THE NUMBER OF SOLUTIONS TO THE CORRELATION EQUATION
R. C. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 133/136.

. . . cyclic binary (0,1) sequence . . . its autocorrelation function . . . solutions to . . . are not unique. But how many solutions are there—apart from cyclic shifts? An upper bound on the number of such solutions is derived here.

Related Publications:

THE INFLUENCE OF A SEQUENCE OF PULSES, MODULATED BY A RANDOM PROCESS ON AN INERT PULSE DETECTOR
G. P. Tartakovskii, et al., Radio Engng., vol. 13, no. 1, 1958, p. 81/90.

ACQUISITION PROCEDURE
JPL Res. Summ., vol. 1, no. 36-6, Oct./Nov. 1960, p. 43/46.

. . . Briefly, it consists of five steps:
(1) Acquire clock
(2) Acquire x-component
(3) Wait (prevent lost lock)
(4) Acquire y-component
(5) Acquire z-component. . . A block of digital equipment has been added to control the acquisition procedure. . . Associated with this block is a manual control assembly. . . The code length switch sets the system for either a 5000-mile range or a 375,000-mile range. . . the integration time selector, selects the time constant of a filter on the output of the lock indicator of the 500-kc clock loop and selects the repetition rate of the pulse generator which times the acquisition control system. . . .

CORRELATION FUNCTIONS OF FILTERED PN SEQUENCES
C. E. Gilchriest, JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 81/87.

AN INTEGRATED "ERROR-FREE" COMMUNICATION SYSTEM

J. C. Hansen, Philco Corp., Palo Alto, Calif., Tech. note no. WDL-TN62-13, 31 Dec. 1962, 17 p., incl. illus., AD 401 182.

. . . a system is proposed which combines the functions of command, synchronization, range, and range rate on one two-way radio link. . . . employing comma-free words which have been coded for error detection. The coding is such that synchronization obtains the same high degree of reliability as the information. . . . offers relative ease of implementation common to the class of cyclic codes.

DELAY-LOCK TRACKING OF BINARY SIGNALS
J. J. Spilker, Jr., Lockheed Aircraft Corp., Sunnyvale, Calif., Technical rept. on Communications, (Rept. no. 6-90-62-85), Sept. 1962, 30 p., incl. illus., refs., AD 285 566.

TRANSPONDER RANGING SYSTEM
JPL Space Progr. Summ., vol. 1, no. 37-14, Jan./Feb. 1962, p. 91/92.

Mod II Coders

. . . are the range code generators associated with the Mod II ranging equipment. In general, they generate the ground transmitter code and the ground receiver code in any ranging system of which the Mod II equipment is a part. . . . They also produce the codes necessary for the turnaround transponder ranging system experiment.

Seven component code lengths have been included in the design of the coders. Provision is made for later addition of two more. . . The component codes are binary PN sequences which have two-level autocorrelation and whose periods are prime.

TRANSPONDER RANGING SYSTEM
JPL Space Progr. Summ., vol. 1, no. 37-14, Jan./Feb. 1962, p. 96/98.

Transponder Coders

. . . generate the ranging codes for the transponder as described in the section on code structure. . . . no attempt is made to make the transponder coders general purpose; equipment is limited to that required for a particular mission. A functional block diagram. . . in Fig. 24.

Sequence generator.

Code timing generator.

Output flip-flops.

Code form control.

CODED PULSE RADAR (Correlation Radar Using Randomly Coded Pulse)
T. Sakamoto, et al., IN: International Symposium on Space Technology and Science, Tokyo, Japan, August 27-31, 1962, 4th, Proceedings, edited by Tamiya Nomura, Tokyo, Japan and Rutland, Vt., Japan Publications Trading Co., 1963, p. 586/591.

. . . improving the performance of long-range-radar systems. . . the product of signal bandwidth and duration, namely, the radar response function, should be sharply defined and possess a low side-lobe. . . laboratory experiments were carried out. . . High range resolution is accomplished by modulating the phase of the carrier of transmitted pulse. Pseudo-random sequence generated by using a feedback shift register is utilized as a modulating signal.

DELAY-LOCK TRACKING OF BINARY SIGNALS
J. J. Spilker, Jr., IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 1, March 1963, p. 1/8.

. . . Binary maximal-length, shift-register sequences are used as the signal because they can easily be regenerated with any desired delay and they possess desirable autocorrelation functions. . . . performance in the presence of additive Gaussian noise is discussed. Computations are made of the effect of amplitude-limiting the received data on the system noise performance. . . .

OPTIMAL AND MINIMAX SEQUENCES
R. C. Titsworth, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 381/389.

. . . Binary cyclic sequences with 'perfect' 2-level autocorrelation functions have been studied by Golomb, Hall, and others. These sequences are useful in communications because delayed replicas of the sequence are maximally distinguishable from the original, insofar as correlation is involved. . . . These sequences all have periods of the form 4t+3, but this condition alone is not sufficient. In fact, their periods grow relatively sparse as their period becomes large. . . . It is advantageous, because of this scarcity, to seek sequences having arbitrary period, with as near-perfect autocorrelation as possible. It is the purpose of this article to study binary cyclic sequences whose maximum out-of-phase autocorrelation value assumes the minimum value possible for its particular period, and to develop a criterion by which one may know whether a given sequence is optimal from this point of view. . . .

THE AUTOCORRELATION FUNCTION OF THE PRODUCT OF MARKOV SIGNALS
R. C. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 136/138.

2.124: Synchronization Codes

Included: PCM synchronization codes; Spread spectrum composite synchronization codes; Barker type codes; Codes with bounded synchronization delay; Acquisition problems of synchronization code words; Self-synchronizing codes; Mutually distinguishable self-synchronizing continuous codes; Comma-free codes for synchronization purposes; Legendre PCM synchronization codes; Scanning techniques for synchronization; Group synchronization for digital communications systems; TIM timing codes; Re-synchronization of error-limiting codes; Path-variant comma-free codes; Synchronization methods for block codes.

Not Included: PCM synchronization methods (1); Frequency synthesizers; Master timing systems.

Cross References: Clock component codes (2.123); Theory of PN codes in general (2.121); Acquirable codes (2.123); Comma-free codes for source encoding (2.211); Codes for nonrandom errors (2.184); Bit-loss and gain correction codes (2.775).

Principal Publications:

SOME PROPERTIES OF SYNCHRONIZATION CODES
J. P. Burg, Texas Instruments Apparatus Division Signal Studies Report, Aug. 1960.

SYNCHRONIZATION OF BINARY MESSAGES
E. N. Gilbert, IRE Trans. Inform. Th., vol. IT-6, Sept. 1960, p. 470/477.

SYNCHRONIZATION METHODS FOR PCM TELEMETRY
Naval Ordnance Lab., Corona, Calif., Final rept., (Rept. no. NOLC-542), April 1959-Sept. 1960, (ASD TR 61-9), Aug. 1962, 59 p., incl. illus. tables, 8 refs, AD 286 835.

A specially coded synchronization pattern is required for proper identification of repetitive frames of pulse-code-modulated (PCM) sequences of binary bits. Study has shown that, with an assumed set of criteria, there are many favorable sync patterns. . . . A recommendation is made that a maximum frame sync pattern of 33 bits be specified at present and the choice of optimal patterns be determined by future study. . . .

SELF ADJUSTING AUTOMATS FOR DECODING MESSAGES (In Russian)
V. I. Levenshtein, Dokl. Akad. Nauk SSSR, vol. 141, no. 6, Dec. 1961, p. 1320/1323, 12 refs.

. . . It is shown that an automatic device for decoding messages can exist if the coding system has the property of limited interruption; the automat can be self-adjusting (self-correcting) if the coding system has a self synchronizing property. The length of interruption caused by accidental misadjustment is found in terms of parameters of the coding system.

MUTUALLY DISTINGUISHABLE SYNCHRONIZING CONTINUOUS CODES
R. Sydnor, et al., JPL Res. Summ., vol. 1, no. 36-9, April/May 1961, p. 33/37.

. . . In almost all coding problems studied to date, the codes used have been digital. However, in the problem of self-synchronous codes the use of continuous codes becomes possible; i. e., we can employ continuous waveforms with the same finite time duration, the same bandwidth, and the same total energy. We can obtain the self-synchronizing property by requiring of every pair of members of a continuous code . . . that the cross correlation . . . should be small, independent both of the choice of tau and the choice of pair. . . The continuous codes which we shall discuss are most simply defined by means of Fourier transforms. . . .

LEGENDRE PCM SYNCHRONIZATION CODES
R. S. Codrington, et al., Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 2.5, 17 refs.

One of the severest specifications on an operational PCM system is the short time required for the ground station to acquire synchronization with the airborne equipment. Synchronization is achieved by the ground station recognizing a coded binary sequence occupying one or more word positions in each frame. . . . The criterion most commonly used in choosing a synchronization code of a given length is that the aperiodic correlation coefficients C_k have the minimum absolute values. The Barker 3, 7, and 11 bit codes have this property but no systematic method of generating longer codes with minimal 1 C_k 1 has been available. In this paper it is shown that some Legendre sequences have the desired properties, and methods of generating Legendre codes of any prime length of 47 bits are given together with their periodic and aperiodic correlation coefficients. . . . In particular it is shown that all the Barker maximal length codes are Legendre codes and Legendre codes of prime length $p = 4_q + 3$, where q is any integer, are pseudo-random codes. . . .

OPTIMUM DECISION AND SCANNING TECHNIQUES FOR SYNCHRONIZATION
J. Z. Grayum, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 170/178.

Assuming both the communicator and his opponent are using optimum strategies, a "most efficient" method of synchronization requires the application of Wald's sequential probability ratio test. The average likelihood ratio, assuming phase unknown, reveals that the receiver includes a correlator, an envelope detector, a weighting filter, and a scanning program generator. . . .

A STATISTICAL ANALYSIS OF THE SYNCHRONIZATION OF DIGITAL RECEIVERS
H. Kaneko, Electronics Research Lab., U. of Calif., Berkeley, AFCRL 62 938, 11 April 1962, 79 p., AD 411 994.

The probability of error of certain digital transmission systems is investigated, under the condition that the transmitter-receiver synchronization is imperfect. It is assumed that the receiver is the Bayes receiver that would be optimum were the synchronization perfect. It is further assumed that a synchronizing signal is transmitted separately from the information-bearing signals, and that the sum of the two signal powers is constrained to a given value. The conditional error probability for a given synchronization error is evaluated for two particular binary systems, one using bipolar rectangular pulses and the other using unipolar cosine-squared pulses. The optimum synchronizer for the case of a sine-wave synchronizing signal is analyzed. . . .

PATH-INVARIANT COMMA-FREE CODES
W. B. Kendall, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 350/355.

Comma-Free codes with fixed word length have become classical both to the subject of genetics and to coding theory. Here we wish to expose a subclass of these codes which has a property called path invariance. The advantage of this subclass is the relative ease of encoding and decoding, i. e., establishing the position of the comma (synchronization). . . .

MAXIMA OF TRIGONOMETRIC SUMS
J. H. Lindsey, II, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 144/146.

In SPS 37-18, Vol. IV, pp. 155/157, the maximum of trigonometric sums with pseudo-random coefficients was discussed. (An application is to achieve bit synchronization through pseudo-random coding.) This article refines the bounds obtained there and indicates some reasoning to explain the bounds.

ADVANCEMENTS IN THE DESIGN AND EVALUATION OF GROUP SYNCHRONIZERS FOR PCM TELEMETRY
M. B. Rudin, et al., Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 35.

GROUP SYNCHRONIZATION FOR DIGITAL TRANSMISSION SYSTEMS
T. Sekimoto, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 381/390.

. . . particularly applicable for PCM systems. . . . used to determine the time origin of a sequence of binary signals by finding a specified deterministic pattern from a randomly modulated binary sequence. . . . A new system with faster recovery characteristics is presented, and an optimal framing pattern is shown. . . .

GROUP SYNCHRONIZATION FOR DIGITAL TRANSMISSION SYSTEMS
T. Sekimoto, et al., IRE Internat. Conv. Rec., pt. 8, vol. 10, March 1962, p. 57/71, 14 refs.

Group synchronization systems with digital feedback are studied, which are particularly applicable for PCM systems. Group synchronization is used to determine the time origin of a sequence of binary signals by finding a specified deterministic pattern from a randomly modulated binary sequence. . . .

SYNCHRONIZATION METHODS FOR BLOCK CODES
J. J. Stiffler, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 25/34.

Efficient use of block codes to communicate over a telemetry channel is dependent upon the knowledge of the instants, in time, that one code word ends and the succeeding waveform begins. This word synchronization is the subject of concern in this paper. Two . . . techniques . . . The first relies upon the identification of periodically transmitted prefixes, which unavoidably increase the redundancy . . . The second . . . eliminates the need for prefixes entirely and relies instead upon certain properties of the code itself. Both these techniques are investigated more closely as applied to binary orthogonal codes.

SYNCHRONIZATION OF TELEMETRY CODES
J. J. Stiffler, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 2, June 1962, p. 112/117.

A well-known means of efficiently transmitting information over the continuous white Gaussian channel involves the encoding of successive blocks of data into sequences of binary digits (called code words). Efficient decoding of these sequences in turn necessitates a knowledge of the instants in time at which one code word ends and the succeeding word begins.

This paper presents a method for obtaining this synchronization which neither decreases the channel capacity nor increses the complexity of the encoding equipment. . . . This technique is applied to an important class of block codes, the binary orthogonal codes. An algorithm for

constructing these codes with the desired self-synchronizing properties is presented, and upper bounds on the value of P_0 are thereby established. . . .

ON THE USE OF BINARY ORTHOGONAL SELF-SYNCHRONIZING CODES
J. J. Stiffler, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 153/155.

OPTIMUM CODE PATTERNS FOR PCM SYNCHRONIZATION
M.W. Williard, Nat. Telem. Conf., May 1962, no. 5-5, p. 1/11.

A DISCUSSION OF SPREAD SPECTRUM COMPOSITE CODES
D. J. Braverman, Aerospace Corp., El Segundo, Calif., Communications Systems Technical, Report No. 3, SSD-TDR-63-306; AD 425 862, 1 Dec. 1963, 49 p., refs, N64-13890.

. . . a technique known as composite code synchronization in which individual element codes of the composite can be synchronized individually . . . The detectability of the elements decreases as the square root of the number of elements. Optimum strategies for communication and jamming imply the use of the majority Boolean function of the elements which are in synchrony. Time averages are computed on an ensemble assumption by using a truth table in which each entry is equally probable.

TEST FOR SYNCHRONIZABILITY OF FINITE AUTOMATA AND VARIABLE LENGTH
S. Even, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 185/189.

A finite automaton is called synchronizable of Nth order if the knowledge of the last N outputs suffices to determine the state of the automaton at one time during the last N outputs (including the initial and the final states). In an analogous manner synchronizability of Nth order is defined for variable length codes. The paper describes a test for synchronizability on a more general model, the coding graphs, and shows that finite automata and variable length codes are special cases of it. . . .

SYNCHRONIZATION
S. W. Golomb, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 481/491.

I. The Panel Chairman's Introduction
II. Synchronization in Data Communication
III. On Synchronization in Communication Theory
IV. Synchronization and Bit Timing
V. Word Synchronization Over Noisy Channels.

CODES WITH BOUNDED SYNCHRONIZATION DELAY
S. W. Golomb, et al., JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 146/149.

. . . Comma-free codes were first introduced in order to facilitate synchronization of coded messages. However, for applications to synchronization, the weaker notion of bounded synchronization delay, to be defined below, accomplishes the same objective—unique location of word synchronization after a certain number of symbols have been received—and allows, in general, a larger dictionary size.

TECHNIQUES FOR SYNCHRONIZING PULSE-CODE MODULATED TELEMETRY
E. R. Hill, Proc. Nat. Telem. Conf., May 1963, no. 3-3.

Techniques for bit and frame synchronization of a non-return-to-zero PCM signal are discussed. . . . (1) where all frequency and phase information is obtained from the video signal, and (2) where frequency information is obtained from the RF carrier and phase information from the video signal (here bit frequency is coherent with the RF carrier). Frame synchronization is achieved with a repetitive group of contiguous bits. . . .

A SEARCH AND DISPLAY UNIT FOR THE TIM TIMING CODES (TYPE 2)
B. Lowe, et al., Weapons Research Establishment (Australia), Aug. 1963, 34 p., refs, N64-10224.

. . . This note describes equipment which has been designed to mark the occurence of any particular minutes and seconds code group in the TIM 10, TIM 100 or TIM 1,000 codes, particularly when these codes are read from magnetic tape. The minutes and seconds groups are continuously sampled, and various outputs are produced when the sampled code coincides with the setting of switches on the equipment . . .

ON BARKER CODES OF EVEN LENGTH (Correspondence)
D. G. Luenberger, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 230/231.

AN EFFICIENT PCM ERROR CORRECTION AND SYNCHRONIZATION CODE
M. S. Maxwell, et al., Rec. Nat. Space Electronics Symp., 1963, no. 7.4.

. . . A more efficient method of frame synchronization and error correction is analyzed. . . . Additional error correction information may be obtained if the voltage from the bit integrator is used with an error detecting code. The equivalent gain in signal to noise ratio, made by suing the additional error correction method, is discussed. . . .

GROUP SYNCHRONIZATION AS AN INFORMATION DETERMINING PROCESS (Correspondence)
D. R. Rhodes, IEEE Trans. Comm. Syst., vol. CS-11, no. 2, June 1963, p. 249/250.

Group synchronization in time-division communication is a special case of the general problem of transmission of information, and, as such, can be treated by the methods of information theory. The information to be communicated is the location of the sync position; i. e., the starting position of the group. . . .

ON SOME PRACTICAL APPROXIMATIONS TO THE IDEAL GROUP SYNCHRONIZATION PROCESS
D. R. Rhodes, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 222/229.

The best possible group synchronization process is the one that selects the most probable starting position of a sync pattern known to have been inserted into the transmission format. Such a device involves computations of an inverse probability function in each possible location of the sync position. The computer proves to be impractical to instrument ... This suggests a new and practical philosophy of group synchronization based on statistical hypothesis testing. . . . performances are analyzed for a PCM waveform, for hypothesis tests for least squared error, maximum cross correlation and maximum digital cross correlation. . . .

DETERMINATION OF AN OPTIMUM SYNCHRONIZATION CODE WORD FOR A CLASS OF BINARY TELEMETRY SYSTEM
A. Romano, et al., IEEE Internat. Conv. Rec., pt. 5, vol. 11, March 1963, p. 225/227.

PSEUDO-RANDOM CODING FOR BIT AND WORD SYNCHRONIZATION OF PSK DATA TRANSMISSION SYSTEMS
J. C. Springett, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 410/422, 14 refs.

. . . A method is presented by which bit and word synchronization can be achieved in a p. c. m. data link without the use of zero-crossing detectors and without the inclusion of sync words within the data format. The modulation and detection system employs maximum length linear shift-register codes (p.n. codes) in conjunction with phase-lock techniques to achieve unambiguous code synchronization, from which all bit sync, word sync, and coherent demodulation signals can be obtained. . . .

SINGLE-CHANNEL SYSTEM ACQUISITION PROPERTIES
J. C. Springett, JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 167/175.

JPL has employed pseudonoise (PN) techniques for the past several years to obtain word and bit synchronization for the telemetry link and bit synchronization for the command link. The acquisition properties of the two-channel systems, similar to that used for Mariner 2, have been treated in RS 36-9, Vol. 1, pp. 51/54. General descriptions of the single-channel system, which is the second generation of the PN synchronization approach, appear in Refs. 1, 2, and SPS 37-19, Vol. II. It is the intent here to examine the acquisition or lock-in properties of the single-channel system and compare the results with those obtained for the two-channel systems.

BOUNDS ON BARKER-TYPE CODES
R. C. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-25, Dec./Jan. 1963, p. 157/158.

ON BARKER CODES OF EVEN LENGTH (Correspondence)
R. Turyn, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1256.

In a recent communication of the same title . . . Luenberger restated the well-known fact that the length of an even-length Barker code is a square if 2, and also . . . The result that there are no such sequences of length 16(N=2) was to the best of my knowledge first noted in (2) Since then, several people have done both N=2 and N=3 (n = 16 and 36) verifying that there are no solutions satisfying just the periodic conditions. . . .

ERROR-LIMITING CODING USING INFORMATION-LOSSLESS SEQUENTIAL MACHINES
P. G. Neumann, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 108/115, 16 refs.

An information-lossless sequential machine is essentially a machine whose input sequence may be recovered from knowledge of its output sequence. A situation is considered in which such a machine is used as the encoder for a communication system. . . . This paper investigates the effects of transient errors in such a system and shows that there are encoders for which the decoder is incorrect . . . Each such encoder has input sequences which resynchronize the encoder following errors, as well as output sequences which resynchronize the decoder. . . .

Related Publications:

SPACECRAFT COMMAND SYSTEM DEVELOPMENT
JPL Res. Summ., vol. 1, no. 36-6, Oct./Nov. 1960, p. 60/63.

. . . The sync portion of the command system has been constructed in the laboratory, and the results of system testing and the solution to system lock-in ambiguities are presented in this report. . . .

PHASE SHIFT PULSE CODES WITH GOOD PERIODIC CORRELATION PROPERTIES
R. C. Heimiller, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 254/257.

A method of generating phase shift pulse codes of arbitrarily long length with zero periodic correlation except for the peak for zero shift is presented. The codes are of length p^2 where p is any prime number, and p different phase shifts corresponding to the pth roots of unity are necessary to generate them. . . . Application of these codes can be made as interpulse phase modulation for range resolution in pulse Doppler radars or for a method of synchronizing a pulse code communication system. . . .

A LINEAR MATCHED FILTER FOR SYNCHRONIZATION OF BINARY CODED MESSAGES
V. A. Jennings, et al., Proc. Nat. Telem. Conf., May 1961, p. 11-1/11-14.

. . . for the purpose of recognizing a seven-bit synchronization word which occurs at the beginning of each frame in a binary coded message. Because of the low bit rate, the design of the matched filter requires the use of a tapped delay line with a total length as great as 600 milliseconds. . . .

PCM TELEMETRY SYNCHRONIZATION
M. W. Williard, Proc. Nat. Telem. Conf., May 1961, p. 11-51/11-74.

PHASE SHIFT PULSE CODES WITH GOOD PERIODIC CORRELATION PROPERTIES (Correspondence)
R. L. Frank, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 381/382.

THE NONEXISTENCE OF COMMA-FREE BINARY ORTHOGONAL SETS OF ORDER 8
M. Hall, et al., JPL Res. Summ., no. 36-14, Feb./March 1962, p. 44/46.

AN INTEGRATED "ERROR-FREE" COMMUNICATION SYSTEM
J. C. Hansen, Philco Corp., Palo Alto, Calif., Tech. note no. WDL-TN62-13, 31 Dec. 1962, 17 p., incl. illus., AD 401 182.

. . . a system is proposed which combines the functions of command, synchronization, range, and range rate on one two-way radio link. . . . enploying comma-free words which have been coded for error detection. The coding is such that synchronization obtains the same high degree of reliability as the information. . . . offers relative ease of implementation common to the class of cyclic codes.

STUDY ON TELEMETRY AND RANGE SAFETY TECHNIQUES FOR ADVANCED AEROSPACE VEHICLES
M. H. Nichols, et al., Michigan U., Ann Arbor, Final rept., 1 Feb. 1961- 31 March 1962, ASD TDR 62 1073, June 1962, 74 p., AD 412 464.

. . . four more or less independent monographs covering certain aspects of the areas of bit, word and frame synchronization for random non return-to-zero PCM and improved demodulation of FM signals.

BIT LOSS AND GAIN CORRECTION CODE
F. F. Sellers, Jr., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 35/38.

ON OPTIMIZING CLOCK-COMPONENT RANGING CODES
R. C. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 91/96.

CORRELATION OF CLOCK COMPONENT CODES
P. Schottler, et al., JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963 , p. 189/192.

COMMA-FREE ERROR-CORRECTING CODES
J. J. Stiffler, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 151/155.

It is demonstrated that all (n, k) cyclic group error-correcting code dictionaries can be made comma-free without adding further redundancy or altering their error-correcting properties, provided that $K \leq (n-1)/2$.

Section 2.13

2.130: Higher Order Codes in General

Included: Discrete ternary codes; Quaternary codes; Signals by flares; Binary-nonbinary coding; Nonbinary PN sequences; Maximum distance q-nary codes; Polyphase codes; Multiletter alphabet codes; Nonlinear recurrent sequences; Nonlinear quaternary codes; Impulse equivalent pulse trains; Phase shift pulse codes with multi-phase shift; Cross-ambiguity function of an ordered pair of sequences; Nonbinary Bose-Chaudhuri codes; Superimposed binary sequences.

Not Included: Nonbinary digital communications systems (1); N-ary communications systems (1); Nonbinary channel models (1).

Cross References: Higher order error correcting codes (2.760); Theory of binary PN sequences (2.121); Reed-Solomon codes (2.734); Binary Bose-Chaudhuri codes (2.742).

Principal Publications:

QUATERNARY CODES FOR PULSED RADAR
G. R. Welti, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 400/408.

. . . A class of quaternary codes is described, and an algorithm for generating the codes is given. The codes have properties that make them useful for radar applications: 1) their auto-correlation consists of a single pulse, 2) their length can be any power of two, 3) each code can be paired with another code (its mate) of the same class in such a way that the crosscorrelation of mates is identically zero, 4) coded waveforms can be generated in a simple network. . . 5) the same network can be readily converted to a matched filter for the coded waveform.

ON THE AMBIGUITY FUNCTIONS OF THE CHARACTERS MODULO p
L. D. Baumert, et al., JPL Res. Summary, no. 36-11, Aug./Sept. 1961, p. 30/31.

The cross-ambiguity function of an ordered pair of sequences. . . of complex numbers, both of period p, is defined as a function ϕ of two integer variables k and s: Several conjectures are discussed.

PHASE SHIFT PULSE CODES WITH GOOD PERIODIC CORRELATION PROPERTIES
R. C. Heimiller, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 254/257.

A method of generating phase shift pulse codes of arbitratily long length with zero periodic correlation except for the peak for zero shift is presented. The codes are of length p^2 where p is any prime number, and p different phase shifts corresponding to the pth roots of unity are necessary to generate them. . . . Application of these codes can be made as interpulse phase modulation for range resolution in pulse Doppler radars or for a method of synchronizing a pulse code communication system. . . .

NONBINARY BOSE - CHAUDHURI CODES
R. P. Loomba, JPL Res. Summ., no. 36-13, Dec./Jan. 1961, p. 28/32.

A double coding scheme incorporating Bose-Chaudhuri codes in fields of more than two elements has been investigated. The scheme consists of encoding the message into several words of a binary code, and then encoding this message of binary words into a Bose-Chaudhuri code in a larger field. . . . In this investigation, the channel is assumed to be perturbed by additive white Gaussian noise.

INTRODUCTION TO NON-BINARY CODES. CODES WITH MINIMUM DISTANCE AND FINITE GEOMETRY (In Italian)
L. Lunelli, Rium Assoc. Elettrotech Ital. (Torino 1961), 1961, 9 p., 19 refs.

Explains the basic theory of group codes in the case of q symbols, (q being a prime number), and demonstrates the necessity for a precise definition of distance. By using concepts taken from finite geometry, it is shown that particular classes of codes with specified minimum distance can be constructed.

MUTUALLY DISTINGUISHABLE NON-BINARY PN SEQUENCES
D. Anderson, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 96/97.

Since there are only limited numbers of binary PN sequences of a given length, a natural problem is the construction of periodic signals which are distinguishable, have good out-of-phase autocorrelation, and occupy the same bandwidth. This occurs, for instance, when it is desired to construct multiple-address systems for groups of satellites or to range several instrument packages simultaneously.

The system to be described here consists of sending, as signals, certain periodic sequences of phases and receiving them by the use of word detection.

PHASE SHIFT PULSE CODES WITH GOOD PERIODIC CORRELATION PROPERTIES (Correspondence)
R. L. Frank, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 381/382.

. . . By "good" is meant that the autocorrelation function of the periodic sequence is everywhere zero except at multiples of the period, where the autocorrelation function has a single maximum. . . . descriptions of polyphase codes are contained in reports having restricted circulation. These reports contain probably the earliest usage of the term "phase-coding" as applied to discrete phase-shift modulation to the carrier of pulse signals. . . .

ON CERTAIN NONLINEAR RECURRING SEQUENCES
S. W. Golomb, JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 45/46.

The study of linear recurring sequences over finite fields has been extremely fruitful for the generation of sequences with prescribed properties for communications purposes. The attempt is now made to study certain nonlinear recurring sequences over the field of algebraic numbers, with the expectation that this will illuminate the study of such sequences over finite fields, as already undertaken in Refs. 12 and 13.

NONLINEAR QUATERNARY CODES
E. Posner, et al., JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 62/64.

It is the purpose of this note to discuss quaternary codes, including non-latin ones. A latin code is defined as follows: let q, n, r be integers $\geq$ 2. Consider codes on q symbols of length n and minimum distance r. A code is called latin if the number of words w in the code is q^{n-r+1}. . . .

SIGNALS BY FLARES
H. C. Rumsey, JPL Res. Summary, no. 36-14, Feb./March 1962, p. 48/51.

Consider a ship at sea wishing to signal another vessel with a sequence of flares of several colors. . . . a signal should not consist of an arbitrary sequence of these flares, since two consecutive flares of the same color might be mistaken for a single flare. We agree to call a sequence of these flares of length a + b + c a signal if no two consecutive flares in the sequence are of the same color.

A generating function for the number of possible signals shall be obtained, as well as a formula for computing this number.

SYMMETRY CLASSES OF PERIODIC SEQUENCES
R. C. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 143.

ACADEMY OF SCIENCES OF THE USSR. LABORATORY OF INFORMATION TRANSMISSION SYSTEMS. PROBLEMS OF INFORMATION TRANSMISSION (Selected Articles)
Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 12 Oct. 1962, 57 p., incl. illus., 34 refs., (Trans. no FTD-TT-62-888 from Akademiya Nauk SSSR. Laboratoriya Sistem Peredachi Informatsii. Problemy Peredachi Informatsii, No. 10, pp. 5/23, 35/41, 42/48, 49/56, 1961), AD 287 733.

. . . The geometry of Boolean functions and self-correcting codes from the point of view of the Erlangen Program. The construction of nonbinary error-correcting codes and the bound of the number of signals in them. . .

POLYPHASE CODES WITH GOOD NON-PERIODIC CORRELATION PROPERTIES
R. L. Frank, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 43/45.

N-phase codes are described which have an autocorrelation function with one main peak and very small side peaks. With N phases an N long pulse sequence is generated. Properties have been verified for N up to 8 and a rule for main peak-to-side-peak ratio is conjectured for larger N. For N greater than 5, the ratio is substantially better than the best ratios which have been shown for binary bipolar codes. Doppler shift effects appear to be similar to those of linear FM radar pulse compression. . . A comparison of the performance of higher-order polyphase codes with similar length binary codes indicates a superiority in the polyphase codes.

SEVERAL CLASSES OF CODES GENERATED FROM ORTHOGONAL FUNCTIONS
P. Hsieh, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 88/91.

. . . utilizing the existing knowledge of discrete error-correcting binary codes. . . The method consists in constructing the transformation matrix . . . that performs the linear transformation by taking the finite set of orthogonal functions into the set of continuous code words. . . . In constructing signals for continuous channels, it is possible to use waveform redundancy to reduce the probability of transmission error. . . . In particular, discrete ternary codes using symbols -1, 0, 1 are constructed to form some classes of continuous codes. . . .

METHODS FOR FORMING CODE COMBINATIONS FOR MULTI-ELEMENTS CODES WITH MULTI-LETTER ALPHABETS
A. G. Mamikonov, (Avtomatika i Telemekhanika, vol. 24, Sept. 1963, p. 1279/1283, In Russian) Automaton and Remote Control vol. 24, Mar. 1964, p. 1159/1163, Translation, A64-16600.

Presentation of a method of making up code tables containing all code combinations for a number of codes utilized in frequency-combinatorial telemetry systems. Single-permutation codes with and without repetitions, and with some repetitions, are treated, as well as one- and two-digit combination codes and an error-correcting code.

ADDENDUM ON BINARY-NONBINARY CODING
H. Rumsey, Jr., et al., JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 99/100.

MAXIMUM DISTANCE Q-NARY CODES
R. C. Singleton, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 116.

Related Publications:

THE GENERATION OF IMPULSE-EQUIVALENT PULSE TRAINS
D. A. Huffman, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S10-16.

. . . An "impulse-equivalent" pulse train is defined as one that yields, as closely as is theoretically possible, the same auto-correlation function that a single pulse gives. . . .

Section 2.14

2.140: Coding Theory for Continuous Channels and Sources

Included: Analog coding methods; Continuous codes; Mutually distinguishable continuous codes.

Not Included: Analog modulation methods (1).

Cross References: Analog compactive coding (Sect. 2.24).

Principal Publications:

A CLASS OF CODES FOR SIGNALING ON A NOISY CONTINUOUS CHANNEL
J. L. Kelly, Jr., IRE Trans. Inform. Th., vol. IT-6, no. 1, March 1960, p. 22/24.

MUTUALLY DISTINGUISHABLE SELF-SYNCHRONIZING CONTINUOUS CODES
R. Sydnor, et al., JPL Res. Summ., vol. 1, no. 36-9, April/May 1961, p. 33/37.

. . . In almost all coding problems studied to date, the codes used have been digital. However, in the problem of self-synchronous codes the use of continuous codes becomes possible; i. e., we can employ continuous waveforms with the same finite time duration, the same bandwidth, and the same total energy. We can obtain the self-synchronizing property by requiring of every pair of members of a continuous code. . . that the cross correlation. . . should be small, independent both of the choice of tau and the choice of pair. . . The continuous codes which we shall discuss are most simply defined by means of Fourier transforms. . . .

Section 2.18
Other Special Purpose Codes

2.181: Codes for Addresses and Call Signs

Included: Error protected names; Missile guidance codes; Codes for command signals; Interrogation codes; Signaling codes; Directory codes.

Not Included: Digicall system; Command systems in actual space missions (4).

Cross References: Signaling in addressing schemes for multiplex facilities (2.610).

Principal Publications:

THE CONSTRUCTION OF MISSILE GUIDANCE CODES RESISTANT TO RANDOM INTERFERENCE
A. R. Eckler, Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 973/994.

Many types of missiles are guided by a finite set of distinct commands radioed from the ground in the form of a time-sequence of RF pulses. The command information is contained in the n - 1 time spacings between successive pulses in a group of size n, and is encoded and decoded by means of multitapped delay lines combined with AND gates. This paper discusses the problem of encoding command information (i.e., selecting the time spacings between pulses) so that m false pulses ($M \leq n-2$) cannot combine with the n true pulses in any way to form a false command. . . . no general methods exist for finding, among codes satisfying these restrictions, those codes in which the longest command is as short as possible. This paper presents certain lower bounds, together with a few empirically derived codes approaching these lower bounds. The relationship between these codes and the well-known error-correcting binary codes of information theory is discussed in an appendix. . . .

MUTUALLY DISTINGUISHABLE NONBINARY PN SEQUENCES
D. Anderson, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 96/97.

Since there are only limited numbers of binary PN sequences of a given length, a natural problem is the construction of periodic signals which are distinguishable, have good out-of-phase autocorrelation, and occupy the same bandwidth. This occurs, for instance, when it is desired to construct multiple-address systems for groups of satellites or to range several instrument packages simultaneously.

The system to be described here consists of sending, as signals, certain periodic sequences of phases and receiving them by the use of word detection.

A CODE SEPARATION PROPERTY (Correspondence)
D. L. Cohn, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 382/383.

. . . comments on a coding property relating to the Hamming distance property. This work was motivated by a search for a selective station calling code. . . .

SELECTION OF SIGNALS FOR SPACE-VEHICLE COMMAND
E. J. Baghdady, ADCOM, Inc., Cambridge, Mass., 1 June 1963, 68 p., N64-12157.

. . . A survey of the types, requirements, and techniques of command signal design. . . provides a basis for conceiving and evaluating specific signals for special command purposes and provides a guide for the classification of command signals.

ERROR PROTECTED NAMES
W. J. Huebner, Jr., Behavioral Sciences Lab., Aeronautical Systems Div., Wright-Patterson AFB, Ohio, Dec. 1963, 22 p., AD 430 714, N64-16433.

. . . Any single name resulting from the application of this system is unique in that at least two of its symbols differ from the symbols in corresponding positions of every other name. . . . Name lists generated by the method described are particularly applicable to identification numbers, license plates, parts lists, etc. . . . A list of 961 three-symbol, error protected names is presented. Also presented is a table showing the number of error-protected names that can be generated with selected combinations of name-length and number of usable symbols. For example, with an alphabet of 23 symbols it is possible to generate a list of 6,400,000 error-protected, six symbol names. . . .

A COMMON DIRECTORY CODE FOR DIGITAL AND ANALOG NETWORKS
W. B. Martin, IEEE Trans. Commun. Electronics, no. 68, Sept. 1963, p. 483/484.

. . . Free flow of traffic from Telegraphic Message Systems into and out of the switched voice network is now blocked by the lack of common directory codes and methods for direct easy translation from the message traffic codes (Baudot, Fieldata, etc.) into switching instructions for use by the line switching gear. This block may be removed by the choice of message directing codes usable by both systems. . .

A METHOD FOR CALCULATING ERROR PROBABILITIES IN A RADAR COMMUNICATION SYSTEM
R. M. Mealey, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 2, June 1963, p. 37/42.

. . . Each pulse code group consists of two or more RF pulses. One of these pulses, called the "triggering pulse" or the "beacon ranging pulse," is used for triggering the beacon and is equivalent to the normal single pulse of the radar in the skin-tracking mode. One or more of the other pulses will, in conjunction with the triggering pulse, form an "interrogation code." One or more of the pulses remaining in the group, time modulated with respect to the triggering pulse, or modulated on and off, will serve to transmit control commands via the beacon. . . .

CODING AND INFORMATION IDENTIFICATION
L. S. Tuomenoksa, et al., IEEE Trans. Commun. Electronics, no. 67, July 1963, p. 403/404.

... Error-detection and -correction codes. . . . methods for using these codes to check whether information from the proper address or from the proper position in a time sequence has been received.

Related Publications:

A NEW SIMPLIFIED AIRCRAFT DATA LINK
M. Cooper, IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 133/136.

. . . The system herein described can readily be priced at a level which will permit even owners of low-priced aircraft to operate a data-link station. The basis of this system is a relatively simple binary logic known as a DIGICALL, which is equally capable of operating as a selective calling decoder, a discrete message decoder, or a versatile encoder. . . . Transmission is possible utilizing several forms of modulation and detection.

A NON-SYNCHRONOUS APPROACH FOR IMPROVED COMMUNICATIONS RELIABILITY
C. H. Stewart, II, et al., Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 141/150.

. . . By using sequential combinations of two audio frequency tones to define the combinatorial possibilities of the standard five-bit teleprinter code, the per-tone sampling period is increased by a factor in excess of three times that of the start-stop system. . . .

SIGNALING SYSTEMS FOR CONTROL OF TELEPHONE SWITCHING
C. Breen, et al., Bell Syst. Tech. J., vol. 39, no.6, Nov. 1960, p. 1381/1444.

DATA PROCESSING AS A TOOL FOR GENERALIZING COMMUNICATIONS SYSTEMS
W. F. Luebbert, Commun. Electronics, vol. 79, no. 50, Sept. 1960, p. 431/436.

. . . Appendix I. Fieldata Alphanumeric Code. . . Appendix II. Fieldata Control and Supervisory Code. . .

DIGITAL SELECTIVE COMMUNICATIONS
G. A. Kious, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 85/90.

. . . Selective addressing means that those not concerned with a message are not bothered by it . . . The An/URA-22 Control Monitor equipment provides for transmission of up to 456,976 different four-letter selective addresses, and recognition of individual, group and general calls, each of which can be any preassigned four-letter call. . . . The name DISCOM (Digital Selective COMmunications) has been given to terminal equipment. . .

CYCLICALLY PERMUTABLE ERROR-CORRECTING CODES
E. N. Gilbert, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 175/182.

In an asynchronous multiplex system a single band of radio frequencies carries many simultaneous conversations, each of which uses a distinguishable train of pulses as a "carrier." . . .

The signals go directly from station to station without any intermediate central office to control them or to make allocations which avoid interference. . . .

2.182: Codes for Small Alphabets

Included: Telegraphic codes; Gaussian code; Gray code; Reflected number systems; Unit distance code for A/D conversion; M-ary gray codes; Affine m-ary codes; Reflected binary codes; Permutation codes; Morse code.

Not Included: A/D converters (3A); Shaft to digital conversion (3A); Quantization theory (1); Sampling theory (1).

Cross References: Minimum redundancy codes (2.211); Comma-free codes (2.211); Unique decipherability (2.211); Efficient codes (2.211); Digital compaction operations (Sect 2.25); Error correcting codes for higher order alphabets (2.760).

Principal Publications:

REFLECTED NUMBER SYSTEMS
I. Flores, IRE Trans. Electronic Comput., vol. EC-5, no. 2, June 1956, p. 79/82.

UNIT-DISTANCE CODES FOR DIGITALIZATION OF ANALOG DATA
H. E. Tompkins, Moore School of Elect. Engng., Univ. of Penn., Philadelphia, in "Theory of Switching Circuits" Second Quarterly Report, Dec. 1956, p. 37.

UNIT-DISTANCE NUMBER-REPRESENTATION SYSTEMS, A GENERALIZATION OF THE GRAY CODE
G. W. Patterson, Proc. IRE, vol. 45, no. 7, July 1957, p. 1024.

RELATIVE SPEEDS OF TELEGRAPHIC CODES
D. A. Bell, et al., Electronic and Radio Engineer. vol. 35, Dec. 1958, p. 476/480.

Codes in common use either employ spacing elements between characters, which considerably reduces speed, or rely on accurate synchronization between transmitter and receiver. There are other codes, the so-called minimum-redundancy codes, which eliminate the synchronizing problem.

GRAY CODES AND PATHS ON THE N-CUBE
E. N. Gilbert, Bell Syst. Tech. J., vol. 37, May 1958, p. 815.

THEORETICAL CONSIDERATIONS ABOUT THE MERITS OF THE NORMAL BINARY TELEGRAPH CODE AND THE SO-CALLED GAUSSIAN CODE, AND SPECIAL METHODS OF DETECTION FOR BOTH CODES
K. Posthumus, Tijdschr. ned. Radiogenoot, vol. 23, March 1958, p. 55/82.

#55 CONVERSION CHART—DECIMAL TO BINARY TO GRAY CODE
J. G. Koch, Electronic Industr., vol. 19, Aug. 1960, p. 115.

BINARY-TO-GRAY CODE CONVERSION
G. D. Beinhocker, Instrum. Control Syst., vol. 34, no. 12, Dec. 1961, p. 2267/2270.

NONSTANDARD DIGITAL TELEMETRY
A. W. Hales, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 67/69.

To phase the problem . . . abstractly, how does one assign the integers, 0, 1, 2, . . . $2^n - 1$, to the vertices of an n-dimensional cube (those vertices correspond to the 2^n binary words of length n) in such a way as to minimize the

maximum of the absolute values of the difference between the numbers at vertices connected by an edge of the n-cube? The standard assignment has a maximum edge difference of 2^n-1.

OPTIMAL PROPERTIES OF STANDARD TELEMETRY
L.H. Harper, Jr., JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 69/71.

In the preceding article (Sect. VIIC2), the problem of non-standard telemetry was discussed. It is the purpose of this note to prove the following theorem concerning the sum of the absolute values of the edge differences . . . . Theorem . . . the standard assignment is optimal with respect to the criterion of the sum of the absolute values of all differences corresponding to single errors.

SOME REMARKS ON CONVENTIONAL AND REFLECTED BINARY CODES AND THEIR CIRCUIT REALIZATION
M. V. Pitke, et al., Matrix Tensor Quart. (GB), vol. 13, no. 1, Sept. 1962, p. 19/24.

The problem of conversion from conventional binary code to reflected binary or Gray code and vice versa has been studied by several authors. The transformations between the two codes are linear transformations from the space onto itself and the linear transformation matrices have been exhibited. . . . It is also observed that for number systems with radix >2, the transformations between the conventional codes and their reflected counterparts are not linear.

AFFINE M-ARY GRAY CODES
M. Cohn, Inform. Control, vol. 6, no. 1, March 1963, p. 70/78.

. . . presents a nontable-lookup technique for generating a class of n-dimensional m-ary Gray codes for every pair (n, m) of integers. It does not seek to exhaust all such codes, but restricts itself to a class characterized by simple encoding and decoding schemes. . . .

LOGICAL CIRCUITS FOR CONTROLLING THE ANGULAR POSITION OF AN EIGHT DIGIT GRAY CODED DISC
R. J. Splatt, Royal Aircraft Establishment, Farnborough (England), RAE Technical note no. IEE7, May 1963, 24 p., AD 420 383.

A laboratory constructed angular position servo and a follow-up servo employing an eight digit Gray coded disc are described. The circuits utilize transistors operating in switching mode throughout. . . .

A HANDBOOK ON COMMUNICATION CODES. PART I. PERMUTATION CODES AND CODED-CHARACTER SETS
ITT Communication Systems, Inc., Paramus, N. J., Rept. no. 64TR364, 31 Jan. 1964, vol. 1, AD 433 200.

Related Publications:

NOTE ON UNIQUE DECIPHERABILITY
E. T. Jaynes, IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 98/102.

. . . alphabet of a letters, . . . restrictions: 1) messages uniquely decipherable into words by use of one of the letters as a space mark, and 2) words limited to a maximum length of L letters.

2.183: Decimal Codes

Included: Reflected number systems in general; Cyclic decimal codes; Binary decimal numbers; Coded decimal number systems; Cyclic binary-decimal code; Alpha-numeric codes.

Not Included: A/D converters with decimal codes (3A); Codes for data processing equipment (3A).

Cross References: Gray code (2.182); Reflected binary codes (2.182).

Principal Publications:

CODED-DECIMAL NUMBER SYSTEMS FOR DIGITAL COMPUTERS
G. S. White, Proc. IRE, vol. 41, no. 10, Oct. 1953, p. 1450/1452.

REFLECTED NUMBER SYSTEMS
I. Flores, IRE Trans. Electronic Comput., vol. EC-5, no. 2, June 1956, p. 79/82.

CYCLIC DECIMAL CODES FOR ANALOG-TO-DIGITAL CONVERTERS
J. A. O'Brien, Trans. AIEE, Comm. and Electronics, vol. 75, no. 1, May 1956, p. 120/122.

CAN YOU TAKE ADVANTAGE OF THE CYCLIC BINARY-DECIMAL CODE?
H. R. Glixon, Control Engng., vol. 4, no. 3, March 1957, p. 87/91.

ENCODING, DECODING AND RECODING WITH BINARY-DECIMAL NUMBERS: AN EXPANDED VIEW
B. Lippel, Nat. Symp. Space Electronics Telem., Sept. 1959. no. 1.5.

. . . to discuss binary-coded decimal numbering . . . more liberal definitions, viewpoints, and classifications . . . can benefit engineers. . . .

EVALUATING ALPHANUMERIC CODES WHEN CONSIDERING TERMINAL EQUIPMENT
H. Landerer, Winter Conv. on Military Electronics, IRE, Biltmore Hotel, Los Angeles, Professional Group-Military Electronics, Feb. 1960.

Related Publications:

DIGITAL CODES IN DATA-PROCESSING SYSTEMS
M. P. Atkinson, Trans. Soc. Instrum. Technol., vol. 10, June 1958, p. 87/90.

CODE CONFIGURATION FOR AUTOMATIC ALTITUDE REPORTING VIA ATCRBS
A. Ashley, IRE Trans. Aerospace Navig. Electronics, vol. ANE-8, no. 4, Dec. 1961, p. 144/148.

. . . This code provides for compatible altitude reporting in increments of 100, 250, and 500 feet within one common system. The code is developed by using Karnaugh mapping techniques. . . . guidance for the determination of the most desirable code. . . .developmental code in use in the United Kingdom . . . flexibility of the unit-distance code affords a satisfactory compromise which can satisfy the objectives of the various users. . . .

2.184: Codes for Non-random Errors

Included: Codes for mistake correction; Codes for detection of systematic errors; Detection and correction of failures in logic units; Failure detection codes; Codes for trouble diagnosis in logic circuits; Diagnostic codes; Reliability codes; Codes for checking logical operation; Fault detection codes; Codes for self repair systems.

Not Included: Automatic test equipment; Failure tracing in automatic checkout equipment; Self-correcting sequential networks; Self-repair techniques.

Cross References: Error location codes (2.776); Error distributing codes (2.110); Error detecting codes (2.772).

Principal Publications:

ON CODES FOR CHECKING LOGICAL OPERATIONS
W. W. Peterson, et al., IBM J. Res. Developm., vol. 3, no. 2, April 1959, p. 163/168.

. . . for checking . . . digit by digit on two vectors of binary digits are studied. . . .

A GENERAL METHOD OF APPLYING ERROR CORRECTION TO SYNCHRONOUS DIGITAL SYSTEMS
D. B. Armstrong, Bell Syst. Tech. J., vol. 40, no. 2, March 1961, p. 577/593.

It includes the familiar scheme fo triplication and "vote taking" as a special case. In principle, the method permits the system to operate continuously, even when a fault is present or maintenance is being performed.

. . .describes some error-correcting codes to implement the scheme, discusses error-correcting circuits in a general way, indicates how to estimate the redundancy, and presents a formula for determining the reliability improvement obtainable with a particular maintenance routine.

A METHOD FOR THE AUTOMATIC DETECTION AND CORRECTION OF DATA MISTAKES
S. H. Chasen, Proc. Nat. Telem. Conf., May 1961, p. 5-1/5-20.

. . . Mistakes, for this paper, are construed as sporadic errors not attributable to expected noise or random errors. The purpose of this paper is to develop a method which will detect and either correct or locate such mistakes in data which are recorded at equispaced intervals. The method is based on a step-by-step analysis of the data and functions of the data and is designed for computer application. This method will not detect systematic errors and it is not designed for data smoothing. . . .

QUALITATIVE LIMITS FOR AUTOMATIC ERROR CORRECTION-SELF-REPAIR
L. Lofgren, Electrical Engineering Research Lab., U. of Illinois, Urbana, (Technical rept. no. 6), 21 June 1961, p. 70, AD 267 842.

DETECTION AND CORRECTION OF FAILURES IN DIGITAL ARITHMETIC UNITS
A. A. Avizienis, JPL Space Progr. Summ., vol. 4, no. 37-25, Dec., Jan. 1963, p. 21/24.

The results of an investigation of redundancy in guidance computers (Ref. 1) led to the choice of product coding of binary numbers to implement the detection of arithmetical and transmission errors. The properties of product codes and arithmetical algorithms for product-coded numbers are discussed in this summary.

NETWORK CODING FOR RELIABILITY
J. Tooley, Commun. Electronics, vol. 81, no. 64, Jan. 1963, p. 407/414, 11 refs.

. . . A redundancy technique for combinational logic networks is described which, for a given redundancy level, permits a much greater reliability improvement than do the classic techniques. This is made possible through new device design and the incorporation of the logic of error correcting codes in the system logic. By exploiting the properties of integrated circuits this technique promises to make passive self-repair through redundancy a practical solution to some of the reliability problems associated with nonrepairability. . . .

AUTOMATIC TROUBLE DIAGNOSIS OF COMPLEX LOGIC CIRCUITS
S. H. Tsiang, et al., Commun. Electronics, vol. 81, no. 64, Jan. 1963, p. 575/583.

Related Publications:

AUTOMATIC FAILURE RECOVERY IN A DIGITAL DATA PROCESSING SYSTEM
R. H. Doyle, et al., IBM J. Res. Developm., vol. 3, Jan. 1959, p. 2/12.

A PROGRAM FOR CORRECTING SPELLING ERRORS
C. R. Blair, Inform. Control, vol. 3, no. 1, March 1960, p. 60/67.

. . . pattern recognition

A STUDY OF SOME SELF-CORRECTING SEQUENTIAL NETWORKS
J. Rubio, Philips Res. Rep., vol. 17, no. 4, Aug. 1962, p. 315/329.

The problem of designing self-correcting counters is considered. Two different cases are studied. . . .

A NEW APPROACH TO RELIABLE DATA TRANSMISSION ERROR-LOCATION CODES
J. K. Wolf, Rome Air Development Center, Griffiss Air Force Base, N. Y., (Rept. no. RADC TDR 62-362), Aug. 1962, p. 10, 7 refs., AD 286 422.

. . . errors are detected within the block of received digits and, in addition, the location of these errors, is specified to within a subblock of the overall larger block of digits. Upper and lower bounds are derived, for error-location codes, for the number of check digits required for a given error-location capability. A method is presented for constructing the parity check matrix for a large family of error-location codes, some of which are optimal in the sense that they satisfy the previously derived lower bound. Comparisons are made of the error-correction capability and error-location capability of codes. Also, applications of error-location codes are discussed.

PERFORMANCE CHARACTERISTICS OF ERROR-LOCATION CODES FOR A SPACE PROBE TELEMETRY SYSTEM
C. P. Carpenter, et al., Rec. Nat. Space Electronics Symp., 1963, no. 7.2.

. . . a new class of codes which combine error location with error correction. . . . Specific examples are given which are applicable to three different types of communication systems. Curves for word error rate and channel capacity are included. . . .

ROOK DOMAINS, LATIN SQUARES, AFFINE PLANES, AND ERROR-DISTRIBUTING CODES
S. W. Golomb, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 196/208.

A problem originally suggested in the context of genetic coding leads naturally to the concept of rook packing and error-distributing codes. . . .

REDUNDANCY AND COMPLEXITY OF LOGICAL ELEMENTS
S. Winograd, Inform. Control, vol. 6, no. 3, Sept. 1963, p. 177/194.

. . . a lower bound on the amount of redundancy necessary to achieve a certain error correcting ability and show how this bound varies with the complexity of the elements used in the design of the redundant circuit, measured by the number of inputs. . . .

2.185: Security Codes (unclassified references only)

Included: Speech security; Scrambling of digital voice; Codes for pay TV systems.

Not Included: Cryptographic equipment.

Cross References: Voice digitization (2.350); Comma-free codes (2.211); Theory of PN sequences (2.121); Binary group codes in general (2.120).

Principal Publications:

SPEECH SECURITY FOR TACTICAL OPERATIONS
A. C. Prichard, Army Signal Research and Development Lab., Fort Monmouth, N. J., May 1959, 12 p., AD 218 449.

Technical and systems aspects of speech scrambling are considered. Reduced requirements . . . can . . . be met . . . by an improved version . . . similar to a system developed during World War II.

HOW A CLOSED-CIRCUIT PAY TV SYSTEM WORKS
P. R. Court, et al., Electronics, vol. 33, no. 34, Aug. 1960, p. 49/55.

PAY TV STARTS IN CANADA
Electronics, vol. 33, no. 12, March 1960, p. 52/53.

New system uses direct wire to bring choice of three channels to Toronto viewers.

SELF ADJUSTING AUTOMATS FOR DECODING MESSAGES (In Russian)
V. I. Levenshtein, Dokl. Akad. Nauk SSSR, vol. 141, no. 6, Dec. 1961, p. 1320/1323, 12 refs.

. . . It is shown that an automatic device for decoding messages can exist if the coding system has the property of limited interruption; the automat can be self-adjusting (self-correcting) if the coding system has a self synchronizing property. The length of interruption caused by accidental misadjustment is found in terms of parameters of the coding system.

SECURE COMMUNICATIONS, A BIBLIOGRAPHY
North American Aviation, Inc., Downey, Calif., Rept. for 1956-1962, (Rept. no. SID 62-518), 19 April 1962, p. 35, AD 282 471.

SYNCHRONIZATION DETECTION ANALYSIS BY SIGNAL FLOW GRAPH TECHNIQUES
A. L. McBride, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 268/276.

. . . The synchronization process is particularly difficult for secure communication systems which depend upon a long, noise-like code sequence for security. . . . the synchronization circuit should be designed to minimize the average time required to sync in presence of noise. . . .

A SYNCHRONIZED PULSE COMMUNICATION SYSTEM WITH PSEUDORANDOM INTER-PULSE PERIOD
R. C. Mackey, IRE Trans. Commun. Systems, vol. CS-10, no. 1, March 1962, p. 109/113.

The security of a pulse type communication system can be improved by the incorporation of an element of randomness in the time of transmission. A system is simulated in which a remote receiver is caused to be gated on at apparently random intervals which are in synchronism with the arrival of the signal from the controlling local transmitter. . . .

Related Publications:

A SIMPLE PROOF OF THE DECIPHERABILITY CRITERION OF SARDINAS AND PATTERSON
B. Bandyopadhyay, Inform. Control, vol. 6, no. 4, Dec. 1963, p. 331/336.

A simple alternative proof is given for a necessary and sufficient condition for the decodability of a sequence of codes. The proof involves no application of linear syntactical bases or other sophisticated algebraic criteria. . . .

TESTS FOR UNIQUE DECIPHERABILITY
S. Even, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 109/112.

. . . The test also shows whether the set is decipherable with a finite delay, and in the latter case, determines the necessary delay. Finally, it is shown how the test of Sardinas and Patterson can be used to get the same result, as was conjectured by Gilbert and Moore. . . .

DIVISION 2.2
FUNDAMENTALS OF INFORMATION COMPRESSION AND DISCRETE DATA COMPACTION

Space communications systems require efficient modulation and coding techniques to transmit a sufficient amount of information back to Earth using low transmitter power in the space craft. The optimization of space links is a matching problem at all levels of the link. The matching of an information source to the communications channel to achieve an optimum information transfer will be discussed in this division.

The section 2.21 contains references to the general theory of such matching operations, which are also called information compression, data compaction, redundancy reduction, efficient source encoding or entropy matching. The next section (2.22) deals with the statistical description of information sources in general. Note that the statistics of voice and music are subjects of division 2.3 and those of pictures are referenced in division 2.4.

Section 2.23 is concerned with a few engineering problems of information compressors, such as buffering problems and some bio-electronic methods. As there are not yet many compactors in operation, there is no large store of publications available in practical compaction techniques. This subject is expected to grow in the near future.

The next two sections discuss analog and digital compaction methods respectively. The first class comprises some older ideas, such as amplitude companding, in use for many decades. Analog compaction is also concerned with frequency and time compression methods, though not all of such methods may be truly redundancy reducing. The second class (2.25) of digital compaction methods includes all efforts to use the sampling and quantization process for redundancy reduction. Note also that asynchronous time division multiplex systems may be designed with strong compactive characteristics. References to such systems will appear in division 2.5.

Pattern recognition (2.26) is a fundamental approach to the compaction problem, which involves both analog and digital techniques. It is digital in the sense that a finite number of patterns must be known to the system. It is analog in the sense that the source information will be submitted to the recognition device in analog form with a statistical variance about the model pattern. The device has to perform a detection and decision operation (see division 2.8). This situation gives pattern recognition a unique position among other subdivisions. It is applicable to problems in phoneme recognition, in target identification, in radar search operation, in noise and jamming identification and in many aspects of adaptive communications systems. Naturally, character recognition, primarily of written and typed alpha-numeric symbols is still the most important application. The applications listed above lead to the classification of PR (pattern recognition) as a fundamental method of compaction, rather than as a picture compaction approach only.

There are some data compaction applications which may not reduce the redundancy of the information, but which may shed light on fundamental compaction problems. Therefore, selected references are included in this division for illustrative purposes. Machine translation is typical of such applications and some references are listed in subdivision 2.282.

Section 2.20

2.200: Surveys and Introduction to Information Compression

Included: Descriptions of experimental data compactors; Adaptive features of information compaction methods; Transient response data reduction; Pretransmission analysis of information sources; Pretransmission; Redundancy reduction methods in general.

Not Included: Design and development report on compactors; Signal processing techniques in general (3A).

Cross References: Engineering details of data compactors (2.230); Statistical analysis of information sources (2.212); Figure of merit of compaction methods (2.210).

Principal Publications:

THE POSSIBILITIES OF INCREASING THE TRANSMISSION SPEED OF TELEGRAPHIC MESSAGES
D. S. Lebedev, et al., Telecommunications, no. 1, 1958, p. 90/92.

AN INTERPLANETARY COMMUNICATION SYSTEM
G. E. Mueller, et al., IRE Trans. Space Electronics Telem., vol. (SET-5), no. 4, Dec. 1959, p. 196/204.

. . . Proper screening and processing of data before their transmission can increase the amount of useful information received at the expense of other data not so valuable and can ease ground data handling problems. A telemetry system, entitled "Telebit," which makes use of some of these principles, and is a forerunner to the application of others, is described. . . .

In case there is a requirement for transmitting pictures, the effective bandwidth and information rate may be reduced by sampling techniques. . .

SOME CODING CONCEPTS TO CONSERVE BANDWIDTH
L. G. Zukerman, et al., Nat. Telem. Conf., May 1959, p. 138/142.

TRANSIENT RESPONSE DATA REDUCTION AND A UNIQUE TRANSIENT WAVE ANALYZER
J. E. Anderson, et al., Proc. Nat. Telem. Conf., May 1960, p. 783/800.

. . . particularly with respect to airplane transient response to impulsive disturbances as used in flight flutter testing. Transient response records of such tests normally represent the combination of several frequency components of various damping ratios, often superimposed on an appreciable noise or buffet signal. The requirement is to seek out the various mode frequencies from this mixed signal and determine the corresponding damping ratios.

WIDE-BAND TELEMETRY SYSTEM FOR MISSILE IMPACT INSTRUMENTATION
R. A. Gronlund, Proc. Nat. Telem. Conf., May 1960, p. 801/810.

Some form of compacting.

PRE-TRANSMISSION ANALYSIS—A CURE FOR TELEMETRY'S GROWING PAINS
J. D. Yeagley, et al., Proc. Nat. Telem. Conf., May 1960, p. 757/770.

ADVANCED TELEMETRY SYSTEM STUDIES
A. Egger, Space Technology Labs., Los Angeles, Calif., (Rept. no. STL/TR-60-0000-19430), Final Rept. 31 Jan. 1961, AD 255 510.

. . . applications of conformal (adaptive) telemetry systems and a description of a prototype conformal unit designed and constructed to demonstrate feasibility of the concept, together with a complete PCM telemetry system designed to operate with the conformal unit.

DATA COMPACTORS FOR SPACE VEHICLES
F. W. Ellersick, East Coast Conf. Aerospace Navig. Electronics, vol. 8, Oct. 1961. no. 6.2.6.

IMPROVED UTILIZATION OF TELEMETRY CAPACITY
B. D. Cobb, et al., Army Missile Command, Redstone Arsenal, Huntsville, Ala., (Rept. no. RG-TR-62-3), 29 June 1962, 39 p. incl. illus., AD 284 440, N63-16843.

. . . to transmit more information as opposed to more data, over. . . An attempt is made to develop a figure of merit for missile instrumentation systems. . . The potential of adaptive technique is discussed. Several recommendations for the immediate improvement of utilization are outlined. . . .

DATA COMPRESSION AT LOW DATA RATES
M. Easterling, et al., JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 54/55.

. . . preprocessing of the data on board the planetary capsule is mandatory in order to obtain sufficient information back on Earth to justify the mission.

. . . to describe various methods of data compression, indicate their feasibility, and initiate some mathematical research required to predict the performance of such systems.

DATA COMPACTION AND HIGH SPEED CIRCUITRY
G. E. Glen, et al., East Coast Conf. Aerospace Navig. Electronics, vol. 9, Oct. 1962, no. 3.2.6.

A solution to the present urgent need for effective and prompt telemetry data reduction appears to be possible only through the use of high speed digital data processing systems. A very high speed computer, developed and built as part of a larger system for the Navy, could be utilized for such a purpose. . . . with present facilities it would take NASA approximately 26 years to reduce all of the data that they presently have in their backlog at Goddard alone. . . . basically two approaches. . . one which has been labeled information destroying . . . The second. . . is one which is referred to as information preserving. This approach has seen much less activity than the former . . . It is the more difficult of the two. . . It is to this second area that this paper is addressed; specifically to the development of a very high speed computer.

A DATA BANDWIDTH COMPRESSOR FOR SPACE VEHICLE TELEMETRY
J. R. Hulme, et al., Proc. Nat. Telem. Conf., May 1962, no. 3.2.

. . . a versatile vehicle-borne data bandwidth compressor which inhibits the transmission of redundant materials, as produced by

measurements of normally unchanging parameters. The resulting system is self-adaptive to varying data traffic conditions. Special channel priorities and functional changes may be specified upon command, in addition to independent control of the tolerance of each channel.

TRENDS IN MISSILE AND SPACE RADIO TELEMETRY
J. W. Muehlner, Lockheed Aircraft Corp., Sunnyvale, Calif., 1962, 45 p., AD 407 379.

. . . it becomes progressively more important to combat the flood of data descending on us from outer space. . . . compression schemes based on elimination of redundancy. Techniques such as are presently under development lead to compression factors of the order of 30, referenced to the indiscriminate data-transmission practices of today.

THE CONCEPT OF SELF-ADAPTIVE DATA COMPRESSION
D. R. Weber, et al., Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 4.1.

. . . reviews the broad aspects of data compression as a means for improving the efficiency of PCM telemetry. . . . attention. . . to redundancy removal methods . . . importance of the higher-order techniques. Results from analysis of actual telemetry data are presented briefly, showing the effectiveness of higher-order redundancy relative to sampling efficiency. Buffer requirements. . . other benefits from self-adaptive data compression, such as selective sampling, variable accuracy, and data priority control . . .

COMPRESSION AND CODING (Correspondence)
E. Weiss, IRE Trans. Inform. Th., vol. IT-8, no. 3, April 1962, p. 256/257.

. . . when there are fairly long sequences of zeros and ones to be transmitted, especially when only a small number of the entries in the sequences are ones. . .

TECHNIQUES FOR NARROW-BAND TELEMETRY OF NONRECURRENT DATA
J. E. Abel, et al., Proc. Nat. Telem. Conf., May 1963, no. 9-5. 23 refs.

. . . pretransmission data processing technique. . . permits telemetering a sequence of nonrecurrent wave forms or pulses over a standard FM-FM radio telemetry system under unusual environmental conditions which preclude radio frequency propagation at the time of data occurrence. . . . design philosophy. . . processing the data wave forms by differentiation to obtain peak amplitudes; integration to obtain energy content; and sequential time sampling to obtain data points from which wave forms can be reconstructed. . . . stored as direct voltages which can be commutated or applied directly to standard FM subcarriers for continuous transmission.

IMPROVED UTILIZATION OF TELEMETRY CAPACITY
C. F. Asquith, Army Missile Command, Redstone Arsenal, Huntsville, Ala., Summary rept., 1962-1963, AMC RA Rept. no. RG TR 63 17, 17 June 1963, 21 p., 4 refs., AD 419 352, N63-22514.

. . . data bandwidth reduction and transmitter bandwidth utilization. Some of the projects have not been completed and work is being continued. Separate reports have been prepared on the completed project.

ADAPTIVE INFORMATION PROCESSING
S.S.L. Chang, IN: 1st International Symposium on Optimizing and Adaptive Control, Proceedings. Pittsburgh, Pa., Instrument Society of America, International Headquarters, 1963, p. 249/265, A63-21803.

Presentation of a statistical basis for generating the numerical formulas to be used by a machine interpolating, integrating, or differentiating numerical data. . . .

THE COMPARATIVE EFFECTIVENESS OF SEVERAL TELEMETRY DATA COMPRESSION TECHNIQUES
J. E. Medlin, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 328/340.

. . . comparisons were made by simulation with an IBM 7090 digital computer with the use of approximately 150,000 samples of actual vehicle telemetry data received during a typical satellite launching. The five compression techniques discussed in this paper employed zero or first-order polynomial predictors, or modifications thereof. . . . In another portion of the paper, brief descriptions are presented of two data compressors, including one spaceborne unit, which have been mechanized at L.M.S.C. . . .

DATA COMPRESSION BY DIVERSE MEANS
E. C. Posner, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 115/117.

. . . some data compression schemes which are of practical importance (but do not lead to hard new mathematical research problems). Methods of data compression yielding very high compression ratios-with little loss of data quality, and which require only simple on-board digital equipment, form the main point of this article.

b. Special events. . .
c. Maxima and minima. . .
d. Spectra by autocorrelation functions. . .
e. Histograms. . .
f. Conclusions. . .

Related Publications:

SIGNAL CONDITIONERS FOR AEROSPACE INSTRUMENTATION
W. C. Below, et al., Proc. Nat. Telem. Conf., May 1961, p. 7-5/7-20.

LOGIC MODULES FOR SIGNAL CONDITIONING IN SPACE RADIATION EXPERIMENTS
F. E. Thompson, Proc. Nat. Telem. Conf., May 1961, p. 7-21/7-66.

THE COMMAND AND CONTROL SYSTEM DILEMMA
B. Baldridge, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 53/55.

The only long-range solution to the increasing requirement for spectrum space and the radio frequency interference problem involves: (1) careful equipment engineering to eliminate spurious signal generation and equipment susceptibility to spurious signals, and (2) conservation and efficient use of the RF spectrum as a natural resource. This means system design to require a minimum of spectrum use. . . .

ELECTRONICS IN NUCLEAR MEASUREMENTS (In French)
D. Boclet, et al., Onde Electr., vol. 43, no. 432, March 1963, p. 311/316.

. . . electronic problem posed by the transmission of results developed by scientific apparatus on powered missiles (rockets and satellites). . . They examine particularly the problem of analysis amplitude in the instance of rapidly occurring events with statistical distribution. . . Two principal methods are explained, one analogue and the other digital. Finally they sketch the more complicated problem set by a satellite.

HUMAN INFORMATION PROCESSING
M. Eden, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 253/256, 60 refs.

Section 2.21
Theory of Compaction Methods

2.210: Compaction Theory in General

Included: Theory of redundancy reduction; Predictive encoding in general; Minimum description; Description mechanics; Figure of merit of compaction; Criterion of fidelity in compaction; Data compression by first differences; Fokker-Planck equation in data compression; Prevarication; Adaptive data prediction; Nonlinear data predictor; Approximation theory; Curve fitting theory in general; Exponential approximation; Entropy reducing transformations (ER); Information preserving transformation (IP); Interpolation by Spline functions.

Not Included: Definitions of terms in information theory (1); Theory of signal processing (3A); Adaptive communications systems (1).

Cross References: Efficient codes for redundancy reduction (2.211); Statistical compaction methods (2.212); Prediction of time series for detection or search operations (2.881); Polynomial fitting of time series (2.253); Polynomial interpolation (2.253); Adaptive data sampling (2.253); Exponential curve fitting (2.253); Floating aperture data compression (2.212); Finite state languages (2.221).

Principal Publications:

THE PREDICTION OF DERIVATIVES OF POLYNOMIAL SIGNALS IN ADDITIVE STATIONARY NOISE
I. Kanter, IRE Wescon Conv. Rec., no. 4, Aug. 1958, p. 131/146.

. . . unifying theory for a problem which arises in a now classical paper on prediction theory.

GENERAL THEORY OF SIGNAL COMPRESSING CODES
D. C. Youla, et al., Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., Rept. No. R-633-57; PIB 561 (RADC TN 58-374), Sept. 1959, AD 206 557

REPRESENTATION OF COMPLEX SIGNALS BY MEANS OF DAMPED OSCILLATORY BASE FUNCTIONS
L. Dolansky, Gordon McKay Lab. of Applied Sciences, Harvard U., Cambridge, Mass., Scientific Rept. # 59-1, AFCRC TN-59-648, Aug. 1958, 42 p., AD 232 538.

. . . An orthonormal set of decaying oscillatory base functions was obtained and the problem of expressing voiced speech sounds by means of a small number of such functions, and of obtaining their coefficients by measurements, was studied.

THE QUESTION OF THE MINIMUM DESCRIPTION
E. L. Blokh, Radio Engng., vol. 15, no. 2, 1960, p. 15/24.

A NOTE ON THE APPROXIMATE REPRESENTATION OF A CURVE WITH LINEAR SEGMENTS
S. G. Shiva, Commun. Electronics, vol. 80, no. 56, Sept. 1961, p. 461/464.

THE COMMON FEATURE METHOD
R. Wells, et al., Interaction Lab., Yale U., New Haven, Conn, (Technical rept. no. 12), Nov. 1961, 51 p., refs., AD 279 210.

DESCRIPTORS: Communication theory, Language, Machine translation . . .

AN ADAPTIVE NONLINEAR DATA PREDICTOR
A. V. Balakrishnan, Proc. Nat. Telem. Conf., vol. 2, 1962, no. 6-5.

. . . Data prediction and/or extrapolation methods are of utility in several phases of telemetry and data processing systems. . . . such methods provide a direct means of exploiting data redundancy for the purpose of bandwidth or power reduction. . . The significance of the adaptive feature lies in the fact that since the prediction is determined by a self-learning process, no a priori assumptions concerning the data need to be made, and thus, for instance, the bandwidth reduction is initiated only if the data redundancy warrants it. The nonlinear feature allows the predictor to be as complex as necessary, avoiding any degradation due to linearity restrictions. . . .

PREVARICATION VS REDUNDANCY (Correspondence)
N. M. Blachman, Proc. IRE, vol. 50, no. 7, July 1962, p. 1711/1712.

MESSAGE COMPRESSION
H. Blasbalg, et al., IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 3, Sept. 1962, p. 228/238.

Two general classes. . . are considered: (1) Entropy-reducing (ER) transformation, and (2) Information preserving (IP) transformation (redundancy removal). . . . A new concept, adaptive coding, is introduced. It is shown that for quasi-stationary source statistics it is possible to obtain estimates of the statistics and to use these subsequently for efficient coding. . . .

IMPROVED UTILIZATION OF TELEMETRY CAPACITY
B. D. Cobb, et al., Army Missile Command, Guidance and Control Lab., Redstone Arsenal, Ala., (RG-TR-62-3), June 29, 1962, 44 p., N63-16843.

. . . attempt is made to develop a figure of merit for. . . Data bandwidth reduction. . .

A LINE SEGMENT CURVE-FITTING ALGORITHM RELATED TO OPTIMAL ENCODING OF INFORMATION
B. Gluss, Inform. Control, vol. 5, no. 3, Sept. 1962, p. 261/267.

A FOKKER-PLANCK EQUATION ARISING IN DATA COMPRESSION
R. M. Goldstein, et al., JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 172/177.

The floating barrier system of data compression was described in SPS 37-16, Vol. IV, p. 54/57. The idea is to transmit a new value when, and only when, the previous transmitted value has been exceeded by more than some constant K (in absolute value). . . .

SOME OBSERVATIONS WITH A VIEW TO AUTOMATIC CODING IN TELECOMMUNICATIONS (In French)
R. Moreau, Automatisme, vol. 7, no. 11, Nov. 1962, p. 425/432.

With a view to the use of computers in coding, a study is made of suitable linguistic units . . . Comparison is made between coding letter by letter, coding by units of two, three, four or five letters, coding by syllables, by pseudo-syllables, and coding by words, and coding letter by letter are given. . . . it is considered that the best practical linguistic unit is the word.

EXTRAPOLATION (PREDICTION) OF A FUNCTION WITH A LIMITED SPECTRUM FROM ITS DISCRETE VALUES
Y. G. Pollyak, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 11, Nov. 1962, p. 59/67.

The possibility of predicting (extrapolating) a continuous function with a limited frequency spectrum from the results of discrete measurements taken at equal "past" time intervals is established. The sufficient conditions for such extrapolations are formulated. The accuracy of the approximate prediction formulas is discussed. . . .

DATA COMPRESSION BY FIRST DIFFERENCES
J. J. Stiffler, JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 57/61.

COMPUTATIONAL ASPECTS OF APPROXIMATION THEORY
B. Boehm, RAND Corp., Santa Monica, Calif., March 1964, 106 p., refs., (RM-4051-PR) AD 433 175, N64-18178.

The theory of approximation by polynomials and rational functions is of considerable

practical significance, due in great part to the efficiency of polynomials and rational functions in representing functions on a high-speed digital computer. . . Topics include problems of existence, uniqueness, characterization, and error estimation of best approximations, and algorithms for interpolation and for obtaining best least-squares and Chebyshev approximations.

CURVE FITTING BY MEANS OF ORTHOGONAL POLYNOMIALS
D. J. Crouse, Philco Corp., Palo Alto, Calif., (Rept. no. WDL-TR1998), 15 March 1963, lv., AD 298 715.

NON-UNIFORMLY-WEIGHTED ORTHONORMAL OVER-DAMPED EXPONENTIAL APPROXIMATIONS
J. M. Mendel, Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div., 7 Jan. 1964, 101 p., refs., N64-17757.

Weighting functions that emphasize small values of time, large values of time, or a range of time (t_1, t_2), $t_1 > 0$, are considered. Exponential approximants are developed in terms of the classical Jacobi Polynomials. Its is shown that these approximants (1) are orthonormal with respect to a nonuniform weighting function. . . (2) are of any asymptotic order (in the s-domain). . . (3) have their poles equally spaced along the negative-real axis of the plane. . .

AN INDEX OF APPROXIMATIONS OF FUNCTIONS
B. Prasad, California Univ., La Jolla, Aug. 1963, 32 p., AD 424 809.

A summary is presented of the rational and polynomial approximations of mathematical functions that are used in scientific computations. . . grouped according to functions and the pertinent data are given, such as the limits of errors, range of independent variables and the author's name with the year of publication. . . The most important approximation techniques used are Maclaurin Power Series, Chebyshev Expansion, Modified Taylor's Expansion. Lanczo's method, Pade's Method, Maehley's Method, Heuristic approach of Hastings.

AN ALGORITHM FOR MINIMAX POLYNOMIAL CURVE-FITTING OF DISCRETE DATA
C. W. Valentine, et al., Association Computing Machinery, Journal, Vol. 10, July 1963, p. 283/290, A63-21006.

. . . the basic outline of which may be regarded as a specialized version of that described by Cheney and Goldstein. It is shown that the special properties of the Vandermonde matrix and its generalizations permit a great reduction in the computations needed in applying the algorithm. . . .

Related Publications:

SORTING, TREWS, AND MEASURES OF ORDER
W. H. Burge, Inform. Control, vol. 3, Sept. 1958, p. 181/197.

DESCRIPTION MECHANICS
D. McLachlan, Jr., Inform. Control, vol. 3, Sept. 1958, p. 240/266.

The concept is developed for the purpose of pointing out a common basis for many of the fields related to information theory. These fields include thermodynamics, photography, language, models, gambling cryptology, and pattern recognition. Many descriptive processes can be reduced to mathematical terminology by dividing the domain of description into cells whose size is determined by the resolution, and filling the cells with occupants where the number of kinds of occupants is determined by the accuracy of distinguishing between them.

IMAGE SIMULATION AND INTERPRETATION
G. L. Meyer, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 335/345.

. . . Two experiments were conducted to find out what the relation is between the quality of the image and the quality of the information that can be extracted from it. An image simulator was constructed to produce imagery that could be used with trained photo-interpreters in the experiments . . .

THE HYPERSPHERE IN PATTERN RECOGNITION
P. W. Cooper, Inform. Control, vol. 5, no. 4, Dec. 1962, p. 324/346.

EFFICIENT UTILIZATION OF CHANNEL CAPACITY FOR SPEECH COMMUNICATION
R. L. Brueck, et al., Texas Instruments, Inc., Dallas, Final rept., pt. 2, July 1963, 96 p., AD 418 178, N63-22191.

. . . research investigation directed toward more efficient utilization of channel capacity for speech communication. . . (1) to theoretically analyze the benefits realized by 'predictive encoding' of vocoded speech sources, (2) to propose and analytically design a model of a typical processing system utilizing predictive coding, and (3) to evaluate the performance characteristics of such a system by simulation with vocoded speech samples on a digital computer. . .

APPROXIMATION THEORY
E. W. Cheney, Numerical Analysis Research, Univ. of California, Los Angeles, Aug. 1963, 150 p., AD 422 089.

NUMERICAL PROCEDURES FOR INTERPOLATION BY SPLINE FUNCTIONS
T. N. Greville, Wisconsin U., Madison, Jan. 1964, 31 p., refs., AD 433 945, N64-18017.

This report describes numerical procedures for interpolation by means of spline functions, that is, functions defined by piecewise polynomial arcs smoothly joined in such a way that derivatives are continuous everywhere up to an order one less than the degree of polynomials used. . .

2.211: Redundancy Reducing Codes

Included: Compactive coding; Comma-free codes; Unitary codes; Fully decodable code word sets; Minimum redundancy codes; Efficient codes; Efficient variable length codes; Decipherability criteria.

Cross References: Path invariant comma-free codes (2.124); Information preserving transformations (2.210); Comma-free error correcting codes (2.740).

Principal Publications:

RELATIVE SPEEDS OF TELEGRAPHIC CODES
D. A. Bell, et al., Electronic & Radio Engng., vol. 35, Dec. 1958, p. 476/480.

Codes in common use either employ spacing elements between characters, which considerably reduces speed, or rely on accurate synchronization between transmitter and receiver. There are other codes, the so-called minimum-redundancy codes, which eliminate the synchronizing problem.

CODING LONG SECTIONS OF BINARY SYMBOLS
V. A. Garmash, Radio Engrg., vol. 14, no. 4, 1959, p. 84/87.

. . . in the transmission of discrete communications over a noiseless channel a considerably long chain N of symbols may be coded in a sequence of binary numbers in such a way that the average number of binary signs on the initial symbols of the communication will be approximately equal to the entropy of the initial communication H. . . . a group of chains with a very small probability will cast aside.

FULL DECODABLE CODE-WORD SETS
M. P. Schutzenberger, et al., IRE Trans. Inform. Th., vol. IT-5, March 1959, p. 12/15, also AD 221 310.

NOTE ON UNIQUE DECIPHERABILITY
E. T. Jaynes, IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 98/102.

. . . alphabet of a letters . . . restrictions: 1) messages uniquely decipherable into words by use of one of the letters as a space mark, and 2) words limited to a maximum length of L letters.

AN OPTIMIZATION PROCEDURE FOR A SINGLE-LINK UNI-DIRECTIONAL DIGITAL COMMUNICATION SYSTEM IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE AND FOR DETECTION INDEPENDENT OF FADING
L. Kurz, New York U. Coll. of Engineering, N. Y., (Scientific rept. 3), 15 Sept. 1960, 51 p., AD 250 210.

. . . A theory of so-called efficient codes (minimax, equal separation, and nearly equal separation) is developed. The theory of equidistant and nearly equidistant codes is extended to the case of non-white gaussian noise. . . Performance results are given for different codes for white gaussian noise and gaussian noise with power spectrum curves that increase slowly and rapidly with frequency.

RECENT RESULTS IN COMMA-FREE CODES
JPL Res. Summ., vol. 1, no. 36-7, Dec./Jan. 1960, p. 44/45.

MINIMUM-REDUNDANCY CODING FOR THE DISCRETE NOISELESS CHANNEL
R. M. Karp, IRE Trans. Inform. Th., vol. IT-7, no. 1, Jan. 1961, p. 27/38.

Good Bibliography.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE
L. Kurz, IRE Trans. on Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 215/223, 23 refs.

. . . A theory of so-called efficient codes (minimax, equal separation, and nearly equal separation) is developed. . . . the theory of equidistant and nearly equisdistant codes is extended to the case of nonwhite Gaussian noise. . . .

THE NONEXISTENCE OF COMMA-FREE BINARY ORTHOGONAL SETS OF ORDER 8
M. Hall, et al., JPL Res. Summ., no. 36-14, Feb./March 1962, p. 44/46.

Consider an 8 x 8 array of ones and zeros with the property that the sum (term-by-term addition modulo 2) of any two rows of this array contain exactly four ones.

Such an array is called an orthogonal set. If this set of rows has the additional property that no overlap formed from any two rows is a third row or the complement of a third row, it is called strongly comma-free of index one. This paper shows that no such set exists.

ON A CLASS OF EFFICIENT ERROR-LIMITING VARIABLE-LENGTH CODES
P. G. Neumann, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 260/266, 17 refs.

Variable length codes are considered whose code-word ends are defined by the occurrences in code text of particular sequences, called partition sequences. Sets of partition sequences are used in this fashion to define exhaustive codes. . . . Because of the partition sequences, these codes are quickly self-resynchronizing following errors. . . . used to encode natural languages. . . .

EFFICIENT ERROR-LIMITING VARIABLE-LENGTH CODES
P. G. Neumann, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 292/304.

. . . Variable-length codes recursively defined by certain sequential machines are investigated. It is seen that the recursive definition may be used to control error propagation as well as to provide a conceptually simple decoding procedure. . . . Methods for obtaining efficient codes are discussed, and examples are given.

A SIMPLE PROOF OF THE DECIPHERABILITY CRITERION OF SARDINAS AND PATTERSON
B. Bandyopadhyay, Inform. Control, vol. 6, no. 4, Dec. 1963, p. 331/336.

A simple alternative proof is given for a necessary and sufficient condition for the decodability of a sequence of codes. The proof involves no application of linear syntactical bases or other sophisticated algebraic criteria. . . .

OPTIMUM PROBABILITIES OF MESSAGES WITH PREASSIGNED CODE WORDS (Correspondence)
S. Chang, Proc. IEEE, vol. 51, no. 5, May 1963, p. 866/867.

. . . a systematic encoding procedure was discovered by Huffman to yield the highest coding efficiency. . . It is of interest to study a converse problem given a set of M code words, what is the best set of probabilities to be assigned to the M messages so that the efficiency of the code η will be maximized?

TESTS FOR UNIQUE DECIPHERABILITY
S. Even, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 109/112.

. . . The test also shows whether the set is decipherable with a finite delay, and in the latter case, determines the necessary delay. Finally, it is shown how the test of Sardinas and Patterson can be used to get the same result, as was conjectured by Gilbert and Moore. . . .

AN ADAPTIVE INFORMATION TRANSMISSION SYSTEM EMPLOYING MINIMUM REDUNDANCY WORD CODES
E. S. Schwartz, Armour Research Foundation, Chicago, Ill., Final rept. on Phases 1 & 2, 1 Feb. 1961-1 April 1963, 1 June 1963, 241 p., AD 404 463.

. . . experimental model of an adaptive information transmission system employing minimum-redundancy word codes. . . Flow charts of computer programs. . . Compression ratios for processed messages were determined and the effectiveness of a modified split-dictionary format providing for word decomposition and synthesis was studied. . . . knowledge concerning the statistics of word and letter frequencies can be effectively utilized in the design of an efficient system. A procedure for determining when dictionary changes are required is outlined.

A DICTIONARY FOR MINIMUM REDUNDANCY ENCODING
E. S. Schwartz, Association Computing Machinery, Journal, vol. 10, Oct. 1963, p. 413/439, 12 refs., A64-11311.

. . . It is shown that a modified split dictionary format is the best compromise between storage cost, coding cost and processing cost. Statistics of an experimental dictionary are presented including word lengths, frequency distribution, and first letter and initial trigram frequencies. The theoretical basis and computer programs for word decomposition and synthesis are described. Procedures for growing a dictionary, accumulating the a posteriori statistics of an information source, and adapting the dictionary to changes in the word frequency distribution are outlined.

2.212: Statistical Compaction Methods

Included: Goodness-of-fit tests for compaction; Data compression by quantiles; Floating aperture data compression; Floating barrier data compression; Statistical coding for redundancy reduction.

Not Included: Theory of random variables (1); Theory of Gaussian noise (1).

Cross References: Entropy reducing transformations (2.210); Quantized floating aperture system (2.254); Theory of moment invariants in pattern recognition (2.260).

Principal Publications:

THE PREDICTION OF GAUSSIAN-DERIVED SIGNALS
D. A. George, Mass. Inst. of Tech., July 1958, p. 104/111.

SOME METHODS OF OBTAINING MORE IN-FLIGHT VIBRATION DATA WITH LESS TELEMETRY BANDWIDTH
W. D. Hancock, Nat. Symp. Space Electronics Telem., Sept. 1959, no. 7.4.

. . . proposal of various in-flight statistical analysis systems and other coding schemes . . . a simple system which will reduce the bandwidth and at the same time preserve the usefulness of the data. . . .

MESSAGE COMPRESSION
H. Blasbalg, et al., IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 3, Sept. 1962, p. 228/238.

Two general classes . . . are considered: (1) Entropy-reducing (ER) transformation, and (2) Information preserving (IP) transformation (redundancy removal). . . . A new concept, adaptive coding, is introduced. It is shown that for quasi-stationary source statistics it is possible to obtain estimates of the statistics and to use these subsequently for efficient coding. . . .

THE FLOATING-APERTURE DATA-COMPRESSION SYSTEM APPLIED TO GAUSSIAN INPUTS
A. Bostrom, et al., JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 81/84.

In SPS 37-16, Vol. 4, pp. 54-57, the floating-barrier data-compression system was discussed . . . This note discusses the floating-aperture system as applied to stationary Gaussian inputs with mean 0. This problem is of interest in the general theory of stochastic processes, as well as being of importance due to the fact that many empirical inputs are roughly of the stationary Gaussian type.

DATA COMPRESSION BY QUANTILES
M. Easterling, et al., JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 74/78.

. . . yields high data compression ratios (e. g., >100) with very little loss of efficiency. . . . a computer on board a space probe which computes the mean and the variance of an empirically determined distribution, and then transmits the values of these parameters to Earth. This assumes that these parameters are the only useful information one wishes to extract from the data. By standard statistical theory this empirical distribution is very likely to be close to normal, so that the mean and variance are rigorously the only information one can extract from the data . . .

However, the amount of computer equipment necessary . . . might be excessive. It is the purpose of this summary to indicate another method of transmitting information to Earth which also has a high compression ratio, and yet does not require so much equipment. The system considered here will transmit the location of several quantiles of the empirical distribution.

QUANTIZATION AND CODING OF TRANSMITTED STATISTICAL INFORMATION
I. Eisenberger, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 46/49.

. . . whether the variances of the estimate of the parameter obtained from uncoded transmission is smaller than that resulting from an optimal method of encoding the data before transmission. This provides a basis for deciding whether or not to code. (The coding considered here is of the kind that adds redundancy in time; using orthogonal codes with correlation detection with no increase in time per information bit is not considered here.)

DATA COMPRESSION BY THE QUANTIZED FLOATING-APERTURE SYSTEM
I. Eisenberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 84/87.

That is, the range of the incoming variable is quantized into 2^m equal levels.

After transmitting the quantized value of the first observation, a quantized value is transmitted if and only if it exceeds the last previously transmitted quantized value by at least K in absolute value, where K is an integral number of quantization levels. Thus, the transmitted quantized values are estimates of the corresponding observed values, and estimates of those values which are not transmitted can be obtained by interpolation. . . . send a zero for each value observed but not transmitted, and for each transmitted value send a 1 followed by the quantized value.

SEQUENTIAL GOODNESS-OF-FIT TESTS USING QUANTILES
I. Eisenberger, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 169/172.

A set of n observations of a random variable obtained as a result of a space experiment may contain sample values taken from two distinct populations rather than from a single population as one might ordinarily expect.

If doubt exists as to which is the true situation, one would like to apply a "goodness-of-fit" test on the basis of which one may decide whether the parent population is actually normally distributed or whether its distribution is described by the . . . density function f(x) . . .

COMPACTION OF INDEPENDENT SAMPLES FROM A GAUSSIAN RANDOM PROCESS
J. Stiffler, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 78/81.

Bounds on amount of possible compression . . .

Methods of encoding . . .

Numerical examples . . .

PROGRAM DOCUMENTATION FOR MARK I STATISTICAL ASSOCIATION PROCEDURES FOR MESSAGE CONTENT ANALYSIS
J. Baker, et al., Mitre Corp., Bedford, Mass., Rept. no. SR 89, Dec. 1963, 48 p., AD 427 004.

A statistical method for automatic document retrieval and message content analysis is described . . . involves building a matrix for the corpus based on word co-occurrences within sentences . . . The normalized matrix is used by the retrieval algorithm to expand a set of query terms . . . All of these operations are performed on an IBM 7090 computer . . . detailed description of the computer programs.

A UNIFORMLY MOST POWERFUL TEST USING QUANTILES
I. Eisenberger, JPL Space Progr. Summ., vol. 4, no. 37-25, Dec./Jan. 1963, p. 194/198.

It has previously been shown that a significant amount of data compression, with a small loss in efficiency, can be achieved if, instead of all the sample values, a relatively small number of sample quantiles are transmitted to Earth during a space probe. . . . This report presents a test of a simple null hypothesis against a simple alternative hypothesis where the test is successively based on one, two, and four quantiles. In each case the power function is derived and the efficiency of the test determined. In particular, it will be shown that with only four quantiles the efficiency of the test is never less than 0.9!

SYSTEMATIC STATISTICS USED FOR DATA COMPRESSION IN SPACE TELEMETRY
I. Eisenberger, et al., Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, (NASA CR-53031: JPL-TR-32-510), 1 Oct. 1963, 48 p. refs, N64-13279.

THE BEST UNBIASED ESTIMATOR AS A LINEAR COMBINATION OF UNBIASED ESTIMATORS
I. Eisenberger, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 117/118.

In SPS 37-17, Vol. IV, pp. 74/78, the problem of obtaining the minimum variance estimate of a population parameter using three and four quantiles was approached by considering a special case of a more general problem. This note extends to the general case the analysis previously given for the special case. The results can then be applied to estimates using any number of quantiles.

ANALYSIS OF DATA TRANSMISSION SYSTEMS FOR STOCHASTIC SIGNALS
E. C. Posner, JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 203/209.

This article analyzes in detail the floating aperture system of data compression as described in SPS 37-17, Vol. IV, pp. 81/87. It is shown that savings of 5 db or more with no loss of fidelity can be achieved for certain types of experiments, but that savings can not be achieved for Gaussian inputs or mean zero. In the latter case, an updated raw data system is best.

CONDITIONAL FIRST PASSAGE TIMES
E. C. Posner, et al., JPL Space Program Summ., vol. 4, no. 37-21, April/May 196[illegible], p. 138/144.

a. Introduction. This article extends work begun in SPS 37-19, Vol. IV, pp. 172/177, and finds the expected time for certain continuous-parameter one-dimensional Markov processes to exit from an interval (b, a), given that at time 0, the process was at x_e (b, a), and given that the exit was from the bottom. . . . b. Processes with finite drift time. . . . c. Non-stationary Gaussian processes. . . . d. Examples. . . . e. Applications. . . . floating-aperture data compression system.

Related Publications:

THEORY OF MOMENT INVARIANTS AND ITS APPLICATIONS TO ADAPTIVE PATTERN RECOGNITION
M. K. Hu, Syracuse U. Research Inst., N. Y., In its Theory of Adaptive Mech., Dec. 1963, p. 16/65, refs, N64-15815.

EXPERIMENTAL STUDIES OF PATTERN RECOGNITION USING MOMENT INVARIANTS
E. Kletsky, Syracuse U. Research Inst. N. Y., In its Theory of Adaptive Mech., Dec. 1963, p. 66/86, refs, N64-15816.

. . . main area of discussion is concerned with receptor simulation. A program that incorporates third-order moments, making it possible to simulate a receptor providing six-moment invariants . . .

JOINT DISTRIBUTIONS WITH PRESCRIBED MOMENTS
E. C. Posner, et al., JPL Space Progr. Summ., vol. 4, no. 37-25, Dec./Jan. 1963, p. 186/194.

Section 2.22 Statistics of Information Sources

2.221: Theory of Source Statistics

Included: Higher order distributions in source statistics; Pattern redundancy; Morse distribution; Statistics of telegraphic messages; Random telegraph signals; Discovery algorithms for grammars; Grammars in the general sense; Context-free languages; Finite state languages; Sensor output statistics; Loglan.

Not Included: Theory of random variables (1); Theory of automata.

Cross References: Redundancy reducing codes (2.211); Pattern recognition methods (Sect. 2.26); Common feature method (2.282).

Principal Publications:

FINITE STATE LANGUAGES
N. Chomsky, Inform. Control, vol. 2, May 1958, p. 91/112.

. . . is a finite or infinite set of strings (sentences) of symbols (words) generated by a finite set of rules (the grammar), where each rule specifies the state of the system in which it can be applied, the symbol which is generated, and the state of the system after the rule is applied.

THE STATISTICAL PROPERTIES OF A LARGE NUMBER OF MESSAGES
D. S. Lebedev, Radio Engng., vol. 13, no. 1, 1958, p. 1/10.

A COMMENT ON PATTERN REDUNDANCY
O. Lowenschuss, IRE Trans. Inform. Th., vol. IT-4, Sept. 1958, p. 127.

PROBABILITY DENSITIES OF THE SMOOTHED "RANDOM TELEGRAPH SIGNAL"
W. M. Wonham, et al., J. Electronics and Control, vol. 4, June 1958, p. 567/576.

THE MORSE DISTRIBUTION
M. Freimer, et al., IRE Trans. Inform. Th., vol. IT-5, March 1959, p. 25/31.

THE INFORMATION CONTENT OF NON-SEQUENTIAL MESSAGES
B. R. Judd, et al., Inform. Control, vol. 2, no. 4, Dec. 1959, p. 315/332.

. . . a mathematical technique is developed for measuring the information in a message where no information is transmitted by the order in which the symbols composing the message are received.

A COMMENT ON A COMMENT OF PATTERN REDUNDANCY
M. C. Paull, IRE Trans. Inform. Th., vol. IT-5, March 1959, p. 34/35.

LOGLAN
J. C. Brown, Sci. American, vol. 202, June 1960, p. 53/63.

NOTE ON THE BOOLEAN PROPERTIES OF CONTEXT FREE LANGUAGES
S. Scheinberg, Inform. Control, vol. 3, no. 4, Dec. 1960, p. 372/375.

A language is considered to be any set of sentences (strings) made up from a finite vocabulary (alphabet). A grammar is a device which enumerates a language, e. g., a Turing machine with any set of input signals, a finite automaton, or a Post system. One often considers the family of languages which have grammars meeting certain specifications . . . A major question of interest is whether such a family is a closed system with respect to the Boolean operations: The family of recursively enumerable languages is . . . closed under union and intersection, but not under difference. . . . the family of finite state languages is closed under all three operations. In this note we answer this question for another family of languages, called "type 2" or "context free" by Chomsky (1959). . . .

It will be seen that a context free grammar is essentially a special case of a semi-Thur system . . .

PROBLEMS OF INFORMATION TRANSMISSION NO. 5 STATISTICAL CODING
Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, July 1961, 159 p., (Trans no. MCL-894/1 of Akademiya Nauk SSSR Laboratoriya Sistem Peredachi Informatsiy, Moskva, 125 p., 1960) AD 269 612.

. . . measuring the frequency distribution of message elements from various sources and adduces the results . . . in the case of certain sources, carried to the level of 4th-order distributions. In appendices to this collection of articles there are provided tables of the functions necessary to compute the entropy of discrete distribution.

THE PROBABILITY DISTRIBUTIONS OF THE OUTPUTS OF FIRST-ORDER AND TUNED SECOND-ORDER FILTERS WITH COIN-TOSS SQUARE WAVE INPUTS
A. R. Cohen, IRE Trans. Circuit Theory, vol. CT-9, no. 4, Dec. 1962, p. 371/377, and AD 407 272.

. . . The input is a binary process in which axis crossings can occur only on a set of equally spaced sample points . . .

A REMARK ON DISCOVERY ALGORITHMS FOR GRAMMARS
E. Shamir, Inform. Control, vol. 5, no. 3, Sept. 1962, p. 246/251.

ON CONTEXT-FREE LANGUAGES AND PUSH-DOWN AUTOMATA
M. P. Schutzenberger, Inform. Control, vol. 6, no. 3. Sept. 1963, p. 246/264.

This note describes a special type of one-way, one-tape automata in the sense of Rabin and Scott that idealizes some of the elementary formal features used in the so-called "push-down store" programming techniques. It is verified that the sets of words accepted by these automata form a proper subset of the family of the unambiguous context-free languages of Chomsky's and that this property admits a weak converse. . . .

Related Publications:

THE PROBABILITY DENSITY OF THE OUTPUT OF A FILTER WHEN THE INPUT IS A RANDOM TELEGRAPHIC SIGNAL: DIFFERENTIAL-EQUATION METHOD
J. A. McFadden, IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 228/233.

PROGRAM DOCUMENTATION FOR MARK I STATISTICAL ASSOCIATION PROCEDURES FOR MESSAGE CONTENT ANALYSIS
J. Baker, et al., Mitre Corp., Bedford, Mass., Rept. no. SR 89, Dec. 1963, AD 427 004.

COMPARISON BETWEEN SPECTRAL SCANNING THEORY AND CLASSICAL COLOR VISION THEORIES
G. Biernson, Sylvania Electric Products, Inc., (NASA CR-50350; Res. Note-396), May 16, 1963, 17 p., 6 refs, N63-17230.

A detailed comparison of experimental evidence relative to the Spectral Scanning theory and the Trichromatic theory, shows that the Spectral Scanning theory is at least as consistent with this evidence as is the Trichromatic theory. . . .

PROBABILITY CHARACTERISTICS OF SENSOR OUTPUT DATA
G. W. McClure, et al., Michigan U. Ann Arbor Inst. of Science and Tech., (Memo-2900-329-R), Sept. 1963, 34 p., 9 refs, N63-21405.

. . . First results of a program to determine the statistical nature of surveillance sensor output data. Most of the data were obtained from negative transparencies of vertically oriented aerial photographs. Smaller sample of radar and infrared films are reported for comparison. A line-scan process was used to generate an electrical analog of the light transmitted by the film. This signal was sampled, amplitude quantized, and recorded for later statistical analysis by a digital computer. . .

INFORMATION PATTERN, LEARNING STRUCTURE, AND OPTIMAL DECISION RULE
M. Sakaguchi, Inform. Control, vol. 6, no. 3, Sept. 1963, p. 218/229.

In Section I various type of information structures in individual decision-making under uncertainty are discussed. A quantity which measures the value of information structure is proposed. In Section II the team decision problem is considered.

Finally, in Section III we consider the multistage decision process with learning and we shall try to evaluate the effect of the learning structure and compute it by the technique of dynamic programming. . . .

2.222: Statistics of Written Languages

Included: Phrase structure grammars; Phrase structure languages; Statistical properties of English language; Redundancy of written languages; Word associations.

Cross References: Statistics of spoken languages (2.314); Machine translation (2.282); Grammars in general (2.221); Finite state languages (2.221); Context-free languages (2.221); Intelligibility problems (2.315).

Principal Publications:

MECHANICAL RESOLUTION OF LINGUISTIC PROBLEMS
A. D. Booth, L. Brandwood and J. P. Cleave, London, England, Butterworth, Inc., 1958, 306 p.

. . . mechanical translation. . . . one language into another . . .

SOME PROPERTIES OF PHRASE STRUCTURE GRAMMARS
N. Chomsky, Quarterly Progress Report, Res. Lab. Elecs. MIT, April 1958, p. 108/111.

THE SOLUTION OF SOME FUNDAMENTAL PROBLEMS IN MECHANICAL SPEECH RECOGNITION
D. B. Fry, et al., University Coll., London (Gt. Brit.), 1958, 58 p., AD 208 865.

. . . The use of language statistics in mechanical recognition is also discussed.

LENGTH-FREQUENCY STATISTICS FOR WRITTEN ENGLISH
G. A. Miller, et al., Inform. Control, Dec. 1958, p. 370/389.

RELATIVE EFFICIENCY OF ENGLISH AND GERMAN LANGUAGES FOR COMMUNICATION OF SEMANTIC CONTENT
B. S. Ramarkrishna, IRE Trans. Inform. Th., vol. IT-4, Sept. 1958, p. 1276.

FREQUENCY OF USAGE AND THE PERCEPTION OF WORDS
M.R. Rosenzweig, et al., Science, vol. 127, Feb. 1958, p. 263/266.

ON CERTAIN FORMAL PROPERTIES OF GRAMMARS
N. Chomsky, Inform. Control, vol. 2, June 1959, p. 137/167.

A NOTE ON PHRASE STRUCTURE GRAMMARS
N. Chomsky, Inform. Control, vol. 2, no. 4, Dec. 1959, p. 393/395.

WORD FREQUENCY EFFECTS IN LEARNING MESSAGE SETS (Correspondence)
L. J. Gerstman, et al., J. Acoust. Soc. Amer., vol. 32, Aug. 1960, p. 1078/1079.

A METHOD OF DETERMINING GRAMMATICAL CONCEPTS ON THE BASIS OF GROUP THEORY
O. S. Kulagina, IN: Problems of Cybernetics, vol. 1, 1960, p. 227/242, New York, Pergamon Press, Ltd.

THE REDUNDANCY OF TEXTS IN THREE LANGUAGES
E. B. Newman, et al., Inform. Control, vol. 3, no. 2, June 1960, p. 141/153.

LINGUISTIC ANALYSIS AND PROGRAMMING FOR MECHANICAL TRANSLATION (Mechanical Translation and Thought) (English text, most of it translated from Italian)
S. Ceccato, (editor), Milan, Feltrinelli Editore, 1961, 246 p.

. . . work on machine translation (MT) of language . . . The authors, members of the Center for Cybernetic and Linguistic Research at the University of Milan . . . approach MT via ideas of a philosophical movement begun by M. Schlick in Vienna in 1924 ("Vienna Circle") Circle"), and known abroad as logical positivism or as scientific operationism. In order to understand the book it is necessary to understand operationism. . . .

A NOTE MATHEMATICAL INDUCTION ON PHRASE STRUCTURE GRAMMARS
R. W. Floyd, Inform. Control, vol. 4, no. 4, Dec. 1961, p. 353/358.

. . . A string is a finite nonempty sequence of characters chosen from a given alphabet. In particular, each character is itself a string. Strings will be represented by small Latin letters. A grammatical category is a (possibly infinite or empty) set of strings. Categories will be represented by Latin capitals. A language is a finite set of categories, of which one may optionally be singled out as the category of sentences or well formed formulas. . . .

STRUCTURE OF LANGUAGE AND ITS MATHEMATICAL ASPECTS
R. Jakobson, (editor), Providence, R. I., American Mathematical Society, 1961, 279 p.

. . . Proceedings of the twelfth symposium on Applied Mathematics, held in New York City on April 14 and 15, 1960. . . .

THE APPLICATION OF CERTAIN THEORIES TO THE PROBLEMS OF DETECTION AND COMMUNICATION (In French)
J. Lochard, et al., Onde Electr., vol. 42, no. 426, Sept. 1962, p. 709/737.

A series of 5 papers . . . the last article . . . shows how the properties of written language . . . can be studied quantitatively . . .

PHRASE STRUCTURE LANGUAGES, FINITE MACHINES, AND CHANNEL CAPACITY
R. B. Banerji, Inform. Control, vol. 6, no. 2, June 1963, p. 153/162.

The concept of channel capacity is applicable and useful in the study of languages with structures more general than those generated by finite state channels discussed in Information Theory. A technique has been developed in this paper whereby the channel capacity of a class of phrase structure languages can be calculated. . . .

AUTOMATIC SYLLABIFICATION OF ENGLISH WORDS (Correspondence)
J. L. Dolby, et al., Proc. IEEE, vol. 51, no. 10, Oct. 1963, p. 1371/1372.

. . . studies that are primarily aimed at uncovering the regularities of written English. . . .

ANALOG NETWORKS FOR WORD ASSOCIATION
V. E. Giuliano, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 221/234.

. . . use of analog electrical networks for the automatic recognition of statistical word associations present in written English text. A general mathematical theory is proposed for the association of linguistic units by means of linear transformations, and it is shown that this theory can be realized through use of passive electrical networks. . . . Roughly speaking, measures of two distinct types of linguistic association can thus be generated—"synonymy" association, which reflects similarity of meaning, and "contiguity" association which reflects relationships among designates. . . .

THREE THEOREMS ON PHRASE STRUCTURE GRAMMARS OF TYPE 1
P. S. Landweber, Inform. Control, vol. 6, no. 2, June 1963, p. 131/136.

It is shown that the class of languages generated by type 1 phrase structure grammars is not enlarged by allowing end markers, that this class is closed under the operation of intersection, and that those languages representable by linear bounded automata belong to this class. . . .

Related Publications:

STANDARD COMMUNICATIONS AND MESSAGE RECEPTION
I. Pollack, et al., J. Acoust. Soc. Amer., vol. 30, no. 1, Jan. 1958, p. 62/64.

AN ADAPTIVE INFORMATION TRANSMISSION SYSTEM EMPLOYING MINIMUM REDUNDANCY WORD CODES
E. S. Schwartz, Armour Research Foundation, Chicago, Ill., Final rept. on Phases 1 & 2, 1 Feb. 1961-1 April 1963, 1 June 1963, 241 p., AD 404 463.

. . . Flow charts of computer programs . . . knowledge concerning the statistics of word and letter frequencies can be effectively utilized in the design of an efficient system. A procedure for determining when dictionary changes are required is outlined.

FOREIGN DEVELOPMENTS IN MACHINE TRANSLATION AND INFORMATION PROCESSING NO. 121
Joint Publications Research Service, Washington, D. C., 13 May 1963, 53 p., AD 408 881.

Entropy of the Russian language, by A. A. Piotrovskaya et al.
. . . Modeling and similarity theory, by V. A. Venikov, Structural and applied linguistics, by V. A. Zvegintsev.

2.229: Measurements of the Statistics of Information Sources

Included: Pattern production for source simulation; Computer simulation of information sources.

Not Included: Experimental evaluation of statistical distributions in general (1); Pattern generators.

Cross References: Pattern recognition (Sect. 2.26); Computer simulation of compaction systems (2.230); Correlation measurements (2.829).

Principal Publications:

ON CERTAIN POSSIBLE METHODS OF MEASURING THE ENTROPY OF DISCRETE AND CONTINUOUS MESSAGE SOURCES
M. P. Dolukhanov, Radio Engng. and Electronics, vol. 4, no. 4, 1959, p. 1/10.

TELEMETRY BANDWIDTH COMPRESSION USING AIRBORNE SPECTRUM ANALYZERS
A. G. Ratz, Proc. IRE, vol. 48, April 1960, p. 694/702.

PROBABILITY CHARACTERISTICS OF SENSOR OUTPUT DATA
G. W. McClure, et al., Institute of Science and Tech., U. of Michigan, Ann Arbor, Rept. no. 2900 329R, Sept. 1963, 31 p., AD 418 179.

. . . program to determine the statistical nature of surveillance sensor output data . . .

THE PRODUCTION OF RANDOMLY DISTORTED AND DETERIORATED PATTERNS
R. E. Manelis, Air Force Special Weapons Center, Kirtland AFB, N. Mex., AFSWC TDR63 44, 11 April 1963, 23 p., AD 405 587.

A set of computer subroutines which attempt to simulate various degrees of distortion and deterioration on an input character . . . A complete set of the letters of the Cyrillic alphabet, numerals, and some punctuation were quantized and punched to be used as ideal input characters to transforming subroutines.

1604 SIMULATION PROGRAM DESCRIPTIONS MILESTONE XI, THE SIMULATED TELEMETRY DATA GENERATION CONTROL PROGRAM (STGR)
J. Ng, System Development Corp., Santa Monica, Calif., 15 March 1963, 31 p., AD 405 132.

. . . designed to provide realistic telemetry data (Fixed Format and Event Items under card input control. The simulated data will be packed in the same format as the Telemetry Report Message (Message Type #13). In the present version, only the FM/FM telemetry data is simulated. Additional capability to simulate PAM and PCM telemetry data (exclusive of spacial vehicle-specific payload telemetry) will be incorporated. . . .

Related Publications:

ACOUSTIC ANALYSIS AND SYNTHESIS OF SPEECH WITH APPLICATIONS TO SWEDISH
G. Fant, Ericsson Tech., vol. 15, no. 1, 1959, p. 3/108.

The theory of short-time frequency analysis by means of spectro-graphic devices is outlined with an emphasis on the formal relations between the function of a band-pass filter and Fourier integral caluculus. Methods of evaluating the transient response and thus the temporal sampling characteristics of low-pass and band-pass filters are reviewed. . . .

A PRECISION AMPLITUDE-DISTRIBUTION AMPLIFIER
W. F. Caldwell, et al., IRE Trans. Electronic Computers, vol. EC-9, no. 2, June 1960, p. 252/255.

SOME OBSERVATIONS WITH A VIEW TO AUTOMATIC CODING IN TELECOMMUNICATIONS (In French)
R. Moreau, Automatisme, vol. 7, no. 11, Nov. 1962, p. 425/432.

With a view to the use of computers in coding, a study is made of suitable linguistic units . . . Comparison is made between coding letter by letter, coding by units of two, three, four or five letters, coding by syllables, by pseudo-syllables, and coding by words, and coding letter by letter are given. . . . it is considered that the best practical linguistic unit is the word.

TECHNIQUES FOR EXAMINING THE STATISTICAL AND POWER SPECTRAL PROPERTIES OF RANDOM TIME HISTORIES
H. A. Leybold, Virginia Polytechnic Inst., Blacksburg, May 1963, 69 p., 29 refs., N63-16730.

A technique for digitally generating random time histories having arbitrarily shaped power spectra is presented. . . .

Section 2.23

2.230: Engineering Problems in Compaction Systems

Included: Physiological analogy in compaction systems; Buffer length requirements in data compressors; Computer simulation of a compaction system.

Not Included: Design of compactors; Actually used compactors in space missions (4); Bionics (3B); Buffer storage devices (3A).

Cross References: Computer simulation of information sources (2.229).

Principal Publications:

THE ADAPTIVE FILTER: A BIONIC APPROACH TO RECOGNITION
F. L. Hiltz, Proc. Nat. Aerosp. Electronics Conf., vol. 9, May 1961, p. 132/133.

BUFFER LENGTH REQUIREMENTS FOR A TELEMETRY DATA COMPRESSOR
J. E. Medlin, Proc. Nat. Telem. Conf., May 1962, no. 14-5.

COMPUTER SIMULATION OF A DATA COMPRESSOR FOR AEROSPACE TELEMETRY SYSTEMS
R. A. Schomburg, Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962. no. 4.2.

. . . investigated the feasibility and effectiveness of a telemetry data compression technique by means of digital computer simulation, using actual satellite vehicle flight telemetry data as the imput to the simulated data compressor. With this particular technique, a data sample is transmitted only if it has changed by more than a preset limit from the last sample transmitted. . . . compression ratios ranging from 27 to 39 were obtained for the orbital data, and a compression ratio of 19 was obtained for the launch data. In contrast, vibration data used in the study exhibited an average compression ratio of only 2. . .

CONFLEX I – A CONDITIONED REFLEX SYSTEM
M. R. Uffelman, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 132/142.

. . . The functional organization of a conditioned-reflex system (CR system) is presented. . . . for the classification of minimally constrained stimuli. Given a system with an input retina containing N_S binary input cells, it is possible to describe 2^{N_S} black-white patterns. . . .

PATTERN RECOGNITION AS A PROBLEM IN DECISION THEORY AND AN APPLICATION TO SPEECH RECOGNITION
V. E. Sackschewsky, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 186/189.

. . . general discussion of pattern recognition as a problem in statistical decision theory . . . application of these concepts . . . to the recognition of speech sounds by a method which uses the same principles for preprocessing of sound as soes the human auditory system. . . . under appropriate conditions a pattern recognition technique which maximizes the cross correlation coefficient of the signal with a set of functions representing the patterns is equivalent to the optimum decision rule. . . .

Related Publications:

SHORT-TERM MEMORY IN VISION
E. Averbach, et al., Bell Syst. Tech. J., vol. 40, no. 1, Jan. 1961, p. 309/328.

Experiments are performed that demonstrate some of the functional properties of short-term storage in the visual system, its decay, readout and erasure. Results indicate that the visual process involves a buffer storage which includes an erasure mechanism that is local in character and tends to erase stored information when new information is put in. . . . eye movements play an important role in the perception of form, and that perceptions of complicated visual fields are built up from information gathered during many fixations of the eyes.

THEORY OF PROBABILITY STATE VARIABLE SYSTEMS, VOLUME I SUMMARY AND CONCLUSIONS
R. J. Lee, et al., Adaptronics, Inc., Alexandria, Va., ASD TDR63 664, vol. 1, Final rept., 15 Oct. 1961 - 14 Oct. 1962, AD 427 872.

. . . Particular emphasis is here placed upon Neurotron artificial nerve cells and networks of these artificial nerve cells, which together with their goal circuits, probably form the most advanced type of PSV systems . . .

EXPERIMENTS IN ADAPTIVE PATTERN RECOGNITION
J. S. Bryan, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 174/179.

. . . experiments . . . to supply data concerning the power of some Perceptron-like adaptive pattern recognition systems using linear discriminate functions. . . .

APPLICATION OF NEURAL LOGIC TO SPEECH ANALYSIS AND RECOGNITION
T. B. Martin, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 189/196.

This paper describes signal-processing techniques for the recognition of speech phonemes by machine. An attempt has been made to employ, wherever useful, basic processing functions of the human auditory system. . . .

FERRIELECTRICS AND THEIR APPLICATION IN SOLID-STATE DEVICES AS AN ADAPTIVE CONTROL
C. F. Pulvari, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 254/260.

. . . Now, for the first time, it is possible to utilize the combination of electrically controlled resistance, inductance and capacitance in circuit design. . . . extremely useful in the fields of pattern recognition, trainable computers and adaptive control. . . .

Section 2.24
Analog Compaction Methods

2.242: Amplitude Compression Methods

Included: Instantaneous value companding in PCM; Pre-modulation clipping; Amplitude clipping in general; Companding operations for redundancy reduction; Dynamic compression of analog waveforms; Gamma transformation in television.

Not Included: PCM transmission methods (1); Compression amplifiers; Logarithmic amplifiers.

Cross References: Speech clipping (2.323); Gamma and range of television sources (2.410); Constant amplitude speech (2.323); Nonlinear quantization methods (2.254); Logarithmic PCM encoding (2.254); Slope feedback coding for voice (2.340); Slope feedback coding for pictures (2.430).

Principal Publications:

DYNAMIC COMPRESSION FOR RADAR RECEIVERS
D. Levine, Electronic Industr., Sept. 1958, p. 102/106.

DYNAMIC COMPRESSION FOR RADAR RECEIVERS
D. Levine, Electronic Industr., vol. 17, Nov. 1958, p. 82/84.

DYNAMIC DISTORTION IN TRANSMISSION IN A COMPRESSOR - INTERMEDIATE CHANNEL - EXPANDER SYSTEM
V. I. Tsapalina, Telecommunications, no. 1, 1958, p. 75/89.

APPLICATION OF INFORMATION THEORY TO AMPLITUDE COMPRESSION (In French)
J. A. Ville, Cables et Transm., vol. 12, April 1958, p. 144/147.

BEITRAG ZUR REZIPROKEN DYNAMIKREGELUNG (Contribution to Reciprocal Dynamics Control) (In German)
H. Volz, Hochfrequenz Tech. u. ElektroAkust., vol. 67, Nov. 1958, p. 87/94.

A DISTORTIONLESS SYSTEM OF FEEDBACK TYPE INSTANTANEOUS COMPANDORS
T. Kasai, J. Inst. Elect. Commun. Engrs., Japan, vol. 42, no. 7, July 1959, p. 665/669.

UNTERSUCHUNGEN UBER DIE GERAUSCHVERMINDERUNG MITTELS PRE-UND DEEMPHASIS BEI RUNDFUNKUBERTRAGUNG (Investigation of Noise Reduction by Pre- and De-emphasis in Broadcast Transmission Channels) (In German)
W. von Guttenberg, et al., Entwicklungs-Berichte, vol. 22, no. 4, Dec. 1959, 317/324.

COMPANDOR EFFECTS ON DATA SIGNALS
E. Enriquez, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 220.

Abstract Only.
While speech transmission profits from the use of compandors in telephone facilities, data transmission does not. In fact, certain types of data signals suffer irreparable damage when sent over existing compandored facilities. The ability to transmit a data signal through compandors without appreciable distortion improves as the instantaneous peak-to-average power ratio of the transmission approaches one. . . .

ON THE RECOVERY OF A BAND-LIMITED SIGNAL, AFTER INSTANTANEOUS COMPANDING AND SUBSEQUENT BAND LIMITING
H. J. Landau, Bell Syst. Tech. J., vol. 39, no. 2, March 1960, p. 351.

If f(t) is a band-limited function, with band limit —, the result of instantaneously companding f(t) is in general no longer band-limited. . . . knowledge of merely those frequencies . . . the band form — is sufficient to recover the original signal f(t). An iteration formula has been proposed that, in theory, performs the desired recovery. In this paper we study in detail some of the practical questions raised by that formula.

COMPANDOR LOADING AND NOISE IMPROVEMENT IN FREQUENCY DIVISION MULTIPLEX RADIO-RELAY SYSTEMS
E. M. Rizzoni, Proc. IRE, vol. 48, no. 2, Feb. 1960, p. 208/220.

PRE-MODULATION AND POST-MODULATION CLIPPING IN SINGLE SIDEBAND TRANSMISSION
L. R. Spogen, et al., Applied Research Lab., U. of Arizona, Tucson, Final rept., Dec. 1960, 46 p., AD 264 260.

The transmitted power of a single sideband (SSB) system is governed by the peak value of the input signal to the final amplifier. Premodualtion and post-modulation clipping reduce the peak-to-average characteristics of this input signal. The benefits are examined of premodulation and post-modulation clipping.

EIN KOMPANDER FÜR RUNDFUNKPROGRAMM-ÜBERTRAGUNG (A Compandor for Broadcast Program Material) (In German)
W. von Guttenberg, et al., Nachrichtentech. Z., vol. 13, Jan. 1960, p. 9/15.

(1) Compandors
(2) Transmission of Hi-Fi over Multiplex Carrier Circuits.

NEW FM-AM METHOD OF COMPRESSION, EXPANSION, AND MULTIPLICATION
W. R. Aiken, et al., Proc. IRE, vol. 49, Oct. 1961, p. 1550/1552.

DATA COMPRESSION
J. Stuart, et al., JPL Res. Summ., vol. 1, no. 36-9, April/May 1961, p. 1/3.

Two approaches have been tried in the area of data compression. One is the use of a logarithmic diode as a feedback element around a suitable operational amplifier. . . . The other approaches utilizes the line segment approximation to the logarithmic curve. . . .

A COMPANDED CODER FOR AN EXPERIMENTAL PCM TERMINAL
H. Mann, et al., Bell Syst. Tech. J., vol. 41, no. 1, Jan. 1962, p. 173/222.

. . . consists of a logarithmic instantaneous compandor plus a linear (equal step) coder. The companded coder plays a major role in determining the over-all performance of the 1- 1/2 megabit system. . . . performance of the all-semiconductor equipment that performs the analog-to-digital and digital-to-analog conversions for the PCM terminal.

INSTANTANEOUS VALUE COMPANDING IN PULSE MODULATED COMMUNICATION SYSTEMS
W. Glaser, Air Force Systems Command, Wright-Patterson AFB, Ohio Foreign Technology Div., Sept. 19, 1963, 39 p., 2 refs., Transl. into English from Nachrichtentechnik, no. 3, 1961, p. 106/114, N63-23377 and also AD 292 315, AD 420 608.

. . . A method is described for instantly companding the values of a time-modulated signal . . . Improvement of various communication system parameters are obtained by pre-emphasis on the transmitter side and an adequate distortion-correction on the receiver side . . . The values of signal-to-noise ratio improvement, made available by the method described are derived . . .

Related Publication:

CONSTANT AMPLITUDE SPEECH
P. J. Ferrell, IRE Nat. Conv. Rec. vol. 6, no. 8, March 1958, p. 190/191.

GRADATIONSENTZERRUNG IM FARBFERNSEHEN (Contrast Linearization in Television) (In German)
J. Kaashoek, Nachrichtentech. Z., vol. 11, Oct. 1958, p. 515/518.

ON THE POWER GAINED BY CLIPPING SPEECH IN THE AUDIO BAND
W. Wathen-Dunn, et al., J. Acoust. Soc. Am., vol. 30, no. 1, Jan. 1958, p. 36/40.

DIODE-COMPRESSOR DATA
R. B. Dome, Electronics, vol. 32, no. 27, Feb. 1959, p. 74.

VOICE RADIO SYSTEMS FOR HIGH NOISE PATHS
J. A. Greefkes, et al., Electronics, vol. 32, no. 50, Dec. 1959, p. 53/57.

When other radio links fail because of noise, this system still works. Frequency and amplitude components of speech are transmitted on separate channels.

A new communications system, in its most refined form, can operate at a signal to noise ratio of 4 db. Other versions of the system do not give as much improvement but still allow operation at ratios of 8 db in one case and 6 db in another. . . . This system is called FRENA . . .

COMPRESSION AMPLIFIER
C.A. Steffey, Army Electronics Research and Development Activity, White Sands Missile Range, N. Mex., Technical rept. no. SELWS-E-108, Oct. 1962, 22 p., incl. illus., 4 refs., AD 401 910.

. . . amplitude-compression amplifier . . . The automatic gain control circuit is capable of maintaining a constant output level over a wide range of input levels . . .

ON THE PROPERTIES OF SOME SYSTEMS THAT DISTORT SIGNALS—I.
I. W. Sandberg, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 2033/2046.

This is the first part of a two-part paper concerned with some generalizations and extensions of the Beurling-Landau-Miranker-Zames theory of recovery of distorted bandlimited signals. We present a uniqueness proof that extends Beurling's result and study a class of functional mappings defined on Hilbert space. As an application, we show that the recovery results can be extended to cases in which a known square-integrable corrupting signal is added to the input signal and the result applied to a time-variable device which may be nonlinear. It is proved that an assumption made by the earlier wirters is in fact necessary in order that stable recovery be possible. . . .

2.243: Frequency Compression Methods

Included: Frequency compression in FM systems; Pre-emphasis in FM systems; Bandwidth compression methods; Subcarrier pre-emphasis in telemetry.

Not Included: Threshold problems in FM systems (1).

Cross References: Statistics of multiplex signals (2.510); Optimum pre-emphasis in FD multiplex systems (2.521).

Principal Publications:

REDUCTION OF THRESHOLD BY FREQUENCY COMPRESSION
A. J. Buxton, et al., Proc. Instn. Elect. Engrs., vol. 105, Part B, Supp. 8, 1958, p. 117/121.

ELEKTRONISCHER LINIENSPEICHER ZUR KOMPRESSION DES FREQUENZBANDES PERIODISCH WIEDERKEHRENDER SIGNALE, INSBESONDERE BEI RADARSCHIRM BILDERN (Electronic Line Storage Device for Bandwidth Compression of Periodically Repeated Signals, Primarily Radar Display Signals) (In German)
K. Lange, Nachrichtentech. Z., vol. 11, Dec. 1958, p. 619/627.

Time expansion and compression is an intermediate stop for bandwidth compression.

FURTHER PROGRESS IN BANDWIDTH COMPRESSION OF RADAR DISPLAYS (In German)
H. Meinke, et al., Nachrichtentech. Z., vol. 11, Aug. 1958, p. 398/404.

ON COMPRESSING THE FREQUENCY BAND OF RADAR SIGNALS BY EMPLOYING A LINE STORAGE TUBE WITH CIRCULAR DEFLECTION OF THE ELECTRON BEAM (In German)
K. Dinter, Telefunken Zeitung, vol. 32, no. 125, Sept. 1959, p. 209.

A NEW PRACTICAL APPROACH TO SUB-CARRIER PRE-EMPHASIS
W. E. Hane, Nat. Telem. Conf., May 1959, p. 151/160.

New designs for fm/fm telemetry often lack a method of obtaining optimum subcarrier pre-emphasis. . . . The use of an optimum pre-emphasis curve rather than a "standard" curve significantly increases the effective range of a given telemetry system. However, when the system has more than six to eight subcarrier oscillators, the data distortion often becomes intolerable. . . .

A COMPRESSED-BANDWIDTH STEREO-PHONIC SYSTEM FOR RADIO TRANS-MISSION
W. S. Percival, Proc. Instn. Elect. Engrs, Paper 3152 E, Conv. on Stereophonic Sound Recording, Reproduction & Broad-casting, p. 234/238.

TELEMETRY BANDWIDTH COMPRESSION USING AIRBORNE SPECTRUM ANALYZERS
A. G. Ratz, Proc. IRE, vol. 48, no. 4, April 1960, p. 694/702.

NEW FM-AM METHOD OF COMPRESSION, EXPANSION, AND MULTIPLICATION
W. R. Aiken, et al., Proc. IRE, vol. 49, Oct. 1961, p. 1550/1552.

LA COMPRESSION DE FREQUENCE ET SON UTILISATION POUR LES TELECOMMUNI-CATION PAR SATELLITES (Frequency Compression and Its Use in Satellite Telecommunications) (In French)
C. Cardot, (International Scientific Radio Union (URSI) Symposium, Paris, France, Sept. 18-22, 1961.), In: Space Radio Communication, New York, Elsevier Publishing Co., 1962, p. 433/446, A63-14257.

. . . The basic principle of frequency compression is indicated - i.e., the application of the general properties of feedback systems to FM receivers. . . .

FM-SIGNAL DEMODULATION IN MICROWAVE FREQUENCY-COMPRESSION RECEIVERS
W. L. Sweet, Electronic Defense Labs., Mountain View, Calif., (Technical memo. no. EDL-M334), 3 Feb. 1961, AD 252 712.

Reception of broad-band FM signals may be improved by employing the techniques of frequency compression in the receiver. Frequency compression is briefly compared with other FM reception techniques, and its application in micro-wave receivers is discussed. . . . the possibility of combining several FM reception techniques is considered.

TESTS OF THREE SYSTEMS OF BANDWIDTH COMPRESSION OF TELEVISION SIGNALS
G. F. Newell, et al., Proc. Instn. Elect. Engrs., Pt. B, vol. 109, no. 46, July 1962, p. 311/324.

. . . investigation into three similar methods of reducing the bandwidth required for the trans-mission of television pictures. . . . all involve the isolation of the essential brightness changes in the picture; these are redistributed to occur at a uniform rate for transmission. A second signal must be transmitted inorder to allow correct repositioning of the brightness changes in the final picture. Partial instrumentation has been carried out, and the methods have been assessed with re-gard to their bandwidth requirements and resultant picture quality.

EFFECTIVE SPECTRUM UTILIZATION BY FREQUENCY TRANSLATION OF SIGNAL SPECTRA
R. A. Runyan, Proc. Nat. Telem. Conf., May 1962, no. 10-4.

. . . provide a means of utilizing data system bandwidth to fit a particular problem. Frequency translation circuits, filter design and reference carrier recovery are the technical problems which must be solved to implement a practical system. . . .

TWO NEW SPEECH COMMUNICATION SYSTEMS
J. L. Stewart, Arizona U., Tucson, Final rept. for 15 Dec. 1960 - 14 Dec. 1961, on Biological Information Handling Systems and Their Functional Analogs, March 1962, 22 p., incl. illus., 29 refs., AD 278 711.

. . . provide certain efficiencies in speech channel usage. One system achieves the equivalent of modest bandwidth compression by permitting two-to-one time multiplexing with simple terminal equipment and with a standard speech (telephone) channel. The other, based on extraction of equivalent amplitude, frequency, and phase modulating components of speech, may yield bandwidth compression comparable to that of a formant-tracking vocoder.

OPTIMUM PREEMPHASIS IN MULTICHANNEL RADIO RELAY LINES WITH FREQUENCY DIVISION MULTIPLEX AND FREQUENCY MODULATION (Translation)
V. B. Tseitlin, Telecommun. Radio Engng., Part I - Telecommunications, Nov. 1962, p. 9/15. A63-19193.

. . . theory . . . and a simple method . . . for finding the characteristics approximating minimum total noise power in the group spectrum. . . .

MINIMUM POWER ANALOGUE COMMUNICATION
J. A. Develet, Jr., Aerospace Corp., Los Angeles, Calif., Rept. no. TDR 169 3250 43 TN2, SSD TDR 63 111, 15 May 1963, 38 p., AD 437 203.

. . . theory of minimum power wide-band frequency modulation communications . . . considered . . . sources of noise, frequency modulation theory, frequency-following reception, phase-lock and FM feedback, thresholding, the effects of system nonlinearities, and the use of pre-emphasis.

INSTANTANEOUS VALUE COMPANDING IN PULSE MODULATED COMMUNICATION SYSTEMS
W. Glaser, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, Trans. from Periodical, Nachrichtentechnik, No. 3, 1961, p. 106/114, 19 Sept. 1963, 39 p., AD 420 608.

. . . application . . . to pulse-modulated systems of an improvement of various communication system parameters to be obtained by a pre-emphasis on the transmitter side and an adequate distortion-correction on the receiver side. . . The values of signal-to-noise ratio inprovement available by the method described are derived and essential information is given as to how to determine the toleration of certain equipment parameters . . .

THE DEVELOPMENT OF AIRBORNE SPECTRUM ANALYZERS FOR TELEMETRY BANDWIDTH COMPRESSION
A. G. Ratz, et al., Proc. Nat. Telem. Conf., May 1963, no. 9-1.

The development work, culminating in practical airborne spectrum analyzers . . . Certain unique features, such as continuous zero and full-scale calibration, extended dynamic range, etc., are considered. . . . Non-stationary situations are discussed, illustrated by the results of actual missile firings. . . .

AN AIRBORNE VIBRATION ANALYSIS SYSTEM
C. L. Schuster, Proc. Nat. Telem. Conf., May 1963, no. 9-2.

. . . a large number of these wide-frequency bandwidth measurements are required. By analyzing these measurements before they are transmitted, the capacity requirements of the telemetry system can be reduced or made available for other measurements. The band-pass filter and peak storage system described here is one method of analyzing vibration data prior to its transmission. . . .

Related Publications:

VARIATION OF BANDWIDTH WITH MODULATION INDEX IN FREQUENCY MODULATION
M. S. Corrington, Proc. IRE, vol. 35, Oct. 1947, p. 1013/1020.

2.244: Time Compression Methods

Included: Optical pulse expansion/compression; Time compressed single sideband system (TICOSS).

Not Included: Re-circulation devices; Time compression equipment.

Cross References: Time compression in voice digitization (2.350); Accordion pulse compression system with random access (2.640).

Principal Publications:

TIME-COMPRESSED SINGLE-SIDEBAND SYSTEM (TICOSS)
M. I. Jacob, et al., IRE Trans. Commun. Syst., vol. CS-6, no. 1, June 1958, p. 2/8.

. . . Ticoss has been proposed that provides the performance required of mobile multi-channel short-to-medium-range communication systems . . . Ticoss handles all transmission with one transmitter, one receiver, and one antenna at each station. The sub-channels to be multiplexed are arranged in sequential time slots to form a frame.

COMPRESSED TIME BOOSTS SINGLE-SIDEBAND CAPACITY
M. I. Jacob, et al., Electronics, vol. 31, no. 4, July 1958, p. 52/56.

TIME COMPRESSOR FOR COHERENT INTEGRATION
R. W. Spencer, General Atronics Corp., July 1958.

SPEECH-TO-CODE CONVERTER STUDY
W. D. Larkin, et al., General Dynamics/ Electronics, Rochester, N. Y., Final rept., 1 July 1959 - 31 Dec. 1960, 30 Sept. 1961, 149 p., 17 refs., AD 272 109.

. . . Time compression permits real-time spectrum analysis with a sweep analyzer and offers the possibility of a reduction in equipment size approaching an order of magnitude compared with conventional parallel-channel analyzers . . .

OPTICAL PULSE EXPANSION/COMPRESSION
A. Reich, et al., Proc. Nat. Aerosp. Electronics Conf., vol. 9, May 1961, p. 163/169.

The desirability of improving radar signal wave-form has led to the development of pulse compression techniques . . . An optical pulse expander-compressor has been designed and constructed. This system provides pulse expansion and pulse compression on a pulse-to-pulse basis in real-time . . .

TIME COMPRESSION AS AN AID TO AIR TRAFFIC CONTROL
S. Adelman, et al., East Coast Conf. Aerospace Navig. Electronics, vol. 9, Oct. 1962, no. 2.2.4.

. . . The aim of the air traffic control equipment designer must be to feed the operator as much information as possible, as fast as possible, and in as simple a form as possible. One important piece of information . . . is past position and speed data . . . are determining factors in anticipating the path of the craft. Time compression is a technique which displays past history in a condensed form. That is, the path of the target for the previous 10 minutes may be displayed in 10 seconds. This permits a radar scope observer to instantaneously and simply observe target position, velocity, direction and past history. Additional operator orientation and training is very nominal . . .

A MOTION-ENHANCEMENT DISPLAY BY TIME-COMPRESSION
M. E. Crost, IRE Internat. Conv. Rec. Pt. 5, vol. 5, March 1962, p. 67/75.

. . . To demonstrate the enhancement of detectability of moving targets in the presence of severe clutter, a display system of electronic time-compression was devised and constructed at USASRDL. The principle of operation is that a number of immediate-past-history scans are stored within the system and then display sequentially at a much faster rate than acquired.

The Westinghouse Permachon storage vidicon was chosen as the storage tube type around which the system would be constructed. . . .

A LOW-ALTITUDE SATELLITE COMMUNICATIONS SYSTEM USING TIME COMPRESSION TRANSMISSION
E. L. Roberts, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 273/275.

Related Publications:

AN ELECTRONICALLY COMBINED RADAR SURVEILLANCE DISPLAY
G. E. Martin, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 6/9.

INSTANTANEOUS VALUE COMPANDING IN PULSE MODULATED COMMUNICATION SYSTEMS
W. Glaser, Foreign Tech. Div., Air Porce Systems Command, Wright-Patterson Air Force Base, Ohio., (Trans. no. FTD-TT-62-32 from Nachrichtentechnik No. 3, p. 106/114, 1961), 20 Aug. 1962, 38 p., incl. illus., 2 refs., AD 292 315.

. . . companding values, instantly, of a time modulated signal which guarantees better utilization of the communication system without increasing the necessary frequency band requirements. . . .

USE OF RECIRCULATORS FOR COMPRESSING FREQUENCY-MODULATED PULSES
V. V. Lebedev, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 11, Nov. 1963, p. 60/68.

The possibility of using circulating memory devices (recirculators) for the optimum extraction of a frequency-modulated pulse in noise is considered. A comparison with the usual filters using dispersive delay lines is carried out. . . .

Section 2.25
Digital Compaction Methods

2.252: Digital-to-Digital Conversion

Included: Run-length coding methods; Digital data compression techniques.

Not Included: Data processing techniques in space communications (3A).

Cross References: Efficient codes (redundancy reducing codes) (2.211); Quantized floating aperture systems (2.254); Floating aperture systems (2.212); Run-length coding of pictures(2.420).

Principal Publications:

A PROBABILISTIC MODEL FOR RUN-LENGTH CODING OF PICTURES
J. Capon, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 421.

Abstract Only — A first-order Markov process representation for pictures is proposed in order to study the picture coding system known as run-length coding (differential-coordinate encoding). A lower bound for the saving in channel capacity of the run-length coding system is calculated on the basis of this model, and is compared with the results obtained by previous investigators . . .

A DIGITAL DATA COMPRESSION TECHNIQUE
J. L. Perry, et al., Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 217/222.

. . . systematic digital technique for removing redundancy from binary data . . .

THE DIGITAL DATA PROCESSOR FOR THE SKYTOP STATIC TEST FACILITY
K. M. Roehr, et al., IRE Trans. Mil. Electronics, vol. MIL-5, no. 4, Oct. 1961, p. 300/306.

. . . implements a new data-acquisition concept which permits self-adaptive, accurate, real-time digitizing and editing of a large number of high-frequency data channels . . . The centrally located processor basically samples 127 channels of analog information from any one of several 1-million-pound static test stands, and produces a digital tape . . .

REDUCED-TIME FACSIMILE TRANSMISSION BY DIGITAL CODING
H. Wyle, et al., IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1961, p. 215/222.

. . . a family of coding methods designed to achieve reduced-time digital facsimile transmission. This paper reports on a study of the effectiveness and feasibility of one of these methods, Run Length Coding (RLC).

DATA COMPRESSION BY FIRST DIFFERENCES
J. J. Stiffler, JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 57/61.

Related Publications:

DATA COMPRESSION BY THE QUANTIZED FLOATING-APERTURE SYSTEM
I. Eisneberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 84/87.

. . . After transmitting the quantized value of the first observation, a quantized value is transmitted if and only if it exceeds the last previously transmitted quantized value by at least K in absolute value, where K is an integral number of quantization levels. . . . send a zero for each value observed but not transmitted, and for each transmitted value send a 1 followed by the quantized value.

2.253: Compactive Sampling Methods

Included: Minimum duty cycle systems; Extremal coding; Non-uniform sampling; Extremal approximations; Optimal sampling times; Exponential curve fitting; Polynomial interpolation; Polynomial fitting of time series; Adaptive data sampling; Compactive analog-to-digital conversion; Sampling of zeros of bandlimited signals; Selective monitoring of physiological data.

Not Included: Sampling theorems (1); Sampled data transmission systems (1); Pulse communications systems (1); Eliasing error (1).

Cross References: Curve fitting theory in general (2.210); Approximation theory in general (2.210); Exponential approximation (2.210); Asynchronous time division systems (2.533); Compactive methods for pictures (2.420).

Principal Publications:

ON SAMPLING THE ZEROS OF BANDWIDTH LIMITED SIGNALS
F. E. Bond, et al., IRE Trans. Inform. Th., vol. IT-4, no. 3, Sept. 1958, p. 110/113.

. . . The sampling theorem has been generalized to include nonuniform sampling and the use of derivatives of the signal. In the present paper, a sampling theorem has been developed which utilizes information related to the zeros of the signal. This sampling theorem can be of use for enabling transmission of binary signals, such as facsimile and infinitely-clipped speech, over a continuous band-limited cahnnel.

EXTREMAL CODING FOR SPEECH TRANSMISSION
M. V. Mathews, IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 129/136.

. . . The coder determines the amplitudes and times of successive extremes (relative maxima and minima) of the signal.

NONUNIFORM SAMPLING AND EXTREMAL APPROXIMATION
J. L. Stewart, Proc. IRE, vol. 49, Feb. 1961, p. 521/522.

A NEW PULSE MODULATED SPEECH COMMUNICATION SYSTEM HAVING A MINIMUM DUTY CYCLE
R. O. Eastman, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 114/118.

. . . The system provides adequate naturalness of speech while maintaining a quantized sampling rate which is proportional to the information bandwidth. . . . generating infinitely clipped signals . . . deriving an optimum sampling rate from these signals. . . . two separate forms of information, amplitude and frequency, are conveyed by a time modulated pulse. . . . results of tests conducted through the system. . . .

OPTIMAL SAMPLING TIMES
I. Eisenberger, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 49/51.

. . . problem . . . of estimating in an optimal manner the slopes of two straight lines from observations received through a transmission channel perturbed by white Gaussian noise when the observations themselves are random quantities.

SAMPLING AND RECONSTRUCTION OF WAVE-NUMBER-LIMITED FUNCTIONS IN N-DIMENSIONAL EUCLIDEAN SPACES
D. P. Petersen, et al., Inform. Control, vol. 5, no. 4, Dec. 1962, p. 279/323.

The well-known Whittaker-Kotel'nikov-Shannon sampling theorem for frequency-bandlimited functions of time is extended to functions of multidimensional arguments. It is shown that a function whose spectrum is restricted to a finite region of wave-number space may be reconstructed from its samples taken over a periodic lattice having suitably small repetition vectors. The most efficient lattice (i.e., requiring minimum sampling points per unit hypervolume) is not in general rectangular, nor is a unique reconstruction function associated with a given sampling lattice. . . .

ADAPTIVE SAMPLING FREQUENCY FOR SAMPLED DATA CONTROL SYSTEMS
IRE Trans, Autom. Control, vol. AC-7, Jan. 1962, p. 38/47.

AN ADAPTIVE DATA SAMPLING SYSTEM
M. Berkowitz, Rec. Nat. Space Elec. Symp., 1963, no. 4-1.

. . . tests the change in signal level of each data channel, from one sample to the next, against a priori, preprogrammed criteria, and . . . utilizes the result of this test to limit the system output to only significantly changed data. . . . resulting in varying amounts of time being liberated depending upon the properties of the signals being sampled. The time thus liberated can be utilized for the insertion of additional lower priority data . . . The usability of micro-electronic techniques to practically accomplish sophisticated operations of this type is illustrated by describing a newly designed microelectronic multiplexer. . . .

THE USE OF SIGITAL DATA SYSTEMS
L. W. Gardenhire, Proc. Nat. Telem. Conf., May 1963, no. 3-1.

. . . provides a method for selecting the proper sampling rate for sampled data systems. . . . based on a more realistic type of input data and actual filters, rather than ideal data and ideal filter response characteristics. The various errors produced are explained and their values predicted for various types of input data. Several methods of interpolating between samples are explained and a new process called computer interpolation is presented which allows for a reduction in required samples by using a computer to look at the correlation between several samples. . . .

SELECTING SAMPLE RATES
L.W. Gardenhire, ISA Journal, vol. II, April 1964, p. 59/64, 7 refs., A64-17502.

Presentation of a method for selecting optimum sampling rates for data reduction systems, using realistic input data and actual filters. Various kinds of errors are investigated, such as step interpolation errors and errors of commission and omission; the values of these errors are predicted for several kinds of input data. Traditional methods of interpolating between samples are explained, and a method,

called computer interpolation, which reduces the number of samples required, is presented. An experiment to determine the validity of the method developed for selecting the proper sampling rates is reviewed.

EXPONENTIAL CURVE FITTING WITH APPLICATIONS
G. E. Hayo, et al., Naval Civil Engineering Lab., Port Hueneme, Calif., Final rept., 24 Sept. 1963, 55 p., AD 421 443.

A method of exponential curve fitting is presented which considers cases where the function tends asymptotically to either a constant slope or maximum value as the abscissa becomes large. Derivations, solutions, and applications of models based on this method are provided. Computer program documentations and sample problems are appended.

ANALOG-TO-DIGITAL CONVERSION BY POLYNOMIAL FITTING
J J. Stiffler, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 171/175.

LEAST-SQUARES ESTIMATION OF PARAMETERS FOR ASYMPTOTES OF EXTREMES
J. E. Walsh, System Development Corp., Santa Monica, Calif., Rept. no. SP1566, 26 Feb. 1964, 21 p., AD 433 836.

Consider a specified one of the largest order statistics of a sample of size n from a continuous population. . . . Development of a nonparametric estimate of the asymptotic distribution for an extreme furnishes the basis for the estimation.

Related Publications:

THEORETICAL BOUNDS ON THE PERFORMANCE OF SAMPLED DATA COMMUNICATIONS SYSTEMS
J. J. Spilker, Jr., IRE Trans. Circuit Theory, vol. CT-7, no. 3, Sept. 1960, p. 335/341.

. . . sampling at a rate two or more times the maximum message frequency. . . . In practical communications systems, the message spectrum is not strictly bandlimited, and noise is necessarily introduced into the sampled message by transmission. . . . message can be recovered with only small error by filtering the message before sampling and carefully choosing the smoothing filter.

ANALYSIS OF ASYNCHRONOUS TIME MULTIPLEXING OF SPEECH SOURCES
T. G. Birdsall, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 390/397.

. . . The analysis here evaluates the asynchronous method when extremal coding is used with the speech sources. . . . For these parameters a 100-source asynchronous system requires only one-third the digit rate of a synchronous multiplex. About a 5-db loss in signal-to-noise may be expected, due to the extremal coding. Two additional features are: 1) 20 percent of digit rate is available for nonreal time data; and 2) the usual elastic overload of asynchronous systems is present. . . .

ADAPTIVE TELEMETRY FORMAT GENERATOR
R. E. Gottfried, et al., Proc. Nat. Telem. Conf., May 1962, no. 10-1.

. . . The great utility of time multiplexed formats for use in telemetry, communications, and data processing has been well extablished over the years. . . . The majority of telemetry formats . . . are fixed according to some prearranged sampling plan. . . . This practice has often resulted in great transmission inefficiency . . . excessive sampling results in redundance. . . . This paper describes a format generation technique which is believed to have great simplicity in terms of implementation and operational usage. The device which results can be controlled by command or self-adaptive means. . . .

TRUNCATION ERROR OF SAMPLING-THEOREM EXPANSIONS
H. D. Helms, et al., Proc. IRE, vol. 50, Feb. 1962, p. 179/184.

. . . arises in reconstituting a band-limited function by summing over only a finite number (instead of the requisite infinite number) of samples of this function in an appropriate sampling-theorem expansion. Upper bounds are given for the truncation errors of the Cardinal and Fogel sampling expansions and for "self-truncating" versions of these two sampling expansions . . .

CODING AND DECODING FOR TIME-DISCRETE AMPLITUDE-CONTINUOUS MEMORYLESS CHANNELS
J. Ziv, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 199/205.

AUTOMATIC DATA COMPRESSION FOR TELEVISION PICTURES
JPL Space Progr. Summ., vol. 6, no. 37-18, Sept./Nov. 1962, p. 61/65.

. . . pictures taken from a spacecraft . . . may have a high percentage of redundancy. . . . an opportuntiy arises for reducing the total amount of information to be televised.

1. Theory of Redundancy Control - A technique that appears particularly suitable for redundancy control in a planetary camera instrumentation system is that of polynomial interpolation.
2. Mechanization of Redundancy Control . . .
3. Experimental Sampling Techniques . . .
4. Data Reductions Possible . . .

NON-UNIFORMLY-WEIGHTED ORTHONORMAL OVER-DAMPED EXPONENTIAL APPROXIMATIONS
J. M. Mendel, Douglas Aircraft Co., Inc., Santa Monica, Calif., Missile and Space Systems Div., 7 Jan. 1964, 101 p., refs., N64-17757.

CODING AND DECODING FOR TIME-DISCRETE AMPLITUDE-CONTINUOUS MEMORYLESS CHANNELS
J. Ziv, Research Lab of Electronics, Mass. Inst. of Tech., Campridge., (Technical rept. no. 399), 31 Jan. 1963, 101 p., AD 299 016.

2.254: Compactive Quantization Methods

Included: Multi-level coding with redundancy reduction; Combit codes; Quantized floating aperture system; Non-uniform discretizing; Nonlinear quantization; Logarithmic PCM encoding.

Not Included: Multilevel PCM methods (1); Quantization theory (1); PCM quantization methods (1); Quantization noise (1); A/D conversion (3A).

Cross References: Floating aperture systems in general (2.212); Statistical compaction methods (2.212); Nonlinear quantization of pictures (2.420); Feedback quantization system for picture compression (2.420).

Principal Publications:

ON THE QUANTIZATION OF FINITE DIMENSIONAL MESSAGES
M. P. Schutzenberger, Inform. Control, vol. 2, May 1958, p. 153/158.

THE PROBLEM OF NONUNIFORM DISCRETIZING OF CONTINUOUS SIGNALS
Z. Fridrikh, et al., (Rept. no. STL-TR61-5110-46, Trans. from Izvestiya Vysshikh Uchebnykh Zavedenii. Radiofisika, 3:316/327, 1960), AD 264 166.

. . . readings are made at uneven distances. The intervals between readings are related to the order of the approximation polynominal by a permissible value of the error of approximation; in addition, readings are taken not of the instantaneous value of the signal, but using the approximation function.

THE FLOATING-APERTURE DATA-COMPRESSION SYSTEM APPLIED TO GAUSSIAN INPUTS
A. Bostrom, et al., JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 81/84.

In SPS 37-16, Vol. 4, pp. 54/57, the floating-barrier data-compression system was discussed. . . This note discusses the floating-aperture system as applied to stationary Gaussian inputs with mean 0. This problem is of interest in the general theory of stochastic processes, as well as being of importance due to the fact that many empirical inputs are roughly of the stationary Gaussian type.

QUANTIZATION AND CODING OF TRANSMITTED STATISTICAL INFORMATION
I. Eisenberger, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 46/49.

. . . whether the variances of the estimate of the parameter obtained from uncoded transmission is smaller than that resulting from an optimal method of encoding the data before transmission. This provides a basis for deciding whether or not to code. (The coding considered here is of the kind that adds redundancy in time; using orthogonal codes with correlation detection with no increase in time per information bit is not considered here.)

OPTIMAL SAMPLING TIMES
I. Eisenberger, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 49/51.

. . . problem. . . of estimating in an optimal manner the slopes of two straight lines from observations received through a transmission channel perturbed by white Gaussian noise when the observations themselves are random quantities.

DATA COMPRESSION BY THE QUANTIZED FLOATING-APERTURE SYSTEM
I. Eisenberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 84/87.

. . . will quantize the incoming experimental analog signal into an m-bit word. That is, the range of the incoming variable is quantized into 2^m equal levels.

After transmitting the quantized value of the first observation, a quantized value is transmitted if and only if it exceeds the last previously transmitted quantized value by at least K in absolute value, where K is an integral number of quantization levels. Thus, the transmitted quantized values are estimates of the corresponding observed values, and estimates of those values which are not transmitted can be obtained by interpolation. . . . send a zero for each value observed but not transmitted, and for each transmitted value send a 1 followed by the quantized value.

MULTILEVEL CODING FOR BANDWIDTH REDUCTION
H. Sullivan, et al., Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 1, Feb. 1962, p. 157.

. . . there are classes of signals having a bandwidth less than one-half the bit rate. A nontrivial example, the "combit codes", is constructed. . . . can be best described in terms of a finite state automaton which generates them. The input to this automaton is an arbitrary binary sequence. . . . For example, one such code maps binary sequences (0, 1) into three level (-1, 0, 1) sequences according to the rule: "following a transition of the input sequence from "1" to "0", change the sign of all subsequent "1's". This code gives approximately 2:1 bandwidth reduction. Other examples are given in the text. . . .

AN ADAPTIVE DATA SAMPLING SYSTEM
M. Berkowitz, Rec. Nat. Space Elec. Symp., 1963, no. 4.1.

. . . tests the change in signal level of each data channel, from one sample to the next, against a priori, preprogrammed criteria, and. . . utilizes the result of this test to limit the system output to only significantly changed data. . . . resulting in varying amounts of time being liberated depending upon the properties of the signals being sampled. The time thus liberated can be utilized for the insertion of additional lower priority data . . . The usability of micro-electronic techniques to practically accomplish sophisticated operations of this type is illustrated by describing a newly designed micro-electronic multiplexer. . . .

BLOCK QUANTIZATION OF CORRELATED GAUSSIAN RANDOM VARIABLES
J. J. Huang, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 289/296.

For the transmission of information from a continuous source over a digital channel. . . The usual procedure is to sample the continuous source output at regular time intervals and then quantize the samples in amplitude. . . . This paper is concerned only with the quantization process. . . . If successive samples are statistically dependent it should clearly be possible to reduce the average quantization error without increasing the total number of digits used for representing a set of N samples. . . .

The present paper deals with a more restricted procedure. Its merits are the absence of any limitation of fineness of quantization and the relative ease of designing quantizers of moderate block length. . . .

LOGARITHMIC PCM ENCODING WITHOUT DIODE COMPANDOR
H. Kaneko, et al., IEEE Trans. Commun. Syst., vol CS-11, no. 3, Sept. 1963, p. 296/307.

Instantaneous companding is a useful technique for the improvement of the transmission quality of PCM systems. . . . various nonlinear encoding and decoding techniques without using diode compandors are stated. . .

A SYSTEM ORIENTED PCM GROUND STATION INCORPORATING DATA COMPRESSION
L. J. Lauler, Rec. Nat. Space Elec. Symp., 1963, p. 4.4.

. . . the "floating aperture" scheme has been found to be an effective T/M data compressor performing redundancy reduction at moderate hardware cost. . . .

A PROTOTYPE SELECTIVE MONITORING SYSTEM FOR PHYSIOLOGICAL DATA
G. W. Morton, et al., Rec. Nat. Space Elec. Symp., 1963, no. 8.2.

. . . selective monitoring techniques to extract the significant information from data typical of that originating in a manned space vehicle. Use of these techniques substantially reduces the load on all portions of the transmission and analysis facilities. . . .

Related Publications:

INSTANTANEOUS VALUE COMPANDING IN PULSE MODULATED COMMUNICATION SYSTEMS
W. Glaser, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 20 Aug. 1962, 38 p., incl. illus., 2 refs., (Trans. no. FTD-TT-62-32 from Nachrich tentechnik, No. 3, p. 106/114, 1961), AD 292 315.

. . . companding values, instantly, of a time modulated signal which guarantees better utilization of the communication system without increasing the necessary frequency band requirements. . . .

AUTOMATIC DATA COMPRESSION FOR TELEVISION PICTURES
JPL Space Progr. Summ., vol. 6, no. 37-18, Sept./Nov. 1962, p. 61/65.

A NEW PULSE MODULATED SPEECH COMMUNICATION SYSTEM HAVING A MINIMUM DUTY CYCLE
R. O. Eastman, IRE Trans. Commun. Systems, vol. CS-10, no. 1, March 1962, p. 114/118.

NON-UNIFORMLY-WEIGHTED ORTHO-NORMAL OVER-DAMPED EXPONENTIAL APPROXIMATIONS
J. M. Mendel, Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div., 7 Jan. 1964, 101 p., refs., N64-17757.

Section 2.26
Pattern Recognition

This area has attracted great interest in the last six years and almost two hundred publications are referenced in this section. While it is the policy of the compilers of this bibliography to subdivide subject codes down to the last identifiable entities, they were at a loss to achieve this goal in the field of pattern recognition. Ironically, it seems to be most difficult to "recognize a systematic pattern" in the field of pattern recognition. The compilers decided therefore, at this time, to treat the entire area as a unit.

The reader is invited to read the introduction to this dividion (2.2); for further comments about pattern recognition.

2.260: Pattern Recognition Methods

Included: Shape recognizers; Automatic character recognition; Minimum scan pattern recognition; Modular geometric shapes; Print recognition; Selection problems in pattern recognition; Cyclops system; Theory of moment invariants in pattern recognition; Rotating raster character recognition system; P_F image transformation; Electro-optical image matching; Inductive probability criterion; Hyperplane techniques in pattern recognition; Random masks recognizers; Consistency technique for pattern association; Adaptive processes in pattern recognition; Digital classification of patterns by computers; Gestalt methods in pattern recognition; Image recognition algorithms; Pre-normalization of reconnaissance data; Classification decisions; Object recognition; Function modeling for pattern recognition; Pattern perception; Pattern separation; Automatic identification systems.

Not Included: Character reading devices (3A); Perceptron (3B)

Cross References: Line drawing pattern recognizer (2.440); Replicating triangles (2.110); Pseudo-random area coding for television (2.440); Perfect maps (2.110); Spatial filtering (2.814); Learning filters (2.855); Picture redundancy reduction (2.400).

Principal Publications:

AUTOMATISCHE ZEICHENERKENNUNG 1. TEIL (Automatic Pattern Recognition) (In German)
K. Steinbuch, Nachrichtentech., vol. 11, April 1958, p. 210/219.

AUTOMATISCHE ZEICHENERKENNUNG 2 TEIL (Automatic Pattern Recognition) (In German)
K. Steinbuch, Nachrichtentech., vol. 11, May 1958, p. 237/280.

AUTOMATIC TYPE SIZE NORMALIZATION IN HIGH SPEED CHARACTER SENSING EQUIPMENT
A. I. Tersoff, IRE Nat. Conv. Rec., March 1958, p. 318/326.

SESSION 1: CHARACTER RECOGNITION (Specialist Discussion Meetings on New Digital-Computer Techniques 16th & 17th Feb. 1959)
C. E. Bailey, Proc. Instn. Elect. Engrs., vol. 106, pt. B-29, Sept. 1959, p. 444/445.

THE APPLICATION OF A PATTERN-RECOGNITION TECHNIQUE TO THE SYNTHESIS OF CODING CIRCUITS
J. H. Calderwood, et al., J. Electronics and Control, vol. 6, no. 6, June 1959, p. 556/566.

THE SYNTHESIS OF A PARALLEL ADDER CIRCUIT USING A PATTERN-RECOGNITION TECHNIQUE
J. H Calderwood, et al., J. Electronics and Control, vol. 6, no. 6, June 1959, p. 567/576.

THE AUTOMATIC RECOGNITION OF TYPE-WRITTEN NUMBERS (Specialist Discussion Meetings on New Digital-Computer Techniques 16th & 17 Feb. 1959)
W. Dietrich, Proc. Instn. Elect. Engrs., vol. 106, pt. B-29, Sept. 1959, p. 446/447.

MINIMUM-SCAN PATTERN RECOGNITION
A. Gill, IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 52/58.

NETWORKS FOR PATTERN PERCEPTION
P. H. Greene, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 357/369.

. . . to show how a certain type of artificial network could exhibit many of the pattern-stabilizing and-perceiving abilities that make human vision meaningful. The model is not intended to do the entire job of pattern recognition; rather, its purpose is to "notice" and hold together good Gestalten, or perceptual units, in order that a pattern recognizer incorporating the network would have stable and meaningful units with which to operate. The model identifies perceptual units with modes of oscillation of a network of oscillators . . .

A SYSTEM FOR THE AUTOMATIC RECOGNITION OF PATTERNS
R. L. Grimsdale, et al., Proc. Instn. Elect. Engrs., pt. B, vol. 106, Mar. 1959, p. 210/222.

A SYSTEM FOR THE AUTOMATIC RECOGNITION OF PATTERNS (Specialist Discussion Meetings on New Digital-Computer Techniques 16th & 17th. Feb. 1959)
R. L. Grimsdale, et al., Proc. Instn. Elect. Engrs., pt. B, vol. 106, Sept. 1959, p. 445/446.

SOME COMMUNICATION ASPECTS OF CHARACTER-SENSING SYSTEMS
C. C. Heasly, Jr., Proc. Western Joint Computer Conf., San Francisco, Calif., March 3-5, 1959, p. 176/180.

A GENERALIZED SCANNER FOR PATTERN- AND CHARACTER-RECOGNITION STUDIES
W. H. Highleyman, et al., Proc. Western Joint Computer Conf., San Francisco, Calif., March 3-5, 1959, p. 291/294.

PATTERN AND CHARACTER RECOGNITION SYSTEMS–PICTURE PROCESSING BY NETS OF NEURON-LIKE ELEMENTS
L. A. Kamentsky, Proc. Western Joint Computer Conf., San Francisco, Calif., March 3-5, 1959, p. 304/309.

PATTERN RECOGNITION
A. A. Kharkevich, Radio Engrg., vol. 14, no. 5, 1959, p. 17/30.

A REVIEW OF THE PERCEPTRON PROGRAM
A. E. Murray, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 346/356.

"Perceptron" is the class name for a family of pattern recognition machines. They can learn to discriminate several categories. After exposure to a few samples in a category, such a machine tends to recognize spontaneously or classify correctly a new sample. . . .

PATTERN RECOGNITION IN SILHOUETTES
G. Sebestyen, MIT Quart. Prog. Rept., no. 53A, April 1959, p. 109/111.

. . . purpose of this investigation is to develop a theory for the construction of an electronic device that can recognize visual patterns in black-and-white figures by automatically extracting group defining properties from sample figures.

RECOGNITION OF NUMERALS BY CONTOUR FOLLOWING (Specialist Discussion Meetings on New Digital-Computer Techniques 16th & 17th February, 1959).
W. Sprick, et al., Proc. Instn. Elect. Engrs., pt. B, vol. 106, Sept. 1959, p. 448/449.

PATTERN RECOGNITION BY MEANS OF AUTOMATIC ANALOGUE APPARATUS
W. K. Taylor, Proc. Instn. Elect. Engrs., pt. B, vol. 106, March 1959, p. 198/210.

PATTERN RECOGNITION BY MEANS OF AUTOMATIC ANALOGUE APPARATUS (Specialist Discussion Meetings on New Digital-Computer Techniques 16th & 17th. Feb. 1959)
W. K. Taylor, Proc. Instn. Elect. Engrs., pt. B, vol. 106, Sept. 1959, p. 447/448.

PATTERN DETECTION AND RECOGNITION
S. H. Unger, Proc. IRE, vol. 47, Oct. 1959, p. 1737/1752.

PATTERN RECOGNITION
J. W. Brouillette, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 4, June 1960, p. 179/182.

. . . machines for recognition of typed or printed characters using magnetic or optical scanning devices are becoming commercially available, and it is natural now to give more serious attention to problems involving identification of geometric patterns which display a greater range of variation in character than is normally the case for stylized, typed letters of the alphabet. In the fall of 1954, the General Electric Company began a survey of the problems. . . .

A CHARACTER-RECOGNITION STUDY
W. E. Dickinson, IBMJ Res. Developm., vol. 4, no. 3, July 1960, p. 335/348.

THE PRINCIPLES OF THE CONSTRUCTION OF A MACHINE FOR PATTERN RECOGNITION
V. S. Fain, Radio Engng: Transl. of Radioteckhnika, vol. 15, no. 3, 1960, p. 16/23.

The problems of the construction of a machine which operates by the "parallel" method are analysed; . . . theoretical considerations . . . circuit . . . examined. . . . compared with the living visual apparatus. . . . messages derived from n different sources are picked up and processed simultaneously by an instrument having n inputs . . . called "a parallel method". . . .

OPTIMIZATION OF REFERENCE SIGNALS FOR CHARACTER RECOGNITION SYSTEMS
I. Flores, et al., IRE Trans. Electronic Computers, vol. EC-9, no. 1, March 1960, p. 54/61.

MINIMUM DESCRIPTION BY CONVENTIONAL PROGRAMME SCANNING
V. A. Garmash, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 10, 1960, p. 21/27.

. . . minimum description of symbols in order to automate their recognition. . . . it is proposed

to use conventional programme scanning in which the exploration of each successive element depends on the value of the preceding element. A description is given of how to determine the sequence of "most informative element-cells" and an example is given. . . .

COMMENTS ON A CHARACTER RECOGNITION METHOD OF BLEDSOE AND BROWNING (Correspondence)
W. H. Highleyman, et al., IRE Trans. Electronic Computers, vol. EC-9, no. 2, June 1960, p. 263.

GENERATING HIGH-QUALITY CHARACTERS AND SYMBOLS
J. K. Moore, et al, Electronics, vol. 33, no. 24, June 1960, p. 55/59.

CLASSIFICATION DECISIONS IN PATTERN RECOGNITION
G. S. Sebestyen, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, TR 381, 25 April 1960, 79 p., AD 411 761, also AD 260 232.

The basic element in the solution of pattern-recognition problems is the requirement for the ability to recognize membership in classes. . . . Each sample is represented by a point in a suitable chosen, finite-dimensional vector space in which a class corresponds to a domain that contains its samples. Boundaries of the domain in the vector space can be expressed analytically with the aid of transformations that cluster samples of a class and separate classes from one another. From these geometrical notions a generalized discriminant analysis is developed which, as the sample size goes to infinity, leads to decision-making that is consistent with the results of statistical decision theory. . . . an illustrative example is given for the automatically learned recognition of spoken words.

PATTERN RECOGNITION BY MACHINE
O. G. Selfridge, et al., Sci. American, vol. 203, no. 2, Aug. 1960, p. 60/68.

A METHOD FOR THE DESIGN OF PATTERN RECOGNITION LOGIC
S. D. Stearns, IRE Trans. Electronic Computers, vol. EC-9, no. 1, March 1960, p. 48/53.

AUTOMATIC CHARACTER RECOGNITION
D. A. Young, Electronic Engng., vol. 32, no. 383, Jan. 1960, p. 2/10.

THE SHAPE RECOGNIZER
Bell Lab. Record, vol. 38, no. 6, June 1960, p. 226.

AUTOMATIC PATTERN RECOGNITION BY A GESTALT METHOD
V. E. Giuliano, et al., Inform. Control, vol. 4, no. 4, Dec. 1961, p. 332/345.

Signals representing coefficients in a series approximation to the two-dimensional density function represented by a pattern are directly measured by focusing an image of the pattern on a small number of weighted masks with a photocell behind each, or alternatively by passing the image of the pattern past a small number of weighted slits. . . .

PATTERN RECOGNITION BY MOMENT INVARIANTS (Correspondence)
M. Hu, Proc. IRE, vol. 49, Sept. 1961, p. 1428.

A NOTE ON REALIZATION OF DECISION NETWORKS USING SUMMATION ELEMENTS
P. M. Lewis, II, Inform. Control, vol. 4, no. 2/3, Sept. 1961, p. 282/290.

Frequently engineering considerations place limitations on the size of decision making systems and on the resources of the system designer. The pertinent high order probability distributions may be unknown and it may not be possible to measure and/or store these distributions in their entirety; some type of approximation is then necessary. One type of approximation that has been studied previously involves measuring and storing several of the lower order component distributions and using these to approximate the high distribution, using the criterion of maximum entropy. . . .

STUDIES PERTAINING TO BAMBI. SPACE-TIME SAMPLING AND FILTERING
W. D. Montgomery, et al., General Dynamics/-Convair, San Diego, Calif., Final rept., Dec. 1961, 75 p., (Rept. ZR-AP-061-23) AD 269 039.

. . . problem of manipulating visual data available to a satellite so as to enhance the detection of a given target. Study was oriented toward the detection of a missile in the powered phase. Considering the intensity distribution on an optical image plane as the input, four different types of spatial filters are developed. The statistical description of the background, which must be known prior to applying the theory, varies from the autocorrelation function for linear filter to a complete statistical description for the general statistical and decision theory filters.

A NOTE ON RECOGNITION OF HAND-PRINTED CHARACTERS
H. W. Tuffill, Inform. Control, vol. 4, no. 2/3, Sept. 1961, p. 197.

. . . series of tests . . . conducted to determine the accuracy of human observers when reading hand-written script. . . . considerable disagreement between . . . two sets of results, and it is the purpose of this note to examine this disagreement. . . .

ROTATING RASTER CHARACTER RECOGNITION SYSTEM
R. W. Weeks, Commun. Electronics, vol. 80, no. 56, Sept. 1961, p. 353/359.

. . . two major problems . . . is to decide which statistical properties are significant (and reasonably independent) for the pattern involved. The second is to choose the means of instrumentation in using these statistics for decision making. . . . this paper describes the procedure used in applying this theory to a rotating raster character recognition system. . . . M. Abramson has presented a more complete and mathematically rigorous treatment of the decision making process. . . .

APPLICATION OS STATISTICAL ESTIMATION PROCEDURES TO THE IDENTIFICATION PROBLEM
R. P. Wishner, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, (Rept. no. 47G-2), 3 Nov. 1961, 24 p., AD 266 877.

The method of maximum likelihood parameter estimation is applied to the problem of measuring parameters of an unknown linear filter or control system from input-output data when it is assumed that the output signal is corrupted with an additive Gaussian noise signal . . . Approximate expressions for the parameter estimates and the covariance matrix of the errors in the parameter estimates are obtained in the strong signal case. This analysis also has applications to the adaptive radar problem.

ON THE RECOGNITION OF SIGNAL PATTERNS IN NOISE
J. K. Wolf, et al., IRE Internat. Conv. Rec., vol. 4, March 1961, p. 155/161.

. . . recognition of two-dimensional patterns in noise, the decision as to which of a set of patterns is present involves the calculation of a likelihood function for each of the possible signals. In this paper, systems are developed for the calculation of these functions when the signal patterns are perturbed by multiplicative and additive noise. The resulting realizations are shown to reduce to two-dimensional matched filters. In the development, a useful orthogonal expansion of two-variable random processes is derived.

LEARNING TO RECOGNIZE PATTERNS IN A RANDOM ENVIRONMENT
N. Abramson, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S58/63.

This paper deals with the optimal use of a sequence of prior observations in order to recognize patterns. . . . the results may be applied to patterns of a visual, aural or electromagnetic origin. . . . the use of prior observations for pattern recognition may be described as a process of learning the statistical characteristics of the patterns involved. . . . The optimum systems are shown to consist of banks of generalized correlators. . . .

ON DESIGNS FOR AUTOMATIC RECOGNITION OF PATTERNS IN NOISE
A. E. Basharinov, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 291/292.

. . . characteristics of extremal algorithms of recognition of patterns affected upon by noise with inter-element correlation and estimation of the information machine memory in case of joint data processing of several frames. . . .

INDUCTIVE PROBABILITY AS A CRITERION FOR PATTERN RECOGNITION (Correspondence)
E. R. Berger, Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2123/2124.

LEARNING FILTERS FOR OPTIMUM PATTERN RECOGNITION
D. Braverman, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 280/285.

. . . An optimum adaptive system is obtained for the identification of pattern samples which are are the sum of a fixed unknown signal, determined by the pattern of the sample, plus Gaussian noise. The system learns the unknown signals from a set of pattern samples, called learning sample, which have been identified with absolute certainty.

. . . apply the techniques of statistical decision theory . . . define the automatic recognition problem . . .

THE HYPERSPHERE IN PATTERN RECOGNITION
P. W. Cooper, Inform. Control, vol. 5, no. 4, Dec. 1962, p. 324/346.

Statistical classification (pattern recognition) in n-dimensional space consists in partitioning the space into category regions with decision boundaries and assigning an unknown to the category in whose region it falls. This paper demonstrates the wide utility of a particular form of decision boundary—the hypersphere—which, while especially easy to implement, is

fully optimum for large classes of distributions which may arise in real problems. . . . particular interest centers on the normal, and the Pearson Type II and Type VII distributions . . . A partial listing of error probabilities is also included. . . .

EYES AND EARS FOR COMPUTERS
E. E. David, Jr., et al., Proc. IRE, vol. 50. May 1962, p. 1093/1101.

. . . character reading and speech recognition. . . .

PRINT RECOGNITION APPARATUS FOR BLIND READERS
J. H. Davis, J. Brit. Instn. Radio Engrs., vol. 24, no. 2, Aug. 1962, p. 103/110, 13 refs.

. . . The facilities offered both to designer and reader by the auditory and tactile types of reading machine are compared. . . . actual machines . . . problems of recognition of the electrical signal and storage and accessibility of the sound tracks in the auditory machine are discussed. . . .

RADAR: DETECTION, DISCRIMINATION, DECOYS AND CAMOUFLAGE: AN ANNOTATED BIBLIOGRAPHY
G. R. Evans, Lockheed Aircraft Corp., Sunnyvale, Calif., (Special bibliography no. SB-61-69; Rept. no. 3-80-61-44), Sept. 1962, 80 p., 248 refs., AD 400 124.

SURVEY OF RESEARCH ON AUTOMATIC PATTERN RECOGNITION
R. Fenton, Ohio State U. Research Foundation, Columbus, Antenna Lab., (Rept. -1222-16), Dec. 31, 1962, 75 p., 185 refs., N63-21447, AD 415 861.

. . . historical development of recognition devices, present and proposed applications . . . a classification of the various recognition methods is suggested . . . Typical recognition techniques in each subclass are outlined. A bibliography and abstracts of selected articles in this field are included.

AN APPROACH TO GENERAL PATTERN RECOGNITION
M. Fischler, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S64/73.

. . . the pattern recognition problem is considered to be composed of two subproblems. The first . . . is one of abstracting significant features or characterics from the patterns being dealt with . . . the second subproblem is concerned with identifying the pattern which gave rise to a particular set of features (i. e., a decision-making problem.)

The decision-making system to be discussed is a special purpose digital computer, which simulates a network of threshold elements designed to correctly identify a preselected set of "typical" patterns. . . .

ON THE DIGITAL COMPUTER CLASSIFICATION OF GEOMETRIC LINE PATTERNS
H. Freeman, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 312/324.

. . . techniques for the systematic classification of planar geometric line patterns of arbitrary configuration. The techniques are based on a method of quantizing and encoding which facilitates classification in a digital computer. Emphasis is placed on three transformations from which a variety of pattern properties can be derived. The transformations involve, in turn, the directional components of the pattern, the pattern's degree of asymmetry about a specified set of axes, and the curvature components contained in the pattern's contours.

MORE MODULAR GEOMETRIC SHAPES
S. W. Golomb, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 146/150.

. . . problem of cutting plane figures into four "replicas," congruent to one another and similar to the original.

THE DESIGN AND ANALYSIS OF PATTERN RECOGNITION EXPERIMENTS
W. H. Highleyman, Bell Syst. Tech. J., vol. 41, no. 2, March 1962, p. 723/744.

LINEAR DECISION FUNCTIONS, WITH APPLICATION TO PATTERN RECOGNITION
W. H. Highleyman, Proc. IRE, vol. 50, June 1962, p. 1501/1514.

INPUT/OUTPUT EQUIPMENT FOR RESEARCH APPLICATIONS
W.S. Holmes, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 509/517.

. . . arising in the areas of photointerpretation, pattern recognition, speech analysis and radar signal analysis . . .

VISUAL PATTERN RECOGNITION BY MOMENT INVARIANTS
M.K. Hu, IRE Trans. Inform. Th., vol. IT-8, no. 2, Feb. 1962, p. 179/187.

VISUAL PATTERN DISCRIMINATION
B. Julesz, IRE Trans. Inform. Th., vol. IT-8, no. 2, Feb. 1962, p. 84/92.

BASIC PRINCIPLES OF SOME PATTERN RECOGNITION SYSTEMS
L. Kanal, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 279/295.

THEORY OF PROBABILITY STATE VARIABLE SYSTEMS, VOLUME VI: PERCEPTION, DECISION-MAKING, AND ACTION
R.J. Lee, Adaptronics, Inc., Alexandria, Va., Final rept., ASD TDR63 664, 15 Oct. 1961 - 14 Oct. 1962, vol. 6, AD 427 771.

. . . discusses approaches whereby Neurotron networks can be used to provide pattern recognition, autonomous decision-making, and action . . .

THE CHARACTERISTIC SELECTION PROBLEM IN RECOGNITION SYSTEMS
P.M. Lewis, II, IRE Trans. Inform. Th., vol. IT-8, no. 2, Feb. 1962, p. 171/178.

A MEASURE OF THE SIGNIFICANCE OF PATTERN FEATURES FOR USE AS AN AID IN THE DESIGN OF RECOGNITION SYSTEMS
C. Maltz, California U., Los Angeles, (Rept. no. 62-68), Dec. 1962, 227 p., AD 299 973.

A TECHNIQUE FOR CHARACTER RECOGNITION BY MOMENTS OF ARC LENGTH
E.R. Sapp, Antenna Lab., Ohio State U. Research Foundation, Columbus, Report on Guidance and Sensing Techniques for Advanced Vehicles, (Rept. no. 1222-9), 15 July 1962, 86 p., incl. illus. tables, AD 289 676.

Recognition of basic characters is demonstrated by correlation of functions of the set of moments of arc length of an unknown character with those of standard figures.

PATTERN RECOGNITION BY AN ADAPTIVE PROCESS OF SAMPLE SET CONSTRUCTION
G.S. Sebestyen, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 82/91.

. . . a parametric representation of input signals or stimuli is employed. An input is considered as a vector, while the stimulus class is a multivariate process in the vector space. An adaptive sample set construction technique is described through which the conditional joint probability density of a class is approximated by the sum of Gaussian densities. . . . Decision making on an incomplete set of parameters and on multiple observations of the input stimulus are discussed. This technique was successfully applied to the automatic recognition of speaker identity regardless of the spoken test. Experimental results are given. . . .

DECISION-MAKING PROCESSES IN PATTERN RECOGNITION
G.S. Sebestyen, New York, The Macmillian Co., 1962, 162 p.

. . . design of practical procedures for solving pattern recognition problems starting from basic decision-theory considerations. . . . not . . . all . . . procedures are directly motivated by decision theory. . . . most seem to have their origins in a common-sense engineering approach to real problems . . . provides additional insight into his common-sense approach by relating it to decision theory or classical statistics. . . . It is this constant feedback between mathematical analysis and engineering design which makes Sebestyen's book so valuable. . . .

CHARACTER RECOGNITION BY DIGITAL FEATURE DETECTION
I.H. Sublette, et al., RCA Rev., vol. 23, no. 1, March 1962, p. 60/79.

. . . Some logical design techniques are proposed which may be useful in the development of a multi-font reading machine. Characters are recognized by detecting the presence of certain combinations of geometric features which tend to be independent of changes in style and imperfections in printing. The effectiveness of these techniques has been tested by simulating them on a general-purpose computer . . .

A CONSISTENCY TECHNIQUE FOR PATTERN ASSOCIATION
J.R. Ullmann, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S75/81.

A new technique based on the consistency of partial classifications is compared with other techniques for pattern association in the light of computer simulations and other considerations. . . .

PATTERN RECOGNITION AND MACHINE LEARNING
N. Abramson, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 257/261, 62 refs.

ERROR ANALYSIS OF A STATISTICAL DECISION METHOD
R. Albrecht, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1963, p. 34/38.

For the recognition of patterns as members of certain classes it is assumed that the probability distributions of certain characteristic features are known. For a decision based on the maximum likelihood criterion bounds on the statistical error are derived. In the case of normally distributed and statistically independent features these bounds are evaluated. . . .

INVESTIGATION IN DIGITAL TECHNOLOGY RESEARCH
M. Aoki, et al., California U., Los Angeles, Annual summary rept., 1 June 1961 - 31 May 1962, Jan. 1963, 171 p., AD 404 016.

. . . Pattern recognition; General discussion and review of automatic pattern recognition . . .

KOTSENKE PARAMETROV SISTEM AVTOMATICHESNOGO OPOZNAVANIIA (Evaluation of Parameters of Automatic Identification Systems) (In Russian)
I.L. Biriukov, Geodeziia i Aerofotos'emka, no. 3, 1963, p. 101/109, A64-13090.

Discussion of the problem, in automatic decoding, of determining the probability of object identification from numerical attributes. The analysis makes use of quantitative identification attributes that are functionals of a function that corresponds to the optical density of a certain circuit. Expressions are derived which relate the number of such functionals with the errors involved in the determination of their values and with the quality of the automatic identification system. . . .

DETERMINATION AND DETECTION OF FEATURES IN PATTERNS
H.D. Block, et al., Cornell U., Ithaca, N.Y., RADC TDR 63 497, Dec. 1963, 52 p., AD 427 840 and N64-14310.

Feature determination as a method of training the first layer of weights in a two layer learning machine (Perceptron) is investigated. The problem is viewed as one of examining a set of patters and determining a set of simpler patterns, or features, so that each of the original patterns can be formed by superposing the features . . . two algorithms were given that solve the problem for restricted pattern sets.

THE PRENORMALIZATION OF RECONNAISSANCE DATA
J.F. Bogusz, et al., Philco Corp., Blue Bell, Pa., RADC-TDR-63-372; Final Report, 25 July 1963, 208 p., AD 422/946, N64-12646.

. . . describes and evaluates . . . the prenormalization of gray-scale aerial photographs prior to their use as input to an adaptive memory recognition system. . . .

RECOGNITION OF TYPED LETTERS IN NOISE
D.W. Brown, Inform. Control, vol. 6, no. 3, Sept. 1963, p. 301/305.

Ten human observers were required to guess the identity of typed letters which were presented in varying amounts of noise. Various criteria were applied to the data, and rank order correlations between criteria were obtained. . . .

NOISE SENSITIVITY IN PROBABILITY STATE VARIABLE DEVICES
H.E. Buroker, Air Force Inst. of Tech., Wright-Patterson AFB, Ohio, Aug. 1963, 44 p., AD 419 665.

An experiment was performed on a self-organizing machine called the LANNET. An investigation of the machine's ability to recognize noise in patterns that had been organized to 100% was accomplished. Simplified ARTRON theory was presented with the use of flow diagrams. The experimental data was tabulated. . . .

HYPERPLANE TECHNIQUES IN PATTERN RECOGNITION (Correspondence)
M.A. Fischler, Proc. IEEE, vol. 51, no. 3, March 1963, p. 497/498.

Two general approaches . . . are discussed . . . the "linear decision" approach and the "correlation" approach. The interrelation of the approaches is examined first, and then a technique which combines the best features of each is offered. . . .

ON THE STATISTICAL INDEPENDENCE OF FEATURES IN A SWITCHING THEORY MODEL FOR PATTERN RECOGNITION (Correspondence)
M.A. Fischler, Proc. IEEE, vol. 51, no. 10, Oct. 1963, p. 1370/1371.

PATTERN RECOGNITION WITH SELF-ORGANIZING MACHINES
A. C. Foreman, Air Force Inst. of Tech., Wright-Patterson AFB, Ohio, Aug. 1963, 90 p., AD 419 094.

Most of the pattern-recognition self-organizing machines can be classified as adjustable-weight threshold-logic machines, statistical-switching machines, or correlation machines. A noisy pattern is a pattern that varies slightly from a model pattern that the machine has been taught. Computer simulations of a typical machine from each of three classes indicate that the noisy pattern recognition capabilities are poor for statistical-switching machines, good for threshold-logic machines, best for correlation type machines. A proposed correlation self-organizing machine is simple, learns in one step, and recognizes noisy patterns accurately.

A GENERAL PURPOSE INSTALLATION FOR THE INVESTIGATION OF IMAGE RECOGNITION ALGORITHMS
V. M. Glushkov, et al., Joint Publications Research Service, Washington, D.C. In its Principles of the Design of Self-Learning Systems, 21 Oct. 1963, p. 93/109, refs., N64-11036.

. . . A general-purpose scanning installation for the investigation of image-recognition . . . is described. This installation, which is used to feed the information about the drawing into the digital computer, is computer controlled. Thus, it is possible to model any method of conversion of the drawing . . . the installation makes it possible to turn to any point of the drawing desired, at any given instant. The installation distinguishes sixteen levels of the gray scale, which means that it can process not only line drawing but also half-tones.

ALGORITHM FOR TEACHING A MACHINE TO RECOGNIZE THE SIMPLEST GEOMETRICAL FIGURES
V.M. Glushkov, et al., Joint Publications Research Service, Washington, D.C., In its Principles of the Design of Self-Learning Systems, 21 Oct. 1963, p. 5/25, refs., N64-11030.

. . . teaching a universal computer to recognize the image of certain simple geometric figures, independently of their size or of their position in the field of vision. The distinguishing characteristics of these figures are the directions of the lines which form their contour. The pattern is thus identified by a group of figures, each of which is proportional to the number of points having a given direction within the contour . . . The learning process of the computer consists in the automatic determination of standards which would afford maximum recognition of the given figures.

THEORETICAL CONSIDERATIONS ANENT PATTERN RECOGNITION BY MEANS OF RANDOM MASKS (Correspondence)
M.J. Golay, Proc. IEEE, vol. 51, no. 4, April 1963, p. 629/630.

AUTOMATIC PATTERN RECOGNITION DURING THE PERIOD 1961 - 1962: AN ANNOTATED BIBLIOGRAPHY
E.E. Graziano, (comp.), Lockheed Missiles and Space Co., Sunnyvale, Calif., May 1963, 44 p., 140 refs., N63-17447, AD 406 279.

. . . the period 1961-1962. Included are references pertaining to theory and experience with systems, components, methods, optics, speech, etc. . . .

THEORY OF MOMENT INVARIANTS AND ITS APPLICATIONS TO ADAPTIVE PATTERN RECOGNITION
M.K. Hu, Syracuse U. Research Inst., N.Y. In its Theory of Adaptive Mech., Dec. 1963, p. 16/65, refs., N64-15815.

THEORY OF ADAPTIVE MECHANISMS
M.K. Hu, et al., Syracuse U., Research Inst., N.Y., Rept. no. EE894 6307F, RADC TDR 63 334, Dec. 1963, 110 p., AD 429 935.

. . . four different but related tasks. . . . (1) Information Contents of Time Continuous Processes. (2) Visual Pattern Recognition by Moment Invariants. (3) Control and Communication Systems in the Blood. (4) Experiments on the Use of Threshold Logic for Learning Machines. . . .

EXPERIMENTAL STUDIES OF PATTERN RECOGNITION USING MOMENT INVARIANTS
E. Kletsky, Syracuse U. Research Inst. N.Y. In its Theory of Adaptive Mech., Dec. 1963, p. 66/86, refs., N64-15816.

. . . main area of discussion is concerned with receptor simulation. A program that incorporates third-order moments, making it possible to simulate a receptor providing six-moment invariants . . . (See N64-15814).

A MATHEMATICAL MODEL OF BLUM'S THEORY OF PATTERN RECOGNITION
J.C. Kotelly, Air Force Cambridge Research Lab., Bedford, Mass., AFCRL 63 164, April 1963, 25 p., AD 412 437.

A geometrical interpretation . . . is presented . . . The model is applied to the pattern masking phenomenon as worked on by Kolers of Harvard, giving a possible explanation of his results.

CORRELATION METHOD FOR RECOGNIZING PATTERNS
V.A. Kovalvskii, Joint Publication Research Service, Washington, D.C., 31 Jan. 1963, 15 p., AD 406 408.

CLASSIFICATION AND RECOGNITION OF HAND-PRINTED CHARACTERS
F. Kuhl, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, no. 4, March 1963, p. 75/93.

PATTERN RECOGNITION AND DETECTION BY MACHINE
A.E. Laemmel, Polytechnic Inst., of Brooklyn, N.Y., Mocrowave Res. Inst., Final Report, March 8, 1963, 68 p., 69 refs., N63-21404, AD 418 387.

. . . optimum estimation of statistical parameters so as to minimize the probability of incorrect classification, non-Gaussian and nonstationary situations, pattern detection in a continuing time series, and calculation of error probabilities. Some of the work is specifically directed toward the problem of radio station recognition . . .

THE PRODUCTION OF RANDOMLY DISTORTED AND DETERIORATED PATTERNS
R.E. Manelis, Air Force Special Weapons Center, Kirtland AFB, N. Mex., AFSWC TDR63 44, 11 April 1963, 23 p., AD 405 587.

A set of computer subroutines which attempt to simulate various degrees of distortion and deterioration on an input character . . . A complete set of the letters of the Cyrillic alphabet, numberals, and some punctuation were quantized and punched to be used as ideal input characters to transforming subroutines.

CYCLOPS-1: A SECOND-GENERATION RECOGNITION SYSTEM
T. Marill, et al., Presented at AFIPS Fall Joint Computer Conf., Las Vegas, 12 Nov. 1963, In its Studies in Autom. Pattern Recognition, 31 Oct. 1963, p. 1/15, refs., N64-19420.

. . . is a working recognition system with the following capabilities: (1) . . . can recognize all handprinted alphabetic and numeric characters . . . (2) . . . can analyze complex visual inputs . . . the characters may be of different sizes and orientations; they may overlap, or be inside of one another; they may

be superimposed on arbitrary background consisting of meaningless lines or spots or geometric shapes . . .

STUDIES IN AUTOMATIC PATTERN RECOGNITION
T. Marill, Bolt Beranek and Newman Inc., Cambridge, Mass., Final rept., Rept. no. 1070, 31 Oct. 1963, 29 p., AD 434 824.

. . . the physical sample to be recognized is first subjected to a battery of tests; on the basis of the test results, the sample is then assigned to one of a number of prespecified categories. . . . Specifically, the following question is considered: What constitutes an effective set of tests, and how is the effectiveness dependent on the correlations among, and the properties of, the individual tests in the set.

A NOTE ON PATTERN-RECOGNITION TECHNIQUES AND GAME-PLAYING PROGRAMS
T. Marill, Inform. Control, vol. 6, no. 3, Sept. 1963, p. 213/217.

A problem encountered in the design of game-playing programs—the evaluation of board positions—is formally identical to a typical pattern-recognition problem. . . .

FEATURE WORD CONSTRUCTION FOR USE WITH PATTERN RECOGNITION ALGORITHMS: AN EXPERIMENTAL STUDY
R. L. Mattson, et al., Association for Computing Machinery, Journal, vol. 10, Oct. 1963, p. 458/477, 15 refs., A64-11312.

Discussion of linear decision elements, with application to pattern recognition. A geometrical model is employed which lends itself to a deterministic design of decision-making devices, using threshold networks. The technique used in the synthesis algorithm is discussed, followed by a description of experiments using two types of feature space coding. The effect of coding on recognition is also investigated using the Pattern Information Processor (PIP) proposed by Healy to process the data.

INFORMATION PROCESSING RELEVANT TO MILITARY COMMAND: SURVEY, RECOMMENDATIONS AND BIBLIOGRAPHY VOLUME II (BIBLIOGRAPHY APPENDIX)
A.E. Murray, et al., Cornell Aeronautical Lab., Inc. Buffalo, N.Y., Final rept., ESD TDR63 349, AD 418 176.

. . . consists of a set of bibliography cards referencing the most recent works in artificial intelligence, pattern recognition, and decision making, . . .

LEARNING, GENERALITY AND PROBLEM SOLVING
A. Newell, RAND Corp., Santa Monica, Calif., (Memo no. RM-3285-1-PR), Feb. 1963, 34 p., AD 298 949.

ELECTRO-OPTICAL IMAGE MATCHER FOR SPACE GUIDANCE APPLICATIONS
J.N. Packard, IEEE Trans. Aerospace Navig. Electronics, vol. ANE-10, no. 3, Sept. 1963, p. 282/289.

Pattern recognition and the determination of relative attitude are capabilities of an electro-optical map matching device that utilizes two-dimensional correlation data processing techniques. This device is the basic element of a Universal Space Tracker that provides pitch, yaw, and roll data with respect to the recognized field (either planetary surface, star field, or planetary rim) for space vehicle guidance applications. . . .

AN ELEMENTARY INFORMATION PROCESSOR FOR OBJECT RECOGNITION
J.C. Pennypacker, Systems Research Center, Case Inst. of Tech., Cleveland, Ohio, Rept. no. SRC31I63 1, May 1963, 105 p., AD 413 370.

A Concept is defined to be a class of objects whose members can be distinguished by processing its properties. A Property is defined to mean a partition of the set of all objects into disjoint classes. The concept is described by a Conception, which is a list structure. . . . A processor, which consists of a series of computer flow charts, is described. The processor is capable of forming conceptions of known and new concepts and is capable of processing information relevant to these concepts. In addition, the processor is capable of elementary learning.

DISCOVERY AND LEARNING TECHNIQUES FOR PATTERN RECOGNITION
R.C. Prather, et al., Systems Development Corp., Santa Monica, Calif., Rept. no. TM1632, 6 Dec. 1963, 19 p., AD 427 164.

. . . describes a pattern recognition program which accepts as input any black-and-white pattern presented on a 20 x 20 grid, reduces it to a one-dimensional pattern consisting of a description of its contour, and then proceeds to identify the pattern as one of the pattern types learned through previous training. Starting with neither operators nor pre-set memory the program learns, via a feedback process, what characterizes each pattern type, . . . some ideas for future pattern recognizers . . .

PATTERN SEPARATION BY CONVEX PROGRAMMING
J.B. Rosen, Applied Mathematics and Statistics Labs., Stanford U., Calif., Technical rept. no. 30, 28 June 1963, 20 p., AD 416 795.

. . . can be formulated and solved as a convex programming problem, i.e., the minimization of a convex function subject to linear constraints . . . Very efficient computer methods have been developed for such programming problems and can be used to advantage for the pattern recognition problem.

ALGORITHMS FOR THE ENCODING OF THREE-DIMENSIONAL GEOMETRIC FIGURES
K. Ruttenberg, Laboratory for Electroscience Research, New York Univ., June 1963, lv., AD 434 320.

Procedures are developed for the chain encoding of linear, planes, conic sections, and quadric surfaces. Encoding of geometric figures in terms of chains facilitates their analysis and manipulation with a digital computer. . . .

INFORMATION PATTERN, LEARNING STRUCTURE, AND OPTIMAL DECISION RULE
M. Sakaguchi, Inform. Control, vol. 6, no. 3, Sept. 1963, p. 218/229.

In Section I various types of information structures in individual decision-making under uncertainty are discussed. A quantity which measures the value of information structure is proposed. In Section II the team decision problem is considered. Finally, in Section III we consider the multistage decision process with learning and we shall try to evaluate the effect of the learning structure and compute it by the technique of dynamic programming. . . .

ADAPTIVE MEMORY RESEARCH
G. Sebestyen, Litton Systems, Inc., Waltham, Mass., Communications Sciences Lab. and Griffiss AFB, N.Y., Inform. Processing Lab., (RADC-TDR-63-371), Nov. 1963, 88 p., refs., AD 427 825, N64-14309.

. . . state-of-the-art of automatic pattern recognition techniques and related hardware developments . . .

A PATTERN RECOGNITION FUNCTION OF INTEGRAL GEOMETRY
G. Tenery, IEEE Trans. Mil Electronics, vol. MIL-7, no. 2/3, April - July 1963, p. 196/199.

ADVANCED RECOGNITION TECHNIQUES STUDY
R.B. Thomas, et al., Radio Corp. of America, Bethesda, Md., Quarterly progress rept. no. 1, Jan- 31 March 1963, AD 413 565, (See also AD 417 813; AD 427 776; AD 435 852).

. . . initial research phase . . . techniques to enhance the output of a hypothetical character-recognition machine by producing solution in those instances where the machine fails to identify a character within an English word in normal technical text material. The primary approach involves analytical processing rather than lexical loop-up. . . . An RCA 301 computer program which implements the initial correction algorithm is also discussed.

THE COMBINED USE OF PULSE ATTRIBUTES IN PROTECTED CIRCULAR SIGNALS
Y. Tomfel'd, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 19 Aug. 1963, 25 p., AD 419 226.

. . . To transmit information concerning the state of M two-position objects in one signal (i.e., for circular transmission in a group), it is necessary to have 2(M) signals, each of which corresponds to one of the combinations of states of the objects of the group. . . . Circular transmission may be accomplished with the aid of systematic codes by using a sampling method close to distributional. . . . protection from distortions may be realized both by the method of protective refusal and through error correction. . . . In the case of multi-position objects it is convenient to use incomplete combination elements.

A STREAM-FOLLOWING TECHNIQUE FOR USE IN CHARACTER RECOGNITION
G.U. Uyehara, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, no. 4, March 1963, p. 64/74.

. . . for multi-font numeric character recognition. . . .

OB ODNOM KLASSE PERSEPTRONOV (On a Class of Perceptrons) (In Russian)
V.N. Vapnik, et al., Avtomatika i Telemkhanika, vol. 25, no. 1, 1964, p. 112/120, 5 refs., A64-15238.

. . . differing from the existing ones in the method of learning . . . A comparison is made between the algorithms of various classes of perceptrons and the theory of pattern recognition using a generalized portrait.

TEACHING THE RECOGNITION OF CONFIGURATIONS BY MEANS OF FORMAL INDICES
V.I. Varshavskiy, et al., Joint Publications Research Service, Washington, D.C., In its Principles of the Design of Self-Learning Systems, 21 Oct. 1963, p. 39/56, refs., N64-11032.

. . . examines an algorithm with variable parameters that can be changed while work is in progress and is designed for the recognition of configurations . . .

DEVELOPMENT OF AN ADVANCED CONDITIONED REFLEX MODEL
Scope, Inc., Falls Church, Va., Final technical rept., Technical Documentary Report ASD-TDR-63-667, 25 Sept. 1963, 84 p., AD 422 467.

. . . consists of an optical sensory (input) system and a digital data processor . . . capability of up to 48 distinct pattern classes. Construction of the reference functions is by means of a simple learning routine in which

patterns are projected onto an array of photoresistors. Information extracted by the sensory system is accumulated in the data processor and the reference functions are formed for each pattern class . . . processes each pattern in the learning mode in 16 millisecond and chooses the class of an unknown from the possible 48 classes in about three-quarters of a second . . . based on a cross-correlation. . . .

ADVANCED CHARACTER RECOGNITION TECHNIQUES STUDY. APPENDIX D. TETRAGRAMS LEGAL WITH RESPECT TO WEBSTER'S INTERNATIONAL DICTIONARY. (UNABRIDGED, SECOND EDITION)
Radio Corp. of America Data Systems Center, Bethesda, Md., Final rept. 1 Jan-31 Dec. 1963, Rept. no. 4, 31 Dec. 1963, 97 p., AD 435 775.

Related Publications:

A CHARACTER READING DEVICE FOR TYPEWRITTEN FIGURES
W. Dietrich, Nachrichtentech. z., vol. 13, July 1960, p. 317/320.

THE PRINCIPLES OF THE CONSTRUCTION OF READING MACHINES
A.A. Kharkevich, Radio Engng., vol. 15, no. 2, 1960, p. 1/14.

AUTOMATIC LETTER SORTING-THE LUTON EXPERIMENT
T. Pilling, et al., Post Off. Elect. Engrs. J., vol. 54, no. 1, April 1961, p. 31/36.

PERCEPTRON COGNITION MACHINE IDENTIFIES LETTERS
Space Aeronautics, vol. 34, no. 2, Aug. 1960, p. 134/136.

Eight response units give Mark I Perceptron 256 possible responses.

DIGITAL SIMULATION OF AN ADAPTIVE WAVEFORM RECOGNITION SYSTEM
C.V. Jakowatz, Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 234/246.

PERFECT MAPS OF SPECIAL TYPE
H. Fredrickson, et al., JPL Space Progr. Summ., vol. 4, no. 37-16, June - July 1962, p. 61/62.

. . . it was suggested that the location of a previously "mapped" (photographed with only two levels in the gray scale) region of 0's and 1's could be found by examining a small region or "window" in the map. (In this note only rectangular windows will be considered; other windows may be useful.) The question then arose as to the size of the largest map in which position could be uniquely located with a given window.

THE "WHIRLING DERVISH", A SIMULATION STUDY IN LEARNING AND RECOGNITION SYSTEMS
A. Hoffman, IRE Internat. Conv. Rec., Pt. 4, vol. 10, no. 4, March 1962, p. 153/160.

. . . An optical correlation device is described. Its function is to generate correlation data between two dimensional patterns and random line templates. The output of the device is paper tape containing the correlation data and sufficient flagging and sync. information to facilitate digital computer processing. The use of this device in conjunction with a digital computer is discussed as a simulation procedure for the evaluation and design of recognition systems. . . . .

SPATIAL FILTERING
W.D. Montgomery, et al., General Dynamics/Astronautics, San Diego, Calif., 1962, 34 p., illus., 8 refs., AD 282 766.

. . . of two-dimensional pictorial data as an extension of one-dimentional filter theory is applied to the problem of enhancing the detection of localized objects which are superimposed upon a noisy background. . . .

PSEUDO-RANDOM AREA CODING FOR TELEVISON USING MODULAR GEOMETRIC SHAPES
E.C. Posner, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec. - Jan. 1962, p. 178/180.

In SPS 37-18, Vol. IV, pp. 149/154, the concept of modular geometric shapes was defined, in connection with applications to packaging problems.

In SPS 37-16, Vol. IV, pp. 56/57 and SPS 37-18, Vol. IV, pp. 157/160, a television data compression technique using line following was described.

Using certain modular geometric shapes instead of squares or hexagons is a systematic way of introducing (pseudo-) randomness into the grid.

NOTE ON THE EXISTENCE OF PERFECT MAPS
I.S. Reed, et al., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 10/12.

AN APPROACH TO AUTOMATIC PHOTO-INTERPRETATION
A. Rosenfeld, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 97/102.

. . . involves the extraction from the photographic image of two basic types of information, one of them relating to the presence in the image of figures having given shapes and sizes, and the other to the "textural" nature of the image. . . .

THRESHOLD LOGIC IN ARTIFICIAL INTELLIGENCE
R.O. Winder, David Sarnoff Research Center, Princeton, N.J., (Scientific rept. no. 6), 15 Nov. 1962, 28 p., AD 298 784.

DESCRIPTORS: Artificial intelligence, Pattern recognition, Bionics.

READING DEVICES
B.M. Avrukh, et al., Joint Publications Research Service, Washington, D.C., Collection of papers presented at the Conference on Processing Information, Machine Translation, and Automatic Reading of Text Matter, Moscow, Jan. 1961; Foreign Developments in Machine Translation and Information Processing no. 113, 13 March 1963, 434 p., 123 refs., JPRS: 18119, AD 401 612.

Basic methods for automatic reading and recognition of text matter. . . the use of the contours of symbols in automatic character recognition . . .

GRAPHICAL DATA PROCESSING RESEARCH STUDY AND EXPERIMENTAL INVESTIGATION
A.E. Brain, et al., Quarterly progress rept. no. 11, 1 Dec. 1962 - 28 Feb. 1963, March 1963, 39 p., AD 404 623.

A pattern may be presented for classification either as a code word of ones and zeros or of plus ones and minus ones. . . . it has been found, by digital computer simulation that convergence is secured much more rapidy when the (+1, -1) representation of the input patterns is used. A discussion is presented of the machine logic and timing which have now been worked out in detail.

GRAPHICAL DATA PROCESSING RESEARCH STUDY AND EXPERIMENTAL INVESTIGATION
A.E. Brain, Stanford Reseach Inst., Menlo Park, Calif., Final rept., 1 April 1960 - 31 May 1963, Rept. no. 12, June 1963, 43 p., AD 417 859.

FUNCTION MODELING EXPERIMENTS
R.O. Duda, et al., Stanford Research Inst., Menlo Park, Calif., Technical rept., Dec. 1963, 67 p., AD 427 018.

. . . capabilities and the limitations of trainable machines for use in function modeling . . . In the simpler experiments the data used for training were noise-free . . . In the prediction experiments, random fluctuations in the data limited performance . . . Viewed as a statistical procedure, this technique is essentially a non parametric procedure that can be efficiently performed by a special purpose computer of the type currently being constructed for pattern recognition problems . . .

SYMMETRY PATTERN RECOGNITION SYSTEM II
F.R. Fluhr, et al., Naval Research Lab., Washington, D.C., (NRL rept. no. 5847), 10 Jan. 1963, 67 p., incl. illus., tables, 3 refs., AD 296 583.

Automatization of satellite detection in the SPASUR system requires a means of discriminating against nonsatellite responses. . . . developing a pattern recognitions system based upon the inherent symmetry of a typical signal due to a satellite pass. . . . performance at the San Diego Space Surveillance Station. In a 10-hour period, 106 alerts were generated; 20 were satellites correctly called symmetrical, and 39 were nonsatellites. . . . No symmetry response was given to 33 verified satellites. . . . Design advances in the SPASUR system minimized the requirement for pattern recognition processing.

THE PORTRAYAL OF BODY SHAPE BY A SONAR OR RADAR SYSTEM
A. Freedman, J. Brit. Instn. Radio Engrs., vol. 25, no. 1, Jan. 1963, p. 51/64.

STILL MORE REPLICATING POLYGONS
S.W. Golomb, JPL Space Progr. Summ., vol. 4, Feb. - March 1963, p. 93/97.

More about rep-4. The 30-deg right triangle has a total of four inequivalent rep-4 dissections. . . . . The first of these is the standard rep-4 dissection of a triangle; the second is the alternative dissection for right triangles; while the remaining two work only for the 30-deg right triangle.

AN INVESTIGATION INTO PATTERN INVARIANCE RECOGNITION CAPABILITIES OF THE HUMAN VISUAL SYSTEM
W.L. Harrison, Air Force Inst. of Tech., Wright-Patternson AFB, Ohio, Aug. 1963, 111 p., AD 419 198.

. . . to find out how the human visual system performs pattern invariance recognition. A detailed study of the human visual system is made, a model of a portion of this system is derived, the model is simulated on a digital computer and tested to determine its pattern invariance recognition capabilities. . . .

AN OPTICAL DECISION FILTER
R.D. Joseph, et al., Proc. IEEE, vol. 51, no. 8, Aug. 1963, p. 1098/1118.

ON THE APPLICATION OF DISCRIMINANT ANALYSIS TO IDENTIFICATION IN AERIAL PHOTOGRAPHY
L.N. Kanal, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 416/419.

A PATTERN RECOGNITION APPROACH TO FAULT ISOLATION
J. Kranton, et al., IEEE Trans. Aerospace, vol. AS-1, no. 2, Aug. 1963, p. 1320/1326.

VERY HIGH RESOLUTION TECHNIQUES
A.A. Ksienski, Hughes Aircraft Co., Culver City, Calif., Quarterly rept. no. 6, 15 Sept. - 15 Dec. 1963, 15 Dec. 1963, 96 p., AD 434 727.

The statistical decision theory approach to radar resolution is investigated. A general system based upon joint parameter estimation

and a zero-one loss function is developed. . . . Various estimation techniques . . . Two alternative designs . . . The multiple target response of matched filter antennas and coherently detecting antenna systems is investigated. Difficulties in pattern recognition are discussed. . . Nonreciprocal correlation arrays operating in a two-way mode are investigated . . .

SIGNAL DETECTION BY COMPLEX SPATIAL FILTERING
A.V. Lugt, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 139/145.

In the past, spatial filtering in coherent optical systems has been limited by the inability to realize practically a general complex filter. This paper describes a technique for realizing such a filter, and gives an application of spatial filtering to the problem of detecting isolated signals in a variety of noise backgrounds . . . will play a key role in such problems as shape recognition and signal detection. . . .

REPLICATING TRIANGLES
E.C. Posner, JPL Space Progr. Summ., vol. 4, Feb. - March 1963, p. 97/98.

. . . prove . . . result on replicating triangles, as a supplement to the preceding article by Golomb.

PATTERN RECOGNITION AS A PROBLEM IN DECISION THEORY AND AN APPLICATION TO SPEECH RECOGNITION
V. E. Sackschewsky, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 186/189.

SKETCHPAD: A MAN-MACHINE GRAPHICAL COMMUNICATION SYSTEM
I. E. Sutherland, Lincoln Lab., Mass. Inst. of Tech., Lexington, AFESD TDR63 52, 30 Jan. 1963, 92 p., AD 404 549.

Descriptors: Pattern recognition. Display systems, . . . uses drawing as a novel means of communicating with a computer. The system contains input, output, and computation programs that enable it to interpret information drawn directly on a computer display. It has been used to draw electrical, mechanical, scientific, mathematical and animated drawings; it is a general purpose system.

A MATHEMATICAL STUDY OF IMAGE ANALYSIS
A. R. Tobey, et al., Stanford Research Inst., Menlo Park, Calif., (NASA CR-53738), Final Report March 1964, 67 p. refs., N64-19353.

This report gives the results of an experimental study of the use of feature detection for television bandwidth compression. The goal is to determine from a set of patterns a set of simpler patterns, or features, so that each of the original patterns can be formed, at least approximately, by superposing the features. Four algorithms for determining features from patterns are described, and the results of experiments using these algorithms are compared and evaluated.

THE BASEBALL PROGRAM: AN AUTOMATIC QUESTION-ANSWERER. VOLUME I.
A. K. Wolf, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Technical rept. no. 306, ESD TDR 63 586, 11 April 1963, 209 p., AD 432 038.

. . . a computer program that answers questions posed in ordinary English about baseball data stored in the computer . . . combined linguistic analysis with data retrieval and processing. A question is read into the computer from punched cards and the words and idioms are looked up in a dictionary. The dictionary definitions are used to analyze the question's syntactic structure and semantic content. . . .

APPLICATION OF RECOGNITION THEORY TO MISSILE IDENTIFICATION AND DECOY DISCRIMINATION, VOLUME 2,
Melpar, Inc., Watertown, Mass, Applied Sci. Div., Second Semi-annual Report, June 30, 1963, 140 p., refs., N62-20404.

. . . aspects of the pattern-recognition problem . . .

PRINCIPLES OF THE DESIGN OF SELF-LEARNING SYSTEMS
Joint Publications Research Service, Washington, D. C., 21 Oct. 1963, 187 p., refs, Transl. into English of A collection of Reports from "Printsipy Postroyeniya Samoobuchayushchiksya Sistem" (Kiev), 1962, (JPRS-18181; OTS-63-21344), N64-11029.

Section 2.28
Special Applications of Information Compression Techniques

2.282: Machine Translation

Included: Automatic language translation; Mechanical translation; Common feature method; Symbolic language translation.

Not Included: Computer programs for machine translation (3A).

Cross References: Statistics of written languages (2.222).

Principal Publications:

MECHANICAL TRANSLATION
J. R. Applegate, The Chemical Bulletin, vol. 45, June 1958, p. 1/2.

THE USAF AUTOMATIC LANGUAGE TRANSLATOR, MARK I
G. Shiner, IRE Nat. Conv. Rec., March 1958, p. 296/304.

RUSSIAN TO ENGLISH MACHINE TRANSLATION WITH SIMPLE LOGICAL PROCESSING
R. E. Wall, Jr., etal., Commun. Electronics, Jan. 1958, p. 709/714.

THE ROLE OF THE DIGITAL COMPUTER IN MECHANICAL TRANSLATION OF LANGUAGES
D. L. Johnson, Western Joint Computer Conf., Abstr. 4755, 1959, p. 161/165.

MECHANICAL TRANSLATION IN THE U.S.S.R (In French)
M. Corbe, Automatisme, vol. 4, no. 7-8, July/Aug. 1959, p. 278/286.

SYMBOLIC LANGUAGE TRANSLATION
E. C. Gluesing, Proc. Western Joint Computer Conf., San Francisco, Calif., March 3-5, 1959, p. 288/291.

A METHOD OF DETERMINING GRAMMATICAL CONCEPTS ON THE BASIS OF GROUP THEORY
O. S. Kulagina, IN: Problems of Cybernetics, vol. 1, 1960, p. 228/242, New York, Pergamon Press, Ltd.

AUTO-TRANSLATION EFFORT LACKS FOCUS
P. Means, Missiles and Rockets, vol. 7, no. 2, July 1960, p. 22/24.

MACHINE TRANSLATION FROM HUNGARIAN TO RUSSIAN
I. A. Mel'chuk, IN: Problems of Cybernetics, vol. 1, 1960, p. 251/306, New York, Pergamon Press, Ltd.

QUESTIONS INVOLVED IN DISTINGUISHING HOMONYMS WHEN TRANSLATING FROM ENGLISH INTO RUSSIAN USING A COMPUTER
T. N. Moloshnaya, IN: Problems of Cybernetics, vol. 1, 1960, p. 243/250, New York, Pergamon Press, Ltd.

LINGUISTIC ANALYSIS AND PROGRAMMING FOR MECHANICAL TRANSLATION (Mechanical Translation and Thought) (English text, most of it translated from Italian)
S. Ceccato (editor), Milan, Feltrinelli Editore, 1961, 246 p.

. . . work on machine translation (MT) of language. . . The authors, members of the Center for Cybernetic and Linguistic Research at the University of Milan. . . approach MT via ideas of a philosophical movement begun by M. Schlick in Vienna in 1924 ("Vienna Circle"), and known aboard as logical positivism or as scientific operationism. In order to understand the book it is necessary to understand operationism. . . .

THE COMMON FEATURE METHOD
R. Wells, et al., Interaction Lab., Yale U., New Haven, Conn., (Technical rept. no. 12), Nov. 1961, 51 p., refs., AD 279 210.

SENTENCE PARSING WITH A SELF-ORGANIZING HEURISTIC PROGRAM
K. C. Knowlton, Mass. Inst. of Technology, Sept. 1962, 400 p.

. . . a very complete investigation of critical problems in machine translation. . . . No importance for space communications.

THEORIE DE LA TRANSFORMATION DE LA PAROLE ET PERSPECTIVES D'APPLICATIONS (Theory of Language Translation and Its Applications) (In French)
L. Pimonow, Ann. Telecomm., vol. 17, no. 11-12, Nov./Dec. 1962, p. 304/313.

U.S.-JAPAN SEMINAR ON MECHANICAL TRANSLATION SUMMARY OF U.S. CONTRIBUTIONS
D. G. Hays, RAND Corp., Santa Monica, Calif., Rept. no. P2892, March 1964, 13 p., AD 433 850.

MACHINE LANGUAGE TRANSLATION STUDY
W. P. Lehmann, Linguistics Research Center, Univ. of Texas, Austin, Rept. no. 17, Aug. 1963, 35 p., AD 422 209, AD 422 221.

Progress is reported in the development of two generalized computer systems: the first designed to implement automatic translation of language, the second to support basic research in linguistics. . . .

MATHEMATICAL LINGUISTICS AND AUTOMATIC TRANSLATION
W. J. Plath, Computation Lab., Harvard Univ., Cambridge, Mass., NSF Rept. no. 12, June 1963, lv., AD 419 967.

A new system for the automatic syntactic analysis of Russian sentences is described in this thesis. . . .

A PREFACE TO COMPUTATIONAL STYLISTICS
S. Y. Sedelow, et al., System Development Corp., Santa Monica, Calif., Rept. no. SP1534, 17 Feb. 1964, 24 p., AD 433 513.

. . . Through the use of computers, it should be possible to achieve more accurate detection and delineation of such linguistic patterns than has hitherto been the case; a quantitatively rigorous and intense study of pattern or style in natural language called computational stylistics. . . .

FOREIGN DEVELOPMENTS IN MACHINE TRANSLATION AND INFORMATION PROCESSING NO. 121.
Joint Publications Research Service, Washington, D. C., 13 May 1963, 53 p., AD 408 881.

Entropy of the Russian language, by A. A. Piotrovskaya, et al.
. . . Modeling and similarity theory, by V. A. Venikov.
Structural and applied linguistics, by V. A. Zvegintsev.

COMPUTER-AIDED RESEARCH IN MACHINE TRANSLATION ENGLISH ARTICLE INSERTION
Thompson Ramo Wooldridge, Inc., Canoga Park, Calif., Progress rept. no. 5, Rept. no. C157 4U1., 20 Jan. 1964, lv., AD 431 125.

COMPUTER SET AN/GSQ-16 (XW-2). VOLUME II. THE LINGUISTIC APPROACH
T. J. Watson Research Center, Yorktown Heights, N. Y., Final rept., RADC TDR 63 100, vol. 2, 23 Sept. 1963, 203 p., AD 431 572.

. . . current status of machine translation work at IBM. . . the Russian Master Dictionary, the bidirectional translation system, and the multipass translation system. . . . The dictionary contains 155,000 entries. . . capable of translating randomly selected tests. . . . The multipass translation program. . . consists of 16 passes, some right-to-left, others left-to-right.

COMPUTER SET AN/GSQ-16(XW-2). VOLUME III. THE SYSTEM ORGANIZATION
Thomas J. Watson Research Center, Yorktown Heights, N. Y., Final rept., RADC TDR63 100, vol. 3, 23 Sept. 1963, 106 p., AD 431 570.

. . . Automatic Translation System. The data handling and processing requirements for the realization of an effective automatic language processing system, and the processing capabilities of the translation system, are briefly discussed. . . . unique table look-up lexical data processing capability. Both the single-pass and multipass operating modes of the translation system are explained. . . . a description of the Sentence Analyzer Memory and indexing arithmetic . . .

COMPUTER SET AN/GSQ-16 (XW-2). VOLUME IV. THE REFERENCE MANUAL FOR LEXICOGRAPHERS
T. J. Watson Research Center, Yorktown Heights, N. Y., Final rept., RADC TDR 63 100, vol. 4, 23 Sept. 1963, 126 p., AD 431 658.

. . . self-contained source of information about programming the Mark II Translator. Although Russian-to-English translation is emphasized in the programming examples, the techniques and procedures are equally applicable to the solution of other linguistic problems. . . .

Related Publications:

ADVANCED LANGUAGE PROCESSING PROCEDURES
S. J. Keyser, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 391/398.

. . . The problem is: How does one impart to a computer based system the ability to be questioned in ordinary English?

ANSWERING ENGLISH QUESTIONS BY COMPUTER: A SURVEY
R. F. Simmons, System Development Corp., Santa Monica, Calif., Rept. no. SP1556, 2 April 1964, 64 p., AD 437 610.

Fourteen question-answering systems which are more or less completely programmed and operating are described and reviewed. The systems range from a conversation machine to programs which make sentences about pictures and systems which translate from English into logical calculi. Systems are classified as data based, text based, and inferential. . . .

DIVISION 2.3
AUDIO COMPRESSION (INFORMATION COMPACTION OF ONE-DIMENSIONAL ANALOG SOURCES)

Information compression of analog sources requires quite different approaches, depending on the dimensionality of the source. Many sources produce one-dimensional continuous time functions, such as the output of a microphone, when recording voice or music in a monaural system. Other sources, primarily picture material, are multi-dimensional and special scanning processes are needed to match their output to a one-dimensional communications channel. The statistical characteristics of sources of the second kind yield multi-dimensional distributions. Correspondingly there are, in this volume, two divisions for these classes of compaction problems. This division deals with the one-dimensional problem and the next division with the two or more dimensional problem. In simpler terms one may say that 2.3 contains references on audio compaction and 2.4 on video compaction.

The first section, after an introduction, has several subdivisions with references to the source characteristics. In particular one may note that subdivision 2.314 is an extension of 2.222. Here in 2.314 we discuss the linguistic-technological problems of spoken text, while in 2.222 the subjects were the statistical characteristics of written text in various languages. The reader is alerted to the fact that, in both cases, our collections are not complete. The search for this bibliography did not extend into acoustics, physics and linguistics publications, which contain the bulk of the material. For the purpose of this space communications bibliography it was not possible to penetrate deeper into the scientific aspects of acoustics and linguistics. We had to concentrate on the technological problems. Similar limitations apply to some of the other subdivisions in this section, primarily to 2.318, which has a few references to the statistical characteristics of music.

The section 2.32 is concerned with some special nonlinear processing methods in speech compaction, some of which have been applied for decades. Speech clipping and speech re-iteration are typical examples.

The most intensively investigated speech processing methods are spectral processing methods, based on short-time spectra, and their frequency quantized approximations. The practical result of these efforts is in use in the form of the many vocoder types of speech compression equipment. Section 2.33 is devoted to this approach.

A number of analog processing methods for speech redundancy reduction are the subject of section 2.34 and their counterpart digital methods are in section 2.35. Primarily the compactive digitization of voice is a problem of great interest to communications systems for manned space flight.

Phoneme recognition methods promise the greatest amount of redundancy reduction and can draw on the experience of pattern recognition methods (see 2.260). They are difficult to instrument and require combinations of analog and digital processing techniques, together with some special bionics methods, for realizing practical solutions. This is why phoneme recognition methods are discussed in a separate section, 2.36, after the discussion of most other methods.

Speech synthesis (2.370) is a special application of all the above-mentioned techniques. It is either applied for purely scientific research, or for digital to analog reconversion of highly compacted speech signals.

One other special application of speech compression techniques is singled out for a separate subdivision: Speaker identification (2.382). It has importance in some reconnaissance and security missions, but it is also an important additional element in future "high compaction" systems for space communications voice links, where all the known speech characteristics of a particular astronaut may be stored as a priori information in both terminals. The repeated transmission of such individual characteristics, along with each phoneme, could then be avoided and the bandwidth of living speech transmission could be closely reduced to the theoretical limit of a few cycles per second.

Section 2.30

2.300: Introductions, Books, Surveys on Speech Compression

Included: Bibliographies on speech compression; Reviews of speech analysis and synthesis; Origin of speech; Speech and communication; Performance factors of speech compression systems.

Not Included: Linguistic and acoustic research on speech.

Cross References: Intelligibility problems (2.315).

Principal Publications:

SPEECH AND COMMUNICATION
G. A. Miller, J. Acoust. Soc. Amer., vol. 30, no. 5, May 1958, p. 397/398.

Symposium on unsolved problems in acoustics . . .

BANDWIDTH COMPRESSION SPEECH - BBN PROJECT 12.022
K. D. Kryter, et al., Bolt, Beranek, and Newman, Inc., Cambridge, Mass., Nov. 1958, 9 p., AD 207 360.

VOICE COMMUNICATION STUDIES
J. W. Black, Ohio State U., Research Foundation, Columbus, Final Rept. - Rept. no. 398, Dec. 1959, 15 p., AD 232 565.

Bibliography . . . between Oct. 1, 1948 & Sept. 30, 1959. (1) voice intelligibility; (2) dimensions of voice; (3) problems in listening; (4) hearing oneself, side tone: (5) the language of voice communication; (6) problems in hearing; and (7) the evalution of equipment. Also see AD 255 716.

PROCEEDINGS OF SEMINAR ON SPEECH COMPRESSION AND PROCESSING, LG HANSCOM FIELD, BEDFORD, MASS.
AF Cambridge Res. Center, Bedford, Mass., Report No. AFCRC TR-59-198, vol. 1, Sept. 1959, AD 233 717.

Contents:
- Basic factors in speech perception and applications to speech processing
- Effects of multiple narrow pass band filtering on the intelligibility of speech
- Some aspects of intonation and stress
- The effective use of digital simulation for speech processing
- Experiments with a dynamic analog of the vocal tract
- Automatic resolution of speech spectra into elemental spectra
- Some progress with vocoder-type systems
- Characteristics of modern vocoders and remaining problems
- Vocoders for military use
- A 12-channel transistorized vocoder
- Simulation of a vocoder
- The SRDE speech bandwidth compression project
- The Formoder as a tool for speech studies
- A digitilized continuous-analysis speech compression system
- A review of Stromberg-Carlson research programs in formant tracking and work recognition

PROCEEDINGS OF SEMINAR ON SPEECH COMPRESSION AND PROCESSING, LG HANSCOM FIELD, BEDFORD, MASS.
Air Force Cambridge Research Center, Bedford, Mass., AFCRC TR 59-198, vol. 2, Sept. 1959, AD 233 720.

Contents:
- The speech research program of the AF Cambridge Research Center
- An approach to speech bandwidth compression
- A digital voice data processor
- Study of correlation instrumentation for speech analysis and synthesis
- Magnetic drum as a component in speech compression and processing equipment
- Speech research at the Royal Institute of Technology, Stockholm
- The speech program at WADC
- The Army and speech processing
- Parametric recognition of phonetic sounds
- Linguistic concepts in automatic speech recognition procedures
- Research on speech recognition at Lincoln Labs.
- Electronic cognition of speech
- Some problems in speech recognition
- Investigation procedures for speech recognition
- Analysis by synthesis
- A round table resume of speech research in Europe

ACOUSTIC THEORY OF SPEECH PRODUCTION
G. Fant, The Hague, Netherlands, Mouton, 1960, 323 p.

It has long been obvious that the designer of a speech communication system is well advised to know a good deal about speech. Fant's book is without doubt the best and most complete contemporary work on the physics of speech. Communication engineers will welcome the liberal use of Laplace transforms and models of network theory. . . .

THE ORIGIN OF SPEECH
C. F. Hockett, Sci. American, vol. 230, no. 3, Sept. 1960, p. 89/96.

NEW INSTRUMENTS AND METHOD FOR SPEECH ANALYSIS
T. Sakai, et al., J. Acoust. Soc. Amer., vol. 32, no. 4, April 1960, p. 441/450.

AN INVESTIGATION OF SELECTED SIGNAL PROCESSING TECHNIQUES
N. A. Shyne, et al., Montana State Coll., Bozeman, May 1960, AD 236 375.

. . . various combinations of linear and instantaneous non-linear types of signal processing were investigated. . . . a speech power-spectrum equalizer; clippers for speech; quadrature functions and SSB signals; integrators and differentiators. . . . certain of these processes afford significant improvements in intelligibility of signals transmitted through the representative systems. The improvements in intelligibility ranged from 9% for quadrature function clipping to 3% for spectrum equalization at median intelligibility levels.

REVIEW OF EXISTING SPEECH COMPRESSION SYSTEMS
K. N. Stevens, Bolt, Beranek, and Newman, Inc., Cambridge, Mass., RADC TN 60-197, Oct. 1960, AD 245 025.

Existing techniques for speech compression which require a channel capacity of less than 10,000 bits/sec are summarized. An estimate is given of the maximum intelligibility for PB words that can reasonably be expected for each technique under the assumption that the complexity of the systems or the amount of delay or memory required is not increased appreciably.

MILITARY APPLICATIONS FOR SPEECH COMPRESSION TECHNIQUES
A. J. Strassman, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 4, June 1960, p. 75/81.

. . . there will be continued, and even increased, usage of voice communications throughout the military complex. . . . If it were possible to provide four times as much voice traffic on the same number of channels, we would be essentially buying spectrum . . . utilization of speech compression techniques would enable us to provide this additional capability. . . . Another obvious military need in the communications field is that of providing proper security . . . to this end also, speech compression can be utilized. . . . If speech is compressed first, and then digitalized, provision for transmission of encrypted digital speech over a normal 3-kc voice circuit can be made. . . . Techniques to satisfy these requirements have been available for some time; however, equipments compact enough and capable of producing a sufficiently good quality of reconstructed speech have not been available as acceptable end items. . . . the Hughes Aircraft Company has developed a miniature Vocoder of sound quality which can be utilized for the above outlined military applications. . . .

STUDY OF A SPEECH COMPRESSION SYSTEM (SPECTRUM SELECTION)
J. H. Ball, et al., Bolt, Beranek, and Newman, Inc., Cambridge, Mass., Quarterly technical rept. no. 8, 15 Sept. 15-Dec. 1961, 30 Jan. 1962, 33 p. incl. illus., AD 274 466.

SPEECH ANALYSIS AND SYNTHESIS
C. G. Fant, Royal Inst. of Tech. (Sweden), 31 Jan 1961, lv., AD 268 482.

Progress . . . during 1960 . . . speech sampling techniques . . . design of spectrum sectioning devices. . . . formant frequency measurements, formant tracking, pitch tracking, pole-zero matching, voice source regeneration, parametric synthesis of speech, and speech perception are discussed. Observations have been made on the production of nasalized sounds by means of cineradiographic and spectrographic methods.

METHODS OF INCREASING THE CAPACITY OF TELEPHONIC TRANSMISSIONS
S. Condrea, Joint Publications Research Service, Washington, D. C., JPRS: 16204, OTS Rept. 63-13101, 15 Nov. 1962, 12 p., AD 299 166.

. . . compression of the available frequency band . . . influencing either simplex or the multiplex signal . . . greater reduction of the frequency band is achieved in the first case than the second, but at the expense of numerous and complicated items of equipment.

SPEECH ANALYSIS AND SYNTHESIS
C. G. Fant, Royal Inst. of Tech. (Sweden) Final rept., (AFCRL 620-790), 31 Jan. 1962, 64 p., AD 298 309.

SPEECH ANALYSIS TECHNIQUES
G. Fant, et al., Royal Inst. of Tech., (Sweden) Final technical rept., 1 July 1960 - 30 June 1962, (Rept. no. 8), 30 June 1962, 143 p. incl. illus., tables , refs., AD 291 799.

. . . theoretical and experimental investigations of speech analysis and synthesis in order to study methodological problems and to construct complete instrumentation.

SPEECH COMPRESSION. AN ASTIA REPORT BIBLIOGRAPHY
C. C. Hutton (comp.), Armed Services Technical Information Agency, Arlington, Va., (Rept. no. ARB-13517), Bibliography for 1953-1962, 19 Nov. 1962, lv., 200 refs., AD 288 850.

SOME PERFORMANCE FACTORS OF SPEECH PROCESSING SYSTEMS
W. A. Runge, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 174/178.

The degree of intelligibility and over-all quality factors of certain vocoders and other speech processing devices was determined. Input magnetic test tapes, containing speech with several background noise conditions, were run through various speech processing devices while in back-to-back operation. Samples from the listeners to obtain intelligibility and quality scores. . . .

SPEECH COMPRESSION STUDIES
C. P. Smith, Air Force Cambridge Research Labs., Bedford, Mass., (Rept. no. AFCRL 63-739), Sept. 1962, 8 p., incl. illus., 6 refs, AD 291 740.

Studies of speech signal structure, and of listener responses to modified and standardized speech signals, are being performed with a special-purpose speech analysis/synthesis facility. The facilities and some findings are discussed.

AN EVALUATION OF SPEECH COMPRESSION SYSTEMS
K. N. Stevens, et al., Bolt, Beranek, and Newman, Inc., Cambridge, Mass., Interim rept., (Rept. no. 914), (RADC TDR 62-171), 1 March 1962, lv. incl. illus., tables, 55 refs., AD 277 457.

The results of PB word and nonsense syllable intelligibility tests, voice quality, talker identification, and continuous speech tests of selected speech compression systems are presented. The systems were: a reference low-pass (approximately 3000 cps) filter system, two channel vocoders, a semi-vocoder, a formant-tracking vocoder and a multiple narrow band filter system . . . Channel vocoders operating at about 2400 bits/sec and semi-vocoders at an estimated 9600 bits/sec provide adequate intelligibility and quality for most military communications; the quality of the semi-vocoder is superior to the channel vocoder. Formant-tracking vocoders utilize the lowest information rate (about 1000 bits/sec) of any of the bandwidth compression techniques. Formant-tracking vocoders require further improvement before they can be as satisfactory for general use.

SPEECH RESEARCH AND INSTRUMENTATION: PHASES I AND II
Haskins Labs., New York, Quarterly progress rept. no. 1, 14 Sept.-13 Dec. 1961, 25 March 1962, lv. incl. illus., tables, AD 282 091.

. . . acoustic factors that determine the intelligibility of speech. . . .

SPEECH ANALYSIS TECHNIQUES
G. Fant, Royal Inst. of Tech., Stockholm (Sweden) Speech Transmission Lab., Final Technical Report, 1 July 1962 - 30 June 1963, (1963) 79 p. refs., N63-21486.

. . . particular emphasis on instrumentation and methods for automatic extraction of speech signal parameters . . . a limited amount of work undertaken on synthesis instrumentation and techniques . . . study of the performance of speech compression systems.

AUTOMATIC PATTERN RECOGNITION DURING THE PERIOD 1961-1962: AN ANNOTATED BIBLIOGRAPHY
E. E. Graziano (comp.), Lockheed Missiles and Space Co., Sunnyvale, Calif., May 1963, 44 p., 140 refs., N63-17447, AD 406 279.

. . . the period 1961-1962. Included are references pertaining to theory and experience with systems, components, methods, optics, speech, etc. . . .

AN EVALUATION OF SPEECH COMPRESSION TECHNIQUES
K. D. Kryter, et al., Bolt, Beranek and Newman, Inc., Cambridge, Mass., BBN 978, RADC TDR 63 90, 25 Feb. 1963, 18 p., AD 402 604.

. . . results of tests of various recently developed speech compression systems . . . Semi-vocoders, operating at 9600 bits/sec, and channel vocoders, at 2400 bits/sec, will provide speech of adequate intelligibility and quality for most military communications. . . . Formant-tracking vocoders . . . at about 1200 bits/sec can probably be developed to the point where they will provide speech intelligibility comparable to that from the channel vocoders operating at 2400 bits/sec. At the present time formant-tracking vocoders operating at 1000 bits/sec do not provide for adequate speech intelligibility. . . . 'pattern' matching technique is still in its early experimental stages . . .

SPEECH SIGNALS IN CYBERNETICS AND COMMUNICATION (SPEECH CONVERSION APPLIED TO PROBLEMS OF COMMUNICATION AND CYBERNETICS TECHNIQUES) (In Russian)
M. A. Sapozhkov, Moscow, Svyaz'izdat, 1963, 450 p.

. . . an attempt is made at unifying the large amount of material connected with problems of the compression and expansion of the volume of speech signals, as well as problems of the automatic recognition of speech sounds and their synthesis. . . . problems of information theory, speech formation, the principles of speech conversion and reproduction, and the characteristics of Russian speech . . . methods of compression and expansion of speech signals . . . method of direct compounding and limiting linguistic and parametric compounding and limiting . . . methods of automatic recognition and synthesis of speech. . . . intended for specialists working in communication techniques, automation and cybernetics . . .

SPEECH PROCESSING STUDIES (VOICE DATA PROCESSING SYSTEM)
H. A. Straight, et al., Melpar, Inc., Falls Church, Va., Final rept., Sept. 1961 - Sept. 1963, Oct. 1963, 115 p., AD 430 461.

. . . in this final period . . . greater selectivity in pattern coding, expanded keyboard capability, and increased reliability in compiling speech statistics. The appendices include a definition of terms and the system operating instructions.

Related Publications:

KORRELATIONSELEKTRONIK (Correlation Electronics) (In German)
F. H. Lange, Berlin, VEB Verlag Technik, 1959, 343 p.

EYES AND EARS FOR COMPUTERS
E. E. David, Jr., et al., Proc. IRE, vol. 50, May 1962, p. 1093/1101.

. . . character reading and speech recognition. . . .

Section 2.31
Fundamental Characteristics of One-Dimensional Audio Information Sources

2.310: Speech Analysis in General

Included: Classes of speech sounds; Speech analyzers; Syllable analyzer; Pitch extraction problem; Vowel intonation contours; Pitch rating for voiced and whispered vowels; Analysis of consonants; Nasal consonants; Information rate of pitch signals.

Not Included: Spectrum analysis in general.

Cross References: Formant tracking filter (2.312); Analog to digital speech analysis equipment (2.350); Melody detector (2.312); Narrow band speech system (2.330); Extraction of pitch from the trachea (2.316); Intonation problems in speech compaction (2.314); Phoneme recognition methods (2.360).

Principal Publications:

SPEECH ANALYSIS
S. H. Chang, et al., Electronics Research, Northeastern U., Boston, Mass., Rept. No. AFCRC TN-58-181, June 1958, 41 p., AD 152 429.

THEORETICAL AND EXPERIMENTAL RESEARCH IN COMMUNICATION THEORY AND APPLICATIONS
E. C. Easton, Bureau of Engrg. Research, Rutgers U., New Brunswick, N. J., Final Report 15 Nov. 1953, 14 June 1957, 18 Feb. 1958, 46 p., AD 158 760.

. . . development of an analysis and synthesis system for speech transmission. . . .

PITCH RATINGS OF VOICED AND WHISPERED VOWELS
G. J. Harbold, J. Acoust. Soc. Amer., vol. 30, no. 7, July 1958, p. 600/601.

The problem was to investigate listener judgments of voiced and whisper vowels in an effort to compare relative pitch of voiced and whispered speech. The results indicate, at least for those vowels that showed significant differences, that tonality may not be the sole determinant of listener's pitch judgments. A comparison of rank orders of the present study and rank order from a previous investigation provided further support to the hypothesis that relative pitch of vowels is not independent of the vowel itself.

ON VOWEL INTONATION CONTOURS
P. Lieberman, Presented at the 55th Meeting, Acoustical Society America, Washington, D. C., May 1958.

PITCH EXTRACTION FOR SPEECH SYNTHESIS WITH SPECIAL TECHNIQUES FOR USE IN DIGITIZED BANDWIDTH COMPRESSION SYSTEMS
L. V. Kriger, Air Force Cambridge Res. Center, Bedford, Mass., Report AFCRC TR 59-116, March 1959, 47 p., AD 214 449.

Pitch channel techniques for voice compression systems are reviewed. Time and frequency domain methods for pitch extraction are compared. . .

AN EXPERIMENTAL PITCH INDICATOR FOR TRAINING DEAF SCHOLARS
F. Anderson, J. Acoust. Soc. Amer., vol. 32, Aug. 1960, p. 1065/1074.

SPECTRUM ANALYZER SUPPLIES PERMANENT RECORD
R. J. Farber, et al., Electronic Industr., vol. 19, no. 1, Jan. 1960, p. 68/72.

NEW INSTRUMENTS AND METHODS FOR SPEECH ANALYSIS
T. Sakai, et al., J. Acoust. Soc. Amer., vol. 32, no. 4, April 1960, p. 441/450.

SYLLABLE ANALYZER, CODER AND SYNTHESIZER FOR THE TRANSMISSION OF SPEECH
H. F. Olson, et al., Proc. Nat. Aerosp. Electronics Conf., vol. 9, May 1961, p. 307/317.

DIE ANFORDERUNGEN SYNTHETISCHER SPRACHE (VOCODERSPRACHE) UND VORVERFORMTER SPRACHE AN DIE KANALKAPAZITAT DES UBERTRAGUNGSWEGES (The Requirements for Channel Capacity when Transmitting Synthesized Speech (Vocoded Speech) or Predistorted Speech) (In German)
K. O. Schmidt, Nachrichtentech. Z., vol. 14, no. 6, June 1961, p. 279/285.

PRELIMINARY SPEECH ANALYSIS
J. West, General Applied Science Labs., Inc., Westbury, N. Y., (GASL rept. no. 5271-FR-1) (RADC TR 61-144), May 1961, 45 p., AD 264 003.

. . . Study of the frequency spectra of speech sounds was made with a high resolution spectrum analyzer. The results of the analysis are summarized in photographs of the changes in the frequency distribution with time. Analyses of the unvoiced stop t in the word tu is provided. The transition frequencies from the consonant to the vowel are easily measured. Twenty millisecond intervals were used to observe the spectrum changes. Other intervals such as 60 milliseconds and 100 milliseconds were employed.

SPEECH ANALYSIS TECHNIQUES
Royal Inst. of Tech. (Sweden), (Rept. 5), Sept. 1961, 15 p., AD 269 293.

. . . work on the 51-channel analyzer was continued. Comparative studies of various means of speech spectrum analysis were concerned with formant frequency measurements from Sona-Graph spectrograms and sections. Evaluations of various means of voice pitch extraction were followed up by a complete construction of a dual channel pitch extractor and decision circuit. Development was continued on various methods for automatic recognition of specific phonetic features and sound categories.

ANALYSIS OF NASAL CONSONANTS
O. Fujimura, J. Acoust. Soc. Amer., vol. 34, no. 12, Dec. 1962, p. 1865/1875, AD 404 135.

THE INFORMATION RATE OF THE PITCH SIGNAL IN SPEECH
T. Koshikawa, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S92/100.

. . . Precise data on the time change of the pitch signal for continuous messages are needed for the purpose of evaluating the minimum requirement for the channel transmitting the pitch signal. . . . based on the frequency modulation model. . . . degradation of naturalness was evaluated by a psychometric method . . . the information rate of the pitch signal . . . has been estimated at approximately 750 bits/sec, or 50 cps in terms of the bandwidth for the pitch signal.

INVESTIGATION OF AUTOMATION OF SPEECH PROCESSING FOR VOICE COMMUNICATION
G. S. Sebestyen, et al., Litton Systems, Inc., Waltham, Mass., (Scientific rept. no. 1), 28 May 1962, 70 p., incl. illus., tables, 6 refs., AD 287 887.

The AFCRL Speech Analyzer consists of an 18-channel vocoder and multiplex which quantizes the amplitudes of each of the 18 bands of frequencies into 3 bits. This results in a 54 bit description of the instantaneous speech spectrum. In addition, the voice amplitude in quantized into 3 bits and the pitch frequency into 6 bits. An additional bit is reserved for indicating whether the sound is voiced or unvoiced. A 64 bit computer word thus describes the speech sound at an instant of time and 50 such samples are taken each second. . . .

PITCH EXTRACTION BY COMPUTER PROCESSING OF HIGH-RESOLUTION FOURIER ANALYSIS DATA
C. M. Harris, et al., J. Acoust. Soc. Amer., vol. 35, March 1963, p. 339/343, A63-19845.

. . . automatic pitch-extraction method, in which speech signals are processed by a real-time Fourier analyzer, the output of which is converted into digital form and recorded on tape for processing on an IBM computer. The logic of the computer program, written in FORTRAN language, is discussed, as is the accuracy of the overall pitch-extraction system.

A STUDY OF SIGNIFICANT PARAMETERS OF SPEECH FOR APPLICATION IN AUTOMATIC SPEECH RECOGNITION SYSTEMS
M. R. Weiss, Federal Scientific Corp., New York, N. Y., Final Report, 1 July 1963, 259 p. refs., AD 423 279, N64-12304.

. . . high-resolution spectrum analyses were obtained as a function of time for each of 7500 spoken words, automatically converted to digital form, and recorded on magnetic tape. The recorded spectra were then processed by a digital computer for which a program was written for the extraction of parameters of speech . . . Results of statistical analyses of parameters extracted from 500 of the words are presented and discussed . . .

Related Publications:

(No Title)
University Coll., London (Great Bt.), Progress rept., July 1963, 41 p., AD 430 704.

. . . (1) a Study of the formants of the pure vowels of British English; (2) Formant frequencies of Hungarian vowels; (3) An experimental study of the relative contributions of vowel duration and spectral form to the recognition of English and German vowels; (4) Pitch perception and temporal patterning; (5) Long term spectral analysis; (6) SPYL- a combination of an instantaneous spectrograph, step synthesizer and a tape loop . . .

2.312: Spectral Analysis of Speech Waveforms

Included: Formant coding; Formant tracking filter; Sampling speech spectra by narrow pass bands; Melody detector for speech analysis.

Not Included: Spectrum analysis in general; Power spectra of random processes (1).

Cross References: Speech analyzers (2.310); Formoder development (2.330); Pitch extraction problems (2.310); Classes of speech sounds (2.310); Formant tracking vocoder system (2.330); Narrow band speech system (2.330); Real time adaptive speech recognition system (2.360).

Principal Publications:

STUDY OF A SPEECH COMPRESSION SYSTEM SPECTRUM SELECTION
Bolt, Beranek, and Newman, Inc., Cambridge, Mass., Technical progress report no. 2, 15 June - 15 Aug. 1959, 20 p., AD 227 658.

This report will present the results of the PB work and sentence intelligibility test scores for various combinations of one, two and three narrow pass band systems set at a number of different center frequencies. For comparative purposes, intelligibility test scores will be given for speech that has been passed through relatively wide pass band filters. In addition, the results of a series of tests using monaural versus binaural listening are reported. Future tests are planned in which pass bands narrower than 500 cps will be used; also time sharing among the several bands are to be investigated.

EIN STETIG VERÄNDERLICHER BANDPASS FÜR DEN HÖRBEREICH (A Continuously Variable Band-Pass Filter for the Audio Range) (In German)
W. Ohme, Frequenz, vol. 14, May 1960, p. 182/186.

This filter is variable over the whole audio range. It can be used to filter out parts of a speech spectrum. . . .

SPEECH BANDWIDTH COMPRESSION THROUGH SPECTRUM SELECTION
K.D. Kryter, J. Acoust. Soc. Amer., vol. 32, May 1960, p. 547/556.

PB word and sentence intelligibility tests were conducted with unfiltered speech and with speech filtered (1) by a 100-7000 cps bandpass filter, (2) by a 100-1600 cps bandpass filter, (3) by a 500-2000 cps bandpass filter, (4) by a 1000-2500 cps bandpass filter, and (5) by various configurations of one, two, or three bandpass filters, each 500 cps wide. The positions of the center frequencies of the bandpass filters 500 cps wide were systematically varied during the tests. If we use constant speech intelligibility as our criterion, the results indicate that the total "effective" bandwidth required for the best multiple pass band system is less than that required for the best contiguous pass band systems by a factor of 2. Also, a feature of the signal resulting from this multiple sampling in the frequency domain is that it sounds "natural" and the identity of a talker's voice appears to be maintained. This article also appears as AD 277 658.

SPEECH-COMPRESSION-SYSTEM STUDY
R.A. Houde, General Dynamics/Electronics, Rochester, N.Y. Final rept., 1 July 1959 - 30 June 1961, 30 June 1961, 77 p., incl. illus., AD 275 336.

. . . formant coding. . . . instrumentation was designed . . . to transform the input speech signal into spectral data in magnetic tape form suitable for computer processing. The system and the computer programs employed to detect the speech formants are described. . . .

STUDY OF A SPEECH COMPRESSION SYSTEM (SPECTRUM SELECTION)
K.D. Kryter, Bolt, Beranek, and Newman, Inc., Cambridge, Mass., Interim rept. no. 2 (Final), 15 Jan. 1960 - 15 May 1961, 21 July 1961, 82 p., AD 261 329.

. . . A six-channel filter system was built; each had a bandwidth of either 135 or 400 measured at the 20 db downpoints on the filter skirts. . . . It was found that for 80% PB word intelligibility and equal talker recognition test scores the total bandwidth required for the best multiple pass band system is 1/3 - 1/4 that required for a low pass band system. It was concluded that narrow band filtering plus time-plexing among the bands does not provide an intelligible speech signal.

STUDY OF A SPEECH COMPRESSION SYSTEM (SPECTRUM SELECTION)
K.D. Kryter, et al., Bolt, Beranek, and Newman, Inc., Cambridge, Mass., (Rept. 7), Sept. 1961, 32 p., AD 269 194.

. . . effect of sampling the frequency spectrum of speech by narrow pass bands is discussed. Also included are results of experiments on companding, delta modulation and straight pulse code modulation of a speech signal. Preliminary results indicate that the 75 cps wide filters, delta modulation and companding can be used to advantage in the transmission of spectrum sampled speech.

INFLUENCE OF TRANSMISSION ERROR ON FORMANT CODED COMPRESSED SPEECH SIGNALS
S.J. Campanella, et al., J. Audio Engng. Soc., vol. 10, no. 2, April 1962, p. 149/155.

Presents an analysis of the performance of a formant tracking speech compression system under the influence of error in the control signals used to communicate the compressed speech information from the analyzer to the synthesizer. The analysis is conducted both for analogue transmission, in which the seven control signal channels of 140 c/s aggregate bandwidth are each perturbed by gaussian random noise, and digital transmission in which the seven analogue control channels are sampled sequentially into a single binary stream of 1000 bits/s and this is subjected to varying degrees of bit error rate. . . .

AN AUTOMATIC SPEECH FORMANT TRACKING FILTER
G.A. Hellwarth, Michigan U., Ann Arbor, (Rept. no. 10), May 1962, 123 p., incl. illus., AD 282 147.

. . . a continuously tuned, automatic tracking filter system is proposed which locates these spectral maxima of speech signals through an application of automatic frequency control techniques. . . . The problem of constructing a complete speech analysis system utilizing tracking filters is discussed.

DESIGN AND CONSTRUCTION OF A MELODY DETECTOR FOR SPEECH ANALYSIS (In French)
R. Carre, et al., Onde Electr., vol. 43, no. 434, May 1963, p. 556/562.

. . . This apparatus is one of the links in an analysis chain for the spoken word. It makes it possible to follow cycle after cycle of the development of the melody of the speech (a component which appears as the highest common factor of the frequencies of the various components present in the speech signal) . . .

Related Publications:

SPECTRA AND ANALYSIS (In Russian)
A.A. Kharkevich, Moscow, Fizmatgiz, 1962, 236 p.

The monograph deals with a selection of spectral representations used in the theory of oscillations, acoustics, and radio engineering, . . . aims to widen the theoretical horizons of engineers working in the fields of radio and acoustics. . . .

FORMANT TRACKING VOCODER SYSTEM
S.J. Campanella, et al., Melpar, Inc., Falls Church, Va., Quarterly rept. no. 5, 1 Sept.-30 Nov. 1963, 30 Nov. 1963, 51 p., AD 434 863.

. . . studies of formant tracking performances by alternative methods . . . tracking by continuous period extraction, and control of adaptive filters by front-back vowel detection. . . . Data are presented on formant position prediction from previous position with assumed predicting courses, and by inserting a delay in the signal path and utilizing an undelayed signal to pre-position the formant trackers.

2.313: Time Domain Analysis of Speech Signals

Included: Optimum speech signal mapping techniques; Time correlation intervals of speech signals; Extremal coding of speech waveforms; Speech processing in real time; Duration of speech sounds in various languages; Skew distribution functions for word frequency analysis; Axis crossing analysis of speech waveforms; Speech samplers; Correlation techniques for speech compression.

Not Included: Correlation analysis of random functions (1).

Cross References: Extremal coding as compaction methods (2.253); Infinitely clipped speech (2.323); TASI multiplex system (2.534).

Principal Publications:

REPRESENTATION OF COMPLEX SIGNALS BY MEANS OF DAMPED OSCILLATORY BASE FUNCTIONS
L. Dolansky, Gordon McKay Lab. of Applied Science, Harvard University, Cambridge, Mass., Scientific Report No. 59-1, AFCRC TN 59-648, Aug. 1958, 42 p., AD 232 538.

. . . An orthonormal set of decaying oscillatory base functions was obtained and the problems expressing voiced speech sounds by means of a small number of such functions, and of obtaining their coefficients by measurement was studied. The experimental results indicate that an analysis of the speech waveform into damped oscillatory base functions and subsequent synthesis within a good approximation is indeed possible. . . .

THEORETICAL AND EXPERIMENTAL RESEARCH IN COMMUNICATION THEORY AND APPLICATIONS
E.C. Easton, Bureau of Engrg. Research, Rutgers U., New Brunswick, N.J., Final Report, 15 Nov. 1953, 14 June 1957, 18 Feb. 1958, 46 p., AD 158 760.

Work is summarized on the development of an analysis and synthesis system for speech transmission. The analyzer produces voltages proportional to pitch frequency, first and

second formant frequences, first formant amplitude, consonant center frequency and consonant amplitude. These voltages are utilized in a synthesizer to reconstruct the transmitted speech. . . .

NUMBER OF AXIS CROSSINGS AND THE INTELLIGIBILITY OF SPEECH (Correspondence)
J.W. Black, et al., J. Acoust. Soc. Amer. vol. 31, no. 10, Oct. 1959, p. 1384/1385.

DESIGN AND STUDY OF CORRELATION INSTRUMENTATION FOR SPEECH ANALYSIS AND SYNTHESIS
G.J. Duscheck, et al., RCA Defense Electronic Products, Camden, N.J., (Scientific rept. no. 1; AFCRC TN-59-173), March 1959, 79 p., AD 214 415.

An optimum analog instrumentation for processing the output signal of a Vocoder for digital transmission is presented. The system is based on the matching of the incoming voice events against a catalog of speech patterns so that only the pattern number, rather than the speech event itself, need be transmitted. In the receiver the proper speech pattern is retrieved from a similar memory and generates the required voltages for the Vocoder synthesizer. . . . (See also AD 119 258).

AN ELECTRONIC SPEECH SAMPLER FOR STUDYING THE EFFECT ON SAMPLE DURATION ON ARTICULATION
R. Fatehchand, et al., J. Inst. Telecommun. Engr., vol. 5, March 1959, p. 86/88.

EXTREMAL CODING FOR SPEECH TRANSMISSION
M.V. Mathews, IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 129/136.

. . . The coder determines the amplitudes and times of successive extremes (relative maxima and minima) of the signal.

DURATION OF SYLLABLE NUCLEI IN ENGLISH
G.E. Peterson, et al., J. Acoust. Soc. Amer., vol. 32, June 1960, p. 693/703.

This study deals with the influence of preceding and following consonants on the duration of stressed vowels and diphthongs in American English. A set of 1263 CNC words, pronounced in an identical frame by the same speaker, was analyzed spectrographically, and the influences of various classes of consonants on the duration of the nucleus were determined. . . .

SOME FURTHER NOTES ON A CLASS OF SKEW DISTRIBUTION FUNCTIONS
H.A. Simon, Inform. Control, vol. 3, no. 1, March 1960, p. 80/88.

. . . certain stochastic model to explain word-frequency data. . . . basic parameter of the distributions is larger or smaller than unity. . . . simple stochastic models can be constructed for either case. . .

SPEECH-TO-CODE CONVERTER STUDY
W.D. Larkin, et al., General Dynamics/ Electronics, Rochester, N.Y., Final rept., 1 July 1959 - 31 Dec. 1960, 30 Sept. 1961, 149 p., 17 refs., AD 272 109.

. . . to determine the parameters necessary for the identification of words spoken in isolation. . . . Time compression permits real-time spectrum analysis with a sweep analyzer and offers the possibility of a reduction in equipment size approaching an order of magnitude compared with conventional parallel-channel analyzers . . .

THE TIME CORRELATION INTERVALS OF SIGNALS AND ITS CONNETION WITH THE PARAMETERS OF THE POWER SPECTRUM
N.A. Zheleznov, Telecommunications, no. 5, Oct. 1961, p. 478/488.

CORRELATION TECHNIQUES FOR SPEECH BANDWIDTH COMPRESSION
M.R. Schroeder, J. Audio Engng. Soc., vol. 10, no. 2, April 1962, p. 163/166.

. . . Methods for analysis and synthesis of speech directly in the time domain (for purposes of time or bandwidth compression) are discussed. Specifically, autocorrelation and cross-correlation are considered and "time-domain vocoders" based on these principles of analysis are described. . . .

SPEECH DATA PROCESSING IN REAL TIME
H.A. Straight, Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 30/35.

The logical techniques by which a high-speed special-purpose digital computer developed by Melpar compares the digital description of speech spectrum patterns with previously recorded description are presented. This set of logic is capable of determining which stored pattern most nearly approximates an unprocessed pattern, and is unique in that it makes possible the sorting and compilation of speech statistics in real time. . . . capability of "learning" speech through the tabulation of a set of mean patterns . . .

Related Publications:

SPEECH ANALYSIS
S.H. Chang, Electronics Res. Lab. Northeastern U., Boston, Mass., Report No. AFCRC TR 58-107, Final Scientific Report, 1 March 1957 - 31 Jan. 1958, 28 Feb. 1958, 36 p., AD 146 814.

. . . studies directed toward the specification of important parameters of speech in speech-band compression systems. The Formoder (Formant-Moment Coder) was described . . .

PROCEEDINGS OF SEMINAR ON SPEECH COMPRESSION AND PROCESSING, LG HANSCOM FIELD, BEDFORD, MASS.
AF Cambridge Res. Center, Bedford, Mass., Report No. AFCRC TR-59-198, vol. 1, Sept. 1959, AD 233 717 (Also AD 233 720).

SPEECH-COMPRESSION-SYSTEM STUDY
R.A. Houde, Stromberg-Carlson Co., Rochester, N.Y., Quarterly Progress Report #1, 1 July 1959 - 31 Jan. 1960, Jan. 1960, 28 p., AD 235 353.

Instrumentation for the first stage of Speech-Compression-System study is underway. A Lawrence-type speech synthesizer and voltage function generator is complete and construction of the Speech-Spectrum Analyzer, which produces data in binary form suitable for processing in a digital computer, is underway. The relationship between synthesized speech quality and the controlling parameters is being investigated.

TASI QUALITY —— EFFECT OF SPEECH DETECTORS AND INTERPOLATION
H. Miedema, et al., Bell Syst. Tech. J., vol. 41, no. 4, July 1962, p. 1455/1473.

. . . tests made to select design parameters for the speech detectors in the TASI system. Results of subjective tests carried out to determine maximum permissible loading in TASI circuits during busy hours are also described . . . observations indicate that TASI is a more satisfactory method of increasing transatlantic cable capacity than alternate methods, such as the use of 2-kc channel banks.

DIGITAL CIRCUIT TECHNIQUES FOR SPEECH ANALYSIS
G.L. Clapper, IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 296/305, 11 refs.

. . . Some early speech devices are noted and current work in the field of computer simulation is considered. . . . description of an experimental word code generator developed at the IBM. . . . This device produces a compressed digital code from the spoken word as a function of frequency, intensity, and time. Individual sound patterns are coded as a function of the changes in word itself. The code is produced as the word is spoken and is displayed in matrix form for immediate analysis. Readout to a card punch or other storage media is easily accomplished.

APPLICATION OF NEURAL LOGIC TO SPEECH ANALYSIS AND RECOGNITION
T.B. Martin, et al., IEEE Trans. Mil Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 189/196.

This paper describes signal-processing techniques for the recognition of speech phonemes by machine. An attempt has been made to employ, wherever useful, basic processing functions of the human auditory system. . . .

PATTERN RECOGNITION AS A PROBLEM IN DECISION THEORY AND AN APPLICATION TO SPEECH RECOGNITION
V.E. Sackschewsky, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 186/189.

A REAL-TIME ADAPTIVE SPEECH-RECOGNITION SYSTEM
L.R. Talbert, et al., Stanford Electronics Labs., Stanford U., Calif., Technical rept. no. 6760, 1: SEL 63 064, ASD TDR 63 600, May 1963, 18 p., AD 420 180.

. . . employing adaptive Adaline threshold-logic elements. Time-normalized digital patterns, representing the time-frequency spectrum, are obtained from amplitude-normalized outputs of eight bandpass filters. . . .

A STUDY OF SIGNIFICANT PARAMETERS OF SPEECH FOR APPLICATION IN AUTOMATIC SPEECH RECOGNITION SYSTEMS
M.R. Weiss, Federal Scientific Corp., New York, Rept. no. T4 114, RADC TD63 335, 1 July 1963, lv., AD 423 279.

. . . procedure for the automatic recognition of a large vocabulary of English words as spoken by many talkers under a wide range of conditions of speaking . . .

SPEECH ANALYSIS TECHNIQUES
Royal Inst. of Tech. (Sweden), Technical rept. no. 4 (Final), 1 July 1962 - 30 June 1963, 30 June 1963, lv., AD 419 261.

. . . emphasis on instrumentation and methods for automatic extraction of speech signal parameters. . . . study of the performance of speech compression systems which were demonstrated at the Stockholm Speech Communication Seminar 1962.

2.314: Linguistic Problems in Spoken Language

Included: Linguistic tokens; Statistical characteristics of various languages; Phonetics of various languages; Message procedures for voice communications; Intonation problems in speech compaction.

Not Included: Linguistic research; Acoustic research problems.

Cross References: Linguistic problems of written languages (2.222); Pitch extraction problems (2.210); Phoneme recognition methods (2.360); Speaker identification (2.382).

Principal Publications:

THE STRUCTURE OF AMERICAN ENGLISH
W. N. Francis, New York, The Ronald Press Co., 1958, 614 p.

THE APPLICATION OF THE FERRANTI MERCURY COMPUTER TO LINGUISTIC PROBLEMS
M. Levison, Inform. Control, vol. 3, no. 3, Sept. 1960, p. 231/247.

STUDY OF INTONATION
P. Lieberman, et al., Res. Lab. Electronics, MIT, Quart. Prog. Rept., Jan. 1958, p. 112/115.

ANATOMY OF UNSTRESSED SYLLABLES
L. Lisker, Presented at the 55th Meeting, Acoustical Society America, Washington, D. C., May 1958.

MESSAGE PROCEDURES FOR UNFAVORABLE COMMUNICATIONS CONDITIONS
T. Pollack, J. Acoust. Soc. Amer., vol. 30, March 1958, p. 196/201.

MEASUREMENTS OF PITCH DISTRIBUTION IN THE GERMAN LANGUAGE
W. Rappaport, Acustica, vol. 8, 1958, p. 220/225.

THE DISTRIBUTION LAWS OF THE ZERO AND EXTREME POINTS OF THE SIGNALS OF RUSSIAN SPEECH WHEN THEY ARE SHARPLY LIMITED IN AMPLITUDE
I. G. Rostovtsev, Radio Engng., vol. 13, no. 4, 1958, p. 85/92.

PROCEEDINGS OF THE EIGHTH INTERNATIONAL CONGRESS OF LINGUISTS
Oslo, Norway, Oslo University Press, 1958.

VOWEL OVERLAP AS A FUNCTION OF FUNDAMENTAL FREQUENCY AND DIALECT
R. S. Brubaker, et al., J. Acoust. Soc. Amer., vol. 31, no. 10, Oct. 1959, p. 1362/1365.

VOWEL AMPLITUDE AND PHONEMIC STRESS IN AMERICAN ENGLISH
I. Lehiste, et al., J. Acoust. Soc. Amer., vol. 31, no. 4, April 1959, p. 428/435.

SOME ACOUSTIC CORRELATES OF WORD STRESS IN AMERICAN ENGLISH
P. Lieberman, J. Acoust. Soc. Amer., vol. 32, no. 4, April 1960, p. 451/454.

COHERENT LANGUAGE: AN EXPERIMENT IN LINGUISTIC CATEGORIZATION
T. G. Belden, et al., Institute for Defense Analyses, Washington, D.C., Rept. no. R104, June 1963, lv., AD 412 874.

MULTIDIMENSIONAL MODEL FOR AUTOMATIC SPEECH RECOGNITION
B. V. Bhimani, Bhimani Research Associates, Lexington, Mass., Final rept., 14 Feb. 1964, 246 p., AD 437 324.

. . . a general purpose speech recognizer. . . . sounds in continuous speech are more likely to modify the production of surrounding sounds than they are in discrete speech. . . . linguistic examples and theories of sound change were studied. . . . a body of rules for sound change or euphonic combination was derived and their applicability to the English language tested. These rules represent an error-correcting code to restore omitted or indefinite word boundaries and/or to restore the orthographic phone classes which are altered in continuous speech. . . .

STUDIES FOR THE DESIGN OF AN ENGLISH COMMAND AND CONTROL LANGUAGE SYSTEM
V. E. Giuliano, et al., Little (Arthur D) Inc., Cambridge, Mass., L. G. Hanscom Field, Mass., Decision Sci. Lab., ESD-TDR-63-673, Nov. 1963, 182 p., refs., AD 433 603, N64-18196.

An associative searching technique has been developed for the automatic storage and retrieval of natural language message information. A user may employ his own vocabulary in formulating a typewritten request, and the technique allows the machine to find relevant information even when there is no direct matching of vocabulary items. . .

ACOUSTIC PHONETICS OF KOREAN
M. S. Han, California U., Los Angeles, Rept. no. TR1., 1 Dec. 1963, 108 p., AD 430 715.

. . . to gather a large amount of language data in standard Korean, and to analyze this data with the aid of the spectrograph in order to ascertain all the significant speech signals which are used in the language. . . .

ADVANCED LANGUAGE PROCESSING PROCEDURES
S. J. Keyser, Electronic Systems Div., Air Force Systems Command, Bedford, Mass., ESD TDR 63 620, Sept. 1963, 24 p., AD 430 608.

A recent theoretical advance is outlined in the science of linguistics which renders possible the use of natural English as a query language in computer based systems. The advantages of this approach are considered.

LINGUISTIC AND NON-LINGUISTIC "UNDERSTANDING" OF LINGUISTIC TOKENS
D. M. MacKay, RAND Corp., Santa Monica, Calif., Rept. no. RM3892PR, March 1964, 17 p., AD 432 308.

. . . to enable a computer to accept data and answer questions in verbal form. . . to attain full linguistic comprehension the program must also embody at least a 'skeleton representation' of the linguistic context in which an utterance originates and from which it derives its linguistic significance as a goal-directed operator. . . .

A STUDY OF SIGNIFICANT PARAMETERS OF SPEECH FOR APPLICATION IN AUTOMATIC SPEECH RECOGNITION SYSTEMS
M. R. Weiss, Federal Scientific Corp., New York, Rept. no. T4 114, RADC TDR63 335, 1 July 1963, lv., AD 423 279.

. . . procedure for the automatic recognition of a large vocabulary of English words as spoken by many talkers under a wide range of conditions of speaking. . . high-resolution spectrum analyses were obtained as a function of time for each of 7500 spoken words, automatically converted to digital form, and recorded on magnetic tape. The recorded spectra were then processed by a digital computer for which a program was written for the extraction of parameters of speech. . . Results from 500 of the words are presented. . . .

AUTOMATIC LANGUAGE TRANSLATION
Thomas J. Watson Research Center, Yorktown Heights, N. Y., Final rept., RADC TDR 63-102, 15 Jan. 1963, 224 p., AD 402 242.

Accomplishments for 1962 in the development of the AN/GSQ-16 language translating complex are described. . . studies in linguistic research, conversion to a bi-directional single-pass dictionary mode. . . its incipient stage. . . to a multipass mode.

(No Title)
University Coll., London (Great Bt.), Progress rept., July 1963, 41 p., AD 430 704.

. . . (1) a Study of the formants of the pure vowels of British English; (2) Formant frequencies of Hungarian vowels; (3) An experimental study of the relative contributions of vowel duration and spectral form to the recognition of English and German vowels; (4) Pitch perception and temporal patterning; (5) Long term spectral analysis; (6) SPYL - a combination of an instantaneous spectrograph, step synthesizer and a tape loop . . .

Related Publications:

LINGUISTIC CONSIDERATIONS IN THE STUDY OF SPEECH INTELLIGIBILITY
I. Lehiste, et al., J. Acoust. Soc. Amer., vol. 31, March 1959, p. 280/286.

. . . Since only meaningful units have normal linguistic distributional properties, only meaningful units have the phonetic properties of actual speech. An auditory intelligibility dialect ratio is defined for a listener relative to a specified message. An analysis is presented of the Harvard PB lists, and a set of 10 lists of 50 monosyllables each is presented having an almost exact first-order phonemic balancing.

STRUCTURE OF LANGUAGE AND ITS MATHEMATICAL ASPECTS
R. Jakobson (editor), Providence, Rhode Island, American Mathematical Society, 1961, 279 p.

SENTENCE PARSING WITH A SELF-ORGANIZING HEURISTIC PROGRAM
K. C. Knowlton, Mass. Inst. of Technology, Sept. 1962, 400 p.

. . . machine translation. . . . No importance for space communications.

CALCULATION AND MEASUREMENT OF SPEECH INTELLIGIBILITY (In Russian)
N. B. Pokrovskiy, Moscow, Svyaz'izdat, 1962, 391 p.

A theory of intelligibility is given with a qualitative and quantitative description of the properties and acoustical characteristics of speech and hearing. The magnitude of phonetic and sensible information transmitted through telephone and radiotelephone communication channels is defined. . . . experimental

determination of intelligibility by articulation measurements. . . method of determining the physical constants of Russian speech. . .

English translation available: N64-10381.

A REMARK ON DISCOVERY ALGORITHMS FOR GRAMMARS
E. Shamir, Inform. Control, vol. 5, no. 3, Sept. 1962, p. 246/251.

ADAPTIVE ENCODING FOR LANGUAGE COMPRESSION
J. W. Falter, Proc. Nat. Aerospace Electronics Conf., May 1963, p. 92/98.

ANALOG NETWORKS FOR WORD ASSOCIATION
V. E. Giuliano, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 221/234.

. . . use of analog electrical networks for the automatic recognition of statistical word associations present in written English text. A general mathematical theory is proposed for the association of linguistic units by means of linear transformations, and it is shown that this theory can be realized through use of passive electrical networks. . . . Roughly speaking, measures of two distinct types of linguistic association can thus be generated—"synonymy" association, which reflects similarity of meaning, and "contiguity" association which reflects relationships among designates. . . .

ERROR PROTECTED NAMES
W. J. Huebner, Jr., Behavioral Sciences Lab., Aeronautical Systems Div., Wright-Patterson AFB, Ohio, Dec. 1963, 22 p., AD 430 714.

. . . Any single name resulting from the application of this system is unique in that at least two of its symbols differ from the symbols in corresponding positions of every other name. . . . Name lists generated by the method described are particularly applicable to identification numbers, license plates, parts lists, etc. . . . A list of 961 three-symbol, error protected names is presented. . . .

ENTROPY OF TAMIL PROSE
G. Siromoney, Inform. Control, vol. 6, no. 3, Sept. 1963, p. 297/300.

The proportions of the different letters of the alphabet in Tamil prose are estimated from a large sample and an optimum code is constructed. The prose is compared with the Tamil poetry of different periods and the one-gram entropy of prose is significantly different from the entropies of the poetical works considered. An estimate is made, experimentally, of the entropy of Tamil prose. . . .

THE BASEBALL PROGRAM: AN AUTOMATIC QUESTION-ANSWERER. VOLUME I.
A. K. Wolf, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Technical rept. no. 306, ESD TDR 63 586, 11 April 1963, 209 p., AD 432 038.

. . . a computer program that answers questions posed in ordinary English about baseball data stored in the computer. . . combined linguistic analysis with data retrieval and processing. . . .

COMPUTER SET AN/GSQ-16 (XW-2). VOLUME II. THE LINGUISTIC APPROACH
T. J. Watson Research Center, Yorktown Heights, N. Y., Final rept., RADC TDR63 100, vol. 2, 23 Sept. 1963, 203 p., AD 431 572.

. . . current status of machine translation work at IBM. . . the Russian Master Dictionary, the bidirectional translation system, and the multipass translation system. . . . The dictionary contains 155,000 entries. . . capable of translating randomly selected texts. . . . The multipass translation program. . . consists of 16 passes, some right-to-left, others left-to-right.

COMPUTER SET AN/GSQ-16 (XW-2). VOLUME III. THE SYSTEM ORGANIZATION
Thomas J. Watson Research Center, Yorktown Heights, N. Y., Final rept., RADC TDR63 100, vol. 3, 23 Sept. 1963, 106 p., AD 431 570.

. . . Automatic Translation System. The data handling and processing requirements for the realization of an effective automatic language processing system, and the processing capabilities of the translation system, are briefly discussed. . . . unique table loop-up logical data processing capability. Both the single-pass and multipass operating modes of the translation system are explained. . . . a description of the Sentence Analyzer Memory and indexing arithmetic . . .

NATIONAL SCIENCE FOUNDATION SYMPOSIUM ON THE CURRENT STATUS OF RESEARCH AT THE LINGUISTICS RESEARCH CENTER THE UNIVERSITY OF TEXAS
Linguistics Research Center, Univ. of Texas, Austin, Rept. no. 63SR1, Oct. 1963, 144 p., AD 422 222.

2.315: Intelligibility Problems of Spoken Information

Included: Theory of speech intelligibility; Speech volumes in communications circuits; Articulation index; Confidence ratings of speech transmissions; Reaction times in speech perception; Perception of special speech sounds; Speech communications in noise; Loudness of voice.

Not Included: Practical intelligibility tests over communication facilities; Perceptron (3B).

Cross References: Linguistic problems of spoken languages (2.314); Linguistic problems of written languages (2.222); Statistical characteristics of special speech sounds (2.310).

Principal Publications:

CONFIDENCE RATINGS AND MESSAGE RECEPTION FOR FILTERED SPEECH
L. Decker, et al., J. Acoust. Soc. Amer., vol. 30, May 1958, p. 432/434.

WORD FREQUENCY AND SPEECH INTELLIGIBILITY FOR UNKNOWN MESSAGE SETS
L. Decker, et al., Presented at 55th Meeting, Acoustical Society America, Washington, D. C., May 1958.

TEST OF PHONEMIC DIFFERENTIATION: THE RHYME TEST
G. Fairbanks, J. Acoust. Soc. Amer., vol. 30, no. 7, July 1958, p. 596/601.

Materials are presented for a test of word identification in which the cues for response are confined to the initial consonants and consonant-vowel transitions. Some preliminary results are discussed.

STUDIES OF THE PERCEPTION OF SPEECH-LIKE SOUNDS
P. Lieberman, Res. Lab. of Elect. MIT, Quarterly Progress Report, July 1958, p. 155/161.

THE SUBJECTIVE MASKING OF SHORT-TIME-DELAYED ECHOES BY THEIR PRIMARY SOUNDS AND THEIR CONTRIBUTION TO THE INTELLIGIBILITY OF SPEECH
J. P. A. Lochner, et al., Acustica, vol. 8, 1958, p. 1/10.

LIMITS OF DIRECT SPEECH COMMUNICATION IN NOISE
J. M. Pickett, J. Acoust. Soc. Amer., vol. 30, no. 4, April 1958, p. 278/281.

Person-to-person tests of sentence intelligibility were carried out in low frequency and white noise at noise levels ranging from 85 to 118 db. Talkers attained shouting levels of vocal effort but the maximum tolerable noise levels for 90% sentence intelligibility and in between talker and listener were estimated to be 95 db for white noise and 105 db for low-frequency noise.

PERCEPTION OF COMPOUND CONSONANTS IN NOISE
J. M. Pickett, Presented at 55th Meeting, Acoustical Society America, Washington, D. C., May 1958.

INTELLIGIBILITY AT HIGH VOICE LEVELS AND THE USE OF A MEGAPHONE
J. M. Pickett, et al., J. Acoust. Soc. Amer., vol. 30, no. 12, Dec. 1958, p. 1100/1104.

STEREOPHONIC LISTENING AND SPEECH INTELLIGIBILITY AGAINST VOICE BABBLE
I. Pollack, et al., J. Acoust. Soc. Amer., vol. 30, no. 2, Feb. 1958, p. 131/133.

Intelligibility of speech against background babble can be improved considerably, if the speech is presented stereophonically. Experiments are described results of measurements shown.

INTELLIGIBILITY OF SELECTED MESSAGE-SETS (Correspondence)
I. Pollack, J. Acoust. Soc. Amer., vol. 30, no. 7, July 1958, p. 643.

INTERAURAL EFFECTS UPON SPEECH INTELLIGIBILITY AT HIGH NOISE LEVELS
I. Pollack, et al., J. Acoust. Soc. Amer., vol. 30, no. 4, April 1958, p. 293/296.

FREQUENCY OF USAGE AND THE PERCEPTION OF WORDS
M. R. Rosenzweig, et al., Science, vol. 127, Feb. 1958, p. 263/266.

INTELLIGIBILITY OF WORDS IN SENTENCES
H. Rubenstein, et al., Presented at 55th Meeting, Acoustical Society America, Washington, D. C., May 1958.

REACTION TIME TO CONSONANT-VOWEL SYLLABLES IN ENSEMBLES OF VARIOUS SIZES
M. G. Saslow, Res. Lab. of Elect. MIT, Quarterly Progress Report, July 1958, p. 143/144.

INFORMATION TRANSMISSION WITH ELEMENTARY AUDITORY DISPLAYS
W. H. Sumby, et al., J. Acoust. Soc. Amer., vol. 30, May 1958, p. 425/429.

The transmission of the letters of the alphabet by tone-coded signals is investigated using codes with two, three or five alternatives per letter and varying each of the four tonal variables. The highest reception rate was obtained with a three-alternative, frequency-coded display.

VOCAL PITCH CHANGES: EFFECTS ON INTELLIGIBILITY TEST SCORES
G. C. Tolhurst, Ohio State U. Research Foundation, April 1958, AD 204 590.

ANNOTATED BIBLIOGRAPHY OF VOICE COMMUNICATIONS RESEARCH COMPLETED UNDER CONTRACT N6ori-104, Task Order II, AD 202 401.

Contents:
Human factors in intelligibility
Speech variables
Psychomotor activity
Personality
Sex
Environmental influences
Characteristics of the message
Voice communication training of talkers
Voice communication training equipment

MULTIPLE OBSERVERS, MESSAGE RECEPTION, AND RATING SCALES
L. R. Decker, et al., J. Acoust. Soc. Amer., vol. 31, no. 10, Oct. 1959, p. 1327/1328.

Two sets of decision rules were employed to select among the responses of three observers. . . . Confidence ratings substantially improved the selection of the correct message reception in the absence of response agreement among observers.

LINGUISTIC CONSIDERATIONS IN THE STUDY OF SPEECH INTELLIGIBILITY
I. Lehiste, et al., J. Acoust. Soc. Amer., vol. 31, no. 3, March 1959, p. 280/286.

Intelligibility is defined as a property of speech communication involving meaning. Since only meaningful units have normal linguistic distributional properties, only meaningful units have the phonetic properties of actual speech. An auditory intelligibility dialect ratio is defined for a listener relative to a specified message. An analysis is presented of the Harvard PB lists, and a set of 10 lists of 50 monosyllables each is presented having an almost exact first-order phonemic balancing.

THE EVOLUTION AND RATIONAL OF THE ICAO WORD-SPELLING ALPHABET
H. M. Moser, Ohio State U. Research Foundation, Columbus, (Technical rept. no. 52; AFCRC TN 59-54), July 1959, AD 227 639.

. . . recommendation of the ICAO alphabet as an optimum list for international communications are summarized. . . . Some 200 word alphabets of the world are appended. (See also AD 111 677).

THE INTELLIGIBILITY OF VERBAL SYMBOLS. II. TWO-, THREE-, AND FOUR-WORD PHRASES OF VERBAL COLOUR SYMBOLS
K. K. Neely, et al., Defence Research Medical Labs., (Canada), (DRML rept. no. 118-3; [Encl. 23 to Air Attache, Ottawa, rept. no. TL-78-59]), March 1958, 18 p., AD 218 032.

LOW-FREQUENCY NOISE AND METHODS FOR CALCULATING SPEECH INTELLIGIBILITY
J. M. Pickett, J. Acoust. Soc. Amer., vol. 31, no. 9, Sept. 1959, p. 1259/1263.

Speech intelligibility was tested in a low-frequency masking noise. Various conditions of speech and noise filtering below 1200 cps were employed in order to test the relative effects of direct low-frequency masking and upward spread of masking to higher frequency regions. . . .

CONFIDENCE RATINGS, SECOND-CHOICE RESPONSES, AND CONFUSION MATRICES IN INTELLIGIBILITY TESTS
F. R. Clarke, J. Acoust. Soc. Amer., vol. 32, no. 1, Jan. 1960, p. 35/46.

EXPERIMENTAL STUDY OF THE RELATIVE INTELLIGIBILITY OF ALPHABET LETTERS
E. T. Curry, et al., J. Acoust. Soc. Amer., vol. 32, no. 9, Sept. 1960, p. 1151/1157.

RELATION BETWEEN LOUDNESS AND DURATION OF TONAL PULSES. II. RESPONSE OF NORMAL EARS TO SOUNDS WITH NOISE SENSATION
F. Miskolczy-Fodor, J. Acoust. Soc. Amer., vol. 32, no. 4, April 1960, p. 482/486.

ANALYSIS OF INCORRECT RESPONSES TO AN UNKNOWN MESSAGE SET
I. Pollack, et al., J. Acoust. Soc. Amer., vol. 32, no. 4, April 1960, p. 454/457.

PROPOSED METHODS FOR THE CALCULATION OF THE ARTICULATION INDEX
K. D. Kryter, Bolt, Beranek, and Newman, Inc., Cambridge, Mass., (Rept. no. 906) (ESD TDR 62-35), Oct. 1961, 20 p., illus., tables, 19 refs., AD 275 558.

DECISION UNITS IN THE PERCEPTION OF SPEECH
G. A. Miller, IRE Trans. Inform. Th., vol. IT-8, no. 2, Feb. 1962, p. 81/83.

Summary—It has been shown experimentally that speech intelligibility is a function of grammatical content. This fact implies that automatic speech recognizers may well need to include information about linguistic structure.

COMPUTATION AND MEASUREMENT OF SPEECH INTELLIGIBILITY
N. B. Pokrovskiy, Joint Publications Research Service, Washington, D. C., Nov. 18, 1963, 350 p., refs., Transl. into English of a book "Raschet i Izmereniye Razborchivosti Rechi" Moscow, Svyaz'izdat, 1962, p. 1/391, (Its Foreign Develop. in Machine Transl. and Inform Process. No. 44) (JPRS-21-885; OTS-63-41146), N64-10381.

. . . presents a theory of speech intelligibility, and gives a qualitative and quantitative description of the properties and acoustical characteristics of speech and hearing which determine the amount of phonetic and semantic information conveyed by telephone and radiotelephone communications channels. . . methods of experimental determination of speech intelligibility by articulation measurements. . . fundamentals of computing optimal electroacoustical characteristics of voice channels in telephone and radiotelephone apparatus. . .

ELECTRONIC EVALUATION OF VOICE COMMUNICATIONS SYSTEMS
R. E. Fitts, Rome Air Development Center, Griffiss AFB, N. Y. Electromagnetic Lab., (RADC-TDR-63-355), Aug. 1963, 37 p., 23 refs., N63-21675.

. . . the Voice Interference Analysis Set . . . tested to determine if it produced results equivalent to articulation tests. In the laboratory. . . results compared with articulation tests. . . field test. . . analyzed for correlation between the two evaluations. . . it is concluded that electronic evaluation of voice communications systems is possibly subject to certain restrictions . . . certain theoretical and practical limitations of the Voice Interference Analysis Set are discussed.

SPEECH VOLUMES ON BELL SYSTEM MESSAGE CIRCUITS—1960 SURVEY
K. L. McAdoo, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 1999/2012.

. . . measured at class 5 offices. Data are presented for intrabuilding, interbuilding, tandem and toll connections. Average speech volume are lowest for intrabuilding calls and increase in level for the other types of connections, with volumes on toll calls being the highest. In general, volumes on business calls are higher than those on social calls, and men speak louder than women. Speech volumes remain substantially the same in locations comparable to those in a survey made in 1950.

Related Publications:

MESSAGE PROCEDURES FOR UNFAVORABLE COMMUNICATION CONDITIONS
I. Pollack, J. Acoust. Soc. Amer., vol. 30, no. 3, March 1958, p. 196/201.

INTELLIGIBILITY OF REITERATED SPEECH
D. J. Sharf, J. Acoust. Soc. Amer., vol. 31, no. 3, March 1959, p. 423/427.

SEMANTIC REACTIONS TO SYSTEMATICALLY VARIED SOUNDS
L. N. Solomon, J. Acoust. Soc. Amer., vol. 31, July 1959, p. 986/990.

THE PERCEPTRON—AN EXPERIMENT IN LEARNING
W. E. Bushor, Electronics, vol. 33, no. 30, July 1960, p. 56/59.

BINAURAL INTERACTION OF HIGH-FREQUENCY COMPLEX STIMULI
E. E. David, Jr., et al., Bell System Tech. J., vol. 39, no. 2, March 1960, p. 423.

2.316: Electrical Analogs of Human Speech Organs

Included: Electrical analog of the human ear; Artificial larynx; EVA = electronic vocal analog; DAVO = dynamic analog of the vocal tract.

Not Included: Physiological problems of speech organs.

Cross References: Intelligibility problems of speech (2.315).

Principal Publications:

OBSERVATIONS ON THE ACOUSTICAL AND MECHANICAL PROPERTIES OF THE VOCAL CORDS
B.R. Fink, et al., Presented at 55th Meeting, Acoustical Society America, Washington, D.C., May 1958.

ESTIMATION OF FORMANT BANDWIDTHS FROM MEASUREMENTS OF TRANSIENT RESPONSE OF THE VOCAL TRACT
A.S. House, et al., J. Speech and Hearing, Dec. 1958, Also available: Acoustics Lab., MIT, Cambridge, 1958, Scientific Report 19, AFCRC TN 59-107, p. 1/7, AD 208 771.

VOCAL VIRILIZATION
J.C. Licklider, Presented at 55th Meeting, Acoustical Society America, Washington, D.C., May 1958.

FUNDAMENTALS OF TESTING THE HEARING OF SPEECH (In German)
F.J. Meister, Arch. Tech. Messen, vol. 264, Jan. 1958, p. 7/8.

DYNAMIC ANALOG SPEECH SYNTHESIZER
G. Rosen, J. Acoust. Soc. Amer., vol. 30, no. 3, March 1958, p. 201/209.

Describes an analog of the vocal tract. There are 14 sections, each individually controllable. The technical details about variable capacitance and variable inductances are described in detail. . . .

INFORMATION TRANSMISSION WITH ELEMENTARY AUDITORY DISPLAYS
W.H. Sumby, et al., J. Acoust. Soc. Amer., vol. 30, no. 5, May 1958, p. 425/429.

MEASUREMENT OF THE CROSS-SECTIONAL AREAS OF VOCAL TRACTS
R.W. Wendahl, Presented at 55th Meeting, Acoustical Society America, Washington, D.C., May 1958.

AN EXPERIMENTAL TRANSISTORIZED ARTIFICIAL LARYNX
H.L. Barney, et al., Bell Syst. Tech. J., vol. 38, no. 6, Nov. 1959, p. 1337/1356.

. . . makes use of transistors and miniaturized components to provide a voice for those who have lost the use of the vocal cords by surgical removal or paralysis.

ACOUSTIC ANALYSIS AND SYNTHESIS OF SPEECH WITH APPLICATIONS TO SWEDISH
G. Fant, Ericsson Tech., vol. 15, no. 1, 1959, p. 3/108.

. . . A theoretical analysis of the vocal tract transmission characteristics is made on the basis of the theory of electrical transmission lines and Laplace transforms. Pole-zero specifications of transfer functions as well as inverse transforms are discussed and applied to problems of speech specification and the design of electrical analogs to the vocal tract.

NATURE OF THE VOCAL CORD WAVE
R.L. Miller, J. Acoust. Soc. Amer., vol. 31, June 1959, p. 667/677.

The shape of the vocal cord wave is an important parameter in a true analog representation of the vocal mechanism, since speech is a function of both the generator wave shape and the transfer impedance of the vocal tract, The shape has been determined by two methods; by using an electrical network which is "inverse" to the vocal tract and by study of motion pictures of the vocal cord. . . .

ESTIMATES OF INTRAGLOTTAL PRESSURE DURING PHONATION
J. L. Flanagan, Bell System Tech. J., vol. 39, no. 2, March 1960, p. 424.

NATURE OF THE VOCAL CORD WAVE
R.L. Miller, Bell System Tech. J., vol. 39, no. 2, March 1960, p. 425.

COMPUTER CONTROL OF AN ANALOG VOCAL TRACT
J.B. Dennis, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 1962, 8 p., incl. illus., 4 refs., AD 289 271.

DAVO is a dynamic analog of the vocal tract and consists of two parts—an electrical model of the human vocal mechanism and a control system for programming utterances. . . .

PHONATION ET FONCTIONNEMENT IMPULSIONNEL DU LARYNX (Sound Formation and Pulse Response of the Larynx) (In French)
J.C. Lafon, et al., Ann. Telecomm., vol. 17, no. 5-6, May/June 1962, p. 107/116.

RECOGNITION OF SOUNDS BY COCHLEAR PATTERNS
W. F. Caldwell, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 179/185.

An electrical analog of the human ear has been developed to provide real-time cochlear patterns of subjective loudness along the basilar membrane. Resulting spatial patterns may be analogous to those found in the auditory centers of the central nervous system. . . .

AN ELECTRONIC ANALOG OF THE EAR
E. Glaesser, et al., Santa Rita Technology, Inc., Menlo Park, Calif., AMRL TD 63 60, June 1963, 66 p., AD 411 320.

An electrical analog of the human ear is described, which includes the external and middle ear, the cochlea, and part of the neutral structure of the cochlea and the higher auditory centers of the central nervous system . . . A pattern theory of loudness detection and sound recognition is discussed . . . The neural volley effect is included. Studies indicate that sound recognition with the analog is similar to that for a human.

AN ANALYSIS OF SPEECH SPECTRA IN TERMS OF A MODEL OF ARTICULATION
J.M. Heinz, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, Rept. no. SR15, AFCRL 63 557, Sept. 1963, 6 p., AD 430 194.

. . . programs to compare an internally generated spectrum with an actual speech spectrum and to vary manually the input parameters until an optimum match is obtained. The results of the match are parameters which relate to the physical dimensions of the vocal tract . . . Currently, data are being collected by this procedure, particularly in the vicinity of vowel-consonant boundaries. . . .

TUNING BETWEEN CENTRAL AUDITORY PATHWAYS AND THE EAR
W.D. Keidel, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 131/143, 62 refs.

Emphasis in research on auditory signal reception has shifted in recent years from studies of the peripheral area alone to include more and more the central portion of the auditory pathways. The findings are characterized by timing mechanisms well balanced between excitatory and inhibitory processes on the one hand and both the selection of auditory information and the concept of two channels of the auditory transmission system on the other.

EXTRACTION OF PITCH FROM THE TRACHEA
H.C. Porter, Air Force Combridge Research Labs., Bedford, Mass., Rept. no. AFCRL 63-24, Feb. 1963, 10 p., incl. illus., 3 refs., AD 401 920.

In a series of experiments investigating tracheal pitch extraction according to a methodology suggested in a Japanese paper, reasonably accurate real-time pitch extraction was achieved. The method has limitation in that the talker must wear a special appliance.

Related Publications:

UNRELEASED VELAR PLOSIVES AFTER BACK-ROUNDED VOWELS (Correspondence)
P. Delattre, J. Acoust. Soc. Amer., vol. 30, no. 6, June 1958, p. 581/582.

Discussion about transitions, cues and loci of p,t,k. Indication that locus and transition depends on preceeding vowel .

FUNDAMENTAL PROBLEMS IN SPEECH PHYSIOLOGY
G.E. Peterson, Presented at 55th Meeting, Acoustical Society America, Washington, D.C., May 1958.

DETECTION OF A PULSED SINUSOID IN NOISE AS A FUNCTION OF FREQUENCY
D.M. Green, et al., J. Acoust. Soc. Amer., vol. 31, no. 11, Nov. 1959, p. 1446/1452.

The detectability of a pulsed sinusoid (0.1 sec) in white noise was measured at sixteen frequencies ranging from 250 to 4000 cps. . . . allows us to determine approximately how the auditory system sums energy over frequency. . . . to relate human performance in signal detection to the theory of ideal detectors . . .

ELECTRO-ACOUSTICS FOR HUMAN LISTENERS
C. Cherry, J. Brit. Instn. Radio Engrs., vol. 21, no. 1, Jan. 1961, p. 5/15.

. . . The way in which human listeners distinguish sounds is discussed and its applications in speech compression systems considered. . . . relationship between speech perception and speech production . . . Stereophonic hearing . . . What is it that an electro-acoustic transducer, such as a microphone, a loudspeaker or a stereophony system, is really required to do? . . .

UN VOCODER MECHANIQUE: LA GUIMBARDE (A Mechanical Vocoder: The Guimbarde) (In French)
E. Leipp, Ann. Telecomm., vol. 18, no. 5-6, May/June 1963, p. 82/87.

2.318: Characteristics of Other One-Dimensional Information Sources

Included: Statistical characteristics of music; Music from mathematics; Electronic music synthesis.

Not Included: Electronic music generation; Spectra of musical instruments.

Cross References: Statistics of information sources in general (2.221).

Principal Publications:

ENERGY DISTRIBUTION IN MUSIC
J. P. Overley, Proc. Instn. Radio Engrs. Australia, vol. 19, Feb. 1958, p. 54/57.

KOMPONIEREN MIT ELEKTRONISCHEN RECHENAUTOMATEN (Composing Music by Electronic Computers) (In German)
P. G. Neumann, et al., Nachrichtentech. Z., vol. 12, Aug. 1959, p. 403/407.

ELECTRONIC MUSIC SYNTHESIS
H. F. Olsen, et al., J. Acoust. Soc. Amer., vol. 32, no. 3, March 1960, p. 311/319.

MATHEMATICAL ANALYSIS OF FORMAL STRUCTURE OF MUSIC
W. Fucks, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 225/228.

Statistical properties of music and their development since about 1500 have been studied; e.g., the properties of frequency distributions of pitch and duration of tones, of intervals of consecutive tones, correlograms of various parameters up to distances of 30 of these parameters, matrices of transition probabilities of various parameters. . . .

MUSIC FROM MATHEMATICS (A RECORDING)
New York, Decca Records, 1962, 33 1/3 rpm.

Related Publications:

ABSOLUTE AMPLITUDES AND SPECTRA OF CERTAIN MUSICAL INSTRUMENTS AND ORCHESTRA
L. J. Sivian, et al., Bell Syst. Tech. J., vol. 39, no. 2, March 1960, p. 426.

Section 2.32
Special Processing Methods in Speech Compression

2.322: Speech Re-Iteration Methods

Included: Interrupted speech methods; Jamming applications of speech re-iteration experiments; Intelligibility of re-iterated speech.

Not Included: Jamming problems in communications channels (1).

Cross References: Time domain analysis of speech (2.313); Intelligibility problems of speech compression methods (2.315).

Principal Publications:

INTELLIGIBILITY OF REITERATED SPEECH
D. J. Sharf, J. Acoust. Soc. Amer., vol. 31, no. 4, April 1959, p. 423/427.

An attempt is made to increase the intelligibility of speech sampled in time (interrupted speech) by filling in the blank spaces with repetitions of the speech samples (reiterated speech). The experiment involves the evaluation of these processes of speech distortion in quiet and in noise with two duty cycles (speech-time fractions), with various rates of interruption of the speech signal, and with various buildup and decay times in the switching operation. The results indicate that (1) there is little difference between the intelligibility of reiterated speech and interrupted speech in quiet, (2) reiterated speech is more intelligible than interrupted speech in noise if signal measurements are based on instantaneous amplitudes of the speech samples, and (3) buildup and decay has little effect on the intelligibility of interrupted speech when the entire buildup phase is confined to the "on" time of the switching period.

A PRACTICAL IMPLEMENTATION OF REITERATED SPEECH CONCEPTS
R. K. Paxton, Nat. Comm. Symp. Rec., vol. 7, Oct. 1961, p. 42/49.

JAMMING IMPLICATIONS OF EXPERIMENTS ON INTERRUPTED SPEECH
D. W. Tufts, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 324/333.

INTERRUPTED SPEECH AND THE POSSIBILITY OF INCREASING COMMUNICATION EFFICIENCY
P. V. Indiresan, J. Acoust. Soc. Amer., vol. 35, no. 3, March 1963, p. 405/407.

It is known that speech remains intelligible when it is interrupted at a slow rate (about 50 c/s). Such interruption reduces the time duration of transmission without increasing the bandwidth and hence can increase the effective utilization of a communication channel. The reasons for the intelligibility of interrupted speech are explained, and the theoretical limits to the interruption rate and sampling period are estimated. . . . will not be directly suitable for communication purposes because of switching noise. Three methods for overcoming this noise, namely, by reverberation, by integration, and by the reiteration of synchronized speech samples are described. . . .

Related Publications:

DEMULTIPLEXER-MULTIPLEXER TD-( )/GSC
Electro-Mechanical Research Inc., Sarasota, Fla., Technical note, (RADC TN61-90), 1 June 1961, lv. incl. illus., AD 258 729.

. . . development of a three-channel speech-processing equipment capable of transmitting and receiving three telephone messages simultaneously. . . . Accomplished through speech reiteration principles. . . . Circuit design and testing of the basic system concept. Results show that the concept is valid, that there are excellent possibilities for further improvement, and that other applications for the basic concept need investigation. (See also AD 268 428).

ASYNCHRONOUS PULSE-CODE MODULATION
J. D. Howells, Electronics, vol. 35, no. 42, Oct. 1962, p. 58/60.

When clocks at receiver and transmitter are not synchronized samples of a speech waveform may be lost. The system described fills the gaps with a work sample generated at the receiver. The only apparent effect is a barely audible click at the output.

VARIABLE-SPEED RECORDER-REPRODUCER
T. Lanyi, et al., American Scientific Corp., Alexandria, Va., Quarterly progress rept. no. 1, (Rept. no. RR 1733), 5 May - 5 Nov. 1962, 27 Nov. 1962, 112 p., incl. illus., tables, AD 296 401.

. . . Deviations from conventional magnetic recording . . . unorthodox tape transport . . . Design and construction changes are described for changes from one-channel operation to a dual-channel system.

TWO NEW SPEECH COMMUNICATION SYSTEMS
J. L. Stewart, Arizona U., Tucson, Final rept. for 15 Dec. 1960-14 Dec. 1961 on Biological Information Handling Systems and Their Functional Analogs, March 1962, 22 p. incl. illus., 29 refs, AD 278 711.

. . . provide certain efficiencies in speech channel usage. One system achieves the equivalent of modest bandwidth compression by permitting two-to-one time multiplexing with simple terminal equipment and with a standard speech (telephone) channel. The other, based on extraction of equivalent amplitude, frequency, and phase modulating components of speech, may yield bandwidth compression comparable to that of a formant-tracking vocoder.

2.323: Speech Clipping Methods

Included: SSB clipping; Infinitely clipped speech; Multiple tone clipping; Constant amplitude speech.

Not Included: Limiter circuits.

Cross References: Intelligibility problems of speech processing systems (2.315); Analog speech compaction methods (Sect. 2.34).

Principal Publications:

VOWEL RECOGNITION IN CLIPPED SPEECH
R. Ahmed, Nature, vol. 181, Jan. 1958, p. 210.

CONSTANT AMPLITUDE SPEECH
P. J. Ferrell, IRE Nat Conv. Rec., vol. 6, no. 8, March 1958, p. 190/191.

ON THE POWER GAINED BY CLIPPING SPEECH IN THE AUDIO BAND
W. Wathen-Dunn, et al., J. Acoust. Soc. Amer., vol. 30, Jan. 1958, p. 36/40.

EFFECT OF SAMPLE DURATION ON THE ARTICULATION OF SOUNDS IN NORMAL AND CLIPPED SPEECH
R. Ahmend, et al., J. Acoust. Soc. Amer., vol. 31, July 1959, p. 1022/1029.

INTELLIGIBILITY OF PEAK-CLIPPED SPEECH AT HIGH NOISE LEVELS
I. Pollack, et al., J. Acoust. Soc. Amer., vol. 31, Jan. 1959, p. 14/16.

The effect of symmetrical speech peak clipping upon speech intelligibility in noise was examined. Over a wide range of conditions, intelligibility is independent of the

level of peak clipping if the postclipping speech power is held constant. Peak clipping thus achieves protection of the ear against painfully loud speech without demanding a penalty of intelligibility. Indeed, under restricted ranges of conditions, peak clipping may actually improve intelligibility with a constant speech power.

SPEECH BANDWIDTH COMPRESSION SYSTEM (SCANNING FILTER)
A. P. Albanese, et al., PRD Electronics, Inc., Brooklyn, N. Y., Final rept. no. 4, 1 July 1960-30 Sept. 1961, (Rept. no. 341.0911FR), Sept. 1961, 82 p., AD 268 351.

. . . A statistical analysis was made to determine the scanning waveforms based on articulation scores for selected zero crossings of infinitely clipped speech. . . .

ANALYSIS OF MULTIPLE TONE CLIPPING
C. J. Styers, IRE Internat. Conv. Rec., vol. 8, March 1961, p. 134/149.

. . . study of the consequences of clipping in a multiple-tone system . . . Mathematical expressions furnish the exact number of jth order; intermodulation terms; including the number of signal terms, in-phase noise terms, and randomly-phased noise terms.

From these expressions is obtained a net peak-signal to rms-noise voltage ratio as a function of the clipping level. The effect of clipping upon the binary error rate is investigated.

SPEECH-SIGNAL PROCESSING AND APPLICATIONS TO SINGLE SIDEBAND
N. A. Shyne, Montana State Coll., Bozeman, Final rept. March 1962, 110 p. incl. illus., tables, 24 refs., AD 276 850.

. . . SSB clipping provided the most significant increase . . .

Related Publications:

A NEW PULSE MODULATED SPEECH COMMUNICATION SYSTEM HAVING A MINIMUM DUTY CYCLE
R. O. Eastman, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 114/118.

. . . The system provides adequate naturalness of speech while maintaining a quantized sampling rate which is proportional to the information bandwidth. . . . generating infinitely clipped signals . . . deriving an optimum sampling rate from these signals. . . . two separate forms of information, amplitude and frequency, are conveyed by a time modulated pulse. . . . results of tests conducted through the system.

EXPERIMENTAL NARROW-BAND SPEECH SYSTEM
J. H. Ball, et al., Bolt, Beranek and Newman, Inc., Cambridge, Mass., Rept. no. 10 (Final), 15 June 1958-13 Oct. 1963, 13 Nov. 1963, 30 p., AD 436 463.

This system involves filtering from the normal speech signal six relatively narrow bands of frequencies which are transposed to form a single, contiguous band prior to transmission. The system includes, as an optional feature, circuits for achieving 18 dB of rf peak-clipping. The results of speech intelligibility tests indicate that this narrow-band system, when operated in the digital mode, provides PB word scores of about 90% correct, when 9600 bits/sec are transmitted, and 60% when 4800 bits/sec are transmitted. When operated in the analog mode (1200 cps bandwidth), the system scores about 90% correct on PB word tests. It was found that combining spectrum-sampling and time-division or time-sharing amongst the narrow bands of speech during transmission in order to achieve a reduction in the information rate required to transmit the speech did not provide satisfactory speech intelligibility.

2.324: Quasi-Period Selection Method

Included: Quasi-periodic characteristics of vowels.

Not Included: Phonetic analysis of speech sounds.

Cross References: Time domain analysis of speech waveforms (2.313).

Principal Publications:

A METHOD OF SPEECH COMPRESSION
R. Lerner, Lincoln Lab., MIT, Lexington, 24 Aug. 1959, AD 244 920.

. . . to determine what improvements could be effected in the operation of Vocoder-type speech compression systems by properly making use of the structure introduced into the speech waveform by the period voicing of most sounds . . . are quasi-periodic . . . Apparatus was constructed which selects for presentation to the ear one in every M cycles of the input speech waveform. To simulate a speech signal in the time interval between selections, the selected waveform is repeated until its selected waveform is repeated until its successor becomes available. This device is a pitch-synchronous speech chopper operating at a compression ratio M.

Section 2.33

2.330: Spectral Speech Processing Methods

Included: Vocoder methods; Multiplex vocoder; Formoder system; Formant vocoder; Channel vocoder; Semi-vocoder; Polymodal vocoder; Formant tracking vocoder system.

Not Included: Design and operation of vocoder equipment.

Cross References: Spectral analysis of speech signals (2.312); Digital vocoder (2.350).

Principal Publications:

SPEECH ANALYSIS
S. H. Chang, Electronics Res. Lab., Northeastern U., Boston, Mass., Final Scientific Report 1, March 1957-31 Jan. 1958, Report No. AFCRC TR 58-107, 28 Feb. 1958, 36 p., AD 146 814.

A summary is presented of studies directed toward the specification of important parameters of speech in speech-band compression systems. The Formoder (Formant-Moment Coder) was described as an experimental speech-band compression system which makes use of from 5 to 7 narrow-band parametric channels (each a 25-c width) to convey information of speech. . . .

PHONETIC PATTERN RECOGNITION VOCODER FOR NARROW-BAND SPEECH TRANSMISSION
H. Dudley, J. Acoust. Soc. Amer., vol. 30, no. 8, Aug. 1958, p. 733/739.

This paper describes a spectral pattern recognition device. Also synthesizer is described. The analyzer identifies the phoneme by its spectral pattern and a corresponding message is transmitted. The corresponding frequency band is about 50 cps. The recognition process assures that spoken words can be printed as phonetic text.

COMMUNICATION EFFICIENCY OF VOCODERS
A. R. Billings, Electronic and Radio Engrg., vol. 36, Dec. 1959, p. 449/453.

SIMPLE MULTIPLEX VOCODER
A. R. Billings, Electronics and Radio Engrg., vol. 36, May 1959, p. 184/188.

SPEECH ANALYSIS
S. H. Chang, et al., Electronics Res. Lab., Northeastern U., Boston, Mass., Scientific Report #1, 15 Jan.-30 June 1958, Report No. AFCRC TN-58-181, June 1959, 41 p., AD 152 429 (Also AD 146 814).

This report summarizes speech analysis studies. Chapter I describes the recent improvements in the Formoder, an experimental speech-band compressions system, and tests designed to evaluate the relative importance of the parameters of the system. Chapter II describes a comparative evaluation of the Formoder and the Melpar Speech Compression System. . . .

SPEECH ANALYSIS
S. H. Chang, et al., Electronics Res. Lab., Northeastern U., Boston, Mass., Final Report, 15 Jan. 1958-31 Aug. 1959, Report #AFCRC TR-59-187, Aug. 1959, 69 p., AD 226 291 (Also AD 146 814 and AD 152 429).
Experimental studies with the Formoder System
- Analysis-synthesis of turbulent sounds
- Variation of parameter channel bandwidth
- Pitch Excitation Studies
- Recognition of voiced-stop sounds

Digitization of Formoder parameters
- Reasons for study
- Preliminary investigation
- Measurement of information handling rate

Formoder instrumentation
- Filter design
- Plan for frequency parameter digitization
- Synthesizer redesign

EFFICIENCY OF VOCODERS (Correspondence)
D. A. Bell, Electronic Technol., vol. 37, July 1960, p. 287.

Short note about the fact that a 10 channel vocoder can be quantized and transmit voice at 1200 b/sec. The assumptions made are: 8 levels and sampling in 30 msec. intervals. . . .

A CORRELATOR EMPLOYING HALL MULTIPLIERS APPLIED TO THE ANALYSIS OF VOCODER CONTROL SIGNALS
A. R. Billings, et al., Proc. Instn. Elec. Engrs., pt. B, vol. 107, no. 35, Sept. 1960, p. 435/438.

. . . discussion of short-term correlation functions . . . design and performance of an auto- and cross-correlator using Hall-effect multipliers . . . It is shown that these devices are well suited to act as the multiplying elements and as modulators in associated circuits, provided that one of the time functions to be multiplied has a narrow bandwidth. Examples of measured auto- and cross-correlation functions are given for sine waves and noise and for the control signals of a vocoder, from which interesting conclusions can be drawn about the redundancy of vocoder signals. . . .

VOCODER INCREASES CHANNELS, SECURITY
P. J. Klass, Aviation Week, vol. 73, no. 4, July 1960, p. 67/69.

INTELLIGIBILITY OF THE CHANNEL VOCODER IN THE PRESENCE OF WHITE NOISE
N. R. Getzin, et al., Nat. Comm. Symp. Rec., vol. 7, Oct. 1961, p. 59/63.

. . . to (a) describe the channel vocoder and the methods used for the evaluation of the performance in the presence of noise (b) establish criteria by which the channel vocoder can be compared to normal speech communication systems, and (c) draw conclusions from the comparison . . .

FEASIBILITY STUDY OF TRANSISTORIZED CODER-MULTIPLEXER
A. S. Howell, General Dynamics/Electronics, Rochester, N. Y., (Rept. no. 1820-TN-2), (RADC TN-61-146), July 1961, 30 p., AD 262 021.

. . . feasibility of providing a system of multiple vocoders fed from telephone inputs and operating over a single voice-frequency channel. . . . Means of optimum pitch extraction and spectrum synthesis, appropriate to speech processing in the analog or binary modes, were investigated. A system of narrow-band multiplexing, compatible with analog transmission, was developed. . . . Successful analog multiplexing of a telephone semi-vocoder within a 900 c bandwidth was accomplished. The system comprises time sampling of the spectrum energy and the transmission of this information, using vestigial sideband techniques. A compatible synchronizing system was achieved.

TSEC/HY-2 CHANNEL VOCODER, MODIFIED
P. E. McChesney, Philco Corp., Philadelphia, Pa., Quarterly rept. 1, 1 June-31 Aug. 1961, 40 p., AD 266 389.

Research is conducted to design, develop, construct and deliver 2 equipments for the laboratory and field evaluation of VOCODER systems. . . The modifications required to make them adaptable to the various digital modes of operation are described . . . The various operational modes are compatible with several transmission bit rates, and can be programmed to vary the number of spectrum channels, spectrum coding levels per sample, and coding levels per sample; any or all of these options can be utilized in either a VOCODER or Semi-VOCODER mode.

FORMANT VOCODER SPEECH COMPRESSION SYSTEM (EXPERIMENTAL MODEL)
L. C. Stewart, General Dynamics/Electronics, Rochester, N. Y., Quarterly rept. 1, 30 Oct. 1961, 21 p., AD 270 971.

. . . to construct an experimental model Formant Vocoder Speech Compression System. The design objective is a 1500 bit-per-second system having a minimum articulation index of 80% for a phonetically balanced word list.

FORMANT VOCODER SPEECH COMPRESSION SYSTEM (EXPERMENTAL MODEL)
L. C. Stewart, General Dynamics/Electronics, Rochester, N. Y., Quarterly progress rept. no. 2, 1 Oct. - 31 Dec. 1961, 31 Dec. 1961, 10 p. incl. illus., AD 277 009.

SUBSCRIBER ACTIVITY-MEASUREMENT OF SOME PERFORMANCE FACTORS OF VOCODERS
C. W. Vaderson, ITT Federal Labs., Palo Alto, Calif., Final rept. ESD TDR 64 227, 31 Oct. 1961, 50 p., AD 431 582.

. . . to determine the degree of intelligibility and overall quality factors of certain speech processing devices. A magnetic tape catalog of speech samples from these devices was prepared for further reference. Additional speech processing equipment data such as size, weight, cost, etc., is summarized. . . Input magnetic test tapes, containing speech with several background conditions, were run through the speech processing devices while in back-to-back operation. . . .

VOICE-EXCITED VOCODERS FOR PRACTICAL SPEECH BANDWIDTH REDUCTION
E. E. David, Jr., et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S101/105.

In spite of their great potential for bandwidth saving in long distance telephony, vocoders have not found wide-spread acceptance. Two major problems . . . First is their strong electrical accent. Second is the so-called "pitch problem;" . . . This limitation can be removed by a new method known as "voice excitation," which eliminates the necessity for a decision making pitch detector. . . . A voice-excited vocoder (VEV) with a 720 cps (250-970 cps) baseband and 17 spectrum channels low-passed to 25 cps each, covering the band 970-3700 cps, has been built and evaluated. . . . Quality tests indicate that listeners rate VEV speech "as good as" the input in about 90% of the test utterances. Only 19% of conventional vocoder utterances were so considered. . . . The transmission band required only 1200 cps.

FORMANT TRACKING VOCODER SYSTEM
D. M. Early, et al., Melpar Inc., Falls Church, Va., Quarterly rept. no. 1, 1 Sept. - 30 Nov. 1962, 107 p., AD 406 128, AD 298 665.

. . . development of formant vocoder speech bandwidth compression systems . . . to provide solutions to problems involved in automatically obtaining control parameters for a serial analog speech synthesizer . . . specific conclusions pertaining to final system design are not made at this time.

FORMANT TRACKING VOCODER SYSTEM
S. J. Campanella, et al., Melpar, Inc., Falls Church, Va., Quarterly rept no. 2, 1 Dec. 1962 - 28 Feb. 1963, 79 p., AD 409 099.

. . . two new formant tracker concepts called Formant Period Tracking and Inverse Network Tracking. Studies have progressed on the derivation of the amplitude parameters (AO, AN, AH, AC) needed for exciting a serial vocal analog. Additional effort has been started on improved synthesis of nasalized sounds by more sophisticated synthesis techniques. Design and development efforts on the transitorized serial analog speech synthesizer have been completed . . .

PITCH-INDUCED SPECTRAL DISTORTION IN CHANNEL VOCODERS
B. Gold, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, 19 Nov. 1962, 2 p., AD 411 891.

. . . severe spectral distortion can be expected in a channel vocoder driven by unsmoothed pitch pulses during those intervals when the pitch is not constant. A vocoder-synthesizer configuration is proposed that minimizes this effect. . . .

CODER-MULTIPLEXER KY-279 ( )/FSC
A. S. Howell, General Dynamics/Electronics, Rochester, N. Y., Final Technical rept. (Rept no. 1820-TDR-1), (RADC TDR 62-490), Sept. 1962, 29 p. incl. illus., AD 290 207.

. . . a full-duplex speech processing terminal. When two such terminals are interconnected they provide a complete bandwidth reduction system accommodating the transmission of three simultaneous telephone conversations within a nominal 3-kc bandwidth. . . .

VOCODER EVALUATION STUDIES
W. F. Meeker, et al., RCA Defense Electronic Products, Camden, N. J., (Scientific rept. no. 3), 74 p. incl. illus., tables, 11 refs, AD 281 836.

Speech transmitted via vocoder suffers peculiar distortions which make evaluation difficult. . . . intelligibility, speech quality, and talker recognition. . . . approximately 70 Air Force communications personnel to elicit their judgments of six speech samples representing a range of vocoder systems. . . . suitability for normal use and preference. . . . Laboratory measurements . . . additional vocoder modifications, including the effects of one, two and three-bit quantization of the normalized spectrum.

FORMANT VOCODER SPEECH COMPRESSION SYSTEM (EXPERIMENTAL MODEL)
L. C. Stewart, General Dynamics/Electronics, Rochester, N. Y., Quarterly progress rept. no. 3, 1 Jan. - 31 March 1962, 31 March 1962, 13 p. incl. illus., AD 276 654.

Effort . . . to construct . . . a 1500 bit-per-second system having a minimum articulation index of 80% for a phonetically balanced word list.

TWO NEW SPEECH COMMUNICATION SYSTEMS
J. L. Stewart, Arizona U., Tucson, Final rept. for 15 Dec. 1960 - 14 Dec. 1961 on Biological Information Handling Systems and Their Functional Analogs, March 1962, 22 p. incl. illus., 29 refs., AD 278 711.

. . . provide certain efficiencies in speech channel usage. One system achieves the equivalent of modest bandwidth compression by permitting two-to-one time multiplexing with simple terminal equipment and with a standard speech (telephone) channel. The other, based on extraction of equivalent amplitude, frequency, and phase modulating components of speech, may yield bandwidth compression comparable to that of a formant-tracking vocoder.

EXPERIMENTAL NARROW-BAND SPEECH SYSTEM
J. H. Ball, et al., Bolt, Beranek and Newman, Inc., Cambridge, Mass., Rept. no. 10, (Final) 15 June 1958 - 13 Oct. 1963, 13 Nov. 1963, 30 p., AD 436 463.

This system involves filtering from the normal speech signal six relatively narrow bands of frequencies which are transposed to form a single, contiguous band prior to transmission. The system includes, as an optional feature, circuits for achieving 18 dB of rf peak-clipping. The results of speech intelligibility tests indicate that this narrow-band system, when operated in the digital mode, provides PB word scores of about 90% correct, when 9600 bits/sec are transmitted, and 60% when 4800 bits/sec are transmitted. When operated in the analog mode (1200 cps bandwidth), the system scores

about 90% correct on PB word tests. It was found that combining spectrum-sampling and time-division or time-sharing amongst the narrow bands of speech during transmission in order to achieve a reduction in the information rate required to transmit the speech did not provide satisfactory speech intelligibility.

FORMANT TRACKING VOCODER SYSTEM
S. J. Campanella, et al., Melpar Inc., Falls Church, Va., Quarterly rept. no. 4, 1 June - 31 Aug. 1963, 15 Sept. 1963, 71 p., AD 427 237.

. . . study of improved logics utilizing amplitude and other additional information for improving the control of Adaptive Filters . . . evaluation and improvement of the analyzer breadboard including: specific design data collected on the adaptive filters, control logic improvement for the adaptive filters, formant period extractor implementation, and spectrographic analysis of the breadboard vocoder performance showing some of the unsolved problems in the tracking of formants . . . (See also AD 421 507 and 434 863.)

THE PRESENT STATUS OF VOCODER SPEECH BANDWIDTH REDUCTION SYSTEMS
E. E. David, Jr., Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 730/740.

The word "vocoder" is a generic term referring to bandwidth reduction systems which transmit not speech itself but a simplified description based upon its spectral or phonetic properties. Vocoders may be based upon any one of several descriptive choices, some providing larger bandwidth economies than others. Generally, the larger the reduction the more sensitive the systems are to noise and distortion at their input terminals . . . finding increasing application where channel space is at a premium . . . equipment complexity is being much reduced.

STUDY AND INVESTIGATION OF SPEECH DATA
L. Dolansky, et al., Northeastern U., Boston, Mass., Final rept. AFCRL 63 118, 15 March 1963, 61 p., AD 413 461, N63-16725.

Speech signals processed by a Vocoder and the digital voice data processing system have been compared with clear-speech signals by means of intelligibility tests; the quantitative intelligibility degradation was measured under various conditions of Vocoder voicing, using varying numbers of quantizing levels for the reproduced signals. It was found that (a) the major decrease of intelligibility was attributable to the Vocoder processing; (b) the reduction of the number of quantizing levels had some effect upon listener confidence, but no noticeable effect upon intelligibility; (c) erroneous voiced responses to unvoiced sounds, processed by the Vocoder, could be eliminated in many cases by a suppression of the fricative-vowel transition region and (d) the elimination of the beginning part of initial voiceless fricatives in clear speech resulted in responses corresponding to other consonants, most frequently to voiced stops.

VOCODED SPEECH
B. Gold, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 62 G1, ESD TDR 63 67, 7 May 1963, 25 p., AD 407 512.

. . . introduction to vocoders . . . brief description of the different branches of speech research work. . . . channel vocoders, voice-excited vocoders, and, finally, the vocoder built for this research.

AN EVALUATION OF SPEECH COMPRESSION TECHNIQUES
K. D. Kryter, et al., Bolt, Beranek and Newman, Inc., Cambridge, Mass., BBN 978, RADC TDR 63 90, 25 Feb. 1963, 18 p., AD 402 604.

. . . results of tests of various recently developed speech compression systems . . . Semi-vocoders, operating at 9600 bits/sec, and channel vocoders, at 2400 bits/sec, will provide speech of adequate intelligibility and quality for most military communications. . . . Formant-tracking vocoders . . . at about 1200 bits/sec can probably be developed to the point where they will provide speech intelligibility comparable to that from the channel vocoders operating at 2400 bits/sec. At the present time formant-tracking vocoders operating at 1000 bits/sec do not provide for adequate speech intelligibility. . . . 'pattern' matching technique is still in its early experimental stages . . .

UN VOCODER MECANIQUE: LA GUIMBARDE (A Mechanical VOCODER, The Guimbarde) (In French)
E. Leipp, Ann. Telecomm., vol. 18, no. 5-6, May/June 1963, p. 82/87.

FORMANT VOCODER SPEECH COMPRESSION SYSTEM (EXPERIMENTAL MODEL)
R. F. Wolff, et al., General Dynamics/Electronics, Rochester, N. Y., 1 July 1961 - 30 April 1963, 47 p., AD 411 453.

. . . laboratory experimental model . . . has been constructed . . . extracts the frequency (5 bits) and amplitude 3 bits, of the first three formants and voice information (6 bits) and transmits this information at a rate of 1500 bits per second (20-ms scan rate) to the synthesizer. The formant analyzer is fed from a 55-channel filter bank covering the frequency range from 100-8000 cps and demonstrates a unique method of pattern matching to extract the formant information . . . In its present form the system achieves an intelligibility score on phonetically balanced word lists of 83.7 percent, satisfying the design goal minimum of 80 percent articulation index . . .

A STUDY OF THE FEASIBILITY OF MULTIPLEXING TELETYPE DATA INTO NON-SPEECH TIME OF VOCODED SPEECH TRANSMISSION
D. R. Ziemer, et al., Texas Instruments, Inc., Dallas, Final rept., pt. 3, June 1963, 29 p., AD 418 177.

. . . to determine (1) the number of teletype transmission channels that might be accommodated (multiplexed) simultaneous with vocoder speech communication system used for speech transmission, (2) the buffer storage requirements to realize the potential teletype transmission rate available due to the silent frames, (3) and the general implementation problem that would be encountered in adding the teletype multiplexing feature into the polymodal vocoder designed and built for AFCRL by Texas Instruments . . .

MANUAL FOR POLYMODAL VOCODER, VOLUME I, SECTIONS I, II, III, IV
Texas Instruments Inc., Dallas, Final Report, Part Two, AFCRL-63-301, Pt. 2; Aug. 1963, 224 p., AD 420 870, N64-10549.

. . . general description . . . listing of the operating characteristics . . . operating procedure . . . describing each control on the control console . . . theory of operation . . . Tuning procedures for the active filters and alignment procedures for the voltage-controlled amplifiers . . . detailed descriptions of critical circuits which aid in trouble-shooting and maintenance . . .

MANUAL FOR POLYMODAL VOCODER. VOLUME II. SECTION V. DRAWINGS
Texas Instruments, Inc., Dallas, Final rept., Pt. 2, Rept. no. HB18A63 AFCRL 63 301, Pt. 2, Aug. 1963, 473 p., AD 437 624.

. . . contains circuit board layouts and electronic and logic drawings for the circuits in the vocoder. . . .

Related Publications:

PROCEEDINGS OF SEMINAR ON SPEECH COMPRESSION AND PROCESSING, LG HANSCOM FIELD, BEDFORD, MASS.
Air Force Cambridge Research Center, Bedford, Mass., AFCRC TR 59-198, vol. 2, Sept. 1959, AD 233 720, 233 717.

A DIGITALIZED SPEECH COMPRESSION SYSTEM
D. C. Boulter, et al., Melpar, Inc., Falls Church, Va., Rept. for Aug. 1959 - Aug. 1961, (ASD TR 61-494), Sept. 1961, 142 p., AD 266 959.

SPEECH BANDWIDTH REDUCTION EQUIPMENT
G. E. Hoffmann, Scope, Inc., Falls Church, Va., (Final technical rept.), (RADC TDR 62-6), 10 July 1961, 114 p., AD 271 732.

Miniature versions of regular and hybrid vocoders, including a capability for binary transmission in the regular vocoder were developed. . . .

STUDY OF A SPEECH COMPRESSION SYSTEM (SPECTRUM SELECTION)
K. D. Kryter, Bolt, Beranek, and Newman, Inc., Cambridge, Mass., Interim rept. no. 2 (Final), 15 Jan. 1960 - 15 May 1961, 21 July 1961, 82 p., AD 261 329.

. . . A six-channel filter system was built; each channel had a bandwidth of either 135 or 400 measured at the 20 db downpoints on the filter skirts. . . . It was concluded that narrow band filtering plus time-plexing among the bands does not provide an intelligible speech signal.

ANALOG/DIGITAL MULTIPLEX EQUIPMENT FOR VOICE SIGNAL PROCESSING
D. Hertz, Epsco, Inc., Boston, Mass., (Final rept.), (AFCRL 62-67), Jan. 1962, 24 p., AD 272 392.

The design of a multiple channel analog-to-digital and digital-to-analog conversion system and multiplex for use in speech analysis and synthesis is described. . . .

INVESTIGATION OF VOCAL QUALITY AND ARTICULATION IMPROVEMENTS OF A SPEECH BANDWIDTH COMPRESSION SYSTEM
D. M. Early, et al., Melpar, Inc., Falls Church, Va., Rept. for April - Oct. 1962, (ASD TRD 62-959), Dec. 1962, 90 p. incl. illus., tables., AD 291 104.

. . . to modify the GFE breadboard to demonstrate at least an 85% PB work articulation score in the analog connection with telephone quality as a design goal. By means of articulation testing, generation of confusion matrices, spectrographic analysis, and listening tests, poorly reproduced sounds were isolated and methods for correcting the deficiencies were studied. . . . Vocal quality was improved; however, it did not attain the goal of telephone quality. . . .

INVESTIGATION OF AUTOMATION OF SPEECH PROCESSING FOR VOICE COMMUNICATION
G. S. Sebestyen, et al., Litton Systems, Inc., Waltham, Mass., (Scientific rept. no. 1), (AFCRL 62-390), 28 May 1962, 70 p., incl. illus., tables, 6 refs., AD 287 887.

The AFCRL Speech Analyzer consists of an 18-channel vocoder and a multiplex which quantizes the amplitudes of each of the 18 bands of frequencies into 3 bits. This results in a 54 bit description of the instantaneous speech spectrum. In addition, the voice amplitude is quantized into 3 bits and the pitch frequency into 6 bits. An additional bit is reserved for indicating whether the sound is voiced or unvoiced. A 64 bit computer word thus describes the speech sound at an instant of time and 50 such samples are taken each second. . . .

SPECTRAL CHARACTERISTIC OF DIGIT-SIMULATING SPEECH SOUNDS
D. P. Borenstein, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2839/2847.

A spectral analysis has been performed on a number of spoken vowel sounds, in particular those sounds causing digit registration in a TOUCH-TONE receiver. The analysis, implemented by computer methods, provides a definitive picture of the nature of digit simulation in TOUCH-TONE calling.

EFFICIENT UTILIZATION OF CHANNEL CAPACITY FOR SPEECH COMMUNICATION
R. L. Brueck, et al., Texas Instruments, Inc., Dallas, Final rept., pt. 2, July 1963, 96 p., AD 418 178.

. . . research investigation directed toward more efficient utilization of channel capacity for speech communication . . . to evaluate the performance characteristics . . . by simulation with vocoded speech samples on a digital computer . . . a compression of 35 to 40 percent was obtained relative to the initial requirements for transmission of the spectrum portion of vocoded speech data . . .

EFFICIENT UTILIZATION OF CHANNEL CAPACITY FOR SPEECH TRANSMISSION, PART III
R. L. Brueck, et al., Texas Instruments, Inc., Dallas, Texas, Final Report, (AFCRL-63-316), July 1963, 78 p., 12 refs., N63-22191.

PITCH EXTRACTION BY COMPUTER PROCESSING OF HIGH-RESOLUTION FOURIER ANALYSIS DATA
C. M. Harris, et al., J. Acoust. Soc. Amer., vol. 35, March 1963, p. 339/343, A63-19845.

. . . automatic pitch-extraction method, in which speech signals are processed by a real-time Fourier analyzer, the output of which is converted into digital form and recorded on tape for processing on an IBM computer. The logic of the computer program, written in FORTRAN language, is discussed, as is the accuracy of the overall pitch-extraction system.

ACCURATE LOG AND INVERSE-LOG FUNCTION GENERATING CIRCUITS: FOR USE IN DIGITAL VOCODER PITCH CHANNEL
L. V. Kriger, Air Force Cambridge Research Labs., Bedford, Mass., AFCRL 63 186, June 1963, 66 p., 11 refs., AD 413 479, N63-19793.

A novel synthesis technique, empirical in nature, is developed for diode-resistance function generation circuits attaining accuracies higher than theoretically possible by classic methods of piecewise-linear approximation. . . . Curvi-linear rather than piece wise linear approximation segments are . . . generated . . . Implementation of the dynamic models into the AFCRL digital vocoder and data processor, is described including tables of quantum frequencies and voltages, calibration data and circuit diagrams.

Section 2.34

2.340: Analog Speech Compression Methods

Included: Slope feedback coding; Phase extraction methods; Variable gamma amplifier; Speech companding methods.

Cross References: Companding of analog signals (Sect. 2.24); Slope feedback coding for pictures (2.430).

Principal Publications:

VOICE RADIO SYSTEMS FOR HIGH NOISE PATHS
J. A. Greefkes, et al., Electronics, vol. 32, no. 50, Dec. 1959, p. 53/57.

When other radio links fail because of noise, this system still works. Frequency and amplitude components of speech are transmitted on separate channels . . .

A SLOPE-FEEDBACK METHOD FOR SPEECH COMPRESSION
M. P. Beddoes, IRE Trans. Commun. Syst., vol. CS-8, no. 4, Dec. 1960, p. 254/258.

. . . The maximum amount of compression is estimated from a quantity called the speech detail factor. This is analogous to the familiar picture detail factor. Measurements of the former show that the following compression ratios are possible. 1) a two-fold compression of "telephone" quality speech, 2) almost five-fold compression of band-filtered speech which has a syllable articulation of 60 per cent.

. . . . . A special feature of the coder is a variable-delay unit and the experimental version is described.

SLOPE FEEDBACK CODERS FOR REDUCING THE BANDWIDTH OF SPEECH BY OPERATING ON FORMANTS
M. P. Beddoes, Sr., et al., Nat. Comm. Symp. Rec., vol. 7, Oct. 1961, p. 50/58.

Developed from an earlier slope-feedback speech compressor. . . takes into account the characteristic formant structure of speech. . . a total bandwidth of 500 cps is required and the signal-to-noise ratio tolerated is of the order of 56 db. . . .

AUDIO COMMUNICATION WITH ORTHOGONAL TIME FUNCTIONS
H. F. Harmuth, Proc. Instn. Elect. Engrs., Pt. C, vol. 108, no. 13, March 1961, p. 139/144.

An audio signal may be decomposed into components having certain frequency and phase. Half the information of the signal is contained in the phase of the frequency components. Since the human ear is almost insensitive to phase, one may eliminate the phase information without causing a noticeable reduction in the signal quality. The elimination of the phase information implies a permissible reduction of the bandwidth required for the transmission of the signal to one-half and a reduction of the signal power by 3 dB without increase of distortions due to additive white normal noise. A method for the elimination of the phase information is based on the decomposition of the audio signal by correlation with a set of orthogonal functions. These correlations yield for each orthogonal process these coefficients in analogue or digital computers to reduce further the bandwidth required for the transmission of audio signals with certain spectral distribution, e.g., voice signals. . . .

A VARIABLE GAMMA AMPLIFIER (Correspondence)
P. Kundu, et al., Proc. IEEE, vol. 51, no. 5, May 1963, p. 867/868.

. . . non-linear device which yields an output varying directly or inversely as the nth power or root of an input signal, where n may be an integer or a fraction. . . .

Related Publications:

EXTREMAL CODING FOR SPEECH TRANSMISSION
M. V. Mathews, IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 129/136.

. . . The coder determines the amplitude and times of successive extremes (relative maxima and minima) of the signal.

EIN KOMPANDER FÜR RUNDFUNKPROGRAMM-ÜBERTRAGUNG (A Compander for Radio Broadcast Material) (In German)
W. von Guttenberg, et al., Nachrichtentech. Z., vol. 13, Jan. 1960, p. 9/15.

(1) Compandors
(2) Transmission of Hi-Fi over Multiplex Carrier Circuits.

STUDY OF A SPEECH COMPRESSION SYSTEM (SPECTRUM SELECTION)
K. D. Kryter, et al., Bolt, Beranek, and Newman, Inc., Cambridge, Mass., (Rept. 7), Sept. 1961, 32 p., AD 269 194.

. . . effect of sampling the frequency spectrum of speech by narrow pass bands is discussed. Also included are results of experiments on companding, delta modulation and straight pulse code modulation of a speech signal. Preliminary results indicate that the 75 cps wide filters, delta modulation and companding can be used to advantage in the transmission of spectrum sampled speech.

A SURVEY OF TELEPHONE SPEECH-SIGNAL STATISTICS AND THEIR SIGNIFICANCE IN THE CHOICE OF A P. C. M. COMPANDING LAW
R. F. Purton, Proc. Instn. Elec. Engrs. (Pt. B), vol. 109, no. 43, Jan. 1962, p. 60/66.

EXPERIMENTAL NARROW-BAND SPEECH SYSTEM
J. H. Ball, et al., Bolt, Beranek and Newman, Inc., Cambridge, Mass., Rept. no. 10, (Final), 15 June 1958-13 Oct. 1963, 13 Nov. 1963, 30 p., AD 436 463.

This system involves filtering from the normal speech signal six relatively narrow bands of frequencies which are transposed to form a single, continuous band prior to transmission. . . .

Section 2.35

2.350: Digital Speech Processing Methods

Included: Digital computers for speech compression investigation; Speech digitization with redundancy reduction; Digital vocoder; Full duplex digital vocoder; Optimum speech signal mapping techniques.

Not Included: PCM communication systems (1); Theory of sampling and quantization (1)

Cross References: Compactive sampling methods (2.253); Compactive quantization methods (2.254); Vocoder methods in general (2.340).

Principal Publications:

DESCRIPTION AND RESULTS OF EXPERIMENTS WITH SPEECH USING DIGITAL COMPUTER SIMULATION
E. E. David, Jr., et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 766/775.

Research in the efficient coding of speech often necessitates building extensive operating models to obtain subjective evaluations of performance. This paper discusses digital simulation of such models on general-purpose computers using actual speech.

A converter which samples, quantizes, and records speech on IBM-704 magnetic tapes is described. It also reproduces speech from tapes prepared by the computer. Computer requirements and characteristics of programming peculiar to simulation in this field are discussed. Results are reported from a comparison of two digital encodings of speech, pulse code modulation and delta modulation, simulated on a digital computer.

SPEECH TRANSMISSION WITH QUANTIZATION IN FEW STAGES (In German)
K. Kupfmuller, et al., Nachrichtentech. Z., vol. 11, Aug. 1958, p. 389/392.

THE QUANTIZATION OF SPEECH WITH A SMALL NUMBER OF STEPS (In German)
W. Andrich, Nachrichtentech. Z., vol. 13, Aug. 1960, p. 379/383.

SPEECH TO CODE CONVERTER STUDY
R. A. Houde, Stromberg-Carlson Co., Rochester, New York, Quarterly report no. 2, 1 Nov. 1959-31 Jan. 1960, Jan. 1960, 11 p., AD 235 705.

The sustained vowel study was continued and listening tests were recorded on tape. Although some tests were performed, the results are still incomplete. A preliminary study of consonant recognition cues was conducted on b, d, t, p, and k. A more complete study will be made using the Speech Spectrum Analyzer now being assembled. Spectrum analysis by frequency multiplication and sweeping filter was also investigated. (See also AD 232 407.)

MILITARY APPLICATIONS FOR SPEECH COMPRESSION TECHNIQUES
A. J. Strassman, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 4, June 1960, p. 75/81.

. . . If speech is compressed first, and then digitalized, provision for transmission of encrypted digital speech over a normal 3-kc voice circuit can be made. . . . Techniques to satisfy these requirements have been available for some time; however, equipments compact enough and capable of producing a sufficiently good quality of reconstructed speech have not been available as acceptable end items. . . . the Hughes Aircraft Company has developed a miniature Vocoder of sound quality which can be utilized for the above outlined military applications. . . .

A DIGITALIZED SPEECH COMPRESSION SYSTEM
D. C. Boulter, et al., Melpar, Inc., Falls Church, Va., Rept. for Aug. 1959-Aug. 1961, (ASD TR 61-494), Sept. 1961, 142 p., AD 266 959.

. . . System. . . flyable, fully transistorized system is designed to permit 2-way voice communication through a digital channel at either 1000 or 12000 bits-per-second. . . Methods used to arrive at a suitable mechanical configuration in order to package the system in 1.3 cu. ft. and to meet MIL-E-5400 are documented. . . Articulation testing demonstrates that the system exhibits a phonetically balanced word-list articulation of over 75%, corresponding to a sentence intelligibility in excess of 94%. Other testing, such as environmental and digital jamming, is also discussed.

DESIGN OF A DIGITALIZED SPEECH COMPRESSION SYSTEM
D. M. Early, et al., Melpar, Inc., Falls Church, Va., Final rept., Sept. 1959-Aug. 1961, on Improvement, Growth Potential, and Boundary Value Coding Study, (ASD TDR 62-70), Jan. 1962, 219 p., AD 271 616.

This rept. includes:

A SPECTROGRAPHIC STUDY OF FORMANT TRACKING
A 1000 BIT PER SECOND SPEECH COMPRESSION SYSTEM
INFLUENCE OF TRANSMISSION ERROR ON FORMANT CODED COMPRESSION SPEECH SIGNALS, by S. Joseph Campanella, D. C. Coulter, and R. Irons. 1962, (Presented at the 13th Annual Meeting Audio Engineering Society, Oct. 9-13, 1961)

A DIGITALIZED, CONTINUOUS-ANALYSIS SPEECH COMPRESSION SYSTEM, by S. Joseph Campanella. 1962, (Proceedings of Seminar on Speech Compression and Processing, 28-30 Sept. 1959).

An improvement study, a growth potential study, and a boundary value coding study, conducted from Sept. 1959 through Nov. 1961, are described.

OPTIMUM SPEECH SIGNAL MAPPING TECHNIQUES
W. B. Floyd, Litton Systems, Inc., Waltham, Mass., Final rept., (RADC TDR 62-598), 30 Nov. 1962, 96 p. incl. illus., tables, 12 refs., AD 297 248.

A format which will facilitate automatic speech transcription.
Periodically sampled outputs of speech parameter extractors.
Reflecting the location of formants and spectral shape information.
Transcription of speech into sequences of language elements suitable for presentation to a human reader.

THEORIE DE LA TRANSFORMATION DE LA PAROLE ET PERSPECTIVES D'APPLICATIONS (A Theory of Voice Transformation into an Artificial Speech and its Applications) (In French)
L. Pimonow, Ann. Telecomm., vol. 17, no. 11-12, Nov./Dec. 1962, p. 304/313.

SOME COMPUTER EXPERIMENTS WITH PREDICTIVE CODING OF SPEECH
M. P. Ristenbatt, et al., Office of Research Admin., U. of Michigan, Ann Arbor, (Tech. rept. no. 132; Rept. no. 4251-1-T), March 1962, 76 p. incl. illus., tables, 14 refs., AD 274 984.

. . . permits reducing the digit rate of high quality speech encoded by PCM. Phonetically balanced speech was used as input . . . found that one should not use more than two past samples in making a prediction. . . . one could reduce the PCM digit rate from the presently-used 48 kc to 40 kc with no easily discernible decrease in quality, using either linear or log quantizing. . . . at 30 kc, a discernible increase in noise was at 30 kc, a discernible increase in noise was found, but the quality was still good. . . . an alternative to delta modulation systems, which are most appropriate for medium or low quality applications, and to Vocoder codings, where one can expect relatively large equipment for high quality speech. . . .

INVESTIGATION OF AUTOMATION OF SPEECH PROCESSING FOR VOICE COMMUNICATION
G. S. Sebestyen, et al., Litton Systems, Inc., Waltham, Mass., (Scientific rept. no. 1), 28 May 1962, 70 p. incl. illus., tables, 6 refs., AD 287 887.

The AFCRL Speech Analyzer consists of an 18-channel vocoder and a multiplex which quantizes the amplitudes of each of the 18 bands of frequencies into 3 bits. This results in a 54 bit description of the instantaneous speech spectrum. In addition, the voice amplitude is quantized into 3 bits and the pitch frequency into 6 bits. An additional bit is reserved for indicating whether the sound is voiced or unvoiced. A 64 bit computer word thus describes the speech sound at an instant of time and 50 such samples are taken each second. . . .

SPEECH DATA PROCESSING IN REAL TIME
H. A. Straight, Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 30/35.

The logical techniques by which a high-speed special-purpose digital computer developed by Melpar compares the digital description of speech spectrum patterns with previously recorded description are presented. This set of logic is capable of determining which stored pattern most nearly approximates an unprocessed pattern, and is unique in that it makes possible the sorting and compilation of speech statistics in real time. . . . capability of "learning" speech through the tabulation of a set of mean patterns. . .

DIGITAL CIRCUIT TECHNIQUES FOR SPEECH ANALYSIS
G. L. Clapper, IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 296/305, 11 refs.

. . . Some early speech devices are noted and current work in the field of computer simulation is considered. . . . description of an experimental word code generator developed at the IBM. . . . This device produces a compressed digital code from the spoken word as a function of frequency, intensity, and time. Individual sound patterns are coded as a function of the changes in the word itself. The code is produced as the word is spoken and is displayed in matrix form for immediate analysis. Readout to a card punch or other storage media is easily accomplished.

STUDY AND INVESTIGATION OF SPEECH DATA
L. Dolansky, et al., Northeastern U., Boston, Mass., Final Report, March 15, 1962-March 14, 1963, (AFCRL-63-118), March 15, 1963, 64 p., 24 refs., N63-16725.

Speech signals processed by a Vocoder and the Digital Voice Data Processing System have been compared with clear-speech signals by means of intelligibility tests; the quantitative intelligibility degradation was measured under various conditions of Vocoder voicing, using varying numbers of quantizing levels for the reproduced signals. . . .

ACCURATE LOG AND INVERSE-LOG FUNCTION GENERATING CIRCUITS: FOR USE IN DIGITAL VOCODER PITCH CHANNEL
L. V. Kriger, Air Force Cambridge Research Labs., Bedford, Mass., AFCRL 63 186, June 1963, 66 p., AD 413 479.

A novel synthesis technique, empirical in nature, is developed for diode-resistance function generation circuits attaining accuracies higher than theoretically possible by classic methods of piecewise-linear approximation. . . . Curvi-linear rather than piece-wise linear approximation segments are. . . generated. . . Implementation of the dynamic models into the AFCRL digital vocoder and data processor, is described including tables of quantum frequencies and voltages, calibration data and circuit diagrams.

A NOTE ON POWER REQUIREMENTS FOR DIGITALIZED VOICE TRANSMISSION
B. Reiffen, Lincoln Lab., Mass. Inst. of Tech., Lexington, 6 May 1963, 7 p., AFESD TDR63 60, AD 405 622.

A digital communication system is analyzed under the following assumptions: (1) equal energy orthogonal signals are used; (2) the channel adds white gaussian noise; and (3) the receiver uses band-pass correlation followed by envelope detection.

FULL-DUPLEX DIGITAL VOCODER
L. A. Yaggi, Jr., Texas Instruments, Inc., Dallas, Tex., AFCRL-63-301, June 10, 1963, 127 p., 42 refs., N63-22230, AD 420 870.

. . . results of the design, development, and manufacture of a polymodal, full-duplex, digital vocoder system. This vocoder equipment provides the user with a choice of five primary modes of operation.

These five modes consist of three digital transmission rates (1200, 2400, and 9600 bps) and four degrees of speech intelligibility, voice, quality, and talker recognition. Spectrum-normalizing techniques used in this system provide more effective quantization of spectrum data and allow fewer bits per second in specifying these data. . . Fully automatic bit and frame synchronization is used. An all digital technique of pitch pulse code modulation encoding-decoding has been designed. . .

A STUDY OF THE FEASIBILITY OF MULTIPLEXING TELETYPE DATA INTO NONSPEECH TIME OF VOCODED SPEECH TRANSMISSION
D. R. Ziemer, et al., Texas Instruments Inc., Dallas, Tex., Final Report, (AFCRL-63-300), June 1963, 32 p., 1 ref., N63-22192.

. . . to determine: (1) the number of teletype transmission channels that might be accommodated (multiplexed) simultaneously with the vocoder speech-communication system used for speech transmission: (2) the buffer storage requirements to realize the potential teletype transmission rate available due to the silent frames; and (3) the general implementation problem that would be encountered in adding the teletype multiplexing feature into the polymodal vocoder. It was found that for normal telephone conversations it would be possible to multiplex in 39.75 word-per-minute teleprinters into a full duplex vocoder speech-communication system. In addition, it would be possible to have these 39 teleprinters running 97 percent of the time while the system was in use for speech transmission. . .

Related Publications:

AN ELECTRONIC SPEECH SAMPLER FOR STUDYING THE EFFECT OF SAMPLE DURATION ON ARTICULATION
R. Fatehchand, et al., J. Inst. Telecommun. Engrs., vol. 5, March 1959, p. 86/88.

STUDY OF A SPEECH COMPRESSION SYSTEM (SPECTRUM SELECTION)
K. D. Kryter, et al., Bolt, Beranek, and Newman, Inc., Cambridge, Mass., (Rept. 7), Sept. 1961, 32 p., AD 269 194.

FORMANT VOCODER SPEECH COMPRESSION SYSTEM (EXPERIMENTAL MODEL)
L. C. Stewart, General Dynamics/Electronics, Rochester, N. Y., Quarterly rept. 1, 30 Oct. 1961, 21 p., AD 270 971.

. . . to construct an experimental model Formant Vocoder Speech Compression System. The design objective is a 1500 bit-per-second system having a minimum articulation index of 80% for a phonetically balanced word list.

STUDY OF SPEECH COMPRESSION SYSTEMS (SYLLABIC COMPRESSION TECHNIQUES)
H. Belar, et al., David Sarnoff Research Center, Princeton, N. J., Quarterly progress rept. no. 2, 16 July 1962-15 Oct. 1962, lv., AD 406 365.

. . . provides a syllable communications system voice-to print or voice-to-voice over a channel of only 6 bits per word for a 50 word vocabulary. The processing of the spoken word is performed by a coarse structure, amplitude comparing and time compensated analyzer. . .

ANALOG/DIGITAL MULTIPLEX EQUIPMENT FOR VOICE SIGNAL PROCESSING
D. Hertz, Epsco, Inc., Boston, Mass., (Final rept.), Jan. 1962, 24 p., AD 272 392.

The design of a multiple channel analog-to-digital and digital-to-analog conversion system and multiplex for use in speech analysis and synthesis is described. . . . designed to be utilized with a high-quality vocoder analyzer and synthesizer for optimum digitization of the speech parameters over a range of data rates. The system samples and holds 22 parallel analog inputs and converts them into a serial digital data stream, in which the voice spectrum data are normalized in amplitude and specified on a logarithmic scale. The demultiplex accepts the serial data and decodes it to reproduce the parallel analog inputs. . . .

VOCODER EVALUATION STUDIES
W. F. Meeker, et al., RCA Defense Electronic Products, Camden, N. J., (Scientific rept. no. 3), 74 p. incl. illus., tables, 11 refs., AD 281 836.

Speech transmitted via vocoder suffers peculiar distortions which make evaluation difficult. . . . intelligibility, speech quality, and talker recognition. . . . approximately 70 Air Force communications personnel to elicit their judgments of six speech samples representing a range of vocoder systems. . . . suitability for normal use and preference. . . . Laboratory measurements. . . additional vocoder modifications, including the effects of one, two and three-bit quantization of the normalized spectrum.

A SURVEY OF TELEPHONE SPEECH-SIGNAL STATISTICS AND THEIR SIGNIFICANCE IN THE CHOICE OF A P.C.M. COMPANDING LAW
R. F. Purton, Proc. Instn. Elec. Engrs., (Pt. B), vol. 109, no. 43, Jan. 1962, p. 60/66.

EXPERIMENTAL NARROW-BAND SPEECH SYSTEM
J. H. Ball, et al., Bolt, Beranek and Newman, Inc., Cambridge, Mass., Rept. no. 10 (Final), 15 June 1958-13 Oct. 1963, 13 Nov. 1963, 30 p., AD 436 463.

EFFICIENT UTILIZATION OF CHANNEL CAPACITY FOR SPEECH TRANSMISSION, PART III
R. L. Brueck, et al., Texas Instruments, Inc., Dallas, Texas, Final Report, (AFCRL-63-316), July 1963, 78 p., 12 refs., N63-22191.

. . . by a program (1) to theoretically analyze the benefits realized by "predictive encoding" of vocoded speech sources (2) to propose and analytically design a model of a typical processing system utilizing predictive coding and (3) to evaluate the performance characteristics of such a system by simulation with vocoded speech samples on a digital computer. . .

EFFECT OF TRANSMISSION ERRORS ON THE INTELLIGIBILITY OF VOCODED SPEECH
R. W. Steele, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 118/123.

SPEECH PROCESSING STUDIES (VOICE DATA PROCESSING SYSTEM)
H. A. Straight, et al., Melpar, Inc., Falls Church, Va., Final rept., Sept. 1961-Sept. 1963, Oct. 1963, 115 p.

. . . in this final period. . . greater selectivity in pattern coding, expanded keyboard capability, and increased reliability in compiling speech statistics. The appendices include a definition of terms and the system operating instructions.

A STUDY OF SIGNIFICANT PARAMETERS OF SPEECH FOR APPLICATION IN AUTOMATIC SPEECH RECOGNITION SYSTEMS
M. R. Weiss, Federal Scientific Corp., New York, Rept. no. T4 114, RADC TDR63 335, 1 July 1963, lv., AD 423 279.

REDUCTION IN QUANTIZING LEVELS FOR DIGITAL VOICE TRANSMISSION
M. J. Wiggins, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 282/288.

. . . A method of processing speech to allow a reduction of quantizing levels for PCM has been developed and applied to a tropospheric scatter communication system. A unique PCM is used which is derived from PPM and is applicable to a random access system for increased bandwidth utilization. An improved detector and demodulator has been developed to provide discrimination against noise and cross talk. . . .

Section 2.36

2.360: Phoneme Recognition Methods

Included: Pattern recognition in speech compression systems; Speech recognition; Mechanical speech recognizer; Vowel amplitudes; Phonemic stress in various languages; Vowel identification; Consonants and their characteristics; Rhyme test; Phonemic differentiation; Word recognition systems; Syllabic compression techniques; Segmentation of phonemic parameters.

Not Included: Intelligibility tests on public communications facilities.

Cross References: Pattern recognition in general (2.260); Speaker identification (2.382); Classes of speech sounds (2.310); Linguistic problems in spoken language (2.314); Voice digitization (2.350).

Principal Publications:

VARIATIONS IN VOWEL DURATION: PHONEMICALLY OR PHONETICALLY CONDITIONED?
S. Belasco, J. Acoust. Soc. Amer., vol. 30, no. 11, Nov. 1958, p. 1049/1050.

UNRELEASED VELAR PLOSIVES AFTER BACK-ROUNDED VOWELS (Correspondence)
P. Delattre, J. Acoust. Soc. Amer., vol. 30, no. 6, June 1958, p. 581/582.

Discussion about transitions, cues and loci of p,t,k. Indication that locus and transition depends on preceeding vowel.

AUTOMATIC RECOGNITION OF PHONETIC PATTERNS IN SPEECH
H. Dudley, et al., J. Acoust. Soc. Am., vol. 30, no. 8, Aug. 1958, p. 721/732.

The mechanical recognition of 10 spoken words (the digits) with near-perfect precision has been demonstrated under laboratory conditions for a single talker after optimum circuit adjustment for his voice. Such word recognition points to the possibility of automatic voice writing and other voice-controlled operations. . . .

PHONETIC PATTERN RECOGNITION VOCODER FOR NARROW-BAND SPEECH TRANSMISSION
H. Dudley, J. Acoust. Soc. Amer., vol. 30, no. 8, Aug. 1958, p. 733/739.

This paper describes a spectral pattern recognition device. Also synthesizer is described. The analyzer identifies the phoneme by its spectral pattern and a corresponding message is transmitted. The corresponding frequency band is about 50 cps. The recognition process assures that spoken words can be printed as phonetic text. . . .

TEST OF PHONEMIC DIFFERENTIATION: THE RHYME TEST
G. Fairbanks, J. Acoust. Soc. Amer., vol. 30, no. 7, July 1958, p. 596/601.

Materials are presented for a test of word identification in which the cues for response are confined to the initial consonants and consonant-vowel transitions. Some preliminary results are discussed.

PITCH DISCRIMINATION FOR SYNTHETIC VOWELS
J. L. Flanagan, et al., J. Acoust. Soc. Amer. vol. 30, no. 5, May 1958, p. 435/442.

A psychoacoustic experiment was conducted to determine the just-discriminable changes in the fundamental frequency of vowels. The vowels were produced by a "terminal-analog" vowel synthesizer (four resonators in series driven by pulses.) Four vowels were taken. . . .

THE SOLUTION OF SOME FUNDAMENTAL PROBLEMS IN MECHANICAL SPEECH RECOGNITION
D. B. Fry, et al., Reprint from Language and Speech 1:35-38, Jan. - March 1958, AD 208 865.

. . . conclusions reached in experiments on the perception and recognition of speech sounds and on experimental results already obtained with a mechanical recognizer. . . . The use of language statistics in mechanical recognition is also discussed. (See also AD 122 686).

PITCH RATINGS OF VOICED AND WHISPERED VOWELS
G. J. Harbold, J. Acoust. Soc. Amer., vol. 30, no. 7, July 1958, p. 600/601.

EFFECT OF THIRD-FORMANT TRANSITIONS ON THE PERCEPTION OF THE VOICED STOP CONSONANTS
K. S. Harris, et al., J. Acoust. Soc. Amer., vol. 30, no. 2, Feb. 1958, p. 122/126.

NASALIZATION OF VOWELS IN RELATION TO NASALS
S. Hattori, et al., J. Acoust. Soc. Amer., vol. 30, no. 4, April 1958, p. 267/274.

ON THE PRODUCTION AND PERCEPTION OF FRICATIVE CONSONANTS
J.M. Heinz, et al., Presented at 55th Meeting Acoustical Society America, Washington, D. C., May 1958.

MODEL STUDIES OF THE PRODUCTION OF FRICATIVE CONSONANTS
J.M. Heinz, Res. Lab of Elect. MIT, Quarterly Progress Report, July 1958, p. 146/149.

STUDY OF SOME CUES IN THE PERCEPTION OF THE VOICED STOP CONSONANTS
H.S. Hoffman, J. Acoust. Soc. Amer., vol. 30, no. 11, Nov. 1958, p. 1035/1041.

ON VOWEL INTONATION CONTOURS
P. Lieberman, Presented at 55th Meeting, Acoustical Society America, Washington, D.C., May 1958.

PERCEPTION OF COMPOUND CONSONANTS IN NOISE
J.M. Pickett, Presented at 55th Meeting Acoustical Society America, Washington, D. C., May 1958.

AUTOMATIC SPEECH RECOGNITION (In German)
K. Steinbuch, Nachrichtentech. Z., vol. 11, Sept. 1958, p. 446/454, 45 refs.

SYNTHESIS AND PERCEPTION OF FRICATIVE CONSONANTS
K.N. Stevens, et al., Res. Lab of Elect. MIT, Quarterly Progress Report, July 1958, p. 150/152.

NOTE ON VOWEL DURATION SEEN CROSS-LINGUISTICALLY (Correspondence)
S.A. Zimmerman, et al., J. Acoust. Soc. Amer., vol. 30, no. 2, Feb. 1958, p. 152/153.

Investigation about the duration of vowels. Comparision between Spanish and English.

SPEECH RECOGNITION
IBM, Final report, 1 July 1956-31 Dec. 1957, Jan. 1958, 21 p., AD 201 393, See also AD 140 933.

This report includes: The Use of the IBM 704 in the Simulation of Speech Recognition Systems, G.L. Schultz. 1 Dec. 1957, 20 p., Research Report RC 37.
Paper presented at 1957 Eastern Joint Computer Conf., Wash., D. C., Dec. 1957.

VOWEL OVERLAP AS A FUNCTION OF FUNDAMENTAL FREQUENCY AND DIALECT
R.S. Brubaker, et al., J. Acoust. Soc. Amer., vol. 31, no. 10, Oct. 1959, p. 1362/1365.

THE DESIGN AND OPERATION OF THE MECHANICAL SPEECH RECOGNIZER AT UNIVERSITY COLLEGE LONDON
P. Denes, J. Brit. Instn. Radio Engrs., vol. 19, April 1959, p. 219/237.

RESULTS OBTAINED FROM A VOWEL RECOGNITION COMPUTER PROGRAM
J.W. Forgie, et al., J. Acoust. Soc. Amer., vol. 31, no. 11, Nov. 1959, p. 1480/1489.

THEORETICAL ASPECTS OF MECHANICAL SPEECH RECOGNITION
D.B. Fry, J. Brit. Instn. Radio Engrs., vol. 19, April 1959, p. 211/219.

PEAK VU DEFLECTION AND ENERGY FOR MONOSYLLABIC WORDS (Correspondence)
D.M. Green, et al., J. Acoust. Soc. Amer., vol. 31, no. 9, Sept. 1959, p. 1264/1265.

VOWEL AMPLITUDE AND PHONEMIC STRESS IN AMERICAN ENGLISH
I. Lehiste, et al., J. Acoust. Soc. Amer., vol. 31, April 1959, p. 428/435.

SNTHESIS AND PERCEPTION OF NASAL CONSONANTS
K. Nakata, J. Acoust. Soc. Amer., vol. 31, no. 6, June 1959, p. 661/666.

THE INTELLIGIBILITY OF VERBAL SYMBOLS. II. TWO-, THREE-, AND FOUR-WORD PHRASES OF VERBAL COLOUR SYMBOLS
K.K. Neely, et al., Defense Research Medical Labs., (Canada), (DRML rept. no. 118-3; Encl. 23 to Air Attaché, Ottawa, rept. no. TL-78-59), March 1959, 18 p., AD 218 032.

THE ROLE OF DURATION IN VOWEL IDENTIFICATION
K.N. Stevens, MIT, Res. Lab. Quarterly Progress Rept. #52, Jan. 1959, p. 136/139.

PROCEEDINGS OF SEMINAR ON SPEECH COMPRESSION AND PROCESSING, LG HANSCOM FIELD, BEDFORD, MASS.
Air Force Cambridge Research Center, Bedford, Mass., AFCRC TR 59-198, vol. 2, Sept. 1959, lv., AD 233 720 (See also AD 233 717).

. . . Parametric recognition of phonetic sounds . . . automatic speech recognition procedures. Research on speech recognition . . . Some problems in speech recognition. Investigation procedures for speech recognition . . .

AMERICAN ENGLISH PHONEMES
(Correspondence)
E.P. Hamp, J. Acoust. Soc. Amer., vol. 32, Aug. 1960, p. 1079/1080.

LA RECONNAISSANCE PHONETIQUE ET SA MESURE (Phoneme Recognition and its Measurement) (In French)
J.C. Lafon, Annales des Telecommunications, vol. 15, Jan. - Feb. 1960, p. 27/37.

SPEECH-TO-CODE CONVERTER STUDY
W.D. Larkin, et al., General Dynamics/ Electronics, Rochester, N.Y., Final rept., 1 July 1959 - 31 Dec. 1960, 30 Sept. 1961, 149 p., 17 refs., AD 272 109.

. . . to determine the parameters necessary for the identification of words spoken in isolation. Segmentation procedures were developed which isolated the minimal unit (a syllable-like C-V-C unit) for study and further subdivided the unit into portions be to considered as potential phonemes . . . Time compression permits real-time spectrum analysis with a sweep analyzer and offers the possibility of a reduction in equipment size approaching an order of magnitude compared with conventional parallel-channel analyzers . . . Feasibility models of two methods of time compression, one using a solid-state analog memory and the other using a novel magnetic drum, were constructed and studied. Results indicate that both methods are basically sound.

AUTOMATIC RECOGNITION OF SPEECH
T. Marill, Bolt, Beranek, and Newman, Inc., Cambridge, Mass., RADC TN 60-196, Oct. 1960, AD 245 024.

Three principal concepts underlying the construction of machines for automatic speech recognition are discussed. The machines which have actually been built and exhibited are examined. The achievements have been modest.

TOWARD A MODEL FOR SPEECH RECOGNITION
K.N. Stevens, J. Acoust. Soc. Amer., vol. 32, no. 1, Jan. 1960, p. 47/55.

An approach to the design of a machine for the recognition and synthesis of speech is proposed . . . As a recognizer, the proposed machine accepts a speech wave . . . and generates a sequence of phonetic symbols . . . as a synthesizer it accepts a sequence of symbols . . . and generates a speech wave. . . .

ON "AMERICAN ENGLISH PHONEMES"
(Correspondence)
J.V. Tobias, J. Acoust. Soc. Amer., vol. 32, Aug. 1960, p. 1080.

VOICE TO TELETYPE CODE CONVERTER RESEARCH PROGRAM. PART I. EXPERIMENTAL VERIFICATION OF A METHOD TO RECOGNIZE PHONETIC SOUNDS
W.F. Meeker, et al., Radio Corp. of America, Camden, N.J., (ASD TR 61-666, pt. 1), Dec. 1961, 125 p., 14 refs., AD 272 024.

. . . basic information for automatic or machine recognition of speech for eventual use in a speech to teletype code converter . . . oriented toward phoneme recognition . . . formant tracking type of bandwidth compression system . . . analysis of sound spectrograms. Speech was also analyzed by means of an 18-channel filter bank, and converted to digital form for analysis with an RCA 501 data processing system. Programs for print-out of digital spectrograms speech segmentation, formant location and plotting, and vowel recognition were developed. Mean segmentation accuracy of 94% was attained. The vowel recognition program provided completely automatic location and recognition of vowels with a mean accuracy of 45% for 10 male talkers speaking isolated CVC words made up of all combinations of 6 possible initial consonants, 10 vowels, and the final consonant /d/. By adding a duration criterion, a mean accuracy of 82% was indicated for vowel recognition.

TWO MULTIVARIATE STATISTICAL COMPUTER PROGRAMS AND THEIR APPLICATION TO THE VOWEL RECOGNITION PROBLEM
P.D. Welch, et al., J. Acoust. Soc. Amer., vol. 33, no. 4, April 1961, p. 426/434.

STUDY OF SPEECH COMPRESSION SYSTEMS (SYLLABIC COMPRESSION TECHNIQUES)
H. Belar, et al., David Sarnoff Research Center, Princeton, N.J., Quarterly progress rept. no. 1, 15 April-15 July 1962, 15 July 1962, 21 p. incl. illus., AD 284 811 (See also AD 406 365).

. . . syllable communication system, voice to voice or voice to print, utilizing the phonetic typewriter developed by RCA and a speech synthesizer which proceeds from pre-recorded spoken syllables. Such a system when ultimately developed should allow transmission of the spoken word at an extremely low rate such as 23 bits/sec calculated for a language of 2000 syllables and a normal speaking rate. Apparatus assembled analyzes and synthesizes 50 syllables or words and has the resolving power and memory capacity to print-out an even larger number of words selected for this purpose when set up for a given speaker. For 50 words the information for print-out or speech synthesis is transmitted at a channel capacity of 6 bits/word. . . .

WORD-RECOGNITION SYSTEM
L. J. Gerstman, et al., Bulova Research and Development Labs., Inc., Woodside, N.Y., (Rept. no. SP-1307), Interim development rept., 2 April-30 Sept. 1962, 17 Oct. 1962, 106 p. incl. illus. tables, AD 288 143.

The feasibility of transforming voice signals into a form suitable for machine recognition is being studied. The ultimate application of this work will be to update the data files of the Navy Tactical Data System in real time. . . .

SEARCH TIME FOR ALPHA-NUMERIC STIMULI
M. M. Grace, et al., Vermont U., Burlington, 1 Aug. 1962, 9 p., AD 435 443.

. . . The stimuli were 2-6 consonant of digit combinations which varied in length (i.e., number of consonants or digits per stimulus) and uncertainty (number of alternatives from which the consonants or digits were selected). . . .

SPEECH RECOGNITION: A MODEL AND A PROGRAM FOR RESEARCH
H. Halle, et al., IRE Trans. Inform. Th., vol. IT-8, no. 2, Feb. 1962, p. 155/159.

. . . the transformation from an input speech signal into a sequence of phonemes is carried out largely through an active or feedback process. In this process, patterns are generated internally in the analyzer according to an adaptable sequence of instructions until a best match with the input signal is obtained . . .

THE MEASUREMENT OF FUNCTIONAL LOAD
W. S. Wang, et al., Michigan U., Ann Arbor, (Rept. no. 8), April 1962, 30 p., 16 refs., AD 277 422.

. . . traditionally used to quantify "extent of contrast" among a set of phonemes. An attempt is made to associate with the concept a precise meaning within the framework of communication theory. . . .

STUDY OF SPEECH COMPRESSION SYSTEMS (SYLLABIC COMPRESSION TECHNIQUES)
H. Belar, et al., David Sarnoff Research Center, Princeton, N.J., Quarterly progress rept. no. 5, 16 April-15 July 1963, 15 July 1963, lv., AD 424 599.

The philosophy of normalization for different speakers is discussed . . . summaries of thousands of voicings of certain sounds by different speakers. What is believed to be a new approach to the detection of low frequency component of speech in the presence of noise is reported . . . Start of work on a 200 syllable synthesizer is reported.

ACOUSTICAL DESCRIPTION OF SYLLABIC NUCLEI: DATA DERIVED BY AUTOMATIC ANALYSIS PROCEDURES
A. S. House, et al., Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, Rept. no. SR13 & SR14, Sept. 1963, AD 430 196/7.

PROGRAM FOR ACTIVE SEGMENTATION AND REDUCTION OF PHONETIC PARAMETERS
S. Inomata, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, Rept. no. SR 12, Sept. 1963, 6 p., AD 430 195.

ON THE EFFECTIVENESS OF RECEPTORS IN RECOGNITION SYSTEMS
T. Marill, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 11/17, 22 refs.

. . . the physical sample to be recognized is first subjected to a battery of tests; on the basis of the test results, the sample is then assigned to one of a number of prespecified categories. The theory of how test results should be combined to yield an optimal assignment has been discussed in an earlier paper. Here, attention is focused on the tests themselves. . . .

APPLICATION OF NEURAL LOGIC TO SPEECH ANALYSIS AND RECOGNITION
T. B. Martin, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 189/196.

This paper describes signal-processing techniques for the recognition of speech phonemes by machine. An attempt has been made to employ, wherever useful, basic processing functions of the human auditory system. . . .

SIMULATION AND EVALUATION OF PHONETIC SPEECH RECOGNITION TECHNIQUES. VOLUME I. SEGMENTATION OF CONTINUOUS SPEECH INTO SYLLABLES
K. W. Otten, National Cash Register Co., Dayton, Ohio, Sept. 1963, 22 p., AD 422 472.

. . . analysis of design parameters required for the simulation and evaluation of phonetic speech methods. An approach to the segmentation of continuous speech into syllables is described, and the results of segmentation experiments . . . are presented . . . divide continuous speech into units which are either silences or what are defined here as impulse syllables. . . . the time between segmentation points, and the binary information on the type of impulse syllable. . . . some of the potential segmentation points are eliminated. The resulting new units are silences and linguistically meaningful syllables.

AUTOMATIC DETERMINATION OF THE PARTS OF SPEECH OF ENGLISH WORDS
H. L. Resnikoff, et al., Proc. IEEE, vol. 51, no. 7, July 1963, p. 1029.

. . . simulation on an IBM-7090 of a first-generation electromechanical machine which determines the parts of speech of English words based on a dictionary containing a total of less than 200 words and less than 200 affixes. . . . It is very difficult to precisely determine the accuracy of such a device for certain reasons which it will be indicated . . .

PATTERN RECOGNITION AS A PROBLEM IN DECISION THEORY AND AN APPLICATION TO SPEECH RECOGNITION
V.E. Sackschewsky, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 186/189.

. . . general discussion of pattern recognition as a problem in statistical decision theory, . . . application of these concepts . . . to the recognition of speech sounds by a method which uses the same principles for preprocessing of sound as does the human auditory system. . . . under appropriate conditions a pattern recognition technique which maximizes the cross correlation coefficient of the signal with a set of functions representing the patterns is equivalent to the optimum decision rule. . . .

A REAL-TIME ADAPTIVE SPEECH-RECOGNITION SYSTEM
L.R. Talbert, et al., Stanford Electronics Labs., Stanford U., Calif., Technical rept. no. 6760, 1: SEL 63 064, May 1963, 18 p., AD 420 180.

. . . employing adaptive Adaline threshold-logic elements. Time-normalized digital patterns, representing the time-frequency spectrum, are obtained from amplitude-normalized outputs of eight bandpass filters. Adaline networks which perform the speech pattern classification are simulated on an IBM 1620 computer. In one experiment, the Adalines were trained on ten samples each of a group of ten phonetically balanced words. . . . When trained on four speakers of the same sex, the system recognized—with 95% accuracy —500 testing samples spoken by these speakers. The use of adaptive networks as pattern classifiers has achieved a high degree of system flexibility since design of the classification system can be accomplished by a training process. . . .

A STUDY OF SIGNIFICANT PARAMETERS OF SPEECH FOR APPLICATION IN AUTOMATIC SPEECH RECOGNITION SYSTEMS
M.R. Weiss, Federal Scientific Corp., New York, Rept. no. T4 114, RADC TDR63 335, 1 July 1963, lv., AD 423 279.

. . . procedure for the automatic recognition of a large vocabulary of English words as spoken by many talkers under a wide range of conditions of speaking . . . high-resolution spectrum analyses were obtained as a function of time for each of 7500 spoken words, automatically converted to digital form, and recorded on magnetic tape. The recorded spectra were then processed by a digital computer for which a program was written for the extraction of parameters of speech . . . Results from 500 of the words are presented. . . .

(No Title)
University Coll., London (Great Bt.), Progress rept., July 1963, 41 p., AD 430 704.

. . . (1) a Study of the formants of the pure vowels of British English; (2) Formant frequencies of Hungarian vowels; (3) An experimental study of the relative contributions of vowel duration and spectral form to the recognition of English and German vowels; (4) Pitch perception and temporal patterning; (5) Long term spectral analysis; (6) SPYL - a combination of instantaneous spectrograph, step synthesizer and a tape loop . . .

Related Publications:

DESCRIPTION MECHANICS
D. McLachlan, Jr., Inform. Control, vol. 3, Sept. 1958, p. 240/266.

. . . Many descriptive processes can be reduced to mathematical terminology by dividing the domain of description into cells whose size is determined by the resolution, and filling the cells with occupants where the number of kinds of occupants is determined by the accuracy of distinguishing between them.

EFFECT OF SAMPLE DURATION ON THE ARTICULATION OF SOUNDS IN NORMAL AND CLIPPED SPEECH
R. Ahmend, et al., J. Acoust. Soc. Amer., vol. 31, no. 7, July 1959, p. 1022/1029.

CLASSIFICATION DECISIONS IN PATTERN RECOGNITION
G.S. Sebestyen, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 25 April 1960, 79 p., AD 411 761.

RELATION BETWEEN LOUDNESS AND DURATION OF TONAL PULSES. III. RESPONSE IN CASES OF ABNORMAL LOUDNESS FUNCTION
F. M. Fodor, J. Acoust. Soc. Amer., vol. 32, no. 4, April 1960, p. 486/492.

BASIC PRINCIPLES OF SOME PATTERN RECOGNITION SYSTEMS
L. Kanal, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 279/295.

SPEECH DATA PROCESSSING IN REAL TIME
H.A. Straight, Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 30/35.

The logical techniques by which a high-speed special-purpose digital computer developed by Melpar compares the digital description of speech spectrum patterns with previously recorded description are presented.

This set of logic is capable of determining which stored pattern most nearly approximates an unprocessed pattern, and is unique in that it makes possible the sorting and compilation of speech statistics in real time. . . . capability of "learning" speech through the tabulation of a set of mean patterns . . .

AN ANALYSIS OF SPEECH SPECTRA IN TERMS OF A MODEL OF ARTICULATION
J.M. Heinz, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, Rept. no. SR15, Sept. 1963, 6 p., AD 430 194.

. . . programs to compare an internally generated spectrum with an actual speech spectrum and to vary manually the input parameters until an optimum match is obtained. The results of the match are parameters which relate to the physical dimensions of the vocal tract . . . Currently, data are being collected by this procedure, particularly in the vicinity of vowel-consonant boundaries. . . .

AN OPTICAL DECISION FILTER
R.D. Joseph, et al., Proc. IEEE, vol. 51, no. 8, Aug. 1963, p. 1098/1118.

PATTERN RECOGNITION PROCESS FOR BUBBLE CHAMBER PICTURES
N.S. Prywes, et al., Computer Command and Control Co., Philadelphia, Pa., Rept. no. 2 101 2, 1 Oct. 1963, 47 p., AD 423 838.

SPEECH ANALYSIS TECHNIQUES
Royal Inst. of Tech. (Sweden). Technical rept. no. 4 (Final), 1 July 1962-30 June 1963, 30 June 1963, lv., AD 419 261.

. . . emphasis on instrumentation and methods for automatic extraction of speech signal parameters. . . . study of the performance of speech compression systems which were demonstrated at the Stockholm Speech Communication Seminar 1962.

Section 2.37

2.370: Speech Synthesis

Included: Segmentation techniques in speech synthesis; Dynamic analog speech synthesizer; Terminal analog synthesizer; Segment inventories; Minimal rules for synthesizing speech; Correlation instrumentation for speech synthesis.

Not Included: Phonetic and acoustic research in speech synthesis; Release of recorded sounds by data signals; Signal processing techniques (3A); Related bionics problems (3B).

Cross References: Speech analysis in general (2.310); Segmentation in phoneme recognition techniques (2.360); Electrical analogs of human speech organs (2.316); Time analysis of speech sounds (2.313).

Principal Publications:

PITCH DISCRIMINATION FOR SYNTHETIC VOWELS
J. L. Flanagan, et al., J. Acoust. Soc. Amer., vol. 30, no. 5, May 1958, p. 435/442.

SOUND SYNTHESIZER WITH OPTICAL CONTROL
O. Fujimura, J. Acoust. Soc. Amer., vol. 30, no. 1, Jan. 1958, p. 56/57.

An optical vocoder is described. The filter bank consists of piezo-electrical crystals. When resonating they shift their polarization plane. Thus the frequency pattern of speech can be translated to a polarization pattern of light.

Very little is described in this article, although much seems to have been accomplished.

SYNTHESIS OF NASAL CONSONANTS BY TERMINAL ANALOG SYNTHESIZER
K. Nakata, Res. Lab, Electronics, MIT, Quarterly Progress Rept., April 1958, p. 104/107; July 1958, p. 144/146.

SEGMENTATION TECHNIQUES IN SPEECH SYNTHESIS (Part I)
G. E. Peterson, et al., University of Michigan, Ann Arbor, Report No. 1, Part I - In cooperation with Oslo U., May 1958, AD 218 620.

A Segment Inventory for Speech Synthesis, Part II by William S-Y Wang and G. E. Peterson, May 1958, 16 p., Report No. 1, Part 2.

SEGMENTATION TECHNIQUES IN SPEECH SYNTHESIS
G. E. Peterson, et al., J. Acoust. Soc. Amer., vol. 30, no. 8, Aug. 1958, p. 739/742.

A basic method of speech synthesis is described in which discrete segments of recorded utterances are joined together to produce continuous speech. . . .

DYNAMIC ANALOG SPEECH SYNTHESIZER
G. Rosen, J. Acoust. Soc. Amer., vol. 30, no. 3, March 1958, p. 201/209.

A dynamically controllable electrical analog of the vocal tract capable of synthesizing sequences of speech sounds . . . The acoustic transmission line between the glottis and lips in the human vocal tract is realized electrically by eleven electronically controlled variable LC sections plus three fixed sections.

SEGMENT INVENTORY FOR SPEECH SYNTHESIS
W. S-Y. Wang, et al., J. Acoust. Soc. Amer., vol. 30, no. 8, Aug. 1958, p. 743/746.

The inventory of segments required to synthesize an idiolect of American speech from recorded utterances has been partially investigated. A total of 43 phonetic units, including a unit of silence, is found essential. . . .

RESEARCH ON SPEECH SYNTHESIS
Acoustics Lab., MIT, Scientific Report #17, AFCRC TN 58-140, March 1958, 49 p., AD 152 365.

Speech communication research at MIT Acoustics Lab. during the period Dec. 1, 1956 to Feb. 28, 1958, under U. S. Air Force sponsorship is summarized. The research included studies of the production and perception of vowels and consonants and the development of instrumentation for the synthesis of speech. . . .

DESIGN AND STUDY OF CORRELATION INSTRUMENTATION FOR SPEECH ANALYSIS AND SYNTHESIS
G. J. Duscheck, et al., RCA Defense Electronic Products, Camden, N.J., Scientific Report 1, AFCRC TN 59-173, March 1959, 76 p., AD 214 415, AD 119 258.

An optimum analog instrumentation for processing the output signal of a Vocoder for digital transmission is presented. The system is based on the matching of the incoming voice events against a catalog of speech patterns so that only the pattern number, rather than the speech event itself, need be transmitted. In the receiver the proper speech pattern is retrieved from a similar memory and generates the required voltages for the Vocoder synthesizer. The recommended system features completely analog processing so that small deviations in the patterns can readily be accommodated. To minimize the number of electronic components and thus increase the equipment reliability, time-sequential rather than parallel pattern matching was employed. A single magnetic storage drum was used as the pattern catalog. In duplex operation, it can serve simultaneously as part of the analyzer of synthesizer and can handle any desired number of voice channels.

ACOUSTIC ANALYSIS AND SYNTHESIS OF SPEECH WITH APPLICATIONS TO SWEDISH
G. Fant, Ericsson Tech., vol. 15, no. 1, 1959, p. 3/108.

DESIGN AND STUDY OF CORRELATION INSTRUMENTATION FOR SPEECH ANALYSIS AND SYNTHESIS
D. T. Hogar, et al., RCA Defense Electronic Products, Camden, N. J., Report No. AFCRC TN 59-566, July 1959, 53 p., AD 225 737.

This report describes further evaluation of the continuous analog system. In particular, the magnetic and optical storage of patterns have been considered in detail, the pattern comparison circuitry has been evaluated, and the entire system has been examined from the standpoint of departures from ideal operation due to inaccuracies introduced by practical components. . . . (See also AD 214 415.)

MINIMAL RULES FOR SYNTHESIZING SPEECH
A. M. Liberman, et al., J. Acoust. Soc. Amer., vol. 31, no. 11, Nov. 1959, p. 1490/1499.

SYNTHESIS OF NASAL CONSONANTS BY A TERMINAL ANALOG SYNTHESIZER
K. Nakata, J. Radio Res. Labs., Japan, vol. 6, April 1959, p. 243/254.

DYNAMIC ANALOG SPEECH SYNTHESIZER
G. Rosen, MIT, Res. Lab. Quarterly Prog. Rept. 52, Jan. 1958, p. 142/144; Quarterly Prog. Rept., 53, April 1959, p. 171/174.

RESEARCH ON SPEECH SYNTHESIS
Research Lab. of Electronics, MIT, Cambridge, Final report for 1 March 1958, 31 Oct. 1959, AFCRC TR 60-101, Dec. 1959, 15 p., AD 232 113, AD 152 365.

Descriptors: Speech; synthesis; speech transmission; intelligibility; acoustics; auditory perception; computers.

SPEECH-COMPRESSION-SYSTEM STUDY
R. A. Houde, Stromberg-Carlson Co., Rochester, N. Y., Quarterly report no. 1, 1 July 1959 - 31 Jan. 1960, 28 p., AD 235 353.

Instrumentation for the first stage of the speech compression system study is underway. A Lawrence-type speech synthesizer and voltage function generator is complete, and construction of a speech spectrum analyzer, which produces data in binary form suitable for processing in a digital computer, is under way. The relationship between synthesized speech quality and controlling parameters is being investigated.

Related Publications:

STUDIES OF THE PERCEPTION OF SPEECH-LIKE SOUNDS
P. Lieberman, Res. Lab. of Elect. MIT, Quarterly Progress Report, July 1958, p. 155/161.

INFORMATION TRANSMISSION WITH ELEMENTARY AUDITORY DISPLAYS
W. H. Sumby, et al., J. Acoust. Soc. Amer., vol. 30, no. 5, May 1958, p. 425/429.

APPLICATION STUDIES OF COMBINED ANALOG-DIGITAL-COMPUTATION TECHNIQUES
F. B. Hills, Electronics Systems Lab., Mass. Inst. of Tech., Cambridge, Feb. 1963, 66 p., AD 404 179.

. . . speech synthesis . . .

Section 2.38
Special Applications of Speech Compression

2.382: Speaker Identification

Included: Adaptive speech recognition systems based on speaker identification; Adaline networks used for speaker identification; Speaker recognition.

Not Included: Related reconnaissance operations.

Cross References: Phoneme identification methods (2.360).

Principal Publications:

PATTERN RECOGNITION BY AN ADAPTIVE PROCESS OF SAMPLE SET CONSTRUCTION
G. S. Sebestyen, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 82/91.

. . . This technique was successfully applied to the automatic recognition speaker identify regardless of the spoken test. Experimental results are given. . . .

SPEAKER RECOGNITION
G. L. Holmgren, Texas Instruments, Inc., Dallas, (Rept. 14-73801-14; AFCRL-63-119), May 1963, 48 p., 27 refs., N63-17644.

. . . defining a perceptual space within which listeners locate voices . . . taped speech samples were rated by listeners using Osgood's semantic differential method. . . .

A REAL-TIME ADAPTIVE SPEECH-RECOGNITION SYSTEM
L. R. Talbert, et al., Stanford Electronics Labs., Stanford U., Calif., Technical rept. no. 6760, 1: SEL 63 064, ASD TDR 63 600, May 1963, 18 p., AD 420 180.

. . . employing adaptive Adaline threshold-logic elements. Time-normalized digital patterns, representing the time-frequency spectrum, are obtained from amplitude-normalized outputs of eight bandpass filters. Adaline networks which perform the speech pattern classification are simulated on an IBM 1620 computer. In one experiment, the Adalines were trained on ten samples each of a group of ten phonetically balanced words. . . . When trained on four speakers of the same sex, the system recognized—with 95% accuracy—500 testing samples spoken by these speakers. The use of adaptive networks as pattern classifiers has achieved a high degree of system flexibility since design of the classification system can be accomplished by a training process. . . .

Related Publications:

A STUDY OF SIGNIFICANT PARAMETERS OF SPEECH FOR APPLICATION IN AUTOMATIC SPEECH RECOGNITION SYSTEMS
M. R. Weiss, Federal Scientific Corp., New York, Rept. no. T4 114, RADC TDR63 335, 1 July 1963, lv., AD 423 279.

. . . procedure for the automatic recognition of a large vocabulary of English words as spoken by many talkers under a wide range of conditions of speaking . . .

DIVISION 2.4
VIDEO COMPRESSION

Video transmission from spacecraft back to Earth and from landing craft to orbiting spacecraft is an essential requirement for space communications systems. The bandwidth requirements for television links of necessary resolution are frequently in excess of the capabilities of the space communications systems. This makes picture compaction, i.e., the redundancy reduction of the video signals, highly desirable.

The introductory section of this division contains references to several state-of-the-art reports. Some general publications, not directly pertinent to other sections, are also included.

Section 2.41 is, as in previous divisions, the theoretical section, giving background material on the physiological fundamentals of vision and on the general analysis of picture links.

Section 2.42 specializes in some picture signal processing techniques which may be applied in many of the following video compression methods. Scanning procedures, sampling and quantization methods and certain general coding principles, such as run-length encoding, are placed in this section.

Analog compaction techniques (2.43) have created some interest for picture compression because they suggest simple equipment. Their compaction efficiency, however, is not very high.

Better results can be expected from pattern recognition methods (2.44), which can draw upon the experience of character recognition systems (2.26). The application of such methods for television information compression requires a number of further considerations to accommodate the multi-dimensional correlations of pictures. It may be expected that operational systems will incorporate many of the methods referenced in this division.

Predictive picture compaction methods (2.45) make use of the strong correlation of picture details between lines and between frames of television images. They require large memories and a sizable equipment complexity but promise very high compaction efficiency.

Most of the above-mentioned video compression efforts will ultimately lead to digital processing systems, since only digital transmission systems will satisfy future space communications requirements. Section 2.46 contains references to efforts in this direction.

There are already some applications of video compaction systems under discussion in the literature. They will be mentioned in section 2.48, with the, presently, only subdivision (2.482) on map compilers.

Simulation, statistical evaluation and measurements (2.49) are required in increasing degree to supply all the necessary data for further research in this developing branch of coding technology.

Section 2.40

2.400: Introduction to Video Compression

Included: Frequency compression in television; Bandwidth compression of visual image signals; Automatic picture detail detection; Compactive coding of pictorial data; Video bandwidth compression.

Not Included: Commercial television systems; Design of picture transmission facilities; Analysis of space links for video transmission.

Cross References: Pattern recognition in general (2.260).

Principal Publications:

BANDWIDTH COMPRESSION OF TELEVISION SIGNALS
G. G. Gouriet, Proc. Instn. Elect. Engrs., May 1957, Part B, p. 104.

WEITERE FORSCHRITTE BEI DER KOMPRESSION DER BANDBREITE VON RADARSCHIRMBILDERN (Further Progress in Bandwidth Compression of Radar Display Pictures) (In German)
H. Meinke, et al., Nachrichtentech. Z., vol. 11, Aug. 1958, p. 398/404.

STATISTICAL ENCODING FOR TEXT AND PICTURE COMMUNICATION
W. S. Michel, Commun. and Electronics, March 1958, p. 33/36.

STORAGE AND FREQUENCY BAND COMPRESSION IN TV (In German)
F. Schroter, Bull. Assoc. Suisse Elect., vol. 51, no. 20, Oct. 1960, p. 999/1004, 12 refs.

Redundance of information and various methods of band-compression are discussed initially. A system is then proposed which, based on the eye's resolution time, combines the techniques of intermediate storage, halving of scan velocity and the twin-frequency low-pass discriminator to give a theoretical band compression of 8:1. Practical considerations limit this figure to 4 or 5.

NEW TYPE OF TELEVISION SYSTEM
I. L. Valik, et al., Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 2, 1961, p. 75/80, 12 refs.

. . . new fields of application of television methods. . . new types of television systems. . . . one of these systems is evaluated—a system with separate processes of recording and reading (small-frame television). . . .
a) Matching a Source of Video Information with a Radio Channel . . .
b) Transmission of Information with Time Delay . . .
c) Possibility of Multi-Frame Transmission Cycle . . .

THE CODING OF PICTORIAL DATA
J. S. Wholey, et al., IRE Trans. Inform. Th., vol. IT-7, no. 2, April 1961, p. 99/104.

VIDEO BANDWIDTH COMPRESSION
W. F. Haagen, Antenna Lab., Ohio State U. Research Foundation, Columbus, Report on Guidance and Sensing Techniques for Advanced Vehicles, (Rept. no. 1222-7), 1 Feb. 1962, 46 p. incl. illus., 16 refs., AD 273 671.

. . . Several methods were employed to analyze a test photograph. The minimum channel capacity found for the test photograph was 3000 bits. The present type system would require 35000 bits. The resultant reduction in channel capacity is especially significant when a reduction in the element size is considered.

VIDEO BANDWIDTH COMPRESSION
W. F. Haagen, IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 95.

Abstract only.

RESEARCH INVESTIGATIONS ON PHOTO FACSIMILE TRANSMISSION TECHNIQUES
W. H. Hell, et al., Marquardt Corp., Van Nuys, Calif., Quarterly progress rept. no. 2, 1 Oct.-31 Dec. 1962, Rept. no. 25069, 31 Dec. 1962, 159 p., AD 401 457.

Representative data for describing scenes . . . guide-lines for transducer requirements . . . Several line scanning techniques for the optical readout of a stored image were investigated. Two image storage techniques were studied: (1) The optron (a photoconductor-electro-luminophor combination); and (2) the ferrotron (a photoconductor-ferroelectric combination). The former has achieved 80 lines per inch resolution and 0.1 foot candle second sensitivity, while the latter has achieved 250 lines per inch under an illumination of 0.001 foot candles, and appearing more promising as a component for an advanced photofacsimile transmission system.

AN EXPERIMENTAL STUDY OF THE POSSIBLE BANDWIDTH COMPRESSION OF VISUAL IMAGE SIGNALS
C. Cherry, et al., Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1507/1517.

. . . experiments upon the possibilities of automatic data reduction or bandwidth compression of visual channels, for both black and white diagrams and for half-tone pictures, using electronic equipment and accepting realistic noise levels.

A SUMMARY OF THE STATE-OF-THE ART OF VISUAL COMMUNICATION
J. H. Harshbarger, Proc. Nat. Aerospace Electronics Conf., May 1963, p. 373/378.

AUTOMATIC PICTURE DETAIL DETECTION IN THE PRESENCE OF RANDOM NOISE
M. H. Kubba, Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1518/1523.

. . . intended to be a companion to the paper in this issue by Cherry, et al., entitled "An Experimental Study of the Possible Bandwidth Compression of Visual Image Signals". . . . concerns particularly that part of the visual signal compression process carried out by the "picture detail detector". The purpose of this detector is to make a continuous running examination of a scanned video signal, in real time and to make successive decisions concerning the location of essential sample points. These points are the boundaries between successive step functions which adequately represent a reduced form of the picture suitable for encoding in a compression scheme. . . .

THE CODING OF VISUAL SIGNALS TO REDUCE CHANNEL-CAPACITY REQUIREMENTS
A. J. Seyler, Proc. Instn. Elect. Engrs., vol. 109C, July 1962, p. 676/684.

Related Publications:

MINIATURE MOVIES OF THE PLANETS
S. C. Baker, et al., Astronautics, vol. 104, May 1959, p. 26/28.

AN INTERPLANETARY COMMUNICATION SYSTEM
G. E. Mueller, et al., IRE Trans. Space Electronics Telem., vol. SET-5, no. 4, Dec. 1959, p. 196/204.

. . . Proper screening and processing of data before their transmission can increase the amount of useful information received at the expense of other data not so variable and can ease ground data handling problems. A telemetry system, entitled "Telebit," which makes use of some of these principles, and is a forerunner to the application of others, is described. . . .

In case there is a requirement for transmitting pictures, the effective bandwidth and information rate may be reduced by sampling techniques. . .

METEOROLOGICAL SATELLITE SYSTEM ANALYSES
T. S. Huang, et al., Allied Research Associates, Inc., Concord, Mass., AFCRL-63-804, 30 June 1962, 155 p., 59 refs., N63-19138.

. . . three articles relating to the design and use of a weather satellite system. "Some Information-Theoretic Considerations and Measurements Concerning the Efficient Processing of Satellite Cloud Pictures" addresses itself to the problem of efficiently reducing the information-bit content of weather-satellite pictures to an amount that can be economically transmitted to operational users and there assimilated.

Section 2.41

2.410: Fundamentals of Video Compression

Included: Theory of redundancy control of visual information; Fidelity criteria of compacted video links; Sensory sensation; Visual stimuli; Related psycho-physics of vision; Probability characteristics of pictorial sensor output data; Image source statistics; Electronic models of visual sensory organs; Model of eye tracking movements; Color vision theories; Theory of video information; Entropy of picture material.

Not Included: Theory of optical systems; Camera technology.

Cross References: Fundamentals of information compression (Div. 2.2); Statistics of information sources (2.221).

Principal Publications:

SOME RELATIONS BETWEEN TELEVISION PICTURE REDUNDANCY AND BANDWIDTH REQUIREMENTS
K. H. Powers, et al., Trans. Amer. Inst. Elect. Engrs., Pt. 1, Sept. 1957, p. 76.

INVESTIGATION OF TECHNIQUES FOR IMPROVING RADIO FREQUENCY SPECTRUM CONSERVATION AND UTILIZATION IN MILITARY TELEVISION APPLICATIONS
H. L. Roberts, Denver Research Inst., April 1958, AD 202 730.

DIE SICHTBARKEIT VON BILDEINZELHEITEN BEWEGTER OBJEKTE IM FERNSEHEN (The Recognition of Picture Details of Moving Objects in Television) (In German)
I. Bornemann, Nachrichtentechnik, vol. 9, Jan. 1959, p. 8/12.

MIKROSTRUKTURUNTERSUCHUNGEN VON FARBFERNSEHBILDERN (Micro Structure of Color Television Pictures) (In German)
I. Bornemann, Nachrichtentechnik, vol. 9, July 1959, p. 313/317.

"SIGNAUX TYPES" ET REGIMES TRANSITORIES EN TELEVISION (Elementary Signals and Transients in Television) (In French)
L. Bourassin, L'Onde Electrique, vol. 39, Jan. 1959, p. 7/31.

DIGITAL SIMULATION IN PERCEPTUAL RESEARCH
E. E. David, Jr., Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 322/328.

Evaluation of communications systems transmitting visual or auditory information is complicated since the final message destination is a human observer. It is the perceptual significance of transmission distortions which must form the basis for evaluation.

Following this prescription, signal samples with specified distortions must be generated to serve as material for subjective evaluation . . . a digital computer can often be programmed to simulate the system and generate the desired samples. Several investigations using this technique have been carried out using a data translator to provide an input-output link to the computer. The significant properties of several band-saving codings have been so obtained. . . Potentially this technique can be extended to generate complex stimuli for psychological explanation of perceptual mechanisms.

DIE ERKENNBARKEIT VON BILDDETAILS BEI FERNSEHBILDERN (The Discriminability of Picture Details in Television Pictures) (In German)
W. Kroebel, et al., Veroffent, aus der Fernsehtechnik, vol. 3, Feb. 1959.

TWO-DIMENSIONAL PREDICTIVE REDUNDANCY IN A TELEVISION DISPLAY
A. V. J. Martin, IRE Trans. Commun. Syst., vol. CS-7, no. 1, May 1959, p. 57/61.

The two-dimensional predictive redundancy of a television picture element is calculated as a function of the preceding point correlation for both interlaced and noninterlaced scanning.

DIE THEORIE DER VIDEOINFORMATION (Theory of Video Information) (In German)
P. Neidhardt, Nachrichtentechnik, vol. 9, Jan. 1959, p. 18/23.

DIE PRAKTISCHE AUSWIRKUNG EINER FREQUENZBAND-BEGRENZUNG AUF FARBFERNSEHBILDER (The Practical Effect of Frequency-band Limitations on Color Television Pictures) (In German)
P. Neidhardt, Nachrichtentechnik, vol. 9, July 1959, p. 318/323.

VISUAL COMMUNICATION AND PSYCHOPHYSICS OF VISION
A. J. Seyler, Proc. Instn. Radio Engrs., Australia, vol. 23, no. 5, May 1962, p. 291/304, 56 refs.

. . . to discuss the effects which result when man is considered to be a constituent part of electrical communication systems in general and in particular of systems designed for visual communication. . . . maximum-contingency criteria are applied to the capacity of the communication channel for each of the visual parameters of spatial, contrast-and motion-resolution independently. . . . it appears. . . that man's sensory capacity is adaptively shared between these parameters, with the result, that at any time a maximum contingency can exist only for one parameter at a time. This adaptive behavior can be applied to signal coding methods which are designated as "Adaptive Parameter Codes" and which may be used alone or in conjunction with statistically matched codes arising from the concepts of Information Theory. . . . by employing such adaptive codes, the channel capacity required for the transmission of visual signals may be reduced. . . additional investigations are still necessary . . . for quantitative communications system design. . . .

STATISTICAL PROPERTIES OF THE CONTOURS OF RANDOM SURFACES
P. Swerling, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 315/321.

A random surface is a sample function of a random process (f (x, y)) depending on two real parameters. Examples of random surfaces would be: photographs or television pictures; topographic maps; atmospheric pressure charts; and the like. . . .

AUTOMATIC DATA COMPRESSION FOR TELEVISION PICTURES
JPL Space Progr. Summ., vol. 6, no. 37-18, Sept./Nov. 1962, p. 61/65.

. . . pictures taken from a spacecraft. . . may have a high percentage of redundancy. . . . an opportunity arises for reducing the total amount of information to be televised.

1. Theory of Redundancy Control—A technique that appears particularly suitable for redundancy control in a planetary camera instrumentation system is that of polynomial interpolation.
2. Mechanization of Redundancy Control. . .
3. Experimental Sampling Techniques. . .
4. Data Reductions Possible. . .

SPECTRAL SCANNING AS A MECHANISM OF COLOR VISION
G. Biernson, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 103/108.

In perceiving color the eye performs a wavelength discrimination process which is analogous to the angular discrimination performed in a tracking radar. . . . This paper postulates that the eye employs the scanning discrimination principles to perceive color. A wavelength-dependent effect within the cone causes light of different wavelengths to produce different spatial distributions of energy in the photodetector region. An electrical process scans across this photodetector region producing a modulated waveform which defines the color information. . .

COMPARISON BETWEEN SPECTRAL SCANNING THEORY AND CLASSICAL COLOR VISION THEORIES
G. Biernson, Sylvania Electric Products, Inc., Applied Research Lab., Waltham, Mass., (NASA CR-50350; Res. Note-396), May 16, 1963, 17 p., 6 refs., N63-17230.

A detailed comparison of experimental evidence relative to the Spectral Scanning theory and the Trichromatic theory, shows that the Spectral Scanning theory is at least as consistent with this evidence as is the Trichromatic theory. . . .

ENTROPY OF SIMPLE LINE DRAWINGS (Correspondence)
W. H. Foy, Jr., IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 165/167.

. . . Laemmel and Wyle, Erb, and Banow have treated white-cell run-length coding; Wholey has studied block coding; and Swerling has considered the statistics of contour lines of random surfaces. This communication gives a computation of the entropy of a general class of line drawings, this statistic being of particular interest since it sets a lower bound on the channel capacity required in the communication link. . . .

FUNCTIONAL ELECTRONIC MODEL OF THE FROG RETINA
M. B. Herscher, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 98/103.

. . . This system duplicates functionally the four image-feature-abstraction process found by Lettvin and co-workers. . .

PROBABILITY CHARACTERISTICS OF SENSOR OUTPUT DATA
G. W. McClure, et al., Michigan U., Ann Arbor Inst. of Science and Tech., (Memo-2900-329-R), Sept. 1963, 34 p., 9 refs., N63-21405.

. . . First results of a program to determine the statistical nature of surveillance sensor output data. Most of the data were obtained from negative transparencies of vertically oriented aerial photographs. Smaller sample of radar and infrared films are reported for comparison. A line-scan process was used to generate an electrical analog of the light transmitted by the film. This signal was sampled, amplitude quantized, and recorded for later statistical analysis by a digital computer. . .

GRUNDSATZLICHE BETRACHTUNG ZUR ANWENDUNG PSYCHOPHYSISCHER GESETZE FUR DEN ENTWURF VISUELLER NACHRICHTENSYSTEME (Psycho-physical Fundamentals for the Design of Picture Transmission Systems) (In German)
A. J. Seyler, Arch. Elekt. Uebertragung, vol. 17, Feb. 1963, p. 51/63, 45 refs.

. . . This paper is primarily concerned with the derivation of fidelity criteria and the resulting required channel capacity for non-utilitarian systems for the transmission of visual messages.

In such systems man acts as an information sink and thus the fact of receiving a certain message cannot be used as an objectively defined fidelity criterion. Rather, the system quality is defined by the criterion of preserving the illusion of direct communication, i. e. by the subjectively unimpaired sensation of sensory stimuli. . . .

OPTICAL IMAGE FORMATION IN TERMS OF FOURIER SUMMATION AND ITS RELATION TO INFORMATION TRANSMISSION
T. Wei-han, et al., Emmanuel Coll., Boston, Mass., Research Language Center, Research trans. ETCh63 5, May 1963, 21 p., AD 420 431.

A DISCRETE MODEL FOR EYE TRACKING MOVEMENTS
L. R. Young, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 113/115.

A sampled data model was developed to describe the major characteristics of the eye movement control system for nonpredictive tracking. It agrees with experimental transient responses and frequency characteristics for normal eye movements during following of a moving target in a horizontal plane. . . .

Related Publications:

DESCRIPTION MECHANICS
D. McLachlan, Jr., Inform. Control, vol. 3, Sept. 1958, p. 240/266.

The concept is developed for the purpose of pointing out a common basis for many of the fields related to information theory. These fields include thermodynamics, photography, language, models, gambling, cryptology, and pattern recognition.

CONTRAST TRANSFER FUNCTIONS FOR THE EVALUATION OF IMAGE QUALITY IN PHOTOGRAMMETRY
K. Schwidefsky, Army Engineer Research and Development Labs., Fort Belvoir, Va., AERDL T1708, 1960, 17 p., AD 428 417.

ANALOGY OF CHARACTERISTICS OF REPRODUCTION IN TELEVISION AND PHOTOGRAPHY
S. B. Gurevich, Joint Publications Research Service, Washington, D. C., JPRS 16930, OTS rept. 63-13666, 2 Jan. 1962, 26 p., 15 refs., AD 298 915.

Comparisons. . . signal-to-noise ratio, contrast and gradation transmission, resolving

power and light-versus-signal characteristics. The possibility of an informational evaluation of reproduction quality and sensitivity is discussed. Formulas for information capacity as well as for sensitivity of ideal and real systems are deduced.

THE PORTRAYAL OF BODY SHAPE BY A SONAR OR RADAR SYSTEM
A. Freedman, J. Brit. Instn. Radio Engrs., vol. 25, no. 1, Jan. 1963, p. 51/64.

. . . mechanism whereby the eye perceives shape and to see how this is applicable to methods of display in sonar and radar equipment. . . .

STUDY ON THE APPLICATION AND INSTRUMENTATION OF VISUAL PERCEPTION FOR SPACE EXPLORATION
Sylvania Electronic Systems, Waltham, Mass., Applied Research Lab., Aug. 27, 1963, 29 p., 74 refs., N63-21731.

. . . utility of human vision and color perception concepts in space exploration. . . (1) the extension of the Yilmaz theory of color perception. . . (2) the extension of the Biernson spectral scanning theory. . .

Section 2.42

2.420: Special Picture Processing Techniques

Included: Image scanning methods for video compression; Run-length coding of pictures; Pre-normalization of pictorial data; De-screening of images; Compactive sampling methods for pictures; Nonlinear quantization methods for pictures; Feedback quantization system; Shape of scanning apertures; Gamma correction methods.

Not Included: Standard TV scanning circuits.

Cross References: Run-length coding methods in general (2.252); Variable scanning methods (2.430); Compactive sampling methods in general (2.253); Compactive quantization methods in general (2.254).

Principal Publications:

SCANNING APERTURES TESTS
S. Deutsch, et al., Microwave Research Inst. Polytechnic Inst. of Brooklyn, N.Y., Rept. No. R-627-57; PIB-555 (RADC TN-58-371), April 1958, AD 206 555.

. . . to evaluate possible improvement of resolution in facsimile transmission by modifying the shape of the scanning apertures. . . .

PREDICTIVE QUANTIZING OF TELEVISION SIGNALS
R.E. Graham, IRE WESCON Conv. Rec., no. 4, Aug. 1958, p. 147/157.

A PROBABILISTIC MODEL FOR RUN-LENGTH CODING OF PICTURES
J. Capon, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 421.

Abstract Only — A first-order Markov process representation for pictures is proposed in order to study the picture coding system known as run-length coding (differential-coordinate encoding). A lower bound for the saving in channel capacity of the run-length coding system is calculated on the basis of this model, and is compared with the results obtained by previous investigators . . .

A PROBABILISTIC MODEL FOR RUN-LENGTH CODING OF PICTURES
J. Capon, IRE Trans. Inform. Th., vol. IT-5, Dec. 1959, p. 157/163.

GRADATIONSENTZERRUNG IM FARBFERNSEHEN (Gamma Correction for Color TV) (In German)
J Kaashoek, Veroffent. aus der Fernehtechnik, vol. 3, no. 4, Feb. 1959.

LE BALAYAGE "CAVALIER", PROCEDE PERMETTANT D'AMELIORER LA FINESSE DES IMAGES EN TELEVISION, SANS AUGMENTER LA LARGEUR DE LA "BANDE PASSANTE". (A Scanning Method Following a "Knights move" of the Chess Game. This Method Promises to Improve the Television Resolution Without an Increase in Transmission Bandwidth). (In French)
P.M. Toulon, Bull. Ass. Suisse Electr., vol. 40, Aug. 1959, p. 638/641.

SAMPLING AND RECONSTRUCTION OF WAVE-NUMBER-LIMITED FUNCTIONS IN N-DIMENSIONAL EUCLIDEAN SPACES
D.P. Petersen, et al., Inform. Control, vol. 5, no. 4, Dec. 1962, p. 279/323.

The well-known Whittaker-Kotel'nikov-Shannon sampling theorem for frequency-band-limited functions of time is extended to functions of multidimensional arguments. It is shown that a function whose spectrum is restricted to a finite region of wave-number space may be

reconstructed from its samples taken over a periodic lattice having suitably small repetition vectors. The most efficient lattice (i.e., requiring minimum sampling points per unit hypervolume) is not in general rectangular, nor is a unique reconstruction function associated with a given sampling lattice. . . .

DIE BILDABTASTUNG ALS TRANSFORMATION DER ZWEIDIMENSIONALEN BILDSYSTEM-CHARAKTERISTIK IN EINE EINDIMENSIONALE FUNKTION (The Scanning Process as a Transformation of the Two Dimensional Picture Contact Into a One Dimensional Function) (In German)
F. Arp, Arch. Elekt. Uebertragung, vol. 17, May 1963, p. 207/216, 20 refs.

The process of image scanning can be associated with a transfer coefficient that links the two-dimensional system properties of optical and electron-optical imaging with the unidimensional system factor of the electric transmission channel. The errors of two-dimensional imaging, to the extent they are stationary, can thus be transformed into the equivalent of the image amplifier. . . .

GRUNDSATSLICHE MOGLICHKEITEN UND GRENZEN DER ZWEIDIMENSIONALEN APERTURKORREKTUR BIE DER BILDABTASTUNG (Fundamentals of the Two Dimensional Aperture Correction of the Scanning Process) (In German)
F. Arp, Arch. Elekt. Uebertragung, vol. 17, June 1963, p. 295/309, 20 refs.

Methods are stated which allow the compensation by suitable networks of the two-dimensional imaging errors caused in the scanning of original picture copy. The transfer constants and the block diagrams of such networks are communicated for sequential and interlaced scanning. A particular feature of these networks are delay elements giving the picture signal with a delay corresponding to multiples of the duration t_z of one scanning line. . . .

THE PRENORMALIZATION OF RECONNAISSANCE DATA
J.F. Bogusz, et al., Philco Corp., Blue Bell, Pa., Final Report, (Philco VO44-F: RADC-TDR-63-372; 25 July 1963, 208 p., AD 422 946, N64-12646.

. . . prenormalization of gray-scale aerial photographs prior to their use as input to an adaptive memory recognition system. . . .

ONE-AND TWO-DIMENSIONAL PROCESSING IN LINE SCANNING SYSTEMS
L.G. Callahan, et al., Appl. Optics, vol. 2, no. 4, April 1963, p. 401/407.

. . . The results apply to systems such as infrared scanners, TV systems, and radar systems. The main objective of the analysis is to compare the performance obtainable when optimum two-dimensional processing of the data is used and the performance obtainable when only one-dimensional (along the lines) processing is used. . . . Quantitative comparisons are made for two cases; specifically, top hat and cone-shaped frequency responses of the aperture are considered. These characteristics occur in coherent and incoherent scanners in which the "resolution" is limited by the optical aperture of the scanner. Three performance criteria are used: least squares error, maximum-peak signal to r.m.s. noise ratio, and minimum system resolution. A table shows the improvement of arbitrary two-dimensional filtering over one-dimensional filtering along the lines.

SYNTHESIS OF OPTIMAL FILTERS FOR A FEEDBACK QUANTIZATION SYSTEM
E.G. Kimme, et al., IEEE Internat. Conv. Rec., Pt. 2, vol. 11, March 1963, p. 16/26.

. . . One proposal for a baseband quantization system for narrow-band television signals incorporates linear predistortion and reconstruction, and a linear noise feedback loop around the quantizer. Using an additive noise model for the quantizer, a procedure is developed for synthesizing a predistortion filter, a reconstruction filter, . . . and a feedback filter . . . for this system so as . . . through a rapidly converging iterative procedure of an IBM 7090 automatic computer. . . .

PICTURE REGENERATION FROM QUANTITIZED DATA
J.G. Raudseps, Ohio State U., Research Foundation, Columbus Antenna Lab., (Rept. 122-19), July 31, 1963, 34 p., 3 refs., N63-22505.

. . . The reduction of the essential information contained in a picture to constant-intensity contours for computer storage and subsequent regeneration by a modified Flexowriter, is reported. Six quantitizing levels were used, and data smoothing methods were developed for both horizontal and vertical scans . . .

LE DETRAMAGE DES IMAGES COMME PROCEDE D'UTILISATION OPTIMALE DES INFORMATIONS (The Descreening of Images as a Means of Optimal Utilization of Information) (In French)
J. Surget, et al., In AGARD, Paris Light and Heat Sensing 1963 p. 137/149, refs., N64-15463.

A plane optical object can perhaps be represented as a function of the position of each of its points in the plane . . . Examples of the application of this technique are the descreening of printed photographs, the suppression of lines in TV images, and the descreening of striograms taken at the cross section of perforated walls set up at the nozzle of a transonic wind tunnel.

Related Publications:

STUDY OF VARIABLE SPEED FACSIMILE SCANNING TECHNIQUES
M. Artzt, David Sarnoff Research Center, Princeton, N.J., Quarterly rept. no. 2, Jan. 1958, 25 p., AD 156 239.

SUMMARIZING A STUDY OF PREVIOUS WORK IN THE FIELD OF REDUCED-TIME FACSIMILE TRANSMISSION
T. Erb, et al., Ford Instrument Co., Long Island City, N.Y., Oct. 1958, 38 p., AD 207 331.

. . . One of these methods, known as Run Length Coding, involves digital transmission. The other, known as variable Speed Scanning, involves analog transmission. . . .

SPECIAL FACSIMILE TECHNIQUES
T. Erb, et al., Ford Instrument Co., Long Island City, N.Y., May 1959, 24 p., AD 217 408.

. . . equipment for a run length statistics measuring program. . . . design aspects of a digitally controlled electronic scanner are also given.

TELEVISION FIELD SCAN LINEARIZATION
H.D. Kitchin, J. Brit. Instn. Radio Engrs., vol. 20, May 1960, p. 357/379.

Section 2.43

2.3240: Analog Picture Compression Methods

Included: Variable line and frame frequency; Variable scan systems; Slope feedback coding of pictures; Variable velocity coding; Cherry-Gouriet method; Randomization of brightness levels; Variable speed facsimile techniques; Stop-go scanning techniques.

Not Included: Design of facsimile equipment.

Cross References: Slope feedback coding of voice (2.340).

Principal Publications:

STUDY OF VARIABLE SPEED FACSIMILE SCANNING TECHNIQUES
M. Artzt, David Sarnoff Research Center, Princeton, N.J., Quarterly rept. no. 2, Jan. 1958, 25 p., AD 156 239, (See also AD 162 908, AD 208 979, AD 219 086, AD 232 685).

STOP-GO SCANNING SAVES SPECTRUM SPACE
H.E. Haynes, et al., Electronic Engrg., vol. 31, Sept. 1958, p. 84/88.

CERTAIN PROPERTIES OF DIGITAL TELEVISION SYSTEMS WITH A CHANGEABLE FREQUENCY OF LINES AND FRAMES
V.P. Mandrazhi, et al., Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 10, Oct. 1962, p. 34/44, 17 refs.

The expediency of constructing an all purpose television system with automatic variation of all of its parameters in correspondence with the properties of the transmitted image is discussed. . . . the properties of digital television systems which are nearly all-purpose are examined. It is shown that the characteristic feature of this class of systems is the variable frequency of lines and frames which depends on the statistical properties of the transmitted image. Questions of synchronization are discussed, the proper ties of the operation in these systems of transmitting tubes with charge accumulation are examined, and requirements for the reproducing receiver are formulated . . .

TESTS OF THREE SYSTEMS OF BANDWIDTH COMPRESSION OF TELEVISION SIGNALS
G.F. Newell, et al., Proc. Instn. Elect. Engrs., (Pt. B), vol. 109, no. 46, July 1962, p. 311/324.

. . . all involve the isolation of the essential brightness changes in the picture; these are redistributed to occur at a uniform rate for transmission. A second signal must be transmitted in order to allow correct repositioning of the brightness changes in the final picture. . . .

A TWO-CHANNEL METHOD FOR COMPRESSING THE BANDWIDTH OF TELEVISION SIGNALS
M.P. Beddoes, Proc. Instn. Elect. Engrs., vol. 110, no. 2, Feb. 1963, p. 369/374.

. . . At the transmitter a "slope-feedback" coder reduced the bandwidth of the television signal before transmission . . . under virtually noiseless conditions, the total bandwidth for the television signal can be reduced some 3·7 times below the normal one. . . .

SOME POSSIBILITIES OF PICTURE SIGNAL BANDWIDTH COMPRESSION
B. Prasada, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 315/328.

An experimental appraisal of the Cherry-Gouriet proposals, for the bandwidth compression of television signals by variable-velocity coding, has been made. A flying-spot variable-velocity scanner was built for this purpose. The encoding of the signal in this system is done by a nonlinear feedback loop. . . . It is concluded that owing to the limitations of the devices, the variable-velocity scanner is not practically feasible for television transmissions. However, this system seems ideally suited for LF transmission of pictures. . . . An open-loop system of bandwidth compression has been described which uses variable-rate sampling. . . .

Related Publications:

GRADATIONSENTZERRUNG IM FARBFERNSEHEN (Gamma Correction in Color Television) (In German)
J. Kaashoek, Narchrichtentech. Z., vol. 11, Oct. 1958, p. 515/518.

Section 2.44

2.440: Pattern Recognition Methods for Video Compression

Included: Reduction to line drawings; Encoding of geometric figures; Perfect maps; Pseudo-random area coding; Parallel method of pattern recognition; Feature detection; Line segment detection; Photo-interpretation methods; Discriminant analysis; Area character coding.

Cross References: Pattern recognition methods in general (2.260); PN picture coding (2.460).

Principal Publications:

THE PRINCIPLES OF THE CONSTRUCTION OF A MACHINE FOR PATTERN RECOGNITION
V.S. Fain, Radio Engng: Transl. of Radioteckhnika, vol. 15, no. 3, 1960, p. 16/23.

The problems of the construction of a machine which operates by the "parallel" method are analysed . . . theoretical considerations . . . circuit . . . examined. . . . compared with the living visual apparatus. . . . messages derived from n different sources are picked up and processed simultaneously by an instrument having n inputs . . . called "a parallel method." . . .

LINE-DRAWING PATTERN RECOGNIZER
L.D. Harmon, Electronics, vol. 33, no. 36, Sept. 1960, p. 39/43.

THE POSSIBILITY OF APPLYING TELEVISION TRANSMISSION TUBES IN THE DETECTION OF FAINT OPTICAL IMAGES (In Russian)
I.L. Valik, et al., Soviet Physics, vol. 4, no. 7, Jan. 1960, p. 796/799.

TECHNIQUES FOR THE DIGITAL COMPUTER ANALYSIS OF CHAIN-ENCODED ARBITRARY PLANE CURVES
H. Freeman, Proc. Nat. Electronics Conf., vol. 17, Oct. 1961, p. 421.

. . . complex geometric patterns such as are found on weather maps.

DATA COMPRESSION OF TELEVISION PICTURES AND AUTOMATIC LANDING SITE SELECTION
I. Eisenberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 56/57.

. . . problem of data reduction of television pictures, together with an application of the same techniques to automatic landing site selection.

The main idea of the method is to obtain a "line drawing" on the photosensitive screen of the vidicon aboard the spacecraft or planetary capsule, instead of a fine-grained photographic-like image. One method of doing this has been proposed in Ref. 20 and involves scanning the surface of the vidicon twice, one with a wide beam and again with a narrow beam.

PERFECT MAPS OF SPECIAL TYPE
H. Fredricksen, et al., JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 61/62.

. . . it was suggested that the location of a previously "mapped" (photographed with only two levels in the gray scale) region of 0's and 1's could be found by examining a small region or "window" in the map. (In this note only rectangular windows will be considered; other windows may be useful.) The question then arose as to the size of the largest map in which position could be uniquely located with a given window.

VISUAL PATTERN RECOGNITION BY MOMENT INVARIANTS
M.K. Hu, IRE Trans. Inform. Th., vol. IT-8, no. 2, Feb. 1962, p. 179/187.

VISUAL PATTERN DISCRIMINATION
B. Julesz, IRE Trans. Inform. Th., vol. IT-8, no. 2, Feb. 1962, p. 84/92,

PSEUDO-RANDOM AREA CODING FOR TELEVISION USING MODULAR GEOMETRIC SHAPES
E.C. Posner, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 178/180.

In SPS 37-18, Vol. IV, pp. 149/154, the concept of modular geometric shapes was defined, in connection with applications to packaging problems.

In SPS 37-16, Vol. IV, pp. 56/57 and SPS 37-18, Vol. IV, pp. 157/160, a television data compression technique using line following was described.

Using certain modular geometric shapes instead of squares or hexagons is a systematic way of introducing (pseudo-) randomness into the grid.

AUTOMATIC RECOGNITION TECHNIQUES APPLICABLE TO HIGH-INFORMATION PICTORIAL INPUTS
A. Rosenfeld, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 114/123.

. . . such as serial photgraphs. . . . based on statistical analysis of the input image. This analysis is used to determine the boundaries of the conspicuous figures which the image contains and to generate a simplified description of the "visual texture" of various parts of the image. Most of the past work in the field of automatic shape and pattern recognition has involved inputs having a relatively low information content. . . .

In this paper, an approach to automatic recognition is described which is applicable to inputs having high information content. . . . particularly applicable to automatic photo-interpretation . . . generally applicable to arbitrary high-information input situations. . . .

AN APPROACH TO AUTOMATIC PHOTO-INTERPRETATION
A. Rosenfeld, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 97/102.

. . . involves the extraction from the photographic image of two basic types of information, one of them relating to the presence in the image of figures having given shapes and sizes, and the other to the "textural" nature of the image. . . .

AN IMAGE CODING SYSTEM WHICH REDUCES REDUNDANCY IN TWO DIMENSIONS
R.A. Schaphorst, et al., Proc. Nat. Aerospace Electronics Conf., vol. 10, May 1962, p. 116/127.

. . . new concept, known as "Area Character Coding", achieves greater channel compression for a wide range of image detail and tonal characteristics than previsouly developed systems.

LINE-SEGMENT DETECTOR FOR LINE PATTERNS
B.F. Wadsworth, Massachusetts Inst. of Tech., Lab. for Nuclear Science, Cambridge, (Tech. Rept. 75; NYO-2667; PEPR-1), Feb. 1962, 16 p., 2 refs., N63-16469.

. . . direct, analog approach to locate line segments in a pattern consisting of simple straight and curved line structures, and to determine what resolution is possible in a measurement of this type. . . .

AUTOMATIC PATTERN RECOGNITION DURING THE PERIOD 1961-1962; AN ANNOTATED BIBLIOGRAPHY
E.E. Graziano, (comp.), Lockheed Missiles and Space Co., Sunnyvale, Calif., May 1963, 44 p., 140 refs., N63-17447.

. . . the period 1961-1962. Included are references pertaining to theory and experience with systems, components, methods, optics, speech, etc. . . .

ON THE APPLICATION OF DISCRIMINANT ANALYSIS TO IDENTIFICATION IN AERIAL PHOTOGRAPHY
L.N. Kanal, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 416/419.

. . . By "Discriminant Analysis" we mean a body of statistical techniques consisting of multivariate tests of significance, measures of distance between samples, between groups, and between a sample and a group; coordinate transformations and projections; and probabilistic methods for classification. . . .

MACHINE PERCEPTION OF THREE DIMENSIONAL SOLIDS
L.G. Roberts, Lincoln Lab., Mass. Inst. of Tech., Lexington, TR 315, 22 May 1963, 40 p., AD 413 529.

In order to enable a computer to construct and display a three-dimensional array of solid objects from a single two-dimensional photograph, the rules and assumptions of depth perception have been carefully analyzed and mechanized. . . .

ALGORITHMS FOR THE ENCODING OF THREE-DIMENSIONAL GEOMETRIC FIGURES
K. Ruttenberg, Laboratory for Electroscience Research, New York Univ. June 1963, lv., AD 434 320.

Procedures are developed for the chain encoding of linear, planes, conic sections and quadric surfaces. Encoding of geometric figures in terms of chains facilitates

their analysis and manipulation with a digital computer. . . .

A MATHEMATICAL STUDY OF IMAGE ANALYSIS
A.R. Tobey, et al., Stanford Research Inst., Menlo Park, Calif., Final Report, March 1964, 67 p., refs., N64-19353.

This report gives the results of an experimental study of the use of feature detection for television bandwidth compression. The goal is to determine from a set of patterns a set of simpler patterns, or features, so that each of the original patterns can be formed, at least approximately, by superposing the features. Four algorithms for determining features from patterns are described and the results of experiments using these algorithms are compared and evaluated.

Related Publications:

A METHOD OF CODING TELEVISION SIGNALS BASED ON EDGE DETECTION
B. Julesz, Bell Syst. Tech. J., vol. 38, no. 4, July 1959, p. 1001/1020.

. . . for transmitting digitalized video signals to reduce channel capacity from that needed for standard PCM. . . . takes advantage of the inability of the human eye to notice the exact amplitude and shape of short brightness transients. These selected samples are coarsely quantized if they belong to high-frequency regions, and the receiver then interpolates straight lines between the samples. The system was simulated on the IBM 704 computer. The processed pictures and obtained channel-capacity savings are presented.

A PATTERN RECOGNITION FUNCTION OF INTEGRAL GEOMETRY
G. Tenery, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 196/199.

A function of integral geometry, called the P_F image transformation, which is characteristic of the shape of an optical image falling on a viewing retina is defined. Machine programming of the image transformation has been accomplished. Results of the machine computation of the function for a set of random imagery are displayed. . . .

THE COMBINED USE OF PULSE ATTRIBUTES IN PROTECTED CIRCULAR SIGNALS
Y. Tomfel'd, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 19 Aug. 1963, 25 p., AD 419 226.

. . . To transmit information concerning the state of M two-position objects in one signal . . .

Section: 2.45

2.450: Predictive Picture Compression Methods

Included: Frame difference coding; Line difference coding; Contour interpolation; Intra-frame correlation method; Predictive redundance in picture signals.

Cross References: Predictive quantizing of video signals (2.420).

Principal Publications:

THE TRANSMISSION OF THE CO-ORDINATES OF OF A TELEVISED IMAGE
I. I. Tsukkerman, Radio Engng., vol. 13, no. 4, 1958, p. 106/109.

The redundancy of a televised image can in certain circumstances be reduced if the signals of the brightness and co-ordinates only of the "new" elements of the decorrelated image are transmitted.

TWO-DIMENSIONAL PREDICTIVE REDUNDANCY IN A TELEVISION DISPLAY
A. V. Martin, IRE Trans. Commun. Syst., vol. CS-7, no. 1, May 1959, p.57/61.

The two-dimensional predictive redundancy of a television picture element is calculated as a function of the preceding point correlation for both interlaced and noninterlaced scanning.

TELEVISION BAND COMPRESSION BY CONTOUR INTERPOLATION
D. Gabor, et al., Proc. Instn. Elect. Engrs., Pt. B, vol. 108, no. 39, May 1961, p. 303/315, 24 refs.

Band saving in television transmissions can be achieved by utilizing redundancies in single lines, between lines, between fields and between frames. The method of contour interpolation exploits the last two. It is based on the facts that (a) field and frame frequencies in conventional television transmission had to be chosen with a view to reducing flicker rather than for conveying more information, (b) the eye fixes mainly on contours which are usually the edges of of objects, (c) these contours are usually smooth enough to allow interpolation over two line spacings, and (d) changes from one picture to the the next come about mostly by the horizontal motion of objects which are sufficiently uniform to allow interpolation over at least two frame intervals. . . . The waveband gain can be

estimated as 4:1 without appreciable deterioration in picture quality, and 8:1 of some deterioration is allowed in the case of rapid and vertical motions. In combination with other methods which utilize redundancies in single lines and which by themselves achieve a gain of 3:1, total compression ratios of 12:1 to 24:1 appear feasible. The principle was realized and tested in a photo-mechanical model working at low speeds. Electronic realizations are proposed and discussed. . . .

THE CODING OF VISUAL SIGNALS TO REDUCE CHANNEL-CAPACITY REQUIREMENTS
A. J. Seyler, Proc. Instn. Elect. Engrs., Pt. C., vol. 109, no. 16, Sept. 1962, p. 676/684, 35 refs.

. . . integrated coding system for visual signals, making use also of intraframe and interframe correlations existing in television signals. . . .

REAL-TIME RECORDING OF TELEVISION FRAME DIFFERENCE AREAS (Correspondence)
A. J. Seyler, Proc. IEEE, vol. 51, no. 3, March 1963, p. 478/480.

. . . reducing channel capacity requirements . . . by transmitting only the differences between consecutive frames had been proposed some thirty years ago . . . apart from measurements by photographic methods on single frames of a motion picture film, no quantitative investigations have to the knowledge of the author been reported in the literature. . . . It is the purpose of this note to report briefly on the method and first results of measuring FD areas frame by frame on acutal TV program material. . . .

OPTIMUM CODING OF PICTORIAL DATA
T. Wichmann, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 18/27.

. . . transmitting data efficiently by eliminating redundancies. In the case of single frames, correlation between adjacent points, offers possibilities for considerably reducing channel capacity. In the case of moving pictures frame-to-frame correlations offer additional savings. A mathematical approach to identifying redundancies based on the use of a random picture model is presented. . . .

Related Publications:

PREDICTIVE QUANTIZING OF TELEVISION SIGNALS
R. E. Graham, IRE WESCON Conv. Rec., no. 4, Aug. 1958, p. 147/157.

STUDY OF TELEVISION MULTIPLE INSERTION TECHNIQUES
E. Herud, DuMont, Allen B., Labs., Inc., Clifton, N. J., Final engineering rept., 25 Oct. 1957, rev. 1 Aug. 1962, 193 p., incl. illus. tables, AD 291 762.

. . . means of combining several moving images to form a composite picture, within a common background, is reported. Video insertion in itself is not new, but the method developed in this study is. Five separate targets may be included at the same time. These targets have the capability of moving independently of each other. Additional data has also been collected on general systems considerations, pickup and display devices, and equipment recommendations.

NOTE ON THE EXISTENCE OF PERFECT MAPS
I. S. Reed, et al., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 10/12.

. . . In determining location in a previously mapped region by map-matching, there arises the question of minimum submap size relative to the size of the complete map of the region for unambiguous determination of position. A lower bound for the size of the submap is obtained for quantized binary maps. . . . The two-dimensional analogy of perfect maps to shift register codes suggests a possible development of planar error-correcting codes and an application to the two-dimensional range-velocity ambiguity problem of radar. . . .

OPTICAL CORRELATION FOR TERRAIN TYPE DISCRIMINATION
A. Goldstein, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 420/424.

Section 2.46

2.460: Digital Video Compression

Included: Stop-scan edge detection system; Elastic coding; Reduced time facsimile system; Compactive delta modulation picture encoders; TV bandwidth reduction by digital coding; Edge detection coding; Pseudo-random noise picture coding; PN picture coding.

Not Included: Delta modulation methods (1); Digital television systems in general; A/D converters (3A).

Cross References: Sampling and quantization for video compression (2.420).

Principal Publications:

A RESEARCH STUDY AND ENGINEERING INVESTIGATION OF A DIGITAL TELEVISION SYSTEM
D. E. Cottrell, et al., Colorado Research Corporation, April 1958, AD 206 778.

TV BANDWIDTH REDUCTION BY DIGITAL CODING
W. F. Schreiber, et al., IRE Nat. Conv. Rec., March 1958, p. 88/99.

A RESEARCH STUDY AND ENGINEERING INVESTIGATION OF A DIGITAL TELEVISION SYSTEM
R. E. Sturm, et al., Colorado Research Corporation, June 1958, 23, p., AD 204 326 and AD 210 656.

"Quarterly progress rept. New Techniques for quantizing a video image were studied and theoretically compared with the well known characterictics of pulse code modulation, a newer process which has been termed constant area delta modulation were studied."

PICTURE PROCESSING
W. A. Youngblood, Res. Lab. Electronics, MIT, Quarterly Progress Rept., Jan. 1958, p. 95/100.

A large general-purpose digital computer provides a flexible means for studying characteristics of pictures.

A RESEARCH STUDY AND ENGINEERING INVESTIGATION OF A DIGITAL TELEVISION SYSTEM
W. C. Coombs, et al., Colorado Research Corp., Denver, Final rept., 1 Dec. 1957 - 1 June 1959., 1v. incl. illus., 14 refs., AD 228 208.

BASIC DESIGN CONSIDERATIONS FOR REDUCED-TIME FACSIMILE SYSTEMS
T. Erb., et al., Ford Instrument Co., Long Island City, N. Y., Feb. 1958, 88 p., AD 211 435.

ENGINEERING INVESTIGATION AND FEASIBILITY STUDY OF REDUCED TIME FACSIMILE TRANSMISSION
T. Erb, et al., Ford Instrument Co., Long City, New York, Final Technical Report, Report No. RADC TR-59-180, 21 Sept. 1959, 105 p., AD 229 293.

. . . A digitally controlled, flying-spot scanner. . . .

A METHOD OF CODING TELEVISION SIGNALS BASED ON EDGE DETECTION
B. Julesz, Bell Syst. Tech. J., vol. 38, no. 4, July 1959, p. 1001/1020.

. . . for transmitting digitalized video signals to reduce channel capacity from that needed for standard PCM. . . . takes advantage of the inability of the human eye to notice the exact amplitude and shape of short brightness transients. These selected samples are coarsely quantized if they belong to high-frequency regions, and the receiver then interpolates straight lines between the samples. The system was simulated on the IBM 704 computer. The processed pictures and obtained channel-capacity savings are presented.

REDUCING CHANNEL CAPACITY REQUIREMENTS IN DIGITAL IMAGERY TRANSMISSION: A STUDY REPORT
A. H. Clinger, et al., Nat. Comm. Symp. Rec., vol. 7, Oct. 1961, p. 75/85.

DIGITAL TELEVISION ENCODING
R. G. Salaman, Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 274/279.

REDUCED-TIME FACSIMILE TRANSMISSION BY DIGITAL CODING
W. Wyle, et al., IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1961, p. 215/222.

. . . a family of coding methods designed to achieve reduced-time digital facsimile transmission. This paper reports on a study of the effectiveness and feasibility of one of these methods, Run Length Coding (RLC).

STOP-SCAN EDGE DETECTION SYSTEM FOR INTERPLANETARY TELEVISION TRANSMISSION
W. K. Pratt, Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, No. 4.3

A complete system is presented to code a television picture for interplanetary transmission in order to reduce either the power or the time required for transmission. Statistical techniques and psychophysical properties of sight form the basis of this coding scheme. . . .

PICTURE CODING USING PSEUDO-RANDOM NOISE
L. G. Roberts, IRE Trans. Inform. Th., vol. IT-8, Feb. 1962, p. 145/154.

TELEVISION EN COULEURS PAR SATELLITE (Color Television via Satellite) (In French)
G. Valensi, Ann. Telecomm., vol. 17, no. 3-4, March/April 1962, p. 67/76.

A RESEARCH STUDY OF IMPROVED CODING FOR MILITARY DIGITAL TELEVISION
R. Van Blerkom, et al., IBM Federal Systems Div., Rockville, Md., Quarterly rept. no. 1, 1 March - 1 June 1962., 1 June 1962, 1v., incl. illus., 29 refs., AD 282 855 and AD 277 020.

. . . to obtain more efficient digital television systems applied to intercommunications (video telephone), briefing, and observing hazardous operations. . . . simulation on an IBM 709 computer. Several methods are

presented for representing a single frame of a television picture and a discussion of computer programs for simulating these processes in non-real-time is included. Experimental results of two-dimensional processes are given and pertinent psycho-physical effects are discussed. (See also AD 412 798; AD 432 243.)

OPTIMIZING SPACE TELEVISION TRANSMISSION
F.A. Gicca, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 313/321.

. . . processing of data for minimum telemetry power is becoming increasingly important. . . . This paper explores how optimum digital television systems may be developed which require a minimum of spacecraft power and weight. Four digital television processing techniques are presented and their performance is compared with conventional analog television. The most promising of these approaches, called 'elastic encoding', provides telemetry power savings of about 5 db when compared to analog television.

Related Publications:

TELE-MAP
H. Hoffmann, Jr., IRE Nat. Conv. Rec., vol. 6, March 1958, p. 314/322.

DEMONSTRATION OF THE FEASIBILITY OF USING DELTA MODULATION FOR PICTORIAL TRANSMISSION
R. V. Cotton, et al., Philco Corp., Blue Bell, Pa., Rept. for 15 April - 15 Nov. 1962 on Phase 1, (Rept. no. 9040-TN), Nov. 1962, 1v., incl. illus., tables, refs., AD 294 689.

A PRECISION FLYING SPOT FILM DIGITIZER
J. A. Russell, California U., Livermore, Calif., Lawrence Radiation Lab., 13 Dec. 1963, 14 p., refs., N64-17291.

. . . measure locations of images on transparent film by automatically scanning an area on the film with a mechanically generated flying spot of light. These location measurements are directly transmitted to a digital computer for subsequent processing. The digital computer controls and monitors the digitizing equipment operations . . .

OPTIMIZED DIGITAL MAPPING SYSTEM
IBM, Rockville, Md., Interim rept. no. 1, 1 Feb. - 1 May 1963, 30 May 1963, 47 p., AD 412 798.

The primary purpose of the DAMC Project is to optimize system hardware and computer programs . . . and to . . . evaluate alternate correlation techniques. . . . The system consists of a photo-digitizer unit for scanning and digitizing a pair of stereo aerial diapositives, specially written computer programs for use on a IBM 7090. Computer to perform a rectification, correlation, and ortho-correction of the digital photo data, and a photomap printer unit for printing the rectified photo or orthophotomap with or without contour and grid tic information. . . . particular emphasis on the non linearities associated with the CRT and optical equipment.

Section 2.48
Special and Related Applications of Video Compression

2.282: Map Compilation Systems

Included: Automatic map compilers; Electronic image correlation; Stereoplotter; Digitized tilt cancellation; Automated coordinatography.

Not Included: Optical and photographic system design.

Cross References: Digital picture compression methods (2.460).

Principal Publications:

THE IMPLEMENTATION OF THE INTEGRATED MAPPING SYSTEM
A. Fein, Conf. Proc. Nat. Conf. Mil. Electronics, vol. 4, June 1960, p. 563/567.

The three products of the Integrated Mapping System as conceived by the Army Map Service and currently being built by the Fairchild Camera and Instrument Corporation are:
1. Plotted Contour Information
2. Orthographically Positioned Photographic Detail, and
3. Stored Profile Data

AUTOMATED COORDINATOGRAPH
C. W. Hargens, J. Franklin Inst., vol. 27, no. 2, Aug. 1960, p. 143/145.

REAL-TIME, DIGITIZED TILT CANCELLATION FOR DRONE AND SATELLITE PHOTOGRAPHY
W. D. McJunkin, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 99/105.

. . . evolved during a study of map compilation . . .

THE AUTOMATIC MAP COMPILATION SYSTEM
S. Bertram, (American Society of Photogrammetry and American Congress for Surveying and Mapping, Convention, Washington, D.C., March. 24-30, 1963.), Photogrammetric Engineering, vol. 29, July 1963, p. 675/679, A63-20258.

. . . uses a small digital computer to position an electronically generated scan on estimated homologous points on a pair of diapositives. The resulting signals are then correlated and used to measure the height error. . . . The system moves through a series of profiling sequences to expose simultaneously a new photograph (with the imagery moved so that it will appear in correct orthographic projection in relation to a selected scale) and an altitude chart showing the contour information. A complete compilation for normal 9 x 9-in. vertical photography is accomplished in about 1.5 hr.

AUTOMATED ANALYTICAL STEREOPLOTTER DESIGN DATA AND ANALYSIS
W. E. Chapelle, Bendix, Southfield, Mich., Rept., 1 July - 31 Oct. 1963., Jan. 1964, 109 p., AD 432 075.

. . . uses electronic image correlation equipment in conjunction with the AS-11A control computer to automatically produce contour and profile charts. Full AS-11A system capability for accommodating frame or panoramic photography, either vertical or convergent, is retained. . . . considerably faster than the practical limit of 1 to 2 millimeters per second for the manually operated standard system. . . .

AUTOMATIC MAPPING SYSTEM DESIGN
H. F. Dodge, (American Society of Photogrammetry, Semiannual Meeting, Wellesley Island, N. Y., Sept. 14, 1963.), Photogrammetric Engineering, vol. 30, March 1964, p. 238/242, 5 refs., A64-17062.

OPTIMIZED DIGITAL AUTOMATIC MAP COMPILATION SYSTEM
IBM Federal Systems Div., Rockville, Md., Interim rept. no. 3, 1 Aug. - 1 Nov. 1963, 30 Nov. 1963, 24 p., AD 432 243, See also: AD 412 798; 282 855; 277 020.

. . . To develop and evaluate alternate methods of correlating conjugate image data scanned from aerial stereo diapositives. The equipment subsystem has the capability to scan, digitize and store information from a stereo pair, as well as reproduce photographic images from a set of previously stored data. The computer programs are written for use on the IBM 7090 and perform the general functions of resection-orientation, rectification, correlation, elevation computation, and generation of ortho-photo and contour output tapes.

Related Publications:

TELE-MAP
H. Hoffmann, Jr., IRE Nat. Conv. Rec., vol. 6, March 1958, p. 314/322.

INVESTIGATION OF ULTRA-HIGH RESOLUTION FLYING SPOT SCANNER AND READOUT FOR PHOTOGRAPHIC REDUCTION
P. N. Hambleton, et al., (CBS-Hytron) Danvers, Mass., (Rept. no. RADC TR-59-170), Sept. 1959, AD 228 399.

Section 2.49

2.490: Simulation and Measurements of Picture Compression Systems

Included: Image recognition algorithm; Special signal generators for picture compression studies; Computer simulation of TV devices; Computer generated patterns; Autocon = system of automatic contour display; Image simulation; Photic stimulator.

Not Included: Optical measurement methods; Testing of television systems; Sequence generators.

Principal Publications:

A HIGH-SPEED DATA TRANSLATOR FOR COMPUTER SIMULATION OF SPEECH AND TELEVISION DEVICES
E.E. David, Jr., et al., Proc. Western Joint Computer Conf., San Francisco, Calif., March 3-5, 1959, March 1959, p. 169/172.

NEUE MESSUNGEN ZUR BESTIMMUNG DER UBERTRAGUNGSEIGENSCHAFTEN VON OBJEKTIVEN VOM STANDPUNKT DER FERNSEHTECHNIK (New Measurements of the Transmission Characteristics of Lens Systems for Television Equipment) (In German)
D. Frenzel, Veroffentlichungen aus der Fernsehtechnik, vol. 3, no. 7, May 1959.

IMAGE SIMULATION AND INTERPRETATION
G. L. Meyer, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 335/345.

Engineers of today are concerned with the information carrying capacity of imagery rather than its aesthetic appeal. Technological difficulties limit the excellence of sensing-transmitting systems for use in satellites. Two experiments were conducted to find out what the relation is between the quality of the image and the quality of the information that can be extracted from it. An image simulator was constructed to produce

imagery that could be used with trained photo-interpreters in the experiments . . . Much work in evaluation still remains to be done, especially in the areas of subjective analysis as opposed to form recognition.

APPLICATION & FUTURE DEVELOPMENT OF THE TEST-LINE TECHNIQUE (In German)
H. Springer, Rundunktech. Mitt., vol. 3, Feb. 1959, p. 40/50.

Experimental transmissions of test lines during the vertical scanning interval by West German transmitters . . .

BINOCULAR DEPTH PERCEPTION OF COMPUTER-GENERATED PATTERNS
B. Julesz, Bell Syst. Tech. J., vol. 39, no. 5, Sept. 1960, p. 1125/1162.

DIGITAL SIMULATION OF AN ADAPTIVE WAVEFORM RECOGNITION SYSTEM
C. V. Jakowatz, Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 234/246.

. . . The system reported on here has been simulated on the 7090 computer for multiple adaptive waveform recognition, which can deal with several signals of high dimension, and thereby become a classification system . . .

A SYSTEM OF AUTOMATIC CONTOUR DISPLAY (AUTOCON)
W. W. Anderson, Marine Engineering Lab., Annapolis, Md., MEL Research and Development rept. no 81284, 11 Sept. 1963, 1v., AD 417 193.

. . . receives analog information from a plane of equally spaced data points and simultaneously converts this information into complete contour response surface plots. The system employs a series of analog storage, scanning, and interpolation operations which take a finite number of data points in a plane, and, from them, generate an interpolated surface over all these points. As the surface is generated, it is quantized into discrete contour levels which are then drawn on a stored television display for immediate use and on 35-mm film for a permanent record. . . . The system's chief advantage in its present use of stray magnetic field investigations is the elimination of the time required to obtain contour displays of 1 or 2 hr by manual plotting.

A GENERAL PURPOSE INSTALLATION FOR THE INVESTIGATION OF IMAGE RECOGNITION ALGORITHMS
V. M. Glushkov, et al., JPRS, Washington, D.C., In its Principles of the Design of Self-Learning Systems, 21 Oct. 1963, p. 93/109, refs., N64-11036.

. . . A general-purpose scanning installation for the investigation of image-recognition . . . is described. This installation, which is used to feed the information about the drawing into the digital computer, is computer controlled. Thus, it is possible to model any method of conversion of the drawing . . . the installation makes it possible to turn to any point of the drawing desired, at any given instant. The installation distinguishes sixteen levels of the gray scale, which means that it can process not only line drawings but also half-tones.

A PHOTIC STIMULATOR
O. Pawloff, et al., Proc. Instn. Radio Engrs., Australia, vol. 24, no. 1, Jan. 1963, p. 53/56.

. . . for medical and psychological research. . . . critical flicker fusion threshold (C.F.F.). . . . The Photic Stimulator (Phot. St.) described here was constructed for the purpose of measuring C. F. F. accurately . . .

AN EXPERIMENTAL FRAME DIFFERENCE SIGNAL GENERATOR FOR THE ANALYSIS OF TELEVISION SIGNALS
A. J. Seyler, Proc. Instn. Radio Engrs., Australia, vol. 24, no. 11, Nov. 1963, p. 797/807.

One proposed method of reducing the channel requirements for the transmission of television signals over long distances is known as Frame Difference Signal (FDS) coding. . . . only those parts of every frame are transmitted which are different in two consecutive frames. . . . it is first necessary to measure and record the probability density of FDS areas in actual TV program signals.

In this paper a FDS generator is described which, by using a vidicon camera tube as storage and subtracting device, produces FDS signals suitable for the purpose of statistical analysis. The generated signals are further processed to obtain the frame by frame integral of the FDS areas, and the ancillary equipment required to carry out this operation is described. The data are recorded for subsequent evaluation. . .

Related Publication:

PICTURE PROCESSING
W. A. Youngblood, Res. Lab. of Elect., MIT, Quarterly Progress Report, July 1958, p. 134/140.

The digital system and test pictures that were presented in an earlier report (1) have been used in several exploratory studies of coding pictures for transmission. These studies are summarized in the following sections.

SPECIAL FACSIMILE TECHNIQUES
T. Erb., et al., Ford Instrument Co., Long Island City, N. Y., May 1959, 24 p., AD 217 408.

. . . design aspects of a digitally controlled electronic scanner . . .

SPECIAL INSTRUMENTS FOR TESTING AND MEASURING PURPOSES IN COLOR TELEVISION (In German)
P. Neidhardt, Nachrichtentechnik, vol. 10, no. 7, July 1960, p. 299/304.

DIVISION 2.5
MULTIPLEXING OF CHANNELS

Space communications links must be designed for high efficiency. One way to accomplish this is to multiplex the various kinds of information of a space link so that they may utilize the same transmitter, the same antenna and the same receiver, all without mutual interference. This approach is preferable to presently used practice, where ranging information, telemetry signals, voice channels and video circuits all go over separate links, requiring separate equipment. The integrated or unified approach of multiplex links results in considerable saving in weight and space requirements. This saving can easily be traded for increased information capacity or increased reliability through redundant equipment of identical design. In volume 4D we shall report references on the first attempts towards such an integrated system, the unified S-band system.

This division on multiplexing opens with an introductory section (2.500) and a small collection of theoretical references (2.510).

Section 2.52 concentrates on the most important class of multiplex methods, frequency division multiplexing. The individual channels of such a multiplex link, normally called subchannels, are assigned to separate and mutually exclusive sub-bands within the wider transmission band of the multiplex link. The various FD-mux arrangements differ primarily in the method of carrier modulation; this is the characteristic which determines the various subdivisions 2.522 to 2.525. The modulation method applied for the various subcarrier channels is also of importance, but the reader is referred to volume 1, division 1.8, which has many references on the various kinds of multiple modulation methods.

Another important multiplexing method is time division (2.53) which is primarily applicable to sampled and digital information transmission systems. Analog transmissions may be subjected to a type of time division multiplexing, which operates either in combination with time compression (2.534) or in connection with the natural time structure of at least one of the participating channels (2.535).

There are many additional approaches to the multiplexing problem listed in section 2.54. Some of them may gain importance in future space communications systems.

A final section 2.57 deals with a number of specialized engineering problems in the multiplex areas.

Section 2.50:

2.500: Introduction to Multiplexing

Included: Historical references; Multiplex applications in space.

Not Included: Multiple modulation methods (1); Unified S-band system for space links (4D).

Cross References: Multiplexing of facilities (Div. 2.6); Carrier telephony (2.520); Voice frequency telegraph systems (2.520); Random access multiplexing (2.640); Multiplexing with quasi-orthogonal binary functions (2.640).

Principal Publications:

THEORETICAL ANALYSIS OF VARIOUS SYSTEMS OF MULTIPLEX TRANSMISSION
V. D. Landon, RCA Rev., June 1948, p. 287/351. Continuation: RCA Rev., Sept. 1948, p. 433/482.

COMPARISION OF REQUIRED RADIO FREQUENCY POWER IN DIFFERENT METHODS OF MULTIPLEXING AND MODULATION
Nicholas, IRE Nat. Conv. Rec., 1954, no. 5, p. 59/65.

MULTIPLEXING TECHNIQUES FOR SATELLITE APPLICATIONS
O. B. King, Electronics, vol. 32, Oct. 1959, p. 58/62.

RADIORELEINAIA SVIAZ' (Radio Relay Communication) (In Russian)
S. V. Borodich, V. P. Minashin and A. V. Sokolov, Moscow, Sviaz'izdat, 1960, p. 435.

. . . Attention is mainly paid to radio relay systems with frequency multiplexing and frequency modulation. . . . Systems with time multiplexing and pulse modulation are considered in brief. . . .

SEMICONDUCTOR SWITCHING AND MULTIPLEXING: A PARTIALLY ANNOTATED BIBLIOGRAPHY
M. Kinney, Autonetics, Downey, Calif., Rept. EM-7590., 4 Dec. 1961, 29 p., AD 268 962.

SPOSOB MNOGOKANAL'NOY SVYAZI (Method of Multichannel Communications)
L. A. Korobkov, Aerospace Technical Intelligence Center, Wright-Patterson Air Force Base, Ohio, (Trans. no. MCL-893 of Byulleten' Izorbeteniy 11: p 24, 1960), 2 May 1961, 1 p., AD 259 248.

ANALOG/DIGITAL MULTIPLEX EQUIPMENT FOR VOICE SIGNAL PROCESSING
D. Hertz, Epsco, Inc., Boston, Mass., (Final rept.) (AFCRL 62-67), Jan. 1962, 24 p., AD 272 392.

The design of a multiple channel analog-to-digital and digital-to-analog conversion system and multiplex for use in speech analysis and synthesis is described. . . . designed to be utilized with a high-quality vocoder analyzer and synthesizer for optimum digitization of the speech parameters over a range of data rates. The system samples and holds 22 parallel analog inputs and converts them into a serial digital data stream, in which the voice spectrum data are normalized in amplitude and specified on a logarithmic scale. The demultiplex accepts the serial data and decodes it to reproduce the parallel analog inputs. . . .

ACADEMY OF SCIENCES OF THE USSR. LABORATORY OF INFORMATION TRANSMISSION SYSTEMS. PROBLEMS OF INFORMATION TRANSMISSION (Selected Articles)
Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 12 Oct. 1962, 57 p., incl. illus., 34 refs., (Trans. no. FTD-TT-62-888 from Akademiya Nauk SSSR. Laboratoriya Sistem Peredachi Informatsii., Problemy Peredachi Informatsii, No. 10, p. 5/23, 35/41, 42/48, 49/56, 1961), AD 287 733.

. . . Some problems of multichannel communications. . . .

A PIONEERING ATTEMPT AT MULTIPLEX TELEPHONY
J. Blanchard, Proc. IEEE, vol. 51, no. 12, Dec. 1963, p. 1706/1709.

A step-by-step narration is given of the conception in the 1890's of multiplex telephony by John Stone Stone. . . . Although he eventually received an unfavorable court decision on his patent application, Stone nevertheless made a brilliant contribution to modern communication technology.

Related Publications:

FREQUENCY TRANSLATION OF FM SUBCARRIERS
O. J. Ott, et al., Proc. Nat. Telem. Conf., May 1960, p. 523/538.

. . . Two specific problem areas are studied; one requiring the transmission of a large number of bands of low frequency information, and the other involving the translation of an entire multiplex.

Section 2.51

2.510: General Theory of Multiplexing

Included: Theory of adaptive multiplex systems; General theory of cross talk; Theory of frequency division multiplex systems with TD multiplex signals on subcarriers; Control of over-modulation; Inter-channel interference in multiplex systems; Analysis of multi-input modulators.

Not Included: Theory of telemetry commutation.

Cross References: Multi-channel diversity systems (2.620); Theory of multiplex loading in FD systems (2.521); Cross talk in FD systems (2.521); Cross talk in TD systems (2.532 or 2.533).

Principal Publications:

INTERCHANNEL INTERFERENCE IN FM AND PM SYSTEMS UNDER NOISE LOADING CONDITIONS
W. R. Bennett, et al., Bell Syst. Tech. J., vol. 34, May 1955, p. 601/636.

REDUCTION OF BANDWIDTH REQUIREMENTS FOR RADIO RELAY SYSTEMS
A. Mack, et al., IRE Nat. Conv. Rec., vol. 6, no. 8, March 1958, p. 114/118.

CONTROL OF OVER-MODULATION WITH MULTIPLEXED COHERENT OR NON-COHERENT FREQUENCIES
D. R. Anderson, et al., IRE Internat. Conv. Rec., vol. 8, March 1961, p. 150/159.

SOME TECHNIQUES FOR THE ANALYSIS AND SYNTHESIS OF NONSTATIONARY NETWORKS
J. B. Cruz, Jr., IRE Internat. Conv. Rec., vol. 4, March 1961, p. 277/285.

A class of nonstationary or time-variable linear networks which are realizable as cascades of fixed multi-output networks and multi-input modulators is studied.

TIME AND FREQUENCY CROSSTALK IN PULSE-MODULATED SYSTEMS
E. A. Marcatili, Bell Syst. Tech. J., vol. 40, no. 3, May 1961, p. 951/970.

COMPRESSION, FILTERING, AND SIGNAL-TO-NOISE RATIO IN A PULSE-MODULATED SYSTEM

E. A. Marcatili, Bell Syst. Tech. J., vol. 40, no. 5, Sept. 1961, p. 1421/1453.

. . . Some aspects of the transmission of Gaussian pulses in a frequency-division multiplex system have been calculated. It is assumed that each channel transmitter includes an amplifier, which may be nonlinear, with input and output filters, and that each channel receiver includes a linear amplifier with a thermal noise source at its input plus input and output filters . . . Influence . . . on the signal-to-noise ratio, time crosstalk, and frequency crosstalk is calculated . . . A proposed long distance waveguide system will transmit a large number of wide-band PCM channels via a single waveguide by means of a frequency multiplexing arrangement.

THE STABILITY OF A FREQUENCY REMOTE CONTROL SYSTEM IN THE PRESENCE OF PULSE NOISE

Y. I. Chugin, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (Trans. no. FTD-TT-62-636 from Avtomatika i Telemekhanika, 23:2, p. 222/241, 1962), 10 May 1962, 33 p., incl. illus., AD 286 132.

The stability of a frequency remote control system under the action of pulse noise with a known law of amplitude distribution is determined The influence of the structure and parameters of a receiver upon its noise stability is investigated. A method is examined for calculating the noise stability of codes with series and parallel transmission of subcarriers. . . .

REQUIRED SIGNAL-TO-NOISE RATIOS, RF SIGNAL POWER, AND BANDWIDTH FOR MULTICHANNEL RADIO COMMUNICATIONS SYSTEMS

E. F. Florman, et al., National Bureau of Standards, Boulder, Colo., (Technical note. no. 100), July 1960, ref., Jan 1962, 182 p., incl. illus., tables, 52 refs., AD 288 285.

A method is outlined for determining the relationships between the grade of performance, or message error rate, of a radio communication system and the system parameters. Results are presented in the form of design equations and system-design curves. The system parameters and variables considered are the following definable and measurable factors: signal-to-noise ratios, carrier-signals power level, message load, receiver noise figure, etc. These factors are used with the design curve scales as normalizing factors in order to yield quantitative results.

ON MULTILINK AND MULTIDIMENSIONAL CHANNELS (Correspondence)

T. Kailath, IRE Trans. Inform. Th., vol. IT-8, no. 3, April 1962, p. 260/262.

Some papers have recently been published on optimal reception in general diversity and optical channels. These papers have used the vector Karhunen-Loeve theorem recently discussed by several authors. In this note we shall present a different approach based on the results for a single-link, single-dimensional channel.

A STUDY OF INTERMODULATION INTERFERENCE IN A MULTITRANSMITTER-MULTIRECEIVER ENVIRONMENT

A. I. Grayzel, Lincoln Lab., Mass. Inst. of Tech., Lexington, Nov. 26, 1962, 28 p., refs., N63-21061.

. . . explains how the level of transmitter-generated intermodulation in terms of various parameters of multitransmitter-multireceiver systems is estimated. Methods are offered for minimizing or eliminating interference by frequency choice and by filtering. Where doubt exists as to interference level, crucial measurements are suggested.

AN ADAPTIVE DATA SAMPLING SYSTEM

M. Berkowitz, Rec. Nat. Space. Electronics Symp., 1963, no. 4.1.

. . . tests the change in signal level of each data channel, from one sample to the next, against a-priori, preprogrammed criteria, and . . . utilizes the result of this test to limit the system output to only significantly changed data. . . . resulting in varying amounts of time being liberated depending upon the properties of the signals being sampled. The time thus liberated can be utilized for the insertion of additional lower priority data . . . The usability of microelectronic techniques to practically accomplish sophisticated operations of this type is illustrated by describing a newly designed microelectronic multiplexer. . . .

ON THE USEFULNESS OF SIGNAL DESIGN TECHNIQUES IN ADAPTIVE TELEMETRY LINKS

J. C. Hancock, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 322/327.

. . . The usefulness of signal design techniques in adaptive communication systems is investigated with primary emphasis on the intersymbol interference problem. . . . Comparisons are made between systems which have been designed to have no intersymbol interference and those which simply use "guard" spaces as protection . . . Applying signal design concepts to eliminate intersymbol interference in a communication channel entails a-priori knowledge of the impulse response of the channel, and this in itself is a major task for most time varying links. . . . we first investigate the advantages of signal design techniques if this a-priori information is known. . . .

Related Publications:

THE NOISE-POWER PROBABILITY DISTRIBUTION IN A MULTIHOP FM RADIO-RELAY SYSTEM

J. Dutka, RCA Rev., vol. 22, no. 3, Sept. 1961, p. 508/521.

ERROR PROBABILITIES FOR ADAPTIVE MULTICHANNEL RECEPTION OF BINARY SIGNALS
R. Price, Lincoln Lab., Mass. Inst. of Tech., Lexington, (Technical rept. no. 258), (AFESD TDR 62-129), 23 July 1962, 58 p., incl. illus., table, 34 refs., AD 284 651.

. . . adaptive receiver that is part of a multichannel communication system over which binary data are conveyed. In the adaptive receiver, noisy measurements are made of presumably nonvarying channel signal strengths and phase shifts. The measurements are then applied to the signal processing in a manner that would be optimum if the measurements were perfect. . . .

A SURVEY OF TELEPHONE SPEECH-SIGNAL STATISTICS AND THEIR SIGNIFICANCE IN THE CHOICE OF A P.C.M. COMPANDING LAW
R. F. Purton, Proc. Instn. Elec. Engrs. (Pt. B), vol. 109, no. 43, Jan. 1962, p. 60/66.

NOISE-LOADING TEST OF A COMPLETE FREQUENCY-DIVISION MULTIPLEX VOICE POINT-TO-POINT COMMUNICATION SYSTEM
L. P. Yeh, Commun. Electronics, vol. 81, no. 59, March 1962, p. 40/43.

CROSSTALK OF FREQUENCY-MULTIPLEXED SIGNALS IN SATURATING AMPLIFIERS
W. Doyle, RAND Corp., Santa Monica, Calif., April 1963, 30 p., 5 refs., N63-18036.

For amplifiers with narrow dynamic range, the crosstalk may be unacceptably high when channels are numerous or close together. . . . When there are many channels, the total interference of any one of them may be regarded as gaussian noise. . . . For the central channel, the worst case, the output signal and crosstalk spectra are given. Also presented are the signal-to-crosstalk ratios in rectangular output filters for a limited number of cases.

Section 2.52
Frequency Division Multiplex

2.520: FD Multiplex Systems

Included: Voice frequency telegraph systems; Coaxial line multiplex equipment; FDM tropospheric multiplex systems in general; Microwave relay multiplex systems in frequency division; Telephone carrier multiplex systems; L-multiplex systems; Carrier telephony; Multi-channel closed circuit TC systems; Exchange trunk carrier system; Multi-channel phase system; Frequency-multiplexed systems; Pulse transmission over FD-multiplex systems.

Not Included: Equipment descriptions of specific multiplex equipment; Characteristics of tropospheric scatter links (1); Transmission characteristics of radio relay links (1).

Cross References: General theory of multiplex systems (2.510).

Principal Publications:

A NEW HIGH-CAPACITY MICROWAVE RELAY SYSTEM
C. G. Arnold, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 128/137, 17 refs.

. . . line-of-sight system operating in the radio frequency band 1700-2300 mc. . . . utilizes frequency modulation and employs heterodyne repeaters at 30 mile (average) intervals to compensate for propagation loss. . . . designed for . . . a large number of message channels, of 4 kc/s nominal bandwidth, or one television signal on a single radio frequency channel. . . .

K24A SYNCROPLEX TELEPHONE CARRIER SYSTEM
B. G. Coetsee, et al., Elect. Commun., vol. 36, no. 4, 1960, p. 230/247.

. . . exchange carrier system . . . electrical characteristics of typical exchange lines . . . application on line lengths between 5 and 20 miles . . . attenuations of the order of 200 decibels at 500 kilocycles per second. . . . Repeaters with slope equalization . . . from a few decibles to a maximum of approximately 16 decibels. . . . Adequate system regulation for 15-to-18-decibel variation . . .

BASIC CARRIER TELEPHONY
D. Talley, New York, John F. Rider Inc., 1960, 176 p.

. . . Telephone carrier definitions . . . Telephone transmission practices . . . Carrier system fundamentals . . . Carrier system operations . . . Cable carrier systems . . . Carrier applications to radio systems . . .

A 12 Mc/s COAXIAL LINE EQUIPMENT - C.E.L. NO. 8A
H.J. Bordiss, et al., Post. Off. Elect. Engrs. J., vol. 54, no. 2, July 1961, p. 73/81.

. . . suitable for 2,700 telephone circuits or up to 1,200 telephone circuits together with a video circuit for a 625-line television signal. Automatic correction is applied for predictable

system variations, and the use of modern components and long-life valves replaces the duplicate-component and standby-amplifier practices adopted hitherto. Up to 13 dependent stations may be power-fed in tandem over the coaxial pairs, and some addition to the conventional power arrangements has been necessary. . . .

NOISE AND INTERMODULATION PROBLEMS IN MULTICHANNEL CLOSED-CIRCUIT TELEVISION SYSTEMS
C. A. Collins, et al., Commun. and Electronics, vol. 80, no. 57, Nov. 1961, p. 486/491.

In the past decade there has been a rapid growth in communication facilities designed to transmit television (TV) signals relatively short distances over coaxial cables. These systems handle six or more video signals which amplitude-modulate (AM) r-f (radio-frequency) carriers in the 8- to 220-mc (megacycle) range. The associated audio signals frequency-modulate (FM) r-f sound carriers whose rest frequencies are 4.5 mc away from their associated picture carriers. . . . This paper will discuss two problems . . . thermal noise and intermodulation products created by amplifier nonlinearity. . . .

AN EXPERIMENTAL INVESTIGATION OF PULSE TRANSMISSION OVER WIRE, RADIO, AND FREQUENCY-DIVISION MULTIPLEXING FACILITIES
E. D. Hanson, Army Signal Research and Development Lab., Fort Monmouth, N. J., (Rept. 2205), June 1961, 36 p., AD 268 995.

. . . experimental investigation into the transmission of binary type signals over field wire cable WF-16 ( )/U, radio set AN/VRC-12, and special services of a frequency-division multiplexing terminal. The signaling modes used in the investigation included straight full baud binary dicode, bipolar, double bipolar, dipulse, and piphase. The transmission rates were at 19.2, 38.4, and 48 kilobits per second. An attempt is made to determine what mode is best suited to each facility tested.

TYPE T-12S-Tr TRANSISTORIZED SHORT-HAUL CARRIER SYSTEM
O. Ishihara, et al., Commun. and Electronics, vol. 80, no. 55, July 1961, p. 193/199.

The toll network in Japan has been expanded and improved through long-term projects, utilizing various types of new equipments. . . . the Nippon Telegraph and Telephone Public Corporation (NTT) decided in 1957 to develop a 12-channel 2-wire-basis short-haul carrier system. . . .designated T-12S-Tr . . . requirements . . . designed for both mechanical and electrical economy. . . . delivered and placed in operation in September 1958. . . .

FREQUENCY DIVISION MULTIPLEXING ON TRANSOCEANIC CABLES
W. Lyons, IRE Internat. Conv. Rec., vol. 8, March 1961, p. 119/125.

Heretofore cable, land line telegraph, and microwave channeling has been limited to approximately 1100 bits per second (bauds), utilizing 22 sub-carriers spaced 120 cps apart. Frequency shift keying, together with more sophisticated filter design, has enabled this capacity to be doubled.

A COMPLETELY TRANSISTORIZED 600-CHANNEL MULTIPLEX SYSTEM
D. W. Sparks, Commun. and Electronics, vol. 80, no. 54, May 1961, p. 121/126.

. . . In 1958, the U.S. Air Force . . . took the leadership in writing specifications for a long-haul transistorized 600-channel system AN-FCC-17 . . . intended to set the standard for the 1960's. . . . a 7-foot relay rack of General Electric Company's TCS-600 carrier system, equipped with 60 telephone channel modems, or modulator-demodulator circuits. An 8-foot relay rack will accommodate 120 channel modems. . . . expandable . . . to accommodate 600 telephone channels. . . .

APPLICATION OF CARRIER SYSTEMS TO EXCHANGE TRUNK PLANT IN CANADA
A. Curran, et al., Commun. and Electronics, vol. 81, no. 60, May 1962, p. 116/120.

. . . demand for relatively long exchange trunk circuits. . . requirement . . . that it may be operated over existing exchange trunk cables. . . . results of tests conducted to determine the range of attenuation, crosstalk coupling loss, and noise liable to be encountered on existing cables. . . . shows how the observed values were used in the design of the NX-1 Exchange Trunk Carrier System. . . .

FREQUENCY DIVISION TRANSMISSION SYSTEMS FOR MEASUREMENT DATA (In German)
H. Karger, et al., Arch. Tech. Messen., no. 322, Nov. 1962, p. 249/252.

Principles of frequency division systems for data transmission are explained on the basis of a block diagram. Various methods of modulation are surveyed, viz. frequency modulation, pulse repetition rate, pulse duration, pulse spacing, pulse code and pulse counting methods. . . .

A MULTICHANNEL PHASE SYSTEM
V. G. Dolotov, Foreign Technology Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (Trans. no. FTD-TT-62-1636 from Soviet Patent no. 145919, (722250/26), 18 March 1961), 24 Jan. 1963, 4 p., AD 298 216.

DESCRIPTORS: Telemeter system . . . Phase shifters . . . Multipath transmission.

VOICE-FREQUENCY TELEGRAPHY SYSTEMS
V. S. Gurov, et al., Joint Publications Research Service, Washington D.C., June 6, 1963, 219

p., refs., Transl. into ENGLISH of a monograph "Sistemy Tonal'noga Telegrafirovaniya", Moscow, Svyazizdat, 1962, p. 3/206, (JPRS-19591; OTS-63-31001), N64-10510.

. . . circuit features, layout of the voice-frequency telegraph equipment, specific design features of the systems, and transistorized voice-frequency telegraphy system.

Related Publications:

DESIGNING A FREQUENCY DIVISION MULTIPLEXER
D. B. Nowakoski, et al., Electronic Industr., no. 20, Aug. 1961, p. 210.

CARRIER SUPPLIES FOR L-TYPE MULTIPLEX
W. G. Albert, et al., Bell Syst. Tech. J., vol. 42, no. 2, March 1963, p. 279/317.

A short review of previous carrier equipment and recent developments in carrier application is followed by a general discussion of the design approach. . . . specific circuits and equipment units are described.

A PHASE-LOCKED PRIMARY FREQUENCY SUPPLY FOR THE L MULTIPLEX
O. P. Clark, et al., Bell Syst. Tech. J., vol. 42, no. 2, March 1963, p. 319/340.

The carriers and pilot tones of the L multiplex are all derived from a single source of 4 kc. The new primary frequency supply provides this primary frequency. It is designed to operate phase-locked to a pilot tone derived from an incoming carrier system and hence to have no frequency error with respect to that tone. The unit features a high degree of frequency stability, even in the absence of the pilot. . . .

NEW GROUP AND SUPERGROUP TERMINALS FOR L MULTIPLEX
R. S. Graham, et al., Bell Syst. Tech. J., vol. 42, no. 2, March 1963, p. 223/278.

L multiplex terminals provide the several stages of modulation required to translate telephone channels into the broad basebands which can be transmitted on long-haul systems. The group and supergroup equipment has been redesigned incorporating many new features. Pilot-controlled regulators are provided to improve performance. Plug-in modules and automated monitoring facilitate maintenance . . . a size reduction of 10 to 1 has been achieved and the required power greatly reduced.

2.521: Theory of FD-Mux Systems

Included: Noise and crosstalk in FD-mux systems; Interstitial channels in radio relay links; Optimum pre-emphasis in FD multiplex systems; Load rating theory; Interference calculations in FD multiplex systems.

Not Included: Noise and disturbances in communications channels (1); RFI in radio relay links (1); Electro-magnetic compatibility.

Cross References: Pre-emphasis in frequency modulation (2.243).

Principal Publications:

LOAD RATING THEORY FOR MULTICHANNEL AMPLIFIERS
B. D. Holbrook, et al., Bell Syst. Tech. J., vol. 18, Oct. 1939, p. 624/644.

THE WHITE-NOISE INTERFERENCE IN MULTICHANNEL TELEPHONE LINK SYSTEM
J. F. Golding, Electronic Engng., vol. 30, May 1958, p. 349/351.

AN EXPANDED THEORY FOR SIGNAL-TO-NOISE PERFORMANCE OF F. M. SYSTEMS CARRYING FREQUENCY DIVISION MULTIPLEX
D. P. Harris, IRE Nat. Conv. Rec., vol. 6, March 1958, p. 298/304.

REDUCTION OF BANDWIDTH REQUIREMENTS FOR RADIO RELAY SYSTEMS
A. Mack, et al., IRE Nat. Conv. Rec., vol. 6, no. 8, March 1958, p. 114/118.

CHANNEL SELECTION FOR MULTICARRIER TELEMETRY
L. S. Taylor, et al., IRE Nat. Conv. Rec., vol. 6, no. 5, March 1958, p. 34/43.

The problem of reducing inter-carrier modulation by the proper selection of carrier frequencies from the uniformly spaced set within the telemetry band.

REDUCTION OF ADJACENT-CHANNEL INTERFERENCE COMPONENTS FROM FREQUENCY-SHIFT-KEYED CARRIERS
A. D. Watt, et al., IRE Trans. Commun. Syst., vol CS-6, no. 2, Dec. 1958, p. 39/47.

NON-LINEAR NOISE IN FDM TROPOSPHERIC SCATTER VOICE COMMUNICATION SYSTEMS
L. P. Yeh, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 152/166.

. . . noise performance. . . is specified as the signal-to-total noise power ratio per

channel at the receiver output. . . . Typical values are 37 db and 47 db flat weighting (unweighted noise), equivalent to 40 db and 50 db FIA weighting respectively. . . . The "weighting" indicates the type of telephone network used when the noise is measured. . . . The total noise has mainly two origins: (a) nonlinear noise (sometimes called intermodulation noise or crosstalk) due to non-linearity of the system components . . . and (b) other noises such as thermal noise inherent in the receiver and external noises such as cosmic noise and man-made noise received by the antenna. . . . variations of nonlinear, thermal and total noises are shown on a statistical basis. . . .

RADIO FREQUENCY INTERFERENCE CONSIDERATIONS IN THE TD-2 RADIO RELAY SYSTEM
H. E. Curtis, Bell Syst. Tech. J., vol. 39, no. 2, March 1960, p. 369.

Relationships are developed between the ratio of a desired RF carrier to an interfacing co-channel RF carrier and the telephone channel interference that results therefrom. Objectives are set down in terms of permissible noise in a telephone channel for each individual RF interference on a hypothetical long system.

INTERSTITIAL CHANNELS FOR DOUBLING TD-2 RADIO SYSTEM CAPACITY
H. E. Curtis, et al., Bell Syst. Tech. J., vol. 39, no. 6, Nov. 1960, p. 1505/1527.

. . . The TD-2. . . at the present time provides six broadband channels in each direction of transmission in the frequency band between 3700 and 4200 mc, each channel being capable of transmitting several hundred voice circuits. This paper describes arrangements and some of the technical problems involved whereby the number of broadband channels can be doubled with no significant penalty to the existing channels. . . .

CARRIER TO NOISE REQUIREMENTS FOR TELETYPE COMMUNICATION VIA NON-FADING OR FADING UHF CARRIERS
R. W. Plush, et al., Nat. Bureau of Standards, Boulder, Colorado, NBS rept. no. 5585, Feb. 1960, lv., AD 233 741.

The characteristics of FM and SSB multichannel systems loaded with speech and FSK teletype subcarriers are described. System loading statistics are discussed and resulting dynamic range and bandwidth requirements presented. Steady carrier performance of SSB and FM systems with and without automatic loading features are shown as percent teletype character errors vs. carrier to noise ratio. Time-amplitude characteristics of beyond-the-horizon UHF carriers are shown by cumulative distributions of amplitude and fade duration. A time-amplitude distribution of a Rayleigh fading carrier is presented in parametric form related to the power spectrum of the unmodulated fading carrier. Fading carrier non-diversity teletype performance is calculated for both FM and SSB systems. Following a discussion of diversity types and combining techniques, the calculated system performance with typical diversity orders is shown. Carrier to noise requirements for a given performance is used to determine transmitter power over a hypothetical 500 mile path.

INTERMODULATION MEASUREMENTS ON MULTICHANNEL CARRIER EQUIPMENT
A. W. Thies, Proc. Instn. Radio Engrs. Australia, vol. 21, no. 10, Oct. 1960, p. 715/718.

INTERSTITIAL CHANNELS FOR DOUBLING TD-2 RADIO SYSTEM CAPACITY
H. E. Curtis, et al., Commun. and Electronics, vol. 79, no. 52, Jan. 1961, p. 646/654.

INTERFERENCE-IMMUNITY OF A COMMUNICATION SYSTEM WITH TONAL MANIPULATION DURING IDEAL RECEPTION
P. A. Konstantinov, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 11, 1961, p. 16/24.

. . . "manipulation" for completely known signals with two different values. Optimal receiver circuits are determined. The criterion of an ideal observer and the apparatus of detection theory are used for the analysis. . . . 2. FM-AM Type Communication System. In such a communication system, frequency manipulation of the subcarrier oscillations and amplitude modulation of the carrier-frequency oscillations are accomplished. . . . 3. PM-AM Type Communication System. . . 4. FM-FM Type Communication System. . . 5. PM-FM Type Communication System. . .

INTERMODULATION NOISE IN LINEAR F. M. SYSTEMS
R. I. Magnusson, Proc. Instn. Elect. Engrs. (GB), Monogr. 459 E., July 1961, 13 p.

By applying a series of detailed approximations to the Rice and Bosse theory of f.m. intermodulation noise, the recent formulae of Medhurst and Roberts for intermodulation noise/signal ratios in f. m. systems with white-noise modulation and networks of polynomial frequency characteristics are extended in three respects . . .

RF SPECTRA AND INTERFERING CARRIER DISTORTION IN FM TRUNK RADIO SYSTEMS WITH LOW MODULATION RATIOS
R. G. Medhurst, IRE Trans. Commun. Syst., vol. CS-9, no. 2, June 1961, p. 107/115.

Numerical results are given for 1800-speech-channel systems. . . . systems using RF multiplex (i. e., systems consisting of a number of carriers each modulated with a signal built up from a large number of speech channels.)

ANALYSIS OF MULTIPLE TONE CLIPPING
C. J. Styers, IRE Internat. Conv. Rec., vol. 8, March 1961, p. 134/149.

. . . study of the consequences of clipping in a multiple-tone system. . . Mathematical expressions furnish the exact number of jth order; intermodulation terms; including the number of signal terms, in-phase noise terms, and randomly-phased noise terms.

From these expressions is obtained a net peak-signal to rms-noise voltage ratio as a function of the clipping level. The effect of clipping upon the binary error rate is investigated.

OPTIMUM PREEMPHASIS IN MULTI-CHANNEL RADIO RELAY LINES WITH FREQUENCY DIVISION MULTIPLEX AND FREQUENCY MODULATION (Translation)
V. B. Tseitlin, Telecommun. Radio Engng., Pt. I, Telecommunications, Nov. 1962, p. 9/15, A63-19193.

. . . theory. . . and a simple method. . . for finding the characteristics approximating minimum total noise power in the group spectrum. . . .

CROSSTALK OF FREQUENCY-MULTIPLEXED SIGNALS IN SATURATING AMPLIFIERS
W. Doyle, RAND Corp., Santa Monica, Calif., April 1963, 30 p., 5 refs., N63-18036.

For amplifiers with narrow dynamic range, the crosstalk may be unacceptably high when channels are numerous or close together. . . . When there are many channels, the total interference of any one of them may be regarded as gaussian noise. . . . For the central channel, the worst case, the output signal and crosstalk spectra are given. Also presented are the signal-to-crosstalk ratios in rectangular output filters for a limited number of cases.

THE TELEPHONE CHANNEL CAPACITY OF TRANSMISSION LINES
D. A. Gray, Proc. Instn. Radio Engrs. Australia, vol. 24, no. 7, July 1963, p. 583/589.

The attenuation of transmission lines used for telephone transmission varies very nearly as the square root of frequency. . . In this paper the maximum number of telephone channels which can be obtained on such a line using AM-FDM, FM-FDM, and PCM-TDM is calculated as a function of line attentuation at a reference frequency, transmitted power level, and signal-to-noise ratio. At moderate and high transmitting levels SSB-AM usually permits the greatest number of channels to be derived. . . .

MOP-UP EQUALIZER FOR AMPLITUDE AND DELAY DISTORTION IN IF BAND FOR 6GC 1800 CHANNEL SYSTEM
T. Kawahashi, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 163/176.

. . . To accomplish high capacity radio transmission, that is, a multi-channel radio relay system capable of carrying 1800 telephone channels. . . it has become necessary to equalize the 3rd and 4th order distortion components of the amplitude-frequency response in the IF stage, not to speak about the residual delay distortion in the FM transmission path.

In order to meet the said requirement . . . we have developed two types of the IF mop-up equalizer: one is the amplitude equalizer. . . and the other is the delay equalizer. . .

When operated as part of the IF stage of the existing Tokyo-Osaka 6Ge-1200 channel system, these equalizers have proved to be effective enough to convert the existing system into a 1800 channel system conforming to the CCIR Recommendation. . .

IMPROVEMENT OF ENERGY DETECTION AS A RESULT OF CHANNEL SUB-DIVISION (Correspondence)
J. A. Knudson, Proc. IEEE, vol. 51, no. 6, June 1963, p. 955.

It has been shown that an energy detector can be calibrated to read likelihood ratio; thus, for that class of signals identified by their energy content alone, the energy detector becomes an optimum receiver. . . . the original bandwidth B is divided into L equal-width subchannels making the individual channel bandwidth B/L cps. . .

DIE STATISTISCHE VERTEILUNG VON AUGENBLICKSWERT UND AMPLITUDE EINER SUMME VON N GLEICH GROREN WECHSELSPANNUNGEN MIT INKOM-MENSURABLEN FREQUENZEN (The Distribution of Instantaneous Values and Amplitudes of a Sum of n Equal Amplitude Voltages with Unrelated Frequencies) (In German)
G. Kraus, et al., Arch. Elekt. Uebertragung, vol. 17, Jan. 1963, p. 6/12.

. . . In proportioning systems for the simultaneous transmission of n equal ac signals of different frequencies (e. g., for VF carrier telegraphy) it is important to know the probability with which certain given instantaneous values or amplitudes are exceeded by the composite voltage. . . .

Related Publications:

SIGNAL SPACE, MODULATION, AND BANDWIDTH
J. M. Kirshner, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 149/153.

The concept of signal space allows one to apply geometric principles to waveforms used in communication. Its use enables a number of interesting conclusions to be drawn. . . . 2. Orthogonality of Functions . . . 3. Modulation, Demodulation, and the Sampling Theorem . . . 4. The Sampling Theorem and Separation of Channels . . . 5. Noise and Channel Capacity . . . 7. Rotation of Coordinates and the Number of Independent Channels. . . 8. Orthogonality of Gaussian Noise Signals. . . .

ERROR PROBABILITIES FOR ADAPTIVE MULTICHANNEL RECEPTION OF BINARY SIGNALS
R. Price, Lincoln Lab., Mass. Inst. of Tech., Lexington, (Technical rept. no. 258), 23 July 1962, 58 p. incl. illus., table, 34 refs., AD 284 651.

2.522: Single Sideband Multiplex Systems (FD-Mux systems with SSB Radio Carrier)

Included: FDM-SSB systems; Frequency division single sideband multiplex systems; Noise and fading problems in SSB-FDM systems; SSB-SSB multiplex systems; FM-SSB multiplex systems; FDM-SSB data systems; Synchronization of SSB multiplex systems.

Cross References: SSB-FM multiplex systems (SSB subcarrier - FM radio carrier) (2.523).

Principal Publications:

SYNCHRONIZATION OF SINGLE-SIDEBAND CARRIER SYSTEMS FOR HIGH-SPEED DATA TRANSMISSION
T. Combellick, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 110/114.

. . . requirements for synchronization of single-sideband carrier systems and the methods of accomplishing absolute synchronization. The problems of application to existing systems and alternative solutions are discussed.

OPTIMIZED SSB TRANSMITTER LOADING BY MULTICHANNEL FREQUENCY DIVISION DATA
A. T. Brennan, et al., IRE Conv. Nat. Rec. Pt. 5, vol. 8, March 1960, p. 188/193.

OPTIMUM LOADING OF SINGLE SIDEBAND TRANSMITTERS WITH MULTITONE DIGITAL SIGNALS
G. C. Porter, et al., General Dynamics/Electronics, Rochester, N. Y., Final rept. 1, 1 Feb. 1960-30 June 1961, AD 268 672.

. . . trade-off between the effects of distortion and increased S/N at a receiver when operating the transmitter at output powers larger than the derated value. Information was transmitted by a 4 Kw. PEP transmitter (T-265/FRC-10) into a dummy load and received by an R-390/URR and CV-157/URR receiver-converter combination under white noise conditions. It was concluded that the transmitter can be operated at full average power output with a reduction of character error rate corresponding to a 6 db increase in S/N.

NOISE AND FADING ACCUMULATION IN SINGLE SIDEBAND RADIO COMMUNICATION RELAY STATIONS
V. I. Siforov, et al., Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 8, 1961, p. 1/14.

A method is presented for the calculation of noise and fading accumulation in a multichannel radio relay line employing single sideband modulation. Certain quantitative expressions are given which establish a relation between the signal-to-noise ratio at the output of the line. It is shown that the noise and fading accumulation process in a single sideband communication line is similar to the process in a line employing frequency modulation. . . .

EFFECTS OF AMPLITUDE AND PHASE FLUCTUATIONS ON THE PERFORMANCE OF DIGITAL DATA SYSTEMS IN FADING FDM-FM AND FDM-SSB SYSTEMS
H. D. Becker, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 93/100.

. . . Emphasis is placed on the theoretical performance of differentially coherent phase-shift keyed (DCPSK) systems in which DCPSK data is transmitted on subcarriers over a frequency-division multiplex single-sideband (FDM-SSB) or an FDM-FM transmission system, such as employed in typical tropospheric scatter links. . . .

PREDETECTION DIVERSITY COMBINING WITH SELECTIVELY FADING CHANNELS
P. Bello, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 32/42.

. . . some form of instantaneous phase correction must be provided prior to the diversity combining so that proper in-phase

addition will result. If the instantaneous fading is not uniform over the width of the channel, the resulting channel incoherence will reduce the efficacy of the phase correction. One way to avoid this difficulty is to divide the selectively fading channel into "flatly" fading subchannels and perform the necessary phasing and combining operations per subchannel. . . . This paper considers this question with reference to FDM-SSB binary data transmission and matched filter reception, wherein a pilot tone is used both for deriving proper phase correction and for providing the weighting necessary for maximal ratio combining. . . .

2.523: Frequency Modulation Multiplex Systems (FD-Mux Systems with FM Radio Carrier)

Included: FM/FM telemetry multiplexing; Distortions in FM frequency division multiplex systems; Noise in multiplexed FM systems; FM multiplex data systems; FDM-FM multiplex telephone systems; SSB-FM multiplex systems; Multitone FM signals.

Not Included: FM-FM double modulation method (1); FM-FM space telemetry equipment (4).

Cross References: Pre-emphasis in FM systems in general (2.243).

Principal Publications:

INTERCHANNEL INTERFERENCE IN FM AND PM SYSTEMS UNDER NOISE LOADING CONDITIONS
W. R. Bennett, et al., Bell Syst. Tech. J., vol. 34, May 1955, p. 601/636.

NOISE AND CROSSTALK IN MULTIPLEXED FM SYSTEMS
R. A. Runyan, IRE Nat. Conv. Rec., Pt. 1, 1956, p. 194/198.

DISTORTION IN FREQUENCY DIVISION MULTIPLEX FM SYSTEM DUE TO AN INTERFERING CARRIER
R. G. Medhurst, et al., Proc. Instn. Elect. Engrs., vol. 105, Pt. B, May 1958, p. 282/292.

DISTORTION IN FM-FM SYSTEMS AND ITS EFFECT ON SYSTEM ACCURACY
W. O. Frost, Nat. Telem. Conf., May 1959, p. 45/52.

SS-FM: A FREQUENCY DIVISION TELEMETRY SYSTEM WITH HIGH DATA CAPACITY
W. O. Frost, et al., Nat. Symp. Space Electronics Telem., Sept. 1959, no. 7.2.

. . . results of a theoretical study. . . preliminary design. . . single sideband AM subcarriers on an FM carrier. . . An analytical comparison with FM-FM is made of the S/N performance of a 15 channel SS-FM system. . . .

THE INFLUENCE OF FM-FM TELEMETRY COMPONENT CHARACTERISTICS ON SYSTEM PERFORMANCE
O. J. Ott, Nat. Telem. Conf., May 1959, p. 31/39.

. . . the major components in a typical FM/FM system are tabulated. . . together with the static and dynamic errors they commonly introduce. . .

ANALYSIS OF MULTIPLEX ERROR IN FM/FM AND PAM/FM/FM TELEMETRY
J. Schenck, et al., IRE Trans. Space Electronics Telemetry, vol. SET-5, no. 3, Sept. 1959, p. 138/147.

. . . frequency division multiplex of FM subcarriers where commutation, or pulse amplitude modulation time division multiplexing, is used on one or more of the FM subcarrier channels.

R. F. SPECTRA OF WAVES FREQUENCY MODULATED WITH WHITE NOISE
R. G. Medhurst, Proc. Instn. Elect. Engrs. Pt. C, vol. 107, no. 12, Sept. 1960, p. 314/323, 26 refs.

Although comprehensive sets of curves are available giving the radio-frequency spectra of waves phase modulated with band-limited white noise (simulating f.d.m. telephony signals), the corresponding problem for frequency modulation turns out to be much more intractable. In the present paper the frequency-modulation problem is attacked using a method employed in an earlier paper, in conjunction with numerical devices for improving the convergence rate of very slowly converging series. . . .

EXPLICIT FORM OF F. M. DISTORTION PRODUCTS WITH WHITE-NOISE MODULATION (Extension and Correction)
R. G. Medhurst, et al., Proc. Instn. Elect. Engrs., Pt. C, vol. 107, no. 12, Sept. 1960, p. 367/369.

EXTENDED ANALYSIS FOR DISTORTION IN FM MULTICHANNEL TRANSMISSIONS
C. A. Parry, et al., Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 183/197.

INTERMODULATION DISTORTION IN MULTICHANNEL LINKS WITH FM IN USW SCATTER PROPAGATION
A. V. Prosin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 1/17.

. . . intermodulation distortions. . . owing to multi-path scatter propagation. . . Formulae are produced for determining the power of transient noise. The author establishes the dependence of intermodulation distortions on the length of the path, the beam-width of the aerial, and a number of other factors. . . .

ANALYSIS AND DETECTION OF ECHO SIGNALS ON MICROWAVE RADIO PATHS
G. E. Rosman, Proc. Instn. Radio Engrs. Australia, vol. 21, no. 11, Nov. 1960, p. 810/820.

An assessment is made of the echo parameters permissible for a specified maximum distortion in a 600 channel frequency-modulated radio bearer circuit. On the assumption that the echoes result from single reflections the effect of aerial directivity on a system operating at 4,000 Mc/s is assessed for specific aerials used on a 40 mile path. A survey of common testing methods. . . outline of the method of height-gain measurement for echo investigation. . .

THE THEORETICAL ANALYSIS ON DEMODULATION SYSTEMS OF FREQUENCY-DIVISION MULTIPLEXED F. M. SIGNAL IN NOISE (In Japanese)
O. Shimbo, J. Inst. Elect. Commun. Engrs. Japan, vol. 44, no. 3, March 1961, p. 368/376.

An analytic comparison is made of the various demodulation systems that have been used up to the present, with particular reference to detection distortion, s./n. ratio, threshold region, etc. The analysis enables the s./n. ratio to be calculated statistically for any state of an arbitrary system.

ON ENERGY BAND, AND DISTORTION PRODUCED BY ATTENUATION AND PHASE CHARACTERISTICS, OF FREQUENCY-DIVISION MULTIPLEXED F. M. SIGNALS (In Japanese)
O. Shimbo, et al., J. Inst. Elect. Commun. Engrs. Japan, vol. 44, no. 3, March 1961, p. 376/383.

The energy bandwidth function of a frequency-multiplexed f.m. signal for various modulation depths is derived by approximation methods, and the function is then applied to determine the distortion due to phase and amplitude characteristics. . . .

CONSIDERATION OF NONLINEAR NOISE AND ITS TESTING IN FREQUENCY DIVISION MULTIPLEX VOICE UHF RADIO COMMUNICATION SYSTEMS
L. P. Yeh, IRE Trans. Commun. Syst., vol. CS-9, no. 2, June 1961, p. 115/129.

When the signal is strong, the nonlinear noise (sometimes called the intermodulation noise) may become the limiting factor. It is, therefore, imperative to control the intermodulation distortion contribution from the system components by careful equipment design and from the medium by appropriate choice of system parameters.

RELAIS HERTZIEN A MODULATION SYNCHRONE (Radio Relay Link with Synchronous Modulation) (In French)
P. V. Cang, Ann. Radioelect; vol. 17, no. 69. July 1962, p. 194/210.

When a frequency modulated reference signal is used to control a reflex klystron through a synchronizing loop in phase, the information contained in this reference signal is transferred to the klystron. A frequency change receiver supplying the reference signal, associated with such an arrangement then constitutes a microwave repeater which may be termed, Synchronous Modulation Repeater.

EFFECTS OF AMPLITUDE AND PHASE FLUCTUATIONS ON THE PERFORMANCE OF DIGITAL DATA SYSTEMS IN FADING FDM-FM AND FDM-SSB SYSTEMS
H. D. Becker, Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 93/100.

. . . Emphasis is placed on the theoretical performance of differentially coherent phase-shift keyed (DCPSK) systems in which DCPSK data is transmitted on subcarriers over a frequency-division multiplex single-sideband (FDM-SSB) or an FDM-FM transmission system, such as employed in typical tropospheric scatter links. . . .

DELAY VARIATIONS IN TELEMETRY FILTERS
K. L. Berns, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 3, Sept. 1962, p. 199/204.

. . . significance of filter delay characteristics in telemetry applications. . . methods of delay measurement. . . experimental results. . . Recommendations. . . regarding filter specifications. . . . Although the study and investigations were conducted with FM/FM telemetry subcarrier discriminators, the results can also be applied to other filter networks such as those used in telemetry transmitting systems. . . .

COHERENT FDM/FM TELEPHONE COMMUNICATION
J. A. Develet, Jr., Proc. IRE, vol. 50, no. 9, Sept. 1962, p. 1957/1966.

. . . telephone communication as applied to a satellite repeater system. Particular emphasis is placed on a method of coherent reception. . . new to the field of common carrier telephony. . . . for the class of signals utilized in common carrier telephony, an attempt is made to place on a quantitative

footing the design of FDM/FM satellite communication systems. The interrelation among such quantities as sensitivity, bandwidth occupancy, and channel quality is presented for a simply realized second-order receiving system. In addition, the maximum sensitivity achievable with the optimum receiving system is shown. . . .

A PHASE-LOCKED DETECTOR FOR FM MULTIPLEX APPLICATIONS
D. W. Ford, Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 179/184.

SUMMARY: . . . to overcome the signal-to-noise ratio threshold that limits the performance of FM receivers employing conventional FM discriminators. To obtain the required bandwidth, a phase-shift type FM oscillator having broadband frequency modulation characteristics has been used as a voltage-controlled oscillator (VCO). The resulting detector circuitry has capabilities for wideband FM demodulation with suitable linearity for FM multiplex applications.

SS-FM: A TELEMETRY TECHNIQUE FOR WIDE-BAND DATA
W. O. Frost, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 4, Dec. 1962, p. 283/289.

. . . The data channels are stacked in the frequency spectrum as single-sideband subcarriers which frequency-modulate the RF carrier. The system design utilizes to advantage the statistical properties of vibration data to achieve maximum data transmission efficiency from the available RF carrier deviation. However, in contrast to proposed statistical predigestion techniques, the data is transmitted in raw form. . . . general description of the SS-FM vehicle and ground telemetry equipment utilized in the Saturn vehicle program and a summary of system characteristics and performance. . . .

A MULTIPLEXED FM DATA SYSTEM WITH IDENTICAL CHANNEL CHARACTERISTICS
W. P. McGarry, Proc. Nat. Telem. Conf., May 1962, p. 1/13, no. 13-3.

Seven systems each with ten FM constant bandwidth channels are discussed. The required bandwidth for the seven systems and the respective maximum deviation are 800KC, 400KC, 200KC, 100KC, 50KC, 25KC, and 12.5KC; ± 16KC, ± 8KC, ± 4KC, ± 2KC, ± 1KC, ± 0.5KC and ± 0.125KC. . . .

INTERMODULATION NOISE IN LINEAR F. M. SYSTEMS
R. I. Magnusson, Proc. Instn. Elect. Engrs., Pt. C, vol. 109, no. 15, March 1962, p. 32/44.

By applying a series of detailed approximations to the Rice and Bosse theory of f. m. intermodulation noise, the recent formulae of Medhurst and Roberts for intermodulation noise/signal ratios in f.m. systems with white-noise modulation and networks of polynomial frequency characteristics are extended in three respects: (a) to the calculation of the noise ratio at any modulation frequency, (b) to network real and imaginary characteristics of eighth and seventh degree, respectively, and (c) to the case of pre-emphasis. The theory is illustrated by application to the cases of a signal with C.C.I.R. pre-emphasis passing a stagger-tuned triple without and with group-delay equalization.

MULTIPLE ECHO DISTORTION IN FREQUENCY-MODULATION, FREQUENCY-DIVISION, MULTIPLEX TRUNK RADIO SYSTEMS
R. G. Medhurst, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 61/71.

. . . concerned with intermodulation distortion in FM, FDM trunk radio systems due to a number of echoes of differing amplitudes and delay times. General formulas are developed, and applied to the case of a 960-channel system subjected to distortion due to echoes from flanges in waveguide runs. Examples considered are 100- and 200-ft. runs of RG-50/U waveguide, in 10-ft. sections, for use in the 6000 Mc band. . . .

DIE ZEIGERMETHODE EIN ANSCHAULICHES VERFAHREN ZUR BEHANDLUNG VON VERZERRUNGEN DER KLEINHUB-FM MIT ANWENDUNG AUF FM-RICHTFUNK (The Phasor Method; an Instructive Method for the Analysis of Distortions in FM with Small Deviation Ratio) (In German)
M. Muller, Arch. Elekt. Ubertragung, vol. 16, no. 1, Jan. 1962, p. 25.

A METHOD FOR PREDICTING INTER-CHANNEL MODULATION DUE TO MULTIPATH PROPAGATION IN FM AND PM TROPOSPHERIC RADIO SYSTEMS
C. D. Beach, et al., Bell Syst. Tech. J., vol. 42, no. 1, Jan. 1963, p. 1/36.

. . . interchannel modulation due to multipath propagation on angle-modulated tropospheric scatter radio systems. Values of signal-to-intermodulation ratio, S/I, are calculated for various pairs of signal reflections in the troposphere, taking into account the base bandwidth and frequency deviation of the system, the antenna patterns, the path geometry, and climatic conditions during the "worst month" of propagation. The lowest value of S/I (worst intermodulation) computed for such pairs of signal reflections is then corrected empirically to account for multiple reflections. The result represents the median value of S/I expected during the worst month of transmission on a specified path.

PUISSANCE MOYENNE DE BRUITE DANS LES FAISCEAUX HERTZIENS TRANS-HORIZON A MODULATION DE FREQUENCE (Average Noise Power in FM Transhorizon Radio Relay Links) (In French)
L. Boithias, et al., Ann. Telecomm., vol. 18, no. 5-6, May/June 1963, p. 88/93.

THE AJAX FRENCH RADIO-TELEMETRY SYSTEM (In French)
G. Greneche, Onde Electr., vol. 43, no. 432, March 1963, p. 286/297.

. . . a French telemetry system using subcarriers of the FM/FM type based on the recommendations of the American organization IRIG (Intermediate-Range-Instrumentation-Group). . . . has been developed on a national basis. All the operating items making it up are manufactured in France.

PARAMETER OPTIMIZATION OF AN FM/FM MULTICHANNEL TELEMETRY SYSTEM
D. H. Sapp, RCA Rev., vol. 24, no. 3, Sept. 1963, p. 381/390.

. . . discusses the r-f equipment parameters and parameter optimization of the r-f portion of a wideband telemetry system containing a combination PCM and FM/FM multiplex. The various sources of distortion in FM systems are discussed and graphs are given to show typical saddle points by means of which parameters can be selected to maximize the channel signal-to-noise ratios. Empirical methods are presented that give a systematic approach to the selection of the parameters that maximize the amount of data transmitted over a telemetry link of a given bandwidth or minimize the bandwidth for a given amount of transmitted data.

DISTORTION OF MULTITONE FM SIGNALS DUE TO PHASE NONLINEARITY
P. D. Shaft, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 1, March 1963, p. 25/35.

An equation is developed for the distortion of multitone FM signals caused by transmission through a network with nonlinear phase characteristics. . . .

Related Publications:

NEW DEVELOPMENTS IN FM RECEPTION AND THEIR APPLICATION TO THE REALIZATION OF A SYSTEM OF "POWER-DIVISION" MULTIPLEXING
E. J. Baghdady, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 147/161.

A HIGH CAPACITY PAM-FM-FM TELEMETERING SYSTEM FOR THE SATURN BOOSTER
O. B. King, Nat. Symp. Space Electronics Telem., Sept. 1959, no. 7.1.

2.524: DSB Multiplex Systems

Included: FD multiplex systems with DSB radio carrier; Amplitude modulated multi-channel systems; Double sideband modulation in multiplex systems; Quadraphase subcarrier techniques; Vestigial sideband techniques for vocoder multiplex system; Coder-multiplex for VSB-vocoder mux system.

Not Included: Fundamentals of DSB (1); Multiple modulation methods with DSB (1).

Cross References: Vocoder techniques (2.330).

Principal Publications:

A DOUBLE SIDEBAND-CARRIER COMMUNICATION SYSTEM FOR TELEPHONE APPLICATION
J. W. Halina, IRE WESCON Conv. Rec., no. 8, Aug. 1958, 61/68.

DOUBLE-SIDEBAND SUPPRESSED-CARRIER MULTIPLEX EQUIPMENT FOR CABLE AND MICROWAVE APPLICATIONS
W. S. Chaskin, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 2, June 1959, p. 92/94.

INTERMODULATION ON AMPLITUDE-MODULATED MULTI-CHANNEL LINE LINKS
J. C. Davis, et al., Proc. Instn. Elect. Engsr., Pt. C, vol. 107, no. 12, Sept. 1960, p. 342/352, 13 refs.

. . . a method for estimating the total intermodulation noise power falling into any channel in the transmission band of an a. m. multi-channel line system with many repeater sections in tandem. These sections may be composed of widely varying lengths of cable imperfectly equalized by non-identical amplifiers whose in-band feedback, output load impedance and output network response all vary with frequency. . . .

FEASIBILITY STUDY OF TRANSISTORIZED CODER-MULTIPLEXER
A. S. Howell, General Dynamics/Electronics, Rochester, N. Y., (Rept. no. 1820-TN-2), (RADC TN-61-146), July 1961, 30 p., AD 262 021.

. . . feasibility of providing a system of multiple vocoders fed from telephone inputs

and operating over a single voice-frequency channel. . . . Means of optimum pitch extraction and spectrum synthesis, appropriate to speech processing in the analog or binary modes, were investigated. A system of narrow-band multiplexing, compatible with analog transmission, was developed. . . . Successful analog multiplexing of a telephone semi-vocoder within a 900 c bandwidth was accomplished. The system comprises time sampling of the spectrum energy and the transmission of this information, using vestigial sideband techniques. A compatible synchronizing system was achieved.

THE 81-A EXCHANGE TRUNK CARRIER SYSTEM–APPLICATIONS
L. R. Cool, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 617/623.

THE 81-A EXCHANGE TRUNK CARRIER SYSTEM–REPEATERS AND REGULATION
E. A. Gilmore, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 606/610.

A QUADRAPHASE SUBCARRIER TECHNIQUE FOR TRANSMISSION OF TWO INDEPENDENT PCM CHANNELS
D. L. Anderson, Proc. Nat. Telem. Conf., May 1963, no. 10-3.

A phase-division multiplex technique (quadraphase modulation) for the simultaneous transmission of two independent PCM Channels is described, analyzed, and compared to frequency and time division multiplex techniques . . . use of a product demodulator for demodulation of the IF carrier. . . .

NEW 12-CHANNEL CARRIER SYSTEM FOR EXTENDED-AREA TRUNK AND SUBSCRIBER SERVICE
O. A. Jorgensen, IEEE Trans. Commun. Elec-Electronics, no. 69, Nov. 1963, p. 643/647.

. . . The dual-sideband AM (Amplitude-modulated) system uses one modulation step only and has a grouped and a stacked frequency allocation for use with and without repeaters respectively. Compandors supplied on an optional basis and the use of high-gain amplifiers make it advantageous to use wire and cable facilities at frequencies as high as 350 kc.

Related Publications:

PHASE CORRELATED PROPERTIES OF SIGNALS AND GAUSSIAN NOISE IN TWO-CHANNEL PHASE SYSTEMS
V. V. Tsvetnov, Radio Engng., vol. 13, no. 4, 1958, p. 69/85.

THE 81-A EXCHANGE TRUNK CARRIER SYSTEM
M. E. Ferguson, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 601/606.

Section 2.53:
Time Division Multiplex Systems

2.531: Theory of TD Systems

Included: Intersymbol interference; Sampling rates TD-mux systems; Aliasing errors in TD-mux systems; Cross talk in TD systems; Theory of time shared systems; Theory of synchronization in TD-mux.

Not Included: Sampled modulation methods (1); Pulse modulation methods (1); Pulse code modulation (1); Sampling theories (1); Distortions in communications channels (1).

Cross References: Intersymbol interference in correlation detectors (2.821).

Principal Publications:

CROSSTALK IN TIME SHARED SYSTEMS AS AFFECTED BY DISCRIMINATOR CHARACTERISTICS
O. J. Ott, Nat. Symp. Space Electronics Telem., Sept. 1959, no. 8.3.

. . . A commonly used method for increasing the number of channels in an FM-FM system is to commutate a group of low frequency inputs and transmit the time shared waveform as PAM or PDM information on one of the subcarrier channels. . . .

SYNTHESIS OF A RESONANT TRANSFER FILTER AS APPLIED TO A TIME DIVISION MULTIPLEX SYSTEM
P. T. May, et al., Commun. and Engineering, vol. 79, no. 51, Nov. 1960, p. 615/620, 13 refs.

In a previous paper, Perkins describes a time division multiplex transmission path, developed for use in an electronic switchboard. This transmission path incorporates the use of a "resonant transfer" filter, the operation of which was first described in reference 3. This type of filter and the associated theory have since been described by several authors. The purpose of this paper is to present a method used to synthesize any economical network whose characteristics will allow it to operate efficiently in this system. . . .

STUDY AND EXPERIMENTAL INVESTIGATION ON SAMPLING RATE AND ALIASING IN TIME-DIVISION TELEMETRY SYSTEMS
J. W. Capps, et al., Aeronutronic, Newport Beach, Calif., Final Rept., March - Sept. 1961, (ASD TR 61-553), June 1962, lv. incl. illus., 22 refs., AD 278 515.

. . . applicable to time-division multiplexed telemetry systems. In particular, the results apply to the commonly used PAM-FM, PDM-FM and PCM-FM telemetry systems. . . . to determine typical telemetry data spectra. . . .

TIME AND FREQUENCY CROSSTALK IN PULSE-MODULATED SYSTEMS
E. A. Marcatili. Bell Syst. Tech. J., vol. 40, no. 3, May 1961, p. 951/970.

STUDY AND EXPERIMENTAL INVESTIGATION ON SAMPLING RATE AND ALIASING IN TIME-DIVISION TELEMETRY SYSTEMS
D. G. Childers, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 4, Dec. 1962, p. 267/283.

. . . to determine the effect of 1) data power spectrum, and 2) system design parameters on aliasing and data interpolation error . . . Results are applicable to time-division multiplexed telemetry systems. In particular, the results apply to the commonly used PAM-FM, PDM-FM and PCM-FM tele-telemetry systems and PACM-FM. . . .

The experimental tests utilized a PAM-FM system to derive an accurate measurement of attainable performance and to indicate when other equipment factors begin to impose a limit on data recovery accuracy. . . . In most applications, especially when the interpolation error must be 1 per cent or better, a minimum samples per cycle of 3 or higher will be required. . . .

REDUCTION OF MUTUAL INTERFERENCE BETWEEN RADIO COMMUNICATIONS CHANNELS DURING THE TRANSMISSION OF A RANDOM SEQUENCE OF SIGNALS
M. S. Gurevich, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 3, March 1962, p. 1/7.

. . . information is presented as a sequence of time-displaced functions. . . . examination of the energy spectrum of the sequence to time-displaced signals . . . the problem of the reduction of mutual interference resolves to finding the basic signal which will generate interference of least energy during transmission by such a system. . . . The number of channels which may be allocated to a given frequency band depends on the frequency separation required between adjacent channels. This separation, in turn, is determined by the mutual interference between channels. . . .

DEPENDENCY OF CROSSTALK OF UPPER AND LOWER CUTOFF FREQUENCIES IN PAM TIME-MULTIPLEXED TRANSMISSION PATHS
H. M. Straube, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 268/276.

In PAM time-multiplexed transmission systems, interchannel crosstalk arises when each sample is not confined to its assigned time slot. . . . transmission through a common medium of limited bandwidth causes each sample pulse to tail off into neighboring time slots . . . Some of the more formidable expressions . . . are . . . reduced to very simple design equations by judicious application of valid and practical assumptions. . . . numerical example. . . .

CERTAIN RESULTS IN PULSE TRANSMISSION THEORY
D. W. Tufts, et al., Cruft Lab., Harvard U., Cambridge, Mass., (Technical rept. no. 355), 5 Feb. 1962, 43 p. incl. illus, 26 refs., AD 275 564.

. . . problem of controlling intersymbol interference and additive noise interference in a certain type of pulse transmission system . . . amplitude modulated, periodic pulse train . . . At the receiver, the amplitude of each transmitted pulse is estimated by performing a weighted integration ot the received waveform. A pulse code modulation link is a special case of such a system. . . .

BOOTHROYD AND INTERSYMBOL INTERFERENCE REDUCTION (Correspondence)
R. D'Attilio, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 257.

SINTEZ DINAMICHESKIKH KHARAKTERISTIK MNOGOKANAL'NYKH SISTEM (Synthesis of The Dynamic Characteristics of Multi-Channel Systems) (In Russian)
I. B. Chelpanov, Akademiia Nauk SSSR, Izvestiia, Tekhnicheskaia Kibernetika, Nov. - Dec. 1963, p. 25/32, 8 refs., A64-14236.

Development of a method for determination of transient impulse functions of filters in a continuous multichannel system with noise characteristics. The analysis is based on the condition of minimum mean-square error at an arbitrary moment of time, and assumes alternating switching of the channels.

THEORETICAL DISCUSSION OF DIPHASE TRANSMISSION
L. U. Dworkin, Army Electronics Research & Development Agency, Ft. Monmouth, N. J., AELRDL TR 2358, Sept. 1963, 26 p., AD 421 519.

The problem of sending many communication channels over a single cable for relatively great distances . . . The present modulation approach . . . is called dipulse and has a

variety of deficiencies associated with its realized system. . . . The use of diphase modulation is proposed in place of dipulse with no change in repeater spacing or pulse transmission frequency. A differential diphase repeater was subjected to extensive theoretical analysis. . . .

THE TELEPHONE CHANNEL CAPACITY OF TRANSMISSION LINES
D. A. Gray, Proc. Instn. Radio Engrs. Australia, vol. 24, no. 7, July 1963, p. 583/589.

The attenuation of transmission lines used for telephone transmission varies very nearly as the square root of frequency . . . In this paper the maximum number of telephone channels which can be obtained on such a line using AM-FDM, FM-FDM, and PCM-TDM is calculated as a function of line attenuation at a reference frequency, transmitted power level, and signal-to-noise ratio. At moderate and high transmitting levels SSB-AM usually permits the greatest number of channels to be derived. . . .

A FUNCTIONAL ANALYSIS RELATING DELAY VARIATION AND INTERSYMBOL INTERFERENCE IN DATA TRANSMISSION
R. W. Lucky, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 2427/2483.

A relationship is derived between the delay characteristic in a data transmission system and the distortion in the form of intersymbol interference created by the delay variation. The relationship is valid for small delay and involves a sequence of linear functionals, each of which has a particular significance. . . .

CROSSTALK IN TIME DIVISION MULTIPLEX SYSTEMS (Correspondence)
L. Saporta, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 250/253.

An analysis of the interchannel crosstalk in time division multiplex systems is given. The results apply to systems with a general linear transmission channel and with arbitrary sampling waveforms. . . .

RESEARCH STUDY OF SYNCHRONIZATION IN DIGITAL SWITCHING SYSTEM
ITT Federal Labs., Nutley, N. J., Quarterly rept. no. 2, 1 July 1962 1 March 1963, 1 March 1963, 52 p., AD 407 314.

. . . various methods of providing synchronization in a switching system using time division multiplex transmission between exchanges. . . . study of techniques for clock synchronization and techniques for operation without clock synchronization and with and without bit integrity. . . . atomic and high stability crystal frequency standards . . . long-term propagation delay variations in microwave radio and cable systems.

Related Publications:

NOISE IN A PCM TRANSMISSION SYSTEM
H. Scheftelowitz, Ericsson Tech., vol. 16, no. 2, 1960, p. 207/244.

The different noise sources in a p. c. m. transmission system have been evaluated and their impact on the overall signal-to-noise ratio calculated. Formulae are given which show the signal-to-noise ratio in relation to repeater spacing. . . .

MATHEMATICAL EXPECTATION OF THE VOLTAGE AND MEAN MUMBER OF PULSES PER UNIT TIME AT THE OUTPUT OF A COINCIDENCE STAGE
M. V. Maksimov, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 11, 1961, p. 57/65.

. . . a coincidence stage at the input of which are transmitted signals and random pulse interference. Formulas have been obtained which permit the calculation . . . analyzing multichannel radio lines with code separation of channels . . . This code is characterized by a definite number of pulses with invariant amplitude and duration and with spacings between them established in advance. . . .

THE STABILITY OF A FREQUENCY REMOTE CONTROL, SYSTEM IN THE PRESENCE OF PULSE NOISE
Y. I. Chugin, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 10 May 1962, 33 p., incl. illus, (Trans. no. FTD-TT-62-636 from Avtomatika i Telemekhanika, 23:2, pp. 222/241, 1962), AD 286 132.

. . . A method is examined for calculating the noise stability of codes with series and parallel transmission of subcarriers. . . .

DIE UBERLAGERUNG VON IMPULSFOLGEN IN SYSTEMEN MIT EINER SCHWELLE (The Superposition of Pulse Trains in Threshold Systems) (In German)
F. Jenik, Arch. Elekt. Uebertragung, vol. 16, April 1962, p. 173/188.

. . . When two pulse trains of different repetition rates are superimposed, a number of pulses will coincide and will accordingly undergo addition or subtraction; with a threshold system the resultant output pulses can be separated from the other input pulses and are then a train of result pulses. The multiplicative relation between the input repetition rates and the output pulse rate is derived. The cluster-periodical structure of result sequence is explained and a calculation method is worked out. . . .

A SURVEY OF TELEPHONE SPEECH-SIGNAL STATISTICS AND THEIR SIGNIFICANCE IN THE CHOICE OF A P. C. M. COMPANDING LAW
R. F. Purton, Proc. Instn. Elec. Engrs, Pt. B, vol. 109, no. 43, Jan. 1962, p. 60/66.

2.532: Synchronous Time Division Systems

Included: Time division systems in general; Pulse multiplex systems; Multi-channel pulse communications systems; Di-phase PCM cable system; Time division multiplex telegraphy; Time division multipled delta modulation system; Synchronization of TD-mux systems.

Not Included: Regenerative repeaters (1); Pulse code modulation method (1); Delta modulation methods (1); Synchronization of PCM systems (1).

Cross References: Asynchronous time division systems (2.532); Random access systems (2.640); Theory of synchronization in TD (2.531).

Principal Publications:

DESCRIPTION ET PARTICULARITES TECHNIQUES DE L'EQUIPEMENT MULTIPLEX PORTABLE A IMPULSIONS MX 641 (Description and Characteristics of the Portable Pulse Multiplex Equipment MX 641) (In French)
M. R. Casse, Ann. Radioelect., vol. 13, April 1958, p. 167/184.

Its capacity is of 3 low-frequency channels or of 12 carrier current channels.

TIME MULTIPLEXING AS APPLIED TO ANALOG COMPUTATION
E. Rawdin, IRE Trans. Electronic Comp., vol. EC-8, March 1959, p. 42/48.

Can perform a common dynamic operation upon several sets of inputs utilizing equipment for one dynamic operation. It is particularly useful to reduce the number of components required when implementing problems in a simulation laboratory.

NEW MICROWAVE DEVELOPMENTS
I. T. Corbell, Wire and Radio Communication, vol. 2, Feb. 1960, p. 11/14/+50.

. . . UA-6-A microwave equipment employs FM operates in the 5900-7400 mc band. . . . operates with either TD (time division) or FD (frequency division) multiplex. . . .

MICROMINIATURE MULTICHANNEL PULSE-POSITION-MODULATION SYSTEM INCORPORATING TRANSISTOR-MAGNETIC-CORE CIRCUITRY
H. Kihn, et al., RCA Rev., vol. 21, no. 2, June 1960, p. 199/227.

An experimental five-channel time-division multiplex system . . . incorporating a microminiature transistor-core ring counter for both the transmitter modulator and receiver sampler. . . . The sampling rate used in the system is 15 kilocycles with an upper limit set only by the transistor and core high-frequency cutoff. Channel cross talk as low as -40 decibels may be obtained by suitable adjustment of operating parameters. . . . Power consumption is approximately 200 milliwatts at the 15-kilocycle rate. Linearity is adequate . . . for voice communication . . .

PULSE-PHASE MODULATION SYSTEM FOR 60 SPEECH CHANNELS
A. Koelbl, Frequenz, vol. 14, no. 10, Oct. 1960, p. 357/359.

In the field of communications, radio delay links long ago reached an equal footing with wire and cable facilities . . . Siemens company developed a pulse-position modulation system for 60 speech channels. Despite moderate requirements on bandwidth, this system satisfies all recommendations of the CCI with a minimum of technical effort per speech channel, a minimum of space requirements and power consumption and extreme simplicity of operation and maintenance. . . .

HIGH FREQUENCY TRANSMISSION FROM WIDELY SEPARATED DATA SOURCES TO A CENTRAL RECEIVING STATION (In German)
W. H. Schonfeld, et al., Abhandle. Braunschw. Wiss. Gesell, vol. 12, 1960, p. 124/134.

. . . becoming increasingly important in industrial enterprises and in large-scale investigations such as geophysical prospecting. . . . A radio system is described by which a number of transmissions may be made simultaneously to a center, using not more than 2 carrier frequencies. This is a time-division-multiplex system, which is illustrated by sampling diagrams and block schematics. Accurate synchronization of the channels provided is essential, and suitable systems for this purpose are described for the various kinds of pulse modulation discussed. Results obtained on an experimental 20-channel system for transmitting seismic data are given. . . .

A VERSATILE DIGITAL DATA MULTIPLEX SYSTEM
J. M. Balderston, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 214/227.

. . . developed by the ACF Electronics Division under its ABCD program, which is concerned with the design of a line of modular data transmission building blocks. . . . transistor circuits built on three by four and one-half inch printed circuit cards, comprising flip-flops, gates, inverters, etc. The multiplex system is constructed from these basic cards . . . can multiplex and demultiplex

from two to sixteen channels . . . accepts asynchronous terminal equipments such as Teletype or IBM Data Transceiver, quasi-synchronous equipment such a Facsimile and synchronous equipment such as the U. S. Army sponsored Fieldata family or IBM high-speed card reader, in any combination. . . . operates at total data rates up to 4800 bits per second in its present form. . . . Because of the multi-plexing scheme selected, the limit to the output bit rate is established only by the circuitry; the maximum bit rate could be extended to 50 Kc, or even higher . . . Time Division Multiplexing . . .

TIME-DIVISION-MULTIPLEX TELEGRAPHY ON THE TRANSATLANTIC TELEPHONE CABLE
H. E. Evans, et al., Post. Off. Elect. Engrs. J., vol. 54, no. 2, July 1961, p. 113/117.

The use of synchronous time-division working, made possible by the excellent performance of the frequency-modulation voice-frequency telegraph channels and the low noise level of the transmission path, offers a method of doubling the traffic-carrying capacity of telegraph channels on the transatlantic telephone cable. . . .

PULSE CODE MODULATION
(Part 2 - An Experimental 12-channel Equipment)
J. R. Jarvis, et al., Post Off. Elect. Engrs. J., vol. 54, no. 3, Oct. 1961, p. 189/195.

. . . using a code of eight binary digits; it was developed to investigate the manner in which the subjective assessment of the transmission performance is related to the design parameters. . . .

A PULSE TIME MULTIPLEX SYSTEM FOR STEREOPHONIC BROADCASTING
G. D. Browne, J. Brit. Instn. Radio Engrs., vol. 23, no. 2, Feb. 1962, p. 129/137.

. . . for v. h. v. broadcasting of stereophonic sound by means of time division multiplex . . . The possibility of adding a third channel is briefly discussed. Encoding, decoding and synchronizing arrangements are shown and results of preliminary measurements are presented. . . .

DEVELOPMENT OF DIPHASE PCM CABLE SYSTEM
R. A. Couturier, Stelma, Inc., Stamford, Conn., Quarterly progress rept. no. 1, and addendum, 29 May - 15 Sept. 1962, 12 Oct. 1962, 15 p., incl. illus., AD 288 000.

. . . design and construction of unattended cable repeaters . . . to provide diphase digital transmission over Cable Assembly CX-4245 ( )/G for 12-, 24-, and 48-channel operation are discussed. In the system, attended repeaters are installed at 40-mile cable intervals, with 39 unattended repeaters (one per 1-mile cable interval) between each pair of attended repeaters. . . .

AN EXPERIMENTAL PULSE CODE MODULATION SYSTEM FOR SHORT-HAUL TRUCKS
C. G. Davis, Bell Syst. Tech. J., vol. 41, no. 1, Jan. 1962, p. 1/24.

An experimentation on 24-channel pulse code modulation system employing solid-state devices is described. Economy of design and ability to operate over existing exchange cable.

THE SUBSCRIBER-LINE CIRCUIT AND THE SIGNALING AND TONE SYSTEM FOR AN EXPERIMENTAL TIME-DIVISION EXCHANGE FEATURING DELTA-MODULATION TECHNIQUES
H. Inose, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 397/407.

The time-slot mismatch loss will be avoided and the time-slot assignment will be simplified in a time-division exchange system in which the calling the called subscriber can use independent time slots arbitrarily assigned. Code-modulation techniques make such systems economically realizable, since a tapped magnetostrictive delay line or a shift register can be used to interchange time slots assigned to the calling and called subscribers. . . .

ELECTRONIC EQUIPMENT INTERFERENCE CHARACTRISTICS - COMMUNICATION TYPE
R. N Bailey, et al., Georgia Inst. of Tech., Engineering Experiment Station, Atlanta, 15 Feb. 1963, 134 p., AD 401 132, AD 415 741.

Band-width and crosstalk tests and test procedures developed for the pulse-position modulated, time-division multiplexer AN/TCC-13 . . . The system error rate test is presented in detail . . . results of mixer studies . . . spurious response bandwidth is found to be inversely proportional to the integer "q" in the spurious response equation.

ADVANCED TIME DIVISION MULTIPLEX COMMUNICATIONS USING PULSE CODE MODULATION
E. E. Bond, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 286/290.

. . . equipment currently being service tested by the U. S. Army Electronic Proving Grounds . . . consists of a family of units . . . to provide terminals or repeaters for 12, 24, 48, 96 telephone channels which will handle voice, teletype, facsimile, and digital data. Transmission may be over radio, coaxial cable, or combinations of the two media in series. . . . replacement of two voice

channels by handling digital data directly . . . allows transmission of 4800 data bits per second. . . .

EXPERIMENTAL PULSE-CODE-MODULATION TRANSMISSION FOR LOCAL-AREA TELEPHONY
K. W. Cattermole, et al., Elect. Commun., vol. 38, no. 1, 1963, p. 56/75.

ENGINEERING OF T1 CARRIER SYSTEM REPEATERED LINES
H. Cravis, et al., Bell Syst. Tech. J., vol. 42, no. 2, March 1963, p. 431/486.

The repeater lines for the T1 carrier system (24 voice channels, PCM) are cable pairs equipped with transistorized regenerative amplifiers. The line signal is a train of 1,544,000 bipolar pulse positions per second. The line engineering methods, which tell how to select cable facilities and where to place repeaters, are based on the theory and measurements reported here . . .

FORWARD AREA PCM TERMINAL (6/12 CHANNEL PCM)
W. Hatton, et al., Raytheon Co., Norwood, Mass, Semi-annual progress rept. no. 1, 1 Oct 1962 - 1 April 1963, 1 April 1963, lv, AD 415 000.

. . . breadboarding of the multiplexer and power supply circuits has been completed. . . .

A METHOD OF FRAME SEPARATION IN THE TIME-DIVISION-MULTIPLEXED DELTA MODULATION SYSTEM
H. Inose, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 469/480.

. . . Employing successive "1" s as the sync pattern, the system detects the sync channel out of the delta modulated information pulses which occur at the rate of one half in average. Using a memory device with the capacity of one frame, the detection is performed by taking successive frame correlation of each channel in parallel. . . . A possibility for shortening further the time required for the frame separation is also described. The method is to modify, at the transmitting end, the information pattern when it appears the same as the sync pattern. . . .

APPLICATION OF PULSE-CODE MODULATION TO AN INTEGRATED TELEPHONE NETWORK (Part 1 - Advantages of Pulse-Code Modulation)
P. Mornet, Elect. Commun., vol. 38, no. 1, 1963, p. 23/31.

GROUP SYNCHRONIZATION AS AN INFORMATION DETERMINING PROCESS (Correspondence)
D. R. Rhodes, IEEE Trans. Commn. Syst., vol. CS-11, no. 2, June 1963, p. 249/250.

Group synchronization in time-division communication is a special case of the general problem of transmission of information, and, as such, can be treated by the methods of information theory. The information to be communicated is the location of the sync position; i. e., the starting position of the group. . . .

TIME-DIVISION-MULTIPLEX ELECTRONIC TELEPHONE EXHANGE SYSTEM FOR SMALL PAX
K. Toyoda, et al., IEEE Trans. Commun. Electronics, no. 68, Sept. 1963, p. 455/464.

. . . An experimental time-division-multiplex electronic telephone exchange on a 200-line 4-wire PAM (pulse amplitude modulation) system is described. . . . For reliable operation, common and multiplexed circuits are duplicated, and fault detection and change-over operation are explained.

Related Publications:

PCM TRANSMISSION IN THE EXCHANGE PLANT
M. R. Aaron, Bell Syst. Tech. J., vol. 41, no. 1, Jan. 1962, p. 97/141.

ADAPTIVE TELEMETRY FORMAT GENERATOR
R. E. Gottfried, et al., Proc. Nat Telem, Conf., vol. 2, May 1962, no. 10-1.

. . . The great utility of time multiplexed formats for use in telemetry, communications, and data processing has been well established over the years. . . . The majority of telemetry formats . . . are fixed according to some prearranged sampling plan. . . . This practice has often resulted in great transmission inefficiency . . . excessive sampling results in redundance. . . . This paper describes a format generation technique which is believed to have great simplicity in terms of implementation and operational usage. The device which results can be controlled by command or self-adaptive means. . . .

TIMING ERRORS IN A CHAIN OF REGENERATIVE REPEATERS, I
B. K. Kinariwala, Bell Syst. Tech. J., vol. 41, no. 6, Nov. 1962, p. 1769/1780.

The pulse displacements produced by timing errors in a chain of regenerative repeaters (using tuned-circuit timing filters) are represented by a linear transformation of the pulse displacements at the output of the first repeaters.

TIMING ERRORS IN A CHAIN OF REGENERATIVE REPEATERS, II
B. K. Kinariwala, Bell Syst. Tech. J., vol. 41, no. 6, Nov. 1962, p. 1781/1797.

The behavior of the timing jitter in a long chain of repeaters is shown to depend on the spectral properties of a linear operator which

maps the space of bounded sequences into itself. . . .

A REFERENCE DISTORTION SYSTEM USING MODULATED NOISE
H. B. Law, et al., Proc. Instn. Elect. Engrs., Pt. B, vol. 109, no. 48, Nov. 1962, p. 484/487.

. . . developed, initially for use in the subjective assessment of pulse-code-modulated telephony links. Noise is amplitude-modulated by the speech signal, and then added to the signal in variable proportion, to produce controllable distortion comparable with the effect of quantizing noise. . . .

AN ANALOG-TO-DIGITAL ENCODER EMPLOYING NEGATIVE RESISTANCE DEVICES
B. Rabinovici, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 435/441.

. . . for use in multiplexing a number of voice communication channels. . . . .

PERFORMANCE LIMITATIONS OF A PRACTICAL PCM TERMINAL
R. H. Shennum, et al., Bell Syst. Tech. J., vol. 41, no. 1, Jan. 1962, p. 143/171.

Limitations which make performance different from more conventional frequency-division systems are considered. Particular emphasis is placed on limitations resulting from nonideal circuits and signal conditions.

A NEW METHOD OF FRAME SYNCHRONIZATION USING LINEAR SEQUENTIAL FEEDBACK GENERATORS
G. E. Goode, Proc. Nat. Telem. Conf., May 1963, no. 3-4.

. . . providing frame (or group) synchronization for time division multiplex communication systems such as those commonly found in telemetry, command, and data communication systems. . . .

A UNITED STATES AIR FORCE FOUR-WIRE ELECTRONIC SWITCHING DEVELOPMENT
F. Kozien, et al., RADC, Griffiss Air Force Base, N. Y., RADC TDR 63 298, Aug. 1963, 17 p., AD 419 485.

. . . based on the time-division-multiplex technique . . . is directly compatible with any transmission network that consists of HF, VHF, UHF, troposcatter, microwave, metallic circuits with or without carrier multiplex or a combination thereof for processing voice, digital data, graphics, etc., with a quality better than present commercial standards. . . .

A PROTOTYPE SELECTIVE MONITORING SYSTEM FOR PHYSIOLOGICAL DATA
G. W. Morton, et al., Rec. Nat. Space Electronics Symp., 1963, no. 8.2.

. . . selective monitoring techniques to extract the significant information from data typical of that originating in a manned space vehicle. Use of these techniques substantially reduces the load on all portions of the transmission and analysis facilities. . . .

ELECTRONIC EQUIPMENT INTERFERENCE CHARACTERISTICS-COMMUNICATION TYPE
C. W. Stuckey, et al., Georgia Inst. of Tech. Engineering Experiment Station, Atlanta, Quarterly rept. no. 3, 15 Aug. - 15 Nov. 1963, Rept. no. 24, 15 Nov. 1963, 56 p., AD 433 705.

. . . employing time division multiplexing . . .

2.533: Asynchronous Time Division Multiplex Systems

Included: Redundancy reducing multiplex speech transmission systems.

Not Included: PCM methods (1).

Cross References: Synchronous TD systems (2.532); Addressing codes (2.181); RADAS systems (2.640); Multiplexing with quasi-orthogonal binary functions (2.640); Accordion pulse type radio telephone system (2.640).

Principal Publications:

ANALYSIS OF ASYNCHRONOUS TIME MULTIPLEXING OF SPEECH SOURCES
T. G. Birdsall, et al., IRE Trans. Commun. Syst., vol CS-10, no. 4, Dec. 1962, p. 390/397.

. . . The analysis here evaluates the asynchronous method when extremal coding is used with the speech sources. . . . For these parameters a 100-source asynchronous system requires only one-third the digit rate of a synchronous multiplex. About a 5-db loss in signal-to-noise may be expected, due to the extremal coding. Two additional features are: 1) 20 percent of digit rate is available for nonreal time data; and 2) the usual elastic overload of asynchronous systems is present. . . .

ASYNCHRONOUS PULSE-CODE MODULATION
J. D. Howells, Electronics, vol. 35, no. 42, Oct. 1962, p. 58/60.

When clocks at receiver and transmitter are not synchronized samples of a speech waveform may be lost. The system described fills the gaps with a work sample generated at the receiver. The only apparent effect is a barely audible click at the output.

DIGITAL COMMUNICATION STUDIES, PART I. COMPARATIVE PROBABILITY OF ERROR AND CHANNEL CAPACITY. PART II. ASYNCHRONOUS TIME-MULTIPLEXING OF MULTICHANNEL SPEECH SOURCES
M. P. Ristenbatt, et al., Office of Research Administration, U. of Michigan, Ann Arbor, (Tech. rept. no. 133; Rept. no. 4251-21T), March 1962, 128 p., incl. illus., tables, 41 refs., AD 275 430.

. . . many signalling methods are considered, some fundamental principles, terminology, and methods of comparing are suggested. An analytical evaluation is presented of asynchronous time-multiplexing for multichannel speech signals. . . . it is proposed that the source-to-channel sample assignment be asynchronous.

TWO NEW SPEECH COMMUNICATION SYSTEMS
J. L. Stewart, Arizona U., Tucson, Final rept. for 15 Dec. 1960 - 14 Dec. 1961 on Biological Information Handling Systems and Their Functional Analogs, (MRL TDR 62-10), March 1962, 22 p., incl. illus., 29 refs., AD 278 711.

. . . provide certain efficiencies in speech channel usage. One system achieves the equivalent of modest bandwidth compression by permitting two-to-one time multiplexing with simple terminal equipment and with a standard speech (telephone) channel. The other, based on extraction of equivalent amplitude, frequency, and phase modulating components of speech, may yield bandwidth compression comparable to that of a formant-tracking vocoder.

STUDIES IN DIGITAL COMMUNICATIONS. PART I. FEASIBILITY OF ASYNCHRONOUS MULTIPLEXING, PART II. PERFORMANCE OF HIGH-SPEED DIGITAL COMMUNICATIONS OVER TROPOSCATTER LINKS
M. P. Ristenbatt, et al., Cooley Electronics Lab., U. of Michigan, Ann Arbor, Technical rept. no. 143; 4951 IT, Aug. 1963, 101 p., AD 416 647.

. . . asynchronous time multiplexing for multichannel speech. . . to elaborate on the theoretical analysis and predictions made previously . . . The work . . . showed that asynchronous time multiplexing is feasible, under the conditions treated, for systems having as few as 24 sources. It was concluded that the advantage of this method over synchronously multiplexed PCM is about 2.7 for 100 sources, and 2.1 and 24 sources. . . The speech quality with this advantage is not distinguishable, with casual listening, from that of the usual PCM.

Related Publications:

RECOVERY OF RANDOMLY SAMPLED TIME SEQUENCES (Correspondence)
C. S. Lorens, IRE Trans. Commun. Systems, vol. CS-10, no. 2, June 1962, p. 214/216.

. . . Normally, the sampling sequence is periodic . . . Yen points out that certain deviations can be made from the periodic structure without destroying the ability of perfect recovery.

In coded communication systems the times of channel availability are random. . . . This paper considers the noise and recovery problem associated with a random sampling of a continuous time sequence. . . .

2.534: Switched Time Division Systems

Included: TASI = time assignment speech interpolation systems; Signalling systems for TASI; Interrupted speech; TICOSS = time compressed single sideband system.

Not Included: Multiple access communications satellites (4A); Transoceanic cable systems.

Cross References: Asynchronous time division systems (2.533); RADAS (2.640); Multiple access systems (2.640); Speech processing systems (Div. 2.3).

Principal Publications:

TIME-COMPRESSED SINGLE-SIDEBAND SYSTEM (TICOSS)
M. I. Jacob, et al., IRE Trans. Commun. Syst., vol. CS-6, no. 1, June 1958, p. 2/8.

. . . Ticoss has been proposed that provides the performance required of mobile multi-channel short-to-medium-range communication systems . . . Ticoss handles all transmission with one transmitter, one receiver, and one antenna at each station. The sub-channels to be multiplexed are arranged in sequential time slots to form a frame.

ENGINEERING ASPECTS OF TASI
K. Bullington, et al., Bell Syst. Tech. J., vol. 38, no. 2, March 1959, p. 353/364.

TIME ASSIGNMENT SPEECH INTERPOLATION SYSTEMS: FACTORS AFFECTING INITIAL CLIPPING OF SINGLE WORDS
Post Office Research Station, Dollis Hill, London N. W. 2, no. 10, June 1960, 12 p.

OVER-ALL CHARACTERISTICS OF A TASI SYSTEM
J. M. Fraser, et al., Bell Syst. Tech. J., vol. 41, no. 4, July 1962, p. 1439/1454.

. . . in service on transatlantic submarine cable channels since mid-1960. Measurement of service quality on one TASI system . . . indicates that system performance equals or exceeds the original engineering objectives in all but a few cases. Field modification now being made should bring these exceptions into closer agreement with objectives.

TASI QUALITY-EFFECT OF SPEECH DETECTORS AND INTERPOLATION
H. Miedema, et al., Bell Syst. Tech. J., vol. 41, no. 4, July 1962, p. 1455/1473.

. . . tests made to select design parameters for the speech detectors in the TASI system. Results of subjective tests carried out to determine maximum permissible loading of TASI circuits during busy hours are also described . . . observations indicate that TASI is a more satisfactory method of increasing transatlantic cable capacity than alternate methods, such as the use of 2-kc channel banks.

INTERRUPTED SPEECH AND THE POSSIBILITY OF INCREASING COMMUNICATION EFFICIENCY
P. V. Indiresan, J. Acoust. Soc. Amer., vol. 35, no. 3, March 1963, p. 405/407.

It is known that speech remains intelligible when it is interrupted at a slow rate (about 50 c/s). Such interruption reduces the time duration of transmission without increasing the bandwidth and hence can increase the effective utilization of a communication channel. The reasons for the intelligibility of interrupted speech are explained, and the theoretical limits to the interruption rate and sampling period are estimated. . . . will not be directly suitable for communication purposes because of switching noise. Three methods for overcoming this noise, namely, by reverberation, by integration, and by the reiteration of synchronized speech samples are described. . . .

LINE AND REGISTER SIGNALLING SYSTEMS FOR DIALLING OVER TRANSOCEANIC TELEPHONE CABLES
S. Welch, Post Off. Elect. Engrs. J., vol. 56, no. 2, July 1963, p. 111/118.

Line and register signalling systems have been developed for dialling over transoceanic cables. The systems are compatible with T. A. S. I. equipment and with both 3 kc/s-spaced and 4 kc/s-spaced circuits. This article describes the circuit principles of both signalling systems. . . .

Related Publications:

STEP DETECTION - REDUCING CROSSTALK IN TIME-DIVISION MULTIPLEX SYSTEMS
A. R. Billings, Electronic and Radio Engng., vol. 35, Dec. 1958, p. 453/455.

Summary. The spectrum of a step-detected signal is derived both an ideal and a practical step detector. It is shown that the attenuation distortion produced by step detection is small, and that step detection, when applied to time-division multiplex systems, can produce a considerable reduction in adjacent-channel crosstalk. A step detector is a device which converts a train of amplitude-modulated pulses into a continuous stepped waveform.

2.535: Hybrid Time Division Systems

Included: Segmentation of speech for hybrid multiplexing; Time division multiplexing of voice and data; Adaptive multiplexing with speech priority; Multiplexing teletype and vocoder speech; Hybrid TD-FD systems; Voice data multiplexing; Vodactor; Vodaplex; PACM-FM as a hybrid multiplex system.

Not Included: PACM telemetry equipment.

Cross References: Asynchronous time division multiplex equipment (2.533); TASI system (2.534); RADAS systems (2.640).

Principal Publications:

CONCERNING THE MULTIPLEXING OF RADIO LINKS WITH PULSE TIME MODULATION AND FREQUENCY MODULATION OF THE RF CARRIER
R. Ebermann, Nachrichtentechnik, vol. 10, March 1960, p. 95/103.

THE C. E. L. T. I. C., A DEVICE FOR USING INACTIVE CIRCUIT TIME (In French)
F. D. Dayonnet, et al., Onde Electr., vol. 42, no. 426, Sept. 1962, p. 675/687.

The French PTT Administration has developed a device for long distance circuits called C. E. L. T. I. C. which puts to profitable use the inactive intervals during conversations so as to route along a network of circuits more conversations than there are circuits. This electronic equipment operates a switching device at each end. . . . Communication on the state of the connections at one terminal are transmitted to the other by signalling channel . . .

PACM-FM TELEMETRY EVALUATION
D. E. Gilcrest, et al., Proc. Nat. Aerospace Electronics Conf., 1962.

FEASIBILITY INVESTIGATION OF A PACM-FM TELEMETRY SYSTEM
Aeronutronic, Newport Beach, Calif., Final rept., June 1961 - May 1962, (ASD TDR 62-637), Oct. 1962, 86 p., incl. illus., tables, 5 refs., AD 289 886.

. . . design and construction of a PACM-FM ground station, . . . design and construction of a vehicleborne data converter to generate PAM, PCM, and PACM formats . . .

Laboratory test with various formats and data rates to establish system performance, and the capabilities of the equipment developed . . . analysis and evaluation of the PACM-FM system . . . equipment electrical and operational characteristics . . . preparation of recommended procurement specifications based on tests, analysis, and evaluation. The tests and analysis disclose that the performance obtainable for PAM and PCM in the PACM format is the same as in the pure PAM and PCM formats. . . .

SIMULATION AND EVALUATION OF PHONETIC SPEECH RECOGNITION TECHNIQUES VOLUME I. SEGMENTATION OF CONTINUOUS SPEECH INTO SYLLABLES
K. W. Otten, National Cash Register Co., Dayton, Ohio, RTD TDR63 4005, vol. 1, Sept. 1963, 22 p., AD 422 472.

. . . analysis of design parameters required for the simulation and evaluation of phonetic speech methods. An approach to the segmentation of continuous speech into syllables is described, and the results of segmentation experiments . . . are presented . . . divide continuous speech into units which are either silences or what are defined here as impulse syllables. . . . the time between segmentation points, and the binary information on the type of impulse syllable . . . some of the potential segmentation points are eliminated. The resulting new units are silences and linguistically meaningful syllables.

A STUDY OF THE FEASIBILITY OF MULTIPLEXING TELETYPE DATA INTO NON-SPEECH TIME OF VOCODED SPEECH TRANSMISSION
D. R. Ziemer, et al., Texas Instruments Inc., Dallas, Tex., Part II Final Report, (AFCRL-63-300), June 1963, 32 p., 1 ref., N63-22192, AD 418 177.

. . . to determine: (1) the number of teletype transmission channels that might be accommodated (multiplexed) simultaneously with the vocoder speech-communication system used for speech transmission: (2) the buffer storage requirements to realize the potential teletype transmission rate available due to the silent frames; and (3) the general implementation problem that would be encountered in adding the teletype multiplexing feature into the polymodal vocoder. It was found that for normal telephone conversations it would be possible to multiplex in 39. 75 word-per-minute teleprinters into a full duplex vocoder speech-communication system. In addition, it would be possible to have these 39 teleprinters running 97 percent of the time while the system was in use for speech transmission . . .

Related Publications:

ANALYSIS OF ASYNCHRONOUS TIME MULTIPLEXING OF SPEECH SOURCES
T. G. Birdsall, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 390/397.

PRACTICAL DESIGN OF PACM TELEMETRY EQUIPMENT
G. J. Pastor, Proc. Nat. Telem. Conf., May 1962, no. 13-4.

. . . hybrid Pulse Amplitude and Pulse Code Modulation . . . Feasibility Model . . . (Contract No. AF33(616)-8432) . . . completed early this year and its evaluation is in progress. . . .

INTERRUPTED SPEECH AND THE POSSIBILITY OF INCREASING COMMUNICATION EFFICIENCY
P. V. Indiresan, J. Acoust. Soc. Amer., vol. 35, no. 3, March 1963, p. 405/407.

Section 2.54
Other Multiplex Systems

2.542: Waveform Multiplexing

Included: Orthomux = orthogonal waveform multiplexing; Boolean function multiplexed telemetry system; Hermite polynoms in orthogonal multiplex systems; Quasi-orthogonal binary functions as multiplexed carriers.

Not Included: Orthogonal signal alphabets (1); Higher order data transmission systems (1).

Cross References: Binary orthogonal codes (2.122); Theory of PN sequences of binary elements (2.121).

Principal Publications:

A NEW CONCEPT FOR MULTIPLEXING COMMUNICATION SIGNALS
A. H. Ballard, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 355/362.

A new multiplexing concept known as ORTHOMUX is described, with particular reference to its applicability in military communication systems. . . .

A NEW MULTIPLEX TECHNIQUE FOR TELEMETRY
A. H. Ballard, Proc. Nat. Telem. Conf., May 1962, no. 6-2.

. . . The name ORTHOMUX (meaning Orthogonal Waveform Multiplexing) has been adopted to describe the new concept. . . . The polynomial waveforms which exhibit this property may be generated in a very simple way by cascading miniature circuit modules fully transistorized in design. . . .

MULTIPLEXING USING QUASIORTHOGONAL BINARY FUNCTIONS
W. J. Judge, Commun. and Electronics, vol. 81, no. 60, May 1962, p. 81/83.

. . . two different codes are linearly added and sent over the same channel, a receiver can accept one code and reject the other by the process of correlation detection. . . . superiority of the maximal linear sequence autocorrelation . . . due to two characteristics . . . the randomness and the shift-and-add properties. . . .

A BOOLEAN-FUNCTION-MULTIPLEXED TELEMETRY SYSTEM
R. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./ Jan. 1962, p. 157/159.

. . . describes a telemetry system in which information from several data sources is sent simultaneously over a single channel, not using time or frequency-multiplexing but in which the input data are inserted simultaneously into a Boolean function . . .

TELEMETRY MULTIPLEXING WITH ORTHOGONAL PULSE WAVEFORMS
A. H. Ballard, Proc. Nat. Telem. Conf., May 1963, no. 10-2.

. . . orthogonal pulse waveforms are used as subcarrier signals. Known as ORTHOMUX, the new technique offers high spectrum efficiency, with maximum rejection of crosstalk and noise. Extremely simple and versatile equipment can be used. The orthogonal waveforms used are similar to the Reed-Muller binary codes. All waveforms are transmitted simultaneously at a common repetition rate. Multi-channel information is conveyed in the form of independent amplitude modulation (analog data) or polarity reversal (digital data) of each subcarrier waveform. The information signals are separated and demodulated without interaction by a process of waveform correlation. . . .

AN ORTHOGONAL MULTIPLEXED COMMUNICATION SYSTEM USING MODIFIED HERMITE POLYNOMIALS
S. Karp, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 341/353.

. . . A pulsed multiplex system is outlined which transmits orthogonal signals and features excellent time bandwidth compression properties. For nominal time-limiting and bandlimiting, the signals preserve orthogonality better than comparable systems utilizing orthogonal sine or Legendre polynomial waveforms. This system generates as its basic signals modified Hermite polynomials which form an orthonormal basis. . . .

Related Publications:

CORRELATION PROPERTIES OF CYCLIC SEQUENCES
R. C. Titsworth, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, JPL-TR-32-388, July 1, 1963, 88 p., 76 refs., N63-23043.

. . . In the unconstrained channel with additive Gaussian noise, where the optimum detector is based on correlation or matched filters, the quality of a code can be expressed as a function of the correlation values between code words. Methods are presented for determining cyclic sequences with given correlation properties. When the amount of equipment in the receiver is limited, matched filtering is no longer the optimal detection scheme. A better system is one which by the use of a Boolean Function, combines several "component" sequences to generate the transmitted signal; the receiver consists of filters matched to each component . . .

2.543: Power Division Multiplexing

Included: Orthogonal signals in power division systems; Reception of weaker signals in co-channel FM reception; Amplitude discrimination for power division reception.

Not Included: FM discriminator problems; Receiver threshold in FM reception; Capture of weaker signal in FM reception.

Cross References: Detection theory (Div. 2.8); Decision theory (Sect. 2.85); Power control link feedback systems (2.952); Dynamics problem in RADAS systems (2.640).

Principal Publications:

NEW DEVELOPMENT IN FM RECEPTION AND THEIR APPLICATION TO THE REALIZATION OF A SYSTEM OF "POWER-DIVISION" MULTIPLEXING
E. J. Baghdady, IRE Trans. Commun. Systems, vol. CS-7, no. 3, Sept. 1959, p. 147/161.

Two techniques—feedforward across a limiter and dynamic trapping—are described to show how the message carried by the weaker of two cochannel FM signals can be extracted with negligible distortion even when its amplitude is much smaller than that of the stronger signal. . . . The development of these new simple techniques . . . opens up many interesting

possibilities. . . . Multiplexing by "power division" and amplitude discrimination becomes practicable. . . . the use of three or more carriers is feasible under appropriate conditions. . . . of particular interest in telemetry, in which separation of frequency-division multiplexed FM subcarriers can be greatly facilitated by judicious use of feedforward technique. . . .

TRANSMISSION OF INFORMATION BY MEANS OF ORTHOGONAL SIGNALS
I. M. Teplyakov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no 4, April 1963, p. 1/5.

. . . We shall consider the transmission of quantized functions, the spectrum of which is contained within the band from zero to a frequency W_0. The interval T_0 between two adjacent samples of a function will then be determined by W_0, i. e., $T_0 = 1/2\ W_0$. All quantization levels will be assumed equiprobable, their number being denoted by L. . . . It is well known that if no delay is introduced either in transmission or reception, the L possible quantization levels must be transmitted by means of a system of L/2 equiprobable orthogonal signals and their opposite signals.

. . . Such a system of signals will be termed optimum. . . . A reduction of the required signal power can be obtained by introducing delays in the transmission and reception of information in the following manner. Two function samples will be combined into one sample having L^2 quantization levels. At the same time an additional delay of value T_0 will be required in transmission. . . .

2.544: Intercarrier Systems

Included: Multiplexing of video and sound in television.

Not Included: Television technology.

Cross References: Stereophonic multiplex systems (2.546).

Principal Publications:

SEPARATE SOUND DETECTION SYSTEMS IN TV RECEIVERS
T. A. Pascoe, Proc. Instn. Radio Engrs. Australia, vol. 24, no. 11, Nov. 1963, p. 808/819.

. . . describes a relatively new approach to the generation of intercarrier sound IF signals at 5.5 Mc/s in black and white television receiver design. It has been conventional practice for the video IF detector to perform this function, resulting in well known compromises in the amplitude-frequency response of the video IF amplifier preceding the detector. . . . A separate sound detector . . . can be preceded by frequency selective circuits which favor the generation of the 5.5 Mc/s intercarrier beat. . . . Several practical methods of approach are described. . . .

Related Publications:

NOISE AND INTERMODULATION PROBLEMS IN MULTICHANNEL CLOSED-CIRCUIT TELEVISION SYSTEMS
C. A. Collins, et al., Commun. and Electronics, vol. 80, no. 57, Nov. 1961, p. 486/491.

In the past decade there has been a rapid growth in communication facilities designed to transmit television (TV) signals relatively short distances over coaxial cables. These systems handle six or more video signals which amplitude-modulate (AM) r-f (radio-frequency) carriers in the 8- to 220- mc (megacycle) range. The associated audio signals frequency-modulate (FM) r-f sound carriers whose rest frequencies are 4.5 mc away from their associated picture carriers. . . . This paper will discuss two problems . . . thermal noise and intermodulation products created by amplifier nonlinearity. . . .

2.545: Parasitic Channels

Included: Order wire facilities; Multiplexing for special service channels; Non-interfering servo and voice transmission systems; Tracking and data multiplex systems; Pilot channels in carrier systems; Pilot waveforms in television systems; Carrier signalling systems over high voltage power transmission systems; Pilot-tone synchronization systems; Emergency warning systems over parasitic channels; SALARM system.

Not Included: PCM transmission techniques; PCM modulation method (1); Synchronization systems in general.

Cross References: Voice and data hybrid time division systems (2.535); Wide band emergency communications (RADAS) (2.640).

Principal Publications:

A SIMULTANEOUS NON-INTERFERING SINGLE CHANNEL SERVO AND VOICE TRANSMISSION SYSTEM
C. A. Crafts, et al., Proc. Nat. Telem. Conf., Sept. 1958, no. 11.1.

COMPARISON OF MODULATION SYSTEMS FOR TELECOMMUNICATION ON POWER SUPPLY NETWORKS (In Italian)
E. Belardinelli, et al., Energia Elett., vol. 37, no. 11, Nov. 1960, p. 1004/1011.

The signal/noise characteristics of various methods of modulation are compared. It is concluded that, for single speech circuit, AM is preferred, with SSB working when more than one channel is required. PCM is best suited to the transmission of metering and control signals.

REMOTE OUTAGE LOCATION BY MEANS OF VERY-HIGH-FREQUENCY RADIO SYSTEMS
M. Cooper, Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 635/639.

. . . services provided by public power utilities . . . Two methods are now used to alert a central operating station to the existence of a failure and its approximate location. Sensors . . . used to generate a signal . . . telephone report of failure . . . The remote alarm system described in this paper uses existing vhf (very-high-frequency) radio networks to alert station personnel rapidly and automatically to system failures and their approximate location. . . .

AN ORDER-WIRE FOR PCM SYSTEMS
R. Gardner, et al., RCA Defense Electronic Products, New York., Final rept., Rept. no. CR-62-419-2, 28 Feb. 1962, 72 p. incl. illus., 3 refs., AD 274 840.

. . . amplitude modulated . . . AN/GRC-50 . . . In an order wire band, 300-2400 c, the signal-to-noise ratio for high RF signal levels was: 33.0 db for full band, normal rate trains, and 28.0 db for full band, double rate (biternary) trains. At an error rate of 10 to the -6th power, a 1.5 db increase in RF signal power is required, to compensate for the effects of 35% AM. . . . operating at a PCM error rate of 10 to the -6th power. Several methods for detecting the AM order wire were tried. The best of these consists in subtracting from the AM-PCM train a delayed replica of the train and then applying half wave envelope detection to both positive and negative envelopes, using the average of the detected voltages for the order wire output. . . .

TRÄGERFREQUENZ-NACHRICHTENÜBERTRAGUNG ÜBER HOCHSPANNUNGSLEITUNGEN, 3. AUFL. (Carrier Frequency Communications Over High Voltage Transmission Lines) (In German)
H. K. Podszeck, Berlin, Springer-Verlag, 1962, 191 p.

FUNDAMENTAL ACCURACY LIMITATIONS FOR PILOT-TONE TIME-BASE CORRECTION
J. A. Develet. Jr., Aerospace Corp., Los Angeles, Calif., Rept. no. TDR269 9990 3, 10 Feb. 1964, 14 p., AD 430 464.

Wiener filtering concepts are applied . . . addition of a stable sinusoid in a clear area of the signal baseband. After transmission through a medium with varying time delay and additive noise, the pilot tone is recovered by a tracking filter, the output of the tracking filter can be used to estimate the variations in time delay of the transmission medium. . . . theory of parameter estimation . . .

PCM TELEMETRY CAPABILITY FOR A PRECISION TRACKING SYSTEM
D. T. Doherty, et al., Proc. Nat. Telem. Conf., May 1963, no. 10-1.

. . . It is desirable to consider the addition of data transmission capabilities to existing links in order to minimize total r-f requirements. A modulation technique for the addition of such a capability to a precision radio tracking system has been successfully employed. . . .

1604 SIMULATION PROGRAM DESCRIPTIONS MILESTONE 11 SIMULATION ALARM MESSAGE DIRECT INPUT ROUTINE (SALARM)
G. A. Madrid, System Development Corp., Santa Monica, Calif., Rept. no. TM734 044 00, 16 Dec. 1963, 6 p., AD 427 324.

. . . SALARM provides a means of inserting alarm messages at specified times during the generation of a simulated data tape for SIMSTN input to the Bird Buffer . . .

PILOT WAVEFORM INSERTION IN TELEVISION SIGNALS
J. B. Potter, Proc. Instn. Radio Engrs. Australia, vol. 24, no. 9, Sept. 1963, p. 685/690.

The provision of pilot-type monitoring and control facilities in television systems by the use of continuous test signal insertion in television signals is discussed with regard to the benefit to be obtained, the equipment required and the possibility of future extensions to the presently available facilities. Recommendations as to the test waveforms to be used and their application in television systems are also made. . . . in the installation of any point-to-point communication system . . . equipment to provide continuous monitoring of system performance in the presence of traffic. . . .

Related Publications:

IMPROVED MULTIPLEX VOICE FREQUENCY CARRIER SYSTEMS USING NEW AUDIO FILTERS
B. Tennent, IRE Trans. Commun. Syst., vol. CS-8, no. 4, Dec. 1960, p. 258/262.

ADAPTIVE COMMUNICATION WITH SOUNDING SIGNALS IN RANDOM CHANNELS
C. K. Rushforth, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 102/106.

. . . describes a communication system which utilizes a sequence of reference or sounding signals to adapt itself to a random linear channel. A particular set of signals is considered, each of which is partitioned into a reference or sounding signal and a message signal . . .

2.546: Stereophonic Multiplex Systems

Included: FM stereophonic multiplex broadcasting; Compatible stereophonic systems; Pulse time multiplex systems for stereophonic broadcasting.

Not Included: Radio broadcasting in general; Phase quadrature transmission systems.

Cross References: Source statistics of music (2.318).

Principal Publications:

TRACING DISTORTION IN STEREOPHONIC DISC RECORDING
M. S. Corrington, et al., RCA Rev., vol. 19, no. 2, June 1958, p. 216/231.

A COMPATIBLE STEREOPHONIC SYSTEM FOR THE AM BROADCAST BAND
J. Avins, et al., RCA Rev., vol. 21, no. 3, Sept. 1960, p. 299/359.

TECHNICAL REQUIREMENTS FOR FM STEREOPHONIC MULTIPLEX BROADCASTING
R. J. Farber, et al., IRE Wescon Conv. Rec., vol 7, Aug. 1960, p. 36/39.

FM STEREO MULTIPLEXING
N. H. Crowhurst, New York, John F. Rider, Inc., 1961, 72 p.

UBERSICHT UBER DIE WICHTIGSTEN VORSCHLÄGE, STEREOPHONIE UBER RUNDFUNK ZU UBERTRAGEN (Survey of Important Methods to Transmit Stereophonic Signals Over Broadcast Transmitters) (In German)
K. Wilhelm, Nachrichtentech. Z., vol. 14, no. 3, March 1961, p. 129/141.

THEORETICAL PLANS FOR THE DISTRIBUTION OF FREQUENCIES IN BAND II IN THE TRANSMITTER NETWORK GROUPED IN TRANSMISSION CENTRES WITH ITS APPLICATION TO STEREOPHONY (In French)
J. Arnaud, Onde Electr. Sp. Issue on Stereo Sound, vol. 42, no. 420, March 1962, p. 208/218.

A PULSE TIME MULTIPLEX SYSTEM FOR STEREOPHONIC BROADCASTING
G. D. Browne, J. Brit. Instn. Radio Engrs., vol. 23, no. 2, Feb. 1962, p. 129/137.

. . . for v.h.f. broadcasting of stereophonic sound by means of time division multiplex. . . The possibility of adding a third channel is briefly discussed. Encoding, decoding and synchronizing arrangements are shown and results of preliminary measurements are presented. . . .

STEREOPHONY IN ITALY (In French)
G. Castelnuovo, Onde Electr. Sp. Issue on Stereo Sound, vol. 42, no. 420, March 1962, p. 225/232.

SOUND PICK-UP AND LISTENING CONDITIONS IN STEREOPHONY (In French)
L. Chatenay, Onde Electr. Sp. Issue on Stereo Sound, vol. 42, no. 420, March 1962, p. 191/199.

STEREOPHONY AND BROADCASTING (In French)
R. Clouard, Onde Electr. Sp. Issue on Stereo Sound, vol. 42, no. 420, March 1962, p. 187/190.

. . . A new improvement lies in stereophony which is provided to the listener by the use of two channels. This has presented a problem to the chief sound operator. Since 1958 R. T. F. has undertaken some tests in this connection. As a result the process of transmitting two channels by a single transmitter with sub-carrier seems to be the most suitable.

FROM PURE STEREOPHONY TO MONOPHONY (In French)
R. Condamines, Onde Electr. Sp. Issue on Stereo Sound, vol. 42, no. 420, March 1962, p. 200/207.

. . . listening in a real world and in the most general framework of sound surroundings . . . adaptation to different kinds of sound arts, from music to the theatre. . . study of compatibility recognized as being strictly impossible but capable of being replaced by a pseudo-compatibility of a practical kind which, without limiting the advance of stereophony, does make it possible to give satisfaction to the majority of listeners.

A STUDY OF STEREOPHONIC BROADCASTING TECHNIQUES (In French)
A. Keller, Onde Electr. Sp. Issue on Stereo Sound, vol. 42, no. 420, March 1962, p. 219/224.

STEREOPHONIC BROADCASTING IN THE EUROPEAN SETTING (In French)
J. Matras, Onde Electr. Sp. Issue on Stereo Sound, vol. 42, no. 420, March 1962, p. 155/171.

Related Publications:

THE PLACING OF SOUNDS IN SPACE (In French)
R. Condamines, Onde Electr. Sp. Issue on Stereo Sound, vol. 42, no. 420, March 1962, p. 183/186.

. . . particular problem of identification of sound-making objects. Even if these objects occupy a part of physical space (an objective position) their subjective projection occupies a certain position in subjective space which can be called their "subjective position".

PRINCIPLES INVOLVED IN A QUANTITATIVE STUDY OF DIRECTIONAL PERCEPTION IN STEREOPHONY (In French)
H. Mertens, Onde Electr. Sp. Issue on Stereo Sound, vol. 42, no. 420, March 1962, p. 176/182.

STEREOPHONY AND MUSICAL PERCEPTION (In French)
M. P. Philippot, Onde Electr. Sp. Issue on Stereo Sound, vol. 42, no. 420, March 1962, p. 172/175.

. . . Disputes have arisen between true and false stereophony. . . it is desirable to make distinction between aural pleasure and musical perception.

Section 2.57

2.570: Special Engineering Problems for Multiplexing

Included: Multiplex detection and processing; Resampling of multiplex signals; Processing of composite (multiplex) signals; Space-time sampling and filtering; Multiple signal detection; Frequency stabilization methods in multiplex systems; Channel dropping problems in multiplex systems.

Not Included: Frequency synthesizers; Multiplex equipment.

Cross References: Spatial filters (2.814).

Principal Publications:

SPACE-TIME SAMPLING AND FILTERING
W. D. Montgomery, et al., General Dynamics/Convair, San Diego, Calif., Semi-annual tech. documentary, (Rept. ZR-AP-061-16), May 1961 66 p., AD 262 649.

. . . enhancing the detection of a missile launch as seen from a satellite. . . three important spatial filters are developed, having two-dimensional outputs. The first filter is a linear one. . . a general statistical one, has considerable discrimination ability but needs a large amount of statistical information of the background. The third filter, developed along the lines of decision theory, turns out to be remarkably similar to the general one. For each filter the application to multiple wave lengths as well as to point source and nonpoint source targets is considered.

SATELLITE COMMUNICATION SYSTEM PROVIDING CHANNEL DROPPING
E. K. Sandeman, Paper delivered at British Interplanetary Society Symposium on Communication Satellites, May 6, 1961, British Aircraft Corp., London, 1961, 39 p., AD 262 637.

. . . The satellite. . . behaves like a telephone exchange: all that is necessary for two ground stations to get into communication is for each of the ground radio receiving stations to tune into one of the communication bands assigned to the radio transmitter of the other ground station. The feature afforded in this way is sometimes referred to as channel dropping.

ON THE STATISTICAL DETECTION PROBLEM FOR MULTIPLE SIGNALS
J. B. Thomas, et al., Rome Air Development Center, Griffiss Air Force Base, N. Y., (Rept. no. RADC TN 61-182), Nov. 1961, 16 p., AD 268 753.

The problem of detecting signals in noise is considered for the multiple input model, where each of the inputs can contain one of many possible signals. The detection procedure for this model becomes, in general, the testing of multiple hypotheses. Two detection criteria are examined for choosing among multiple hypotheses and it is found that, for both criteria, the decision is based on the likelihood functions for the various signals. Systems for computing likelihood ratios are examined in detail for the multiple input case. A multidimensional matched filter is considered and its relationship to the likelihood ratios is shown. Optimum signals are determined for the two-hypothesis problem.

FREQUENCY-GENERATING EQUIPMENT FOR THE TRANSOCEANIC LINE-SIGNALLING SYSTEM
J. H. Gee, Post Off. Elect. Engrs. J., vol. 56, no. 2, July 1963, p. 119/121.

. . . motor alternators whose speed is controlled so that the frequencies produced are accurate to within ± 5 c/s. The speed-control and frequency-deviation-detector equipments associated with the motor alternators are described. . . .

Related Publications:

ANALYSIS OF MULTIPLE TONE CLIPPING
C. J. Styers, IRE Internat. Conv. Rec., vol. 8, March 1961, p. 134/149.

. . . study of the consequences of clipping in a multiple-tone system. . . Mathematical expressions furnish the exact number of jth order; intermodulation terms; including the number of signal terms, in-phase noise terms, and randomly-phased noise terms.
From these expressions is obtained a net peak-signal to rms-noise voltage ratio as a function of the clipping level. The effect of clipping upon the binary error rate is investigated.

DEMULTIPLEXER-MULTIPLEXER TD-( )/GSC
Electro-Mechanical Research Inc., Sarasota, Fla., (RADC TN61-90), Technical note, 1 June 1961, lv. incl. illus., AD 258 729.

. . . development of a three-channel speech-processing equipment capable of transmitting and receiving three telephone messages simultaneously. . . . Accomplished through speech reiteration principles. . . . Circuit design and testing of the basic system concept. Results show that the concept is valid, that there are excellent possibilities for further improvement, and that other applications for the basic concept need investigation.

THE STABILITY OF A FREQUENCY REMOTE CONTROL SYSTEM IN THE PRESENCE OF PULSE NOISE
Y. I. Chugin, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 10 May 1962, 33 p., incl. illus., (Trans. no. FTD-TT-62-636 from Avtomatika i Telemekhanika, 23:2, p. 222/241, 1962), AD 286 132.

The stability of a frequency remote control system under the action pulse noise with a known law of amplitude distribution is determined. The influence of the structure and parameters of a receiver upon its noise stability is investigated. A method is examined for calculating the noise stability of codes with series and parallel transmission of subcarriers. . . .

A P. C. M. LOGARITHMIC ENCODER FOR A MULTI-CHANNEL T. D. M. SYSTEM
J. C. Davis, Proc. Instn. Elect. Engrs. (Pt. B), vol. 109, no. 48, Nov. 1962, p. 481/483.

A digitally controlled logarithmically-varying current source is described which is suitable for incorporation in a p.c.m. feedback encoder and decoder working at 1.6 megabits/sec and transmitting telephone-quality speech. . . . P.C.M. systems for the transmission of speech often use some form of linear encoder and decoder with a separate compandor. Instantaneous compandors have been described for use in multi-channel systems where they form part of the equipment common to a number of channels. . . . In the development of practical and rugged p.c.m. systems there are advantages in using a coding system which has an inherent non-linear characteristic and thus needs no separate compandor. . . .

ASYNCHRONOUS PULSE-CODE MODULATION
J. D. Howells, Electronics, vol. 35, no. 42, Oct. 1962, p. 58/60.

When clocks at receiver and transmitter are not synchronized samples of a speech waveform may be lost. The system described fills the gaps with a work sample generated at the receiver. The only apparent effect is a barely audible click at the output.

NOISE-LOADING TEST OF A COMPLETE FREQUENCY-DIVISION MULTIPLEX VOICE POINT-TO-POINT COMMUNICATION SYSTEM
L. P. Yeh, Commun. and Electronics, vol. 81, no. 59, March 1962, p. 40/43.

DIVISION 2.6
MULTIPLEXING OF FACILITIES

This division deals with several methods of multiple usage of communications facilities. Most of these methods will be of some importance to space communications as indicated below.

Section 2.62 contains references on diversity methods in communications links. These methods include the separate reception of one and the same transmission wave at different locations and the optimum methods of combining such "space diversity signals" (2.622). They also include the duplicate transmission of the same information over two or more parallel channels and the optimum methods of combining the signals in such a method known as frequency diversity transmission (2.623). Further diversity methods are used in the form of time diversity (2.624), polarization diversity (2.625) and others. Polarization diversity and, to some extent, space diversity are already of importance in space communications systems. Their applications will increase and other diversity methods will win interest in the future.

Section 2.63 is concerned with certain aspects of cascaded facilities with typical application in radio relay links, where signals must pass many relay stations (amplifiers) in tandem before they reach their destination. There are many conceivable applications of cascaded links in space communications. Already in operation are cascades of two links, an up-link and a down-link, in highly accurate deep space ranging and communications systems (see volume 4C). Future applications may include multi-hop cascades of radio relay links or optical links on the surface of the Moon or on planets. Communications to other star systems may involve cascades from Earth to Moon to outer planets and further on to other stars.

Section 2.64 incorporates references to a new class of multiplex systems, where many subscribers share the same transmission medium in a random manner, with each subscriber having instantaneous access to the medium, unless a priority scheme or an overload situation prevents such access. One principal advantage of these systems is the elimination of a switching center or a master (control) station, though the latter can still be applied as a sort of emergency control in the event that the random operation of the system should reach a breakdown point. One group of implementations of such a system has attained publicity under a variety of names, such as RADAS (random access and discrete address system), RADA, RADACS (C = communications), RACEP (Random Access and Correlation for Extended Performance) and others. More, similar systems are conceivable; their applications in space communications are primarily in the area of communications satellites (see volume 4A).

Section 2.60

2.600: Introduction to Multiplexing of Facilities

Included: Channel dropping satellite facilities; Message switching operations in general; Computer controlled communications; Time separated integrated communications; Simultaneous access to communications satellites; Connectivity of survivable radio networks; Computer based communications control.

Not Included: Message switching processors (3A); Communications satellites design (4A); Switching centers; Digital communications control computers (3A).

Cross References: Time division multiplex systems (Sect. 2.53); Random access multiplexing systems (2.640).

Principal Publications:

RESEARCH MODEL FOR TIME-SEPARATION INTEGRATED COMMUNICATION
H. E. Vaughan, Bell Syst. Tech. J., vol. 38, no. 4, July 1959, p. 909/932.

. . . important step toward an all-digital telecommunication plant . . . ESSEX (Experimental Solid State Exchange) . . . combines remote line concentration, time-separation switching and PCM transmission.

COMPUTER DIRECTED COMMUNICATIONS
R. F. Filipowsky, Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 251/257.

DESIGN AND APPLICATION OF MESSAGE SWITCHING TO COMMUNICATIONS SYSTEMS
W. B. Groth, Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 183/193.

. . . covers the operation basic to store-and-forward handling of message traffic, and

also describes the functions of message queueing, message interpolation, line preemption, multi-address handling, and language and transmission speed conversions . . . describes the effect of system user requirements on the design and engineering of a switching system . . .

CONCEPT FOR AN INTERCONTINENTAL SATELLITE COMMUNICATIONS SYSTEM
E. A Laport, et al., RCA Rev., vol. 22, no. 3, Sept. 1961, p. 555/566.

. . . provides for simultaneous and continuous access by any desired number of earth stations with full interconnectivity between them . . . uses a single repeater in a stabilized stationary satellite, with standard single-sideband suppressed-carrier telephone channels (width and separation) translated to the microwave region. The various station transmitting channels are interleaved at the satellite input, and their aggregate frequency-modulates the satellite transmitter.

ON SWITCHING PROBLEMS REQUIRING QUEUING THEORY IN COMPUTER-BASED SYSTEMS
M. Eisen, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 299/303.

. . . The data to be processed is entered at . . . terminal sets which are remotely located from the computer. The information is then transmitted over low-speed lines to a terminal exchange where lines from many terminal sets meet. Here high-speed lines transmit the information to the computer where it is processed. The resulting information is sent back to the terminal sets. Such systems have been constructed by IBM for various airlines to keep track of reservations, flight schedules, etc. . . .

CONNECTIVITY OF A BROADCAST STATION NETWORK
C. R. Lindholm, RAND Corp., Santa Monica, Calif., (Research Memo. no. 3441-PR), Dec. 1962, 21 p., incl. illus., tables, 5 refs, AD 293 865.

A redundant network consisting of AM broadcast stations . . . to illustrate commercial communication facilities likely to survive an attack on the USZI. Results of the analysis are displayed in a series of maps. This type of network appears feasible for transmission of a few teletype channels even under worst noise conditions.

Related Publications:

A REMOTE LINE CONCENTRATOR FOR A TIME-SEPARATION SWITCHING EXPERIMENT
D. B. James, et al., Bell Syst. Tech. J., vol. 39, no. 1, Jan. 1960, p. 31/57.

Remote line concentration, time-separation switching and PCM transmission are combined in a communication system experiment called ESSEX (Experimental Solid State Exchange).

EVALUATION OF CONTROL MONITOR AN/GGS-11 PROTOTYPE
R. S. Menchel, Air Force Cambridge Research Labs., Bedford, Mass., Aug. 1961, 51 p., AD 269 406.

. . . The AN/GGA-1 provides a means for a station to subscribe to receive only desired information from traffic passing on a high-speed party line type of communications network. The Control Monitor is also capable of activating one of six transmitters to transmit information upon request from a Master Control Station. . . .

SATELLITE COMMUNICATION SYSTEM PROVIDING CHANNEL DROPPING
E. K. Sandeman, Paper delivered at British Interplanetary Society Symposium on Communication Satellites, May 6, 1961, British Aircraft Corp., London, 1961, 39 p., AD 262 637.

. . . The satellite . . . behaves like a telephone exchange: all that is necessary for two ground stations to get into communication is for each of the ground radio receiving stations to tune into one of the communication bands assigned to the radio transmitter of the other ground station. The feature afforded in this way is sometimes referred to as channel dropping.

ELECTRONIC SWITCHING FOR COMMUNICATIONS SYSTEMS
P. O. Dahlman, IBM Federal Systems Div., Bethesda, Md., Final rept., Jan. - Dec. 1962, (Rept. no. TR-023-027), (RADC-TDR-63-47), 26 March 1963, lv., AD 299 220.

RESEARCH ON MAGNETIC ROD STORAGE AND CONTROL UNITS FOR A SWITCHING CENTRAL OFFICE
D. Rork, et al., National Cash Register Co., Hawthorne, Calif., Final progress rept., (Rept. no. 4), 15 April 1961 - 30 Sept. 1962, 30 Sept. 1962, 134 p. incl. illus., tables, AD 289 096.

The system has two basic units: a central exchange and one or more remote line concentrators. . . . Each remote concentrator is capable of handling 60 subscriber lines with a maximum load of 15 subscribers at the same time. Communication between the remote concentrators and the central exchange is handled by a time-multiplex system consisting of 16 channels . . . The switching central, normally provides service for 240 subscribers. . . .

Section 2.61

2.610: Signalling and Addressing Schemes

Included: Trunk carrier system signalling; Multi-frequency code signalling; Megacoder; BASIC = battle area surveillance integrated communications; Signalling for transoceanic telephone cables; Touch-tone calling system; Reed selector calling system; Digicall system; Digital selective communications (DISCOM); Guarded tone signalling; Tone ringing; Push button calling; Selective calling systems; Digit simulating speech sounds.

Not Included: Automatic telephone signalling; Switching centers.

Cross References: Signalling and address codes (2.181); Directory codes (2.181); TASI system of time sharing transoceanic cables (2.534); Speech synthesis (2.370).

Principal Publications:

TONE RINGING AND PUSHBUTTON CALLING
L. A. Meacham, et al., Bell Syst. Tech. J., vol. 37, no. 2, March 1958, p. 339/360.

. . . takes advantage of new electronic devices such as the silicon junction diode, the transistor and the ferrite coil. . . . employ signals within the telephone speech band.

THE ADVANTAGES OF DIGITAL TECHNIQUES FOR COMMUNICATIONS IN THE SPACE AGE
J. Cohn, Proc. Nat. Aeron. Electronics Conf., vol. 7, May 1959, p. 129.

. . . a simple data link, the Motorola DIGICALL System, is described. . . .

THE MEGACODER–A HIGH-SPEED, LARGE-CAPACITY MICROMINIATURE DECODER
H. Kihn, et al., RCA Rev. vol. 20, no. 1, March 1959, p. 153/179.

A SIMPLE SELECTIVE CALLING SYSTEM
A. I. Perlin, East Coast Conf. Aerosp. Navig. Electronics, vol. 6, Oct. 1959,

. . . light weight, small size and low cost . . . operates in the 300-3000 cps audio passband at S/N ratios of better than -6 db . . . permits an operator to select and contact any station, of a total possible 100,000, without the other operators experiencing any type of interference; in fact, the other operators are completely unaware of the contact being made . . . air traffic control expediting; remote control links for airborne equipment; basic data links; etc. . . .

SIGNALING SYSTEMS FOR CONTROL OF TELEPHONE SWITCHING
C. Breen, et al., Bell Syst. Tech. J., vol. 39, no. 6, Nov. 1960, p. 1381/1444.

Telephone signaling is basically a matter of transferring information between machines, and between humans and machines. . . . history of . . . systems used between central offices of the nationwide telephone network . . . influence on such systems of the characteristics of switching systems and their information requirements, the transmission media and the compatibility problem. . . . some of the . . . systems presently in use. . . . problem of signaling between Bell System and overseas telephone systems . . . new transmission media. . . . some speculation is made on the future trends of telephone signaling systems. . . .

DIGITAL SELECTIVE COMMUNICATIONS
G. A. Kious, Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 66/70.

. . . DISCOM refers to digital selective communications equipment . . . Selective addressing and control equipment provides for selecting any four letter call, giving a capability of over 456,000 differing possibilities . . .

PUSHBUTTON CALLING WITH A TWO-GROUP VOICE-FREQUENCY CODE
L. Schenker, Bell Syst. Tech. J., vol. 39, no. 1, Jan. 1960, p. 235/255.

DIGITAL BATTLEFIELD COMMUNICATIONS
W. C. Slagle, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 4, June 1960, p. 289/293.

BASIC is digital communications equipment developed by Stromberg-Carlson–San Diego for the United States Marine Corps. The name BASIC stands for Battle Area Surveillance and Integrated Communications. . . . an electronic display on a CHARACTRON Shaped Beam Tube served as the output device. . . . The transmitted message contains 22 characters. . . . thumb-operated information switches . . . have 10 positions each, are marked for an intelligence application. . . . 10 digits of position information . . .

GUARDED TONE SIGNALLING
W. B. Smith, Jr., IRE WESCON Conv. Rec., vol. 7, Aug. 1960, p. 117/123.

A method of audio frequency tone signalling which utilizes the maximum number of combinations of a given number of tone channels is described. . . . include selective party-line telephone ringing, and aircraft selective call.

A MINIATURE TUNED REED SELECTOR OF HIGH SENSITIVITY AND STABILITY
L. G. Bostwick, IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 21/27.

. . . describes a selective contacting device that is responsive only to sustained frequencies in a discrete narrow band and is insensitive to speech and noise interference. . . . of small size suitable for use in a pocket carrier radio receiver . . . sufficiently stable to permit 33 discrete resonant frequencies . . . has a threshold sensitivity of about 35 microwatts. . . .

DIGITAL SELECTIVE COMMUNICATIONS
G. A. Kious, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 85/90.

Digital techniques promise to be a major factor in future aerospace communications systems. . . . Selective addressing means that those not concerned with a message are not bothered by it . . . This paper describes terminal equipment developed for test and evaluation by the Air Force. The AN/URA-22 Control Monitor equipment provides for transmission of up to 456,976 different four-letter selective addresses, and recognition of individual, group and general calls, each of which can be any preassigned four-letter call. Remote switching is provided through the use of two mode characters, giving up to 676 possible combinations. The Fieldata code is used. Mode characters and addressor call are displayed at the receive end. The AN/URA-29 Digital Data equipment adds message capability, using both words and alpha-numeric characters to provide three word messages, followed by up to 48 alpha-numeric characters in three lines of 16 characters each. . . . The composed message is retained in storage until cleared. . . . The name DISCOM (DIgital Selective COMmunications) has been given to terminal equipment . . .

RECEIVER OF SELECTIVE CALL SIGNALS
Z. Krajewski, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 25 July 1962, 10 p., incl. illus., (Trans. no. FTD-TT-62-460 from Przeglad Telekomunikacyjny, No. 8, pp. 246/249, 1961), AD 284 096.

This article offers a general characteristic of installations serving for selective calling as well as the advantages of applying selective calling in star-shaped lines. . . . The cooperation with radio communications installations is discussed.

THE 81-A EXCHANGE TRUNK CARRIER SYSTEM—SIGNALING
E. F. Tuck, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 610/617.

APPLICATION OF TOUCH-TONE CALLING IN THE BELL SYSTEM
M. L. Benson, et al., IEEE Trans. Commun. Electronics, no. 65, March 1963, p. 1/5.

SPECTRAL CHARACTERISTICS OF DIGIT-SIMULATING SPEECH SOUNDS
D. P. Borenstein, Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2839/2847.

A spectral analysis has been performed on a number of spoken vowel sounds, in particular those sounds causing digit registration in a TOUCH-TONE receiver. The analysis, implemented by computer methods, provides a definitive picture of the nature of digit simulation in TOUCH-TONE calling.

SPECTRAL ANALYSIS TECHNIQUES APPLIED TO AN IN-BAND SIGNALING PROBLEM
G. H. Grenier, IEEE Paper no. 63-435, Feb. 1963, 25 p.

INTERREGISTER MULTIFREQUENCY-CODE SIGNALLING FOR TELEPHONE SWITCHING IN EUROPE
M. D. Hertog, Elect. Commun., vol. 38, no. 1, 1963, p. 130/164.

Important developments in the technique of signalling used in telephone switching have taken place during the past few years in Europe and will have a far-reaching effect on the basic principles underlying switching methods as well as on the operating facilities that will be provided for both national networks and for international connections in Europe . . . agreement . . . has now been reached. . . . description of these developments . . . is thought to be timely . . . Appendix with terminology. . . .

AUTOMATIC CALLING AND COMPUTER SYSTEMS
H. C. Kuntzleman, IEEE Paper no. 63-483, Feb. 1963, 6 p.

LINE AND REGISTER SIGNALLING SYSTEMS FOR DIALLING OVER TRANSOCEANIC TELEPHONE CABLES
S. Welch, Post Off. Elect. Engrs. J., vol. 56, no. 2, July 1963, p. 111/118.

Line and register signalling systems have been developed for dialling over transoceanic cables. The systems are compatible with T. A. S. I. equipment and with both 3 kc/s-spaced and 4 kc/s-spaced circuits. This article describes the circuit principles of both signalling systems. . . .

Related Publications:

VOICE IMMUNITY OF TONE OPERATED SWITCHING CENTERS
J. H. Guenther, et al., Commun. and Electronics, vol. 79, no. 51, Nov. 1960, p. 553/557.

Tone operation of electronic switching centers is the natural outgrowth of 4-wire operation of communication systems using a radio link. . . . to determine what part of the spectrum should be utilized for the control tones. . . . The system here described was . . . for the Army field switchboard. . . . specifications . . .

THE NEW NATION-WIDE TELEPHONE NUMBERING PLAN
O. Myers, Commun. and Electronics, vol. 79, no. 52, Jan. 1961, p. 673/675.

The present nation-wide telephone numbering plan, adopted in 1947, was expected to last beyond the year 2000, but now it appears that it will be outgrown by about 1975. The telephone industry in the United States and Canada has, therefore, adopted a new plan with several times the code capacity of present one which should last well into the next century.

The new plan, shown in Table I, provides uniform dialing procedures for all types of central offices. . . .

A COMMON DIRECTORY CODE FOR DIGITAL AND ANALOG NETWORKS
W. B. Martin, IEEE Trans. Commun. Electronics, no. 68, Sept. 1963, p. 483/484.

. . . Free flow of traffic from Telegraphic Message Systems into and out of the switched voice network is now blocked by the lack of common directory codes and methods for direct easy translation from the message traffic codes (Baudot, Fieldata, etc.) into switching instructions for use by the line switching gear. This block may be removed by the choice of message directing codes usable by both systems . . .

Section 2.62
Diversity Operations

2.620: Diversity Methods in General

Included: Redundant carrier transmissions; Correlation radiometers; IF correlation; Video frequency correlation; IF switching method of diversity combining; Automatic phase correction in diversity reception; Base-band diversity combining; Tests of diversity improvement on actual links.

Not Included: Phase equalization in communications channels (1).

Cross References: Multiplex transmission methods (Div. 2.5).

Principal Publications:

DIVERSITY RECEPTION IN UHF LONG RANGE COMMUNICATIONS
C. L. Mack, Proc. IRE, vol. 43, Oct. 1955, p. 1281/1289.

ON DIVERSITY-RECEPTION THEORY FOR ULTRA-SHORT WAVES PROPAGATED OVER LARGE DISTANCES BY MEANS OF THE TROPOSPHERE
A. V. Prosin, et al., Radio Engng., vol. 14, no. 5, 1959, p. 31/44.

The correlation of received signals for both space & frequency diversity reception is studied, using the theory of radio-wave scattering by anisotropic turbulence, as a function of the parameters of a long-distance forward-scattering ultra-short wave system & the parameters of the propagating medium. . . .

TELEMETRY DIVERSITY RECEPTION TECHNIQUES
V. A. Ratner, Nat. Symp. Space Electronics Telem., Sept. 1959, no. 3.5.

EVALUATION OF INTERMEDIATE-FREQUENCY AND BASEBAND DIVERSITY COMBINING RECEIVERS
R. T. Adams, et al., Elect. Commun., vol. 36, no. 2, May 1960, p. 123/131.

DIVERSITY RECEPTION FOR METEORIC COMMUNICATIONS
A. W. Ladd, IRE Trans. Commun. Syst., vol. CS-9, no. 2, June 1961, p. 145/148.

A METHOD OF I. F. SWITCHING FOR A MICROWAVE DIVERSITY SYSTEM
D. R. Bester, J. Brit. Instn. Radio Engrs., vol. 24, no. 2, Aug. 1962, p. 171/179.

. . . deals with the various factors involved when considering the use of diversity on a microwave radio link. . . . An i.f. switching circuit designed for use on such systems is described which uses high speed diode switches working at the i.f. of 70 Mc/s. The switch control circuits are partially transistorized. . . .

DIVERSITY RECEPTION AND AUTOMATIC PHASE CORRECTION
L. Lewin, Proc. Instn. Elect. Engrs., (Pt. B), vol. 109, no. 46, July 1962, p. 295/304.

DESIGN OF RELIABLE LONG-DISTANCE AIR-TO-GROUND COMMUNICATIONS SYSTEMS INTENDED FOR OPERATION UNDER SEVERE MULTIPATH PROPAGATION DISTURBANCES
K. W. Otten, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 67/78.

. . . methods to counteract the effects of multipath distortion in connection with the proper special demodulation and diversity reception techniques. . . .

TRANSMISSION-LOSS MEASUREMENTS AND DIVERSITY TESTS MADE ON TWO KNIFE-EDGE DIFFRACTION PATHS IN EUROPE
R. E. Gray, Elect. Commun., vol. 38, no. 4, 1963, p. 457/464.

. . . tests were made on two knife-edge diffraction paths having a common receiving terminal near Genoa in northern Italy. . . . Diversity tests, using receiving antennas spaced 47 feet. . . horizontally and 10 feet . . . vertically, showed that there was little correlation on either path in the received carrier-level variations at the two antennas. . . .

PHASE AND AMPLITUDE DIVERSITY IN OVER-WATER TRANSMISSIONS AT TWO MICROWAVE FREQUENCIES
H. B. James, et al., National Bureau of Standards, Boulder, Colo., (Rept. no. NBS-7656, 8390-12-83491), 26 Feb. 1963, 66 p., AD 298 908.

Related Publications:

RECEPTION OF SPACE DIVERSITY TRANSMITTERS
J. W. Koch, Wireless World, vol. 65, no. 10, Nov. 1959, p. 512/514.

DEWDROP COMMUNICATION SYSTEM PERFORMANCE
W. G. Donaldson, et al., Elect. Commun., vol. 37, no. 3, 1962, p. 222/229.

Dewdrop is a single-sideband suppressed-carrier quadruple-diversity communication system operating between 350 and 450 megacycles per second and employing tropospheric scatter propagation. . . .

OPTIMUM DETECTION OF A RADAR SIGNAL WHEN SEVERAL RECEIVING CHANNELS ARE USED
V. B. Fedorov, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 9, Sept. 1962, p. 58/66.

A TECHNIQUE FOR IMPROVING THE TRANSMISSION RELIABILITY OF A FADING CHANNEL
S. Kitces, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 154/162.

. . . In a channel where the duration of a fade is much longer than that of a code word, the common low-order error-correcting codes, although easily implemented, do not materially increase transmission reliability.
A technique is proposed which enables one to use simple codes to combat fading by transmitting the individual bits of a code word, not in succession, but separated in time by the length of expected fades. This transforms a channel with a correlated error pattern into one with random errors across the code words. The gaps between the bits of the code word are taken up by bits from other code words arranged in a similar fashion. . . .

2.621: Theory of Diversity Systems

Included: Theory of diversity signal combining; Coherent diversity reception; Non-coherent diversity reception; Square-law combining; Pre-detection diversity combining; Diversity improvement; Piece-wise diversity combining; Linear diversity combining techniques; Fading loss in diversity systems; Diversity locked loop; Multi-dimensional signals.

Not Included: Phaselock loop design.

Cross References: Detection theory (Div. 2.8); Anti-fading reception methods (2.873).

Principal Publications:

EFFECT OF CORRELATION ON COMBINER DIVERSITY
K. S. Packard, Proc. IRE, vol. 46, Jan. 1958, p. 362/363.

MULTIDIMENSIONAL ENVELOPE AND POWER DISTRIBUTIONS WITH EXPONENTIAL CORRELATION; APPLICATIONS TO DIVERSITY
J. N. Pierce, Air Force Cambridge Research Center, Report No. AFCRC TR-58-121, March 1958, 30 p., AD 146 893.

LINEAR DIVERSITY COMBINING TECHNIQUES
D. G. Brennan, Proc. IRE, June 1959, p. 1076/1102, AD 221 266.

FADING LOSS IN DIVERSITY SYSTEMS
M. Brilliant, IRE Trans. Commun. Syst., vol. CS-8, no. 3, Sept. 1960, p. 173/176.

In a communication system using optimum diversity combining, the mean signal-to-noise ratio of the combined signal is the sum of the mean signal-to-noise ratios of the separate signals. However, the effective signal-to-noise ratio of the combined signal is less than this. The ratio of the mean to effective signal-to-noise ratios of the combined signal is called the fading loss.

THEORETICAL LIMITATIONS ON FREQUENCY AND TIME DIVERSITY FOR FADING BINARY TRANSMISSIONS
J. N. Pierce, Air Force Command and Control Dev. Div., Air Res. and Dev. Command, Bedford, Mass., ERD TR 60-169, July 1960, 22 p., AD 245 723.

IDEAL SIGNAL ENHANCEMENT WITH DIVERSITY RECEPTION OF DISCRETE INFORMATION
D. D. Klovskiy, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 3, 1961, p. 21/29.

Criteria are obtained for coherent and non-coherent diversity reception in the presence of fluctuation noise, with a noncorrelated Rayleigh amplitude distribution of signals received in separate branches. . . .

ON OPTIMAL DIVERSITY RECEPTION
G. L. Turin, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 154/166.

. . . The ideal probability-computing M-ary receiver is derived for a fading, noisy, multidiversity channel, in which the link fadings may be mutually correlated, as may the link noises. The results are interpreted in terms of block diagrams involving various filtering operations. Two special cases, those of very fast and very slow fading, are considered in detail.

THEORETICAL LIMITATIONS ON FREQUENCY AND TIME DIVERSITY FOR FADING BINARY TRANSMISSIONS (Correspondence)
IRE Trans. Commun. Syst., vol. CS-9, no. 2, June 1961, p. 186/187.

The purpose of this note is to point out that for either frequency diversity or time diversity, the dependence of required transmitted power on number of branches is quite different than for space diversity. . .

PIECE-WISE DIVERSITY COMBINING
R. T. Adams, et al., IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 156.

By subdividing a broad channel in narrower bands, and subsequently re-assembling the division, predetection diversity combining can be extended to wide-band signals in a multipath environment, where a single phase adjustment is not adequate for proper combining. . . . (Abstract only).

PREDETECTION DIVERSITY COMBINING WITH SELECTIVELY FADING CHANNELS
P. Bello, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 32/42.

. . . some form of instantaneous phase correction must be provided prior to the diversity combining so that proper in-phase addition will result. If the instantaneous fading is not uniform over the width of the channel, the resulting channel incoherence will reduce the efficacy of the phase correction. One way to avoid this difficulty is to divide the selectively fading channel into "flatly" fading subchannels and perform the necessary phasing and combining operations per subchannel. . . . This paper considers this question with reference to FDM-SSB binary data transmission and matched filter reception, wherein a pilot tone is used both for deriving proper phase correction and for providing the weighting necessary for maximal ratio combining. Analytical expressions are derived for error probabilities which show the deleterious effects of frequency selectivity and pilot tone additive noise. . . .

PREDETECTION DIVERSITY COMBINING WITH SELECTIVELY FADING CHANNELS
P. Bello, et al., IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 140/155.

THEORETICAL DIVERSITY IMPROVEMENT IN MULTIPLE FREQUENCY SHIFT KEYING
P. M. Hahn, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 177/184.

SIGNAL POWER IMPROVEMENT THROUGH CODING AND DIVERSITY
J. Mott-Smith, et al., Air Force Cambridge Research Labs., Bedford, Mass., (Rept. no. AFCRL 62-383), June 1962, 37 p., incl. illus., tables, 6 refs., AD 283 349.

ERROR PROBABILITIES FOR ADAPTIVE MULTICHANNEL RECEPTION OF BINARY SIGNALS
R. Price, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 305/316.

. . . two slightly different forms of an adaptive receiver. . . Each channel has a non-dispersive non-fading propagation path and additive white gaussian noise that is independent of and equal in intensity to, the other channel noises. Either phase-independent orthogonal signaling (such as FSK) or phase-reversal-comparison signaling is employed to convey to the receiver both the message and information about the path strengths and phases. The receiver measures the path parameters and applies the results to the detection processing as though they were perfectly accurate . . . The distribution of the received signaling energy among the channels is immaterial. . . .

ERROR PROBABILITIES FOR ADAPTIVE MULTICHANNEL RECEPTION OF BINARY SIGNALS: ADDENDUM (Correspondence)
R. Price, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 387/389.

Exact results have been given. . . R. Price, "Error probabilities for adaptive multichannel reception of binary signals," IRE Trans. on Information Theory, vol. IT-8, p. 305/316, Sept. 1962. . . . The purpose of the present letter is to take cognizance of a convenient approximation to this error probability that was given some time ago by Sussman in a slightly different context, and to examine its accuracy. . . .

ON OPTIMAL DIVERSITY RECEPTION, II
G. L. Turin, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 22/32.

In a previous paper. . . assumption that the memory of the receiver does not extend beyond the time interval of the signal currently being received. The probability of error for such a receiver is determined herein under the following assumptions: the channel is binary and symmetric; the (Gaussian) noises in the various diversity links are white and independent; and the fadings in the various links are Rayleigh distributed and slow, but not necessarily independent. Detailed curves of this probability of error are given for various orders of diversity in the two cases of independent fadings and "exponentially correlated" fadings.

Since the optimal receiver may be difficult to implement, a more easily implemented "square-law combining" receiver is also considered, and it is shown that for all practical purposes this simpler receiver behaves optimally. Finally the effect of the assumption that the receiver has a short memory is considered by comparing its performance with that of a longer-memory receiver studied by Pierce and Stein. . . .

DIVERSITY COMBINATION OF FADING SIGNALS WITH UNEQUAL MEAN STRENGTHS
B. B. Barrow, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 73/78.

. . . compares several techniques of diversity combination without placing the usual restriction requiring the mean signal-to-noise ratios on the various diversity branches to be equal. The probability distribution of the postcombination SNR is calculated for various cases, and it is shown that the shape of this distribution curve is not greatly affected either by the choice of diversity technique or by reasonable unbalance in the mean SNR's on the various diversity branches. . . . comparison. . . for a number of different types of fading, including Rayleigh fading. . . correlated Rayleigh fading, and certain non-Rayleigh types. . . .

FEHLERWAHRSCHEINLICHKEIT BINARER UBERTRAGUNGEN BEI MEHRFACH-EMPFANG UND BEI FREQUENZSELEK-TIVEM SCHWUND (Error Probability of Binary Transmission Systems Under Selective Fading Conditions Applying Diversity Reception Techniques) (In German)
P. Besslich, Arch. Elekt. Uebertragung, vol. 17, June 1963, p. 271/277.

The error probabilities of binary transmission systems are calculated for Rayleigh fading and optimum diversity reception of n-th order and shown as functions of the error probability with non-diversity reception. Although the error probability of non-coherent transmission methods is reduced more by diversity reception than in the case of coherent methods, the coherent systems remain decidedly superior in diversity reception. . . .

PUISSANCE MOYENNE DE BRUIT DANS LES FAISCEAUX HERTZIENS TRANS-HORIZON A MODULATION DE FREQUENCE (Average Noise Power in Transhorizon Radio Relay Links With FM) (In French)
L. Boithias, et al., Ann. Telecomm., vol. 18, no. 5-6, May/June 1963, p. 88/93.

ON THE CORRELATION RADIOMETER TECHNIQUE
K. Fujimoto, IEEE Trans. Microwave Th. Tech., vol. MTT-12, March 1964, p. 203/212, 24 refs., A64-17234.

Study of the two basic types of correlation radiometers, the intermediate-frequency correlation (IF) type and the video-frequency correlation (ENV) type. The correlation radiometer is a system in which two antenna-receiver systems are employed, the outputs of the two systems being correlated electronically. The SNR's, the minimum detectable temperature sensitivities, the effects of receiver gain and phase fluctuations and the uses of the two types are studied. A comparison. . . with. . . the Dicke-type radiometer is made.

THE DIVERSITY-LOCKED LOOP—A COHERENT COMBINER
C. R. Laughlin, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 3, Sept. 1963, p. 84/92.

. . . development of practical coherent diversity combining systems. Phase-locked loops can convert each received signal of a diversity system to an essentially constant frequency and phase for coherent combination prior to demodulation. . . . systems of this type. . . have a disadvantage in that each of the phase locked loops are controlled by the individually fading signals. . . . This paper describes a multiple-input servosystem in which a primary phase-locked loop is controlled by the combined signal while auxiliary loops within the primary loop assure phase coherence. In this way, the full diversity improvement is realized in both locking and in demodulation and the probability of losing lock is correspondingly decreased. . . .

APPROXIMATE ERROR PROBABILITIES FOR OPTIMAL DIVERSITY COMBINING (Correspondence)
J. N. Pierce, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 352/354.

. . . a problem which frequently arises in studies relating to binary transmissions over Rayleigh fading circuits. . . .

THE STRUCTURE OF EFFICIENT DEMODULATORS FOR MULTIDIMENSIONAL PHASE MODULATED SIGNALS
H. L. Van Trees, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 261/271.

The structure of optimum receivers for multilink diversity reception of analog, nonlinear modulated signals is outlined. . . . the authors treat the AM case in detail and indicate that the equations for the PM case suggest mechanization schemes. . . . a common multiple-carrier modulation scheme PM_n/PM is discussed. . . . show that. . . estimators are essentially optimum for the multilink FM, and FM_n/FM case. . . . concerned with optimum processing schemes for analog modulated signals. . . . consider both real-time and nonreal-time processing. . . .

DIVERSITY RECEPTION OF NONFADING FREQUENCY SHIFT KEYING
J. K. Wolf, Rome Air Development Center, Griffiss AFB, N.Y., (RADC-TDR-63-475, Jan. 1964, 23 p., refs., AD 431 870, N64-17302.

. . . Both a noncoherent receiver system and a coherent receiver system are considered. . . compared for both manmade and natural interference. . .

Related Publications:

THE STATISTICS OF RADAR VIDEO AFTER LINEAR AND NONLINEAR MIXING
P. R. Dax, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 850/859.

. . . In this paper, the statistics of the video after resistance (linear) mixing or diode (peak or trough selection) mixing are derived. . . .

CODED, DIVERSIFIED, RAYLEIGH-FADED BINARY SYMMETRIC THRESHOLD CHANNELS
Research Lab. of Electronics, MIT, Cambridge, (Tech. rept. 384), 4 Dec. 1960, 32 p., AD 264 722.

. . . A qualitative determination of the situation for which it appears feasible to combine null-zone detecting, diversity, and coding is given.

ERROR PROBABILITIES FOR DATA TRANSMISSION OVER FADING RADIO PATHS
B. B. Barrow, SHAPE Air Defense Technical Center, The Hague (Netherlands), (SADTC Technical memo. no. TM-26), Feb. 1962, 148 p., incl. illus., tables, refs., AD 273 846.

. . . Theoretical results. . . . various receiving systems, including some that use diversity reception, are examined. . . .

THE INFLUENCE OF FADING SPECTRUM ON THE BINARY ERROR PROBABILITIES OF INCOHERENT AND DIFFERENTIALLY COHERENT MATCHED FILTER RECEIVERS
P. A. Bello, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 160/168.

DISTRIBUTION OF THE NORMALIZED PERIODOGRAM DETECTOR
R. P. Wishner, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 342/349.

. . . This problem also has applications to a problem in diversity reception.

THE EFFECT OF FREQUENCY SELECTIVE FADING ON THE BINARY ERROR PROBABILITIES OF INCOHERENT AND DIFFERENTIALLY COHERENT MATCHED FILTER RECEIVERS
P. A. Bello, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 170/186.

. . . receivers employing postdetection diversity combining. . . .

CORRELATION DETECTION OF SEISMIC DISTURBANCES
P. W. Cooper, Sylvania Electric Products, Inc., Waltham, Mass., Research rept. no. 374, 27 June 1963, 16 p., AD 427 392.

DOUBLE-RECEPTION DISCRETE DATA OPTIMUM CONTINUOUS SIGNAL RECOVERY
J. C. Hung, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 241/253.

. . . A procedure for the optimum recovery of a continuous signal using two sets of discrete input-data will be developed, and methods for evaluating the mean square-error will be shown. . . .

ASYMPTOTIC PERFORMANCE CHARACTERISTICS FOR MULTI-RECEIVER COMMUNICATIONS THROUGH THE RICIAN MULTI-CHANNEL
W. C. Lindsey, JPL Tech. Rept. 32-440, April 1963, 15 p.

A NOTE ON BAYES DETECTION OF SIGNALS
F. C. Ogg, Jr., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 57/60.

. . . The likelihood function detector for multiple signal classes is extended to include overlapping signal classes which occur in adaptive detection and in detection of stochastic signals. Specification of a multiple-signal detector in terms of its error probabilities is discussed . . .

MINIMUM-ERROR DEMODULATION OF BINARY PCM SIGNALS
E. F. Smith, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 400/409.

. . . determined for binary pcm waveforms with statistical dependence between the data samples. It is assumed that the demodulation decisions are made one-word-at-a-time, but utilizing an arbitrary number, n, of statistically dependent, received noisy words.

For additive, bandlimited white Gaussian noise, a method is developed for simulating with a digital computer the minimum-error demodulation. . . .

2.622: Space Diversity Methods

Included: Radio interferometer channel combiners; Multiple diversity; Triple space diversity methods; Optimum feed configurations for space diversity.

Not Included: Design of diversity combiners.

Cross References: Angle of arrival diversity methods (2.628); Space diversity transmitters (2.628).

Principal Publications:

SPACE-FREQUENCY EQUIVALENCE
W. E. Kock, et al., Proc. IRE, vol. 46, Feb. 1958, p. 499/500.

Correlation systems comprising a pair of widely separated antennas have been suggested for the detection of signals encompassing a wide frequency band.

EXPERIMENTAL INVESTIGATION OF THE LONG RANGE TROPOSPHERIC PROPAGATION OF ULTRA-SHORT WAVES IN DOUBLE RECEPTION CONDITIONS
A. V. Prosin, et al., Radio Engng., vol. 14, no. 10, 1959, p. 1/18.

An account is given of the results of an experiment conducted at a frequency of 3000 Mc/s and over a route 275 km in extent. The signals were received simultaneously by two antennas located in a direction normal to the route.

MULTIPLE DIVERSITY WITH NON-INDEPENDENT FADING
J. N. Pierce, et al., Proc. IRE, vol. 48, no. 1, Jan. 1960, p. 89/104.

OPTIMUM FEED CONFIGURATION
Cornell U. School of Electrical Eng., Ithaca, N. Y., Final rept., (Research rept. no. EE 464) (RADC TR 61-23), 31 Dec. 1960, 17 p., AD 251 725.

Diversity improvement is discussed as a function of the number of feeds, assuming idealized antenna beam patterns and no correlation between channels. An experiment is described in which the cross correlation between scattered signals received on angularly separated beams was measured.

A DIVERSITY COMBINER GIVING TOTAL POWER TRANSFER
J. M. Sidwell, Proc. Instn. Elect. Engrs., (Pt. B), vol. 109, no. 46, July 1962, p. 305/310.

A method is described of combining two or more carrier signals, which may be from a space-diversity aerial system, in such a way that the output power is always the sum of the individual signal powers. This gives the optimum signal/noise ratio under the commonly assumed Rayleigh distributed fading conditions. The control signals are taken from the i.f. amplifier of the main receiver; no extra detecting facilities are therefore required. . . .

AN INVESTIGATION OF SPACE DIVERSITY RADIO DIRECTION FINDING
R. L. Sydnor, Electrical Engineering Research Lab., U. of Illinois, Urbana, (Technical rept. no. 17), 30 April 1962, 150 p., incl. illus., tables, 40 refs., AD 286 032.

. . . Crossed-Adcock type direction finders were used and the separation distance was varied from 1/32 to 1/4 mi. . . .

Related Publications:

RECEPTION OF SPACE DIVERSITY TRANSMITTERS
J. W. Koch, Wireless World, vol. 65, no. 10, Nov. 1959, p. 512/514.

ANOTHER VERSION OF A RADIO INTERFEROMETER CHANNEL COMBINER
M. G. Kaufman, East Coast Conf. Aerospace Navig. Electronics, vol. 9, Oct. 1962, no. 3.2.2.

2.623: Frequency Diversity Methods

Included: Frequency shift keying diversity reception; Double FSK demodulation; Frequency diversity in troposcatter systems; Combined frequency and time diversity systems.

Not Included: FSK data transmission method.

Cross References: Frequency division multiplex methods (Sect. 2.52).

Principal Publications:

FREQUENCY AND TIME DIVERSITY IN SCATTER COMMUNICATION
N. H. Bryant, et al., Cornell U. School Electrical Engng., Feb. 1958, 24 p., AD 148 956.

THEORETICAL DIVERSITY IMPROVEMENT IN FREQUENCY-SHIFT KEYING
J. N. Pierce, Proc. IRE, vol. 46, May 1958, p. 903/910.

Error rate has been found. If signal amplitude and phase are exactly known prior to reception of the signal, coherent combination and detection are optimum; for dual diversity, correlation of the fading on the separate antennas does not give a large loss if the correlation coefficient is moderate.

VEREINFACHTES FREQUENZDIVERSITY-VERFAHREN (Simple Frequency Diversity System) (In German)
H. Volz, Elektronische Rundschau, vol. 12, June 1958, p. 200/202.

NEW FREQUENCY-SHIFT TELEGRAPHY SYSTEM
Wireless World, vol. 64, Feb. 1958, p. 93/94.

Brief account of a system of frequency-diversity reception described in 2278 of 1957 (Allnatt et al.).

AN/FRC-68 ANGLE DIVERSITY COMMUNICATION SYSTEM
I. A. Fantera, et al., Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 61/75.

An experimental system for studying tropospheric scatter communications employing multiple angle diversity is described. . . . in the 7125 to 8500 mc range over a 185 mile path. . . facilities for performing simultaneous comparisons of angle diversity combinations with space or frequency diversity. . . instrumentation for automatically computing and recording various signal statistics. . . Data collected to date. . .

EXPERIMENTS IN FREQUENCY DIVERSITY FOR TROPOSCATTER SYSTEMS
W. S. Patrick, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 217/232.

. . . previously reported work which showed that relatively closely spaced frequencies experience substantially uncorrelated fading when propagated through a

tropospheric scatter mechanism. . . . Experiments have been carried out over other distances with different combinations of frequencies and spacings. For an overall bandwidth of 8 mc, which is a practical limit, the optimum combination seems to be four frequencies spaced 2 mc apart. This combination provides approximately fourth-order diversity. Digital data have been transmitted using Time Shift Keyed (TSK) signals. This system (FSK) in conventional systems, shows a substantial advantage over the simple AM system used previously. . . . a digital "one" is made up of a mark-space pattern, and a digital "zero" is made up of a space-mark pattern. . . .

COMBINED FREQUENCY AND TIME-SHIFT KEYED TRANSMISSION SYSTEMS
F. G. Splitt, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 414/421.

. . . the two possible states of a binary waveform are represented by the order of two pulses which occur on different frequencies, for instance, f_1 and f_2. For example, if the ordered pair (f_1, f_2) represents a Mark, then (f_2, f_1) represents a Space. The power spectrum, as well as the performance of both coherent and noncoherent systems in an interference environment, is investigated. . . . FTSK's dual frequency diversity is shown to provide a substantial antifading capability to both coherent and noncoherent transmissions. Furthermore, it is observed that FTSK offers the potential for: 1) complete rejection of CW and other forms of narrow-band interference, 2) simplified post-detection signal coupling circuits, 3) enhanced performance of digit synchronization circuits and 4) error detection and correction. . . .

DIVERSITY RECEPTION OF NONFADING FREQUENCY SHIFT KEYING
J. K. Wolf, RADC, Griffiss AFB, N. Y., RADC TDR 63 475, Jan. 1964, 23 p., AD 431 870.

. . . Both a noncoherent receiver system and a coherent receiver system are considered. The performance of these systems are compared for both man-made and natural interference.

DOUBLE FREQUENCY-SHIFT KEY DEMODULATION STUDY
Page Communications Engineers, Inc., Washington, D. C., Final rept., 4 April 1962-30 June 1963, Rept. no. PCE R—52 0028A, Aug. 1963, AD 422 929.

. . . detection of received signals in double frequency-shift keying systems is reported. . . earlier. . . a variable decision technique was applied to an experimental DFSK demodulator and, in controlled tests, achieved a substantial reduction in teleprinter errors during frequency selective fading. . . the decision logic was refined and simplified. . . . Actual performance was tested over a 2500-mile radio path in comparison with a conventional DFSK system. In single-diversity operation, the experimental demodulator performed as well as the conventional system in dual diversity. With both systems in single diversity, it appeared to outperform the conventional demodulator by about 40 to 1 in error rate. . .

2.624: Time Diversity Methods

Included: Repetitive transmissions; Retransmission of digital messages; Echoplex technique.

Not Included: Storage devices for time diversity.

Cross References: ARQ operation in practical links (2.926).

Principal Publications:

A PROPOSED TROPOSPHERIC SCATTER COMMUNICATIONS EQUIPMENT CONFIGURATION FOR TIME DIVERSITY RECEPTION
C. F. Huntington, Rome Air Development Center, Griffiss Air Force Base, N. Y., Report no. RADC TN-59-304, Dec. 1959, 18 p., AD 231 258.

. . . Appropriate time delay is introduced at the transmitter terminal to provide signal channels in which the intelligence is incoherent. Signal channels are separated at the receiver terminal by polarization. The introduction of time delay to the received signal channels provides coherence of intelligence for detection and uncorrelation of fast fade which is necessary for effective combining.

COMPUTER SIMULATION OF THE USE OF GROUP CODES WITH RETRANSMISSION ON A GILBERT BURST CHANNEL
W. R. Cowell, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 577/585.

A study of error control by coding was made by Monte-Carlo simulation of a burst-noise channel on an IBM (International Business Machines) 7090. Using short group codes, comparisons were made between correction and detection with retransmission. Also, the effect of interleaving the code words was studied. Error detection with retransmission showed a consistently better performance than error correction and the time division resulting from interleaving was effective in combating burst type error patterns. . . .

A TIME DIVERSITY TECHNIQUE FOR SPEECH TRANSMISSION OVER RAPIDLY FADING CHANNELS (ECHOPLEX)
L. R. Kahn, IRE Internat. Conv. Rec., Pt. 8, vol. 10 March 1962, p. 157/160.

. . . Time diversity systems are not in general use because the methods proposed to date require additional spectrum and much additional equipment. . . . Echoplex is a new time diversity technique that does not require increased spectrum space nor does it require additional antennas, receivers or transmitters. However, in its present form, its use is restricted to the transmission of signals having a high degree of frequency redundancy, such as voice or music. . . .

2.628: Other Diversity Methods

Included: Angle diversity; Angular diversity methods; Phase channel combiners; Polarization diversity; Angle tracking receiver; Multiple angle diversity; Beam tagging diversity; Multi-beam channels; Space diversity transmitters; Transmission at the same frequency with the same information from different locations.

Not Included: Electronically steerable antennas; Theory of polarization propagation effects; Diversity combiners.

Cross References: Space diversity reception (2.622).

Principal Publications:

UNTERSUCHUNGEN ZUM DIVERSITY-EMPFANG NACH DEM ANTENNEN-AUSWAHL-SYSTEM (Investigations of Diversity Reception with the Antenna Selection System) (In German)
R. Heidester, et al., Nachrichtentech. Z., vol. 11, June 1958, p. 315/319.

ANGULAR DIVERSITY RECEPTION AT 2290 MC OVER A 188-MILE PATH
J. H. Chisholm, et al., IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 195/201.

. . . over the 188-mile Round Hill-Crawfords Hill path . . . to determine the feasibility of using angular diversity reception in a tropospheric scatter system. Using a 28-foot reflector, two beams were produced with two separate feed systems. The correlation of the signals received on one of the two beams with that receiver on the other was determined for various spacing of the beams, as well as for the azimuthal position of the antenna. . . .

POLARIZATION CONTROL WITH OPPOSITELY SENSED CIRCULARLY POLARIZED ANTENNAS
S. R. Jones, et al., Proc. Nat. Aeron. Electronics Conf., vol. 7, May 1959, p. 588/595.

RECEPTION OF SPACE DIVERSITY TRANSMITTERS
J. W. Koch, Wireless World, vol. 65, no. 10, Nov. 1959, p. 512/514.

TROPOSPHERIC SCATTER SYSTEM USING ANGLE DIVERSITY
J. H. Vogelman, et al., Proc. IRE, vol. 47, May 1959, p. 688/696.

SHF ANGULAR DIVERSITY STUDY PROGRAM
Philco Corp., Philadelphia, Pa., Final rept., (RADC TR 60-30), Nov. 1959, lv., AD 234 425.

Angular diversity measurements at 7630 Mcps over a 247 effective-mile tropospheric path show that diversity improvements comparable to theoretical ones are available; that elevation squint is superior to azimuth squint for the system tested; and that essentially uncorrelated signals are received by a paraboloidal antenna with twin feedhorns whose beam separation is one beamwidth. . . .

RELIABLE HIGH-FREQUENCY COMMUNICATIONS
R. D. Guhne, et al., Developmental Engrg., Corp., Wash., D. C., Quarterly progress rept. no. 4, 1 Oct.- 31 Dec. 1959, (Rept. no. 20-P-4), Jan. 1960, lv., AD 233 156.

. . . A system of probes promises to provide the desired 5:1 bandwidth for polarization diversity. (See also AD 230 395).

OBSERVATIONS ON ANGLE DIVERSITY (Correspondence)
H. Staras, Proc. IRE, vol. 48, June 1960, p. 1173.

AN APPLICATION OF POLARIZATION DIVERSITY FOR IMPROVEMENT OF TELEMETRY PERFORMANCE
A. G. Williams, et al., Proc. Nat. Telem. Conf., May 1960, p. 353/359.

. . . application . . . to a specific antenna system. The antenna automatically tracks a radiating target in the VHF telemetry band, for all signal levels down to -115 dbm. The antenna system provides seven data output channels from each of the two signal channels. . . . When orthogonal probes are used and combined in an

RF hybrid ring a loss of 3 db is incurred. By separation of the probes and post detection combining, this loss can be regained. . . . The diversity system discussed in this paper was developed in conjunction with a modification on the TLM-18 Automatic Tracking Antenna for the Air Force Missile Test Center under Contract AF 08(606)-2787. The Diversity Combiner is being incorporated into antenna systems which Dynatronics, Inc. is currently developing for the Pacific Missile Range and the Eglin Gulf Test Range.

MULTIPLE ANGLE DIVERSITY
R. A. Johnson, Syracuse U. Research Inst., N. Y., SURI rept. EE752-616F, 28 June 1961, 91 p., AD 261 217.

. . . applying diversity techniques to improve the performance of communication systems . . . calculation of the performance of four models of idealized receivers. . . . the range of parameters is extended in the present work. . . . results are presented for the performance of a diversity system in which the input signal means may be different with or without correlation. . . . analysis of a specific circuit (the Vector Combiner) for combining the several inputs to a diversity system.

USE OF POLARIZATION ANALYSIS AND SYNTHESIS TO IMPROVE COMMUNICATIONS PERFORMANCE
B. J. Lamberty, Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 151/172.

. . . by matching the polarization of the received and transmitted electromagnetic waves in the antennas of the system. This paper describes a method which uses analog techniques to continuously determine the orientation angle of the major axis of the incident wave polarization ellipse and then to align the polarization of a linear antenna at this orientation angle. An experimental model has been constructed and operated successfully at X-band. . . .

RESULTS OF SOME ANGLE DIVERSITY TEST AT 4600 MC
E. J. Mueller, Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 115.

THE CAPACITY OF MULTIBEAM CHANNELS FOR DIVERSITY RECEPTION WITH AUTOMATIC SELECTION
A. S. Nemirovskiy, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 9, 1961, p. 33/38.

. . . The obtained capacity is compared with that of a single-wire channel with constant parameters, and with the capacity of a multibeam channel during nondiversity reception. . . .

A POLARIZATION-DIVERSITY SIMULTANEOUS-LOBING ANGLE-TRACKING RECEIVER
W. B. Renhult, Lincoln Lab., Mass. Inst. of Tech., Lexington, (Rept. no. 42G-0002), 31 Aug. 1961, 49 p., incl. illus., AD 267 532.

. . . operations in the 225-260 mc telemetry band and employing polarization diversity. Its operation is considered primarily in the context of the Mercury range and tracking of the Mercury capsule. Several methods of providing diversity are briefly considered, and ways of implementing the phase shifts required at one polarization for coherent signal addition are discussed. A prototype receiver is briefly described although circuitry which may be somewhat novel is covered in greater detail. . . .

AN/FRC-68 ANGLE DIVERSITY COMMUNICATION SYSTEM
I. A. Fantera, et al., Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 61/75.

An experimental system for studying tropospheric scatter communications employing multiple angle diversity is described. . . . in the 7125 to 8500 mc range over a 185 mile path . . . facilities for performing simultaneous comparisons of angle diversity combinations with space or frequency diversity . . . instrumentation for automatically computing and recording various signal statistics . . . Data collected to date . . .

DESIGN OF A SYSTEM FOR TRACKING LINEARLY POLARIZED SIGNALS
W. F. Gillmore, Jr., JPL Res. Summ., no. 36-14, Feb./March 1962, p. 66/71.

A detection system capable of producing an error signal ϵ dependent upon the angle θ between the plane of polarization of an incoming signal and the plane of polarization of the receiving antenna has been described previously (RS 36-12). It will be shown here how a simple closed-loop system can be constructed using this error signal. The closed loop system has some interesting properties which are considerably different from typical linear systems.

BEAM TAGGING DIVERSITY
R. T. Adams, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 233.

Abstract only . . . Diversity combining is normally regarded as part of the receiving process. If the individual transmitted signals are suitably tagged, however, combining can be performed in the transmission medium. The composite signal is analyzed at the receiver to obtain phase-control information, which is relayed to the transmitting site for controlling the individual signals.

When used to combine a set of transmitted signals in space diversity, beam-tagging yields

an advantage equivalent to the array-gain of the set of transmitting antennas. . . .

RADIO-INTERFEROMETER ANALOG PHASE-CHANNEL COMBINER (MOD II) FOR UN-AMBIGUOUS SPACE ANGLE MEASUREMENTS IN THE NAVY SPACE SURVEILLANCE SYSTEM
M. G. Kaufman, et al., Naval Research Lab., Washington, D. C. Final rept., NRL 5980, 30 Oct. 1963, 62 p., AD 423 924.

An electronic system called the MOD II phase-channel combiner is described, which automatically combines several noise phase channels into one quiet channel, with two additional channels being available for vernier readout. . . . time displacement is detected and transformed into a dc voltage by an analog phase meter for presentation on a recorder, or it is digitalized and fed to a computer.

RADIO INTERFEROMETER PHASE-CHANNEL COMBINER MOD. II FOR THE NAVY SPACE SURVEILLANCE SYSTEM
M. G. Kaufman, Rec. Nat. Space Electronics Symp., 1963, no. 5.4.

. . . With the increasing satellite population the number of fence crossings has increased considerably. Automation in the detection process is needed to facilitate identification and sorting of satellites from each other if a large backlog of data is to be avoided. . . . this report is to describe an electronic system which automatically combines several noisy ambiguous radio interferometer phase channels into one unambiguous quiet channel. . .

A PHASE-LOCKED RECEIVING ARRAY FOR HIGH-FREQUENCY COMMUNICATIONS USE
D. E. Svoboda, IEEE Trans. Antennas Propagation, vol. AP-12, March 1964, p. 207/215, 6 refs, A64-16611.

Discussion of an automatically phased HF receiving array that employs separate RF amplifiers for each element and IF signal combination. The array corrects essentially all phase errors between the distant transmitter and the point where the received signals are combined. The phase errors include those due to the propagation path, array element motion, near-field obstructions, and the instabilities in electronic equipment and RF cables. The array also corrects phase shifts due to changes in angle of arrival, thus giving it the ability to automatically track a desired signal. . . . A six-element experimental array is described with a technique for measuring patterns, and measured array patterns are compared with calculated patterns.

POLARISATIONS-DIVERSITY BEI METEOR-VERBINDUNGEN (Polarization Diversity in Meteoric Radio Communications) (In German)
L. Triskova, Bull. Astron. Inst. Czechoslovakia, vol. 15, no. 2, 1964, p. 67/74, 13 refs., A64-17867.

. . .possibility of increasing the duty cycle in polarization-diversity reception, for meteoric radio communications. . . . The 24-hour variation in the probability of the appearance of a signal at a vertical receiver antenna is defined for a horizontal polarization of the emitting antenna. Measurements indicate a 25% maximum increase in duty cycle.

Related Publications:

WAVEGUIDES OF CIRCULAR CROSS-SECTION FOR RADIO RELAY SYSTEMS
A. A. Metrikin, et al., Radio Engng: Trans. of Radiotekhnika, vol. 15, no. 7, Sept. 1960, p. 13/23.

It is possible to increase the number of simultaneously operating links in radio relay systems by using vertical and horizontal polarization of the field for the signals to be transmitted and received. Using this type of system, the aerials can be used to receive and transmit signals at the same time. . . .

POLARIZATION CONSIDERATIONS FOR A DUAL CHANNEL RECEIVING ELEMENT
E. J. Christopher, et al., Rome Air Development Center, Techniques Lab., Griffiss AFB, N. Y., (RADC-RAL-TM-63-9), June 1963, 20 p., N63-18377.

. . . means of optimumly receiving electromagnetic energy from a wave whose polarization is not necessarily constant or known. The recent increase in ranges covered by radar and communication systems requires consideration of the effects of Faraday rotation on the polarization of the received signal . . .

A PHASE-CHANNEL COMBINER, MOD. I, FOR THE NRL SPACE SURVEILLANCE SYSTEM
M. G. Kaufman, IEEE Trans. Instrumentation Measurement, vol. IM-12, Dec. 1963, p. 106/119, A64-17344.

. . . for the detection of Earth satellites. The system forms a fence consisting of four receiver and three CW transmitter sites across the southern part of the U. S. . . . The CW transmitters illuminate the satellite and radio-interferometer techniques incorporated in the receivers determine the satellite's position in the east-west and north-south planes. An electronic system which automatically combines the phase channels into one unambiguous channel and depicts the angles of arrival of the radio energy from the satellites is described. The results of noise, stability, response time, sensitivity, and life tests of the phase-channel combiner are presented, and several coincidence pulse graphs are included.

Section 2.63

2.630: Cascaded Facilities

Included: Multi-hop communications systems; Cascaded binary links; Multi-section FM microwave systems; Multi-trunk communications systems; Outage intervals in multi-link systems; Tropospheric links in tandem; Regenerative repeaters in multi-hop links; Chains of digital repeaters.

Not Included: Integrated space communications links (4); Unified S-band space communications system (4D); PCM regenerative repeaters (1); Propagation effects in radio relay links (1); Multi-hop hf propagation (1); Channel characteristics of tropospheric scatter systems (1).

Cross References: Link feedback systems (2.920).

Principal Publications:

STATISTIK DER SCHWUNDABHANGIGEN GERAUSCHLEISTUNG FUR BREITBAND-RICHTFUNKVERBINDUNGEN MIT VIELEN FUNKFELDERN (Statistics of the Noise Processes Under Fading Conditions in Wide-band Radio Relay Links With Many Sections) (In German)
W. Hormuth, Entwicklungs-Berichte, vol. 21, Dec. 1958, p. 306/316.

TIMING IN A LONG CHAIN OF REGENERATIVE BINARY REPEATERS
H. E. Rowe, Bell Syst. Tech. J., vol. 37, Nov. 1958, p. 1543/1598.

PROBABILITY DISTRIBUTION OF NOISE DUE TO FADING ON MULTISECTION FM MICROWAVE SYSTEMS
H. E. Curtis, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 161/167.

ERROR PROBABILITY OF CASCADED BINARY COMMUNICATION LINKS PERTURBED BY ADDITIVE GAUSSIAN NOISE AND RAYLEIGH FADING
H. D. Goldman, et al., New York U., Coll. of Engineering, N. Y., (Rept. 6), Sept. 1961, 46 p., AD 269 087.

. . . for the cases of constant and Rayleigh distributed signal levels. An exact expression is derived for over-all error probability for any number of links with constant signal levels. With Rayleigh fading, the cases of independent and completely correlated fading are considered.

AN ANALYSIS OF CASCADED BINARY COMMUNICATION LINKS
H. D. Goldman, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 291/299.

. . . in the presence of additive white Gaussian noise is investigated for the cases of constant and Rayleigh-distributed signal levels. An exact expression is derived for over-all error probability for any number of links with constant signal levels. . . . The use of satellite relays appears to be particularly advantageous for wide-band VHF and UHF global communications. . . . the error probabilities of cascaded links have been found for the following modulation techniques:
1) Coherent phase-shift keying (CPSK)
2) Coherent frequency-shift keying (CFSK)
3) Coherent carrier keying (CCK)
4) Noncoherent frequency-shift keying (NCFSK)
5) Differentially coherent phase-shift keying (DCPSK)
. . .

PERFORMANCE PREDICTIONS FOR SINGLE TROPOSPHERIC COMMUNICATION LINKS AND FOR SEVERAL LINKS ON TANDEM
A. P. Barsis, et al., National Bureau of Standards, Boulder, Colo., NBS-TN-102, Aug. 1961, 161 p., refs., N64-17996.

. . . probability of obtaining a specified grade of service or better for various percentages of time. . . acceptable ratio of hourly median predetection-RMS-signal-to RMS-noise for the type of intelligence to be transmitted. The standard deviation of prediction errors depends upon the percentage of hours the specified grade of service is required. . . The possibility of reducing this standard deviation by making path-loss measurements is discussed. . .

SYSTEMATIC JITTER IN A CHAIN OF DIGITAL REGENERATORS
C. J. Byrne, et al., Bell Syst. Tech. J., vol. 42, no. 6, Nov. 1963, p. 2679/2714.

Digital pattern variations are a major source of timing jitter in self-timed digital regenerators. In a chain of similar regenerators, the same jitter is introduced at each one. Therefore, the jitter accumulates systematically.

A model is introduced to predict the accumulation of jitter in a chain of identical regenerators with single timing filters. . .

Measurements on a chain of 84 regenerators in a field installation are in excellent agreement with the theory.

CALCULATING THE DISTRIBUTION OF TOTAL TRUNKING LOSSES IN A MULTI-TRUNK MILITARY COMMUNICATION SYSTEM
N. W. Feldman, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 177/181.

. . . This paper describes a technique for calculating variations of trunk gain or loss, as a function of probability, in a multi-trunk system that suffers from system tolerances.
Many of the pertinent parameters have significant tolerance figures that undergo random variations. . . . Since the distribution of loop loss has received adequate attention this paper deals exclusively with the distribution of trunk loss. It will be assumed that the nominal per trunk loss is zero and the distribution of the number of trunks per call is gaussian, the maximum number of trunks is 10, and that 50% will be three or less. . . .

INNAGE AND OUTAGE INTERVALS IN TRANSMISSION SYSTEMS COMPOSED OF LINKS
S. O. Rice, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 2267/2283.

This note. . . is concerned with the distribution and average durations of innages and outages occurring in transmission system composed of a number of links. The links of such a composite system may be either in series, as in a radio relay system, or in parallel, as in a many-satellite system. Several results regarding composite transmission systems, including some due to D. S. Palmer, are reviewed, restated, and extended.

NOMOGRAMS FOR THE STATISTICAL SUMMATION OF NOISE IN MULTIHOP COMMUNICATIONS SYSTEMS
B. Sheffield, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 285/288.

Several authors have shown methods for calculating the long-term fluctuation of noise power of multihop systems in which the propagation loss has a log-normal distribution such as in troposcatter FM. . . . shortcomings are remedied by two pairs of nomographs which eliminate the laborious exponential computations and permit the noise performance calculation to be made within seconds. . . .

Related Publications:

STATISTICS OF REGENERATIVE DIGITAL TRANSMISSION
W. R. Bennett, Bell Syst. Tech. J., vol. 37, Nov. 1958, p. 1501/1542.

EFFECT OF A NONIDEAL REGENERATOR SLICING CHARACTERISTIC ON THE ERROR RATE OF A BINARY PULSE TRANSMISSION SYSTEM
V. Keder, IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 308/314.

. . . Numerous theoretical studies have been made of the error rate of a binary pulse transmission system using ideal regenerators . . .

Section 2.64

2.640: Random Multiple Access Systems

Included: Multiplexing with quasi-orthogonal binary functions; RACEP; Wideband emergency communications; Selective calling system with random access; Address communications systems; Non-synchronous communications; Random access discrete address systems (RADAS); Interference in RADAS systems; Multiplexing of intermittent transmitters; Intermittent transmission systems; Traffic efficiencies in medium sharing random access systems; Accordion communication system; Mutually distinguishable quasi PN sequences; Analog pseudo noise multiplex systems; RASA = RACEP adaptive satellite communications; RADA system; Nonbinary PN RADAS systems.

Not Included: Channel characteristics of meteoric scatter systems (1); Channel characteristics of multipath channels (1); Neural nets (3B); Random access satellite communications systems (4A); FT dodging modulation methods (1); Frequency hopping systems (1); Delta pulse modulation (1); PCM (1).

Cross References: Emergency warning systems (2.545); Signalling and addressing schemes (2.610); Signalling and address codes (2.181); Theory of PN sequences of binary elements (2.121); Asynchronous time division multiplex systems (2.533); Time compression methods (2.244); Controlled carrier transmission (2.952); Threshold decision systems (2.853).

Principal Publications:

A SIMPLE SELECTIVE CALLING SYSTEM
A. I. Perlin, East Coast Conf. Aerosp. Navig. Electronics, vol. 6, Oct. 1959, no. 1.2.

. . . light weight, small size and low cost. . . operates in the 300-3000 cps audio passband at S/N ratios of better than -6°db. . . permits an operator to select and contact any station, of a total possible 100,000, without the other operators experiencing any type of interference; in fact, the other operators are completely unaware of the contact being made. . . air traffic control expediting; remote control links for airborne equipment; basic data links; etc. . . .

SYSTEM CONCEPTS FOR ADDRESS COMMUNICATION SYSTEMS
D. H. Hamsher, IRE Wescon Conv. Rec., vol. 7, Aug. 1960, p. 102-106.

. . . a form which we call random access-discrete address. In the literature this is also referred to as non-synchronous or asynchronous communication.

TRAFFIC EFFICIENCIES IN CONGESTED BAND RADIO SYSTEMS (Correspondence)
J. H. Weber, Proc. IRE, vol. 48, Nov. 1960, p. 1910/1911.

In a recent paper. . . Statistical methods were used to show that broad-band techniques are in a certain sense superior to presently used narrow-band methods. It is the purpose of this note to show that a somewhat different point of view will find the narrow-band system always superior.

CHANNEL UTILIZATION BY INTERMITTENT TRANSMITTERS
F. F. Fulton, Jr., Stanford Electronics Labs., Stanford U., Calif., Technical rept. no. 2004-2, 12 May 1961, 91 p., AD 258 998.

. . . The limit of channel utilization is studied by postulating a model of a band-limited, noisy channel that incorporates the feature of random selection of a subset of transmitters to be multiplexed within the bandwidth. It is shown by a random coding argument that sets of waveforms certainly exist that can provide operation without interference for any finite number of transmitters assigned to the channel, provided only that the total information transmitted by any subset of transmitters be appropriate for the signal powers involved.

PARAMETERS OF A NON-SYNCRONOUS, RANDOM ACCESS, DISCRETE ADDRESS COMMUNICATIONS SYSTEM
Applied Research Lab., U. of Arizona, Tucson, Final rept., Jan. 1961, 34 p., 11 refs., AD 264 259.

. . . evaluated for two types of discrete addressing. These types are: (1) time division and (2) time and frequency division. A brief discussion of a random access system using continuous wave transmission is also included. For discrete values of error rate, it is shown that the amount of bandwidth necessary increases as a function of subscriber activity. . . . It will be necessary to use transmitters in the kilo-megacycle range, i.e., on the order of 30 or more.

EFFICIENT MULTIPLEXING OF INTERMITTENT TRANSMITTERS
E. F. Fulton, Lockheed Aricraft Corp., Sunnyvale, Calif., Rept. 6-90-61-47, July 1961, 54 p., AD 262 544.

The limit of channel utilization is studied by postulating a model of band-limited, noisy channel that incorporates the feature of random selection of a subset of transmitters to be multiplexed within the bandwidth. It is shown by a random coding argument that sets of waveforms certainly exist that can provide operation without interference for any finite number of transmitters assigned to the channel, provided only that the total information transmitted by any subset of transmitters be appropriate for the signal power involved. . . Even at the minimum length represented by binary coding, an example using waveforms taken from a systematically related set shows that a power increase of 7 db permits ten transmitters to be assigned to a bandwidth appropriate for three, if not more than three are active simultaneously.

WIDEBAND CHANNEL FOR EMERGENCY COMMUNICATION
H. Magnuski, IRE Internat. Conv. Rec., vol. 8, March 1961, p. 80/84.

MUTUALLY DISTINGUISHABLE NONBINARY PN SEQUENCES
D. Anderson, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 96/97.

Since there are only limited numbers of binary PN sequences of a given length, a natural problem is the construction of periodic signals which are distinguishable, have good out-of-phase autocorrelation, and occupy the same bandwidth. This occurs, for instance, when it is desired to construct multiple-address systems for groups of satellites or to range several instrument packages simultaneously.

The system to be described here consists of sending, as signals, certain periodic sequences of phases and receiving them by the use of word detection.

APPLICATION OF OPERATIONS RESEARCH TO INTERFERENCE
F. Bock, et al., Armour Research Foundation, Chicago, Ill., Rept. no. ARF 5149-13, RADC TDR 62-33, March 1962, 200 p., incl. illus., tables, 16 refs., AD 275 374.

. . . The methods investigated include linear programming, network optimization techniques, dynamic programming, queuing theory, and certain restricted combinatorial search procedures. A digital computer program was written to predict interference. Various possible quantitative definitions of interference are discussed. A field test was carried out involving co-channel operation of two pairs of AN/GRC-27 communication transmitter-receivers with powers attenuated to the low levels calculated in the linear-programming approach. The results of the field test validate the use of the linear-programming model for power assignment.

MULTIPLEXING USING QUASIORTHOGONAL BINARY FUNCTIONS
W. J. Judge, Commun. and Electronics, vol. 81, no. 60, May 1962, p. 81/83.

. . . two different codes are linearly added and sent over the same channel, a receiver can accept one code and reject the other by the process of correlation detection. . . . superiority of the maximal linear sequence autocorrelation. . . due to two characteristics . . . the randomness and the shift-and-add properties. . . .

AN ACCORDION COMMUNICATION SYSTEM FOR MOBILE USE
J. Klapper, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 352/354.

This paper describes a synchronous pulse-type radio telephone system for mobile communication use. The system features user-to-user access without a central switching system. All users share a common frequency band but avoid interference by operating in different time channels. The "accordion" feature, i. e., time compression at the transmitter and time expansion at the receiver, creates sufficient guard time to compensate for unknown propagation delays and other timing errors. A central clock is desirable but not indispensable. Systems calculations are described indicating 10 simultaneous conversations per megacycle, using delta modulation. . . . A large number of addresses and features such as ringing and busy tones are easily accommodated. . . .

RADAS AND SATELLITE COMMUNICATION
H. Magnuski, Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 1.2.

ANALYSIS OF RANDOM ACCESS DISCRETE ADDRESS SYSTEM
H. Magnuski, et al., Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 101/110.

. . . discussion of the basic concept of operation. . . definitions are provided and a model of operation is discussed including comparisons with existing systems. . . .

RACEP PROTOTYPE EQUIPMENT
Martin-Marietta Corp., Orlando, Fla., Final rept. (Rept. no. OR 2495-1), (AFCRL 62-767), Dec. 1962, 95 p., incl. illus., tables, 9 refs., AD 291 207.

RANDOM ACCESS DISCRETE ADDRESS SYSTEM. VOLUME A. SUMMARY
Motorola, Inc., Chicago, Ill., 19 April 1962, 16 p., AD 420 113.

. . . digital techniques will be employed in both the modulation and demodulation processes and in the majority of equipment circuitry for low cost. . . expect field army communications to go digital with RADAS.

STUDY OF SAC BASE NON-TACTICAL RADIO SYSTEMS
ITT Communication Systems, Inc., Paramus, N. J., Rept. no. 62TR72, ESD TDR 63 688, 31 Aug. 1962, 18 p., AD 429 829.

. . . A discussion of the new spread spectrum systems is also presented. . . . existing systems and conventional equipment, with one exception, meet the present operating requirements. . . . Random access discrete address type systems are not recommended for this application.

MUTUALLY DISTINGUISHABLE QUASI PN SEQUENCES
D. R. Anderson, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 124/132.

. . . shows how to construct periodic p-ary digital signals which have small out-of-phase autocorrelation and which have small in- and out-of-phase cross-correlation. For each prime p, finite field theory is used to construct families of p-ary signals of period p^m-1 corresponding to each positive integer m. . . .

CYCLICALLY PERMUTABLE ERROR-CORRECTING CODES
E. N. Gilbert, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 175/182.

In an asynchronous multiplex system a single band of radio frequencies carries many simultaneous conversations, each of which uses a distinguishable train of pulses as a "carrier." . . .

The signals go directly from station to station without any intermediate central office to control them or to make allocations which avoid interference. . . .

LOW-LEVEL SATELLITE COMMUNICATIONS USING RACEP
H. W. Grossman, Rec. Nat. Space Electronics Symp., 1963, no. 3.3.

. . . frequency-time coded pulsed communication techniques offer advantages in power and bandwidth efficiency and in system flexibility over conventional approaches to solutions to military communications problems. Anti-jam characteristics are comparable to or better than for conventional modulation techniques. . . . This document presents the Martin Company's concept for a military satellite communication system using RACEP techniques. . . offers random-multiple communication access to a satellite relay without the use of a central pre-programming control facility. . . .

A RANDOM ACCESS SATELLITE COMMUNICATION SYSTEM (Correspondence)
P. I. Hershberg, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 501/502.

. . . the communications satellite of the next ten years may be within the range of many ground stations simultaneously. . . . If real-time information of a typical communications network variety is involved, it may be impossible to program the efficient utilization of all channels prior to their actual availability. The result has been the proposal of order-wire systems, in which one or more channels are set aside strictly to accommodate the system control function. . . . Other proposals have been adaptive systems, which require sophisticated control loops, and networks which allocate separate channels to each receiving station. The latter proposal is usually unsatisfactory. . . The result has been the design of the presently described modified party-line system. . . .

SYSTEM OFFERS PRIVATE-LINE RADIO SERVICE
P. J. Klass, Aviation Week and Space Technology, vol. 78, May 13, 1963, p. 115, 117, 119, 121, 125, A63-17203.

. . . random access discrete address (RADA) system. . . provides the radio equivalent of private-line telephone service. Research aimed at the incorporation of the system into a communications-satellite system and its use for military and space applications is described.

RANDOM MULTIPLE ACCESS
H. E. Lanning, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 169/174.

The most obvious means of providing random multiple access to a satellite communication system is through the use of frequency and time division multiplex. . . . methods of assigning channels are not completely satisfactory. . . It is possible to eliminate some of the problems associated with standard frequency and time division multiplex by combining them and using one wideband channel in a signal stacking arrangement. . . . orthogonal signals can be constructed. . . Unfortunately, these codes require inter-channel synchronization and complex address generation. . . . by constructing interference rejecting codes an efficient system of channel utilization could be developed. The generation of these interference rejecting codes is most easily accomplished by utilizing pseudo-random sequence generators. The resulting signals will be quasiorthogonal and have a cross channel interference level controllable to any arbitrarily low level. . . .

AN EFFICIENT DEMODULATOR FOR AN ANALOG PSEUDO NOISE MULTIPLEX SYSTEM
H. L. VanTrees, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 65G3, 2 July 1963, 25 p., AD 410 795.

The advantages of wide band pseudo noise communications system are well known. A disadvantage which has restricted its use is the bandwidth requirement. In order to compensate for the large bandwidth, one may put several wide band carriers in the same bandwidth. . . each carrier acts as an uncorrelated noise to every other carrier. . . Unfortunately, we have been unable to perform a rigorous analysis of the system behavior. It is felt that the concept involved is new and interesting and should be presented in its current state of development.

REFLECTIVE MULTIPATH EFFECTS ON BINARY PSK TRANSMISSIONS
V. F. Volertas, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 342/349.

The effects of reflective multipaths on pseudo-random, binary PSK transmissions with quadrature detection are investigated. The paper considers reflective multipaths with long delays and reflective multipaths with delays shorter than a keying element duration. . . .

RASAC, RACEP, ADAPTIVE SATELLITE COMMUNICATIONS
Martin Marietta Corp., Orlando, Fla., Rept. no. OR2544P, 1963, 14 p., AD 418 653.

RASAC is a military satellite communications system employing RACEP modulation techniques. Approximately 50 active satellites are employed is asynchronous orbits at an approximate altitude of 700 miles. Routing and switching of. . . by a new technique called propagated switching which has evolved from studies in survivable communications networks. The summary characteristics of RASAC are given.

Related Publications:

THE MEGACODER—A HIGH-SPEED, LARGE-CAPACITY MICROMINIATURE DECODER
H. Kihn, et al., RCA Rev., vol. 20, no. 1, March 1959, p. 153/179.

. . . which can be preset to respond to any one of one million possible code combinations provided by a bipolar twenty-pulse binary code. . . . occupying less than one cubic inch . . . incorporated in a pocket size FM personal paging receiver to provide a personal paging system capable of selectively calling one million subscribers at rates exceeding 5,000 calls per minute. . . .

MULTIPLE SIGNAL COUNTING
W. M. Gersch, Electronics Research Labs., Columbia Labs., Columbia U., New York, Tech. rept. no. T-1/161; CU-21-61-AF-1971-ERL, RADC TN 61-218, 28 July 1961, 160 p., AD 266 940.

. . . estimation of the number of signals present in a sample containing signals plus noise. . . .

SINGLE PULSE AFC SYSTEM
J. G. Isabeau, IRE Internat. Conv. Rec., vol. 5, March 1961, p. 278/284.

. . . uses a fast feedback loop in order to reach steady state in less than 1 μsec. . . used in conjunction with a radar transmitter, the frequency of which is altered from pulse to pulse. . .

SPECTRUM CONSERVATION THROUGH FREQUENCY SPREADING
H. Wamboldt, Proc. Nat. Aerosp. Electronics Conf., vol. 9, May 1961, p. 319/324.

In general there are three possible ways (other than FM) in which r-f energy may be spread out. One. . . whereby. . . sidebands . . . spread out over a relatively broad band . . . Another method. . . by so-called correlation techniques. The other, which will be discussed more fully hereafter, will be referred to as frequency-hopping. . .

TECHNIQUES FOR THE CONSTRAINED OPTIMIZATION OF COMMUNICATION NETS
L. P. Costa, Northeastern U., Boston, Mass., Scientific rept. no. 8, 15 May 1962, 47 p., incl. illus., tables, 23 refs., AD 276 916.

. . . In particular, three classes of communication nets are considered. Wire nets, possessing communication links of finite capacity. . . . Radio nets, with communication centers of finite capacity. . . . Mixed nets, composed of communication centers and links . . .

TECHNIQUES FOR INCOHERENT SCATTER COMMUNICATION
D. P. Harris, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 154/160.

. . . performance analysis of some digital communication techniques that can be used when most other techniques fail. Error-probability expressions are derived and evaluated for a wide range of possible operating conditions. Effective use of available signal power is found to be possible on badly behaved channels, provided there is sufficient bandwidth available for the optimization of performance. . . . a class of digital communication systems that employ sinusoidal pulse-transmissions with frequency-shift or time-position-shift modulation, or a combination of these techniques. The magnitudes of the shifts are to be selected such that the received waveforms (corresponding to different possible transmitted-pulse positions) can be observed independently . . .

DIE UBERLAGERUNG VON IMPULSFOLGEN IN SYSTEMEN MIT EINER SCHWELLE (The Superposition of Pulse Trains in Systems With Threshold) (In German)
F. Jenik, Arch. Elekt. Uebertragung, vol. 16, April 1962, p. 173/188.

. . . When two pulse trains of different repetition rates are superimposed, a number of pulses will coincide and will accordingly undergo addition or subtraction; with a threshold system the resultant output pulses can be separated from the other input pulses and are then a train of result pulses. The multiplicative relation between the input repetition rates and the output pulse rate is derived. The cluster-periodical structure of the result sequence is explained and a calculation method is worked out. . . .

A WIDE BAND MICROWAVE COMPRESSIVE RECEIVER
F. J. Mueller, et al., IRE Internat. Conv. Rec., Pt. 3, vol. 10, March 1962, p. 103/119.

. . . The compressive receiver, developed by W. D. White of AIL and others, is useful when both high-frequency resolution and a fast scan rate are desired. The receiver uses a network "matched" to an internally-generated FM wave of large bandwidth-duration derived from the external signal.

A practical receiver is described. . .

AFC FOR FREQUENCY HOPPING SYSTEMS
T. J. Rey, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 202/208.

. . . stabilizing the frequency of a voltage-tunable oscillator near any one of many discrete frequencies. A delay line takes the place of the conventional cavity in the discriminator. . . .

SPECTRUM ECONOMY THROUGH CONTROLLED TRANSMITTER POWER LEVELS
A. A. Barrios, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 2, Feb. 1963, no. 3-6.

. . . based on a mathematical analysis of the radio frequency interference problem and suggests a technique for evaluating spectrum economy when transmitter power emission levels are controlled. . . . a probability of interference model is derived for co-channel and adjacent frequency channel assignments. Interfering transmitters are considered to be distributed in a random fashion within specified constraints. The effects of terrain variations, based on a statistical terrain model are also considered. The results show that a significant savings in spectrum can be achieved through control of transmission levels in a military communications area. (Abstract only.)

GROUNDWAVE PROPAGATION EFFECTS ON MICROSECOND PULSES AT 141 MCS
R. W. Heffner, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 182/196.

. . . A test program was performed to investigate the propagation effects around 141 mcs using microsecond pulses of different carrier frequencies. These investigations used omnidirectional antennas at the transmitter and receiver locations. Antenna height at both locations was twelve feet. The results to be discussed are: a) propagation attenuation contour; b) pulse stretching; c) selective fading and enhancement of pulses within the time-frequency matrix frame; d) backscatter pulse stretching, and; e) polarization dependence. . . . only limited information was applicable to the special wide band multiple pulse system requirements of RACEP. . . .

EFFECT OF SEVERAL REGULAR PULSE TRAINS ON A DECODING CIRCUIT WITH DELAY LINE AND COINCIDENCE STAGE
A. R. Livshits, Radiotekhnika i Elektronika, vol. 8, June 1963, p. 930/937, (In Russian) Radio Engineering and Electronic Physics, vol. 8, June 1963, p. 941/947, 9 refs., (Translation), A64-17557.

Presentation of formulas for the duty ratio, the number of pulses, and the average duration in the coincidence train obtained from the action at the decoding circuit of N disturbing regular pulse trains. . . . The problem of the effect of n-regular pulse trains on a decoding circuit with delay line and coincidence stage is solved. Such a problem is stated to arise in practice in investigating multichannel systems for the the transmission of information with code division of channels. The N regular trains have a disturbing effect on the signal to which the decoding circuit is tuned. Each train is a periodically repeated code group consisting of n pulses; the time intervals between the pulses are not equal to the time delays between the ends of the delay line, and differ therefrom by at least the duration of the pulses.

ON A CLASS OF CYLICALLY PERMUTABLE ERROR-CORRECTING CODES
P. G. Neumann, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 75/78.

Cyclically permutable codes have error-correcting properties which are invariant under arbitrary cyclic permutation of any of their code words. This paper summarizes the results of an empirical investigation of certain of these codes, which have parameters not covered by a previous paper of E. N. Gilbert. These codes are thought to be nearly optimal. Estimates of the obtainable number of code words are given. The codes may be suitable for use in certain asynchronous multiplex communication systems. . . .

COMMUNICATION NETS IN RANDOM BEHAVIOR
Z. Prihar, Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 175/189, 18 refs.

Concepts of random neural nets, as treated in mathematical biophysics, are used to describe the random behavior of communication nets. Application of the steady state as well as message spread threshold concepts to communication nets are considered. . . . Part II of this paper discusses the use of the spread of contagion theory and Part III deals with the random behavior of mobile communication nets.

REDUCTION IN QUANTIZING LEVELS FOR DIGITAL VOICE TRANSMISSION
M. J. Wiggins, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 282/288.

. . . A method of processing speech to allow a reduction of quantizing levels for PCM has been developed and applied to a tropospheric scatter communication system. A unique PCM is used which is derived from PPM and is applicable to a random access system for increased bandwidth utilization. An improved detector and demodulator has been developed to provide discrimination against noise and cross talk. . . .

DYNAMIC PROGRAMMING TECHNIQUES
Sylvania Electric Products, Inc., Waltham, Mass., Final rept., Rept. no. F2030 1, RADC TDR 64 10, 11 Dec. 1963, 108 p., AD 433 897.

. . . Problems discussed include the optimum scheduling of link-to-satellite assignments in a nonsynchronous satellite communication system and the computation of optimum discrete allocations.

DIVISION 2.7
PROTECTIVE CODING

Many of the fundamental coding methods discussed in division 2.1 have been applied for the detection and correction of errors in digital communication systems. This division presents references to publications on such protective coding methods published from 1958 to 1963. However, many of fundamental papers in this area originated prior to 1958 and the reader is advised to check the books, surveys and bibliographies mentioned in subdivision 2.700 for such earlier references.

The first section (2.71) of this division shows references to the general theoretical aspects of protective coding. A special subdivision 2.719 deals with tests and experiments in error correction.

Section 2.72 mentions a few equipment and engineering problems in connection with protective coding methods.

"Elementary block codes" is a title for section 2.73 that indicates the historical, original character of these codes, rather than elementary, simple coding procedures. Many of the codes which formed the foundation of the first decade of coding research have their special subdivisions here. Hamming codes and Reed-Muller codes are familiar names from textbooks and publications. The continued research in the coding area has demonstrated more recently that many of these elementary codes now appear as special codes of much broader classes of higher order codes.

The cyclic block codes of section 2.74 is the most intensively explored class of such, more general, codes. They are finding increasing application in areas outside the protective coding field.

Only recently has interest in coding research turned to codes which do not meet the definition of a block code. So-called random codes or codes for sequential operations (2.752) show promise for important practical applications. Other special cases of protective codes are mentioned in subdivision 2.758.

The importance of non-binary digital transmission systems was recognized as early as 1953. Coding theory concentrated on mathematical generalizations from any particular codes and investigated nonbinary alphabets for purely scientific reasons. The success of quaternary transmission systems and, more recently, of systems with very large signalling alphabet has put the practical importance of higher order protective coding methods into focus. We include relevant references in section 2.76.

Another dimension of the classification of protective codes is represented by section 2.77 where we have placed references to codes with special corrective powers. The various subdivisions of this section overlap with other subdivisions in previous sections. A certain amount of duplicate entries has been tolerated in order to facilitate the use of this bibliography. Cross references will guide the reader, as usual, to related subdivisions, if an exhaustive literature search is planned.

The last section (2.78) is devoted to selected application areas and thereby constitutes yet another dimension of classifying protective coding methods. So it may happen that a particular cyclic code for higher order alphabets may be a burst error correcting code for feedback links and thus should be entered in four different subdivisions: 2.740; 2.760; 2.774 and 2.782. In the interest of saving space the compilers of this bibliography could rarely afford such multiple entries. The reader is advised to search several subdivisions, and should consider this multi-dimensional character of the classification system.

Section 2.70

2.700: Introduction to Protective Coding

Included: Binary coding in general; Error correcting codes in general; Noise improvement through coding; Codes for the noisy continuous channel; Arithmetic correcting codes in general; Redundant codes; Ergodic codes in general; Interference killing codes.

Not Included: Design of logical units for protective coding; Data processing for space communications (3A).

Cross References: Fundamentals of coding (Div. 2.1); Redundancy reducing codes (2.211); Codes for erasure channels (2.782).

Principal Publications:

ON THE CONSTRUCTION OF A CLASS OF ERROR-CORRECTING BINARY SIGNALING CODES
R. C. Bose, et al., Inst. of Statistics, State College Raleigh, North Carolina, May 1958, 173 p., AD 158 368.

EVALUATION OF SOME ERROR CORRECTION METHODS APPLICABLE TO DIGITAL DATA TRANSMISSION
A. B. Brown, et al., IRE Nat. Conv, Rec., March 1958, p. 37/55.

ON CODING FOR THE BINARY SYMMETRIC CHANNEL
A. B. Fontaine, et al., Commun. and Electronics, Nov. 1958, p. 638/647.

THE PROBLEM OF NOISE SUPPRESSION IN COMMUNICATION SYSTEMS WHICH AFFECT SIGNAL RECEPTION AS A WHOLE
K. A. Meshkovskii, Radio Engng., vol. 13, no. 6, 1958, p. 1/19.

Methods for determining the probabilities of the correct reception of certain types of optimum and nearly optimum codes are developed. A short analysis of the advantages and disadvantages of some communication systems which serve for the transmission of a finite number of equally probable and mutually-independent messages is given. A new system of communication free of these shortcomings is proposed.

ON THE CHARACTERISTICS OF ERROR-CORRECTING CODES (Correspondence)
R. Chien, IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 91.

SIGNAL TO NOISE IMPROVEMENT THROUGH CODING
J. C. Mott-Smith, Air Force Cambridge Research Center, Bedford, Mass., (Rept. no. AFCRC TR-59-143), May 1959, 17 p., AD 215 115.

The error rate of a binary symmetric memoryless channel is a function of an effective signal-to-noise ratio that combines the input signal-to-noise ratio with the time bandwidth product. The capacity of this channel is found for 4 different error rate expressions corresponding to correlation detection under varying assumptions. The derived capacity is interpreted as the maximum rate achievable through digital encoding while satisfying an arbitrary reliability requirement. The results are presented in terms of the maximum signal-to-noise ratio improvement achievable by such codes as a function of the maximum allowable error rate.

INVESTIGATION AND STUDY OF ERROR DETECTION AND CORRECTION FOR DATA LINKS
E. S. Schwartz, Armour Research Foundation, Illinois Inst. of Tech., RADC-TR-59-19, Jan. 1959, 156 p., AD 210 397.

A CLASS OF CODES FOR SIGNALING ON A NOISY CONTINUOUS CHANNEL
J. L. Kelly, Jr., IRE Trans. Inform. Th., vol. IT-6, no. 1, March 1960, p. 22/24.

ON BINARY SIGNAL CORRECTOR SCHEMES (In Russian)
V. M. Ostianu, Avtomatika i Telemekhanika, vol. 21, no. 5, Dec. 1960, p. 426/431.

BINARY CODES FOR ERROR CONTROL
W. W. Peterson, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 15/21, 33 refs.

. . . several error-correcting codes will be listed with a brief description of their error-correcting capabilities and feasibility of their implementation.

The most promising class of codes for implementation at the present are cyclic codes. The burst-error correcting cyclic codes are especially attractive from the point of view of implementation ; and a simplified block diagram for implementing a practical example of such a code will be shown and discussed.

APPLICATIONS OF REDUNDANT CODES TO A DIGITAL COMMUNICATION SYSTEM
R. L. Sharma, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 241/249.

. . . An error detecting scheme is discussed for a card-to-card or tape-to-tape digital communication system. Hamming code is analyzed for application to a teletype data. M-sequence codes are also investigated and are shown to be best suited for group synchronization and some selective calling systems. . . .

ERROR CORRECTING CODES
JPL Res. Summ. vol. 1, no. 36-7, Dec./Jan. 1960, p. 61/62.

. . . a voluminous literature has been accumulating on the construction and, more recently, on the decoding of error-correcting codes. . . . It has been only a year, however, since a discovery of Bose and Ray-Chaudhuri, with subsequent developments by Peterson, Gorenstein, and Zierler . . . has provided many highly efficient codes, with minimal decoding procedures, for the correction of errors in a wide variety of channels. It should be emphasized that in exchange for the extremely high efficiency-and encoder simplicity of these codes, one has to contend with a certain more-or-less irreducible complexity of decoding equipment.

. . . It is planned to instrument one of these codes in order to demonstrate its feasibility and for possible future application. . . . The original uncoded message may be any sequence of 75 bits . . . The block of 155 bits is transmitted, and decoder will reproduce the 75-bit message correctly when the received 155-bit block contains errors of the following types: Any 8-digit errors . . . Any 4 error clusters of length 6 or less. . . Any 2 crror clusters of length 16 or less . . . This performance may be compared with the Lincoln Laboratory Reed-Muller equipment which encodes 64-bit messages into 128-bit blocks and can correct any 7 bit errors but almost no others. . . .

APPLICATION OF BINARY ERROR-CORRECTING CODES IN TRANSMISSION CHANNELS OF DISCRETE INFORMATION
L. M. Fink, Radio Engng: Transl. of Radio tekhnika, vol. 16, no. 10, 1961, p. 1/8.

By means of asymptotic expressions for the equivalent error probability we derive conditions of "acceptability" of correcting code, which are satisfied by very few of the codes described in the literature. In fading channels these conditions can be made less rigid, if we allow for a decorrelation error upon construction of the code. . . .

For group (systematic) codes, and also for any error-correcting codes in which closed code combinations of definite length are used, . . . the equivalent error probability practically agrees with the "specific error probability", introduced by V. I. Siforov . . .

PERFORMANCE OF ERROR-CORRECTING CODES
M. E. Mitchell, Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 233.

Summary only.

ERROR-CORRECTING CODES
W. W. Peterson, New York, John Wiley & Sons and Mass. Inst. Technol. Press, 1961, 285 p.

. . . devoted exclusively to error-detecting and error-correcting codes for information transmission and storage systems, deserves the attention of communications and computer engineers, information theorists, mathematicians, and anyone else who is interested in learning about recent developments in coding theory, primarily in the area of fixed-length codes for transmission over transmission over a communication channel perturbed by symmetric noise. . . .

INTERFERENCE KILLING CODE FOR REMOTELY CONTROLLED TRANSMISSION SYSTEMS
I. Y. Gol'dbaum, et al., Priborostroyeniye, no. 10, 1962, p. 3/4, AD 400 794.

BINARY CODES FOR ERROR CONTROL
W. W. Peterson, Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 648/652.

The model of a communication channel used in the study of binary codes, its relation to real data transmission channels, and assumptions about noise, will be reviewed briefly. Several error-correcting codes will be listed with a brief description of their error-correcting capabilities and feasibility of their implementation. . . .

ERROR-CORRECTING CODES: AN AXIOMATIC APPROACH
E. F. Assmus, Jr., Inform. Control, vol. 6, no. 4, Dec. 1963, p. 315/330.

This paper emphasizes that coordinates of an error-correcting code are functions. We have incorporated certain ideas already present in the literature into an axiomatic treatment of error-correcting codes. . . .

AN EVALUATION OF SOME METHODS OF ERROR DETECTION AND CORRECTION FOR BINARY DATA TRANSMISSION
K. E. Knuth, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 148/157.

. . . to present . . . basic methods of error detection and correction and to evaluate them with respect to their possible use in detecting or correcting errors in binary data transmission. The paper gives a brief outline of each method . . . compared with respect to their rates of redundancy and their ease of implementation.

ON THE ARITHMETIC CORRECTING CODES
Y. T. Mironchikov, et al., Joint Publications Research Service, Washington, D. C., In its Transl. on USSR Electron., 12 April 1963, p. 1/12, refs., N64-11834.

Arithmetic codes which correct individual errors are described, and the properties of such codes are defined. Also, the synthesis of an error corrector is described. The corrector consists of digital filters (coding and decoding filters), which are multicycle systems built with shift registers having logical feedback. This corrector does not lower the high speed of the serial-type computer.

EXPECTED ERROR LENGTH AND PROBABILITY OF LOSS OF SYNCHRONISM OF CERTAIN EROGODIC CODES
S. P. Morse, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., 10 April 1963, 30 p., AD 418 419.

. . . Several ergodic codes are compared with respect to both expected error length and probability of loss of synchronism due to channel errors as a function of compressibility . . .

source bits are then passed into a coder which, by use of a neat input code, creates words from the source bits and, by use of output code, decomposes the words into channel bits. Both input and output codes are unitary (i.e., no word begins another word) but the output code need not be neat. The combination of an input and an output code is called a coding scheme. Two schemes using the same input and output codes but differing in the number of code words "n" are said to belong to the same code scheme family. This paper deals with a comparison of different code familes . . . Hamming output codes are discussed and compared to the codes listed with respect to expected error length.

CODING THEORY
W. W. Peterson, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 223/229, 120 refs.

CODING AND INFORMATION IDENTIFICATION
L. S. Tuomenoksa, et al., IEEE Trans. Commun. Electronic, no. 67, July 1963, p. 403/404.

. . . Error-detection and -correction codes. . . . methods for using these codes to check whether information from the proper address or from the proper position in a time sequence has been received.

A HANDBOOK ON COMMUNICATION CODES. PART I, PERMUTATION CODES AND CODED-CHARACTER SETS
ITT Communication Systems, Inc., Paramus, N. J., Rept. no. 64TR364, 31 Jan. 1964, lv., AD 433 200.

Related Publications:

PHONE LINE DIGITAL TRANSMISSION STUDY
Hughes Aircraft Co., Culver City, Calif., (RADC TR 60-153), Sept. 1960, 240 p., AD 244 193.

. . . The subject of error control by means of coding techniques is treated, and a representative transmission problem discussed to demonstrate application of such techniques. . . .

SURVEY OF DIGITAL COMMUNICATIONS
C. A. Deutschle, Hughes Aircraft Co., Culver City, Calif, Rept. on 480L System, 15 April 1961, (Rept. no. TR-1), (ESD TDR 62-158), 386 p., incl. illus., tables, 7 refs., AD 277 176.

Discrete message types . . . Transmission requirements and techniques . . . cryptography . . . Transmission media . . . Error control . . . Comparative evaluations . . .

ON THE DESIGN OF A HIGHLY RELIABLE HF DIGITAL COMMUNICATION SYSTEM. PROBLEMS, DESIGN PROCEDURES AND THE DESCRIPTION OF A PROPOSED DESIGN
K. Otten, National Cash Register Co., Dayton, Ohio, Rept. 3-45, Oct. 1961, 38 p., AD 269 891.

. . . using pulse redundancy, it was concluded that statistical information on the correlation between disturbances must be known . . .

ELEMENTS OF ENCODING
F. M. Renza, Rome Air Development Center, Griffiss Air Force Base, N. Y., (RADC TN 61-3), Feb. 1961, 57 p., AD 253 442.

The common terms of encoding such as source, efficiency, redundancy and decipherability are defined in this report. A criterion is given for uniquely decipherable codes. Shannon-Fano, Huffman, Gilbert-Moore, Elias and Hamming error correcting codes are discussed. . . .

JAMPROOF AUTOMATIC FREQUENCY CONTROL. VOLUME I, ANALYTIC STUDIES
A. Bond, et al., Bendix Systems Div., Bendix Corp., Ann Arbor, Mich., (Rept. no. BSR-546, vol. 1, (ASD TR 61661, vol. 1), Jan. 1962, lv., 28 refs., AD 270 529.

A study of modulation, detection and correction techniques . . . to develop design criteria for communication equipment that could provide adequate performance when subjected to severe doppler shifts and other effects encountered in communications from rapidly moving vehicles. . . .

THE DEGARBLER—A PROGRAM FOR CORRECTING MACHINE-READ MORSE CODE
C. K. McElwain, et al., Inform. Control, vol. 5, no. 4, Dec. 1962, p. 368/384.

An IBM 7090 program automatically corrects garbled samples of English text. The garbles are intended to resemble those caused by Morse Code transmissions.

The program has access to a vocabulary and a table of the Morse Code equivalents of the English alphabet.

The correction rate on text in which 0-10% of the characters have been subjected to Morse Code garbles is about 70%. The apparent improvement in intelligibility is very marked. . . .

Section 2.71

2.710: General Theory of Protective Coding

Included: Asymptotic properties of error correcting codes; General methods of constructing codes.

Cross References: General coding theory (2.110).

Principal Publications:

A GENERAL METHOD OF CONSTRUCTING LOSS-LESS ERROR-CORRECTION CODES FOR A NONPRIME BASE
R. T. Chien, Paper from IRE-URSI Joint Meeting - Oct. 19-21, 1959, San Diego, Calif.

PROBABILITY OF ERROR FOR OPTIMAL CODES IN A GAUSSIAN CHANNEL
C. E. Shannon, Bell Syst. Tech. J., vol. 38, May 1959, p. 611/656.

ON THE MATHEMATICAL THEORY OF ERROR-CORRECTING CODES
H. S. Shapiro, et al., IBM J. Res. Developm., vol. 3, no. 1, Jan. 1959, p. 25/34.

A SYSTEMATIC METHOD FOR THE CONSTRUCTION OF ERROR-CORRECTING GROUP CODES
R. B. Banerji, Nature, vol. 186, no. 4725, May 1960, p. 627.

APPLICATION OF BINARY ERROR-CORRECTING CODES IN TRANSMISSION CHANNELS OF DISCRETE INFORMATION
L. M. Fink, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 10, 1961, p. 1/8.

By means of asymptotic expressions for the equivalent error probability we derive conditions of "acceptability" of correcting code, which are satisfied by very few of the codes described in the literature. In fading channels these conditions can be made less rigid . . . For group (systematic) codes, and also for any error-correcting codes in which closed code combinations of definite length are used . . . the equivalent error probability practically agrees with the "specific error probability", introduced by V. I. Siforov . . .

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE
L. Kurz, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 215/223.

. . . A theory of so-called efficient codes (minimax, equal separation, and nearly equal separation) is developed. . . . It is shown that efficient codes perform better than equidistant codes if the noise is nonwhite . . . The detection scheme used does not require estimation of the signal or the noise levels at the receiver and is thus independent of fading.

CODES, ENERGY CONTRAST, AND TRANSMISSION RATE
J. H. Van Horn, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 256/267.

IMPROVED ASYMPTOTIC PROPERTIES OF ERROR CORRECTING CODES
S. M. Johnson, RAND Corp., Santa Monica, Calif., (Research memo. RM-3232-PR), Sept. 1962, 31 p., 4 refs., AD 286 756, N63-19051.

A new upper bound on nonsystematic binary error-correcting codes, using a sphere-packing approach and combinatorial analysis . . . A possible application might be in the use of a larger code giving almost certain error correction rather than a smaller one with certain correction capability.

ERROR-CORRECTING CODES AT VERY LOW SIGNAL-TO-NOISE RATIOS
E. C. Posner, JPL Res. Summ., no. 36-14, Feb./March 1962, p. 34/36.

. . . the signal-to-noise ratio at the output of the receiver can be less than one . . . If a (linear) error-correcting code is used to encode the telemetry, one is interested in the asymptotic performance of the code as the signal-to-noise ratio approaches zero. This asymptotic result is needed in order to compare the thresholding properties of error-correcting encoding with the performance of other encoding systems.

ERROR-CORRECTING CODES: AN AXIOMATIC APPROACH
E. F. Assmus, Jr., et al., Inform. Control, vol. 6, Dec. 1963, p. 315/330, 21 refs., A64-12158.

Discussion of the coordinate functions of an error-correcting code. Certain ideas already present in the literature are incorporated into an axiomatic treatment of error-correcting codes. . . .

BURST-ERROR CORRECTION FOR RANDOMLY-CHOSEN BINARY GROUP CODES
J. J. Metzner, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 281/285.

A method of burst-error correction is presented which works for a large class of codes. Any single burst of length up to somewhat less than one half the number of check

digits can be corrected. The number of decoding computations per code word is proportional to the square of the code length for long codes. . . .

Related Publications:

COMPARISON OF TWO METHODS OF UTILIZATION OF ONE-DIMENSIONAL COMMUNICATION STATISTICS TO IMPROVE FREEDOM FROM NOISE
Y. N. Mel'nikov, Aerospace Technical Intelligence Center, Wright-Patterson AFB, Ohio, 24 Aug. 1961, 19 p., (Trans. MCL-983 of Izvestiya Akademii Nauk SSSR, Otdeleniye Tekhnicheskikh Nauk, Energetika i Avtomatika 5:116/123, 1960, AD 265 663.

. . . The redundancy in practically every communication transmitted does not always optimally improve freedom from noise. In order to utilize the redundancy defined by a 1-dimensional communication statistics to improve the freedom from noise, two different methods are described.

THE ASYMPTOTIC BEHAVIOR OF LINEAR DECODING FOR THE BINARY SYMMETRIC CHANNEL (Correspondence)
T. J. Wagner, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 47/48.

One asks if in the binary symmetric channel it is possible to have a sequence of codes with linear decoders such that 1) the maximum probability of error tends to zero with block length and 2) the code rates converge to a positive rate less than channel capacity. The answer, unfortunately, is no. . . .

2.711: Definitions and Theoretical Bounds of Codes

Included: Word error probabilities; Bit error probabilities; Pseudo-redundancy in communications systems.

Not Included: Definitions in information theory (1); Channel models (1).

Cross References: General theory of coding (2.110).

Principal Publications:

ON THE MATHEMATICAL THEORY OF ERROR-CORRECTING CODES
H. S. Shaprio, et al., IBM J. Res. Developm., vol. 3, no. 1, Jan. 1959, p. 25/34.

A BOUND FOR ERROR-CORRECTING CODES
J. H. Griesmer, IBM J. Res. Developm., vol. 4, no. 5, Nov. 1960, p. 532/542.

Gives two new bounds for the code word length n which is required to obtain a binary group code of order 2k with mutual distance d between code words. These bounds are compared with previously known bounds . . .

UPPER BOUNDS FOR ERROR DETECTING AND CORRECTING CODES
J. P. Lipp, IRE Trans. Inform. Th., vol. IT 6, no. 5, Dec. 1960, p. 557/558.

CONSTRUCTION OF GALOIS FIELDS OF CHARACTERISTICS TWO AND IRREDUCIBLE POLYNOMIALS
J. D. Swift, Math. Comput., vol. 14, no. 70, April 1960, p. 99/103.

PSEUDO-REDUNDANCY IN COMMUNICATIONS SYSTEMS
M. Chomet, et al., IRE Internat. Conv. Rec., vol. 8, March 1961, p. 169/173.

. . . increases the reliability of a multichannel communications system without complex decision-making circuits or switching devices. Non-redundant and pseudo-redundant systems are presented and compared.

ON "UPPER BOUNDS FOR ERROR DETECTING AND CORRECTING CODES OF FINITE LENGTH " (Correspondence)
F. F. Sellers, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 276.

In a recent article, Wax cited the results of Laemmel that the best value for the number of sequences of length 14 which correct two errors is "48 (?)." A better value is 64. To see this, consider a code developed by Bose and Chaudhuri of length 15 with 7 information bits which is able to correct 2 errors. Leaving off one information bit, this would be a code of length 14 with 6 information bits, or 64 code points. . . .

A LOWER BOUND FOR ERROR-DETECTING AND ERROR-CORRECTING CODES (Correspondence)
P. T. Strait, IRE Trans. Inform. Th., vol. IT-7, no. 2, April 1961, p. 114/118.

SOME BOUNDS FOR ERROR-CORRECTING CODES
L. D. Grey, IRE Trans. Inform. Th., vol. IT-8, no. 3, April 1962, p. 200/202.

. . . binary coding and more specifically with an upper bound for the number of binary code words of length n such that every two differ in at least d positions from each other. It is

shown that there is a relationship between this problem and a well-known extremum problem . . .

A NEW UPPER BOUND FOR ERROR-CORRECTING CODES
S. M. Johnson, IRE Trans. Inform. Th., vol. IT-8, no. 3, April 1962, p. 203/207.

By refining Hamming's geometric sphere-packing model a new upper bound for non-systematic binary error-correcting codes is found. . . .

ERROR PROBABILITIES FOR OPTIMAL CODES IN A GAUSSIAN CHANNEL
T. Kailath, JPL Res. Summ., no. 36-14, Feb./Mar. 1962, p. 39/41.

In a paper in 1959 Shannon (Ref 6) derived several lower and upper bounds on the error probability . . . for an optimal code signalling over a channel perturbed by additive white noise. . . . the final results were remarkably elegant. . . . it seems desirable to obtain as much of an understanding of the results and the methods of obtaining them as possible. In 1956 Shannon (Ref 7) described general and powerful techniques for obtaining such results. These techniques were delineated earlier in a paper by Cramer (Ref 8). In this report we shall give a brief discussion of the essentials of this method and show how it can be used to obtain, in a special case, the results of Shannon.

UPPER BOUND FOR ERROR-DETECTING AND ERROR-CORRECTING CODES (Correspondence)
L. Norwood, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 58.

In the excellent paper of Wax and the subsequent note of Lipp, the conjecture of Laemmel is cited that the best value actually found for the number of sequences of length 14 with a minimum Hamming distance of 5 is "48(?)". Here it will be shown that this number has been increased to 64, by displaying a specific error detecting and correcting code. . . .

A REDUCED UPPER BOUND ON THE ERROR CORRECTION ABILITY OF CODES (Correspondence)
J. E. Bartow, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 46.

Lipp's upper bound on the number of errors (e_c) that can be corrected by a code of length n with v message points can be refined to give a bound smaller by one in many cases. . . .

AN UPPER BOUND ON THE ERROR CORRECTION ABILITY OF CODES (Correspondence)
J. E. Bartow, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 290.

The bound previously presented by the author was derived for an even number of message points . . . A somewhat lower bound can be found for an odd number of message points. . . .

IMPROVED COMPUTATIONAL BOUND FOR THE BINARY ERASURE CHANNEL (Correspondence)
M.A. Epstein, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 51.

ERROR CODING BOUNDS FOR THE BINARY ASYMMETRIC CHANNEL (Correspondence)
T.H. Gordon, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 206/208.

. . . results of an effort to find a quantitative estimate of the loss in reliability if group or linear codes are used on the binary asymmetric channel . . . instead of optimum codes . . .

IMPROVED ASYMPTOTIC BOUNDS FOR ERROR-CORRECTING CODES
S.M. Johnson, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 198/205.

The author has previously developed a new upper bound on nonsystematic binary error-correcting codes, using a sphere-packing approach and combinatorial analysis. A significant refinement is now added; together with a detailed study of the asymptotic behavior of the upper bound, this enables one to show that any large code must correct almost all sequences with a larger number of errors than the code was designed for. . . .

A NOTE ON THE WORD ERROR PROBABILITY ASSOCIATED WITH A SEQUENCE OF DIGITS HAVING UNEQUAL ERROR PROBABILITIES (Correspondence)
F.G. Splitt, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 492/493.

. . . in cases where the interference is nonstationary or where a quantized frequency modulation (QFM) transmission is perturbed by colored noise, the digit error probabilities will be unequal. These unequal digit error probabilities lead to cumbersome expressions for the probability distribution function for the number of ones in the error sequence and the word error probability. It is to the simplification of these problems that this note is addressed. . . .

GENERAL ERROR CRITERIA (Correspondence)
M. Zakai, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 94/96.

Related Publications:

FEHLERWAHRSCHEINLICHKEIT BINÄR KODIERTER MELDUNGEN BEI STÖRUNG DURCH WEISSES RAUSCHEN (Error Probability of Binary Coded Messages Under White Noise Disturbances) (In German)
H.J. Held, Nachrichtentech. Z., vol. 11, May 1958, p. 244/249.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN AND IMPULSIVE NOISE
L. Kurz, IRE Internat. Conv. Rec., Pt. 4, vol. 4, March 1962, p. 161/173.

. . . Basically, it is shown that subdividing the decision interval (O, T) and coding each subinterval using optimum waveforms is a more efficient method of combatting the impulse noise than using optimum waveforms in the full decision interval. . . .

2.712: Comparison of Various Protective Codes

Included: Comparison of coded with uncoded transmission; Effectiveness of error correcting codes; Effective power gain for special codes.

Not Included: Comparison of modulation methods (1); criteria for comparison of communications channels (1).

Cross References: Block codes; Group codes, Systematic codes (Sect. 2.73); Cyclic codes (Sect. 2.74).

Principal Publications:

NOTES ON ERROR-CORRECTING TECHNIQUES I. EFFICIENCY OF SINGLE-ERROR-CORRECTING CODES WITH A CONSTANT BIT RATE OF TRANSMISSION
J. Dutka, RCA Rev., vol. 19, no. 4, Dec. 1958, p. 628/641.

. . . the efficiency of single-error-correcting codes for binary data compared with unprotected codes . . . The relative power gain obtained by using single-error-correcting codes is also determined. . . .

FEHLERWAHRSCHEINLICHKEIT BINAR KODIERTER MELDUNGEN BEI STORUNG DURCH WEISSES RAUSCHEN (Error Probability of Binary Messagnes Under White Noise Condtions) (In German)
H. J. Held, Nachrichtentech. Z., vol. 11, May 1958, p. 244/249.

A NOTE ON THE APPLICABILITY OF ERROR CORRECTING CODES
J. E. Palmer, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 4, June 1960, p. 190/193.

. . . In order to properly evaluate the performance of an error correcting code, it is necessary to consider both the increased immunity to errors and the decreased ability to transmit information. Such an evaluation technique will be described in this paper, using several numerical examples of the use of this evaluation technique . . .

EFFECTIVE POWER GAIN USING HAMMING CODES
E. C. Posner, JPL Res. Summ., no. 36-13, Dec. - Jan. 1961, p. 35/37.

EFFECTIVENESS OF ERROR-CORRECTING CODES COMPARISION OF BIT ERROR PROBABILITIES
E. C. Posner, JPL Res. Summ., no. 36-13, Dec.-Jan. 1961, p. 32/37.

In discussing the capabilities of codes, one is interested in an equivalent bit error probability which one has when the code is used. One definition is the "word bit error probability," p_w, which is defined as that bit error probability on a binary symmetric channel such that $(1 - p_w)^k$, the probability of transmitting k uncoded information bits without error, is the same as the probability of correct decoding when the code is used on the original channel. Here one uses maximum likelihood decoding (that is, decoding into the closest word) . . . Another definition of bit error probability is p_b, the "expected bit error probability," which is defined as that bit error probability on a binary symmetric channel such that the expected number of bits in error in an uncoded word of k information bits, namely kp_b, equals the expected number of information bits in error when the code is used with maximum likelihood decoding on the original channel.

ERROR PROBABILITIES OF LINEAR CODES AT HIGH SIGNAL-TO-NOISE RATIO
E. C. Posner, et al., JPL Res. Summ., no. 36-13, Dec.-Jan. 1961, p. 37/38.

The problem is this: given an (n, k) linear code, should one transmit the k information bits uncoded using a given time per symbol, or should one use the code with a time per symbol shorter by factor of k/n, and thus have a lower signal-to-noise ratio? Here the criterion can be based upon either p_w or p_b (Sec V-E-1); as the symbol error probability in the channel approaches zero, it will be seen that the two criteria give the same result as to whether to use the code.

DATA TRANSMISSION OVER A NOISY GAUSSIAN CHANNEL
L. H. Zetterberg, K. Tekn. Hogsk. Handle, no. 184, 1961, 87, p. 46 refs.

. . . A binary coded 2-signal system is compared with a system using error-correcting codes, and also with a multi-signal system, the systems being rated according to the tolerated noise level.

ERROR CORRECTION IN DATA TRANSMISSION SYSTEMS
E.R. Aylott, et al., J. Brit. Instn. Radio Engrs. vol. 24, no. 2, Aug. 1962, p. 141/148.

. . . Typical error detection and correction equipments for both the telephone and telex networks are shown. Finally methods for the evaluation of the relative efficiencies of the various error correction and detection codes are described. . . .

QUANTIZATION AND CODING OF TRANSMITTED STATISTICAL INFORMATION
I. Eisenberger, JPL Space Progr. Summ., vol. 4, no. 37-15, April-May 1962, p. 46/49.

. . . whether the variances of the estimate of the parameter obtained from uncoded transmission is smaller than that resulting from an optimal method of encoding the data before transmission. This provides a basis for deciding whether or not to code. (The coding considered here is of the kind that adds redundancy in time; using orthogonal codes with correlation detection with no increase in time per information bit is not considered here.)

ON FSK PARITY CHECKING (Correspondence)
N.M. Blachman, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 121/123.

. . . compares the error probabilities for a fixed-information-transmission-rate FSD channel, with and without one parity-checking bit per word, for various word lengths, any word whose parity does not check at the receiver being retransmitted. . . .

PERFORMANCE OF HAMMING CODES
R.G. Marquart, et al., IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 4, Dec. 1963, p. 115/126.

Evaluation of the performance of error-correcting codes has, in the past, been severely hampered by the lack of functional relationships between the uncoded and coded binit error rates. In this paper, such relationships yielding the exact decoder output error rates are developed for Hamming SED codes. . . and for Hamming SEC/DED codes . . . In addition, for the DED codes, a similar family of formulas are derived for the probability that a received information binit is contained in a word containing an error pattern that can be detected but not corrected. . . .

Related Publications:

SIGNAL TO NOISE IMPROVEMENT THROUGH CODING
J.C. Mott-Smith, Air Force Cambridge Research Center, Bedford, Mass., (Rept. no. AFCRC TR-59-143), May 1959, 17 p., AD 215 115.

The error rate of a binary symmetric memoryless channel is a function of an effective signal-to-noise ratio that combines the input signal-to-noise ratio with the time bandwidth product. The capacity of this cahnnel is found for 4 different error rate expressions corresponding to correlation detection under varying assumptions. The derived capacity is interpreted as the maximum rate achievable through digital encoding while satisfying an arbitrary reliability requirement. The results are presented in terms of the maximum signal-to-noise ratio improvement achievable by such codes as a function of the maximum allowable error rate.

SOME RECENT DEVELOPMENT IN DATA TRANSMISSION
K.L. Smith, J. Brit. Instn. Radio Engrs., vol. 24, no. 5, Nov. 1962, p. 405/414.

. . . use of error correction and error detection systems are also discussed. . . .

AN EVALUATION OF SOME METHODS OF ERROR DETECTION AND CORRECTION FOR BINARY DATA TRANSMISSION
K.E. Knuth, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 148/157.

. . . to present. . .basic methods of error detection and correction and to evaluate them with respect to their possible use in detecting or correcting errors in binary data transmission. The paper gives a brief outline of each method. . . compared with respect to their rates of redundancy and their ease of implementation.

2.719: Tests and Experiments With Error Correcting Codes

Included: Test methods for counting errors; Experimental comparison of various codes.

Not Included: Code generators; Design of test equipment; Test of the characteristics of communications channels (1).

Cross References: Comparison of protective codes with uncoded transmissions (2.712).

Principal Publications:

AN EXPERIMENTAL STUDY OF A BINARY CODE
W. W. Peterson, Commun. and Electronics, July 1958, p. 388/392.

INVESTIGATION AND STUDY OF ERROR DETECTION AND CORRECTION FOR DATA LINK
E. S. Schwartz, Armour Research Foundation, Illinois Inst. of Tech., RADC-TR-59-19, Jan. 1959, 156 p., AD 210 397.

MEASURED ERROR DISTRIBUTION ON THE BELL A-1 FACILITY OVER VARIOUS MEDIA
E. J. Hofmann, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 37/44.

Error distributions have been obtained by experiments carried out using an automatic digital data error recorder which is described. Media include several land line telephone circuits and the Hawaiian cable. Both data and sync error rates are shown, and their temporal and amplitude characteristics are examined. . . . The effectiveness of parity checking as an error-detecting device is also evaluated. . . .

SOME RESULTS IN THE MEASUREMENT OF IMPULSE NOISE ON SEVERAL TELEPHONE CIRCUITS
H. L. Yudkin, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 222/231.

Equipment known as the ANALOGER (analog error recorder), used for the recording of impulse noise, is described. Impulse noise, nit and burst are defined. The analysis of noise recordings taken on H-44, K-carrier and TD-2 circuits is presented. Variation of noise activity with time of day, circuit and weather conditions is shown. Correlations between thunderstorm activity and noise on the H-44 circuit are given. Noise is classified in terms of pulse shape and time of occurrence and the pulse shape is related to the filter characteristics of the telephone circuits. Distributions of impulse noise, amplitude and duration are given. Comments are made on the interpretation of impulse noise statistics and the relationships between these and statistics of errors in data transmission are discussed. . . .

APPLICABILITY OF CODING TO RADIO TELETYPE CHANNELS
A. B. Fontaine, Lincoln Lab., MIT, Lexington, Rept. 25G-3, 27 Oct. 1961, 6 p. AD 266 827.

Approximately 300 hours of radio teletype data were analyzed. . . to determine the applicability of coding theory to radio teletype channels. . . . error detect and repeat schemes with about 10% redundancy will reduce the probability of error to a negligible amount.

THE EXAMINATION OF ERROR DISTRIBUTIONS FOR THE EVALUATION OF ERROR-DETECTION AND ERROR-CORRECTION PROCEDURES
T. A. Maguire, et al., IRE Trans. Commun. Syst., vol. CS-9, no. 2, June 1961, p. 101/106.

It is concluded that there is a substantial advantage in the use of large (500-bit) rather than small (50-bit) blocks for detecting errors. It is also suggested that the practical evidence of error patterns which remain undetected should enable more effective detection designs to be produced.

AUTOMATIC ERROR-DETECTION SYSTEM FOR TOLL-GRADE TELEPHONE CIRCUIT DATA TRANSMISSION
W. G. Schmidt, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 25G-5, 27 Nov. 1961, 11 p., AD 268 128.

. . . The general system, the logical design considerations, the hazards encountered, and the debugging and test methods used are described. . . .

DATA SYSTEM TESTS USING SIMULATED TRANSMISSION IMPAIRMENTS
F. T. Andrews, Jr., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 590/596.

Test instrumentation has been developed for simulating the principal types of transmission impairments that will be encountered on voice-frequency telephone circuits. Such impairments include delay and attenuation distortion, frequency shift, phase and amplitude hits, interfering tones, and noise. This test equipment, together with conventional random-data signal generators and error comparators, makes possible the evaluation of data systems with a wide range of transmission characteristics. . . .

TESTING RADIO-TELEGRAPH AUTOMATIC ERROR-CORRECTING EQUIPMENT
A. C. Croisdale, et al., Post Off. Elect. Engrs. J., vol. 54, no. 4, Jan. 1962, p. 245/249.

RECORDING AND VISUAL ANALYSIS OF NOISE ERRORS
A. E. Johanson, Commun. and Electronics, vol. 81, no. 60, May 1962, p. 90/94.

. . . In a recent data transmission test, a method for visually evaluating the causes of errors was tried. Photographic reproductions of error messages were produced by the combined use of a magnetic tape recorder and a recording oscillograph. These were analyzed visually and the errors classified by cause into eight categories. In several

of these categories, the fault lies in the terminal equipment, in the rest, apparently in the transmission channel. Examples are given of various types of errors encountered. . . .

FURTHER ANALYSIS OF ERRORS REPORTED IN "CAPABILITIES OF THE TELEPHONE NETWORK FOR DATA TRANSMISSION"
R. Morris, Bell Syst. Tech. J., vol. 41, no. 4, July 1962, p. 1399/1414.

The recorded error data from a field testing program reported on by Alexander, Gryb, and Nast have been further analyzed. New methods of analysis have given more information on the causes and nature of errors experienced by data in the switched telephone plant. The results obtained will enable workers in the field of error control to use the field test data more effectively. . . .

TELEPHONE CIRCUIT EVALUATION FOR DATA TRANSMISSION
K. L. Smith, et al., J. Brit. Instn. Radio Engrs., vol. 24, no. 4, Oct. 1962, p. 297/308, 11 refs.

. . . statistical methods based on extended tests using special measuring equipment and computer-based data reduction methods. From these, mathematical models of the various circuits can be formulated whereby the optimum arrangement of the transmitted data and the effectiveness of various error detection and correction systems, can be determined. . . .

CODES FOR PROVIDING PROTECTION AGAINST ERRORS IN DATA TRANSMISSION (In French)
F. Corr, et al., Onde Electr., vol. 43, no. 431, Feb. 1963, p. 117/127.

. . . includes a statistical description of typical errors obtained in a series of tests on real lines, the theoretical development of the best codes suitable for detecting or correcting these representative errors and a practical study of their operational efficiency.

A METHOD OF OBTAINING AND ANALYZING DIGITAL ERROR PATTERNS
D. G. Iram, et al., Rome Air Development Center, Griffiss Air Force Base, N. Y., RADC TDR 63 255, July 1963, 13 p., AD 413 474.

. . . on. . . digital communications channels. . . . experiments were made on a tropospheric scatter channel. . . . indicate the improvement possible on this channel by using a burst-error correction code. Curves are presented showing this improvement as a function of reduced information rate and digit block length.

AN EXPERIMENTAL COMPARISON OF SOME ERROR-DETECTING CODES
J. N. Prewett, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 423/431.

. . . The effectiveness of three error-detecting codes is compared by simultaneous transmission over 200 miles of rented G. P. O telephone line. A constant-ratio code, a row-and-column parity code and a multi-diagonal-parity code are built into a 128-digit message. Both f.m. and p.m. systems are used at 750 bauds. The results are collected on punched paper tape and analysed by computer. . . . The results show that whilst constant-ratio codes may be adequate for 50 bauds, more elaborate schemes are required at higher speeds. . . .

DATA TRANSMISSION INVESTIGATION
R. F. Salava, Quarterly progress rept. no. 3, 11 March 1963-10 June 1963, Rept. no. 7; 10 June 1963, 38 p., AD 417 754.

. . . performance of the clock generator and clock recovery circuits is discussed. The limits of the code's error correcting and detecting capability are shown, and the code's performance when these capabilities are exceeded. . .

Related Publications:

NOTES ON TRANSMISSION OF DATA AT 750 BAUDS OVER PRACTICAL CIRCUITS
P. A. Chittenden, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 22/28.

SOME ERROR CHARACTERISTICS OF A DATA COMMUNICATION SYSTEM
R. L. Townsend, presented at the Fall General Meeting, AIEE, Oct. 15-20, 1961, Detroit, Michigan.

ON SOME CONNECTIONS BETWEEN THE DESIGN OF EXPERIMENTS AND INFORMATION THEORY
R. C. Bose, Case Inst. of Tech., Cleveland, Ohio, 1962, 15 p., AD 408 295.

The interconnection between the theory of confounding and fractional replication developed by Fisher, Finney, Bose and Kishen, and the theory of error-correcting codes due to Hamming and Slepian are discussed. . . the packing problem. . . finding the maximum possible number of distinct points in the finite projective space PG(r=1, s) . . .

DIGITAL CIRCUIT TECHNIQUES FOR SPEECH ANALYSIS
G. L. Clapper, IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 296/305, 11 refs.

. . . Some early speech devices are noted and current work in the field of computer simulation is considered. . . . description of an experimental word code generator

developed at IBM. . . . This device produces a compressed digital code from the spoken word as a function of frequency, intensity, and time. . . .

ESTIMATES OF ERROR RATES FOR CODES ON BURST-NOISE CHANNELS
E. O. Elliott, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 1977/1997.

The error structure on communication channels used for data transmission may be so complex as to preclude the feasibility of accurately predicting the performance of given codes when employed on these channels. Use of an approximate error rate. . . allows . . . an economical evaluation of large collections of error detecting codes. Exemplary evaluations of error detecting codes on the switched telephone network are included in this paper.

On channels which may be represented by Gilbert's model of a burst-noise channel, the probabilities of error or of retransmission may be calculated without approximations for both error correcting and error detecting codes.

Section 2.72
Equipment and Engineering Problems for Error Correction Methods

2.720: Circuit Techniques and Related Problems

Included: Algebraic decoding; Inhibited error-correction decoder; Time decoding for satellite tracking systems; Modulator sequential circuits.

Not Included: Design of coders and decoders; Design of tracking systems; Design of logic circuitry in general.

Principal Publications:

ALGEBRAIC DECODING FOR A BINARY ERASURE CHANNEL
M. A. Epstein, IRE Nat. Conv. Rec., March 1958, p. 56/69.

APPLICATION OF MODULAR SEQUENTIAL CIRCUITS TO SINGLE ERROR CORRECTING P-NARY CODES
T. E. Stern, et al., IRE Trans. Inform., Th., vol. IT-5, no. 3, Sept. 1959, p. 114/123.

ERROR CORRECTING CODES FROM LINEAR SEQUENTIAL CIRCUITS
M. Abramson, Stanford Electronics Labs., Stanford U., Calif., (Technical rept. no. 2002-1), 13 June 1960, 20 p., 25 refs., AD 239 777.

SYNTHESIS OF BINARY RING COUNTERS OF GIVEN PERIODS
G. B. Fitzpatrick, J. Assoc. Comput. Machinery, vol. 7, no. 3, July 1960, p. 287/297.

DETECTION OF TRANSMISSION ERRORS IN 5-LEVEL PUNCHED TAPE
R. Steeneck, et al., West. Union Tech. Rev., vol. 14, no. 1, Jan. 1960, p. 2/8.

INHIBITED ERROR-CORRECTION DECODER PERFORMANCE
M. E. Mitchell, IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 425/435.

. . . An "inhibited" error-correction decoder is defined as one which inhibits its output of decoded information bits when an uncorrectable error is detected. . . . the effect of such errors on several error-correction decoders of practical interest is described in terms of the numerical results of a computer simulation. . . .

TIME DECODING FOR SATELLITE TRACKING SYSTEMS
Alan Demmerle, et al., Electronic Indust., vol. 22, Oct. 1963, p. 182/189, A64-13484.

Description of an error detection and correcting time decoder designed for use with satellite data reduction facilities to cope with the large number of erroneous time readings. This decoder is an improvement over the straightforward instance-by-instance time decoding because short-term perturbations in the time code will not produce an incorrect output from the decoder. It is also an improvement over a single read-in method of data-time decoding updated by a standard frequency because it continually correlates the time words with the data. The decoder further decodes both a serial decimal (SD) time code and binary coded decimal (BCD) time code. . . .

SOME OPTIMUM PROCESSORS FOR MODERN COMMUNICATIONS AND CONTROL APPLICATIONS
A. H. Sepahban, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 768/792.

Engineering examples of data and signal processing problems from communications coding and control applications are presented . . . special purpose stored-program flexibility. . . and often efficiency and economy in their design and operation. . .

Related Publications:

DATA TRANSMISSION INVESTIGATION
R. F. Salava, Motorola, Inc., Chicago, Ill., Quarterly progress rept. no. 5, 11 Sept.-10 Dec. 1963, Rept. no. 9, 10 Dec. 1963, 1 v., AD 430 726.

. . . The digital Encoder and digital Decoder constructed for the program are discussed. . .

2.722: Protective Coding by Computer Operation

Included: Programs for simulating error correction systems.

Not Included: Data processors for space communications (3A); Real time applications of computers.

Cross References: Codes for feedback links and terminal processors (2.782).

Principal Publications:

A NOTE ON ERROR DETECTION IN NOISY LOGICAL COMPUTERS
M. Eden, Inform. Control, vol. 2, no. 3, Sept. 1959, 310/313.

The proposal extends the range of the propositional variables so that residue class check symbols may be used in error detection. The principal consequence is that individual logical elements may be designed to process binary inputs with arbitrary reliability and nonzero channel capacity.

A SYSTEMATIC METHOD FOR THE CONSTRUCTION OF ERROR-CORRECTING GROUP CODES
R. B. Banerji, Nature, vol. 186, no. 4725, May 1960, p. 627.

PERIODIC SEQUENCES WITH AUTO-CORRELATION PROPERTIES
JPL Res. Summ., vol. 1, no. 36-4, June/July 1960, p. 62/63.

. . . A program has been written for the IBM-704 which computes all of the most general prime implicants. . . consistent with a given partially specified Boolean function. . . .

CHAIN CODES AND THEIR ELECTRONIC APPLICATIONS
F. G. Heath, et al., Proc. Instn. Elect. Engrs. Pt. C, vol. 108, no. 13, March 1961, p. 50/57.

A type of binary digital code is described which is easily generated by computer circuits. The important properties of these codes are described, and various electronic applications enumerated. . . .

COMPUTER SIMULATION OF THE USE OF GROUP CODES WITH RETRANSMISSION ON A GILBERT BURST CHANNEL
W. R. Cowell, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 577/585.

A study of error control by coding was made by Monte-Carlo simulation of a burst-noise channel on an IBM (International Business Machines) 7090. Using short group codes, comparisons were made between correction and detection with retransmission. Also, the effect of interleaving the code words was studied. Error detection with retransmission showed a consistently better performance than error correction and the time division resulting from interleaving was effective in combatting burst type error patterns. . . .

CASCADED BINARY ERROR CODES. PART 2. DECODING ALGORITHM FOR COMPONENT CODES
W. Altar, Aerospace Corp., Los Angeles, Calif., Rept. no. TDR 169 3250, 42TN2, 21 Oct. 1963, 97 p., AD 431 842.

Cascading of well-behaved group codes of moderate size, such as the Golay codes and some Hamming codes, permits the generation of codes of large overall size which can be stepwise decoded using the exhaustive and convenient decoding algorithms of the component codes. . . For the Golay (23, 12) code, an expedient and exhaustive algorithm requiring in the order of two matrix multiplications on the average for 23 digits is presented. This code permits correction of all errors of multiplicities 1, 2, 3. . . . An SDS 920 all-purpose digital computer has been programed to (a) instrument the Golay (23, 12), decoding algorithm and (b) execute a statistical

survey of 80 different implementations of the algorithm, including computation of performance parameters. . . .

SOME OPTIMUM PROCESSORS FOR MODERN COMMUNICATIONS AND CONTROL APPLICATIONS
A. H. Sepahban, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 768/792, 17 refs.

Engineering examples of data and signal processing problems from communications coding and control applications are presented to demonstrate the importance of a judicial selection of the mathematical approach to problem solution in the choice of optimum processor for each application. . . special purpose stored-program flexibility. . . and often efficiency and economy in their design and operation. . .

Coding for signal detection by matched filter correlation of signal trains is compared with pure error correction coding. Digital processors for implementation of these two schemes are also compared.

AN ERROR-CORRECTING PROCEDURE FOR THE PERFECT GOLAY (23, 12) CODE
J. Widrewitz, RADC, Griffiss Air Force Base, N. Y., RADC RAW TM 63 7, Aug. 1963, 13 p., AD 415 421.

. . . particularly effective. . . the associated UNIVAC 1103A computer decoding scheme. Allowable range in probability of binary digit error is established. Finally, estimated minimum and maximum computer time required for the error-correction procedure is given.

Related Publications:

CYCLIC DECIMAL CODES FOR ANALOG-TO-DIGITAL CONVERTERS
J. A. O'Brien, Trans. AIEE, Commun. and Electronics, vol. 75, no. 1, May 1956, p. 120/122.

ERROR-CORRECTING CODES—LINEAR PROGRAMMING APPROACH
E. J. McCluskey, Jr., Bell Syst. Tech. J., vol. 38, no. 6, Nov. 1959, p. 1485/1512.

. . . Two theorems are proved that characterize the matrices used to construct systematic error-correcting codes. A lower bound on the number of required check bits is derived, . . . A linear program whose solutions correspond directly to a minimum-redundancy error-correcting code is derived . . . Explicit solutions in closed form that specify the codes directly are derived for the cases when the specified code parameters satisfy certain restrictions.

AN ERROR-CORRECTION PROCEDURE FOR A CLASS OF BOSE-CHAUDHURI CODES
A. L. Duquette, et al., JPL Res. Summ., no. 36-14, Feb./March 1962, p. 41/44.

Bose-Chaudhuri codes are cyclic codes that are best defined in terms of the roots of the generator polynomial.

In this paper an error-correction procedure will be given that will apply to a large class of Bose-Chaudhuri codes and that will correct all error patterns that are correctible by a given code.

PERFORMANCE VS COMPLEXITY OF SOME NEW DECODERS FOR THE BINARY ERASURE CHANNEL
M. E. Mitchell, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 36.(Appendix E).

Summary only . . . decoding techniques for the binary erasure channel (BEC) have been investigated. . . three new types of BEC decoders have been obtained, each having unusual simplicity even for long codes, as evidenced by their approximately linear increase in complexity with code length. . .

Section 2.73
Elementary Block Codes

2.730: Protective Block Codes in General

Included: Group codes; Systematic codes.

Cross References: Cyclic codes in general (2.740); Bose-Chaudhuri codes (2.742); Polynomial codes (2.740).

Principal Publications:

A CLASS OF SYSTEMATIC CODES FOR NON-INDEPENDENT ERRORS
N. M. Abramson, IRE Trans. Inform. Th., vol. IT-5, Dec. 1959, p. 150/157.

. . . will correct all single errors and all double errors which occur in adjacent digits. These codes use significantly fewer checking digits than codes which correct all double errors. . . . these codes may be instrumented in a strikingly simple fashion.

ERROR-CORRECTING CODES—A LINEAR PROGRAMMING APPROACH
E. J. McCluskey, Jr., Bell Syst. Tech. J., vol. 38, no. 6, Nov. 1959, p. 1485/1512.

. . . Two theorems are proved that characterize the matrices used to construct systematic error-correcting codes. . . .

CONSTRUCTION OF RELATIVELY MAXIMAL, SYSTEMATIC CODES OF SPECIFIED MINIMUM DISTANCE FROM LINEAR RECURRING SEQUENCES OF MAXIMAL PERIOD
C. N. Campopiano, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 523/528.

ON CONSTRUCTING GROUP CODES
R. B. Benerji, Inform. Control, vol. 4, no. 1, March 1961, p. 1/14.

The problem of constructing systematic error correcting codes has been stated as follows, "Construct a group code such that each word representing an error pattern to be corrected lies in a separate coset." A computational method is described which will generate such codes of any given word length correcting any arbitrarily chosen set of error patterns. The method suggested by Sacks (1958) turns out to be a special case of the method here described, where the set of error patterns are the set of all n-tuple errors.

Codes having up to 10 check bits have been constructed using this method for correcting double and triple errors as well as burst-type errors of 3 digit width. The computation for each code took an LGP-30 computer 3 to 4 hr. The resulting codes have been compared to other known codes. . . .

APPLICATION OF BINARY ERROR-CORRECTING CODES IN TRANSMISSION CHANNELS OF DISCRETE INFORMATION
L. M. Fink, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 10, 1961, p. 1/8.

By means of asymptotic expressions for the equivalent error probability we derive conditions of "acceptability" of correcting code, which are satisfied by very few of the codes described in the literature. In fading channels these conditions can be made less rigid, if we allow for a decorrelation error upon construction of the code. . . . For group (systematic) codes, and also for any error-correcting codes in which closed code combinations of definite length are used . . . the equivalent error probability practically agrees with the "specific error probability", introduced by V. I. Siforov. . .

SIMPLE DERIVATION OF THE LOWER ESTIMATE OF THE NUMBER OF CHECKING SYMBOLS IN A SYSTEMATIC CORRECTING CODE
A. A. Kharkevich, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 7, July 1962, p. 78/79.

A THEOREM APPLYING TO CORRECTING CODES
A. A. Kharkevich, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 5, May 1962, p. 79/80.

A uniform block code is examined. . . . theorem defines the correcting capacity of a code. . . .

GENERALIZED CODING AND UNIFORM FINITE MEMORY CODES
T. J. Wagner, Electronics Research Lab., U. of Calif., Berkeley, 26 Dec. 1962, 35 p., AD 408 706.

A general framework for encoding and decoding is presented which includes block coding. The key concept used with the generalized codes is that of decoding rate. . . Uniform finite memory codes are defined from the general framework. . . is defined for these codes but what its value is remains an open question. . .

AN OPTIMUM IDENTIFYING DEVICE FOR SYSTEMATIC CODES AND CERTAIN TYPES OF CHANNELS
I. I. Grusko, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 20 March 1963, 10 p., incl. illus., table, 4 refs., Trans. no. FTD-TT-63-248 from Izvestiya Akademii Nauk SSSR, OTN, Energetika i Avtomatika, No. 3, p. 105/109, 1961, AD 402 454.

A THEOREM ON THE DISTRIBUTION OF WEIGHTS IN A SYSTEMATIC CODE
J. MacWilliams, Bell Syst. Tech. J., vol. 42, no. 1, Jan. 1963, p. 79/94.

A systematic code of word length n is a subspace of the vector space of all possible rows of n symbols chosen from a finite field. The weight of a vector is the number of its nonzero coordinates; clearly any given code contains a certain finite number of vectors of each weight from zero to n. This set of integers is called the spectrum of the code, and very little is known about it, although it appears to be important both mathematically and as a practical means of evaluating the error-detecting properties of the code.

In this paper it is shown that the spectrum of a systematic code determines uniquely the spectrum of its dual code (the orthogonal vector space). . . .

PRINCIPLES OF SYSTEMATIC CODING FOR ERROR CORRECTION
B. W. Russell, Electronic Warfare Div., Air Force Avionics Lab., Aeronautical Systems Div., Wright-Patterson Air Force Base, Ohio, Rept. for Jan. 1962-March 1963, ASD TDR 63 439, June 1963, 56 p., AD 411 767.

. . . an elementary discussion of the principles of systematic, or "group" binary codes as used in digital type communications systems. . . . The importance and salient features of maximum likelihood detection are stressed. The cost and effectiveness of simple codes are discussed in general terms. . . . The problem of comparing the information transfer efficiency of coded and uncoded systems is considered and quantitative results are given for a couple of simple short codes.

Related Publications:

POLYNOMIAL CODES OVER CERTAIN FINITE FIELDS
I. S. Reed, et al., J. Soc. Industr. Applied Math., vol. 8, no. 2, June 1960, p. 300/304.

A NOTE ON OPTIMUM BURST-ERROR-CORRECTING CODES
B. Elspas, et al., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 39/42.

2.732: Hamming Codes

Included: P-nary Hamming codes; Generalized Hamming codes.

Cross References: Non-binary protective codes (2.760).

Principal Publications:

PERFORMANCE CHARACTERISTICS OF HAMMING CODES
W. Altar, Westinghouse Res. Lab. Res. Rept., 8-1040-R11, March 1958, p. 1/53.

THE NOISE-PROOF FEATURE OF THE HAMMING CODE (In Russian)
G. A. Shastova, Radiotekhnika i Elektronika, vol. 3, 1958, p. 24/37.

A comparison is made between the noise-proof feature of the information transmission by the Hamming code, by the simple binary code and by the code with repetitition and parity check.

COMMENTS ON A PAPER BY WAX (Correspondence)
L. D. Grey, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 270.

In a recent article, Wax determined upper bounds for the maximum number of code symbols in a Hamming code of length n and distance D. The purpose of this note is to point out a simple argument which will result in an improvement on Wax's bound when D is small compared with n. . . .

THE APPLICATION OF A HAMMING ERROR CORRECTING CODE TO A STANDARD TELETYPE EQUIPMENT
R. W. Levell, J. Brit. Instn. Radio Engrs., vol. 22, no. 5, Nov. 1961, p. 377/392.

. . . describes apparatus which enables a standard single-channel teletype equipment to be converted for use with a Hamming error correcting code. The added apparatus is of small size and involved little interference with existing equipment. . . .

SEQUENTIAL GENERATION AND DECODING OF THE P-NARY HAMMING CODE (Correspondence)
A. B. Marcovitz, IRE Trans. Inform. Th., vol. IT-7, no. 1, Jan. 1961, p. 53/54.

. . . linear sequential circuits operating over a modular field may be used to generate and decode single- and multiple-error correcting codes. This note is concerned with the possibility of generating and decoding Hamming codes with the same type of circuit, which has the feature of requiring only as many delays as there are checking digits, and also leads to a simple decoder . . .

EFFECTIVE POWER GAIN USING HAMMING CODES
E. C. Posner, JPL Res. Summ., no. 36-13, Dec./Jan. 1961, p. 35/37.

ROOK DOMAINS AND GENERALIZED HAMMING CODES
A. W. Hales, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 33/34.

UPPER BOUNDS FOR ERROR-DETECTING AND ERROR-CORRECTING CODES (Correspondence)
L. Norwood, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 58.

In the excellent paper of Wax and the subsequent note of Lipp, the conjecture of Laemmel is cited that the best value actually found for the number of sequences of length 14 with a minimum Hamming distance of 5 is "48(?)". Here it will be shown that this number has been increased to 64, by displaying a specific error detecting and correcting code. . . .

PERFORMANCE OF HAMMING CODES
R. G. Marquart, et al., IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 4, Dec. 1963, p. 115/126.

Evaluation of the performance of error-correcting codes has, in the past, been severely hampered by the lack of functional relationships between the uncoded and coded binit error rates. In this paper, such relationships yielding the exact decoder output error rates are developed for Hamming SED codes . . . and for Hamming SEC/DED codes . . . In addition, for the DED

.codes, a similar family of formulas are derived for the probability that a received information binit is contained in a word containing an error pattern that can be detected but not corrected. . . .

Related Publications:

A CYCLIC CODE FOR DOUBLE ERROR CORRECTION
C. M. Melas, IBM J. Res. Developm., vol. 4, no. 3, July 1960, p. 364/366.

. . . using maximal-length shift-register sequences . . . The codes are systematic and can be readily constructed for any block length. They can be implemented in a very simple manner, described by Meggitt . . . A criterion is also given which can be applied to the construction of sequence codes of arbitrary Hamming distance. . . .

ON SOME CONNECTIONS BETWEEN THE DESIGN OF EXPERIMENTS AND INFORMATION THEORY
R. C. Bose, Case Inst. of Tech., Cleveland, Ohio, 1962, 15 p., AD 408 295.

The interconnection between the theory of confounding and fractional replication developed by Fisher, Finney, Bose and Kishen, and the theory of error-correcting codes due to Hamming and Slepian are discussed . . . the packing problem . . . finding the maximum possible number of distinct points in the finite projective space PG(r=1, s) . . .

A CODE SEPARATION PROPERTY (Correspondence)
D. L. Cohn, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 382/383.

. . . comments on a coding property relating to the Hamming distance property. This work was motivated by a search for a selective station calling code. . . .

ON THE USE OF COSET CODES IN ASYMMETRIC CHANNELS (Correspondence)
C. V. Freiman, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 118.

. . . a coset code is formed whenever an n-place binary sequence other than a code word is added to each of the code words of a redundant n-place binary group code. In this communication we shall show that any coset code formed from a close-packed single error-correcting (Hamming) code outperforms that code in any memoryless binary channel of nonzero capacity which is not perfectly symmetric. . . .

2.733: Golay Code and Related Linear Recurrent Codes

Included: Linear-recurrent codes; Golay (23, 12) code; Perfect Golay code.

Cross References: Linear error correcting codes in general (2.711); Cyclic codes in general (2.740); Bose-Chaudhuri codes (2.742).

Principal Publications:

ON DECODING LINEAR ERROR-CORRECTING CODES–I
N. Zierler, IRE Trans. Inform. Th., vol. IT-6, no. 4, Sept. 1960, p. 450/459.

LINEAR CODES FOR SINGLE ERROR CORRECTION IN SYMMETRIC AND ASYMMETRIC COMPUTATIONAL PROCESSES
A. J. Bernstein, et al., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 29/34.

CASCADED BINARY ERROR CODES. PART 2. DECODING ALGORITHM FOR COMPONENT CODES
W. Altar, Aerospace Corp., Los Angeles, Calif., Rept. no. TDR 169 3250, 42TN2, 21 Oct. 1963, 97 p., AD 431 842.

Cascading of well-behaved group codes of moderate size, such as the Golay codes and some Hamming codes, permits the generation of codes of large overall size which can be stepwise decoded using the exhaustive and convenient decoding algorithms of the component codes . . . For the Golay (23, 12) code, an expedient and exhaustive algorithm requiring in the order of two matrix multiplications on the average for 23 digits is presented. This code permits correction of all errors of multiplicities 1, 2, 3. . . . An SDS 920 all-purpose digital computer has been programmed to (a) instrument the Golay (23, 12), decoding algorithm and (b) execute a statistical survey of 80 different implementations of the algorithm, including computation of performance parameters. . . .

A DECODING PROCEDURE FOR MULTIPLE-ERROR-CORRECTING CYCLIC CODES
T. Kasami, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 134/138.

Applications are made to the cyclic Golay code, the Bose-Chaudhuri (63, 45), (31, 16), (31, 11) codes and the (41, 21) cyclic codes. A block diagram for decoder for the Golay code is shown. . . .

AN ERROR-CORRECTING PROCEDURE FOR THE PERFECT GOLAY (23, 12) CODE
J. Widrewitz, RADC, Griffiss Air Force Base, N. Y., RADC RAW TM, Aug. 1963, 13 p., 63 7, AD 415 421.

. . . particularly effective . . . the associated UNIVAC 1103A computer decoding scheme. Allowable range in probability of binary digit error is established. Finally, estimated minimum and maximum computer time required for the error-correction procedure is given.

Related Publications:

LINEAR-RECURRENT BINARY ERROR-CORRECTING CODES FOR MEMORYLESS CHANNELS
W. L. Kilmer, IRE Trans. Inform. Th., vol. IT-7, no. 1, Jan. 1961, p. 7/13.

. . . analysis of recurrent-type parity-check, error-correcting codes for memoryless, binary symmetric channels. These codes are defined to consist of message sequences augmented by insertions of r successive parity digits every b successive message digits . . . An example is given of a linear-recurrent code which has a lower probability of error than the best comparable block code, and several outstanding problems are discussed.

A 32-POINT n = 12, d = 5 CODE (Correspondence)
M. Nadler, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 58.

2.734: Reed-Muller Codes

Included: Tree-like structure of block codes; Generalized Reed-Muller codes; Fermat numbers; Lambert irrationals; Reed-Solomon codes.

Not Included: Generations for RM codes.

Cross References: General coding theory (2.110); Theory of protective coding (2.710); Theory of PN sequences (2.121); Reed-Solomon higher order codes (2.760).

Principal Publications:

DECODING GROUPS FOR REED-MULLER CODES
N. Zierler, JPL Res. Summ., no. 36-8, Feb./March 1961, p. 51.

. . . In spite of the fact that the Reed decoding procedure for the Reed-Muller codes is quite efficient, it is of interest to apply the general method to these codes . . .

REED-MULLER CODES, FERMAT NUMBERS, AND LAMBERT IRRATIONALS
S. W. Golomb, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 55/57.

GENERALIZED REED-MULLER CODES
E. Weiss, Inform. Control, vol. 5, no. 3, Sept. 1962, p. 213/222.

Related Publications:

ERROR CORRECTING CODES
JPL Res. Summ., vol. 1, no. 36-7, Dec./Jan. 1960, p. 61/62.

. . . a voluminous literature has been accumulating on the construction and, more recently, on the decoding of error-correcting codes. . . . It has been only a year, however, since a discovery of Bose and Ray-Chaudhuri, with subsequent developments by Peterson, Gorenstein, and Zierler . . . has provided many highly efficient codes, with minimal decoding procedures, for the correction of errors in a wide variety of channels. It should be emphasized that in exchange for the extremely high efficiency-and encoder simplicity of these codes, one has to contend with a certain more-or-less irreducible complexity of decoding equipment. . . . It is planned to instrument one of these codes in order to demonstrate its feasibility and for possible future application. . . . The original uncoded message may be any sequence of 75 bits . . . The block of 155 bits is transmitted, and the decoder will reproduce the 75-bit message correctly when the received 155-bit block contains errors of the following types: Any 8-digit errors . . . Any 4 error clusters of length 6 or less . . . Any 2 error clusters of length 16 or less. . . . This performance may be compared with the Lincoln Laboratory Reed-Muller equipment which encodes 64-bit messages into 128-bit blocks and can correct any 7-bit errors but almost no others. . . .

TREE-LIKE STRUCTURE OF BLOCK CODES (Correspondence)
D. M. Jones, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 384/385.

. . . By way of illustration, the message set for a Reed-Muller code, in which 4 information digits are encoded into 8 transmitted digits, is shown in tree form. . . .

2.735: Iterated Codes

Included: Planar codes; Matrix type of codes; Low-density parity-check codes; Elias codes.

Cross References: Hamming codes (2.732); Golay code (2.733); Block codes in general (2.730).

Principal Publications:

ERROR CORRECTING CODES AND THEIR IMPLEMENTATION FOR DATA TRANSMISSION SYSTEMS
J. E. Meggitt, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 234/244.

. . . a practical automatic error-correcting system that may be applied to many data transmission problems. It is particularly suited to the correction of bursts of errors . . . It is so simple that it can readily be incorporated into much existing equipment. In the system, messages are transmitted in blocks and each block is coded separately. The codes used within the blocks are cyclic codes. This means that coders and decoders employ linear feedback shift registers to form check digits and to correct errors. The basic ideas are presented in terms of the hardware components to which the system gives rise and analyzed afterwards in terms of mathematics so that it is easy for the engineer to see, at once, what is involved. . . .

CERTAIN SPECIAL ERROR-CORRECTING CODES OF MATRIX TYPE
G. B. Ol'derogge, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 7, July 1963, p. 12/18.

Error-correcting binary codes in which parity-check symbols are added to the rows and columns of two matrices, specially made up from the sequence of information symbols are considered. . . . permit detection and correction of single, double and triple errors . . . and . . . detection of quadruple errors. . . . the proposed code is close to optimum. . . .

Related Publications:

LOW-DENSITY PARITY-CHECK CODES
R. G. Gallager, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 21/28.

A low density parity-check code is a code specified by a parity-check matrix with the following properties: each column contains a small fixed number $j \geq 3$ of 1's and each row contains a small fixed number $k > j$ of 1's. The typical minimum distance of these codes increases linearly with block length for a fixed j. . . . the typical probability of decoding error decreases exponentially with block length for a fixed rate and fixed j. . . .

2.738: Other Elementary Block Codes

Included: Wagner code; Wagner's correction scheme; "Wagnerized" codes.

Principal Publications:

WORD ERROR RATE FOR GROUP CODES DETECTED BY CORRELATION AND OTHER MEANS
C. M. Hackett, Jr., IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 24/33.

. . . Correlation detection, digital decoding, straight Wagner codes, "Wagnerized" codes, and direct transmission are covered. . . .
. . . The purpose of this paper is to derive an accurate estimate of the correlation performance of any group code perturbed by white Gaussian noise . . .

THE NOISE IMMUNITY OF OPTIMUM HIGHER BINARY CODES
N. P. Khvorostenko, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 12, Dec. 1962, p. 1/8.

Expressions characterizing the noise immunity of Wagner's correction scheme for FSK and PSK systems are obtained under the following conditions: fluctuation noise is present, the amplitudes of the received signals are Rayleigh distributed, and no correlation exists between either fading or noise at instants of sampling different positions of a code word.
It is shown that Wagner's correction scheme is optimum in the sense of minimizing the mean probability of incorrect detection of a code word, and is sufficiently close to optimum in the sense of minimizing the mean probability of incorrect detection of each information symbol of this code word. . . .

Section 2.74
Cyclic Block Codes

2.740: Cyclic Block Codes in General

Included: Cyclic permutation error-correcting codes; Ring codes; Polynomial codes; Theory of weight distribution; Cyclic codes from irreducible polynomials; Comma free error-correcting codes; Punctured cyclic code; Decoding procedure for cyclic codes; Perfect punctured q-ary codes; Cyclic behaviors of sequence generators; Cyclic spot error-correcting codes; Prange code (21, 11); Solomon-Stiffler codes; Punctured cyclic codes for error correction.

Not Included: Shift register design; Code generators.

Cross References: Cyclic codes for double error correction (2.773); Multiple error-correcting codes (2.774); M-sequence codes (2.121); Comma free redundancy reducing codes (2.211); Higher order codes (2.760); Cyclic Golay code (2.733); Quaternary cyclic codes (2.760); Punctured cyclic codes in general (2.121).

Principal Publications:

SOME CYCLIC ERROR-CORRECTING CODES WITH SIMPLE DECODING ALGORITHMS
E. Prange, Air Force Cambridge Center, Rept. No. AFCRC TN-58-156, April 1958, 15 p., AD 152 386.

The properties of two cyclic error-correcting codes of length 21 in the two symbols 0 and 1 are studied. The codes are of orders 211 and 212 respectively. Coding for each code is by means of a linear recursion. Both codes have simple decoding algorithms. The second is quasi-perfect.

RING CODES
R. W. Brooks, Instrum. Control Syst., vol. 33, no. 6, June 1960, p. 954/955.

ANALYTICAL DEVELOPMENT AND IMPLEMENTATION OF AN OPTIMUM ERROR CORRECTING CODE
R. G. Fryer, Sylvania Technol., vol. 13, no. 3, July 1960, p. 101/110.

The theory relating to the construction of group error-correcting codes is outlined and used to construct a (15, 5)-triple-error-correcting code. It is shown that all (15, 5)-triple-error correcting codes have the same weight structure and all are optimum. Because of the ease of implementation of maximum-length binary shift-register sequences, the (15, 5)-code is then implemented using "m-sequences". The theory of m-sequences is also discussed. . . .

BINARY CODES FOR ERROR CONTROL
W. W. Peterson, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 15/21, 33 refs.

The most promising class of codes for implementation at the present are cyclic codes. The burst-error correcting cyclic codes are especially attractive from the point of view of implementation and a simplified block diagram for implementing a practical example of such a code will be shown and discussed.

POLYNOMIAL CODES OVER CERTAIN FINITE FIELDS
I. S. Reed, et al., J. Soc. Industr. Applied Math., vol. 8, no. 2, June 1960, p. 300/304.

EXPERIMENTAL DETERMINATION OF CYCLIC BEHAVIOR OF SEQUENCE GENERATORS
JPL Res. Summ., vol. 1, no. 36-4, June/July 1960, p. 63/64.

Consider an M-stage shift register with an appropriate feedback logic to generate a desired periodic sequence. If this period is less than 2^M, there will exist possible starting positions (vectors) for the shift register that do not belong to the desired cycle. The question arises as to whether these vectors will lead into the desired cycle, or perhaps into separate closed cycles. In particular, it is desired to know specifically which, if any, of the 2^M possible vectors do not lead into the desired cycle. This summary describes an experimental method of answering this question. . . .

RELIABLE DATA TRANSMISSION THROUGH NOISY MEDIA—A SYSTEMS APPROACH
C. M. Melas, Commun. and Electronics, vol. 80, no. 57, Nov. 1961, p. 501/504.

. . . Transmission errors can be corrected either by adding redundancy bits to the information to generate an error correcting code, or by automatically retransmitting the message when erroneously received. The relative merits of the two techniques are discussed in terms of both error control and systems compatibility. A class of powerful and easily implemented cyclic error detection and correction codes was recently developed which, in combination with automatic retransmission, should give effective error protection. . . .

PERFORMANCE OF ERROR-CORRECTING CODES
M. E. Mitchell, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 72/85.

Binary decoding of relatively short codes corrupted by Gaussian noise or pulse interference has been considered in applications

for which the minimum useful information block length is unity, equal to the information bit capacity of a code, or equal to an integral multiple of the information capacity of a code. . . . results . . . characterized by the performance criterion of minimizing error rate and transmitter power, with only minor restrictions on transmission bandwidth . . . Relatively short codes (10 to 50 information bits) of moderate redundancy (40 to per cent) are available which can reduce bit error rates by factors of 10 to 400, or equivalently, permit 1 to 3 db reductions in transmitter power, when the coded system bit error rate is 10^{-6} (Gaussian noise). . . . These same codes can alternatively reduce word error rates by factors of 10 to 10^4 . . . Under worst-case pulse interference, these codes permit 4 to 7 db reductions in transmitter power for average word error rates less than 20 per cent. . . . All of these codes are easily encoded and decoded. Considered are: cyclic binary group codes. The (15, 7) code is now known as a Bose-Chaudhuri code. The (21, 11) code was discovered by Prange . . . The (23, 12) code was first discovered by Golay and later by Paige. . . .

SIMPLE DECODERS AND CORRELATORS FOR CYCLIC ERROR-CORRECTING CODES
M. E. Mitchell, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 284/290.

Several promising techniques for instrumenting error-correcting codes are briefly described. . . . consist of digital decoders for the binary symmetric channel and for the binary erasure channel, and analog word correlators for variable and low bit-rate operation. . . .

A NOTE ON CYCLIC PERMUTATION ERROR-CORRECTING CODES
P. G. Neumann, Inform. Control, vol. 5, no. 1, March 1962, p. 72/86.

Error-correcting codes with n binary digits per code word are considered, in which the distances are fairly large (roughly n/2) and the number of code words relatively small (roughly 2n). . . .

SIMULTANEOUS ERROR CORRECTION AND BURST-ERROR DETECTION USING CYCLIC CODES
E. Posner, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 150/151.

THE USE OF INFORMATION SETS IN DECODING CYCLIC CODES
E. Prange, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S5/9.

A class of decoding algorithms using encoding-and-comparison is considered for error-correcting code spaces. Code words, each of which agrees on some information set for the code with the word r to be decoded, are constructed and compared with r. An operationally simple algorithm of this type is studied for cyclic code spaces A. . . .

CYCLIC CODES FROM IRREDUCIBLE POLYNOMIALS FOR CORRECTION OF MULTIPLE ERRORS
L. Zetterberg, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 13/20.

. . . A class of shift-register codes is studied . . . The errors are classified in terms of error cycles and a simple procedure is suggested to determine if error cycles are distinquishable. . . .

CYCLIC CODES AND DATA TRANSMISSION (In French)
S. Fontanes, Onde Electr., vol. 43, no. 431, Feb. 1963, p. 128/140.

. . . Cyclic codes contain a number of advantages, concerning in particular: the detection of interruptions, the correction of some of these. A study is made particularly of: the general characteristics of these codes, various ideas concerning polynomial analysis, their principal characteristics in connection with the detection and correction of errors, the design of circuits, the evaluation of various codes . . .

CYCLIC SPOT-ERROR-CORRECTING CODES
C. R. Foulk, Digital Computer Lab. U. of Illinois, Urbana, Rept. 141, 22 July 1963, 106 p., AD 414 155.

. . . Several methods of adding redundant information to a message have been suggested. The method which we shall investigate is an outgrowth of the parity check. . . .

CYCLICALLY PERMUTABLE ERROR-CORRECTING CODES
E. N. Gilbert, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 175/182.

In an asynchronous multiplex system a single band of radio frequencies carries many simultaneous conversations, each of which uses a distinguisable train of pulses as a "carrier." . . . The signals go directly from station to station without any intermediate central office to control them or to make allocations which avoid interference. . . .

OPTIMUM SHORTENED CYCLIC CODES FOR BURST-ERROR CORRECTION
T. Kasami, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 105/109.

The paper is concerned with the construction of the most efficient shortened cyclic (pseudo-cyclic) codes that can correct every burst-error of length b or less. These codes have the maximum number of information digits k among all shortened cyclic burst-b

codes with a given number of check digits r. The search procedure described is readily programmable for computer execution and efficient particularly for the case where r is close to the theoretical minimum of 2b check digits. . . .

A DECODING PROCEDURE FOR MULTIPLE-ERROR-CORRECTING CYCLIC CODES
T. Kasami, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 134/138.

Applications are made to the cyclic Golay code, the Bose-Chaudhuri (63, 45) (31, 16), (31, 11) codes and the (41, 21) cyclic codes. A block diagram for a decoder for the Golay code is shown. . . .

SOME EFFICIENT SHORTENED CYCLIC CODES FOR BURST-ERROR CORRECTION (Correspondence)
T. Kasami, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 252/253.

RESEARCH PROGRAM TO EXTEND THE THEORY OF WEIGHT DISTRIBUTION AND RELATED PROBLEMS FOR CYCLIC ERROR-CORRECTING CODES
H. Frazyer Mattson, Jr., Sylvania Electronic Systems, Waltham, Mass., Applied Research Lab., Summary Scientific Report, AFCRL-TDR-63-321; July 1963, 31 p., 7 refs., AD 449 000, N63-23375.

. . . Methods of induced representation are applied to questions of weight distribution in certain quadratic residue codes . . . main result . . . new code . . . In addition, a class of cyclic codes over GF (2) of block length 3p, where p is prime and 2 has even multiplicative order h modulo p are defined . . . Specifically, the codes correspond naturally and in such a way that each vector in the long code has twice the weight of the corresponding vector in the short code.

A COMBINATORIAL PROBLEM AND SIMPLE DECODING METHOD FOR CYCLIC CODES (Correspondence)
M. Nesenbergs, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 250/252.

ON A CLASS OF CYCLICALLY PERMUTABLE ERROR-CORRECTING CODES
P. G. Neumann, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 75/78.

Cyclically permutable codes have error-correcting properties which are invariant under arbitrary cyclic permutation of any of their code words. This paper summarizes the results of an empirical investigation of certain of these codes, which have parameters not covered by a previous paper of E. N. Gilbert. These codes are thought to be nearly optimal. Estimates of the obtainable number of code words are given. The codes may be suitable for use in certain asynchronous multiplex communication systems. . . .

IMPLEMENTATION OF DECODERS FOR CYCLIC CODES (Correspondence)
L. D. Rudolph, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 259/260.

This communication describes three methods of implementing "syndrome decoders" for cyclic group codes. . . .

SINGLE BURST ERROR CORRECTION CAPABILITIES OF BINARY CYCLIC CODES
F. D. Schmandt, Rome Air Development Center, Griffiss Air Force Base, N. Y., RADC TDR63 301, Aug. 1963, p. 41, AD 418 725, N63-21458.

. . . a mathematical system which can be used to determine n and b of a binary cyclic code given (g(x)) . . .

PUNCTURED CYCLIC CODES
G. Solomon, et al., JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 100/104.

. . . a class of codes which are obtained from maximal length shift register codes by deleting or puncturing certain of their coordinates. The "punctured cyclic codes" thus obtained are shown to be optimum and an encoding and decoding procedure is outlined. In the demonstration of the optimality of these codes, a new group code is derived. This bound is always as good as and generally better than, the well-known Plotkin bound (Ref. 4).

PUNCTURED CYCLIC CODES: A DECODING PROCEDURE
G. Solomon, et al., JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 149/151.

. . . a single machine for all rates and fixed k encoder-decoder with full error-correcting capabilities becomes technically feasible and desirable. The decoding procedure presented here fulfills these requirements . . .

PERFECT PUNCTURED Q-ARY CODES
G. Solomon, et al., JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 185/187.

In SPS 37-20, Vol. IV, the authors presented a new class of optimal binary codes, along with a new bound for the largest minimum distance actually obtainable with an (n, k) binary group code. This optimal class of codes is now extended to include codes over an alphabet of q sumbols (q a prime power), and the bound previously obtained is generalized to the q-ary case. This class of codes contains as a sub-class the new codes of J. MacWilliams (Ref. 2)

(in both the binary and q-ary case). These results are derived here in a simpler, i.e., a more direct, arithmetical fashion.

A NEW DECODING PROCEDURE FOR PUNCTURED CYCLIC CODES
G. Solomon, et al., JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 184/185.

An alternate algebraic decoding procedure is presented here for the "perfect" punctured cyclic codes of Solomon-Stiffler (SPS 37-20, Vol. IV).

COMMA-FREE ERROR-CORRECTING CODES
J. J. Stiffler, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 151/155.

It is demonstrated that all (n,k) cyclic group error-correcting code dictionaries can be made comma-free without adding further redundancy or altering their error-correcting properties, provided that $k \leq (n-1)/2$.

Related Publications:

A CLASS OF MULTIPLE-ERROR-CORRECTING BINARY CODES FOR NON-INDEPENDENT ERRORS
P. Fire, Stanford Electronic Labs., Stanford University, July 1959, 27 p., AD 219 307.

A class of parity-check error-correcting codes is described. These codes have the peculiar property that the check word derived in the normal decoding process is composed of two subwords; one defining the errors, pattern and the other indicating the error pattern's location within the word.

A CYCLIC CODE FOR DOUBLE ERROR CORRECTION
C. M. Melas, IBM J. Res. Developm., vol. 4, no. 3, July 1960, p. 364/366.

. . . using maximal-length shift-register sequences . . . The codes are systematic and can be readily constructed for any block length. They can be implemented in a very simple manner, described by Meggitt . . . A criterion is also given which can be applied to the construction of sequence codes of arbitrary Hamming distance. . . .

ERROR CORRECTING CODES AND THEIR IMPLEMENTATION FOR DATA TRANSMISSION SYSTEMS
J. E. Meggitt, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 234/244.

. . . messages are transmitted in blocks and each block is coded separately. The codes used within the blocks are cyclic codes. This means that coders and decoders employ linear feedback shift registers to form check digits and to correct errors. The basic ideas are presented in terms of the hardware components to which the system gives rise and analyzed afterwards in terms of mathematics so that it is easy for the engineer to see, at once, what is involved. . . .

EQUIVALENCE OF CYCLIC SEQUENCES UNDER TRANSFORMERS OF THE AFFINE GROUP
E. C. Posner, et al., JPL Res. Summ., vol. 1, no. 36-10, June/July 1961, p. 17/21.

Cyclic sequences which differ only in time-origin have the same autocorrelation function; some sequences, notably those with two-level autocorrelations, are insensitive to certain permutations of the sequence terms. . . .

A NOTE ON OPTIMUM BURST-ERROR-CORRECTING CODES
B. Elspas, et al., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 39/42.

. . . These codes—generalizations of codes discovered by Abramson and Melas—are cyclic codes designed to correct any single burst of errors per n-digit word provided that the width of the burst (regarded cyclically) does not exceed a certain number of digits, . . .

BINARY CONTROLS FOR ERROR CONTROL
W. W. Peterson, Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 648/652.

. . . Several error-correcting codes will be listed with a brief description of their error-correcting capabilities and feasibility of their implementation. . . .

A WEIGHT FORMULA FOR GROUP CODES
G. Solomon, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S1/4.

. . . An explicit expression is given for the weights of any group code. . . . The formula is, in general, quite complicated and requires a computer for computation of its explicity form. However, for the new practical codes of a highly algebraic nature (Bose-Chaudhuri, Cyclic, Polynomial, Jump-Shift Register codes which are characterized by simple field parameters and polynomials), the formula emerges more pliable. . . .

SIMULTANEOUS MULTIPLE ERROR-CORRECTION AND BURST ERROR-DETECTION
E. C. Posner, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 98/99.

2.742: Bose-Chaudhuri Codes and Related Codes

Included: D. U. Ray-Chaudhuri and R. C. Bose codes; Quais-perfect double error correcting B. C. codes; Bose-Chaudhuri Hocquenghem coding system; Hocquenghem-Bose-Chaudhuri codes.

Cross References: Double error correcting codes (2.773); Burst error correcting codes (2.774).

Principal Publications:

ON A CLASS OF ERROR CORRECTING BINARY GROUP CODES
R. C. Bose, et al., Inform. Control, vol. 3, no. 1, March 1960, p. 68/79.

FURTHER RESULTS ON ERROR CORRECTING BINARY GROUP CODES
R. C. Bose, et al., Inform. Control, vol. 3, no. 3, Sept. 1960, p. 279/290.

. . . a sequel to the paper "On a class of error-correcting binary group codes," by R. C. Bose and D. K. Ray-Chaudhuri, appearing in Information and Control. . . The present paper generalizes the methods of the earlier paper and gives a method of constructing a t-error correcting code with n places for any arbitrary n.

TWO-ERROR CORRECTING BOSE-CHAUDHURI CODES ARE QUASI-PERFECT
D. Gorenstein, et al., Inform. Control, vol. 3, no. 3, Sept. 1960, p. 291/294.

. . . A method is also given. . . which suggests that no other nontrivial codes are close-packed. . . .

ENCODING AND ERROR-CORRECTION PROCEDURES FOR THE BOSE-CHAUDHURI CODES
W. W. Peterson, IRE Trans. Inform. Th., vol. IT-6, no. 4, Sept. 1960, p. 459/470.

ERROR CORRECTING CODES
JPL Res. Summ., vol. 1, no. 36-7, Dec./Jan. 1960, p. 61/62.

. . . It has been only a year . . . since a discovery of Bose and Ray-Chaudhuri, with subsequent developments by Peterson, Gorenstein, and Zierler. . . has provided many highly efficient codes, with minimal decoding procedures, for the correction of errors in a wide variety of channels. . . .

A DECODING PROCEDURE FOR DOUBLE-ERROR CORRECTING BOSE-RAY-CHAUDHURI CODES (Correspondence)
R.B. Banerji, Proc. IRE, vol. 49, Oct. 1961, p. 1585.

NONBINARY BOSE-CHAUDHURI CODES
R. P. Loomba, JPL Res. Summ., no. 36-13, Dec./Jan. 1961, p. 28/32.

A double coding scheme incorporating Bose-Chaudhuri codes in fields of more than two elements has been investigated. The scheme consists of encoding the message into several words of a binary code, and then encoding this message of binary words into a Bose-Chaudhuri code in a larger field. . . . In this investigation, the channel is assumed to be perturbed by additive white Gaussian noise.

ON THE NUMBER OF INFORMATION SYMBOLS IN BOSE-CHAUDHURI CODES
H. B. Mann, Mathematics Research Center, U. of Wisconsin, Madison, (Tech. summary rept. 249), Aug. 1961, 13 p., AD 264 829.

. . . Examples and proofs are presented and a table of values is given.

ON THE CONSTRUCTION OF MINIMALLY REDUNDANT RELIABLE SYSTEM DESIGNS
D. K. Ray-Chaudhuri, Bell Syst. Tech. J., vol. 40, no. 2, March 1961, p. 595/611.

. . . general mathematical theory for generating minimally redundant error-correcting codes for the scheme in question. . . . results in what are called "minimally redundant reliable systems." . . . An example is considered in detail showing how the mathematical theory can be actually applied.

AN ELECTRONIC DECODER FOR BOSE-CHAUDHURI-HOCQUENGHEM ERROR-CORRECTING CODES
T. C. Bartee, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 17/24.

. . . design and construction of an electronic error-correcting encoder and decoder for a communications channel. . . . The specific code used in the encoder described adds 35 digits, forming a 127-binary-digit code word which is then transmitted. The decoder . . . can correct all combinations of five or fewer errors which occur during transmission of the 127-digit block and detect all occurrences of ten or fewer errors. The encoder consists of a 35-stage shift register with feedback and a small control unit. . . .

AN ERROR-CORRECTION PROCEDURE FOR A CLASS OF BOSE-CHAUDHURI CODES
A. L. Duquette, et al., JPL Res. Summ., no. 36-14, Feb./March 1962, p. 41/44.

Bose-Chaudhuri codes are cyclic codes that are best defined in terms of the roots of the generator polynomial.

In this paper an error-correction procedure will be given that will apply to a large class of Bose-Chaudhuri codes and that will correct all error patterns that are correctible by a given code.

ON THE NUMBER OF INFORMATION SYMBOLS IN BOSE-CHAUDHURI CODES
H. B. Mann, Inform. Control, vol. 5, no. 2, June 1962, p. 153/162.

PERFORMANCE OF ERROR-CORRECTING CODES
M. E. Mitchell, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 72/85.

. . . Relatively short codes (10 to 50 information bits) of moderate redundancy (40 to 50 per cent) are available which can reduce bit error rates by factors of 10 to 400, or equivalently, permit 1 to 3 db reductions in transmitter power, when the coded system bit error rate is 10^{-6} (Gaussian noise). . . . Considered are: cyclic binary group codes. The (15, 7) code is now known as a Bose-Chaudhuri code. The (21, 11) code was discovered by Prange. . . The (23, 12) code was first discovered by Golay and later by Paige. . . .

A WEIGHT FORMULA FOR GROUP CODES
G. Solomon, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S1/4.

. . . An explicit expression is given for the weights of any group code. . . . The formula is, in general, quite complicated and requires a computer for computation of its explicity form. However, for the new practical codes of a highly algebraic nature (Bose-Chaudhuri, Cyclic, Polynomial, Jump-Shift Register codes which are characterized by simple field parameters and polynomials), the formula emerges more pliable. . . .

AUGMENTED BOSE-CHAUDHURI CODES WHICH CORRECT SINGLE BURSTS OF ERRORS (Correspondence)
A. J. Gross, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 121.

COMPARISON OF THE 3-OUT-OF-7 ARQ WITH BOSE-CHAUDHURI-HOCQUENGHEM CODING SYSTEMS
M. Nesenbergs, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 202/212.

The performance of coding schemes can be expressed by two criteria; the useful transmission rate R, and output character-error probability P. Both quantities are expressed in a form applicable to a binary forward channel coupled with an arbitrary feedback channel. . . . If the element errors are independent of each other a purely error-correcting arrangement looks attractive. If the errors are correlated (i. e., occur in bursts), error detection holds more promise. . . .

AN INVESTIGATION OF METHODS OF DETECTING AND CORRECTING ERRORS IN DATA TRANSMISSION SYSTEMS
W. W. Peterson, et al., Florida U., Gainesville Engineering and Industrial Experiment Station, AFCRL-64-121, Feb. 1964, 30 p., refs., AD 436 587, N64-19208.

. . . properties of Bose-Chaudhuri codes. Several theorems on coding have been found, and one potentially important property has been observed in many Bose-Chaudhuri codes, but it has not yet proved to be true in general. Slight progress on bit-loss-correcting codes is reported.

REAL-CHANNEL ASPECTS OF AN ERROR-FREE DATA TRANSMISSION SYSTEM FOR TOLL-GRADE TELEPHONE CIRCUITS
W. G. Schmidt, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 69/72.

. . . Utilizing the results of the error-detection code study by Fontaine and Gallager, a feedback system logic was designed around the use of the (255, 231) Hocquenghem-Bose-Chaudhuri code. . . .

Related Publications:

ERROR CORRECTING CODES AND THEIR IMPLEMENTATION FOR DATA TRANSMISSION SYSTEMS
J. E. Meggitt, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 234/244.

A NOTE ON A NEW CLASS OF CODES
G. Solomon, Inform. Control, vol. 4, no. 4, Dec. 1961, p. 364/370.

Error correcting codes of all Kk, p) group codes (p odd), i. e., linear mappings of k-tuples of zeros and ones into p-tuples of zero and ones, are viewed as a purely

algebraic problem. This problem concerns the zeros of certain polynomials on pth roots of unity. These polynomials are parameterized via elements of subgroups of the smallest field containing the pth roots of unity. . . .

Error correcting codes of all (k, p) group codes (p odd), i. e., linear mappings of

A PROTOTYPE SELECTIVE MONITORING SYSTEM FOR PHYSIOLOGICAL DATA
G. W. Morton, et al., Rec. Nat. Space Electronics Symp., 1963, no. 8.2.

. . . selective monitoring techniques to extract the significant information from data typical of that originating in a manned space vehicle. Use of these techniques substantially reduces the load on all portions of the transmission and analysis facilities. . . .

SOME RESULTS ON BURST-CORRECTING RECURRENT CODES
A. D. Wyner, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 139/152.

. . . A low-density-burst-correcting code, based on the Bose-Chaudhuri code, is also presented. . . .

Section 2.75
Other Protective Codes

2.752: Codes for Sequential Operation

Included: Variable length encoding; Error-limiting coding; Error-limiting variable length codes; SECO=self regulating error correction scheme; Convolution codes; Hagelbarger codes; Probabilistic decoding; Successive decoding; Sequential decoding.

Not Included: Theory of sequential machines.

Cross References: Sequential detection methods (2.854).

Principal Publications:

PATTERN OF DIGITS FOR CONVOLUTION CODES
M. A. Epstein, Mass. Inst. of Tech. Progress Report #52, Jan. 1959, p. 109/111.

VARIABLE-LENGTH BINARY ENCODINGS
E. N. Gilbert, et al., Bell Syst. Tech. J., vol. 38, no. 4, July 1959, p. 933/967.

. . . of the sort which could be used for the storage or transmission of information. Some of these, such as the prefix and finite delay properties, deal with the time delay with which circuits can be built to decipher the encodings. The self-synchronizing property deals with the ability of the deciphering circuits to get in phase automatically with the enciphering circuits. Exhaustive encodings have the property that all possible sequences of binary digits can occur as messages.

RECURRENT CODES: EASILY MECHANIZED BURST-CORRECTING, BINARY CODES
D. W. Hagelbarger, Bell Syst. Tech. J., vol. 38, July 1959, p. 969/984.

. . . capable of correcting multiple errors.

CONVOLUTION CODES THROUGH SUB-OPTIMIZATION
M. A. Epstein, Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 286/291.

Convolution codes are one of the most promising code types available for a binary channel as they are easily coded and decoded (3-6). Also, random convolution codes for the binary symmetric and binary erasure channels have a probability of error which, on the average, decreases exponentially with code length at a rate close to optimum.

EFFICIENT ERROR-LIMITING VARIABLE-LENGTH CODES
P. G. Neumann, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 292/304.

. . . Variable-length codes recursively defined by certain sequential machines are investigated. It is seen that the recursive definition may be used to control error propagation as well as to provide a conceptually simple decoding procedure. . . . Methods for obtaining efficient codes are discussed, and examples are given.

ON A CLASS OF EFFICIENT ERROR-LIMITING VARIABLE-LENGTH CODES
P. G. Neumann, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 260/266, 17 refs.

Variable length codes are considered whose code-word ends are defined by the occurrences in code text of particular sequences, called partition sequences. Sets of partition sequences are used in this fashion to define exhaustive codes. . . . Because of the partition sequences, these codes are quickly self-resynchronizing following errors. . . . used to encode natural languages. . . .

SECO: A SELF-REGULATING ERROR CORRECTING CODER-DECODER
K. E. Perry, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S128/135.

SECO is an efficient engineering realization of a coding-decoding scheme designed to use variable redundancy and feedback in a two-way communication system to increase the rate of information transfer between users connected by a channel having a slowly time-varying capacity. . . . The decoding computer is designed to detect channel errors with very high probability and to correct as many of these as it can, subject to the current channel condition and decoder state. When a detected error cannot be corrected easily, the decoder stops and uses the feedback channel to request retransmission at a lower information rate. . . .

A CLASS OF CONVOLUTION CODES
E.R. Berlekamp, Inform. Control, vol. 6, no. 1, March 1963, p. 1/13.

. . . describes a class of infinite convolution codes which are designed to minimize the time required to recover from an erasure burst on the binary erasure channel. It is shown that for any given rate, there exists a unique optimum erasure burst correcting code. For rates of the restricted form $R = n/(n + 1)$, an algorithm is given by which the code of this rate may be written down by inspection. For other rates, the codes can be determined by a more complicated procedure based on evaluating large binary determinants. . . .

ON ERROR-CORRECTING, VARIABLE-LENGTH CODES
L. Calabi, Parke Mathematical Labs., Inc., Carlisle, Mass., Scientific Report No. 9, (Rept. 7493-SR-9; AFCRL-64-9), Dec. 1963, 56 p., refs., AD 430 198, N64-15736.

Binary, variable length codes are introduced that are capable of detecting and correcting transmission errors. The study of prefix codes, and of block codes with distance d, are considered special cases of the theory developed in this report.

TEST FOR SYNCHRONIZABILITY OF FINITE AUTOMATA AND VARIABLE LENGTH CODES
S. Even, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 185/189.

A finite automaton is called synchronizable of Nth order if the knowledge of the N outputs suffices to determine the state of the automaton at one time during the last N outputs (including the initial and the final states). In an analogous manner synchronizability of Nth order is defined for variable length codes. The paper describes a test for synchronizability on a more general model, the coding graphs, and shows that finite automata and variable length codes are special cases of it. . . .

A HEURISTIC DISCUSSION OF PROBABILISTIC DECODING
R.M. Fano, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, no. 64/74.

. . . probabilistic decoding of digital messages after transmission through a randomly disturbed channel. The adjective "probabilistic" is used to distinguish the decoding procedures discussed here from algebraic procedures based on special structural properties of the set of code words employed for tranmission. . . . The first probabilistic decoding procedure of practical interest was presented by J.M. Wozencraft, in 1957, and extended soon thereafter by B. Reiffen. Equipment implementing this procedure has been built at Lincoln Laboratory and is at present being tested in conjunction with telephone lines.

REGULAR EXPRESSIONS AND VARIABLE LENGTH ENCODINGS (Correspondence)
B. Hazeltine, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 48.

. . . show how properties of an encoding can be deduced from a sequential circuit realizing a particular regular expression. . . .

APPLICATION OF LYAPUNOV'S DIRECT METHOD TO THE ERROR-PROPAGATION EFFECT IN CONVOLUTIONAL CODES (Correspondence)
J.L. Massey, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 248/250.

ON ERROR-LIMITING VARIABLE-LENGTH CODES (Correspondence)
P.G. Neumann, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 209.

ERROR-LIMITING CODING USING INFORMATION-LOSSLESS SEQUENTIAL MACHINES
P.G. Neumann, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 108/115, 16 refs.

An information-lossless sequential machine is essentially a machine whose input sequence may be recovered from knowledge of its output sequence. A situation is considered in which such a machine is used as the encoder for a communication system. . . . This paper investigates the effects of transient errors in such a system and shows that there are encoders for which the decoder is incorrect . . . Each such encoder has input sequences which resynchronize the encoder following errors, as well as output sequences which resynchronize the decoder. . . .

SEQUENTIAL DECODING ON A CHANNEL WITH SIMPLE MEMORY
J.E. Savage, Lincoln Lab., Mass. Inst. of Tech., Lexington, Group rept. no. 1964 5, ESD TDR 64 42, 2 April 1964, 23 p., AD 437 163.

A model for a binary channel with additive Markovian noise is presented. The behavior of the Sequential Deciding cutoff rate . . . for this channel is studied under various degrees of memory. . . .

SUCCESSIVE DECODING SCHEME FOR MEMORYLESS CHANNELS
J. Ziv, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 97/104.

. . . a new decoding scheme for random convolutional codes . . . is different from other effective decoding schemes, such as sequential decoding and low-density parity check codes. The new scheme yields (for a certain region of information rates) an upper bound on the average number of computations which is independent of the coding constraint length. Furthermore, unlike sequential decoding, a bound on the total number of computations (rather than just on the "incorrect subset") is derived in this paper. . . .

Related Publications:

A GENERAL METHOD OF APPLYING ERROR CORRECTION TO SYNCHRONOUS DIGITAL SYSTEMS
D. B. Armstrong, Bell Syst. Tech, J., vol. 40, no. 2, March 1961, p. 577/593.

It includes the familiar scheme of triplication and "vote taking" as a special case. In principle, the method permits the system to operate continuously, even when a fault is present or maintenance is being performed. . . .

LOW-DENSITY PARITY-CHECK CODES
R. G. Gallager, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 21/28.

TREE-LIKE STRUCTURE OF BLOCK CODES (Correspondence)
D. M. Jones, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 384/385.

An important property of the message sets associated with convolutional codes is their tree-like structure. This property simplifies the decoding procedure, in that it permits many sequences in the message set to be compared simultaneously to the received sequence. It is apparently not generally known that the message sets associated with many block codes also possess a tree-like structure. By way of illustration, the message set for a Reed-Muller code, in which 4 information digits are encoded into 8 transmitted digits, is shown in tree form. . . .

THRESHOLD DECODING
J. L. Massey, Massachusetts Inst. of Tech., Cambridge Research Lab. of Electronics, MIT-TR-410; 5 April 1963, 131 p., refs., AD 407 946, N64-14111.

Two procedures for decoding linear systematic codes, majority decoding and a posteriori probability decoding, are formulated. The essential feature of both methods is a linear transformation of the parity-check equations of the code into "orthogonal parity checks." The decoding decisions are then made on the basis of the values assumed by the orthogonal parity checks . . . circuitry for instrumenting these decoding rules is an ordinary threshold logical element. For this reason, these decoding rules are referred to as forms of "threshold decoding." It is shown that threshold decoding can be applied effectively to convolutional codes up to approximately 100 transmitted bits in length over an interesting range of rates . . .

A NOTE ON "VERY NOISY" CHANNELS
B. Reiffen, Lincoln Lab., Mass. Inst. of Tech., Lexington, June 1963, 5 p., AD 416 195.

. . . a "very noisy" channel is defined. This definition corresponds to many physical channels operating at low signal-to-noise ratio. . . . the computation cutoff rate for sequential decoding, R (comp), is shown to be one-half the capability, C . . .

SOME RESULTS ON BURST-CORRECTING RECURRENT CODES
A. D. Wyner, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 139/152.

. . . A definition of a recurrent code is given in a framework which renders it amenable to mathematical analysis. Codes which correct single, burst, and low-density (bursts of limited weight) errors are discussed. In each case bounds on the error free distance (guard space) required between bursts are obtained . . . A low-density-burst-correcting code, based on the Bose-Chaudhuri code, is also presented. . . .

ANALYSIS OF RECURRENT CODES
A. D. Wyner, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 143/156.

A definition of a recurrent code is given in a framework which renders it amenable to mathematical analysis. Recurrent codes for both independent and burst errors are considered, and a necessary and sufficient condition for either type of error correction is established. . . .

CODING AND DECODING FOR TIME-DISCRETE AMPLITUDE-CONTINUOUS MEMORYLESS CHANNELS
J. Ziv, Massachusetts Inst. of Tech., Cambridge Research Lab. of Electronics, RLE-TR-399; 31 Jan. 1963, 108 p., ref., AD 299 016, N64-18366.

A scheme for constructing a discrete signal space, for which sequential encoding-decoding methods are possible for the general continuous memoryless channel, is described. Random code selection is considered from a finite ensemble. The engineering advantage is that each code word is sequentially generated from a small number of basic waveforms . . . The application of sequential decoding to the continuous asymmetric channel is discussed. A new decoding scheme for convolutional codes, called successive decoding scheme for convolutional codes, called successive decoding, is introduced . . .

2.758: Any Other Protective Codes

Included: Kautz's codes; Decoding rules for the correction of scattered errors; Product codes: Hobb's codes; Cascaded binary error codes; Jump shift register codes.

Principal Publications:

CASCADED BINARY ERROR CODES. PART 1: PERFORMANCE CRITERIA FOR CASCADED AND OTHER ERROR CODES
W. Altar, Aerospace Corp., Los Angeles, Calif., Semiannual rept., 1 July-31 Dec. 1962, on Research and Experimentation on Design and Implementation of Error Correcting Codes of Low Density, (Rept. no. TDR-169(3250-42)TN-1), AD 298 269.

DECODING RULES FOR CERTAIN PRODUCT CODES
L. Calabi, et al., Parke Mathematical Labs., Inc., Carlisle, Mass., AFCRL 63 137, March 1963, 25 p., AD 409 453.

. . . products of binary group codes . . . Hobbs' codes . . .

DECODING RULES FOR KAUTZ'S CODES
H. G. Haefeli, Parke Mathematical Labs., Inc., Carlisle, Mass., AFCRL 63 514, Report nos. SR8, 7493SR8, Oct. 1963, 19 p., AD 424 051, N64-12289.

. . . can be applied to any Kautz's code . . . correct any number of scattered errors as well as any error burst within the theoretical performance of the code . . . practical importance comes from the possibility of introducing modifications to shorten the decoding work by considering only subclasses of codes. . . .

Section 2.76

2.760: Non-binary Protective Codes

Included: Maximum-weight codes for m-ary channels; Non-binary error correcting codes; Error correcting codes for multi-level transmissions; P-nary adjacent error correcting codes; Ternary protective codes; Non-binary Bose-Chaudhuri codes; Binary-non-binary coding; Cubes with zeros and ones; Quaternary cyclic codes; Non-binary PN sequences; Affine codes of order n; Non-linear quaternary codes; Reed-Solomon higher order codes.

Not Included: Multi-level PCM (1); Higher order data transmission systems (1).

Cross References: M-ary Gray codes (2.182); Perfect punctured q-ary codes (2.740); Cyclic codes in general (2.740); Theory of PN-sequences (2.127); Higher order codes in general (2.130); Reed-Solomon codes (2.734).

Principal Publications:

SOME PROPERTIES OF NONBINARY ERROR-CORRECTING CODES
C. Y. Lee, IRE Trans. Inform. Th., vol. IT-4, June 1958, p. 77/82.

RESULTS OF A GEOMETRIC APPROACH TO THE THEORY AND CONSTRUCTION OF NON-BINARY, MULTIPLE ERROR AND FAILURE CORRECTING CODES
B. M. Dwork, et al., W. Electronics Div. Adv. Development, April 1959, p. 1/15.

APPLICATION OF MODULAR SEQUENTIAL CIRCUITS TO SINGLE ERROR-CORRECTING P-NARY CODES
T. E. Stern, et al., IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 114/123.

A NOTE ON P-NARY ADJACENT-ERROR-CORRECTING CODES
B. Elspas, IRE Trans. Inform. Th., vol. IT-6, no. 1, March 1960, p. 13/15.

MAXIMUM-WEIGHT GROUP CODES FOR THE BALANCED M-ARY CHANNEL
C. W. Helstrom, IRE Trans. Inform. Th., vol. IT-6, no. 5, Dec. 1960, p. 550/555.

CONSTRUCTION OF NON-BINARY SELF-CORRECTING CODES AND EVALUATION OF THE NUMBER OF SIGNALS IN THEM (In Russian)
V. M. Ostianu, Dokl. Akad. Nauk, SSSR, vol. 135, no. 6, Dec. 1960, p. 1382/1384.

Non-binary codes, i.e., codes made up of several kinds of signals, are considered. Such signals when transmitted may contain errors. A mathematical discussion is presented in which a linear method of evaluating the signals in such codes is given.

SINGLE ERROR-CORRECTING CODES FOR NONBINARY BALANCED CHANNELS
C. W. Helstrom, IRE Trans. Inform. Th., vol. IT-7, no. 1, Jan. 1961, p. 2/7.

NONBINARY BOSE - CHAUDHURI CODES
R. P. Loomba, JPL Res. Summ., no. 36-13, Dec./Jan. 1961, p. 28/32.

A double coding scheme incorporating Bose-Chaudhuri codes in fields of more than two elements has been investigated. The scheme consists of encoding the message into several words of a binary code, and then encoding this message of binary words into a Bose-Chaudhuri code in a larger field. . . . In this investigation, the channel is assumed to be perturbed by additive white Gaussian noise.

INTRODUCTION TO NON-BINARY CODES, CODES WITH MINIMUM DISTANCE AND FINITE GEOMETRY (In Italian)
L. Lunelli, Rium Assoc. Elettrotech Ital., RC(62), Fasc. III, Paper 224, 19 refs., 1961, 9 p.

Explains the basic theory of group codes in the case of q symbols, (q being a prime number), and demonstrates the necessity for a precise definition of distance. By using concepts taken from finite geometry, it is shown that particular classes of codes with specified minimum distance can be constructed.

ERROR-CORRECTING CODES FOR MULTIPLE-LEVEL TRANSMISSION
J. MacWilliams, Bell Syst. Tech. J., vol. 40, no. 1, Jan. 1961, p. 281/308.

A q-level alphabet is defined as a row vector space over a finite field with q elements. The letters of the alphabet are the rows of the vector space, each consisting of n symbols from the ground field. The weight of a letter is the number of nonzero symbols it contains. The minimum weight of the letters of the alphabet, excluding zero, is denoted by d.

AN ERROR-CORRECTION CODE FOR QUATERNARY DATA TRANSMISSION
E. H. Scherer, Commun. and Electronics, vol. 80, no. 55, July 1961, p. 231/236.

. . . This paper presents an error-correction code and a suggested embodiment for encoder and decoder which may be used for improving a quaternary system. . . .

MUTUALLY DISTINGUISHABLE NONBINARY PN SEQUENCES
D. Anderson, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 96/97.

Since there are only limited numbers of binary PN sequences of a given length, a natural problem is the construction of periodic signals which are distinguishable, have good out-of-phase autocorrelation, and occupy the same bandwidth. This occurs, for instance, when it is desired to construct multiple-address systems for groups of satellites or to range several instrument packages simultaneously.

The system to be described here consists of sending, as signals, certain periodic sequences of phases and receiving them by the use of word detection.

CODES WITH CONSTANT DISTANCE BETWEEN CODE WORDS
R. Block, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 151/152.

In SPS 37-16, Vol. IV, p. 42/45, affine codes . . . were studied. These codes have the property that the distance between every two distinct words is exactly q. Here a study will be made of the class of codes with this constant distance property.

ON THE SIZE OF NONBINARY CODE DICTIONARIES
R. Block, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 152/153.

QUATERNARY CYCLIC CODES
A. L. Duquette, et al., JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 38/42.

Quaternary cyclic (linear) codes are especially interesting because the encoding can be done very compactly by means of shift registers. The four symbols in this case are taken to be the four elements of $GS(2^2)$, the finite field of four elements.

CUBES WITH ZEROS AND ONES
A. W. Hales, JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 35/36.

. . . the following problem, relating to coding over an n-symbol alphabet, was discussed: The cells of a hyperchessboard of dimension k and edge length n are to be colored in a maximum number of colors w (k,n) such that a rook placed anywhere will attack or occupy at least one cell of each color.

NONBINARY CODES AND PROJECTIVE PLANES
E. C. Posner, JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 42/45.

In an article of Golomb (RS 36-13, p. 23/24), it was shown that t orthogonal n X n latin squares correspond in a natural fashion to a code over an n symbol alphabet of length t + 2 with n^2 code words and minimum distance t + 1.

. . . it was suspected that a direct way of going from code to plane, and vice versa, exists. Throughout this article, n is taken as being ≥ 2.

CYCLIC IMPLEMENTATION OF AFFINE CODES
E. Posner, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 61/62.

In SPS 37-16, Vol. 4, p. 42, the notion of affine code of order n was defined as a code on an n-symbol alphabet of length n + 1 and minimum distance n with n^2 code words. A desarguian affine code is an affine code whose associated plane is desarguian; thus, n must be a prime power . In this note it will be demonstrated that if is a power of 2, the desarguian affine code of order can be implemented as a -ary cycle code. If is a power of an odd prime, the desarguain affine code is a shortened cycle code. . . .

NONLINEAR QUARTERNARY CODES
E. Posner, et al., JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 62/64.

It is the purpose of this note to discuss quaternary codes, including non-latin ones. A latin code is defined as follows: let q,n,r be integers ≥ 2. Consider codes on q symbols of length n and minimum distance r. A code is called latin if the number of words w in the code is q^{n-r+1}. . . .

ACADEMY OF SCIENCES OF THE USSR. LABORATORY OF INFORMATION TRANSMISSION SYSTEMS. PROBLEMS OF INFORMATION TRANSMISSION (Selected Articles)
Foreign Tech. Div., Air Force Systems Command, Wright Patterson Air Force Base, Ohio, 12 Oct. 1962, 57, p. incl. illus., 34 refs., (Trans. no. FTD-TT-62-888 from Akademiya Nauk SSSR. Laboratoriya Sistem Peredachi Informatsii, Problemy Peredachi Informatsii, No. 10, p. 5/23, 35/41, 42/48, 49/56, 1961), AD 287 733.

. . . The geometry of Boolean functions and self-correcting codes from the point of view of the Erlangen Program. The construction of nonbinary error-correcting codes and the bound of the number of signals in them. . . .

COLLINEATIONS IN A PLANE OF ORDER 10
M. Hall, Jr., et al., JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 137/144.

Recently, articles have appeared in SPS's showing the equivalence between finite projective planes and error-correcting codes. (See SPS 37-16, Vol. IV, p. 42/45; SPS 37-17, Vol. IV, p. 61/62; SPS 37-19, Vol. IV, p. 151/152 . . .) The general idea of the above SPS articles is to obtain codes from planes by first choosing a line as the line at infinity. . . . The codes obtained in this way are called affine codes of order n.

This article considers the problem of the existence of projective planes of order 10 with a special property - the possession of a nontrivial collineation.

SEVERAL CLASSES OF CODES GENERATED FROM ORTHOGONAL FUNCTIONS
P. Hsieh, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 88/91.

. . . In particular, discrete ternary codes using symbols -1, 0, 1 are constructed to form some classes of continuous codes. . . .

ADDENDUM ON BINARY-NONBINARY CODING
H. Rumsey, Jr., et al., JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 99/100.

MAXIMUM DISTANCE Q-NARY CODES
R. C. Singleton, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 116.

. . . In this paper, the class of codes with $d = r + 1$ and $N = q^k$ is considered. These codes will be called maximum-distance separable (M.D.S.) codes . . . The Reed-Solomon codes are a known class of M.D.S. code. . . . The

M.D.S. codes were investigated initially because of their usefulness in constructing constant-weight binary codes with large N and large binary distance for use as superimposed codes. . . .

PERFECT PUNCTURED Q-ARY CODES
G. Solomon, et al., JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 185/187.

. . . now extended to include codes over an alphabet of q symbols (q a prime power), and the bound previously obtained is generalized to the q-ary case. This class of codes contains as a sub-class the new codes of J. MacWilliams (Ref. 2) (in both the binary and q-ary case). . . .

Related Publications:

ERROR RATES IN DATA TRANSMISSION
S. Reiger, Proc. IRE, vol. 46, May 1958, p. 919/920.

error rate reduction by the use of error correcting codes, gain obtainable by choosing signaling alphabets other than binary.

MULTIVALUED SWITCHING ALGEBRAS AND THEIR APPLICATION IN DIGITAL SYSTEMS
E. I. Muehldorf, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 467/480.

. . . For some applications . . . there is a need for a nonbinary switching algebra. The natural step from two to three leads from a binary switching algebra to a ternary switching algebra. . . .

CONSTRUCTION OF ERROR CORRECTING CODES USING FILTERING TECHNIQUES
T. E. Stern, Columbia University, School of Engng., N. Y., Tech. Rept. T-1/M; CU 4-59, July 1959, AD 218 673.

Nonlinear filtering techniques are used to develop systematic methods for the construction of close packed multilevel single error-correcting codes, coders and decoders. Coding and decoding are achieved through the use of linear modular sequential circuits followed by a nonlinear decision element. The synthesis of an appropriate decoding filter is based upon the selection of a matrix over the modular field GF(p), whose powers display periodicity with maximal length period. The properties of these matrices are shown to depend upon the properties of the elements of a Galois field and several theorems from Galois theory are in the selection of the decoding filter.

SOME REMARKS ON COMVENTIONAL AND REFLECTED BINARY CODES AND THEIR CIRCUIT REALIZATION
M. V. Pitke, et al., Matrix Tensor Quart., vol. 13, no. 1, Sept. 1962, p. 19/24.

. . . It is also observed that for number systems with radix 2, the transformations between the conventional codes ant their reflected counterparts are not linear.

AFFINE M-ARY GRAY CODES
M. Cohn, Inform. Control, vol. 6, no. 1, March 1963, p. 70/78.

. . . presents a nontable-lookup technique for generating a class of n-dimensional m-ary Gray codes for every pair (n, m) of integers. It does not seek to exhaust all such codes, but restricts itself to a class characterized by simple encoding and decoding schemes. . . .

POLYPHASE CODES WITH GOOD NONPERIODIC CORRELATION PROPERTIES
R. L. Frank, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 43/45.

N-phase codes are described which have an autocorrelation function with one main peak and very small side peaks. With N phases an N long pulse sequence is generated. Properties have been verified for N up to 8 and a rule for main peak-to-side-peak ratio is conjectured for larger N. For N greater than 5, the ratio is substantially better than the best ratios which have been shown for binary bipolar codes. Doppler shift effects appear to be similar to those of linear FM radar pulse compression . . . A comparison of the performance of higher-order polyphase codes with similar length binary codes indicates a superiority in the polyphase codes.

DISTRIBUTED SATELLITE CIRCUMGLOBAL COMMUNICATION TECHNIQUE STUDY
R. E. Graham, et al., Bell Telephone Lab., Inc., New York, Rept. for 11 Jan. 1962 - 11 March 1963, RADC TDR 63 216, 11 March 1963, 96, p. AD 408 269.

. . . propagation of errors resulting from the use of the 1-of-5 quaternary code . . .

CERTAIN SPECIAL ERROR-CORRECTING CODES OF MATRIX TYPE
G. B. Ol'derogge, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 7, July 1963, p. 12/18.

Error-correcting binary codes in which parity-check symbols are added to the rows and columns of two matrices, specially made up from the sequence of information symbols are considered. . . . permit detection and correction of single, double and triple errors . . . and . . . detection of quadruple errors. . . . the proposed code is close to optimum. . . .

A NEW DECODING PROCEDURE FOR PUNCTURED CYCLIC CODES
G. Solomon, et al., JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 184/185.

An alternate algebraic decoding procedure is presented here for the "perfect" punctured cyclic codes of Solomon-Stiffler (SPS 37-20, Vol. IV).

Section 2.77
Codes with Special Protective Characteristics

2.772: Error Detecting Codes

Included: Error checking for telegraphic signals; Burst error detecting codes; Erasure fill-in operation; Gauss-Jordan procedure; Error detection codes for asymmetric channels; Generalized parity checking; Unit distance error checking codes; FSK parity checking; Optimum block length in error checking schemes.

Not Included: Mathematical models of erasure channels (1).

Cross References: Burst error detecting codes (2.774); Codes for tne binary erasure channel (2.782); Elias codes (2.735); Failure detecting codes (2.184); Error locating codes (2.776); Null-zone detection methods (2.853).

Principal Publications:

ERROR-CHECKING FOR 5-CHANNEL TELEGRAPHIC TAPE
R. A. Barbeau, Commun. and Electronics, May 1958, p. 190/193.

GENERALIZED PARITY CHECKING
H. L. Garner, IRE Trans. on Electronic Comp., vol. EC-7, Sept. 1958, p. 207/213.

UNIT-DISTANCE ERROR-CHECKING CODES
W. H. Kautz, IRE Trans. Electronic Comp., vol. EC-7, June 1958, p. 179/180.

A NOTE ON ERROR DETECTION IN NOISY LOGICAL COMPUTERS
M. Eden, Inform. Control, vol. 2, no. 3, Sept. 1959, p. 310/313.

The proposal extends the range of the propositional variables so that residue class check symbols may be used in error detection. The principal consequence is that individual logical elements may be designed to process binary inputs with arbitrary reliability and nonzero channel capacity.

OPTIMUM BLOCK LENGTH FOR DATA TRANSMISSION WITH ERROR CHECKING
F. B. Wood, Commun. and Electronics, Jan. 1959, p. 855/861.

ERROR CHECKING POSSIBILITIES CONCEALED WITHIN THE 5-UNIT CODE
R. Steeneck, Western Union Tech. Rev., vol. 14, no. 2, April 1960, p. 69/71.

A NOTE ON ERROR DETECTION CODES FOR ASYMMETRIC CHANNELS
J. M. Berger, Inform. Control, vol. 4, no. 1, Mar. 1961, p. 68/73.

Recently the fixed weight codes, notably the four out of eight, have been adopted as transmission codes in some communication systems. . . . their advantages. . . in a completely asymmetric channel. . . The major disadvantage of the fixed weight code is the fact that it is nonseparable. . . It is our purpose here to describe some codes that are separable and which also detect all possible errors in a completely asymmetric channel. We will describe one simple such code in detail and give the results of comparison of some of its features with a fixed weight code. . . .

ERASURE FILL-IN FOR BINARY ERASURE CHANNEL
A. L. Duquette, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 64/66.

The concept of the binary erasure channel was first introduced by Elias (Ref. 8). Utilizing the properties of modulo 2 arithmetic, an analog of the Gauss-Jordan procedure (Ref. 9) may be employed. . .

An alternate decoding procedure for the binary erasure channel is given here which, for certain cyclic codes, has obvious advantages.

OPTIMAL ERROR DETECTION CODES FOR COMPLETELY ASYMMETRIC BINARY CHANNELS
C. V. Freiman, Inform. Control, vol. 5, no. 1, March 1962, p. 64/71.

The (n/2)-out-of-n code is proved to be the least redundant binary block code which permits the detection of all errors in completely asymmetric channels. It is then proved that the sum code of Berger, Smith, and Freiman is the least redundant of all separable codes of this type. . . . An efficient method of constructing separable codes which detect up to a given number, but not all, asymmetric errors is included as an appendix. . . .

A CLASS OF ERROR-DETECTING CODES WITH ABSENT PARITY BITS
P. I. Hershberg, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 280/284.

All possible data symbols are divided into two categories, designated A and B. Transmitted data is subject to the constraint that all information appears in fixed locations within any message. In addition, the message is divided into segments, with each segment containing symbols

SINGLE- AND DOUBLE-ADJACENT ERROR-CORRECTING CODES FOR ARITHMETIC UNITS (Correspondence)
A. J. Bernstein, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 209/210.

. . . extends work done in a previous paper on single error-correcting codes for binary arithmetic units. . . .

Related Publications:

ANALYTICAL DEVELOPMENT AND IMPLEMENTATION OF AN OPTIMUM ERROR CORRECTING CODE
R. G. Fryer, Sylvania Technol., vol. 13, no. 3, July 1960, p. 101/110.

The theory relating to the construction of group error-correcting codes is outlined and used to construct a (15, 5)-triple-error-correcting code. It is shown that all (15, 5)-triple-error correcting codes have the same weight structure and all are optimum. Because of the ease of implementation of maximum-length binary shift-register sequences, the (15, 5)-code is then implemented using "m-sequences". The theory of m-sequences is also discussed. . . .

2.774: Burst Error Correcting Codes

Included: Single burst-error correcting capability; Multiple burst error correction; Triple-error correcting codes; Burst detecting sum codes; Prime residue error correcting codes; Multiple error correction; Coding for the Gilbert burst channel; Shortened cyclic codes; Correction of clustered errors.

Not Included: Pulsive noise disturbances (1).

Cross References: Golay codes (2.733); Reed-Muller codes (2.734); Bose-Chaudhuri codes (2.742); Protective coding for telephone plants (2.783).

Principal Publications:

MULTIPLE ERROR CORRECTION BY MEANS OF PARITY CHECKS
G. E. Sacks, IRE Trans. Inform. Th., vol. IT-4, Dec. 1958, p. 145/147.

A CLASS OF BINARY SYSTEMATIC CODES CORRECTING ERRORS AT RANDOM AND IN BURSTS
L. Calabi, et al., IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 79/94.

RECURRENT CODES: EASILY MECHANIZED, BURST-CORRECTING, BINARY CODES
D. W. Hagelbarger, Bell Syst. Tech. J., vol. 38, no. 4, July 1959, p. 969/984.

MULTI-ERROR CORRECTING CODES FOR A BINARY ASYMMETRIC CHANNEL
W. H. Kim, et al., IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 71/78.

ANALYTICAL DEVELOPMENT AND IMPLEMENTATION OF AN OPTIMUM ERROR CORRECTING CODE
R. G. Fryer, Sylvania Technol., vol. 13, no. 3, July 1960, p. 101/110.

The theory relating to the construction of group error-correcting codes is outlined and used to construct a (15, 5)-triple-error-correcting code. It is shown that all (15, 5)-triple-error correcting codes have the same weight structure and all are optimum. Because of the ease of implementation of maximum-length binary shift-register sequences, the (15, 5)-code is then implemented using "m-sequences". The theory of m-sequences is also discussed. . . .

ERROR CORRECTING CODES FOR CORRECTING BURSTS OF ERRORS
J. E. Meggitt, IBM J. Res. Developm., vol. 4, no. 3, July 1960, p. 329/334.

BINARY CODES FOR ERROR CONTROL
W. W. Peterson, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 15/21, 33 refs.

. . . several error-correcting codes will be listed with a brief description of their capabilities and feasibility of their implementation.

The most promising class of codes for implementation at the present are cyclic codes. The burst-error correcting cyclic codes are especially attractive from the point of view of implementation and a simplified block diagram for implementing a practical example of such a code will be shown and discussed.

CODES FOR THE CORRECTION OF "CLUSTERED" ERRORS
S. H. Reiger, IRE Trans. Inform. Th., vol. IT-6, no. 1, March 1960, p. 16/21.

A NOTE ON BURST DETECTING SUM CODES
J. M. Berger, Inform. Control, vol. 4, no. 2/3, Sept. 1961, p. 297/299.

A new burst error detecting code is described which has the form of the sum codes in that the check bits are determined from the algebraic sum of suitably weighted information bits. . . .

of only one category. . . . Surprisingly, codes subject to the initial constraint can find fairly wide application in weather data transmission equipment, airline reservation systems, commercial data communication networks, and other fixed-format type information-handling and processing systems. . . .

SIMULTANEOUS ERROR CORRECTION AND BURST-ERROR DETECTION USING CYCLIC CODES
E. Posner, JPL Space Progr. Summ., vol. 4, no. 37/19, Dec./Jan. 1962, p. 150/151.

ON FSK PARITY CHECKING (Correspondence)
N. M. Blachman, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 121/123.

. . . compares the error probabilities for a fixed-information-transmission-rate FSD channel, with and without one parity-checking bit per word, for various word lengths, any word whose parity does not check at the receiver being retransmitted. . . .

SIMULTANEOUS MULTIPLE ERROR-CORRECTION AND BURST ERROR-DETECTION
E. C. Posner, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 98/99.

Related Publications:

MEASURED ERROR DISTRIBUTIONS ON THE BELL A-1 FACILITY OVER VARIOUS MEDIA
E. J. Hofmann, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 37/44.

OPTIMUM ERROR DETECTION CODES FOR NOISELESS DECISION FEEDBACK
I. Jacobs, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 359/371, 18 refs.

LOW-DENSITY PARITY-CHECK CODES
R. G. Gallager, Cambridge, Mass., MIT Press, 1963, 102 p.

This book is an expanded and revised version of the author's doctoral dissertation. It presents one of several fruitful approaches to the practical implementation of Shannon's Noisy Channel Coding Theorem which have been developed during the last few years. . . . maximum likelihood decoding of such codes requires either a storage capacity or a computational capability which grows exponentially with the code length. . . . In order to circumvent this problem, the author has introduced the concept of low-density parity-check (LDPC) codes and a probabilistic (as opposed to algebraic) method of decoding which takes advantage of their special structure. . . .

2.773: Double Error Correcting Codes

Included: Double error correcting Bose-Chaudhuri codes; Close-packed double error correcting codes; Cyclic codes for double error correction; Adjacent error correcting codes.

Cross References: Bose-Chaudhuri codes (2.742); Cyclic codes in general (2.740).

Principal Publications:

A CYCLIC CODE FOR DOUBLE ERROR CORRECTION
C. M. Melas, IBM J. Res. Developm., vol. 4, no. 3, July 1960, p. 364/366.

. . . using maximal-length shift-register sequences. . . The codes are systematic and can be readily constructed for any block length. They can be implemented in a very simple manner, described by Meggitt. . . A criterion is also given which can be applied to the construction of sequence codes of arbitrary Hamming distance. . . .

A DECODING PROCEDURE FOR DOUBLE-ERROR CORRECTING BOSE-RAY-CHAUDHURI CODES (Correspondence)
R. B. Banerji, Proc. IRE, vol. 49, Oct. 1961, p. 1585.

ON CLOSE-PACKED DOUBLE ERROR-CORRECTING CODES ON P SYMBOLS (Correspondence)
C. Engelman, IRE Trans. Inform. Th., vol. IT-7, no. 1, Jan. 1961, p. 51/52.

ON "UPPER BOUNDS FOR ERROR DETECTING AND CORRECTING CODES OF FINITE LENGTH" (Correspondence)
F. F. Sellers, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 276.

In a recent article, Wax cited the results of Laemmel that the best value for the number of sequences of length 14 which correct two errors is "48(?)." A better value is 64. To see this, consider a code developed by Bose and Chaudhuri of length 15 with 7 information bits which is able to correct 2 errors. Leaving off one information bit, this would be a code of length 14 with 6 information bits, or 64 code points. . . .

ERROR-CORRECTING CODES FOR CORRECTING BURSTS OF ERRORS
J. E. Meggitt, Commun. and Electronics, vol. 79, no. 52, Jan. 1961, p. 708/711.

MULTIPLE BURST ERROR CORRECTION
J. J. Stone, Inform. Control, vol. 4, no. 4, Dec. 1961, p. 324/331.

. . . a theorem is given which increases the feasibility of correcting such errors in codes. . . by constructing cyclic codes of a given weight. . . . a method is given for constructing quasi-cyclic codes. . . which will correct multiple bursts of errors. . . .

DIE WIRKSAMKEIT VON BLOCKSICHERUNGSVERFAHREN GEGENUBER GEBUNDELTEN STORUNGEN BEI DER DATENUBERTRAGUNG (The Effectiveness of Protective Block Coding Against Bursts of Disturbances in Data Transmission) (In German)
E. R. Berger, Arch. El. Übertragung, vol. 16, no. 2, Feb. 1962, p. 51.

BOUNDS ON BURST-ERROR-CORRECTING CODES (Correspondence)
C. N. Compopiano, IRE Trans. Inform. Th., vol. IT-8, no. 3, April 1962, p. 257/259.

COMPUTER SIMULATION OF THE USE OF GROUP CODES WITH RETRANSMISSION ON A GILBERT BURST CHANNEL
W. R. Cowell, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 577/585.

A study of error control by coding was made by Monte-Carlo simulation of a burst-noise channel on an IBM (International Business Machines) 7090. Using short group codes, comparisons were made between correction and detection with retransmission. Also, the effect of interleaving the code words was studied. Error detection with retransmission showed a consistently better performance than error correction and the time division resulting from interleaving was effective in combatting burst type error patterns. . . .

A NOTE ON OPTIMUM BURST-ERROR-CORRECTING CODES
B. Elspas, et al., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 39/42.

. . . a certain class of systematic binary error-correcting codes that will correct the error bursts typical of some digital channels. These codes—generalizations of codes discovered by Abramson and Melas—are cyclic codes designed to correct any single burst of errors per n-digit word provided that the width of the burst (regarded cyclically) does not exceed a certain number of digits, b. Moreover, these codes are optimum in the sense that they employ the minimum number of redundant digits theoretically possible for a cyclic code with given values of n and b. . . .

BINARY GROUP CODES WHICH CORRECT ERRORS IN BURSTS OF THREE OR LESS FOR ODD REDUNDANCY
A. J. Gross, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 356/359.

Abramson and Bose and Chakravarti have constructed, simultaneously and independently, binary group codes which correct errors in bursts of three or less for even redundancy. In this paper the corresponding problem when the redundancy is odd is considered. . . .

A NOTE ON SOME BINARY GROUP CODES WHICH CORRECT ERRORS IN BURSTS OF FOUR OR LESS (Correspondence)
A. J. Gross, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 384.

EVALUATION OF A BURST-ERROR CORRECTION CODE ON A GILBERT CHANNEL
D. G. Iram, Rome Air Development Center, Griffiss Air Force Base, N. Y., (RADC-TDR-62-189), May 1962, 57 p., incl. illus., 8 refs., AD 276 527.

. . . A technique for evaluating the improvement afforded a fading-type channel by the use of a burst-error correcting code is illustrated. The Gilbert model of a fading channel is then evaluated using this technique.

TWO CLASSES OF CODES FOR IMPROVING FEEDBACK COMMUNICATION EFFICIENCY
J. J. Metzner, New York U. Coll. of Engineering, N. Y., (Scientific rept. no. 10), (AFCRL 62-525), 15 June 1962, 55 p., incl. illus., tables, 12 refs., AD 286 304.

. . . to improve system efficiency by allowing greater error correction while maintaining reliability. Hobbs' codes are analyzed with respect to reliability and complexity for correction of single-, double-, triple-, and partial four-error correction. A class of burst-error correcting codes with a somewhat random structure. . . reasonably simple decoding which allows correction of all bursts of length up to somewhat less than half the number of check digits.

SIMULTANEOUS ERROR CORRECTION AND BURST-ERROR DETECTION USING CYCLIC CODES
E. Posner, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 150/151.

CYCLIC CODES FROM IRREDUCIBLE POLYNOMIALS FOR CORRECTION OF MULTIPLE ERRORS
L. Zetterberg, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 13/20.

. . . A class of shift-register codes is studied. . . The errors are classified in terms of error cycles and a simple procedure is suggested to determine if error cycles are distinguishable. . . .

LINEAR CODES FOR BURST-ERROR-CORRECTION IN BINARY ARITHMETIC AND TRANSMISSION
R. T. Chien, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 133/138.

. . . When used in data-transmission, they do not require special coding equipment, an encoding and decoding operation may be easily carried out in digital computers. . . . number-theoretic concepts are used to construct linear residue codes for the correction of burst errors. . . .

ON LINEAR RESIDUE CODES FOR BURST-ERROR CORRECTION
R. T. Chien, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 127/133.

Linear residue codes are useful for error control in both arithmetic operations and data transmission. . . . number-theoretic concepts are used to construct linear residue codes for the correction of burst errors. . . .

AUGMENTED BOSE-CHAUDHURI CODES WHICH CORRECT SINGLE BURSTS OF ERRORS (Correspondence)
A. J. Gross, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 121.

OPTIMUM SHORTENED CYCLIC CODES FOR BURST-ERROR CORRECTION
T. Kasami, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 105/109.

This paper is concerned with the construction of the most efficient shortened cyclic (pseudo-cyclic) codes that can correct every burst-error of length b or less. These codes have the maximum number of information digits k among all shortened cyclic burst-b codes with a given number of check digits r. The search procedure described is readily programmable for computer execution and efficient particularly for the case where r is close to the theoretical minimum of 2b check digits. . . .

NOTE ON RECURRENT CODES (Correspondence)
E. R. Berlekamp, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 257/258.

. . . Wyner and Ash have given bounds on the minimum guard space necessary to correct all bursts of a specified maximum length with a recurrent code. . . . this communication gives an explicit construction for achieving their lower bound for recurrent codes designed to correct error bursts of a known phase (called "Type B2 Codes"). . . .

A DECODING PROCEDURE FOR MULTIPLE-ERROR-CORRECTING CYCLIC CODES
T. Kasami, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 134/138.

Applications are made to the cyclic Golay code, the Bose-Chaudhuri (63, 45), (31, 16), (31, 11) codes and the (41, 21) cyclic codes. A block diagram for a decoder for the Golay code is shown. . . .

SOME EFFICIENT SHORTENED CYCLIC CODES FOR BURST-ERROR CORRECTION (Correspondence)
T. Kasami, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 252/253.

COMPUTER CONSTRUCTION AND EVALUATION OF LONG BURST-ERROR CORRECTING CODES
J. J. Metzner, New York U., Coll. of Engineering, N. Y., Scientific rept. no. 12, AFCRL 63 28, 31 Jan. 1963, 91 p., AD 402 676.

A specific method of programming a digital computer to construct and evaluate codes suitable for use in a burst-error correction decoding scheme . . . Two (100, 50) codes. . . were constructed. . . One is found capable of correcting uniquely all bursts of length 21 or less. . . . Memory limitations have restricted the present program to code lengths not exceeding 105 digits, of which at most 63 may be check digits.

BURST-ERROR CORRECTION FOR RANDOMLY-CHOSEN BINARY GROUP CODES
J. J. Metzner, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 281/285.

A method of burst-error correction is presented which works for a large class of codes. Any single burst of length up to somewhat less than one half the number of check digits can be corrected. The number of decoding computations per code word is proportional to the square of the code length for long codes. . . .

CERTAIN SPECIAL ERROR-CORRECTING CODES OF MATRIX TYPE
G. B. Ol'derogge, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 7, July 1963, p. 12/18.

Error-correcting binary codes in which parity-check symbols are added to the rows and columns of two matrices, specially made up from the sequence of information symbols are considered. . . . permit detection and correction of single, double and triple errors . . . and. . . detection of quadruple errors. . . . the proposed code is close to optimum. . . .

SIMULTANEOUS MULTIPLE ERROR-CORRECTION AND BURST ERROR-DETECTION
E. C. Posner, JPL Space Progr. Summ., vol. 4, Feb./March 1963, p. 98/99.

SINGLE BURST-ERROR-CORRECTION CAPABILITIES OF BINARY CYCLIC CODES
F. D. Schmandt, Air Force Systems Command, Griffiss AFB, N. Y. Rome Air Development Center, (RADC-TDR-63-301), Aug. 1963, 45 p., 10 refs., N63-21458, AD 418 725.

. . . contains a definition and discussion of a mathematical system which can be used to determine n and b of a binary cyclic code given g(x). It includes tables listing g(x), n and b for all polynomials of degree 2 through 11 over the binary ground field (0.1). . .

PRIME RESIDUE ERROR CORRECTING CODES (Correspondence)
J. J. Stein, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 170.

SOME RESULTS ON BURST-CORRECTING RECURRENT CODES
A. D. Wyner, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 139/152.

. . . A definition of a recurrent code is given in a framework which renders it amenable to mathematical analysis. Codes which correct single, burst, and low-density (bursts of limited weight) errors are discussed. In each case bounds on the error free distance (guard space) required between bursts are obtained . . . A low-density-burst-correcting code, based on the Bose-Chaudhuri code, is also presented. . . .

Related Publications:

A NEW GROUP OF CODES FOR CORRECTION OF DEPENDENT ERRORS IN DATA TRANSMISSION
C. M. Melas, IBM J. Res. Developm., vol. 4, no. 1, Jan. 1960, p. 58/65.

Multiple related errors of any configuration can be automatically corrected by a class of codes having the property of using two groups of parity bits, one defining the error pattern, the other determining the location of the errors within the block. In particular, error bursts can be corrected with a minimum amount of redundancy. . . .

MODEL OF ERROR BURST STRUCTURE IN DATA TRANSMISSION
P. Mertz, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 232/240.

. . . assumes a distribution of burst durations that follows recent experimental data. It is multiple in form, and consists of a proportion of 1-bit bursts superimposed on a "triangular" continuous distribution. Some analysis shows the equivalence of this model with equal duration bursts, when the constant duration is suitably chosen. . . .

SOME RESULTS IN THE MEASUREMENT OF IMPULSE NOISE ON SEVERAL TELEPHONE CIRCUITS
H. L. Yudkin, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 222/231.

ON CONSTRUCTING GROUP CODES
R. B. Benerji, Inform. Control, vol. 4, no. 1, March 1961, p. 1/14.

EFFECTS OF IMPULSE NOISE ON DIGITAL DATA TRANSMISSION
A. B. Bodonyi, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., Master's thesis, (Research rept. no. PIBMRI-975-61), 11 Dec. 1961, 23 p., illus., 14 refs., AD 285 511.

. . . basic characteristics of impulse noise and effects of impulse noise on various types of binary data transmission systems. . . (2) The simple error-detecting and error-correcting systems, designed to combat the effects of gaussian noise, can be utilized only to a fraction of their theoretical advantage in case of impulse noise. . . .

LINEAR-RECURRENT BINARY ERROR-CORRECTING CODES FOR MEMORYLESS CHANNELS
W. L. Kilmer, IRE Trans. Inform. Th., vol. IT-7, no. 1, Jan. 1961, p. 7/13.

. . . analysis of recurrent-type parity-check, error-correcting codes for memoryless, binary symmetric channels. These codes are defined to consist of message sequences augmented by insertions of r successive parity digits every b successive message digits. . . An example is given of a linear-recurrent code which has a lower probability of error than the best comparable block code, and several outstanding problems are discussed.

ERROR CORRECTING CODES AND THEIR IMPLEMENTATION FOR DATA TRANSMISSION SYSTEMS
J. E. Meggitt, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 234/244.

STATISTICS OF HYPERBOLIC ERROR DISTRIBUTIONS IN DATA TRANSMISSION
P. Mertz, IRE Internat. Conv. Rec., vol. 8, March 1961, p. 160/166.

Error bursts in data transmission. . . . follow a hyperbolic rather than a Poisson distribution.

ON "UPPER BOUNDS FOR ERROR DETECTING AND CORRECTING CODES OF FINITE LENGTH" (Correspondence)
F. F. Sellers, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 276.

In a recent article, Wax cited the results of Laemmel that the best value for the number

of sequences of length 14 which correct two errors is "48(?)." A better value is 64. To see this, consider a code developed by Bose and Chaudhuri of length 15 with 7 information bits which is able to correct 2 errors. Leaving off one information bit, this would be a code of length 14 with 6 information bits, or 64 code points. . . .

ERROR BURST CHAINS IN DATA TRANSMISSION
P. Mertz, IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 47/56.

. . . the bursts themselves also show "bunching" rather than complete randomness. This has been described with hyperbolic rather than classical Poisson laws. The error bursts form into occasional chains. Such chains are highly improbable in an all-Poisson distribution. Their expectancy has been determined under assumptions that within a chain the distribution is Poisson, but the long-time distribution is hyperbolic. The results show the moderate probability of the chains observed in experience. . . .

BINARY CODES FOR ERROR CONTROL
W. W. Peterson, Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 648/652.

The model of a communication channel used in the study of binary codes, its relation to real data transmission channels, and assumptions about noise, will be reviewed briefly. Several error-correcting codes will be listed with a brief description of their error-correcting capabilities and feasibility of their implementation. . . .

ERROR CONTROL IN DIGITAL COMMUNICATIONS
A. M. Manders, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., Research rept. no. PIBMRI-1076-62, Jan. 1963, 73 p., incl. illus., 13 refs., AD 402 113.

. . . error correction device (ECD) that examines the signal for signs that a burst of impulse noise is likely to have occured. The bits that are in doubt are erased and replaced by use of a two-dimensional parity check. The two-dimensional code used is to break the received string of bits in sequences that are used as rows. By making the rows sufficiently long the probability that one noise burst will cause more than one error in any one column can be made very small.

ESTIMATES OF ERROR RATES FOR CODES ON BURST-NOISE CHANNELS
E. O. Elliott, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 1977/1997.

The error structure on communication channels used for data transmission may be so complex as to preclude the feasibility of accurately predicting the performance of given codes when employed on these channels. Use of an approximate error rate. . . allows . . . an economical evaluation of large collections of error detecting codes. Exemplary evaluations of error detecting codes on the switched telephone network are included in this paper.

On channels which may be represented by Gilbert's model of a burst-noise channel, the probabilities of error or of retransmission may be calculated without approximations for both error correcting and error detecting codes.

FEEDBACK FOR ERROR CONTROL AND TWO-WAY COMMUNICATION
L. S. Schwartz, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 49/56.

. . . considers the usefulness of feedback relative to coding, the kind of feedback system to use, the advantages of combining feedback with coding and the characteristics of a system that results thereform. . . . effectiveness of block codes plus feedback in combatting burst-type noise. . . . a brief discussion of existing feedback systems using some of these principles. . . .

ANALYSIS OF RECURRENT CODES
A. D. Wyner, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 143/156.

A definition of a recurrent code is given in a framework which renders it amenable to mathematical analysis. Recurrent codes for both independent and burst errors are considered, and a necessary and sufficient condition for either type of error correction is established. . . .

2.775: Bit-loss or Gain Correction Codes

Principal Publications:

BIT LOSS AND GAIN CORRECTION CODE
F. F. Sellers, Jr., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 35/38.

A block code is presented that will correct an error consisting of the gain or loss of a bit (binary digit) within the block. The code can be generalized to correct the loss or gain of a burst of bits. A further feature is the possibility of correcting additive errors appearing in the vicinity of the bit loss or gain. . . . a received message has a different number of bits (binary digits) than the transmitted message had. One cause of such errors is the temporary loss of synchronization between the transmitter and the receiver. . . . Even the self synchronizing comma-free codes are not able to decode a character containing a bit loss or gain error. . . .

2.776: Error Locating Codes

Included: Sub-block codes.

Cross References: Error detecting codes (2.772); Failure detecting codes (2.184).

Principal Publications:

A NEW APPROACH TO RELIABLE DATA TRANSMISSION ERROR-LOCATION CODES
J. K. Wolf, Rome Air Development Center, Griffiss Air Force Base, N. Y., (Rept. no. RADC TDR 62-362), Aug. 1962, 10 p., 7 refs., AD 286 422.

. . . errors are detected within the block of received digits and, in addition, the location of these errors, is specified to within a sub-block of the overall larger block of digits. Upper and lower bounds are derived, for error-location codes, for the number of check digits required for a given error-location capability. A method is presented for constructing the parity check matrix for a large family of error-location codes, some of which are optimal in the sense that they satisfy the previously derived lower bound. Comparisons are made of the error-correction capability and error-location capability of codes. Also, applications of error-location codes are discussed.

ERROR-LOCATION CODES FOR A DEEP SPACE PROBE TELEMETRY SYSTEM
C. P. Carpenter, et al., Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 6/13.

Error-location (EL) codes are a new class of codes in which a received block of message digits is exhaustively subdivided into mutually exclusive sub-blocks. Error detection is performed at the receiver through the use of parity check matrix, and, in addition, the erroneous sub-blocks are identified. . . . The use of EL codes permits error detection and the location of the erroneous digits to within a sub-block of the received message block, but insufficient information is given to precisely locate the erroneous digits within a sub-block.

PERFORMANCE CHARACTERISTICS OF ERROR-LOCATION CODES FOR A SPACE PROBE TELEMETRY SYSTEM
C. P. Carpenter, et al., Rec. Nat. Space Electronics Symp., 1963. no. 7.2.

. . . a new class of codes which combine error location with error correction . . . Specific examples are given which are applicable to three different types of communication systems. Curve for word error rate and channel capacity are included. . . .

ERROR-LOCATION CODES—A NEW CONCEPT IN ERROR CONTROL
J. K. Wolf, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 113/117.

A new coding technique is proposed lying midway between error-detection and error-correction coding. The block of received digits is regarded as subdivided into mutually exclusive sub-blocks. Errors occurring within particular sub-blocks are detected at the receiver and, in addition, the receiver is able to determine, by using the code redundancy, which particular sub blocks contain errors. Such error-locating cod permit the location of digit errors to within a sub-block of the recieved message block withou in general, permitting the precise determinatio of erroneous digit positions. . . .

Section 2.78
Protective Codes for Special Applications

2.782: Codes for Feedback Links

Included: Erasure codes; Codes for the binary erasure channel; Retransmission error control.

Cross References: Feedback link communication systems (2.920); ARQ procedures (2.926); Null-tone decision systems (2.853); Adaptive communication systems (2.930); Sequential decoding (2.752); Sequential detection methods (2.854).

Principal Publications:

ALGEBRAIC DECODING FOR A BINARY ERASURE CHANNEL
M. A. Epstein, Mass. Inst. of Tech. - T. R. #340, March 1958, 14, p., AD 208 649.

CODED BINARY DECISION-FEEDBACK COMMUNICATION SYSTEMS
J. J. Metzner, et al., IRE Trans. Commun. Syst., vol. CS-8, no. 2, June 1960, p. 101/113.

CONSTANT-RATIO CODE AND AUTOMATIC-RQ ON TRANSOCEANIC HF RADIO SERVICES
J. B. Moore, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 72/75.

THE DESIGN OF AN "ERROR-FREE" DATA TRANSMISSION SYSTEM FOR TELEPHONE CIRCUITS
B. Reiffen, et al., Lincoln Lab., MIT, Lexington, 22 Dec. 1960, AD 248 637.

. . . easily implemented codes can detect essentially all errors occurring in digital data sent over toll grade telephone circuits. A two-way communications system is described which uses these codes to detect the occurrence of errors and requests a retransmission of any data in error. . . . The philosophy that guided the design of this system can be applied to other media where high noise bursts or low signal levels occur infrequently.

A GENERAL METHOD OF APPLYING ERROR CORRECTION TO SYNCHRONOUS DIGITAL SYSTEMS
D. B. Armstrong, Bell Syst. Tech. J., vol. 40, no. 2, March 1961, p. 577/593.

It includes the familiar scheme of triplication and "vote taking" as a special case. In principal, the method permits the system to operate continuously, even when a fault is present or maintenance is being performed.
. . . describes some error-correcting codes to implement the scheme, discusses error-correcting circuits in a general way, indicates how to estimate the redundancy, and presents a formula for determining the reliability improvement obtainable with a particular maintenance routine.

THE DESIGN OF AN ERROR-FREE DATA TRANSMISSION SYSTEM FOR TELEPHONE CIRCUITS
B. Reiffen, et al., Commun. and Electronics, vol. 80, no. 55, July 1961, p. 224/231.

Recent experimental results verify that easily implemented codes can detect essentially all errors occurring in digital data sent over toll-grade telephone circuits. . . . request a retransmission . . . The feedback logic is detailed herein, and the buffer required to adapt the system to various data sources is discussed. Extrapolated experimental results indicate an average delivery rate in each direction of approximately 7/8 the modem (modulation system) bit rate with a mean time to error of several hundred years. . . . The Bose-Chaudhuri codes used in the test were the 511, 493, the 255, 239, and 127, 113. . . .

RELIABLE DATA TRANSMISSION THROUGH NOISY MEDIA—A SYSTEMS APPROACH
C. M. Melas, Commun. and Electronics, vol. 80, no. 57, Nov. 1961, p. 501/504.

. . . Transmission errors can be corrected either by adding redundancy bits to the information to generate an error correcting code, or by automatically retransmitting the message when erroneously received. The relative merits of the two techniques are discussed in terms of both error control and systems compatibility. A class of powerful and easily implemented cyclic error detection and correction codes was recently developed which, in combination with automatic retransmission, should give effective error protection. . . .

SOME RECENT DEVELOPMENTS IN DIGITAL FEEDBACK COMMUNICATION SYSTEMS
L. S. Schwartz, IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 51/57.

. . . reports the rejection to the transmitter. . . . the transmitter subsequently repeats the message. . . . feedback channel to be error-free.

ERROR PROBABILITY AND TRANSMISSION SPEED ON CIRCUITS USING ERROR DETECTION AND AUTOMATIC REPETITION OF SIGNALS
H. C. A. Van Duuren, IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 38/50.

COMPUTER SIMULATION OF THE USE OF GROUP CODES WITH RETRANSMISSION ON A GILBERT BURST CHANNEL
W. R. Cowell, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 577/585.

A study of error control by coding was made by Monte-Carlo simulation of a burst-noise channel on an IBM (International Business Machines) 7090. Using short group codes, comparisons were made between correction and detection with retransmission. Also, the effect of interleaving the code words was studied. Error detection with retransmission showed a consistently better performance than error correction and the time division resulting from interleaving was effective in combatting burst type error patterns. . . .

ERASURE FILL-IN FOR BINARY ERASURE CHANNEL
A. L. Duquette, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 64/66.

The concept of the binary erasure channel was first introduced by Elias (Ref. 8). Utilizing the properties of module 2 arithmetic, an analog of the Gauss-Jordan procedure (Ref. 9) may be employed . . .

An alternate decoding procedure for the binary erasure channel is given here which, for certain cyclic codes, has obvious advantages.

OPTIMUM ERROR DETECTION CODES FOR NOISELESS DECISION FEEDBACK
I. Jacobs, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 359/371, 18 refs.

Iterative error-detection codes are applied to a decision-feedback communication system employing a noisy binary-symmetric forward channel and a noise-free feedback channel. The optimum (maximum information rate) code is shown to be one in which only a single parity check is made at each stage of the iteration. This code is referred to as the SPC code. For this code, the probability of an undetected error P_M tends to zero algebraically, rather than exponentially, with block length. However, the complexity of the necessary decoder grows only as log log $1/P_M$, a drastic improvement over the log $1/P_M$ growth encountered in error-correction systems. . . .

AN ITERATIVE-CODE COMMUNICATIONS SYSTEM WITH NOISY DELAYED DECISION FEEDBACK
I. M. Jacobs, et al., Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 37/45.

. . . provides the attractive possibilities of realizing high data-rate transmission at arbitrarily low error probabilities while providing good adaptation to time-varying channel statistics. The "cost" is a feedback channel with (typically) a rate requirement approximating 1/3 of the forward channel rate plus a relatively large bulk storage at transmitter and receiver. Decoder complexity is minimal. . . .

TWO CLASSES OF CODES FOR IMPROVING FEEDBACK COMMUNICATION EFFICIENCY
J. J. Metzner, New York U. Coll. of Engineering, N. Y., (Scientific rept. no. 10), 15 June 1962, 55 p., incl. illus., tables, 12 refs., AD 286 304.

. . . to improve system efficiency by allowing greater error correction while maintaining reliability. Hobbs' codes are analyzed with respect to reliability and complexity for correction of single-, double-, triple-, and partial four-error correction. A class of burst-error correcting codes with a somewhat random structure . . . reasonably simple decoding which allows correction of all bursts of length up to somewhat less than half the number of check digits.

PERFORMANCE VS COMPLEXITY OF SOME NEW DECODERS FOR THE BINARY ERASURE CHANNEL
M. E. Mitchell, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 36. (Appendix E)

Summary only . . . decoding techniques for the binary erasure channel (BEC) have been investigated . . . three new types of BEC decoders have been obtained, each having unusual simplicity even for long codes, as evidenced by their approximately linear increase in complexity with code length. . . .

SECO: A SELF-REGULATING ERROR CORRECTING CODER-DECODER
K. E. Perry, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S128/135.

SECO is an efficient engineering realization of a coding-decoding scheme designed to use variable redundancy and feedback in a two-way communication system to increase the rate of information transfer between users connected by a channel having a slowly time-varying capacity. . . . The decoding computer is designed to detect channel errors with very high probability and to correct as many of these as it can, subject to the current channel condition and decoder state. When a detected error cannot by corrected easily, the decoder stops and uses the feedback channel to request retransmission at a lower information rate. . . .

ON REPEATING A DIGITAL MESSAGE TO INCREASE THE PROBABILITY OF CORRECT RECEPTION
H. Dym, Mitre Corp., Bedford, Mass., Rept. no. TM3389, ESD TDR 63 239, July 1963, 38, p. AD 412 918.

The theoretical aspects are considered relative to the repetition of messages as a means of error detection and correction, where, on the average, less than 50% of the digits received are in error, and reception reliability is obtained at the expense of a lower data rate. Two repetition schemes, fixed and sequential, are considered. . . Comparison is made of such repetition schemes with more sophisticated techniques, e. g., those involving optimum coding.

RETRANSMISSION ERROR CONTROL
T. G. Kuhn, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 186/201.

. . . discusses . . . the use of vertical and horizontal block parity checks. . . . provides a level of error rate performance which is far better than that which can be expected from the equipment into which it must operate. For instance, for a random bit error probability of 10^{-4}, a 22 x 22 bit block yields an output error rate of $4.4(10)^{-14}$, with an efficiency of 87 per cent. . . . An analysis is presented which determines the parameters for optimum performance for both random and bunched errors. . . .

APPLICATION OF SEQUENTIAL DECODING TO HIGH-RATE DATA COMMUNICATION ON A TELEPHONE LINE
I. L. Lebow, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 124/126.

. . . some preliminary experimental results . . . the transmission medium is a toll-grade nonswitched, K-carrier telephone voice channel. Virtually error-free communication of 6000-9000 data bits per second has been achieved. . . . The structure of the encoder-decoder (referred to as SECO), as well as some experimental results obtained with its use on a binary-symmetric channel, have been reported previously. . . .

COMPARISON OF THE 3-OUT-OF-7 ARQ WITH BOSE-CHAUDHURI-HOCQUENGHEM CODING SYSTEMS
M. Nesenbergs, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 202/212.

The performance of coding schemes can be expressed by two criteria; the useful transmission rate R, and output character-error probability P. Both quantities are expressed in a form applicable to a binary forward channel coupled with an arbitrary feedback channel. . . . If the element errors are independent of each other a purely error-correcting arrangement looks attractive. If the errors are correlated (i.e., occur in bursts), error detection holds more promise. . . .

ERROR-LIMITING CODING USING INFORMATION-LOSSLESS SEQUENTIAL MACHINES
P. G. Neumann, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 108/115, 16 refs.

An information-lossless sequential machine is essentially a machine whose input sequence may be recovered from knowledge of its output sequence. A situation is considered in which such a machine is used as the encoder for a communication system. . . . This paper investigates the effects of transient errors in such a system and shows that there are encoders for which the decoder is incorrect . . . Each such encoder has input sequences which resynchronize the encoder following errors, as well as output sequences which resynchronize the decoder. . . .

FEEDBACK FOR ERROR CONTROL AND TWO-WAY COMMUNICATION
L. S. Schwartz, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 49/56.

. . . considers the usefulness of feedback relative to coding, the kind of feedback system to use, the advantages of combining feedback with coding and the characteristics of a system that results therefrom. . . . effectiveness of block codes plus feedback in combatting burst-type noise. . . . a brief discussion of existing feedback systems using some of these principles. . . .

ASYMPTOTIC ERROR CODING BOUNDS FOR THE BINARY SYMMETRIC CHANNEL WITH FEEDBACK
E. J. Weldon, Jr., Florida U., Engineering and Industrial Experiment Station, Gainesville, Scientific rept. no. 1, AFCRL Rept. no. 63 122, 1 April 1963, 122 p., 10 refs., AD 412 793, N63-18274.

Various asymptotic upper and lower bounds are calculated for linear (parity check) codes used with the Binary Symmetric Channel (BSC) with feedback. The feedback channel is taken to be noiseless and capable of instantaneous transmission. . . . The bounds calculated herein indicate that the best variable-length code has a higher probability of erroneous decoding than the best fixed-length code in which the feedback is used to vary the number of information symbols per word. They also indicate that the best code used without feedback has a higher probability of erroneous

decoding than the best code used with decision feedback, which in turn has a higher probability of erroneous decoding than the best code used with information feedback.

Related Publications:

RELIABLE FAIL-SAFE BINARY COMMUNICATION
J. J. Metzner, et al., New York U. Coll. of Engineering, N. Y., (Scientific rept. no. 2), (AFCRL TN 60-791), 10 July 1960, AD 245 253.

. . . employing long codes with feedback, correcting only very small numbers of errors, and utilizing a new technique which effectively prevents any type of disturbance in the feedback channel from harming system reliability. The resulting system yields excellent reliability, "fails safe" (an error probability of 10^{-10} when the signal-to-noise ratio falls to zero, for instance), and operates at a relatively high per-symbol information rate. . . . when severe burst-type noise or heavy fading is encountered. The cost of this performance is far less than that of comparable unidirectional systems. . . .

STUDY OF ADAPTABLE COMMUNICATIONS SYSTEMS
D. Chesler, Sylvania Electric Products, Inc., Waltham, Mass., Final rept., (Rept. no. F-1008-1), (RADC TDR 62-314), 14 July 1962, 293, p. incl. illus., tables, refs., AD 286 504.

. . . The study on error-detecting codes deals with a multi-stage error-detection repeat-request system in which the receiver performs error detection on small blocks of binary digits and requests a repeat of each block in which an error is detected. . . .

THE AN/GSC-5 ( ) DIGITAL COMMUNICATIONS SYSTEM
R. G. Matteson, et al., Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 155/162.

. . . All error correction is accomplished by decision feedback. . . .

THEORETICAL INVESTIGATION OF DUAL RATE TRANSMISSIONS OVER GAUSSIAN MULTIPLICATIVE CIRCUITS
Sylvania Electric Products, Inc., Waltham, Mass., Final rept. (Rept. no. F-1004-1), (AFCRL-62-198), 12 April 1962, 127, p. incl. illus., tables, 12 refs., AD 278 139.

The simplest form of a variable data rate communication system, an on-off system, which in the ideal case has been shown to be almost as good as the continuously variable rate system is detailed. The effects of Rayleigh fading and additive Gaussian noise in both the forward and feedback channels are studied.

HIGH FREQUENCY DIGITAL COMMUNICATION SYSTEM
National Cash Register Co., Dayton, Ohio, Quarterly progress engineering rept. no. 5, 1 June - 31 Aug. 1962, (NCR rept. no. 3-5Q), 15 Oct. 1962, 101, p. incl. illus., AD 287 485.

. . . system that provides highly reliable operation in the presence of multipath propagation and doppler shift. . . . operation of the circuits used in the control and coding equipment. . . .

AN INVESTIGATION OF THE FANO SEQUENTIAL DECODING ALGORITHM BY COMPUTER SIMULATION
G. Blustein, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 62G5, AFESD TDR 63 88, 12 July 1963, p. 35, AD 412 632.

. . . A computer program (FSD) for executing the algorithm on a simulated binary symmetric channel is discussed and certain results . . . are reported. . . .

A HEURISTIC DISCUSSION OF PROBABILISTIC DECODING
R. M. Fano, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 64/74.

. . . probabilistic decoding of digital messages after transmission through a randomly disturbed channel. The adjective "probabilistic" is used to distinguish the decoding procedures discussed here from algebraic procedures based on special structural properties of the set of code words employed for transmission. . . . The first probabilistic decoding procedure of practical interest was presented by J. M. Wozencraft, in 1957, and extended soon thereafter by B. Reiffen. Equipment implementing this procedure has been built at Lincoln Laboratory and is at present being tested in conjunction with telephone lines.

ON THE CHOICE OF BINARY CODES AND THRESHOLDS (Correspondence)
C. V. Freiman, Proc. IEEE, vol. 51, no. 3, March 1963, p. 478.

. . . example illustrates the fact that, when designing error-correcting codes for memory-less binary channels with controllable decision thresholds, best performance is not always realized by choosing the threshold which maximizes channel capacity.

"THE RAPIDATA S" SYNCHRONOUS SYSTEM FOR THE HIGH SPEED TRANSMISSION OF INTELLIGENCE (In French)
A. Girinsky, et al., Onde Electr., vol. 43, no. 431, Feb. 1963, p. 186/198.

. . . Reliability of transmission is ensured by an automatic device for the detection of errors which transmits the intelligence in block form and obtains the repetition of any among them which are disturbed. . . .

SEQUENTIAL TRANSMISSION USING NOISELESS FEEDBACK
M. Horstein, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 136/143.

A sequential continuous-transmission system employing a binary symmetric forward channel (but which is suitable for use with any discrete memoryless forward channel) and noiseless feedback channel is described. Its error exponent is shown to be substantially greater than the optimum block-code error exponent at all transmission rates less than channel capacity. The average value and the first-order probability distribution of the effective constraint length, found by simulating the system on an IBM 709 computer, are also given. . . .

2.783: Protective Coding for Telephone Plants

Not Included: Characteristics of telephone plants (1); Pulsive noise characteristics (1).

Cross References: Burst error correcting codes (2.774).

Principal Publications:

STATISTICAL ERROR CONTROL OF A REALIZABLE BINARY SYMMETRIC CHANNEL
I. S. Reed, Lincoln Lab., Mass. Inst. of Tech., Lexington, 1 Nov. 1959, 13 p., AD 241 453.

. . . It is shown how the statistics of a channel can be measured as the message is being received. A confidence level acceptance or rejection criterion is presented which is based on these measurements. In order to accomplish this aim, a phone line channel is studied. . . . binary symbols are distinguished from one another by 180° phase reversals of a carrier . . . noise . . . occurs in bursts . . . no a priori knowledge of the expected noise power. . . .

A GENERAL METHOD OF APPLYING ERROR CORRECTION TO SYNCHRONOUS DIGITAL SYSTEMS
D. B. Armstrong, Bell Syst. Tech. J., vol. 40, no. 2, March 1961, p. 577/593.

It includes the familiar scheme of triplication and "vote taking" as a special case. In principle, the method permits the system to operate continuously, even when a fault is present or maintenance is being performed.
. . . describes some error-correcting codes to implement the scheme, discusses error-correcting circuits in a general way, indicates how to estimate the redundancy, and presents a formula for determining the reliability improvement obtainable with a particular maintenance routine.

SOME RESULTS ON THE EFFECTIVENESS OF ERROR-CONTROL PROCEDURES IN DIGITAL DATA TRANSMISSION
W. R. Bennett, IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 58/65.

A number of error-correcting methods are evaluated by a computer simulation technique using the parameters of several hypothetical transmission channels which might be representative of telephone circuits. Emphasis has been placed on the recurrent codes, when subjected to actual errors collected from Data-Phone test calls, is compared to the performance of these codes using the assumed channel parameters.

THE USE OF GROUP CODES IN ERROR DETECTION AND MESSAGE RETRANSMISSION
W. R. Cowell, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 168/171.

ERROR STATISTICS AND CODING FOR BINARY TRANSMISSION OVER TELEPHONE CIRCUITS
A. B. Fontaine, et al., Proc. IRE, vol. 49, no. 6, June 1961, p. 1059/1065.

THE EXAMINATION OF ERROR DISTRIBUTIONS FOR THE EVALUATION OF ERROR-DETECTION AND ERROR-CORRECTION PROCEDURES
T. A. Maguire, et al., IRE Trans. Commun. Syst., vol. CS-9, no. 2, June 1961, p. 101/106.

It is concluded that there is a substantial advantage in the use of large (500-bit) rather than small (50-bit) blocks for detecting errors. It is also suggested that the practical evidence of error patterns which remain undetected should enable more effective detection designs to be produced.

ERROR CORRECTING CODES AND THEIR IMPLEMENTATION FOR DATA TRANSMISSION SYSTEMS
J. E. Meggitt, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 234/244.

. . . a practical automatic error-correcting system that may be applied to many data transmission problems. It is particularly suited to the correction of bursts of errors . . . It is so simple that it can readily be incorporated into much existing equipment. In the system, messages are transmitted in blocks and each block is coded separately. The codes used within the blocks are cyclic codes. This means that coders and decoders employ linear feedback shift registers to form check digits and to correct errors. The basic ideas are presented in terms of the hardware components to which the system gives

rise and analyzed afterwards in terms of mathematics so that it is easy for the engineer to see, at once, what is involved. . . .

ERROR STATISTICS AND CODING FOR DIGITAL DATA TRANSMISSIONS OVER TELEPHONE AND TELETYPE CIRCUITS
A. B. Fontaine, Lincoln Lab., Mass. Inst. of Tech., Lexington, (AFESD TDR 63-22), 21 Jan. 1963, 12 p., AD 298 114.

. . . decision-making, rather than demodulation. . . . Various error-correcting codes are compared with the second formula. It is shown that correlation-detection is equivalent to minimum-distance detection provided all code groups are of equal mean power, and that a binary-coded signal can always be adjusted to the constant-power state.

Related Publications:

DETECTION AND INFORMATION RATE OF TELEGRAPHIC SIGNALS
D. A. Bell, IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 70/77.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN AND IMPULSIVE NOISE
L. Kurz, IRE Internat. Conv. Rec., Pt. 4, vol. 4, March 1962, p. 161/173.

2.784: Protective Coding for Radio Facilities

Included: Automatic error correction over HF circuits; Seven unit error correcting TTY code; Codes for fading circuits.

Not Included: Channel characteristics of radio links (1).

Cross References: Anti-fading detection systems (2.873); Adaptive communication links (2.930).

Principal Publications:

TELEPRINTING OVER LONG-DISTANCE RADIO LINKS (Part 2 - Automatic Error-Correcting Methods Used Over Long-Distance Radio Links)
A. C. Croisdale, Post Office. Elect. Engrs. J., vol. 51, Oct. 1958, p. 219/225.

NOISE-REDUCING CODES FOR PULSE-CODE MODULATION
J. E. Flood, Proc. Instn. Elect. Engrs., Pt. C., vol. 105, Sept. 1958, p. 391/397.

AUTOMATIC ERROR CORRECTION ON HF TELEGRAPH CIRCUITS
P. R. Keller, Point to Point Telecomm., vol. 2, Feb. 1958, p. 25/48.

SIMPLE CODES FOR FADING CIRCUITS
H. B. Voelcker, Jr., IRE Trans. Commun. Syst., vol. CS-6, Dec. 1958, p. 47/52.

Four relatively simple, redundantly-coded, binary communication systems are considered under certain limiting conditions of signal fading. White noise is assumed to be the only source of errors. A nonredundant, synchronous teletype system is used as a standard of comparison.

SOME OPERATIONAL CONSIDERATIONS AFFECTING THE USE OF AUTOMATIC ERROR CORRECTING EQUIPMENT ON HF TELEGRAPH NETWORKS
E. G. Copper, Point to Point Telecommun., vol. 3, Feb. 1959, p. 21/34.

AUTOMATIC ERROR DISCRIMINATION AND CORRECTION IN RADIO TELETYPE SYSTEMS
W. J. Griffiths, Proc. Instn. Radio Engrs., Australia, vol. 20, no. 10, Oct. 1959, p. 591/600.

SINGLE ERROR-CORRECTING CODES FOR ASYMMETRIC BINARY CHANNELS
W. H. Kim, et al., IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 62/66.

ERROR-CORRECTING CODES FOR AN ASYMMETRIC NONBINARY CHANNEL (Correspondence)
W. H. Kim, IRE Trans. Inform. Th., vol. IT-5, Dec. 1959, p. 189/190.

A MONITOR FOR 7-UNIT SYNCHRONOUS ERROR-CORRECTING SYSTEMS FOR USE ON RADIO-TELEGRAPH CIRCUITS
R. P. Froom, et al., Post Off. Elect. Engrs. J., vol. 53, April 1960, p. 1/8.

A CLASS OF CODES FOR SIGNALING ON A NOISY CONTINUOUS CHANNEL
J. L. Kelly, Jr., IRE Trans. Inform. Th., vol. IT-6, no. 1, March 1960, p. 22/24.

DETECTION OF TRANSMISSION ERRORS IN 5-LEVEL PUNCHED TAPE
R. Steeneck, et al., Commun. and Electronics, no. 46, Jan. 1960, p. 1005/1009.

THE RATE OF INFORMATION TRANSMISSION THROUGH SYMMETRIC CHANNELS
L. F. Borodin, Foreign Tech. Div., Air Force Systems Command, Wright Patterson Air Force Base, Ohio, 10 Sept. 1962, 27 p., incl. illus., 9 refs., (Trans. no. FTD-TT-62-878, from Sto Let so Dnya Rozhdeniya A.S. Popova, Yubileynaya Sessiya, Izdatel'stvo Akademii Nauk SSSR, p. 57/73, 1960), AD 286 603.

. . . A graphical method is given for determining the optimum value of the probability of symbol erasure (in the sense of the maximum traffic capacity of a channel). . . . It is shown that the optimum code of an erase channel in the presence of a sufficiently large number of symbols in a code combination allows information to be transmitted through an erase channel with a previously assigned uncertainty and rate, close to the traffic capacity of the channel. A method is indicated for setting up codes which have properties close to those of the optimum code of an erase channel, and also in which all combinations differ from one another exactly by d = a to the m - 1 positions.

SIGNAL POWER IMPROVEMENT THROUGH CODING AND DIVERSITY
J. Mott-Smith, et al., Air Force Cambridge Research Labs., Bedford, Mass., Rept. no. AFCRL 62-383 , June 1962, 37 p., incl. illus., tables, 6 refs., AD 283 349.

. . . calculated as a function of bandwidth, capacity, and reliability for gaussian noise and independent Rayleigh fading on a binary symmetric channel.

CODING FOR PRACTICAL COMMUNICATIONS SYSTEMS
P. Elias, In: RADIO WAVES AND CIRCUITS; Proceedings of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier, Puslishing Co., 1963, p. 125/147, 27 refs., A64-10831.

. . . application of error-correcting codes to practical communications systems. . . . coding and decoding equipment to implement known schemes is feasible. . . . For a scatter link with time-varying path loss, three channels are considered. Their average capacities can be measured and the measurement need not be precise . . . Reliability is adversely affected in decoding blocks of consecutive bauds by the correlation of the fading, but, by interlacing a number of coded sequences, the bauds in any one may be made independent.

ADVANCED COMMUNICATION THEORY TECHNIQUES
J. C. Hancock, et al., Purdue Research Foundation, LaFayette, Ind., ASD TDR63 186, March 1963, 253 p., AD 405 154.

. . . channels are characterized by a model which accounts for both multiplicative and additive disturbances. A large amount of experimental data pertaining to radio disturbances is evaluated and correlated. The importance of the Rayleigh fading channel is emphasized and previous work is extended to determine the capacity and efficiency of the Rayleigh channel. . . . signal detection in the presence of statistically unknown additive disturbances. Several detectors based on non-parametric statistical techniques are treated in detail. . . . compared to the conventional likelihood detectors. Signal design techniques are used to optimize transmitted waveforms. The tradeoffs available between transmitter power and coding complexity are thoroughly investigated for the binary symmetric channel. Results are obtained for both Hamming and Bose-Chaudhuri codes.

A SELF CORRECTING SEQUENTIAL CIRCUIT UTILIZING ERROR CORRECTING CODES
J. R. Hobbs, Air Force Inst. of Tech., Wright Patterson AFB, Ohio, Aug. 1963, 43 p., AD 420 630.

. . . Linear error correcting codes and elementary finite polynomial field theory are reviewed to familiarize the reader with the notation and mathematics of the development. The basic model consists of two parts: the encoder and the corrector. . . .

ERROR-CORRECTING CODES APPLIED TO COMPUTER TECHNOLOGY
J. L. Massey, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 142/147.

The modes of communication encountered with the modern digital computers can be classified as inter-machine, e. g., a data link between computing centers, and intra-machine, e. g., transfer of data from the memory unit to the arithmetic unit. The error-correction requirements of each mode are discussed and specific techniques suitable for immediate implementation are developed from existing coding techniques . . .

ERROR-CONTROL CODING IN DIGITAL TELEMETRY SYSTEMS
L. D. Rudolph, et al., Proc. Nat. Telem. Conf., May 1963, no. 10-4.

. . . discusses . . . in broad terms, how error-control coding can be utilized in digital telemetry systems to (1) improve the data transmission efficiency, (2) eliminate the problems associated with the one-zero ambiguity found in phase-lock receivers, (3) serve as the basis for a word synchronization technique, and (4) provide error rate monitoring for closed-loop adaptive operation or to give an indication of confidence in the incoming data. . . .

Related Publications:

DATA TRANSMISSION EQUIPMENT CONCEPTS FOR FIELDATA
W. F. Luebbert, Proc. Western Joint Computer Conf., San Francisco, Calif., March 3-5, 1959, p. 189/196.

SATELLITE COMMUNICATIONS SYSTEM PROVIDING CHANNEL DROPPING. (Appendix I, II - COMPARATIVE SATELLITE R. F. POWERS REQUIRED WITH DIFFERENT CODES)
E. K. Sandeman, (British Interplanetary Society, Symposium on Communications Satellites, London, England, May 12, 1961), In: Communications Satellites, New York, Academic Press, Inc., 1962, p. 17/73, 27 refs., A63-12457.

EFFECTS OF IMPULSE NOISE IN DIGITAL DATA TRANSMISSION
A. B. Bodonyi, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N.Y., Master's thesis, Research rept. no. PIBMRI-975-61, 11 Dec. 1961, 23 p., illus., 14 refs., AD 285 511.

PERFORMANCE OF ERROR-CORRECTING CODES
M. E. Mitchell, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 72/85.

Binary decoding of relatively short codes corrupted by Gaussian noise or pulse interference has been considered in applications for which the minimum useful information block length is unity, equal to the information bit capacity of a code, or equal to an integral multiple of the information capacity of a code. . . . results . . . characterized by the performance criterion of minimizing error rate and transmitter power, with only minor restrictions on transmission bandwidth. . . .

Relatively short codes (10 to 50 information bits) of moderate redundancy (40 to 50 per cent) are available which can reduce bit error rates by factors of 10 to 400, or equivalently, permit 1 to 3 db reductions in transmitter power, when the coded system bit error rate is 10^{-6} (Gaussian noise). . . . These same codes can alternatively reduce word error rates by factors of 10 to 10^4 . . . Under worst-case pulse interference, these codes permit 4 to 7 db reductions in transmitter power for average word error rates less than 20 per cent. . . . All of these codes are easily encoded and decoded. Considered are: cyclic binary group codes. The (15, 7) code is now known as a Bose-Chaudhuri code. The (21,11) code was discovered by Prange . . . The (23, 12) code first discovered by Golay and later by Paige. . . .

A TECHNIQUE FOR IMPROVING THE TRANSMISSION RELIABILITY OF A FADING CHANNEL
S. Kitces, et al., IEEE Internat. Conv. Rec., Pt. 8, no. 11, March 1963, p. 154/162.

. . . In a channel where the duration of a fade is much longer than that of a code word, the common low-order error-correcting codes, although easily implemented, do not materially increase transmission reliability.

A technique is proposed which enables one to use simple codes to combat fading by transmitting the individual bits of a code word, not in succession, but separated in time by the length of expected fades. This transforms a channel with a correlated error pattern into one with random errors across the code words. The gaps between the bits of the code word are taken up by bits from other code words arranged in a similar fashion. . . .

THE NOISE IMMUNITY OF OPTIMUM HIGHER BINARY CODES
N. P. Khvorostenko, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 12, Dec. 1963, p. 1/8.

Expressions characterizing the noise immunity of Wagner's correction scheme for FSK and PSK systems are obtained under the following conditions: fluctuation noise is present, the amplitudes of the received signals are Rayleigh distributed, and no correlation exists between other fading or noise at instants of sampling different positions of a code word.

It is shown that Wagner's correction scheme is optimum in the sense of minimizing the mean probability of incorrect detection of a code word, and is sufficiently close to optimum in the sense of minimizing the mean probability of incorrect detection of each information symbol of this code word. . . .

DIVISION 2.8
DETECTION THEORY

Theoretical investigations showed the way to many improved detection methods for modulated radio and carrier signals. Space communications is in need of such improved methods. This bibliography should assist engineers and mathematicians who would like to have an updated review of most of the theoretical work. This volume of the bibliography contains primarily the analytical systems approaches, but many circuit oriented subjects have to be excluded. Phase lock loops as synchronous detectors, frequency discriminators, limiters, low noise receiver input devices and all receiver design problems are excluded. It is interesting to see the large remaining number of publications, considering the restriction to the narrow field of detection theory, that are listed.

Section 2.81 introduces the fundamentals of detection theory with the historically very important area of optimum filtering. It appears in two subdivisions; one on linear theory and the other on nonlinear detection theory.

Section 2.82 follows with the practically, much applied correlation methods. The success of the American planetary radar systems and of the Mariner spacecraft is largely due to the correlation detection schemes for ranging and communications signals (see volume 4C).

A large variety of other detection methods are referenced in section 2.83 where one may find listings of publications on subjects such as power law detection, coherent detection and others.

Statistical extraction methods are gaining increasing importance, not only for applications in space communications receivers but also in signal conditioning subsystems as information compression methods. Section 2.84 has subdivisions on estimation techniques, moment detection, post detection analysis and others.

Decision theory with maximum likelihood detection and sequential detection methods is the subject of Section 2.85.

A different dimension, applications oriented, is the backbone of the classification in the last two sections. Section 2.87 has a number of subdivisions for special communications applications of detection theory, while section 2.88 deals with related applications for radar and tracking.

Section 2.80

2.800: Introduction to Detection Theory

Included: Comparisons of various detection methods; Books on statistical detection theory; Theory of optimum noise immunity; Isolation of signals from noise; Statistical theory of signal detection.

Not Included: Special detection circuits; Phase lock loops; Limiters; Low noise receivers; Error probabilities of special digital transmission systems (1); Books on noise and disturbances (1); Books on communications theory (1); Fundamentals of statistical mathematics (1).

Cross References: Detection of Error protected coded information (Div. 2.7).

Principal Publications:

THE PROBLEMS OF NOISE SUPPRESSION IN COMMUNICATION SYSTEMS WHICH AFFECT SIGNAL RECEPTION AS A WHOLE
K. A. Meshkovskii, Radio Engng., vol. 13, no. 6, 1958, p. 1/19.

Methods for determining the probabilities of the correct reception of certain types of optimum and nearly optimum codes are developed. A short analysis of the advantages and disadvantages of some communication systems which serve for the transmission of a finite number of equally probable and mutually-independent messages is given. A new system of communication free of these shortcomings is proposed.

DEMODULATION AND DETECTION
D. A. Bell, Electronic and Radio Engineer., vol. 36, Jan. 1959, p. 21/24.

THE THEORY OF OPTIMUM NOISE IMMUNITY
V. A. Kotel'nikov, New York, McGraw-Hill Book Co., Inc., 1959, 140 p.

. . . first English-language account of Dr. Kotel'nikov's 1947 doctoral dissertation at the Molotov Energy Institute. . . . interesting addition to . . . the statistical theory of signal detection . . . a study of considerable historical interest.

ZUSAMMENSTELLUNG UND VERGLEICH BEKANNTER VERFAHREN ZUR AUFFINDUNG PERIODISCHER PULSE BEI ANWESENHEIT VON GERAUSCHEN (Survey and Comparison of Methods for the Detection of Periodical Pulses in the Presence of Noise) (In German)
D. Haubig, Hochfrequenztech. u. Elekt. Akust., vol. 69, no. 3, June 1960, p. 94/103.

STATISTICAL THEORY OF SIGNAL DETECTION
C. W. Helstrom, Oxford, England, Pergamon Press Ltd., 1960, 334 p.

SIGNAL DETECTION IN A NOISY WORLD
W. H. Huggins, Rand Corp., Santa Monica, Calif., 3 May 1960, 82 p., AD 241 288.

. . . when interfering signals and noise of unpredictable form and widely varying intensities are present, linear filtration is no longer adequate. It is then necessary to accept or reject the signal on the basis of its signature or waveshape. This problem is discussed in terms of the geometrical notions of a signal space and shows how signal energy, waveshape, and bandwidth are related respectively to the length, direction and angular velocity of a signal vector in this signal space. Attention is directed to the practical problem of relating these abstract ideas to engineering practice and to designing an efficient signal analyzer which will measure the principal components of a signal ensemble so that each signal may be adequately characterized by specifying the fewest number of coordinates, thus simplifying the data-processing problem. A presentation and discussion are presented of experimental data which compare the correlation and similarity indices as criteria for detection of a known signal among various signals and noise.

OPTIMUM DEMODULATION
F. W. Lehan, et al., Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, External pub. no. 164, 1960, AD 252 348.

. . . curve fitting is applied to the problem of developing a system for the optimum demodulation of generalized modulated signals. The resulting equation is shown, under certain assumptions, to apply to a wide class of modulated signals. The implications of such application are discussed.

A REVIEW OF METHODS FOR IMPROVED DETECTION OF PULSES IN NOISE
F. E. Slojkowski, Bell Telephone Labs., Inc., Whippany, N. J., Technical memo. no. MM-60-6412-4, 26 May 1960, AD 251 550.

. . . three most commonly considered methods for improvement in signal detection are presented. Correlation, comb filters and integration techniques are discussed along with the advantages and disadvantages of each.

ON THE STATISTICAL THEORY OF OPTIMUM DEMODULATION
J. B. Thomas, et al., IRE Trans. Inform. Th., vol. IT-6, no. 4, Sept. 1960, p. 420/426.

VYDELENIE SIGNALOV NA FONE SLUCHAINYKH POMEKH (The Isolation of Signals in a Background of Random Noise) (In Russian)
L. A. Vainshtein and V. D. Subakov, Moscow, Izd. Sov. Radio, 1960, 448 p.

LECTURES ON COMMUNICATION SYSTEM THEORY
E. J. Baghdady (editor), New York, McGraw-Hill Book Co., Inc., 1961.

. . . The theorist has claimed that the engineer is a technical reactionary, unable or unwilling to accept or try new approaches, preferring the familiarity and relative safety of proven and generally accepted techniques. The theorist, on the other hand, has been accused of being disinterested in the real challenges which exist, preferring instead to invent problems for which he has or wishes to find solutions. . . .

. . . the book does more to demonstrate the current situation in communications than to alter it. Communication systems will still be designed by "seat-of-the-pants" engineering, the "forest of formulae" to the contrary. . . . when viewed as a report on the current status of communications philosophy, the book succeeds rather well. . . . essentially a collection of papers resulting from the MIT summer program (1959) on "Reliability Long-Range Radio Communication." The 18 authors are recognized authorities in their respective specialities . . . book review by John P. Costas . . .

THEORY OF OPTIMUM METHODS OF RADIO RECEPTION WITH FLUCTUATING NOISE (In Russian)
L. S. Gutkin, Moscow, Gosenergoizdat, 1961, 488 p.

. . . The analysis is made mainly in application to radio signals, but the majority of the methods under consideration and the results obtained are applicable also to signals of other kinds (wire communication, acoustics, etc.). . . . knowledge of the principles of probability theory is required . . . intended for a wide circle of specialists . . .

DIGITAL METHODS FOR THE EXTRACTION OF PHASE AND AMPLITUDE INFORMATION FROM A MODULATED SIGNAL
R. S. Lawrence, et al., J. Res. Nat. Bur. Stand., vol. 65D, no. 4, July/Aug. 1961, p. 351/356.

A description is given of three digital methods which have been used to recover amplitude and phase information from a modulated sinusoidal signal sampled at equal intervals of not more than one-sixth of a period. The first method, the "zero-crossing" method, is economical of computer time and, for modulation which is not too deep and does not contain frequencies near the carrier frequency, accurately recovers the phase and amplitude modulation. The second method, the "filter" method, is more laborious but it gives better accuracy and will operate with deeper and more rapid modulation. The third method, a statistical approach, will work with severely overmodulated signals, but it yields only a statistical summary of the modulation. The methods were designed specifically for analysis of radio-star scintillation records but they may be applied to many other modulated signals.

A NEW APPROACH TO THE COMPARISON OF DETECTION SYSTEMS
D. M. Levy, Naval Supersonic Lab., MIT, Cambridge, Tech. rept. 470 , Sept. 20, 21 p., AD 261 709.

The application of statistical decision theory to the problem of comparing 2 detection systems is discussed. It is shown that the optimum system is quite sensitive to the details of the noise statistics. It is concluded that if 2 systems are evaluated in the presence of the same, but not necessarily known, background statistics then the better system is that which provides a uniformly lower cost.

NONLINEAR TRANSFORMATIONS OF RANDOM PROCESSES
R. Deutsch, Englewood Cliffs, N. J., Prentice-Hall, Inc., 1962, 138 p.

. . . few selected topics . . . are as follows: "Envelopes and Pre-Envelopes": Hilbert transforms and application. "Characteristic Function Method": "Correlation Function Method" "Multiplication and Power Law Devices": "Modulation and Detection": "Sampling Theorem" . . .

THE APPLICATION OF CERTAIN THEORIES TO THE PROBLEMS OF DETECTION AND COMMUNICATION (In French)
J. Lochard, et al., Onde Electr., vol. 42, no. 426, Sept. 1962, p. 709/737.

A series of 5 papers . . . the first develops the thought that research . . . of signals carrying information has, up to now, been less developed than those applied to . . . materials and mechanism of transmission . . . the second . . . explains . . . results of the theory of probability . . . their applications to signals . . . the third article . . . deals with . . . mathematical statistics . . . in the reception of signals immersed in noise . . . fourth article . . . shows how the results of statistical theory . . . can be applied or cannot be applied to the practical problems of signal transmission . . . the last article . . . shows how the properties of written language . . . can be studied quantitatively . . .

RECENT DEVELOPMENTS IN INFORMATION AND DECISION PROCESSES
R. E. Machol and P. Gray (editors), New York, The MacMillan Co., 1962, 194 p.

DEMODULATION BY SAMPLING COMPARED WITH PHASEDEPENDENT RECTIFICATION (In German)
F. Unger, Elektron. Rundschau, vol. 16, no. 9, Sept. 1962, p. 400/402.

EXTRACTION OF SIGNALS FROM NOISE
L. A. Wainstein and V. D. Zubakov, Englewood Cliffs, N.J., Prentice-Hall, Inc., 1962, 382 p.

The Wiener-Kolmogorov theory of filtering and prediction of stationary random processes and sequences in analyzed, and optimum filters for the detection of signals of known form are discussed.

ADVANCED DOMMUNICATION THEORY TECHNIQUES
J. C. Hancock, et al., Purdue Research Foundation, LaFayette, Ind., ASD TDR63 186, March 1963, 253 p., 37 refs., AD 405 154, N63-15324.

. . . channels are characterized by a model which accounts for both multiplicative and additive disturbances. A large amount of experimental data pertaining to radio disturbances is evaluated and correlated. The importance of the Rayleigh

fading channel is emphasized and previous work is extended to determine the capacity and efficiency of the Rayleigh channel. . . . signal detection in the presence of statistically unknown additive disturbances. Several detectors based on non-parametric statistical techniques are treated in detail. . . . compared to the conventional likelihood detectors. Signal design techniques are used to optimize transmitted waveforms. The tradeoffs available between transmitter power and coding complexity are thoroughly investigated for the binary symmetric channel. Results are obtained for both Hamming and Bose-Chaudhuri codes.

SIGNAL ANALYSIS II: ESTIMATION OF THE AMPLITUDES OF NARROW BAND DETERMINISTIC SIGNALS OBSERVED INCOHERENTLY IN NORMAL NOISE BACKGROUNDS
D. Middleton, Carlyle Barton Lab., Johns Hopkins U., Baltimore, Md., Technical rept. no. AF-100 , Feb. 1963, 103 p., AD 297 870.

COMMUNICATION AND RADAR — SECTION A. General
R. Price, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 240/246, 146 refs.

. . . digital communication and radar, particularly from the point of view of detection and parameter-estimation theory. . . .

PATTERN RECOGNITION AS A PROBLEM IN DECISION THEORY AND AN APPLICATION TO SPEECH RECOGNITION
V. E. Sackschewsky, et al., IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 186/189.

CODING, FILTERING, AND INFORMATION THEORY
L. S. Schwartz, New York U., N.Y., in Md. U. Proc. of the Space Communications Inst., Md. U., College Park, June 23-28, 1963, 1963, p. 15-35, refs., N64-17196.

. . . theory of communications . . . largely the work of two men, Claude Shannon and Norbert Wiener . . . recent developments . . . reliability improvement . . . method of decision in the receiver . . . feedback channel . . .

IMPROVEMENT IN GAUSSIAN SIGNAL PERCEPTION BY DETERMINISTIC SIGNAL INJECTION AND HARMONIC-ZONE DETECTION
A. Weiner, et al., Electronic Defense Lab., Mountain View, Calif., 8 Feb. 1963, 28 p., AD 404 476.

. . . perception of narrowband, Gaussian signals . . . using a reference sine wave, a stiff limiter, and a harmonic-zone filter . . . The comparison of this new technique with energy detection showed equal signal perception at 3-db lower S/N ratios for perception probabilities greater than 0.5 at fixed, false-alarm probabilities of 1/1000, 1/10,000, 1/100,000 and 10 to the minus 6th power.

Related Publications:

THEORY OF RANDOM FUNCTIONS AND ITS APPLICATION TO PROBLEMS OF AUTOMATIC CONTROL
V. S. Pugachev, Moscow, Fizmatgiz, 1957, 750 p.

ACOUSTICAL SIGNAL DETECTION IN TURBULENT AIRFLOW
M. W. Smith, et al., J. Acoust. Soc. Amer., vol. 32, no. 7, July 1960, p. 858/866.

INTRODUCTION TO THE STATISTICAL DYNAMICS OF AUTOMATIC CONTROL SYSTEMS
V. V. Solodovnikov, New York, Dover Publications, Inc., 1960, 308 p.

. . . Solodovnikov's book was first published in the USSR in 1952. It belongs to a time when there was little expository information on the new statistical point of view, and the principal urgency was to make something—anything—available in a hurry. . . . it provides its readers with extracts from the best that was available on the subject in the American and (to a far lesser extent) in the Russian periodical literature. . . .

WIDE-BAND CARRIER COMMUNICATIONS. VOLUME III. BINARY COMMUNICATION BY MEANS OF NOISE SAMPLES
R. L. Luedtke, et al., Lockheed Aircraft Corp., Sunnyvale, Calif., Rept. no. LMSD-704048, vol. 3 , Nov. 1961, 1 v., AD 253 283.

. . . A short elaboration is given on the low detectability of the signal by an unfriendly observer while operating at low signal-to-noise ratios . . .

Section 2.81
Fundamentals of Detection Theory

2.811: General Analytical Problems in Detection Theory

Included: Elementary theory of Gaussian signals in Gaussian noise; Detection of pulse signals in noise; Stochastic approximation methods of optimum filter design; Separability of signals with overlapping spectra; Youla's integral equations in demodulation problems; Relationship between various concepts of detection theory; General problems of noise threshold; General problems in detection systems with finite observation time; Theory of an ideal receiver; Asymptotic forms of detectors.

Not Included: Statistics of Gaussian noise (1); Statistics of certain signal plus noise processes (1); Statistics of certain signal plus noise processes (1); Noise threshold in FM (1); Design of FM and PM detection circuits; Design of signal processing subsystems (3A).

Cross References: Detection under special non-Gaussian conditions (2.871); Detection in channels with non-additive noise (2.872); Radar detection theory (2.883); Detection of special signals in specified channels (2.870); Separation of two signals with coincident spectra (2.845); Detection under multipath conditions (2.873).

Principal Publications:

DISCUSSION ON "DETECTION OF PULSE SIGNALS IN NOISE: THE EFFECT ON VISUAL DETECTION OF THE AREA OF THE SIGNAL POINT"
D. C. Fakley, et al., J. Brit. Instn. Radio Engrs., vol. 18, May 1958, p. 317/318.

A PHYSICAL INTERPRETATION OF SHANNON'S AMBIGUITY (In French)
J. Loeb, Ann. Telecommun., vol. 13, March/April 1958, p. 78/82.

. . . for the case of Gaussian noise superposed on an AM signal, by a transitional probabilities matrix ("grille"). . . . can also be applied to problems involving non-Gaussian noise or nonlinear circuit elements.

SOME COMMENTS ON THE DETECTION OF GAUSSIAN SIGNALS IN GAUSSIAN NOISE
D. Slepian, IRE Trans. Inform. Th., vol. IT-4, June 1958, p. 65/68.

GRAPHICAL PRESENTATION OF DATA IN THE FRAMEWORK OF THE THEORY OF SIGNAL DETECTABILITY
W. P. Tanner, Jr., J. Acoust. Soc. Amer., vol. 31, Feb. 1959, p. 243/244.

. . . data relating measures of performance to signal energy in psychophysical experiments. Recently some papers have appeared in the psychoacoustic literature presenting data analyzed within the framework of the theory of signal detectability. . . .

AN IDEAL IDENTIFICATION DEVICE FOR COMPLEX SIGNALS
L. F. Borodin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 60/74.

. . . an identification device which for a given receiver will ensure the maximum probability of correct reception of the combinations in a correcting code. It is shown that the use of this ideal device and "equidistant" codes makes it possible to transmit messages along channels with the desired degree of authenticity. The possibility of correcting errors by arithmetic operations is indicated. The results are given of an experiment carried out on a high-speed electronic computer to compare a number of other methods of reception with the ideal method. The results of the experiment confirm that the "symbol" method of reception is imperfect. . . .

CERTAIN RELATIONSHIPS IN OPTIMUM SYSTEMS OF SIGNAL DETECTION
L. S. Gutkin, Radio Engrg., vol. 15, no. 2, 1960, p. 73/88.

REPRESENTATION AND ANALYSIS OF SIGNALS. PART VII. SIGNAL DETECTION IN A NOISY WORLD
W. H. Huggins, Johns Hopkins U. School of Engineering, Baltimore, Md., AFCRC TN 601360, 15 Sept. 1960, 82 p., incl. illus., AD 245 887.

. . . when interfering signals and noise of unpredictable form and widely varying intensities are present, linear filtration is no longer adequate. It is then necessary to accept or reject the signal on the basis of its signature or waveshape, and this requires the measurement of many coordinates. . . . Attention is directed to the practical problem of relating these abstract ideas to engineering practice and to designing an efficient signal analyzer which will measure the principal components of a signal ensemble so that each signal may be adequately characterized by specifying the fewest number of coordinates,

thus simplifying the data-processing problem. The phase-principle of signal detection is generalized to be applicable to signals of arbitrary waveform and it is shown that a particular realization of a phase detector using superlimiters requires about 5 db more S/N than does a conventional matched-filter amplitude detector for the same detection and false-alarm probabilities.

THE METHOD OF DETERMINING OPTIMUM SYSTEMS USING GENERAL BAYES CRITERIA
V. S. Pugachev, IRE Trans. Circuit Theory, vol. CT-7, no. 4, Dec. 1960, p. 491/505.

. . . problems of finding an algorithm of an optimum system designed for detecting or estimating signals in the presence of interferences may be formulated as follows. . . .

DETECTION OF UNKNOWN SIGNALS IN STRONG NOISE
JPL Res. Summ., vol. 1, no. 36-7, Dec./Jan. 1960, p. 53/54.

. . . it is assumed that the detailed form of the signal is unknown but that a rough knowledge of its power spectrum exists. It is assumed also that the spectrum of the noise is known, and (for simplicity) it is supposed to be white. . . . However, making an accurate measurement of a power spectrum poses a considerable problem. Any given sample of the input signal can be analyzed exactly, by computer, but the spectrum so found will be only for that particular sample. A different sample will, in general, yield a different spectrum. The central problem of power spectrum measurement lies in the reduction of this variability. . . . Computer programs exist that can quickly find the spectrum of 10^4 data points. But 10^8 data points is another matter, requiring hundreds of hours on a machine such as the IBM 704. . . . This report is a summary of some research into a method to alleviate this difficulty. The plan is to use a special purpose computer to evaluate the auto-correlation function of the signal, and to achieve this in real time so that the data will be ready as soon as the observation is finished. . . .

INFORMATION THEORY AND THE SEPARABILITY OF SIGNALS WITH OVERLAPPING SPECTRA
L. L. Campbell, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 193/194.

ON THE ASYMPTOTIC EFFICIENCY OF LOCALLY OPTIMUM DETECTORS
J. Capon, IRE Trans. Inform. Th., vol. IT-7, no. 2, April 1961, p. 67/71.

A detector examines an unknown waveform to determine whether it is a mixture of signal and noise, or noise alone. The Neyman-Pearson detector. . . is optimum for all values of the signal-to-noise ratio, and its implementation is usually quite complicated. . . it is desired to detect signals which are very weak compared to the noise. The locally optimum detector is defined as one which has optimum properties only for small signal-to-noise ratios. It is proposed as an alternative to the Neyman-Pearson detector . . .

A STATISTICAL MEASURE OF THE EFFECTIVENESS OF ADAPTATION IN CONTROL SYSTEMS
R. A. Nesbit, IRE Internat. Conv. Rec., vol. 4, March 1961, p. 18/24.

APPLICATION OF STOCHASTIC APPROXIMATION METHODS OF OPTIMUM FILTER DESIGN
D. J. Sakrison, IRE Internat. Conv. Rec., vol. 4, March 1961, p. 127/135.

DETERMINATION OF THE FUNCTION OF AN IDEAL RECEIVER
N. L. Teplov, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 3, 1961, p. 30/38.

Functions of an ideal receiver are defined, depending on the statistical structure of information and on the signal form. Parameters of an almost ideal receiver are shown. . . .

METHOD AND MERIT OF BINARY CODING FOR ANALOG CHANNELS
I. M. Jacobs, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 765/773.

. . . The reception of coded signals is conveniently considered as two steps, detection and decoding, the first largely analog and the second largely digital. . . .

In this paper, we consider the improvement in rate and signal-to-noise ratio offered by coding and decoding for three values of detector quantization; Q = 2 (binary detection), Q = 3 (ternary or null-zone detection), and Q = (continuous or unquantized detection). A qualitative insight is then provided into convolutional encoding and sequential decoding as one means, adaptable to any value of Q, for realizing these gains.

THE ONE-SIDED BARRIER PROBLEM FOR GAUSSIAN NOISE
D. Slepian, Bell Syst. Tech. J., vol. 4, no. 2, March 1962, p. 463/501.

ON THE NOISE THRESHOLD OF CONVENTIONAL FM AND PM DEMODULATORS (Correspondence)
E. J. Baghdady, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1260/1261.

Controversy has recently raged over the threshold of linear variation of base-band S/N ratio with IF S/N ratio for conventional exponent demodulators—in particular, the cause of departure from linearity, the effect of postdemodulation linear filtering, and hence the dependence of the threshold upon the deviation ratio of the expected signal. The purpose of this communication is to present a simple analysis that clarifies this situation completely. . . .

PREDICTION AND FILTERING
A. V. Balakrishnan, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 237/240, 48 refs.

PREFACE TO NORTH PAPER
L. Blake, Proc. IEEE, vol. 51, no. 7, July 1963, p. 1015/1027.

This classic report, written in 1943 by Dwight O. North, appears here for the first time in a publication readily available to the engineering profession, although it was issued as a military-security-classified report during World War II (RCA Laboratories Report PTR-6C, dated June 25, 1943). It is reprinted here because of its historical importance and because it is still a basic but otherwise unavailable reference of great value in current research. . . .

STRUCTURE OF V. A. KOTEL'NIKOV'S IDEAL RECEIVER FOR EQUIPROBABLE SIGNALS
Y. V. Khomenyuk, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 1, Jan. 1963, p. 22/29.

The structure of ideal Kotel'nikov receivers for general equiprobable signals, for signals of equal power, and for signals which differ by a constant factor is established. For equiprobable signals of equal power a receiver structure is described which has all the properties of an ideal receiver and, in addition, is not sensitive to the level of input and local oscillator signals. . . .

Conclusions. . . The ideal Kotel'nikov receiver is a correlation receiver. . . . In the majority of important practical cases . . . the ideal receiver is reduced to one correlator. . . and one local oscillator. . . . The credit in the field of correlation reception belongs entirely to Soviet scientists. . . .

RECEPTION OF A PULSE PACKET IN THE PRESENCE OF CORRELATED NOISE
V. F. Nesteruk, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 8, Aug. 1963, p. 8/14.

A method of calculating the optimum configuration of a packet of coherent pulses received on a background of correlated noise is described. The optimum configuration of the packet is found for Markov noise.

A distinctive feature in the reception of a finite pulse packet is the fact that noise cannot be assumed to be uncorrelated. As a result, the probability of correct detection of a pulse packet will depend not only on the power level of the packet but also on the shape of the pulses of which the packet consists and on the power distribution over the packet. . .

AN ANALYSIS OF THE FACTORS WHICH DETERMINE SIGNAL/NOISE DISCRIMINATION IN PULSED-CARRIER SYSTEMS
D. O. North, Proc. IEEE, vol. 51, no. 7, July 1963, p. 1016/1027.

OPTIMUM DECODING AT LOW SIGNAL-TO-NOISE RATIOS
E. C. Posner, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 155/156.

. . . this note. . . continues previous JPL work on the use of error-correcting codes on a white Gaussian channel as the signal-to-noise ratio approaches zero (RS 36-13, p. 32/37; RS 36-14, p. 34/39). Two criteria of performance are used: expected number of information bits in error, and probability of word error. It is shown that if bit-by-bit detection is used, and if the expected number of bits in error is to be minimized, then maximum likelihood decoding is not optimum at low signal-to-noise ratios. (In fact, coding should be abandoned at low signal-to-noise ratios in favor of longer integration time per bit, as in RS 36-14.)

ASYMPTOTIC FORMS OF DETECTORS OF SIGNALS IN NOISE
W. L. Root, Mathematics Research Center, U. of Wisconsin, Madison, Feb. 1964, 39 p., AD 437 292.

. . . The first result is. . . an approximation, asymptotically correct as the observation interval becomes infinite, to. . . the optimum detector for sure signals in Gaussian noise. . . . has previously only been justified heuristically. The second result . . . a detector of noise like signals in noise

which has the merit of minimizing asymptotically a certain bound on the errors from among a wide class of quadratic detectors, specified in a completely practical way. A theorem giving asymptotic expressions for the mean and variance of a class of estimators of power spectral density, of more or less standard type, is used in this discussion and is proved in an appendix.

COMMUNICATION SYSTEMS TECHNIQUE BASED ON FUNDAMENTAL CONCEPTS OF JACQUES HADAMARD
R. G. Segers, Vitro Labs., West Orange, N. J., Final rept., RADC TDR63 177, 10 June 1963, 70 p., AD 406 902.

A variety of fundamental investigations, with common analytical foundation in the work of Jacques Hadamard, was conducted for the purpose of development of advanced communications systems. . . . demodulation problem as formulated in a system of integral equations by D. C. Youla. . . . communication techniques derivable from incidence matrices of balanced incomplete block design configurations.

METHODS OF THRESHOLD SIGNAL RECEPTION IN THE PRESENCE OF NOISE
J. Seidler, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 7 Oct. 1963, 139 p., AD 424 402.

ESTIMATION OF THE CONSTANT COMPONENT OF A DETECTED PERIODIC SIGNAL MIXED WITH ADDITIVE GAUSSIAN NOISE USING A SEGMENT OF A SINGLE SAMPLE OF FINITE DURATION
A. B. Tatarinov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 6, June 1963, p. 5/14.

OBNARUZHENIE SIGNALOV V SHUMAKH PRI NALICHII NEIZVESTNYKH PARAMETROV (Signal Detection in Noise When Some of the Parameters are Unknown) (In Russian)
A. F. Terpugov, Radiotekhnika i Elektronika, vol. 9, Jan. 1964, p. 61/66, A64-15781.

. . . two approaches. . . The second approach yields a new criterion of gain which is used in the solution of the above problem.

DETECTION OF A SINUSOID IMMERSED IN NOISE-FINITE INTEGRATION TIME AND LINEWIDTH (Correspondence)
S. V. Yadavalli, Proc. IEEE, vol. 51, no. 5, May 1963, p. 865.

In many practical problems concerning the detection of signals immersed in noise, one has to choose an observation time T (and consequently integration time as well) which is rather short. T may sometimes be of the order of a few periods of a sinusoid. . .

Related Publications:

MODULATION AND SIGNAL SELECTION FOR DIGITAL DATA SYSTEMS
R. M. Lerner, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 2/14, 28 refs.

The statistical decision model of a communication channel is used to discuss a variety of signal modulation techniques intended to overcome the problems met in the use of voice-bandwidth channels for high performance digital data transmission. . . .

A NOTE ON THE FORMATION OF CONCEPT AND OF ASSOCIATION BY INFORMATION-THEORETICAL CORRELATION ANALYSIS
S. Watanabe, Inform. Control, vol. 4, no. 2/3, Sept. 1961, p. 291/296.

. . . hereafter referred to as ITCA provides a powerful tool in producing mechanizable models of a certain type of cognitive and recognitive processes, such as concept formation, formation of association, pattern recognition, indexing, taxonomical and other classification, identification of "clusters," medical diagnoses, etc. . . .

SOME OBSERVATIONS ON MEASURABLE PROPERTIES OF RANDOM PROCESSES AND FIELDS. I
D. Middleton, Litton Systems, Inc., Waltham, Mass., Rept. no. TR63 4BF, 16 March 1964, 54 p., AD 434 120.

A number of useful, measurable properties of random processes and random fields are defined and discussed, and it is shown how these results may be applied to observations necessarily finite in time and in space. . . .

2.812: Optimum Linear Filtering

Included: Mean-square error criteria; Non-mean-square error performance criteria; Linear prediction filters; Optimum weighting functions in linear filtering; Prediction theory in general; Wiener filters; Linear prediction theory; Prediction of time series; Optimum continuous filter; Finite memory filters in Wiener's detection theory; Optimum zero memory filters; Iterative design of optimum filters; Optimum filtering of non-stationary random signals; Optimum linear multi-variable filters; Wiener-Masani technique of multiple spectra factorization; Toeplitz equations; Levinson recursion; Wiener-Kalman optimal filtering.

Not Included: Circuit design of filters; Matched filter receiving systems (1).

Cross References: Least square estimators (2.842); Smoothing processes (2.846); Detection under special noise conditions (2.871); Finite memory filters in coherent detection (2.834); Comb filters (2.836).

Principal Publications:

PREDICTION AND FILTERING FOR RANDOM PARAMETER SYSTEMS
F. J. Beutler, IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 167/171.

LINEAR LEAST-SQUARES SMOOTHING AND PREDICTION, WITH APPLICATIONS
S. Darlington, Bell Syst. Tech. J., vol. 37, no. 5, Sept. 1958, p. 1221/1294.

. . . calculation of smoothing and prediction operators of the linear least-squares sort using techniques derived from a circuit theory point of view. The techniques are developed explicitly for time series which are continuous and statistically stationary.

LEAST SQUARES FILTERING AND PREDICTION OF NONSTATIONARY SAMPLED DATA
B. Friedland, Inform. Control., vol. 1, Dec. 1958, p. 297/313.

DETECTION OF PULSED SIGNALS IN NOISE (OPTIMUM BUTTERWORTH THIRD-ORDER FILTERS)
H. S. Heaps, et al., Electronic and Radio Engrg., vol. 35, May 1958, p. 190/193.

OPTIMUM FILTER FUNCTIONS FOR THE DETECTION OF PULSED SIGNALS IN NOISE
H. S. Heaps, Canad. J. Phys., vol. 36, June 1958, p. 692/703.

THE PREDICTION OF DERIVATIVES OF POLYNOMIAL SIGNALS IN ADDITIVE STATIONARY NOISE
I. Kanter, IRE WESCON Conv. Rec., no. 4, Aug. 1958, p. 131/146.

Unifying theory for a problem which arises in a now classical paper on prediction theory.

NON-MEAN SQUARE ERROR CRITERIA
S. Sherman, IRE Trans. Inform. Th., vol. IT-4, Sept. 1958, p. 125/126.

ON THE MEAN-SQUARE NOISE POWER OF AN OPTIMUM LINEAR DIGITAL FILTER FOR CORRELATED NOISE INPUT
M. Blum, IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 58/61.

OPTIMUM TCHEBYCHEFF THIRD-ORDER FILTERS
H. S. Heaps, et al., Electronic and Radio Engr., vol. 36, Oct. 1959, p. 388/391.

. . . It is found that for a given length of input pulse the signal-to-noise ratio in a sample of the output is almost independent of the value of the filter parameter (chosen between zero and unity). The ratio of output signal energy to output noise energy is calculated for output samples that contain given percentages of the total available output-signal energy. The optimum Tchebycheff filter produces signal-to-noise ratios which are not quite as large as those obtained by use of the optimum Butterworth filter considered in a previous paper.

OPTIMUM LINEAR LEAST-SQUARE SMOOTHING AND PREDICTION
R. Mittra, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 422/430.

. . . discusses the mathematical problem of the design of smoothing and prediction filters for stationary random processes. . .

DIGITAL DATA PROCESSING FOR FINITE MEMORY FILTERS
A. J. Monroe, et al, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 49/56.

The theory of continuous optimum time invariant filtering of non-random signals from stationary random noise has been of interest. . . for the past few years. Following the Wiener approach, extensions have been made to include either the finite or infinite past history of the input. In some instances these results have been modified to include

the time varying case. With the introduction of discontinuous control, some of the above results have been worked into their discrete equivalent. This paper is concerned with one such modification of this type; namely the analysis and/or synthesis of digital programs to operate on an input signal so as to give some particular desired output. . . . will include ordinary smoothing, smoothing with prediction and differentiation. . . smoothing with prediction and integration. . . .

ON A PROPERTY OF WIENER FILTERS
M. Zakai, IRE Trans. Inform. Th., vol. IT-5, March 1959, p. 15/17.

SMOOTHING AND PREDICTION OF TIME SERIES BY CASCADED SIMPLE AVERAGES
R. B. Blackman, IRE Trans. Circuit Theory, vol. CT-7, Aug., 1960, p. 136/143.

ON THE MEAN-SQUARE NOISE POWER OF AN OPTIMUM CONTINUOUS FILTER FOR CORRELATED NOISE
M. Blum, IRE Trans. Inform. Th., vol. IT-6, no. 4, Sept. 1960, p. 426/434.

SIGNALS VS NOISE SELECTION BY FILTERING
H. Debart, Cables et Transmission, vol. 14, no. 1, Jan. 1960, p. 3/11.

. . . accompanying noise. . . may be characterized wither as a disturbance of an a priori known wave shape or as a random one, the spectral power density of which is given . . . A method of building filters is suggested. . . . A comparison is made of this method of approach with that proposed by Zadeh-Ragazzini.

CERTAIN RELATIONSHIPS IN OPTIMUM SYSTEMS OF SIGNAL DETECTION
L. S. Gutkin, Radio Engng., vol. 15, no. 2, 1960, p. 73/88.

PREDICTION FOR WIDE-SENSE MARKOV PROCESSES (Correspondence)
F. J. Beutler, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 267/269.

. . . minimum-mean-square linear estimator. . . solution of a generalized Wiener-Hopf equation. . . . nonrealizable time-varying weighting function. . .

OPTIMUM PREFILTERING OF SAMPLED DATA (Correspondence)
W. M. Brown, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 269/270.

Let f denote a stochastic signal and n denote additive noise; consider a prefilter which prepares f + n for sampling. The sampled data is interpolated to recover an estimate of f. . . .

NEW METHODS AND RESULTS IN LINEAR PREDICTION & FILTERING THEORY
R. E. Kalman, RIAS, Inc., Baltimore, Md., (Tech. rept. 61-1), 1961, 159 p., Presented at the Symposium on Engineering, Applications of Random Function Theory and Probability, Purdue U., Nov. 1960, AD 257 580.

Overcoming difficulties for synthesizing a filter with a prescribed impulse response is discussed. . . data are given in such a form that computation of the optimal filter is highly simplified, with a single equation covering all cases. The Wiener problem is reduced to the classical Hamiltonian formalism of the calculus of variations; many long-standing difficulties of the theory are resolved or greatly clarified. The solution consists in the specification of the differential equation of the optimal filter.

A NOTE ON OPTIMUM LINEAR MULTI-VARIABLE FILTERS
R. J. Kavanagh, Proc. Instn. Elect. Engrs., Pt. C, vol. 108, no. 14, Sept. 1961, p. 412/417.

. . . This note contributes a method of factorizing any power-spectra matrix in the required manner. As a result, the explicity solution for the optimum filter is obtainable in a number of cases not previously solvable without resort to implicity methods. . . .

THEORY OF OPTIMAL SIGNAL FILTRATION IN THE PRESENCE OF INTERNAL NOISE IN SYSTEMS WITH VARIABLE PARA-METERS
L. K. Von, ARS Journal, vol. 31, no. 9, Sept. 1961, p. 1306/1314.

A FREQUENCY-WEIGHTED MEAN-SQUARE ERROR CRITERION
D. S. Ruchkin, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 192/193.

OPTIMUM ZERO MEMORY FILTERS
L. I. Bluestein, et al., IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 337/342.

. . . using the mean absolute error criterion. It is shown that the characteristic of this filter is antisymmetric about a certain point when the signal and noise densities have symmetry properties. The coordinates of this point are found. . . . The optimum zero memory filter is shown to be a quantizer for quantized signals and a method of obtaining the characteristic of this filter is developed when the signal has a finite number of levels. . . .

OPTIMAL FILTERING AND LINEAR PREDICTION APPLIED TO A MIDCOURSE NAVIGATION SYSTEM FOR CIRCUM-LUNAR MISSION
J. D. McLean, et al., NASA TND-1208, March 1962.

OPTIMAL MESSAGE FOR ZERO MEMORY SYSTEMS WITH ADDITIVE GAUSSIAN NOISE (Correspondence)
F. Tung, Proc. IRE, vol. 50, no. 4, April 1962, p. 481/482.

The unconventional approach to the problem of least-square filtering by finding the characteristics of a class of input processes for which the optimal operator is in the form of a polynomial was treated recently by Balakrishnan. This note is concerned particularly with the case in which the noise is additive Gaussian and the prescribed filter belongs to the class of all zero memory systems. . . .

A TELEMETRY IMPROVEMENT STUDY
Philco Corp., Palo Alto, Calif. Technical documentary rept., (Rept. no. WDL-TR1909), 1 Oct. 1962, lv. incl. illus., tables, AD 289 875.

An abbreviated derivation is given for a tapped delay-line Wiener filter. An attempt is made to apply filtering of this type to a PCM-PC-PM telemetry signal. Both i-f filtering and post-detection filtering are considered. . . . Results show that such filtering is of marginal value for the particular telemetry signal investigated.

ONE-AND TWO-DIMENSIONAL PROCESSING IN LINE SCANNING SYSTEMS
L. G. Callahan, et al., Appl. Optics, vol. 2, no. 4, April 1963, p. 401/407.

. . . Three performance criteria are used: least squares error, maximum-peak signal to r.m.s. noise ratio, and minimum system resolution. A table shows the improvement of arbitrary two-dimensional filtering over one-dimensional filtering along the lines.

OPTIMUM WEIGHTING FUNCTIONS FOR THE DETECTION OF SAMPLED SIGNALS IN NOISE
J. Capon, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 152/159.

The problem of designing a linear pre-detection filter for the detection of a sampled random signal in additive noise is considered. The design of the filter is based on an optimality criterion which maximizes the signal-to-noise ratio enhancement. . . .

FUNDAMENTAL ACCURACY LIMITATIONS FOR PILOT-TONE TIME-BASE CORRECTION
J. A. Develet, Jr., Aerospace Corp., El Segundo, Calif., (SSD-TDR-64-9; TDR-269(9990)-3, 10 Feb. 1964, 13 p., refs., AD 430 464, N64-16447.

Wiener filtering concepts are applied. . . After transmission through a medium with varying time delay and additive noise, the pilot tone is recovered by a tracking filter. The output of the tracking filter can be used to estimate the variations in time delay of the transmission medium. A statistical optimization is then performed to find the minimum residual time-base error in the desired signal after correction by such a system.

SYNTHESIS OF FIXED AND VARIABLE NETWORKS FOR FILTERING NON-STATIONARY RANDOM SIGNALS
C. H. Knapp, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 276/280.

. . . Inasmuch as the ensemble mean-squared error (M.S.E.) is not an effective error criterion for this purpose, the integral of the weighted M.S.E., Ie, is used. Necessary and sufficient conditions are determined for minimization of Ie by filters with some rather general constraints, and three examples of the solution for these filters are given. . . .

ITERATIVE DESIGN OF OPTIMUM FILTERS FOR NON MEAN-SQUARE-ERROR PERFORMANCE CRITERIA
D. J. Sakrison, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 161/167.

. . . In an earlier paper, the design of filters by means of an iterative adjustment scheme was described. The filter was assumed to be of a fixed form but to contain k variable parameters. The problem is to find the parameter setting that minimizes the expectation of some weighted value of the error. . . .

this paper presents the results of work that has eliminated. . . difficulties. . . . presents a scheme for continuously adjusting the filter parameters and proves that, under reasonable conditions, the parameter setting converges to the optimum. . . .

MIDCOURSE GUIDANCE USING RADAR TRACKING AND ON-BOARD OBSERVATION DATA
G. L. Smith, et al., National Aeronautics and Space Administration, Ames Research Center, Moffet Field, Calif., (NASA TN D-2238), April 1963, 28 p., refs., N64-17773.

The Wiener-Kalman optimal filtering technique is applied to the problem of utilizing combined radar tracking (range and range rate) data and on-board observations for estimating the trajectory of a space vehicle and for guiding the vehicle in cislunar space.

SYNTHESIS OF OPTIMAL FILTERS WITH MULTIPLE INPUTS AND FINITE MEMORY
I. M. Tseitlin, Tekhnicheskaia Kibernetika, Jan.-Feb. 1963 (In Russian), Engineering Cybernetics, Jan.-Feb. 1963, p. 39/46, 7 refs., Translation, A64-15927.

Investigation of a linear filter having inputs and outputs, in which useful signal and additive noise are supplied to each of the inputs. The signal has two components—a stationary random function whose correlation function is known, and a non-random function which is approximated by a polynomial of a given degree, but with unknown coefficients. The noise is represented by a stationary random function with a known correlation function. . . .

RECURSIVE SCHEMES FOR NORMAL EQUATIONS OF TOEPLITZ FORM
R. A. Wiggins, et al., Massachusetts Inst. of Tech., Cambridge, In its Studies in Optimum Filtering of Single and Multiple Stochastic Processes, 30 June 1963, p. 80/99, N64-15483.

The solution of the least square Optimum filtering problem involves solving a set of simultaneous equations. . . efficient schemes for arriving at the desired filter are outlined in this report. The following types of equations are discussed: (1) single processes—the Levinson-recursion to larger operators; (2) multi-input processes-recursion to larger operators and recursion to move output origin; and (3) multi-dimensional processes—recursion to larger operators.

NORMAL EQUATION FORMS IN OPTIMUM FILTERING PROBLEMS
R. A. Wiggins, Massachusetts Inst. of Tech., Cambridge, In its Studies in Optimum Filtering of Single and Multiple Stochastic Processes, 30 June 1963, p. 65/79, N64-15482.

THE WIENER-MASANI TECHNIQUE OF MULTIPLE SPECTRAL FACTORIZATION
C. I. Wunsch, Massachusetts Inst. of Tech., Cambridge, In its Studies in Optimum Filtering of Single and Multiple Stochastic Processes, 30 June 1963, p. 100/140, refs., N64-15484.

The prediction problem for single stationary time series is reviewed, and the least square and Kolmogoroff solutions are given. . .

Related Publications:

THE ROOT SQUARE LOCUS PLOT—A GEOMETRICAL METHOD FOR SYNTHESIZING OPTIMUM SERVO SYSTEMS
S. S. L. Chang, IRE Nat. Conv. Rec., March 1958, p. 79/87.

REPRESENTATION AND ANALYSIS OF SIGNALS. PART II. AN ORTHONORMAL FILTER FOR EXPONENTIAL WAVEFORMS
D. C. Lai, Johns Hopkins U. School of Engrg., June 1958, 49 p.

A newly designed device is described which will generate sets of orthonormalized exponential functions.

THE QUANTIZATION OF STOCHASTIC SIGNALS WITH INFINITE SPECTRUM AND SOME RESULTS OF THE THEORY OF PULSE TRANSMISSION OF INFORMATION (In Russian)
N. A. Zheleznov, Radiotekhnika i Elektronika, vol. 3, 1958, p. 1/23.

A theorem is proved about the optimum resolution of signals into orthogonal components, which gives the smallest mean square error.

MAXIMUM BANDWIDTH UTILIZATION DEMODULATOR
A. G. Gatfield, IRE Trans. Commun. Syst., vol. CS-8, no. 2, June 1960, p. 83/86.

A SIMPLE TECHNIQUE FOR MEASURING THE SIGNAL-TO-NOISE RATIO AT THE OUTPUT OF A PULSED SINUSOID MATCHED FILTER (Correspondence)
H. E. White, Proc. IRE, vol. 48, no. 2, Feb. 1960, p. 241/242.

. . . usual method for measuring signal-to-noise ratios in teletype receiving systems . . . is wholly dependent on knowing the noise bandwidth of the bandpass filter and the figure of merit of the matched filter. . . . the following technique. . . does not require a band-pass filter preceding the matched filter.

OPTIMUM SAMPLED-DATA CONTROL
R. Jackson, Proc. Instn. Elect. Engrs., Pt. C, vol. 108, no. 14, Sept. 1961, p. 309/316.

A method of rendering feedback control systems amenable to treatment by the Wiener theory is applied to the case in which the controller operates on a sampled measurement. An explicity expression is obtained for the minimum attainable mean-square error for certain classes of system transfer functions and disturbance power spectra, and the form of the optimum controller is derived. . . .

LINEAR RECONSTRUCTION OF QUANTIZED AND SAMPLED RANDOM SIGNALS
D. S. Ruchkin, IRE Trans. Commun. Syst., vol. CS-9, no. 9, Dec. 1961, p. 350/355.

AN ANALYTICAL DETERMINATION OF THE EXISTENCE OF OPTIMUM POINTS IN A CLASS OF NETWORKS
M. Golinsky, Institute of Science and Tech., U. of Michigan, Ann Arbor, Rept. on Proj. Michigan, (Rept. no. 2900-351-T), Aug. 1962, 116 p., incl. illus., tables, 23 refs., AD 282 413.

. . . technique for determining whether there exists, in a certain class of networks, an operating point which minimizes a particular index of performance is discussed. The index which is selected is the rms error. . . . The class. . . includes closed-loop feedback systems as well as passive networks. . . .

THE RELATIVE EFFICIENCIES OF VARIOUS BINARY DETECTION SYSTEMS
R. O. Rowlands, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 185/189.

. . . Five common binary detection systems are analyzed and formulas are derived for the signal-to-noise ratios required to give the same probabilities of error in each system. . . .

REPRESENTATION AND ANALYSIS OF SIGNALS. PART IX. "COMPLEMENTARY" SIGNALS AND ORTHOGONALIZED EXPONENTIALS
T. Y. Young, et al., Johns Hopkins U. School of Engineering, Baltimore, Md., 1 Jan. 1962, 32 p., AD 271 107.

MULTIVARIATE WIDE-SENSE MARKOV PROCESSES AND PREDICTION THEORY
F. J. Beutler, Ann. Math. Statistics, v. 34, no. 2, June 1963, p. 424/438, 7 refs., N63-19978.

. . . (MWM processes). . . only the stationary multivariate gaussian Markov process appears to have been studied. Analysis of this process has centered on its second-order properties, the gaussian density function serving as a principal tool. The same second-order properties hold for any MWM, and these depend on the covariance matrix. . . . The most significant application of MWM processes is to the theory of linear minimum mean square error prediction of multivariate stochastic processes. . . .

2.813: Nonlinear Detection Theory in General

Included: Nonlinear filters; Nonlinear operators; Optimum nonlinear detection theory; Polynomial filtering of signals; Nonlinear statistical estimators; Bayes' optimum filters; Optimum filtering of periodic pulse-modulated time series.

Not Included: Nonlinear feedback theory; Nonlinear distortions in channels (1); Limiters in receiving systems; Noise in signal statistics when passing through nonlinear devices (1).

Cross References: Learning filters (2.855); Parameter estimation techniques (2.842); Detection of sampled transmission systems (2.875); Bayes' decision rule (2.852); Coincidence methods of detection (2.835).

Principal Publications:

A COMMENT ON THE OPTIMUM NONLINEAR FILTERING OF BALAKRISHNAN AND DRENICK
F. J. Beutler, IRE Trans. Inform. Th., vol. IT-4, June 1958, p. 88/89.

OPTIMUM NONLINEAR FILTERS WITH FIXED OUTPUT NETWORKS
D. A. Chesler, Quarterly Progress Report Res. Lab of Elect. MIT, July 1958, p. 118/124.

SECOND-ORDER NONLINEAR FILTERS
D. A. Chesler, MIT, Quart, Progress Rept., no. 53, April 1959, p. 68/71.

OPTIMAL FILTERING OF PERIODIC PULSE-MODULATED TIME SERIES
W. A. Janos, IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 67/74.

. . . class of input time series in which the amplitude is modulated by uniformly-pulsed periodic functions. A uniform sampling of the output at a period equal to the pulsing period displays the property of time invariance.

THE OPTIMIZATION OF A CLASS OF NONLINEAR FILTERS
J. K. Lubbock, Ministry of Supply (Gt. Brit.), D.G.G.W. Report No. EMR/59/2, 1959, 13 p., AD 226 239.

THE PROBLEM OF OPTIMIZING SYSTEMS WHICH CONTAIN ESSENTIALLY NONLINEAR ELEMENTS
E. P. Merkulova, Automat. Remote Control, vol. 20, Oct. 1959, p. 1303/1318.

A Method is given for finding the optimal weight function of the linear portion of a stationary system which contains an arbitrary number of essentially nonlinear elements. . . . The input is a stationary random function of time consisting of signal plus noise. The linearization of the nonlinear elements is carried out by a statistical method.

CANONICAL FORMS FOR NONLINEAR STATISTICAL ESTIMATORS
G. D. Zames, MIT, Res. Lab. Quarterly Progress Rept. no. 52, Jan. 1959, p. 91/104.

The optimum predictor, filter, coder, and decision operator are considered for processes that are random and stationary. Discrete processes are studied first, and then Wiener's representation (1) is used for continuous processes in conjunction with a definition of "probability density". In a sense, the method is an extension of that used by Bose (2).

NONLINEAR OPERATORS—CASCADING, INVERSION, AND FEEDBACK
G. D. Zames, MIT Quart. Prog. Rept., no. 53, April 1959, p. 93/108.

NONLINEAR LEAST-SQUARES FILTERING AND FREQUENCY MODULATION
A. D. Hause, Research Lab. of Electronics, MIT, Cambridge, (Tech. rept. 371), 25 Aug. 1960, 49 p., AD 258 225.

. . . Each filter has a linear section and a nonlinear, memoryless section. Attention is focused primarily on the latter. A simplified review of important properties of the orthogonal polynomials employed by Weiner for representation of the nonlinear filter section is included . . .

THE OPTIMIZATION OF A CLASS OF NON-LINEAR FILTERS
J. K. Lubbock, Proc. Instn. Elect. Engrs., Pt. C, vol. 107, no. 11, March 1960, p. 60/74.

ANALYSIS OF OPTIMUM NON-LINEAR FILTERS AND THE RECEPTION OF BINARY TELEGRAPH SIGNALS
V. Klezha, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 5, 1961, p. 20/35

. . . all a priori information about the signal and noise is used in the form of n-dimensional distribution laws governing the probability of the signal and noise. The author calculates the noise immunity of a special filter for telegraph signals in the presence of Gaussian noise. . . .

POLYNOMIAL FILTERING OF SIGNALS
F. W. Nesline, Jr., Conf. Proc. Natl. Conv. Mil. Electronics, vol. 5, June 1961, p. 531/542.

. . . Even though this subject has received considerable attention in the literature during the last several decades, there is no reference specific enough to aid the engineer materially in selecting and evaluating a filter for a particular application. The purpose of this paper is to fill this need by presenting the detailed properties of filters that regenerate a signal as a continuous, or as a discrete, polynomial in time. The properties of interest in design and evaluation are presented for polynomial outputs as high as third order. The formulas clearly show the interactions between input parameters, network parameters, and output parameters, and in addition, they eliminate much of the tedious calculation usually associated with the design and evaluation of an optimum filter. . . .

OPTIMUM NONLINEAR FILTERS FOR QUANTIZED INPUTS
F. Tung, et al., IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 257/265.

Attention is restricted to those systems whose present output is influenced only by a portion of the past input. The input signal consists of a message and noise, both of which are stationary random processes. It is assumed that the amplitude of the input time series is bounded and takes on discrete values at all times. This assumption leads to a nonlinear filter which can be realized as a quantizer. . . followed by a parallel set of linear filters. . . . This method is illustrated by an example, and the mean-square error of the nonlinear filter so obtained is compared with the best linear filter. . . .

BAYES' OPTIMUM FILTERS DERIVED USING WIENER CANONICAL FORMS
D. B. Brick, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S35/46.

Canonical forms and circuit structures are derived for Bayes' optimum decision rules utilizing Wiener-like functionals. . . . The structures derived consist of orthogonal filter sets (usually Laguerre filters) followed by combinations of vth-law-devices (Hermite polynomial generators of the Laguerre coefficients), amplifiers of specified gains, and then summing and division circuits. . . . many forms of previously synthesized Bayes' structures. . . . have been valid primarily for processes obeying Gaussian or other special statistics and/or for the limiting cases

of small or large signal-to-noise ratios. In many cases, they have involved the use of so-called Bayes' matched filters followed by zero-memory quadratic (or non-linear) and finite-memory linear operations. . . .

OPTIMUM MULTIPLE-INPUT NONLINEAR SYSTEM WITH GAUSSIAN INPUTS
D. A. Chesler, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 237/246.

Methods are developed for optimizing a general, realizable, multi-input, single-output, nonlinear system whose inputs are correlated, stationary, Gaussian random processes. The optimum system is nonlinear rather than linear if the desired output is not Gaussian. The output of the nonlinear system is expressed as a sum of functional polynomials of the inputs. The only statistical information needed for the optimization is composed of the first-order autocorrelations and crosscorrelations among the inputs, and the higher-order crosscorrelations between the inputs and the desired output.

THE DESIGN OF NONLINEAR FILTERS AND CONTROL SYSTEMS. PART I.
J. Katzenelson, et al., Inform. Control, vol. 5, no. 2, June 1962, p. 108/143.

. . . to provide a systematic analytical approach to the synthesis of continuous nonlinear filters and to apply the results to a variety of problems, e. g., filtering of signals from noise, characterization of nonlinear systems, and the design of compensation networks for control systems. . . .

A NONLINEAR FILTER FOR IMPROVEMENT OF SIGNAL DETECTABILITY IN THE PRESENCE OF NON-GAUSSIAN NOISE
R. H. Richard, Carlyle Barton Lab., Johns Hopkins U., Baltimore, Md., (Technical rept. no. AF-98), Oct. 1962, 115 p., incl. illus., 14 refs., AD 288 679.

. . . The filter consists of a zero-memory nonlinear device followed by a low-pass filter, the nonlinear device being designed on the basis of only the first-order statistics on the interfering noise and of the sum of signal and noise. The class of noise used in the study is that obtained by passing Gaussian noise through a zero-memory nonlinear element. Because of this the non-Gaussian process can still be characterized by relatively few parameters. . . .

PROBLEM IN NONLINEAR FILTERING
I. A. Bol'shakov, Radiotekhnika i Elektronika, vol. 8, June 1963, p. 938/941, (In Russian), Radio Engng. Electronic Phys., vol. 8, June 1963, p. 948/951, (Translation), A64-17558.

Presentation of a new variant of an optimum filter with minimum error in reproducing a randomless varying Gaussian process, a parameter which is nonadditively contained in another random process. It is stated that the superiority of the new filter lies largely in the elimination of the limitation on the width of the a priori distribution at the initial moment t_0. While previously it had to be narrower than the linear portion of the optimum discriminator characteristic, it is now considerably wider. It is noted that this fact is important at the signal recovery stage. . . The linear region in the nonservo characteristic is expanded at the cost of simplicity of processing of the signal.

SINTEZ OPTIMAL'NOGO FIL'TRA DLIA SIGNALOV, IZMENIAIUSHCHIKH STATISTICHESKIE SVOISTVA V POSLEDOVATEL'NYE INTERVALY VREMENI (Synthesis of an Optimal Filter for Signals with Statistical Properties Successively Varying With Time) (In Russian)
I. B. Chelpanov, Avtomatika i Telemekhanika, vol. 24, Oct. 1963, p. 1331/1336, A64-13215.

. . . design of a filter that is optimum with respect to minimum mean square error, for the case where the statistical properties of both the useful signal and the noise signal are subject to abrupt changes at definite instants of time. The signal properties are given in the form of matrices of correlation functions. The problem is reduced to the solution of a system of integral equations of the first type. This solution is obtained by the Zadeh-Ragazzini method.

A RANDOM ACCELERATION MODEL FOR FILTERING POLYNOMIAL-LIKE SIGNALS
L. Jones, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 28G3, AFESD TDR63 567, 25 Oct. 1963, 15 p., AD 423 431.

Random type models for filtering discrete time, polynomial-like signals from noise are discussed. The particular model analyzed is a second-degree polynomial with the acceleration (second derivative) considered to be a random process. The optimum filter corresponding to this model is derived. . . .

A NONLINEAR FILTER FOR NON-GAUSSIAN INTERFERENCE
R. H. Richard, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Dec. 1963, p. 436/443.

. . . The results of the study indicate that, when the noise probability density function is sufficiently different from Gaussian, a considerable improvement in detection reliability can be obtained. When the noise is Gaussian the filter reduces to a linear one. . . .

GENERAL RESULTS IN THE MATHEMATICAL THEORY OF RANDOM SIGNALS AND NOISE IN NONLINEAR DEVICES
H. B. Shutterly, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 74/84.

An analysis is made of the output resulting from passing signals and noise through general zero memory nonlinear devices. New expressions are derived for the output time function and autocorrelation function in terms of weighted averages of the nonlinear characteristic and its derivatives. These expressions are not restricted to Gaussian noise and apply to any nonlinearity having no more than a finite number of discontinuities. The method of analysis used is heuristic. . . .

SOME APPLICATIONS OF STOCHASTIC DIFFERENTIAL EQUATIONS TO OPTIMAL NONLINEAR FILTERING
W. M. Wonham, Martin Co., Baltimore, Md. RIAS Div., (NASA CR-53567; RIAS-TR-64-3), Feb. 1964, 35 p., refs., N64-18447.

A current problem in control theory is that of estimating the dynamical state of a physical system on the basis of data perturbed by noise. . .

The performance of an ideal limiter followed by a synchronous detector and a low-pass filter has been studied. . . . The signal suppression resulting from the presence of noise controls the effective noise bandwidth of the loop. . . .

DECISION THEORY SOLUTIONS FOR NONLINEAR DEVICES (Correspondence)
D. B. Brick, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 205/206.

Relationships are derived showing that the optimum processor for a process that has been transformed by a memoryless nonlinear device is of the same form as that for the original untransformed process if we replace the measured values of the process by their inversely transformed values.

In the response of Lumicon, Vidicon, or Image Orthicon TV Systems, it is not unusual to operate in the nonlinear region. . . . Since the actual characteristics of the TV systems are pseudologarithmic in shape, a specialization to a log characteristic and Gaussian noise is made at the end of this communication. Optimality is specified in terms of minimum risk. . . .

Related Publications:

PHASE MODULATION THROUGH A LIMITER
JPL Res. Summ., vol. 1, no. 36-7, Dec./Jan. 1960, p. 54/60.

2.814: Spatial Filtering

Included: Detection in the presence of spatial noise; Two-dimensional signal processing; Optimum filtering for multiple processes; Banks of parallel filters; Multiple signal counting; N-path filters; Diagonalizing quadratic filters; Space-time filtering; Detection in multi-dimensional channels; Multi-dimensional detection theory; Multi-dimensional space filters; Complex spatial filtering.

Not Included: Signal processors (3A); Optical signal processing (3B).

Cross References: Time analysis in detection operations (2.837); Detection under multipath conditions (2.873); Comb filters (2.836).

Principal Publications:

MULTIDIMENSIONAL SPACE FILTERS
B. Kron, The Tensor Club of Gt. Britain, vol. 9, Dec. 1958, p. 40/46.

INTERCHANNEL CORRELATION IN A BANK OF PARALLEL FILTERS
J. Galejs, et al., IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 106/117.

The first-order effects of interchannel noise correlation on the false alarm and incorrect dismissal probabilities are computed for a bank of parallel RLC filters by expanding the envelope distribution of the n filter outputs in a power series.

AN ALTERNATIVE APPROACH TO THE REALIZATION OF NETWORK TRANSFER FUNCTIONS: THE N-PATH FILTER
L. E. Franks, et al., Bell Syst. Tech. J., vol. 39, no. 5, Sept. 1960, p. 1321/1350.

A particular time-varying network consisting of several parallel transmission paths, each containing input and output modulators, is described and analyzed. It is shown that, under certain conditions, the network may be characterized by a transfer function.

A NOTE ON THE SPATIAL INFORMATION AVAILABLE FROM MONOPULSE RADAR
D. B. Anderson, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 268/278, 12 refs.

. . . Structural spatial information determined by the usual angle detection radar is restricted to position data; however, there are other features of the echo signature which may be determined by angle detection radar. Some of these features are: a measure of the target extent, a measure of the target deviation from an isotropic scatterer, and a measure of the target rotation. The delineation of a monopulse radar which extracts the additional structural information of the target echo signature is the authors' intent. . . .

SPATIAL FILTERING
F. Ayres, Antenna Lab., Ohio State U. Research Foundation, Columbus, Rept. no. 1222-2, 15 May 1961, 47 p., AD 407 427.

The mathematical relationships for filtering in a space domain are developed in a general analogy with temporal filtering.

MATCHED FILTERS FOR MULTIPLE PROCESSES (Correspondence)
A. V. Balakrishnan, IRE Trans. Inform. Th., vol. IT-7, no. 1, Jan. 1961, p. 52.

By a multiple process is meant a q-dimensional (real-value) vector stochastic process. As is well-known, a matched filter is defined for one-dimensional processes as one that minimizes the noise-to-signal ratio. Now, in the multiple process case we can define noise-to-signal ratio in several ways and it is the purpose of this note to examine the corresponding matched filters.

MULTIPLE SIGNAL COUNTING
W. M. Gersch, Electronics Research Labs., Columbia U., New York, (Tech. rept. no. T-1/161; CU-21-61-AF-1971-ERL), 28 July 1961, 160 p., AD 266 940.

. . . estimation of the number of signals present in a sample containing signals plus noise. The signal sample is divided into M cells, of which N contain signals and noise, and (M-N) contain noise alone. The signals are assumed distributed in amplitude, with the distribution known to within p parameters. The noise statistics are assumed known. The observable quantities are R sub i, (i = 1, 2, . . . M) the magnitude of the envelope of the cell contents. The problem is one of parameter estimation, called Multiple Signal counting, which is an idealized model for a radar operating in a multiple signal environment.

SPACE-TIME SAMPLING AND FILTERING
W. D. Montgomery, et al., General Dynamics/ Convair, San Diego, Calif., Semi-annual tech. documentary, (Rept. ZR-AP-061-16), May 1961, 66 p., AD 262 649.

. . . enhancing the detection of a missile launch as seen from a satellite. . . three important spatial filters are developed, having two-dimensional outputs. The first filter is a linear one. . . a general statistical one, has considerable discrimination ability but needs a large amount of statistical information of the background. The third filter, developed along the lines of decision theory, turns out to be remarkably similar to the general one. For each filter the application to multiple wave lengths as well as to point source and nonpoint source targets is considered.

STUDIES PERTAINING TO BAMBI. SPACE-TIME SAMPLING AND FILTERING
W. D. Montgomery, et al., General Dynamics/ Convair, San Diego, Calif., Final rept., Dec. 1961, 76 p., AD 269 839.

. . . problem of manipulating visual data available to a satellite so as to enhance the detection of a given target. Study was oriented toward the detection of a missile in the powered phase. Considering the intensity distribution on an optical image plane as the input, four different types of spatial filters are developed. The statistical description of the background, which must be known prior to applying the theory, varies from the autocorrelation function for linear filter to a complete statistical description for the general statistical and decision theory filters.

ON THE STATISTICAL DETECTION PROBLEM FOR MULTIPLE SIGNALS
J. B. Thomas, et al., Rome Air Development Center, Griffiss Air Force Base, N. Y., (Rept. no. RADC TN 61-182), Nov. 1961, 16 p., AD 268 753.

The problem of detecting signals in noise is considered for the multiple input model, where each of the inputs can contain one of

many possible signals. The detection procedure for this model becomes, in general, the testing of multiple hypotheses. Two detection criteria are examined for choosing among multiple hypotheses and it is found that, for both criteria, the decision is based on the likelihood functions for the various signals. Systems for computing likelihood ratios are examined in detail for the multiple input case. A multidimensional matched filter is considered and its relationship to the likelihood ratios is shown. Optimum signals are determined for the two-hypothesis problem.

ON THE DETECTION AND ESTIMATION PROBLEM FOR MULTIDIMENSIONAL GAUSSIAN RANDOM CHANNELS
J. K. Wolf, Rome Air Development Center, Griffiss Air Force Base, N. Y., (RADC-TR-61-214), Nov. 1961, 26 p., AD 268 492.

. . . Such a channel is characterized by the property that a deterministic input results in a set of received waveforms which are sample functions of Gaussian processes. For the detection problem, a receiver is found which operates on the set of received waveforms and gives as outputs, voltages proportional to the logarithm of the likelihood functions of the possible transmitted signals. For the estimation problem, it is assumed that the intelligence-carrying signal is itself a sample function of a Gaussian process and a mathematical description is presented of a receiver which has as its output the maximum a posteriori estimate of this signal. Examples are presented in which optimum receivers are found for both the detection and estimation problem.

ON THE RECOGNITION OF SIGNAL PATTERNS IN NOISE
J. K. Wolf, et al., IRE Internat. Conv. Rec., vol. 4, March 1961, p. 155/161.

. . . recognition of two-dimensional patterns in noise, the decision as to which of a set of patterns is present involves the calculation of a likelihood function for each of the possible signals. In this paper, systems are developed for the calculation of these functions when the signal patterns are perturbed by multiplicative and additive noise. . . .

TWO-DIMENSIONAL SPATIAL FILTERING AND COMPUTERS
W. D. Fryer, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 529/535.

Processing of two-dimensional signals has important applications, for example, in photographic image analysis. . . The principal purpose of this paper is to show how a broad and useful class of two-dimensional filtering operations can have notably shortened execution time in the digital case, and be put into a particularly convenient form for electrical filtering. The procedure includes a reduction of dimension from two to one. . . and finally, for the digital case, the transformation of a direct many-term convolution expression into a compact cursive form ideally suited for digital computation. An important class of smoothing filters, with weighting functions approximately Gaussian, is derived and used for illustration. . . .

DIAGONALIZING QUADRATIC FILTERS (Correspondence)
A. D. Hause, Proc. IRE, vol. 50, no. 4, April 1962, p. 484.

SPATIAL FILTERING
W. D. Montgomery, et al., General Dynamics/Astronautics, San Diego, Calif., 1962, 34 p., illus., 8 refs., AD 282 766.

. . . of two-dimensional pictorial data as an extension of one-dimensional filter theory is applied to the problem of enhancing the detection of localized objects which are superimposed upon a noisy background. Four types of filters are derived. These are the Linear, Quadratic, General Statistical, and Decision filters. Each filter is of the matched type, the different designs being associated with various degrees of knowledge about the noise statistics. A computer simulation of the linear and general statistical filters was done and examples are shown.

ONE-AND TWO-DIMENSIONAL PROCESSING IN LINE SCANNING SYSTEMS
L. G. Callahan, et al., Appl. Optics, vol. 2, no. 4, April 1963, p. 401/407.

. . . The results apply to systems such as infrared scanners, TV systems, and radar systems. The main objective of the analysis is to compare the performance obtainable when optimum two-dimensional processing of the data is used and the performance obtainable when only one-dimensional (along the lines) processing is used. . . . Quantitative comparisons are made for two cases; specifically, top hat and cone-shaped frequency responses of the aperture are considered. These characteristics occur in coherent and incoherent scanners in which the "resolution" is limited by the optical aperture of the scanner. Three performance criteria are used: least squares error, maximum-peak signal to r.m.s. noise ratio, and minimum system resolution. A table shows the improvement of arbitrary two-dimensional filtering over one-dimensional filtering along the lines.

OPTIMUM SIGNAL PROCESSING IN THE PRESENCE OF SPATIAL NOISE
D. G. Childers, et al., University of Southern Calif., Engineering Center, Los Angeles, USCEE Rept. 108, March 1964, 88 p., AD 437 824.

An optimum signal processing theory for active radar (sonar) arrays is developed. . . . An optimum linear processor is developed which maximizes the output signal-to-noise ratio when the input is known signal imbedded in correlated and uncorrelated noise. The signal processing theory requires a knowledge of some of the statistical properties of the noise field. Therefore, a stochastic representation for a general, polarized, nonisotropic noise process is formulated. This representation is used to determine the cross-spectral densities and cross-correlation functions between antenna array element in the presence of the noise field only.

THE EXTENSION TO PROBABILITY DISTRIBUTIONS FOR DETECTION SPATIAL FILTERS
W. D. Montgomery, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 2/5.

The idea of extending partial descriptions to a probability density function on a minimum information (maximum entropy) basis is applied in the context of detection spatial filters . . . Several two-dimensional moment descriptions are thus extended and worked in detail. . . .

THE EXTENSION OF PARTIAL INFORMATION TO PROBABILITY DISTRIBUTIONS FOR DETECTION SPATIAL FILTERS
W. D. Montgomery, General Dynamics/ Astronautics, San Diego, Calif., Chicago U. Labs. for Applied Sciences, III. Symp. on Background Radiation. Ultraviolet, Visible and Infrared Levels and Distribution (Spring 1962), April 1963, p. 107/117, 8 refs., N63-18483.

. . . Several two-dimensional moment descriptions are. . . extended and worked out in detail.

STUDIES IN SPATIAL FILTERING
W. D. Montgomery, General Dynamics/ Astronautics, San Diego, Calif., Final rept., Sept. 1963, 31 p., GDA63 0861, AD 417 903.

Two types. . . are considered one is the neighborhood modification process while the other determines each value in the output by a separate function of all input values. The former type is applied to a maximum signal to noise ratio filter and the latter to a maximum shape reproduction filter. . .

SPACE-TIME SAMPLING AND LIKELIHOOD RATIO PROCESSING IN ACOUSTIC PRESSURE FIELDS
P. L. Stocklin, J. Brit. Instn. Radio Engrs., vol. 26, no. 1, July, 1963, p. 79/91.

. . . based on a three-dimensional Whitaker sampling function. . . Two examples are treated: the one-dimensional resolution problem for Gaussian signal in Gaussian noise, and the space-time likelihood ratio processor for signal known exactly in Gauss and Markov-Gauss noise. . . .

ON THE STATISTICAL DETECTION PROBLEM FOR MULTIPLE SIGNALS
J. B. Thomas, et al., IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 274/280.

. . . each of the inputs can contain one of many possible signals. The detection procedure for this model becomes, in general, the testing of multiple hypotheses. Two detection criteria are examined for choosing among multiple hypotheses and it is found that, for both criteria, the decision is based on the likelihood functions for the various signals.

Systems for computing ratios are examined in detail for the multiple input case. A multidimensional matched filter is considered and its relationship to the likelihood ratios are shown. Optimum signals are determined for the two-hypothesis problem.

SIGNAL DETECTION BY COMPLEX SPATIAL FILTERING
A. V. Lugt, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 139/145.

In the past, spatial filtering in coherent optical systems has been limited by the inability to realize practically a general complex filter. This paper describes a technique for realizing such a filter, and gives an application of spatial filtering to the problem of detecting isolated signals in a variety of noise backgrounds. . . . will play a key role in such problems as shape recognition and signal detection. . . .

SIGNAL DETECTION BY COMPLEX SPATIAL FILTERING
A. V. Lugt, Institute of Science and Tech., U. of Michigan, Ann Arbor, Rept. no. 4594 22 T, July 1963, 41 p., AD 411 473.

SIGNAL DETECTION BY COMPLEX SPATIAL FILTERING
A. B. Vander Lugt, Michigan U. Inst. of Science and Tech., Ann Arbor, Rept. 2900-394-T, July 1963, 47 p., 7 refs., N63-19114.

. . . a coherent optical system. . . accomplishes this filtering process. . . technique for realizing the required complex filter. . . . excellent two-dimensional filtering capability that will play a key role in problems such as shape recognition and signal detection.

SIGNAL DETECTION BY COMPLEX SPATIAL FILTERING
A. B. Vander Lugt, Institute of Tech., U. of Minn., Minneapolis, July 1963, 39 p., AD 411 384.

Related Publications:

A NOTE ON OPTIMUM LINEAR MULTI-VARIABLE FILTERS
R. J. Kavanagh, Proc. Instn. Elect. Engrs., Pt. C, vol. 108, no. 14, Sept. 1961, p. 412/417.

The explicity solution for the optimum linear physically realizable multi-variable filter involves the factorization of a power-spectra matrix into two matrices, one having all its poles in the left-half p-plane and the other having all its poles in the right-half p-plane. No general method of accomplishing this factorization has previously been available. This note contributes. . . method of factorizing any power-spectra matrix in the required manner. . . .

ON OPTIMAL DIVERSITY RECEPTION
G. L. Turin, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 154/166.

. . . The ideal probability-computing M-ary receiver is derived for a fading, noisy, multidiversity channel, in which the link fadings may be mutually correlated, as may the link noises. The results are interpreted in terms of block diagrams involving various filtering operations. Two special cases, those of very fast and very slow fading, are considered in detail.

NOTE ON THE EXISTENCE OF PERFECT MAPS
I. S. Reed, et al., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 10/12.

. . . The two-dimensional analogy of perfect maps to shift register codes suggests a possible development of planar error-correcting codes and an application to the two-dimensional range-velocity ambiguity problem of radar. . . .

AN OPTICAL DECISION FILTER
R. D. Joseph, et al., Proc. IEEE, vol. 51, no. 8, Aug. 1963, p. 1098/1118.

. . . an advanced type of self-organized image filter. . . . has the capability of recognizing and classifying three-dimensional objects regardless of their size and orientation with respect to the viewing mechanism. . . .

ELECTRO-OPTICAL IMAGE MATCHER FOR SPACE GUIDANCE APPLICATIONS
J. N. Packard, IEEE Trans. Aerospace Navig. Electronics, vol. ANE-10, no. 3, Sept. 1963, p. 282/289.

Pattern recognition and the determination of relative attitude are capabilities of an electro-optical map matching device that utilizes two-dimensional correlation data processing techniques. . . .

DUAL-MODE FILTERING OF POLYNOMIAL SIGNALS IN NOISE
L. G. Shaw, IEEE Trans. Automatic Control, vol. AC-8, April 1963, p. 136/142, A63-17514.

. . . procedure for finding the best (minimum mean-square error) filter of a class of dual-mode (adaptive) filters when the input consists of a sample from an ensemble of fixed-order polynomials plus "almost white" noise.

THE PANCHROMATIC PRINCIPLE IN OPTICAL FILTERING
R. E. Williams, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 227/234.

The panchromatic optical correlator is a coherent correlator which uses a slightly broadened light spectrum to correlate simultaneously a number of reciever channels against a continuous range of Doppler distortions of the transmitted signal. . . . A strong need exists in active search and surveillance systems for simultaneous multi-channel signal processing capability. . . . a number of signal processing techniques have been proposed in recent years . . . . The panchromatic optical correlator is one attempt to satisfy a particular requirement of high data rate receivers matched to the transmitted waveform. . . .

2.815: Game Theory in Signal Detection

Included: Detection in unspecified noise.

Not Included: Channel models (1); Information theory in general (1).

Cross References: Detection under specified noise conditions (2.871).

Principal Publications:

AN APPLICATION OF THE THEORY OF GAMES TO RADAR RECEPTION PROBLEMS
N. J. Nilsson, Stanford Electronics Labs., April 1958, AD 203 099.

COMMUNICATIONS THROUGH UNSPECIFIED ADDITIVE NOISE
W. L. Root, Inform. Control, vol. 4, no. 1, March 1961, p. 15/29.

. . . to suggest the feasibility . . . of applying a maximum or minimax type decision criterion to the design of the receiver, to illustrate this decision criterion in two rather straightforward examples involving binary data links, and to look at the information rate which can be achieved. We are concerned here with the . . . problem . . . when the additive noise has no statistical regularity or predictability of which advantage can be taken. Thus the "noise" may be natural or man-made and subject to influences unknown to the communicators. Essentially the only restriction on the noise is that its power be bounded. . . .

THE EFFECT OF STATISTICALLY DEPENDENT INTERFERENCE UPON CHANNEL CAPACITY
N. M. Blachman, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S53/57, 10 refs.

Bounds are derived and plotted for the capacity of a band-limited communication channel that accepts signals of specified average power as input, adding to them white gaussian noise and interference of specified average power which may depend on the signal being sent on all of the other signals in the code book. . . . The present paper deals with a game in which a code is first selected —including explicit methods for both encoding and decoding—with the intention that it be as resistant to interference of any kind as possible. Then a message is sent by means of this code, subject to additive interference which may depend on the message being sent (it might be inferred from a short sample of the beginning of the signal) and on the code. The pay-off is the amount of information that is reliably received. . . .

EQUIVALENCE OF INFORMATION PATTERNS AND ESSENTIALLY DETERMINATE GAMES
N. Dalkey, RAND Corp., Santa Monica, Calif., Rept. no. P265, 20 Feb. 1962, p. 38., AD 422 815.

A necessary and sufficient condition is derived for the equivalence of information patterns in general games. . . .

SIGNAL DETECTION UNDER NOISE INTERFERENCE IN A GAME SITUATION
L. Zetterberg, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 47/52, 11 refs.

With application to radar and data transmission, a game situation is studied where one player selects a suitable receiving filter, and the other a function describing the noise power density under restriction of a fixed total amount of power. The payoff function is a signal to noise ratio. . . .

A NOTE ON PATTERN-RECOGNITION TECHNIQUES AND GAME-PLAYING PROGRAMS
T. Marill, Inform. Control, vol. 6, no. 3, Sept. 1963, p. 213/217.

A problem encountered in the design of game-playing programs—the evaluation of board positions—is formally identical to a typical pattern-recognition problem. . . .

Section 2.82
Correlation Detection Methods

2.820: Correlation Detection Methods in General

Included: Correlation electronics.

Not Included: Correlation receivers for digital communications systems (1); Signal processing receivers.

Cross References: Correlation detection of random binary sequences (2.825).

Principal Publications:

CORRELATION DEVICES DETECT WEAK SIGNALS
H. R. Raemer, et al., Electronics, vol. 32, no. 22, May 1959, p. 58/62.

CORRELATION DETECTION OF SIGNALS PERTURBED BY A RANDOM CHANNEL
T. Kailath, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 361/366.

CORRELATIONAL AND SPECTRAL TECHNIQUES IN MODERN COMMUNICATION AND CONTROL SYSTEMS
N. D. Diamantides, Electrical Engng., vol. 80, no. 11, Nov. 1961, p. 860/865.

The needs of the space age have imposed a severe burden on information-gathering media, forcing a new approach to communication and control systems design. These systems are now tailored for system-to-signal

compatibility and must reject unwanted statistical signals that enter as unavoidable disturbances. For this purpose the general and/or special purpose computer is an indispensable tool. . . .

THEORY AND APPLICATIONS OF CORRELATION TECHNIQUES
P. H. Haas, Air Force Inst. of Tech., Wright Patterson Air Force Base, Ohio, Master's thesis, (Rept. no. GE/EE/61-6), Aug. 1961, p. 68, 13 refs., AD 270 272.

A survey . . . as applicable to the statistical analysis of communication is presented. Corresponding frequency domain relations in terms of the power-density spectrum are also developed.

WORD ERROR RATE FOR GROUP CODES DETECTED BY CORRELATION AND OTHER MEANS
C. M. Hackett, Jr., IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 24/33.

. . . Correlation detection, digital decoding, straight Wagner codes, "Wagnerized" codes, and direct transmission are covered. . . .

KORRELATIONS ELECTRONIK (Correlation Electronics) (In German)
F. H. Lange, Berlin, Germany, Veb Verlag Technik Berlin, 1963, p. 355.

Related Publications:

A REVIEW OF METHODS FOR IMPROVED DETECTION OF PULSES IN NOISE
F. L. Slojkowski, Bell Telephone Labs., Inc., Whippany, N. J., (Technical memo. no. MM-60-6412-4), 26 May 1960, AD 251 550.

. . . three most commonly considered methods for improvement in signal detection are presented. Correlation, comb filters and integration techniques are discussed along with the advantages and disadvantages of each.

METHODS OF COMPARISON AND EVALUATION OF COMMUNICATION SYSTEMS
L. Valcik, et al., Armour Research Foundation, Chicago, Ill., 26 July 1960, AD 244 887.

. . . discussion of matched filters and correlation detectors . . . An extensive list of references is included.

DIGITAL DATA TRANSMISSION SYSTEMS OF THE FUTURE
R. F. Filipowsky, et al., IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 88/96.

AMPLIFICATION OF LOW POWER PERIODIC SIGNALS
B. A. Mamyrin, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 3, 1961, p. 46/52.

A method of amplifying periodic wide-band low-power signals, and of observing their form at the output, is examined. It is shown that with the indicated method of signal spectrum transformation it is possible to obtain a substantial improvement in the signal-to-noise ratio. . . . The idea of transforming the spectrum of the periodic signal is as follows: a periodic signal reaches the amplifier input through a gating circuit, which passes the signal only during a short time-interval . . . 2. . . . to transmit samples of that signal. . . 3. Change of signal voltage during transformation. . . . 4. Change of noise voltage due to transformation. . . .

2.821: Theory of Correlation Detectors

Included: Output probability distributions of correlation detectors; Theory of analog correlators; Theory of clipper correlators; Effect of noise dependence on correlation detection; Finite correlation; Probability density of correlators; Intersymbol interference in correlation detectors; Mean-square error in correlation demodulators.

Not Included: Correlation functions of random processes (1); Theory of correlation reception in data transmission (1).

Cross References: Intersymbol interference in time division multiplex systems (2.531); Mean-square error criterion in optimum filters (2.812); Analog correlators in general (2.823); Integration techniques in detection systems (2.833); Polarity coincidence correlator (PCC) (2.835).

Principal Publications:

THE EFFECT OF INSTANTANEOUS NONLINEAR DEVICES ON CROSS-CORRELATION
R. Leipnik, IRE Trans. Inform. Th., vol. IT-4, 1958, p. 73/76.

If $X(t)$, $X_2(t)$ are two noises (stochastic processes), f and g are functions describing the action of two instantaneous nonlinear devices, we say that the (m, n) cross-correlation property-holds. . . . whenever f and g are polynomials of degrees not exceeding m and n, respectively.

SIGNALS WITH UNIFORM AMBIGUITY FUNCTIONS
R. M. Lerner, IRE Nat. Conv. Rec., March 1958, p. 27/36.

The response of a correlation detector or matched filter at time to a signal differing by Doppler shift ω from the expected one is a function of these two variables, $s(t,\omega)$, known as the ambiguity function.

A THEOREM ON CROSS CORRELATION BETWEEN NOISY CHANNELS
J. Keilson, et al., IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 77/79.

THE AUTO AND CROSS CORRELATION FUNCTIONS OF ELEMENTARY WAVEFORMS
E. Muehldorf, et al., Proc. Nat. Aeron. Electronics Conf., May 1959, p. 232/239.

SOME PROBLEMS OF THE SPECTRAL-CORRELATION THEORY OF NON-STATIONARY SIGNALS
N. A. Zheleznov, Radio Engng. and Electronics, vol. 4, no. 3, 1959, p. 12/30.

For the description of non-stationary signals we introduce energetic characteristics connected with the present moment of time, and time-average characteristics, also frequency correlation functions characterizing the correlative relationship between the harmonic components of a random spectrum. Relationships are formulated between the corresponding spectral and correlation functions in the form of Fourier transformation pairs. The ergodic theorems are proved for non-stationary signals and the physical content of the conditions for which these theorems are valid are explained. The spectral and correlational functions of a few classes of non-stationary signals are examined.

ON THE CROSS CORRELATION BETWEEN TWO NOISY CHANNELS
J. L. Brown, Jr., IRE Trans. Inform. Th., vol. IT-6, no. 1, March 1960, p. 54.

THE EFFECT OF MIXING TWO NOISY SIGNALS
N. A. Huttly, Marconi Rev., (4th Qtr. 1960), vol. 23, 1960, p. 153/169.

Each signal is taken to be a sine wave with random noise. The signals are multiplied together and the product passed through a bandpass filter with a given impulse response. Integrals are given for the output signal amplitude and for the variance of the noise output. These are evaluated for the particular case where the bandpass filter is a single tuned circuit. Approximate solutions are given for the output signal-to-noise ratio when certain assumptions can be made about the bandwidths and the beat note frequency. . . .

CORRELATION DETECTION OF SIGNALS PERTURBED BY A RANDOM CHANNEL
T. Kailath, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 361/366.

OUTPUT SIGNAL-TO-NOISE CHARACTERISTICS OF CORRELATORS
B. R. Mayo, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 4, June 1960, p. 70/74.

This paper presents a detailed analysis of the output signal-to-noise ratio for a correlator consisting of a multiplier followed by an RC averager. Both the signal and the noise are assumed to be band-limited functions with Gaussian amplitude distribution; but no restrictions are imposed on either the input signal-to-noise ratio or the product of the bandwidth and the time constant of the averager. A family of curves are plotted relating output and input signal-to-noise ratios for values of $RC\Delta f$ ranging from 0.1 to 100. . . .

INFORMATION THEORETICAL ANALYSIS OF MULTIVARIATE CORRELATION
S. Watanabe, IBM J. Res. Developm., vol. 4, no. 1, Jan. 1960, p. 66/82.

As illustrations, two problems are discussed at the end of the paper: (1) redundancy in geometrical figures in pattern recognition, and (2) randomization effect of shuffling cards marked "zero" and "one".

ON THE POSTDETECTION CORRELATION BETWEEN TWO SINUSOIDAL SIGNALS WITH SUPERIMPOSED CORRELATED NOISE (Correspondence)
K. Blotekjaer, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 271/272.

The problem of measuring autocorrelation and cross-correlation is frequently encountered in experimental analysis. . . . The results of the present paper have also been successfully applied to the analysis of signals from earth satellites. Since most of the signals used in transmission techniques are high-frequency signals with relatively narrow bandwidths, the correlation measurements are most easily performed on the detected signals, whereas for theoretical calculations the correlation between the undetected signals is required. It is therefore of great importance to know the relationship between the correlation before and after detection. It is the purpose of this paper to establish this relationship for a special class of signals, namely signals consisting of a sinusoidal component with superimposed narrow-band Gaussian noise. . . .

PERFORMANCE AND REJECTION CRITERIA FOR TRANSMISSION OF BINARY DATA IN GAUSSIAN NOISE
A. J. Viterbi, JPL Res. Summ., vol. 1, no. 36-12, Oct./Nov. 1961, p. 79/80.

. . . the detector which minimizes the error probability is a correlation detector or matched filter . . .

SIGNAL DETECTION BY FINITE CORRELATION
C. J. Clark, Electronic Defense Labs., Mountain View, Calif., (Technical memo. no. EDL-M489), 28 Sept. 1962, p. 35, AD 297 951.

PROBABILITY DENSITY FOR CORRELATORS (Correspondence)
M. C. Grignetti, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 383/384.

In a recent paper, probability densities for the output of short-time cross-correlators were derived, yielding rather unwieldy expressions involving infinite series of higher transcendental functions. . . . As a consequence, the authors of the above-mentioned paper worked out a saddle-point approximation which gives numerical results that, the s - s case, have not been checked against the exact expressions. We shall show, however, that one of these expressions can be considerably simplified. . . .

ON THE DETECTION OF A RANDOMLY DISTORTED SIGNAL IN GAUSSIAN NOISE
L. Halsted, et al., Michigan U., Ann Arbor, (Technical rept. no. 129; Rept. no. 3674-2-T), Oct. 1962, p. 38, AD 291 982.

. . . Various facets of the performance of two two nonoptimum receivers, the crosscorrelator . . . the clipper crosscorrelator, were . . . evaluated using the computer.

THE OUTPUT PROBABILITY DISTRIBUTION OF A CORRELATION DETECTOR WITH SIGNAL PLUS NOISE INPUTS
M. J. Jacobson, Rensselaer Polytechnic Inst., Troy, N. Y., (RPI Math Rep. no. 55), 1 June 1962, p. 28, incl. illus., refs, AD 276 364.

EFFECT OF NOISE DEPENDENCE ON CORRELATION DETECTION AND MEASUREMENT
M. J. Jacobson, Rensselaer Polytechnic Inst., Troy, N.Y., 5 Nov. 1962, p. 9, AD 409 187.

This paper is concerned with the effect of noise cross correlation on the detection of a signal in noise by means of a correlation detector . . . the probability of detection and sample size are investigated under the influence of noise cross-correlation . . . Detailed results are presented when the inputs have the characteristics of RC-filtered white noise and when the detector includes a finite-time perfect averager . . . the required increase in sample size is investigated.

MEAN-SQUARE ERROR IN CORRELATION DEMODULATORS
B. F. Ludovici, Microwave Lab., Stanford Univ., Calif., 19 Nov. 1962, 11, p. AD 434 512.

Four different methods of extracting the intelligence from an amplitude-modulated carrier in the presence of noise are analyzed on a mean-square error basis. . . . Included . . . are the square-law, autocorrelation, two-amplifier and cross-correlation demodulators. . . . investigation shows that the autocorrelation demodulator offers no significant improvement over the simple square-law demodulator. Improvements of approximately 3 dB and 6 dB can be expected from the two-amplifier and cross-correlation demodulators, respectively. These results agree essentially with those of other authors who carried out similar analyses on a signal-to-noise ratio basis.

ANALYSIS OF CORRELATOR SIGNAL-TO-NOISE CHARACTERISTICS
B. R. Mayo, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 276/279.

. . . correlator consisting of a multiplier followed by an RC averager. Both the signal and the noise are assumed to be band-limited functions with Gaussian amplitude distribution; but no restrictions are imposed on either the input SNR or the product of the bandwidth and the time constant of the averager. A family of curves are plotted relating output and input SNR's . . .

ON CERTAIN STRATEGIES OF SIGNAL DETECTION USING CLIPPER CROSSCORRELATOR (SINGLE SIGNAL SIZE)
G. P. Patil, et al., Office of Research Administration, U. of Michigan, Ann Arbor, (Technical rept. no. 128; Rept. no. 3674-1-T), Oct. 1962, 37, p. incl. illus., tables, 6 refs., AD 288 028.

. . . clipper crosscorrelator . . .

CORRELATION FUNCTION AT THE OUTPUT OF A NONLINEAR DEVICE (Correspondence)
G. E. Roberts, et al., IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 322/323.

. . . to point out a questionable result given by Davenport and Root in their analysis of finding the autocorrelation function at the output of a power-law device when the input consists of an AM signal plus Gaussian noise. . . .

THE RELATIVE EFFICIENCIES OF VARIOUS BINARY DETECTION SYSTEMS
R. O. Rowlands, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 185/189.

. . . 1. Ideal Correlator . . . 2. Square-Law Detector . . . 3. Two-Channel Correlator . . . 4. Sign Correlator . . . 5. Two-Channel Sign Correlator.

A GENERAL THEORY OF AMPLITUDE QUANTIZATION WITH APPLICATIONS TO CORRELATION DETERMINATION
D. G. Watts, Proc. Instn. Elect. Engrs, London, (Pt. C), vol. 109, no. 15, March 1962, p. 209/218.

. . . used to investigate the effects of signal quantization on the determination of correlation functions. Theoretical expressions are obtained for the cross-correlation between signals and quantization noises and for the cross-correlation between quantization noises. From considerations of the theory of amplitude quantization, a general

form for multiplier correlators is determined. The perfect analogue correlator, the digital computer applied to correlation determination, the relay correlator and the polarity-coincidence correlator are all shown to be special cases of this general form. In addition, a new correlation method termed Stieltjes correlation is deduced. This method, in which one of the inputs is coarsely quantized and the other is not, is described in detail and is shown to possess many advantages over the correlators mentioned above. . . .

DER EINFLUSS DER MITTELWERTBILDUNG AUF DIE WIRKSAMKEIT VON KORRELATIONSDETEKTOREN (The Influence of the Average Value Formation on the Effectiveness of Correlation Detectors) (In German)
G. Winkler, Arch. Elekt. Uebertragung, vol. 16, July 1962, p. 347/350.

. . . Theoretical investigations into the performance of correlation detectors have been considering so far ideal integrators or low-pass filters with only one energy store in the steady-state condition, for the averaging in time of the multiplicator output. The present contribution is to discuss in a more general way the influence the kind of averaging effected in the correlation detector has on the signal-to-noise ratio at the output. . . .

REDUCING THE EFFECTS OF INTERSYMBOL INTERFERENCE WITH CORRELATION RECEIVERS
J. M. Aein, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 167/175.

. . . optimization of a class of linear receivers to minimize the effects of this interference. . . . The optimum decision level as well as optimum impulse response is determined for receivers with and without memory where a priori knowledge of the channel characteristics are available. . . .

THE VARIANCE OF THE MEAN OF CORRELATED SAMPLES
I. Eisenberger, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 168/170.

Problem . . . arises in planetary radar, and elsewhere, . . . One has a receiver containing a certain filter. A radar return of mean u is added to receiver noise to create a white Gaussian stochastic process of mean u and variance σ_0^2 . . . The process is passed through a linear filter . . . The resulting function is then sampled periodically. One wishes to estimate u by taking the average of n samples. The question is, what is the variance of this estimate, and in particular, how does the variance decrease with n?

ESTIMATION OF THE ACCURACY OF THE CROSS-CORRELATION FUNCTION AS IT DEPENDS ON THE TIME DURATION OF THE EXPERIMENTAL RECORDING
I. A. Gelfanbein, Tekhnicheskaia Kibernetika, Jan.-Feb. 1963, In Russian, Engineering Cybernetics, Jan.-Feb. 1963, p. 54/60, Translation, A64-15929.

Evaluation of the error occurring in the calculation of the cross-correlation functions of two stationary random processes, on the assumption that the duration of the experimental recording is finite and equal. . . .

OUTPUT PROBABILITY DISTRIBUTION OF A MULTIPLIER AVERAGER WITH PARTIALLY CORRELATED INPUTS
M. J. Jacobson, Rensselaer Polytechnic Inst., Troy, N.Y., Rept. no. MATHREP 62, 19 July 1963, 7, p. AD 432 656.

This paper studies the problem of determining the probability density function of the filtered output of a multiplier when the crosscorrelation function of the inputs is proportional to the autocorrelation function of the inputs. The two inputs are assumed to consist of identical signal plus uncorrelated noise. It is shown that the solution is known once the solution has been found for pure signal inputs. The general theory is applied to the problem where both inputs have the characteristics of RC-filtered white noise and where the postmultiplier filter is also an RC. . . .

EFFECT OF NOISE DEPENDENCE ON CORRELATION DETECTION AND MEASUREMENT
M. J. Jacobson, J. Acoust. Soc. Amer., vol. 35, March 1963, p. 296/304, A63-19844.

. . . influence of dependent noise inputs in the detection of a signal in noise. Also considered is the effect of noise cross correlation on statistical errors arising in the approximate measurement of a signal cross correlation by the sample mean of the output of a multiplier-averager.

OUTPUT PROBABILITY DISTRIBUTION OF A CORRELATION DETECTOR WITH SIGNAL-PLUS-NOISE INPUTS
M. J. Jacobson, J. Acoust. Soc. Amer., vol. 35, July 1963, p. 1041/1048, A63-19599.

. . . determining the probability density function of the output of a correlation detector whose inputs consist of correlated signal corrupted by uncorrelated noise. The inputs are stationary and Gaussian, one having the characteristics of white noise and the other being RC-filtered white noise. The postmultiplier averager is also an RC filter.

MEAN-SQUARE ERROR IN CORRELATION DEMODULATORS (In German)
B. F. Ludovici, Arch. Elekt. Uebertragung, vol. 17, June 1963, p. 278/288.

Four different methods of extracting the intelligence from an amplitude-modulated carrier in the presence of noise are analyzed on a mean-square error basis. Assumed is band-limited

white gaussian noise and a noise-like modulating intelligence of uniform power spectrum ranging from dc to an upper limiting frequency equal to two-thirds of the carrier frequency. Included in the analysis are the square-law, autocorrelation, two-amplifier and cross correlation demodulators. . . . shows that the autocorrelation demodulator offers no significant improvement over the simple square-law demodulator. Improvements of approximately 3 dB and 6 dB can be expected from the two-amplifier and cross-correlation demodulators, respectively. These results agree essentially with those of other authors who carried out similar analyses on a signal-to-noise basis. . . .

EIN AHNLICHKEITSPRINZIP, BETREFFEND DIE STATISTISCHE VERTEILUNG DER AUSGANGSSPANNUNG VON TECHNISCHEN KORRELATOREN BEI NORMAL VERTEILTEN EINGANGSSPANNUNGEN (A Similiarity Relationship of the Output Voltages of Technical Correlators Under Input Process With Normal Distribution) (In German)
R. Rucklin, Arch Elekt. Uebertragung, vol. 17, March 1963, p. 108/112.

The statistical distribution of the output voltage of a technical correlator depends on the cross and autocorrelation function of the input voltages, the characteristics of the multiplication circuit, and the transfer coefficient of the smoothing network. Let us assume that for a certain technical correlator the statistical distribution of the output voltage with the delay time tau as parameter has been determined for given, steady-state, ergodic, normally-distributed input voltages with zero averages. If now the statistical relationships at the inputs are modified according to a certain rule a smoothing network can be stated to the same multiplication circuit with the aid of the here derived similarity principle, at whose output, apart from an increase in the delay time tau, the same distribution of the output voltage comes about. . . .

A STUDY OF CORRELATOR BEHAVIOR USING "NON STATIONARY" SIGNALS, PART I
W. G. Shesnut, Dewey, G.C. and Co., Inc., New York, Rept. no. R127 1, 17 June 1963, 54, p. AD 411 249.

. . . developing the expected correlation behavior of analog and clipper correlators processing non-stationary signals . . . Non-stationary noise may degrade analog processing gain whereas it appears to improve the processing by the clipper correlator. The development is restricted to the case of small signals buried in noise. . . .

A STUDY OF CORRELATOR BEHAVIOR USING "NON-STATIONARY" SIGNALS. PART II
Dewey, G. C. and Co., Inc., New York, R127 1, 17 June 1963, p. 38, AD 412 534.

. . . cross-correlation gains of an analog and clipper correlator . . . The signals and noise used in this study we have characterized as being non-stationary. An attempt has been made to compare experimentally determined gains for the case of small signals buried in noise with those predicted theoretically.

Related Publications:

THE INVARIANCE PROPERTY OF CORRELATION FUNCTIONS UNDER NONLINEAR TRANSFORMATIONS
A. H. Nuttall, Res. Lab. Electronics, MIT, Quarterly Progress Report, April 1958, p. 75/76.

STUDY OF PCM-FM TRANSMISSION OVER TROPOSPHERIC SCATTER SYSTEMS
F. Assadourian, RCA Defense Electronic Products, N.Y., Final rept. on Task 4, Sept. 1959, AD 230 426.

. . . detailed survey of necessary background topics such as binary digital error rates for various types of PCM-FM signals and for correlation or non-correlation detection. . . .

ASYMPTOTIC FORMS OF DETECTORS OF SIGNALS IN NOISE
W. L. Root, Mathematics Research Center, U. of Wisconsin, Madison, Feb. 1964, p. 39, AD 437 292.

2.822: Autocorrelation Detectors

Included: Orthogonal filtering; Linear autocorrelators; Multichannel autocorrelators.

Not Included: Autocorrelation functions of random processes (1); Autocorrelation of noise and disturbances (1).

Cross References: Autocorrelation detection of binary code words (2.825).

Principal Publications:

NOISE SUPPRESSION IN THE AUTOCORRELATED RECEPTION OF AMPLITUDE MODULATED SIGNALS
L. Z. Kliachkin, Radio Engng., vol. 14, no. 2, 1959, p. 31/37.

. . . It is shown that for an optimum filter pass-band the gain does not on the average exceed 1.5dB over the whole modulated frequency spectrum and that when the passband increases beyond the optimum the gain tends to 3 dB.

INCREASING THE RELIABILITY OF DIGITAL COMMUNICATIONS SYSTEMS UNDER POOR SIGNAL CONDITIONS
N. Levine, et al., Air Force Cambridge Research Center, Bedford, Mass., Rept. no. AFCRC TR-59-158, June 1959, 31 p., AD 288 773.

. . . Amplitude modulation using an autocorrelation receiver . . .

AUTOCORRELATION AND SPECTRAL ANALYSIS
R. W. Southworth, In: Mathematical Methods for Digital Computers, New York, John Wiley and Sons, Inc., Sept. 1959, p. 213/221.

THE COMPUTATION OF CORRELATION AND SPECTRAL FUNCTIONS BY ORTHOGONAL FILTERING
E. G. Gilbert, Commun. and Electronics, no. 46, Jan. 1960, p. 954/959.

OVER-HORIZON RADAR'S ROLE IN DEFENSE
Electronics, vol. 33, no. 6, Feb. 1960, p. 28/29.

. . . employs some sophisticated techniques, including autocorrelating circuits which use a magnetic-drum record of the transmitted pulse to correlate successive echoes.

MEASURING THE COEFFICIENT OF AUTOCORRELATION OF A RANDOM SIGNAL ABOVE THE THRESHOLD LEVEL BY MEANS OF PULSE COUNTERS
V. V. Viter, et al., Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 6, 1961, p. 39/43.

The method under examination, for calculating the coefficient of autocorrelation and the correlation function for pulse amplitudes of random sequence exceeding a certain threshold level, is based on the measurement of the mean operating frequency of the threshold equipment and its additive components. . . .

AUTOCORRELATION OF PULSE POSITION MODULATED SIGNALS
N. G. Gionis, Air Force Inst. of Tech., Wright Patterson Air Force Base, Ohio, Master's thesis, Rept. no. GE/EE/62-7, Dec. 1962, 65 p., incl. illus., tables, 10 refs., AD 294 922.

ADVANCED RECEIVING TECHNIQUES
JPL Space Progr. Summ., vol. 1, no. 37-14, Jan./Feb. 1962, p. 111/116.

1. High Speed and High Capacity Autocorrelator.
The central problem of estimating, or measuring, the power spectrum of a random signal is the stability of the measurement . . . An effective way to produce stable spectral estimates is to measure the autocorrelation (Ref. 11) function of the signal, and then take the Fourier transform of that function. This yields the desired power spectrum.
The most convenient way of mechanizing this method is to sample the signal, quantize and record the samples, and use a general purpose digital computer to find the autocorrelation functions.
This discussion describes, in some detail, a special purpose computer which can measure the autocorrelation function of the signal as fast as samples arrive; so that the answer is ready at the end of the observation.

A LINEAR AUTOCORRELATOR FOR SYNCHRONIZATION OF BINARY CODED MESSAGES
V. A. Jennings, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 151/158.

. . . One method by which the synchronization reliability may be improved is to increase the length of the synchronization word, particularly if Barker or other optimum words are employed. The full theoretical improvement . . . can be approached . . . if the word is recognized . . . by a device which processes the combination of signal and noise as a linear mixture . . . The delay line autocorrelator provides a convenient method for accomplishing this result . . .

NINE-CHANNEL AUTOCORRELATOR
JPL Space Progr. Summ., vol. 3, no. 37-25, Nov./Dec. 1963, p. 33/38.

A nine-channel autocorrelator is currently being constructed for use with the planetary radar receiver located at the Venus site in Goldstone, California. This instrument is a real-time device for processing the reflected signal from a planetary surface.

Related Publications:

A PULSE COMPRESSION SYSTEM EMPLOYING A LINEAR FM GAUSSIAN SIGNAL
E. N. Fowle, et al., Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 304/312.

. . . A signal of Gaussian envelope and linear frequency modulation is shown to have an autocorrelation function of Gaussian shape. . . . design and construction of equipment used to generate and receive the signal . . .

2.823: Matched Filter Correlation Detectors

Included: Delay line correlators; Analog correlators in general.

Not Included: Matched filter data transmission systems (1); Design of matched filters; Construction of delay lines.

Cross References: Theory of analog correlators (2.821); Digital delay line correlator (2.814); Digital matched filter detectors (2.824); Matched filter detection in anti-multipath systems (2.873).

Principal Publications:

DESIGN OF A DELAY LINE FOR AN ANALOG CORRELATOR
T. R. Benedict, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 715/723.

CORRELATION AND DELAY LINE ATTENUATION
M. J. Jacobson, IRE Trans. Inform. Th., vol. IT-5, March 1959, p. 4/9.

A MATCHED FILTER DETECTION SYSTEM FOR COMPLICATED DOPPLER SHIFTED SIGNALS
R. M. Lerner, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 373/385.

MATCHED FILTER APPROXIMATION ERRORS (Correspondence)
M. J. Levin, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 254.

. . . a simple, easily visualized expression for the deterioration in output signal-to-noise ratio caused by approximation errors in a matched filter (or correlation) detector. . . .

Related Publications:

ON NEW CLASSES OF MATCHED FILTERS AND GENERALIZATIONS OF THE MATCHED FILTER CONCEPT
D. Middleton, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 349/360.

AN INTRODUCTION TO MATCHED FILTERS
G. L. Turin, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 311/329.

SOME RESULTS ON NEW CLASSES OF MATCHED FILTERS
D. Middleton, Rand Corp., Santa Monica, Calif., Rept. no. RM-2625, 12 July 1961, 34 p., AD 261 027.

ON THE POTENTIAL ADVANTAGE OF A SMEARING-DESMEARING FILTER TECHNIQUE IN OVERCOMING IMPULSE-NOISE PROBLEMS IN DATA SYSTEMS
R. A. Wainwright, IRE Trans. Commun. Syst., vol. CS-9, no. 9, Dec. 1961, p. 362/366.

PULSE COMPRESSION TECHNIQUES (Correspondence)
M. Bernfield, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1261.

A SIMPLE DERIVATION OF THE MATCHED FILTER CONCEPT (Correspondence)
N. C. Hekimian, Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 373/374.

2.824: Digital Correlation Detectors

Included: Digital matched filter detectors; Parallel digital delay line correlator; Linear digital correlator (DICOR); Digital filters as correlation detectors; Digital computers as correlation detectors; Hybrid digital-analog correlation detector.

Not Included: Digital signal processing equipment (3A); Design of digital filters.

Cross References: Detection under multipath conditions (2.873); Correlation detection of binary sequences (2.825).

Principal Publications:

SIMPLE DIGITAL CORRELATOR
C. Collins, Rev. Sci. Instruments, vol. 29, June 1958, p. 487/490.

. . . which employs punched-tape input and visual digital readout.

THE USE OF TRANSISTORS IN A DIGITAL CORRELATOR FOR PROCESSING RADAR INFORMATION
A. L. Cain, et al., Proc. Instn. Elect. Engrs., Paper 3037 E., Part B Suppl. No. 16, p. 649/56, 1960.

IMPLEMENTATION OF THE CORRELATION PROCESS IN THE MANNER OF A PARALLEL DIGITAL COMPUTER
R. L. Boyell, et al., IRE Internat. Conv. Rec., vol. 9, March 1961, p. 219/228.

. . . most existing systems for performing correlation tend to be limited in their accuracy and coverage. However, if the correlation processor is designed around logic elements typical of those used in digital computers, many of the desirable features of mechanization become easier to obtain, and at only a small loss in signal/noise ratio. This paper sketches the theory of a correlation processor that operates on quantized, sampled signals, using binary logic elements. The cross-correlation function can be obtained in real time, with no loss of information.

INTEGRATION UND EFFEKTIVE INTEGRATIONSZEIT IM ABTAST-KORRELATOR (Integration and Effective Integration Time in a Scanning Correlator) (In German)
C. Moeller, Hochfrequenz-technik und Elektroakustik, vol. 70, no. 4, Aug. 1961, p. 128/131.

APPLICATIONS OF THIN FILM TRANSISTORS TO DIGITAL CORRELATION TECHNIQUES
E. W. Doolittle, et al., David Sarnoff Research Center, Princeton, N.J., Final Rept., 31 Dec. 1962, 23 p., illus., 12 refs., AD 297 420.

. . . to fabricate integrated arrays of TFT's . . . A register of TFT flip-flops and comparator circuitry was chosen as a suitable test vehicle. The flip-flops used were capable of switching at 4 mc when over-driven from a low impedance source. A 1 mc rate was achieved when driven from a high impedance source. The internal speed of the TFT was determined to be in the nanosecond range, the operating speed being limited primarily by the input electrode and feedback capacitance.

DIGITAL FILTERS AND APPLICATIONS TO SEISMIC DETECTION AND DISCRIMINATION
J. F. Claerbout, Mass. Inst. of Tech, Cambridge, AFCRL 63 604, Feb. 1963, 89 p., AD404 851.

The mathematics of filtering in discrete time are presented. Filters are defined for the purposes of (1) condensing waveforms into impulsive functions, (2) wave shaping, (3) noise suppression, (4) signal detection according to the criterion of maximum signal-to-noise output at an instant, and (5) the same over an interval. The behavior of the complex Fourier transforms of some of these filters is considered and connection is made with the theory of orthogonal polynomials.

ERROR PROBABILITIES FOR A DIGITAL MATCHED FILTER
M. Koerner, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 158/160.

As detection systems become increasingly complex in an effort to extract information from noisy signals in an optimum or nearly optimum manner, analog mechanizations become unwieldy and use of a digital computer . . . to perform the required data processing, becomes attractive. . . . the detection system is independent of the computer hardware and depends only on the manner in which the received signal is sampled and converted to digital form. The effect of sampling and quantization shall be the subject of this report.

LINEAR DIGITAL CORRELATOR (DICOR)
M. H. Mott, et al., Navy Electronics Lab., San Diego, Calif., Research and Development Report (Oct. 1958-June 1963), NEL-1194, 8 Nov. 1963, 31 p., refs., AD 429 308, N64-17362.

. . . design evolved from investigations of matched filtering of coded-pulse radar signals utilizing digital techniques . . . represents an attempt to find an economical means of eliminating or reducing the strong-signal capture effect, which leads to complexity and high cost in digital matched filters . . .

PARALLEL DIGITAL DELAY-LINE CORRELATOR (Correspondence)
H. J. Whitehouse, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 237/238.

. . . application of cross-correlation techniques to the field of underwater acoustics . . .

Related Publications:

DEVELOPMENT OF AN ADVANCED CONDITIONED REFLEX MODEL
Scope, Inc., Falls Church, Va., Final technical rept., ASD TDR63 667, 25 Sept. 1963, 84 p., AD 422 467.

SOME OPTIMUM PROCESSORS FOR MODERN COMMUNICATIONS AND CONTROL APPLICATIONS
A. H. Sepahban, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 768/792, 17 refs.

Engineering examples of data and signal processing problems from communications coding and control applications are presented . . .
Coding for signal detection by matched filter correlation of signal trains is compared with pure error correction coding. Digital processors for implementation of these two schemes are also compared.

2.825: Correlation Detection of Binary Sequences

Included: Correlators for pseudo-random signals; Detectors for coded phase-coherent communications systems; Autocorrelation detection of binary code words; Correlation functions of filtered PN sequences.

Not Included: Data transmission systems with binary sequences (1); Correlation functions of random processes (1).

Cross References: Theory of PN codes (2.121); Autocorrelation detectors in general (2.822); Digital correlators (2.824); Phase coherent detection methods (2.834).

Principal Publications:

A METHOD OF SIDE-LOBE SUPPRESSION IN PHASE-CODED PULSE COMPRESSION SYSTEMS
E. L. Key, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Tech. rept. no. 209, Aug. 1959, 8 p., AD 229 403.

This report presents a method whereby the side-lobe level of a phase-coded pulse autocorrelation function may be suppressed, in principle, to any desired level.

A BOUND ON THE CROSSCORRELATION FUNCTIONS OF A SET OF BINARY SEQUENCES OF FINITE LENGTH
G. E. Mongold, Jr., MIT, Res. Lab. Quarterly Progress Rept. no. 52, Jan. 1959, p. 112/128.

. . . form a class of signals that might be used as modulating functions in a communication system employing correlation detection.

EXPERIMENTAL AUTOCORRELATION OF BINARY CODES
D. F. DeLong, MIT Lincoln Laboratory, Oct. 1960.

ON CODED PHASE-COHERENT COMMUNICATIONS
A. J. Viterbi, IRE Trans. Space Electronics Telemetry, vol. SET-7, no. 1, March 1961, p. 3/14.

. . . this paper considers the result of encoding independent equiprobable binary words or sequences of independent binary digits into sets of binary code words. These are transmitted over a channel perturbed by additive white Gaussian noise and detected by correlating them with their stored or locally generated replicas at the receiver . . . It is shown that in the limit as the code word length and the bandwidth approach infinity, the received information rate approaches the channel capacity for only one value of the above ratio.

ON CODED PHASE-COHERENT COMMUNICATIONS
A. J. Viterbi, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, Technical rept. no. 32-25 15 Aug. 1960, AD 243 735.

. . . This report considers the result of encoding independent equiprobable binary words or sequences of independent binary digits into sets of binary code words. These are transmitted over a channel perturbed by additive white gaussian noise and detected by correlating them with their stored or locally generated replicas at the receiver. . . .

CONTINUOUS-WAVE RADAR WITH HIGH RANGE RESOLUTION AND UNAMBIGUOUS VELOCITY DETERMINATION
S. E. Craig, et al., IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 153/161.

. . . operating with continuous transmission, suitably modulating the transmitter power and correlating returned echoes with a delayed replica of the modulating signal. . . . An excellent waveform for modulating the transmitter is the pseudo-random code generated by a shift register with multiple feedback paths. . . . It is shown that phase-reversal modulation results in little distortion of the code, while frequency modulation can give rise to false range indications.

CORRELATION FUNCTIONS OF FILTERED PN SEQUENCES
C. E. Gilchriest, JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 81/87.

Spacecraft communications systems developed by JPL depend quite heavily on pseudo-noise (PN) synchronization techniques . . . adaption to new systems nearly always uncovers new problems to be solved. Such is the case on the current spacecraft telemetry, command, and ranging systems.

WEIGHTED STATISTICAL AVERAGES AS A MEANS OF CALCULATING MULTIPLIER OUTPUTS AND CARRIER POWERS FOR NOISE MODULATED CARRIERS
C. E. Gilchriest, JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 87/92.

Weighted mean averages have proved to be a very convenient tool in the analysis of correlation detectors when the reference signal has noise modulation in phase or, equivalently, modulation in time. In particular, the first moment is capable of yielding the average correlator output or, equivalently, the amount of power remaining in the carrier under the noisy phase modulation process.

TRANSPONDER RANGING SYSTEM
JPL Space Progr. Summ., vol. 3, no. 37-16, May-June 1962, p. 53/64.

. . . shows the correlation output during transponder-to-ground acquisition in the laboratory with both units operating at Mars nominal levels. Correlation is noisier than in the closed-loop case because the noise of the transponder-clock VCO is added to the other noise in the system.

A NOTE ON ORTHOGONAL DIGIT CODING
L. Kurz, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 775/782.

. . . considers some general ideas pertaining to multisignal coding for digital communication systems perturbed by additive Gaussian noise which may be non-white with a known demodulated noise power density spectrum. The signals are formed from weighted sums of the orthogonal set of eigenfunctions generated by an integral equation with its kernel corresponding to the inverse Fourier transform of the Gaussian noise power density spectrum. The orthogonal digit codes thus generated afford greater reliability for fixed data rate and average power limited communication links then do binary digit codes . . . A new interpretation of the results in terms of the matched-filter-theory is given.

SELF-NOISE OF RANDOM BINARY PULSE TRAIN OF FIXED PULSE WIDTH (Correspondence)
P. W. Cooper, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 118/121.

. . . at the output of a finite-time correlator. . .

POWER AND SIGNAL-TO-NOISE CALCULATIONS OF A CERTAIN PSEUDO-RANDOM SIGNAL
E.J. McManus, Jr., Army Missile Command, Redstone Arsenal, Huntsville, Ala., Rept. no. RE-TR-63-1, 25 Jan. 1963, p. 16, incl. illus., 3 refs, AD 297 096.

. . . is shown that the amplifier bandwidth which maximized the output signal-to-noise ratio is given by 2/tau, when tau is the bit length in the pseudo-random sequence.

ON THE APPLICATION OF SOME DIGITAL SEQUENCES TO COMMUNICATION
J.K. Wolf, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 422/427.

The effects of filtering a random binary sequency with certain finite memory linear and nonlinear filters are considered. Of interest are the statistical properties of the filtered sequence such as the power spectral density and amplitude distribution function, as well as methods for recovering the original sequence. Applications of these techniques to communication systems are discussed. . . .

Related Publications:

SIDELOBE SUPPRESSION IN A RANGE-CHANNEL PULSE-COMPRESSION RADAR
C.L. Temes, IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 162/169.

. . . the problem of suppressing sidelobes in the compressed pulse is discussed. It is concluded that amplitude-weighting in the time domain (at IF) is a convenient method of suppressing sidelobes. An integration loss factor is defined which characterizes the decrease in signal-to-noise ratio (SNR) resulting from the inclusion of weighting. . . .

A LARGE TIME-BANDWIDTH PRODUCT PULSE-COMPRESSION TECHNIQUE
R.C. Thor, IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 169/173.

. . . system which utilizes a linear FM waveform has a theoretical upper limit to the magnitude of its compression ratio or time-bandwidth product. This limit is a function of the observed target's relative radial velocity, and the effect on the return signal is characterized by both a pulse stretching and amplitude reduction if the limit is exceeded. The use of a logarithmic phase-modulation signal waveform and a corresponding "matched" receiver possesses the desirable characteristics of the linear FM and in addition has no upper limit to the magnitude of the compression ratio. A single receive pulse-compression filter is matched for all target velocities. . . . For pulse-compression systems with T-F products larger than 10^4 . . . LOGMOP . . . speed almost entirely independent of frequency. . . . approximately a speed of 5000 meters per second . . . At frequencies higher . . . the delay increases with frequency . . . closely linear over a large part of the dispersive range. . . this portion . . . is used . . . The best lines made to date have had a product of delay variation times bandwidth in the order of 300. . . . synthesizing a desired phase response of a LOGMOP. . .

CORRELATION FUNCTION FOR THE RANDOM BINARY WAVE (Correspondence)
P.W. Cooper, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 496/497.

This note presents expressions for the autocorrelation function, its Hilbert Transform, and the associated "envelope" and "phase" functions for the band-limited random binary wave. Interest in these functions could arise, for example, in analysis of the "envelope" of a signal and in correlation detection of a single sideband waveform . . .

STATISTICAL PROPERTIES OF THE INTEGRAL OF A BINARY RANDOM PROCESS
D.G. Lampard, et al., IEEE Trans. Circuit Th., vol. CT-10, no. 3, Sept. 1963, p. 413/427, 26 refs.

. . . Statistical properties of the output z(t) of a finite time integrator are discussed. The input process considered is a binary random process y(t) having successive axis-crossing intervals which are statistically independent. Transform expressions are derived for the first- and second-order transition probability densities of the integrated process, and it is shown how these results may be extended to three or more dimensions. Four processes are considered as examples.

2.828: Special Applications of Correlation Detectors

Included: Correlation systems for underwater sound; Correlation frequency tracker; Seismic correlation detectors; Macomatic correlation signal processing systems for sonar; Cross correlation techniques for antenna arrays; Correlators for error correcting detection; Correlation devices in speech processing; Correlation radiometer techniques; Correlation methods for recognizing patterns; Cross correlation radar detectors.

Not Included: Phase lock loop detection circuits; Signal processing methods (3A); Optical cross correlators (3B).

Cross References: Detection theory for special communications applications (Sect. 2.87); Analytical problems in radar detection (2.883); Error correcting codes (Div. 2.7); Speech processing methods (Div. 2.3); Pattern recognition techniques (Sect. 2.26); Phase coherent detection methods (2.834).

Principal Publications:

A DIGITAL DATA TRANSMISSION SYSTEM USING PHASE MODULATION AND CORRELATION DETECTION
F.A. Losee, Proc. Nat. Aeron. Electronics Conf., May 1958, p. 88/93.

DESIGN AND STUDY OF CORRELATION INSTRUMENTATION FOR SPEECH ANALYSIS AND SYNTHESIS
D.T. Hoger, et al., RCA Defense Electronics Products, Camden, N.J., Rept. no. AFCRC TN-59-566 , July 1959, 53 p., AD 225 737.

CORRELATION OF A FINITE DISTANCE POINT SOURCE
M.J. Jacobson, J. Acoust. Soc. Amer., vol. 31, April 1959, p. 448/449.

A two-receiver steerable correlation system intended to process signals from point sources at a large distance from and in a common plane with the receivers.

A CORRELATOR EMPLOYING HALL MULTIPLIERS APPLIED TO THE ANALYSIS OF VOCODER CONTROL SIGNALS
A.R. Billings, et al., Proc. Instn. Elect. Engrs. Pt B, vol. 107, no. 35, Sept. 1960, p. 435/438.

. . . discussion of short-term correlation functions . . . design and performance of an auto-and cross-correlator using Hall-effect multipliers . . . It is shown that these devices are well suited to act as the multiplying elements and as modulators in associated circuits, provided that one of the time functions to be multiplied has a narrow bandwidth. Examples of measured auto- and cross-correlation functions are given for sine waves and noise and for the control signals of a vocoder, from which interesting conclusions can be drawn about the redundancy of vocoder signals. . . .

ACQUISITION AND TRACKING SYSTEMS FOR SPACE VEHICLES
Philco Corp., Philadelphia, Pa., 29 Nov. 1960 AD 250 110, vol. 1, AD 250 111, vol. 2.

An advanced tracking system which will be capable of locating space vehicles with high precision out to interplanetary ranges has been designed. Employing state-of-the-art techniques, a range-measuring accuracy of 15 feet can be achieved at a distance of 100 million miles; this accuracy is sufficient to ensure successful midcourse guidance of interplanetary probes with a completely earth-based triangulation network . . . VERNITRAC (VERNIer TRacking by Automatic Correlation), involves long term correlation of the received signal with series of waveforms generated at the receiver. This process, properly implemented, enhances the detection of very low level signals, and provides for accurate measurement of time delay. A number of factors which affect system design, including vehicle characteristics, propagation losses, and refraction effects, are discussed.

RANGE-ONLY TARGET CORRELATION
D.F. Allen, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 430/436.

. . . The technique utilizes inherently higher granularity in range compared with angle measurements to eliminate noise and to correlate target returns. State-of-the-art digital logic and a limited stored program computer can be specified for real-time correlation is presently realizable radar systems. . . . The Range-Only Target Correlator has been successfully simulated on the IBM 704 computer. . . .

OPTIMUM PCM FRAME SYNCHRONIZATION CODES AND CORRELATION DETECTION
G.E. Goode, et al., Proc. Nat. Telem. Conf., May 1961, p. 11/15-11/50.

. . . frame synchronization correlator . . .

RATE COMPENSATING TRACKER WOX-2A
C.R. Greene, et al., Naval Ordnance Lab., White Oak, Md., Rept. NOLTR 61-37 , July 1961, 13 p., AD 266 706.

An automatic tracker was built to follow the position of the maximum of a correlation function generated by a DELTIC correlator. The position-correcting decisions, made for each successive correlogram, are fixed size (0.8 microsec) . . . This is similar to the WOX-1A tracker, except that the WOX-2A is digital. This tracker includes a rate tracking capability so that a correlogram whose position changes at a constant rate (up to 28.2 microsec/sec) may be tracked without lag. . . . Theoretical analysis shows that with such rate compensation the tracker performance approximates that of the uncompensated tracker for input standard deviations up to about 300 microsec, in addition to eliminating the lag.

ENTWICKLUNGSTENDENZEN DER MODERNEN ORTUNGSTECHNIK: KORRELATIONSORTUNGSVERFAHREN (Development Trend in Modern Navigation Technique: Correlation Navigation Systems) (In German)
F.H. Lange, Nachrichtentechnik, vol. 11, no. 1, Jan. 1961, p. 2/7.

PROCEDURE FOR THE EVALUATION OF CORRELATION TRACKING AND RANGING (COTAR)
C.H. Tapper, Land-Air, Inc., Point Mugu, Calif., Rept. no. 30, 14 Aug. 1961, 164 p., AD 264 009.

. . . Evaluation tests at the Pacific Missile Range of the correlation tracking and ranging (COTAR) system, as a radar acquisition device. The instrumentation system is described. The theory of operation and supporting mathematics is presented to explain the method of determining directional cosine functions for the X and Y axes of its specialized antenna field by measuring the phase difference in signals received. Working forms, data reduction procedures, and computer programming developed for these evaluation and acceptance tests are included.

APPLICATION OF TECHNIQUES FOR STATISTICAL COMMUNICATION THEORY IN UNDERWATER ACOUSTICS
Raytheon Co., Portsmouth, R.I., Quarterly status rept. 2 for Sept. 1961, Rept. R155, Sept. 1961, 32 p., AD 266 138.

. . . analytical solutions of selected passive sonar problems by use of the techniques of statistical communication theory . . . (1) The characteristics of the adaptive nonparametric-type detector functional when used to detect both gaussian and non-gaussian signals in either gaussian or non-gaussian noise; (2) The characteristics of the detector for noise-like signals in the presence of impulse-type background noise . . . The practical implementation of the adaptive detector was considered. A design was obtained which could process 1000 data samples and 3000 noise samples taken at a 2-kc rate, in real time. The detector outputs would be available with 1/2 sec of the epoch of the final data sample. A research report describing the status of the analysis on optimal array detection systems is appended to this report.

A VHF SOLAR RADAR SYSTEM
W.G. Abel, et al., IRE Internat. Conv. Rec., Pt. 5, vol. 10, March 1962, p. 58/66.

. . . Radar echoes from the sun at a frequency near 38 mcps have been obtained regularly since April 19, 1961 at the MIT Lincoln Lab. radar site near El Campo, Tex. These echoes are buried in solar and cosmic noise and can be detected only after cross-correlation with the transmitted signal and integration over at least several minutes. . . . summary of data analysis . . .

INVESTIGATION OF CORRELATION TECHNIQUES FOR MICROWAVE RADIOMETRIC SENSORS
W.E. Budd, et al., Melabs, Palo Alto, Calif., Quarterly engineering rept. no. 2, 15 Aug.-15 Nov. 1962, 15 Nov. 1962, 59 p., illus., AD 291 626.

A LOW NOISE CORRELATION FREQUENCY TRACKER
R.R. Jennings, et al., Naval Avionics Facility, Indianapolis, Ind., NAF TR129, 8 Feb. 1962, 209 p., AD 412 630.

TARGET TRACK CORRELATION WITH A SEARCH MEMORY
E.C. Joseph, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 255/261.

OPTIMUM CROSS-CORRELATION RADAR SYSTEM (Correspondence)
R.H. MacPhie, Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2508/2509.

. . . R.L. Mattingly reported. . . that the conventional Dolph-Chebyshev design of linear arrays was inadequate in the radar case. . . . improvement over the conventional Dolph-Chebyshev system . . .

SIMPLE DECODERS AND CORRELATORS FOR CYLIC ERROR-CORRECTING CODES
M.E. Mitchell, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, p. 284/290.

Several promising techniques for instrumenting error-correcting codes are briefly described. . . . consist of digital decoders for the binary symmetric channel and for the binary erasure channel, and analog word correlators for variable and low bit-rate operation. . . .

CORRELATION DETECTION AND SEQUENTIAL TESTING FOR PCM GROUP SYNCHRONIZATION
J.L. Phillips, et al., Proc. Nat. Telem. Conf., May 1962, 5-4, p. 1/15.

MACOMATIC CORRELATION SIGNAL PROCESSING SYSTEM
W.B. Allen, et al., Navy Electronics Lab., San Diego, Calif., NEL-1161, 14 March 1963, 39 p., 8 refs., N63-18854.

. . . developed for incorporation into a pseudorandom-signal-correlation sonar system. . . . highly flexible input sampling rate — any rate up to 400 bits per second — and a storage capacity of 2048 bits. Special timing pulses in the core matirx permit Doppler correction by adding or subtracting bits of information to effectively compress or expand the stored signal . . . recommended particularly for use with spectrum analyzers for investigating low-and very-low-frequency phenomena.

CORRELATION DETECTION OF SEISMIC DISTURBANCES
P.W. Cooper, Sylvania Electric Products, Inc., Waltham, Mass., Research rept. no. 374, 27 June 1963, 16 p., AD 427 392.

In a medium in which noise and signal propagate with different velocities, a detection

scheme making use of the cross-correlation between the received waveforms at two different locations offers a number of distinct advantages over one making use of ordinary autocorrelation of the received waveform . . . allowing for separation of noise and signal when the noise characteristics or statistics are unknown, and even where the processes are non-stationary . . .

ON THE CORRELATION RADIOMETER TECHNIQUE
K. Fujimoto, IEEE Trans. Microwave Th. Tech., vol. MTT-12, March 1964, p. 203/212, 24 refs., A64-17234.

Study of the two basic types of correlation radiometers, the intermediate-frequency correlation (IF) type and the video-frequency correlation (ENV) type. The correlation radiometer is a system in which two antenna-receiver systems are employed, the outputs of the two systems being correlated electronically. The SNR's, the minimum detectable temperature sensitivities, the effects of receiver gain and phase fluctuations and the uses of the two types are studied. A comparison . . . with . . . the Dicke-type radiometer is made.

CORRELATION METHOD FOR RECOGNIZING PATTERNS
V.A. Kovalvskii, Joint Publication Research Service, Washington, D.C., 31 Jan. 1963, 15 p., AD 406 408.

DEVELOPMENT OF AN INTEGRATED CORRELATION SYSTEM
B. Leven, Marine Engineering Lab., Annapolis, Md., 17 March 1964, 12 p., AD 432 474.

Descriptors . . . Sound transmission . . . Underwater sound . . . Spectrum analyzers . . . Special purpose computers, Acoustic properties. . . . to provide the data necessary to discern and identify noise propagation paths in mechanical structures . . .

APPLICATION OF CROSS CORRELATION TECHNIQUES TO LINEAR ANTENNA ARRAYS
R.H. MacPhie, Illinois U. Antenna Lab., Urbana, Tech. Rept. 67, March 1963, 168 p., 54 refs., N63-18675 and AD 410 149.

. . . The basic cross-correlation system, which is considered, consists of two linear receiving arrays excited by a distribution of remote radio sources. The terminal voltage of each array is passed through a narrow-band RF filter, and the two resulting signals are cross correlated . . . a three-dimensional principal solution can be deduced; it is a generalization of the one-dimensional principal solution given by Bracewell and Roberts in connection with radio astronomy.

USE OF A TIME-DELAY CORRELATOR IN SOLVING AN ACOUSTIC MULTIPATH PROBLEM (Correspondence)
A.G. Ratz, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 239.

PULSE-COMPRESSION SUBSYSTEM FOR A DOWN-RANGE TRACKER
C.L. Temes, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 71/81.

. . . installed in a Down-Range tracking radar of the Atlantic Missile Range. . . . The subsystem transmits a 4mc frequency ramp and achieves a nominal range resolution of 120 feet with a time bandwidth product of 8000. . . .

THE PANCHROMATIC PRINCIPLE IN OPTICAL FILTERING
R.E. Williams, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 227/234.

The panchromatic optical correlator is a coherent correlator which uses a slightly broadened light spectrum to correlate simultaneously a number of receiver channels against a continuous range of Doppler distortions of the transmitted signal. . . .

Related Publications:

THE THEORY AND DESIGN OF CHIRP RADARS
J.R. Klauder, et al., Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 745/808.

ADJUSTABLE DOPPLER TOLERANCE WAVEFORM FOR CORRELATION DETECTION
P.R. Karr, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 1, Feb. 1962, p. 1.

III. THE MARINER PLANETARY COMMUNICATION SYSTEM DESIGN
B.D. Martin, Proc. Nat. Telem. Conf., vol. 2, 1962, no. 8-3.

. . . will be used on the first Mariner spacecraft, a Venus probe, to be launched during the summer of this year. While the basic design philosophy and implementation techniques remain essentially the same, the major system difference between that reported here and that used in the Mariner is the deletion of the S-band transponder system. . . .

SIGNAL FIDELITY IN RADAR PROCESSING
W.A. Penn, IRE Trans. Mil Electronics, vol. MIL-6, no. 2, April 1962, p. 204/218.

CODED PULSE RADAR (CORRELATION RADAR USING RANDOMLY CODED PULSE)
T. Sakamoto, et al., In: International Symposium on Space Technology and Science, Tokyo, Japan, Aug. 27-31, 1962, 4th, Proceedings, edited by Tamiya Nomura, Tokyo, Japan and Rutland, Vt., Japan Publications Trading Co., 1963, p. 586/591, A64-15039.

. . . improving the performance of long-range-radar systems . . . the product of signal bandwidth and duration, namely, the radar response function, should be sharply defined and possess a low side-lobe . . . laboratory experiments were carried out . . . High range resolution is accomplished by modulating the phase of the carrier of transmitted pulse. Pseudo-random sequence generated by using a feedback shift register is utilized as a modulating signal.

STUDY OF MULTI-FUNCTION SENSORS FOR GUIDANCE SUBSYSTEMS
A.A. Miccioli, Wright-Patterson AFB, Ohio, AF Avionics Lab., Final Report, 1 July 1962-30 June 1963, RTD-TDR-63-4049, Dec. 1963, 82 p., refs., AD 425 224, N64-13127.

Experimental and analytical investigations of the extension of the GPL area correlation technique from terrain matching to simultaneous star field and beacon tracking in the context of a space rendezvous mission. . . It was indicated that the extension was a feasible one . . .

A SPECTRUM COMPRESSION RADAR TECHNIQUE
W.E. Wood, et al., Army Missile Command, Huntsville, Ala., RE-TR-63-23, 8 Aug. 1963, 60 p., refs., AD 425 675, N64-12220.

. . . investigating a particular cross-correlation signal processing technique, (spectrum compression) and to define characteristics of interest in potential applications to Army weapons systems . . .

2.829: Correlation Measurements

Included: Correlation analyzers; Measurement of systems characteristics by means of a cross correlator.

Not Included: Experimental evaluation of statistical populations (1); Design of measurement instruments; Measurements of channel characteristics (1).

Cross References: Measurements of the statistics of information sources (2.229).

Principal Publications:

EINFACHE KORRELATIONSMESSVERFAHREN (Simple Correlation Measurement Methods) (In German)
P. Fey, Nachrichtentechnik, vol. 8, Jan. 1958, p. 12/16.

THE MEASUREMENT OF CONTROL SYSTEM CHARACTERISTICS BY MEANS OF A CROSS-CORRELATOR
M. T. G. Hughes, Proc. Instn. Elec. Engrs., Pt. B, vol. 109, no. 43, Jan. 1962, p. 77/83.

A TIME-DIVISION ANALOGUE MULTIPLIER FOR CORRELATION MEASUREMENTS AND MIXING AT FREQUENCIES UP TO 100 KILOCYCLES PER SECOND
R.F. Johnson, Aeronautical Research Council (Gt. Brit.), 1963, 33 p., refs., N64-14130.

. . . capable of accepting signals from zero frequency to 100 kc/s. Preamplifiers and associated circuits are described that enable the multiplier to be used for the measurement of a wide range of parameters encountered in the turbulence and noise field . . .

AN EXPERIMENTAL CORRELATION ANALYZER FOR MEASURING SYSTEM DYNAMICS
C.W. Ross, et al., IEEE Trans. Commun. Electronics, no. 68, Sept. 1963, p. 554/562, 16 refs.

. . . This paper describes an experimental analyzer which utilizes a modified form of the sine-wave correlation principle to measure the dynamic characteristics of systems including industrial processes and instruments.

Related Publications:

CORRELATION BETWEEN FADING SIGNALS
J. Bell, Electronic Technol., vol. 37, no. 1, Jan. 1960, p. 36/40.

Simple resistance-capacitance circuits enable the positive rectified fading signals, obtained at the outputs of two conventional radio receivers, to be made to fluctuate about zero. The instantaneous sum and the instantaneous difference of the fluctuations are then separately squared, smoothed and displayed continuously on pen recordings.

IMPULSE RESPONSE OF LINEAR SYSTEMS USING CORRELATION AND DIRECT MEASUREMENT
B.E. Berson, Rochester U., N.Y., Aug. 1962, 58 p., incl. illus., 17 refs., AD 281 770.

If a pseudo-random noise sequence is used as the input to a linear system, then by suitably correlating the output of the system and a delayed version of the input, the impulse response of the system can be obtained. The effect of the finite size of the sequence auto-correlation function upon the expected results is analytically determined. . . . a simple method of obtaining a delayed sequence. . . .

Measurements. . .on low pass rc filters. . . .
A polarity-coincidence correlator was used. . .

THE WHIRLING DERVISH, A SIMULATION STUDY IN LEARNING AND RECOGNITION SYSTEMS
A. Hoffman, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 153/160.

. . . An optical correlation device is described. Its function is to generate correlation data between two dimensional patterns and random line templates. The output of the device is paper tape containing the correlation data and sufficient flagging and sync. information to facilitate digital computer processing. The use of this device in conjunction with a digital computer is discussed as a simulation procedure for the evaluation and design of recognition systems. . . .

Section 2.83
Special Detection Methods

2.831: Detection of Analog Signals in General

Included: Detection of asymmetric sideband signals; Maximum bandwidth utilization demodulator.

Not Included: Analog modulation methods (1); Comparisons of analog modulation methods (1); Synchronous detection circuits; Phase lock loops; Frequency demodulators; Demodulation subsystems in radio receivers.

Cross References: Analog correlators (2.813); Optimum linear filtering (2.812); Coherent detection methods (2.834); Detection theory for special communications applications (Sect. 2.87).

Principal Publications:

ENVELOPES AND PRE-ENVELOPES OF REAL WAVEFORMS
J. Dugundji, IRE Trans. Inform. Th., vol. IT-4, no. 1, March 1958, p. 53/57.

. . . Rice's formula is very cumbersome . . . different formula. . .easier to handle analytically.

DETECTION OF ASYMMETRIC SIDEBAND SIGNALS IN THE PRESENCE OF NOISE
T. Murakami, et al., RCA Rev., vol. 19, Sept. 1958, p. 388/417.

NOISE SUPPRESSION IN THE AUTOCORRELATED RECEPTION OF AMPLITUDE MODULATED SIGNALS
L.Z. Kliachkin, Radio Engrg., vol. 14, no. 2, 1959, p. 31/37.

. . . It is shown that for an optimum filter pass-band the gain does not on the average exceed 1.5 db over the whole modulated frequency spectrum and that when the pass-band increases beyond the optimum the gain tends to 3 db.

INCREASING THE RELIABILITY OF DIGITAL COMMUNICATIONS SYSTEMS UNDER POOR SIGNAL CONDITIONS
N. Levine, et al., Air Force Cambridge Research Center, Bedford, Mass., Rept. no. AFCRC TR-59-158, June 1959, 31 p., AD 228 773.

Synchronous communication using phase modulation . . . Amplitude modulation using an autocorrelation receiver. . . .

TRANSIENT CROSS MODULATION IN THE DETECTION OF ASYMMETRIC SIDEBAND SIGNALS
T. Murakami, et al., RCA Rev., no. 3 Sept. 1959, p. 455/472.

THE DEMODULATION OF AM SIGNALS IN NOISE
J. B. Thomas, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 138/146, 25 refs.

Over the past twenty years . . . received considerable attention. . . . More recently

. . . statistical communication theory has stimulated work on optimum AM receiving systems, where systematic attempts are made to minimize the effects of noise. . . . In this paper, AM receivers which are optimum in a minimum mean-squared error sense are examined and compared to conventional small signal AM receivers. Both one-dimensional and multi-dimensional inputs are considered. The latter are particularly interesting in that certain problems which are essentially one-dimensional, such as single-sideband reception, are easily treated as special examples of the multi-dimensional case. . . .

THE DETECTION OF COHERENT SIGNALS IN THE PRESENCE OF CORRELATED NOISE
V.D. Zubakov, Radio Engrg. and Electronics, vol. 4, no. 4, 1959, p. 100/110.

THE OPTIMUM DETECTION OF ANALOG-TYPE DIGITAL DATA (Correspondence)
E. Bedrosian, Proc. IRE, vol. 48, Sept. 1960, p. 1655/1656.

MAXIMUM BANDWIDTH UTILIZATION DEMODULATOR
A.G. Gatfield, IRE Trans. Commun. Syst., vol. CS-8, no. 2, June 1960, p. 83/86.

ON THE RECOVERY OF A BAND-LIMITED SIGNAL, AFTER INSTANTANEOUS COMPANDING AND SUBSEQUENT BAND LIMITING
H.J. Landau, Bell Syst. Tech. J., vol. 39, no. 2, March 1960, p. 351/364.

ENVELOPE PROBABILITY AS A FUNCTION OF E/N. (Correspondence)
L.E. Davies, Proc. IRE, vol. 49, May 1961, p. 971/972.

MEAN-SQUARE ERROR IN CORRELATION DEMODULATORS
B.F. Ludovici, Microwave Lab., Stanford Univ., Calif., 19 Nov. 1962, 11 p., AD 434 512.

Four different methods of extracting the intelligence from an amplitude-modulated carrier in the presence of noise are analyzed on a mean-square error basis. . . . Included . . . are the square-law, autocorrelation, two-amplifier and cross-correlation demodulators.

Related Publications:

A STATISTICAL MEASURE OF THE EFFECTIVENESS OF ADAPTATION IN CONTROL SYSTEMS
R.A. Nesbit, IRE Internat. Conv. Rec., vol. 4, March 1961, p. 18/24.

SIGNAL SELECTION FOR CONTINUOUS CHANNELS
T.L. Grettenberg, Stanford Electronic Labs., Stanford U., Calif. Tech. rept. on communications, rept. no. 6-90-62-46, July 1962, lv. incl. illus., 19 refs., AD 283 996.

2.832: Envelope Detection Methods

Included: Power law detectors; Square law demodulators; Logarithmic detectors; General theory of rectification; Nonlinear detection in general; Full wave linear demodulator; Half wave detector; Pseudo rectification; Band pass nonlenearities; Null zone envelope detection; Cube law detectors.

Not Included: Diode detection circuits; Signal plus noise in nonlinear circuits (1); Threshold in frequency demodulators.

Cross References: Nonlinear optimum filter theory (2.813); Null zone decision systems (2.853).

Principal Publications:

RADAR DETECTION PROBABILITY WITH LOGARITHMIC DETECTORS
B. A. Green, Jr., IRE Trans. Inform. Th., vol. IT-4, no. 1, March 1958, p. 50/52

. . . use of a logarithmic (rather than square-law) . . . detector in a search radar system inflects a loss of sensitivity equivalent to a power loss of the order of one db under typical conditions.

DETECTION OF ASYMMETRIC SIDEBAND SIGNALS IN THE PRESENCE OF NOISE
T. Murakami, et al., RCA Rev., vol. 19, no. 3, Sept. 1958, p. 388/417, 19 refs.

The first part of this paper analyzes three methods of detection of signals contaminated by fluctuation noise:
(1) Linear Envelope Detectors
(2) Product Detectors
(3) Exalted Carrier Detectors

A TABLE OF BIAS LEVELS USEFUL IN RADAR DETECTION PROBLEMS
J. Pachares, IRE Trans. Inform. Th., vol. IT-4, no. 1, March 1958, p. 38/45.

. . . integrating over m independent noise pulses using a radar system with a square-law detector . . . Practical Tables.

A USEFUL THEOREM FOR NONLINEAR DEVICES HAVING GAUSSIAN INPUTS
R. Price, IRE Trans. Inform. Th., vol. IT-4, June 1958, p. 69/72.

SOME GENERAL PROPERTIES OF NONLINEAR ELEMENTS. II. SMALL SIGNAL THEORY
H. E. Rowe, Proc. IRE., vol. 46, May 1958, p. 850/860.

AN EXTENDED GENERAL NETWORK THEOREM ON RECTIFICATION
H. Stockman, Proc. IRE, vol. 46, March 1958. p. 615/616.

Gewartowki's timely and highly useful theorem about the need for nonlinear resistance for rectified ac output from one or more ac sources.

NONLINEAR PROBLEMS IN RANDOM THEORY
N. Wiener, MIT Res. Lab. Electronics Quaterly Progress Rept., April 1958, p. 50/74 and July 1958, p. 63/94.

A STUDY OF BAUD SYCHRONOUS TELETYPE RECEPTION. ENVELOPE DETECTION
T. J. Klein, Army Signal Research and Development Lab., Fort Monmouth, N. J., ASRDL Techn. Rept. No. 2033, April 1959, 23 p., AD 216 503.

TRANSIENT CROSS MODULATION IN THE DETECTION OF ASYMMETRIC SIDEBAND SIGNALS
T. Murakami, et al., RCA Rev., vol. 20, no. 3, Sept. 1959, p. 455/472.

. . . Various signal conditions and detection methods are considered. The transient cross-talk in both an idealized system and in a practical system is determined. . . .

EFFECT OF HARD LIMITING ON THE PROBABILITIES OF INCORRECT DISMISSAL AND FALSE ALARM AT THE OUTPUT OF AN ENVELOPE DETECTOR
P. Bello, IRE Trans. Inform. Th., vol. IT-7, no. 2, April 1961, p. 60/66.

. . . The input to the system is a pulsed IF signal immersed in noise whose power spectrum is uniform over a band of width W cycles . . .

A GENERALIZATION OF WOODWARD'S THEOREM AND THE SPECTRUM OF A HIGH HARMONIC OF A SINUSOID PLUS NARROW-BAND GAUSSIAN NOISE
N. M. Blachman, Electronic Defense Labs., Mountain View, Calif., Technical memo. EDL-M367, 28 March 1961, 12 p., AD 263 056.

. . . Woodward's theorem asserts that the power spectrum of a slowly frequency-modulated signal is given by the first-order probability density of the modulation. It can be extended to cover the case where there is slow amplitude modulation as well (correlated or uncorrelated and deterministic or random) by weighting each frequency by the mean square amplitude associated with it . . . It is applied to the case of a sinusoid plus narrow-band gaussian noise that has been passed through a power-law device to generate a high harmonic.

PSEUDO-RECTIFICATION AND DETECTION BY SIMPLE BILATERAL NONLINEAR RESISTORS
J. E. Bridges, Proc. IRE, vol. 49, Feb. 1961, p. 469/478.

. . . Ordinary carbon resistors . . . and to a more marked degree, certain symmetrical or bilateral nonlinear resistors containing no unilateral elements, can, when a pulse-type ac waveform is impressed upon them, perform a rectification process; this process may be considered solely as a circuit effect. Four basic ac-to-dc converting circuits, some of which are largely independent of temperature, and which employ symmetrical nonlinear resistors, are analyzed.

DETECTION OF A SIGNAL IN NOISE BY A HALF-WAVE DETECTOR
C. A. Marsh, Electronic Defense Labs., Mountain View, Calif., Tech. memo no. EDL-M323, 7 Feb. 1961, 27 p., AD 251 645.

Theory and formulas are presented which compare the detected output power spectrum of a signal in noise for a square-law detector and a "linear" detector. Consideration is given to the effects of different predetection pass-band shapes and of post-detection narrow-band filtering. . . . Comparison of output signal-to-noise ratios are made for various combinations of detectors, pre-detection pass-band shapes and post-detection bandwidth filtering. Applications to receiver design are discussed.

A NOTE ON POWER-LAW DEVICES AND THEIR EFFECT ON SIGNAL-TO-NOISE RATIO
C. N. Berglund, Queen's U., Belfast (Gt. Brit.), Research rept. no. 62-3, Aug. 1962, 21 p., incl. illus., 5 refs., AD 291 427.

. . . used as either band-pass non-linear amplifiers or enveloped detectors . . . determined for both limiting cases of very large and very small input signal-to-noise ratios. . . . The results are general, applying to Gaussian and non-Gaussian noises and modulated and unmodulated signals, and allow important conclusions to be reached concerning the value of power-law devices in communication systems in various signal and noise environments. . . .

DEMODULATION EFFECT OF AN ENVELOPE DETECTOR AT LOW SIGNAL-TO-NOISE RATIOS (Correspondence)
A. Grumet, Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2133/2134.

. . . effective loss of percentage modulation when the signal-to-noise ratio (SNR) approaches unity. The mechanism responsible is discussed . . . A method for partially correcting this condition is suggested.

DEMODULATORS (Correspondence)
J. Knudson, Proc. IRE, vol. 50, no. 8, Aug. 1962, p. 1855/1856.

In the detection of a signal ensemble which is a sample of white Gaussian noise, an approximation to the optimum receiver consists of a full-wave square law demodulator followed by an integrator, or summer. If a full-wave linear demodulator is used in place of the "optimum" demodulator, the degree of suboptimality is of interest. . . .

THE RELATIVE EFFICIENCIES OF VARIOUS BINARY DETECTION SYSTEMS
R. O. Rowlands, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 185/189.

. . . This paper attempts to fill the need of the engineer who is designing a signal detection system and who wants a rough idea of the relative merits of the various basic detection methods that are available. Five common binary detection systems are analyzed . . . 2. Square-Law Detector . . .

NATURE OF OUTPUT SIGNAL FLUCTUATIONS IN INTERFERENCE RECEPTION OF RADIO WAVES ON SURFACE PATHS
A. A. Semenov, et al., Radio Engng. Electronic Phys., vol. 11, Nov. 1962, p. 1749/1754, Translation, A63-20085.

. . . fluctuations in the signal at the output of a square-law detector in interferential reception. The fluctuations depend, in part, on fluctuations in amplitude and phase of the wave, the coefficients of correlation between amplitudes and phases . . . on the phase difference of the regular components of the two received waves. . . .

ON OPTIMAL DIVERSITY RECEPTION, II
G. L. Turin, IRE Trans. Commun. Syst., vol. CS-10, no. 1, March 1962, p. 22/32.

. . . Since the optimal receiver may be difficult to implement, a more easily implemented "square-law combining" receiver is also considered, and it is shown that for all practical purposes this simpler receiver behaves optimally. . . .

A NOTE ON POWER-LAW DEVICES AND THEIR EFFECT ON SIGNAL-TO-NOISE RATIO
C. N. Berglund, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 52/57.

The effect of power-law devices, used as either band-pass nonlinear amplifiers or envelope detectors, on the signal-to-noise ratio is determined for both limiting cases of very large and very small input signal-to-noise ratio. . . .

BAND-PASS NONLINEARITIES
N. M. Blachman, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 162/164.

. . . a simple method for analyzing the effect of a nonlinearity sandwiched between band-pass filters, applying it to the case of weak signals when both filters pass the same band of frequencies, and obtaining completely general expressions for the output signal and noise when the output filter passes a harmonic of the input band. . . .

RELATION BETWEEN OUTPUTS OF A FULL-WAVE AND HALF-WAVE LINEAR RECTIFIER FOR A CLASS OF NON-GAUSSIAN INPUTS (Correspondence)
J. L. Brown, Jr., IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 288/289.

EXPERIMENTAL INVESTIGATIONS OF THE PEAKS OF THE SMOOTHED ENVELOPE OF QUASI-SINUSOIDAL NOISE
V. T. Goryainov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 3, March 1963, p. 1/8.

An experimental setup is described for obtaining samples (oscillograms) of the smoothed envelope of quasi-sinusoidal noise. A method of processing the oscillograms to determine the statistical characteristics of the peaks of the smoothed envelope is given. Experimental results are presented, showing the distribution of the highest maxima, of the lowest minima and of the vertical distance between a minimum and the following maximum in samples of the smoothed envelope of the sum of a sinusoidal signal and Gaussian noise. . . .

CUBE-LAW DETECTION OF ASYMMETRIC VOLTAGE MODULATION
E. T. Hooper, IEEE Trans. Commun. Electronics, no. 67, July 1963, p. 332/338.

A cube-law device is normally considered to be useless as a detector. A symmetrical nonlinear resistance has a cube-law characteristic and can be used as a detector when the input voltage is asymmetric about the time axis. Such asymmetry in voltage is commonly found in a class of nonlinear devices whose waveshapes are characterized by a firing angle. . . . utilized . . . in connection with a saturable magnetic core to obtain rectification.

PERFORMANCE OF THE BIASED SQUARE-LAW SEQUENTIAL DETECTOR IN THE ABSENCE OF SIGNAL
W. B. Kendall, RAND Corp., Santa Monica, Calif., July 1963, 30 p., 10 refs., N63-19402.

AN INTEGRAL EQUATION ARISING IN MULTICHANNEL COMMUNICATION PERFORMANCE CHARACTERISTICS
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 156/158.

Suitable for specifying the performance characteristic for a non-coherent multilink communication system employing two correlated equiprobable, equal-energy signals . . . The result is, in fact, a generalization of a result obtained by Helstrom (Ref. 16) and includes results obtained by Turin (Ref. 17), Lindsey (SPS 37-20, Vol. IV), Reiger (Ref. 18), and Pierce (Ref. 19) as special cases. . . . The waveforms transmitted into the multichannels are presumed to be perturbed by Rician Fading

and additive white Gaussian noise . . . Cross-correlation or matched filter quadratic envelope detection is used.

SURVEY OF SQUARE LAW DEVICES
J. E. Longfoot, Proc. Instn. Radio Engrs., Australia, vol. 24, no. 5, May 1963, p. 430/439, 20 refs.

A square law device may be considered as being any circuit or component configuration capable of producing an output proportional to the mathematical square of the input. . . . Such devices find wide application in situations where a true rms voltage or current reading is desired, independent of waveform, and in analogue computing where accurate squarers and multipliers are required.

The paper describes some of the uses of squarers and the properties desirable for different applications. . . .

NULL-ZONE ENVELOPE DETECTION IN BINARY SYSTEMS
J. J. Metzner, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 219/227, 12 refs.

. . . The effects of applying the null-zone decision mechanism to two types of envelope-detection systems are investigated, and comparisons are made with previous results for synchronous-detection systems. It is demonstrated conclusively that, just as for the synchronous system, null-zone reception offers a means of improving the information rate of a uni-directional systems.

SIGNAL-TO-NOISE RATIO ANALYSIS OF A SYSTEM CONTAINING A SQUARE LAW DETECTOR AND A LIMITER
T. Nishimura, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 161/167.

In the system to be analyzed, a PN sequence on-off modulates an RF carrier, and the resulting signal is then contaminated by additive white Gaussian noise before it is demodulated by a square law detector followed by a limiter.

ESTIMATION OF THE CONSTANT COMPONENT OF A DETECTED PERIODIC SIGNAL MIXED WITH ADDITIVE GAUSSIAN NOISE USING A SEGMENT OF A SINGLE SAMPLE OF FINITE DURATION
A. B. Tatarinov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 6, June 1963, p. 5/14.

Using a single sample of finite duration, the problem of estimation of the mean value of a detected harmonic signal on a background of additive Gaussian noise, mixing with the signal before the detection process, is considered. For linear and square-law detectors, equations are derived for the relative bias of the estimate . . .

AN ENVELOPE DETECTOR UTILIZING AN "IDEAL" DIODE
Q. Veit, Philco Corp., Philadelphia, Pa., Communications and Electronics Div., RADC-TDR-63-222, June 1963, 11 p., 4 refs, N63-19630.

. . . for use as an envelope detector in the receiver portion of the AN/TRC-56 multiplex. A functional description, circuit diagram, and test results are given.

Related Publications:

A NOTE ON THE EVALUATION OF THE RESPONSE OF A NON-LINEAR ELEMENT TO SINUSOIDAL AND RANDOM SIGNALS
J. L. Douce, Proc. Instn. Elect. Engrs., pt. C, vol. 105, March 1958, p. 88/92.

EIN BILDUNGSGESETZ ZUR ERMITTLUNG DES FREQUENZPEKTRUMS POTENZIERTER DOPPELTONE (A Generative Law for The Evaluation of Frequency Spectra of Powers of Double Tones) (In German)
W. Grahnert, Hochfrequenztech. U. Elekt. Akust., vol. 67, July 1958, p. 4/18.

THE EFFECT OF INSTANTANEOUS NONLINEAR DEVICES ON CROSS-CORRELATION
R. Leipnik, IRE Trans. Inform. Th., vol. IT-4, June 1958, p. 73/76.

GAIN-PHASE RELATIONS OF NON-LINEAR CIRCUITS
E. Levinson, IRE Nat. Conv. Rec., March 1958, p. 141/159.

Several examples of non-linear circuits exhibiting gain reduction without phase change are described and analyzed.

A PHYSICAL INTERPRETATION OF SHANNON'S AMBIGUITY
J. Loeb, Ann. Telecommun., vol. 13, March, April 1958, p. 78/82.

. . . for the case of Gaussian noise superposed on an AM signal, by a transitional probabilities matrix ("grille"). . . . can also be applied to problems involving non-Gaussian noise or nonlinear circuit elements.

RANDOM FUNCTION PROBABILITY DISTRIBUTIONS AFTER A NONLINEAR FILTER
G. O. Young, IRE WESCON Conv. Rec., no. 4, Aug. 1958, p. 164/172.

RECTIFICATION OF NARROW-BAND NOISE
K. S. Stull, Jr., Electronic Industr., vol. 19, May 1960, p. 103.

DETECTION OF SIGNALS IN NON-GAUSSIAN NOISE-COMPUTATION RESULTS FOR THE RATIO DETECTOR SYSTEM
J. W. McGinn, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 47G-0015, 3 April 1961, 20 p. incl. illus., AD 254 035.

. . . the ratio detector is a simplified version of a normalized periodogram detector. A ranking of the detection performance of the three systems studied so far would place the performance of the ratio system roughly midway between the linear and limiting systems.

ON THE NOISE THRESHOLD OF CONVENTIONAL FM AND PM DEMODULATORS (Correspondence)
E. J. Baghdady, Proc. IEEE, vol. 51, no. 9, Sept. 1963, p. 1260/1261.

Controversy has recently raged over the threshold of linear variation of base-band S/N ratio with IF S/N ratio for conventional exponent demodulators – in particular, the cause of departure from linearity, the effect of postdemodulation linear filtering, and hence the dependence of the threshold upon the deviation ratio of the expected signal. The purpose of this communication is to present a simple analysis that clarifies this situation completely. . . .

PERFORMANCE ANALYSIS FOR THE COHERENT MULTIRECEIVER IN SPECULAR AND RANDOM MULTICHANNELS
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 154/156.

The multireceiver combines, at the conclusion of each signaling interval, samples taken from both the matched filter and square law detector outputs (Fig. 6). Under the . . . assumptions . . . that the signals are assumed to be selected from an equal energy signaling alphabet which occurs with equal probability, the detection system is optimum in the a posteriori probability computing sense (Ref. 9).

OBRASHCHENNYI DIOD V KACHESTVE DETEKTORA MALOGO SIGNALA (Inverted Diode as a Detector of Weak Signals) (In Russian)
L. A. Logunov, Radiotekhnika i Elektronika, vol. 8, April 1963, p. 722/723, A63-19892.

. . . nonlinearity of the current-voltage characteristics of an inverted diode. . . . the rectification of a weak signal by an inverted diode will be far more efficient than that by a conventional semiconductor diode.

MEAN-SQUARE ERROR IN CORRELATION DEMODULATORS
B. F. Ludovici, Microwave Lab., Stanford Univ., Calif., 19 Nov. 1962, 11 p., AD 434 512.

. . . Included . . . are the square-law, autocorrelation, two-amplifier and cross-correlation demodulators. . . . investigation shows that the autocorrelation demodulator offers no significant improvement over the simple square-law demodulator. . . .

BINARY DECISION FEEDBACK WITH ENVELOPE DETECTION
J. J. Metzner, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 227/239.

The performance of discarding and of cumulative decision-feedback systems employing null-zone reception is evaluated for two common types of envelope detection. Compared with a synchronous phase-detection system, of course, the envelope-detection systems necessarily suffer somewhat. . . . Nevertheless, feedback is again shown to permit an unlimited trade-off between error probability and transmission time.

DETECTION OF NON GAUSSIAN PROCESSES IN NON GAUSSIAN NOISE
F. C. Ogg, Jr., Carlyle Barton Lab., Johns Hopkins U., Baltimore, Md., RADC TDR 63 192, June 1963, 32 p., AD 408 986.

. . . The detector structure is found in terms of the semi-invariants of the signal and noise processes . . . For symmetric processes with zero mean and independent sampling, the energy detector is obtained. . . .

2.833: Integration Techniques in Detection Systems

Included: Passage of signals through limiter/integrator circuits; Feedback integrators; Analog integrator; Coherent integration in detection systems; Integration over several pulses; Electromagnetic integrators in instrumentation; Optimum integration time; Video integrators; Single loop video integrator; Detection of recurrent pulses in noise by integration; Power law demodulator plus integrator detection system; Binary integration; Interrogation frequency in binary integration; Integrating capacitor storage; Statistical properties of finite time integrators; Post detection integration systems; Rectangular integration process in detection systems.

Not Included: Statistics of signal plus noise after nonlinear elements (1); Integration circuits.

Cross References: Correlation detection (Sect. 2.82); Coherent detection (2.834); Radar detection theory (2.883).

Principal Publications:

THE REDUCTION OF LOW-FREQUENCY NOISE IN FEEDBACK INTEGRATORS
E. M. Dunstan, et al., Proc. Instn. Elect. Engrs., Pt. B., vol. 105, Nov. 1958, p. 532/545.

AN IMPROVED ELECTROMAGNETIC INTEGRATOR
A. J. Dyer, J. Sci. Instrum., vol. 35, July 1958, p. 240/242.

OPTIMUM FILTER FUNCTIONS FOR THE DETECTION OF PULSED SIGNALS IN NOISE
H. S. Heaps, Canad. J. Phys., vol. 36, June 1958, p. 692/703.

The filter characteristic which yields the optimum ratio of integrated signal power to noise power over a number of pulses is derived. The transfer function is shown to be realizable, and for a rectangular pulse is closely approximated by a third-order low-pass Butterworth filter.

ELECTRONIC INTEGRATOR WITH IMMEDIATE DIGITAL OUTPUT
B. L. Hisey, et al., J. Sci. Instrum., vol. 35, May 1958, p. 355/359.

A TABLE OF BIAS LEVELS USEFUL IN RADAR DETECTION PROBLEMS
J. Pachares, IRE Trans. Inform. Th., vol. IT-4, March 1958, p. 38/45.

. . . integrating over m independent noise pulses using a radar system with a square-law detector.

TIME COMPRESSOR FOR COHERENT INTEGRATION
R. W. Spencer, General Atronics Corp., July 1958, AD 160 805.

SPEICHERVORGANGE ZUR VERBESSERUNG DES RAUSCHABSTANDS VON NAHEZU PERIODISCHEN SIGNALEN, INSBESONDERE IN DER RADARTECHNIK (Storage Processes for the Improvement of the Signal to Noise Ratio of Quasi-Periodical Signals, Particularly in RADAR Systems) (In German)
H. Meinke, et al., Nachrichtentech. Z., vol. 12, April 1959, p. 176/181.

THE PASSAGE OF A PULSE SIGNAL AND NOISE THROUGH A LIMITER AND AN INTEGRATOR
B. N. Mitiashev, Radio Engng., vol. 14, no. 10, 1959, p. 70/81.

OPTIMUM RADAR INTEGRATION TIME
J. M. Flaherty, et al., IRE Trans. Antennas Propagation, vol. AP-8, no. 2, March 1960, p. 183/185.

VIDEO INTEGRATION IN RADAR AND SONAR SYSTEMS
D. C. Cooper, et al., J. Brit. Inst. Radio Engrs., vol. 21, no. 5, May 1961, p. 421/433, 14 refs.

The performance of some basic integration systems is analyzed, and the effect of beam pattern on their performance is considered. A new system is described employing two delay loops which, in general, will give a small improvement in threshold detection and furthermore has a number of practical advantages. . . .

SMALL-SIGNAL RECEPTION BY THE METHOD OF BINARY INTEGRATION (Translation)
V. I. Bunimovich, et al., Radio Engng. Electronic Physic., vol. 11, Nov. 1962, p. 1734/1740.

. . . binary integration with regard to detection of a weak signal which is a stationary, random, Gaussian process against a background of stationary Gaussian noise possessing a spectral density curve of the same shape as that of the signal. The SNR at the output of the binary integration device is plotted as a function of the interrogation frequency at optimum threshold level, and as a function of the threshold level for different interrogation frequencies. . . .

OPTIMUM CRITERIA FOR THE DETECTION OF SIGNALS IN NOISE (In Japanese)
T. Inoue, et al., J. Inst. Elect. Commun. Engrs. Japan, vol. 45, no. 5, May 1962, p. 605/612.

. . . Application is made to the basic digital post-detection integration system in which the sampled inputs are fed to a detector followed by a slicer and a counter, and the optimum slice level and optimum count were evaluated by a computer.

DEMODULATORS (Correspondence)
J. Knudson, Proc. IRE., vol. 50, no. 8, Aug. 1962, p. 1855/1856.

In the detection of a signal ensemble which is a sample of white Gaussian noise, an approximation to the optimum receiver consists of a full-wave square law demodulator followed by an integrator, or summer. If a full-wave linear demodulator is used in place of the "optimum" demodulator, the degree of suboptimality is of interest. . . .

THE EFFECTS OF NOISE THROUGH AN ANALOG INTEGRATOR WHICH INTEGRATES WITH RESPECT TO AN ARBITRARY VARIABLE
P. R. Westlake, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 3, Sept. 1962, p. 151/158.

. . . to consider the effects of noise, both internal and external, on any possible computation control process. The external noises would arise in communication links, the drifts of gyros, possible variations in external conditions, variations in amounts and rates of rocket burning, and other causes. The internal noises could be those electronically generated (such as short and Johnson noises) and those generated by digital computation processes. . . . In the event that an incremental digit or analog computer is part of a control loop, a typical problem would be signal plus noise into an analog or digital integrator.

THE EFFECTS OF NOISE THROUGH A RECTANGULAR-INTEGRATION PROCESS AND SOME SAMPLED SPECTRAL-DENSITY METHODS
P. R. Westlake, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 3, Sept. 1962, p. 159/175.

. . . the effect of signal plus noise on the rectangular integration process that . . . a digital integrator might use. The arguments are cased in the form taken by a digital differential analyzer (DDA) integrator. . . .

VISUAL DISPLAYS OF INTEGRATED VIDEO WAVEFORMS
D. C. Cooper, J. Brit. Instn. Radio Engrs., vol. 25, no. 3, March 1963, p. 277/285.

The operation of single loop and double loop video integrators is discussed briefly and a qualitative measure of integrator performance is given in terms of a simple video signal/noise ratio. . . .

TRANSRADAR - A NARROW-BAND RADAR RELAY EQUIPMENT USING STORAGE CAPACITORS
K. Jekelius, Elect. Commun., vol. 38, no. 4, 1963, p. 501/510, 18 refs., A64-11609.

Description of a bandwidth compression system developed for the long-range narrow-band transmission of radar signals . . . uses an integrating capacitor storage unit to perform the bandwidth compression . . . applications . . . in an integrated radar network for aerospace surveillance . . . a centralized ATC system.

STATISTICAL PROPERTIES OF THE INTEGRAL OF A BINARY RANDOM PROCESS
D. G. Lampard, et al., IEEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 413/427, 26 refs.

. . . Statistical properties of the output z(t) of a finite time integrator are discussed. The input process considered is a binary random process y(t) having successive axis-crossing intervals which are statistically independent. Transform expressions are derived for the first- and second-order transition probability densities of the integrated process, and it is shown how these results may be extended to three or more dimensions. Four processes are considered as examples.

DETECTION OF A SINUSOID IMMERSED IN NOISE-FINITE INTEGRATION TIME AND LINEWIDTH (Correspondence)
S. V. Yadavalli, Proc. IEEE., vol. 51, no. 5, May 1963, p. 865.

In many practical problems concerning the detection of signals immersed in noise, one has to choose an observation time T (and consequently integration time as well) which is rather short. T may sometimes be of the order of a few periods of a sinusoid . . .

Related Publications:

THE GENERAL THEORY OF COMB FILTERS
G. T. Flesher, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 282/295, 14 refs.

. . . Signal integration is defined in the comb filter context. Feedback and non-feedback filter types are compared. . . .

CERTAIN RELATIONSHIPS IN OPTIMUM SYSTEMS FOR DETECTING SIGNALS (Continuation)
L. S. Gutkin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 4, 1960, p. 34/43.

4. The detection of pulse packets . . . If all the pulses in the packet are coherent one with another (i.e., rigidly inter-connected in phase) and consequently their coherent summation is possible, then all the formulae in Part I remain true if the energy of the signal is understood to mean the energy of the whole packet of n pulses . . .
a. Binary detection . . . b. Optimum system for m-alternative discrimination and detection. . . .

A REVIEW OF METHODS FOR IMPROVED DETECTION OF PULSES IN NOISE
F. E. Slojkowski, Bell Telephone Labs., Inc., Whippany, N. J., Technical memo. no. MM-60-6412-4, 26 May 1960, AD 251 550.

. . . three most commonly considered methods for improvements in signal detection is presented. Correlation comb filters and integration techniques are discussed along with the advantages and disadvantages of each.

A MOTION-ENHANCEMENT DISPLAY BY TIME-COMPRESSION
M. E. Crost, IRE Internat. Conv. Rec., Pt. 5, vol. 5, March 1962, p. 67/75.

. . . To demonstrate the enhancement of detectability of moving targets in the presence

of severe clutter, a display system of electronic time-compression was devised and constructed at USASRDL. The principle of operation is that a number of immediate-past-history scans are stored within the system and then display sequentially at a much faster rate than acquired.

The Westinghouse Permachon storage vidicon was chosen as the storage tube type around which the system would be constructed. . . .

STATISTICAL PROPERTIES OF THE DICON RECEIVER
J. A. Dumanian, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 52 G-2, AFESD TDR 62-85, 2 March 1962, 11 p., illus., 3 refs., AD 275 278.

. . . frequency-shift keying and energy detection. . . . The final bit decision is performed by subtracting the outputs of two channel receivers tuned to the two information frequencies and determining the sign of the result. Results were obtained for a variety of parameters representative of the range of experimental conditions expected in West Ford communications.

A VIDEO SIGNAL ENHANCER FOR USE WITH OBLIQUE-INCIDENCE IONOSPHERIC SOUNDERS
D. C. Coll, et al., Defense Research Telecommunications Establishment, (Canada), DRTE 1127, Jan. 1964, 16 p., AD 434 874.

. . . concerned with a post-detection, RC, range-gate signal enhancer developed to improve the performance of oblique-incidence, sweep-frequency, ionospheric sounders. The enhancer utilizes the energy available from the multiplicity of sounding pulses that are transmitted on each frequency, together with the coherence of pulse-to-pulse amplitude, to increase the signal-to-noise ratio available to display devices. . . . its performance in the presence of wideband HF interference has been shown to be very good.

2.834: Coherent Detection Methods

Included: Synchronous detection methods; Noisy stored reference in coherent detection; Growing memory digital filters; Finite memory filters in coherent detection; Coherent memory filter (CMF); Enhanced carrier system; Quadrature detection method; Quadrature reception; Coherent signal processor; Phase coherent detection methods; Coherent cycle counter.

Not Included: Synchronous detection circuits; Phase lock loops; Digital filter design; Homodyne detection circuit; Synchrodyne detection circuit; Comparision of coherent communications systems (1); Digital signal processors (3A); Storage devices; Anti-doppler detection systems.

Cross References: Coherent integration detectors (2.833); Adaptive decision systems (2.855); Finite memories in Wiener's detection theory (2.812); Detection of analog signals in general (2.831); Circulating memory devices (2.835); Multiple synchronous storage (2.835); Detection of multiple epoch signals (2.835); Coherent sequential detection (2.854); Coherent multireceiver (2.873); Coherent multi-channel detector (2.873).

Principal Publications:

RECURSION FORMULAS FOR GROWING MEMORY DIGITAL FILTERS
M. Blum, IRE Trans. Circuit Theory, vol. IT-4, March 1958, p. 24/30.

IMPROVED COMMUNICATIONS THROUGH SYNCHRONOUS DETECTION
R. J. Lutze, Proc. Nat. Aeron. Electronics Conf., April 1958, p. 94/98.

THE EFFECT OF NOISE UPON A METHOD OF FREQUENCY MEASUREMENT
T. B. Pickard, IRE Trans. Inform. Th., vol. IT-4, no. 2, June 1958.

. . . The information is coded as the frequency shift of a carrier. The carrier is assumed to be transmitted over two channels with 90° phase difference. The recovery of the information is accomplished by means of a "coherent cycle counter".

THE PROBABILITY DENSITY OF THE PHASE DERIVATIVE OF THE SUM OF A SINUSOIDAL SIGNAL AND GAUSSIAN NOISE
L. T. Remizov, Radio Engng. and Electronics, vol. 4, no. 3, 1959, p. 270/273.

THE DETECTION OF COHERENT SIGNALS IN THE PRESENCE OF CORRELATED NOISE
V. D. Zubakov, Radio Engng. and Electronics, vol. 4, no. 4, 1959, p. 100/110.

DETECTION OF A SIGNAL SPECIFIED EXACTLY WITH A NOISY STORED REFERENCE SIGNAL
T. G. Birdsall, J. Acoust. Soc. Amer., vol. 32, Aug. 1960, p. 1038/1045.

IMPLEMENTATION OF THE IDEAL RADAR RECEIVER USING THE COHERENT MEMORY FILTER (CMF)
C. L. Temes, East Coast Conf. Aerosp. Navig. Electronics, vol. 7, Oct. 1960, no. 2.1.6.

. . . The Coherent Memory Filter, a component having the property that its real-time output voltage envelope is the amplitude spectrum (Fourier transform) of its input modulation. This implementation possesses range-delay channels rather than the Doppler channels of the matched-filter type of implementation. Ideal signal-to-noise enhancement is obtained, dynamic ranges of 40 db to 50 db are practical

and large time-band-width products can be achieved. . . .

COHERENT DETECTION BY QUASI-ORTHOGONAL SQUARE-WAVE PULSE FUNCTIONS (Correspondence)
IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 410/411.

SUMMARY OF THE PRELIMINARY STUDY OF THE APPLICABILITY OF THE ORDER SYSTEM TECHNIQUES TO THE TRACKING OF PASSIVE SATELLITES
Electronics Research Labs., Columbia Univ., New York, Final rept., Rept. nos. CU2 600RD, F157, 11 Feb. 1960, 154 p., AD 419 772.

The results of a study of the problems of coherent integration and frequency estimation in a CW Doppler earth satellite tracking system are presented. . . . incorporating the coherent signal processor known as the Circulating Memory Filter (CMF) into the satellite tracking system. . . .

ANOTHER METHOD OF OPTIMUM PROCESSING OF A RECEIVED SIGNAL IN THE PRESENCE OF NOISE
F. P. Tarasenko, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 2, 1961, p. 7/13.

It is shown that there exists at least one more method of demodulation of an AM signal which is just as effective in information content as synchronous detection. The method known as quadrature detection, consists in the weighted summation of the output signals of two coherent detectors with phases differing by pi/2. Knowledge of the phase of the effective signal is used in calculating the weight coefficients. It is shown that with slight modification the quadrature detector may (in case of ergodic signals) operate without prior data concerning the amplitude and phase of the effective signal. In this case, it begins to operate as a square-law detector, and then its properties asymptotically approach those of a synchronous detector. . . .

THEORY OF COHERENT SYSTEMS
W. M. Brown, et al., IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 187/196.

A circuit theory model is derived for coherent radar, communication, sonar and antenna systems. The model involves linear time invariant operators and hence can be thought of as cascaded filters. The model provides insight for such systems not previously available, and it provides a unified approach to the analysis of all the above systems. . . . emphasis on the range channel of coherent radars with particular attention to pulse compression radars. Performance limitations are imposed by various random phenomena; specifically, phase errors which take into account deviations from perfect coherence are included in the analysis.

COHERENT DETECTION ON PULSED RADARS
A. Kerdock, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N. Y., Research rept. no. PIBMRI-1103-62, June 1962, p. 33, incl. illus., 4 refs., AD 295 076.

. . . discussed from a statistical decision theory viewpoint. The Neyman Pearson test is applied to two cases . . .

EFFECTS OF FADING ON QUADRATURE RECEPTION OF ORTHOGONAL SIGNALS
G. Lieberman, RCA Rev., vol. 23, no. 3, Sept. 1962, p. 353/395.

. . . An analysis of effects of fading, frequency instability, and noise on quadrature reception of orthogonal signals is given . . . The analysis includes effects of the shape of the spectrum of the fading carrier. The model assumes nonselective fading consisting of a specular component superposed on a Gaussian-process random component. The measure of error probability performance used consists of quantiles of error probability as well as the mean probability of error.

ERROR PROBABILITIES FOR EQUICORRELATED M-ARY SIGNALS UNDER PHASE-COHERENT AND PHASE-INCOHERENT RECEPTION
A. H. Nuttall, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 305/314, 72 refs.

. . . derived in the form of previously untabulated single and double integrals. These integrals are amenable to computer evaluation for arbitrary M. Two modes of reception are considered. In the first, one of M equal energy equiprobable signals is known to be transmitted during a symbol interval of T seconds through a nonfading channel with additive white Gaussian noise. . . . the cross-correlation coefficients between all the signals are equal. The probability of correct decision in both phase-coherent and phase-incoherent reception is derived exactly, as a function of the signal-to-noise ratio, the common cross-correlation coefficient, and the size of the signal set M. In the second mode of reception, the only difference is that a threshold is incorporated in the receiver. The probability of false detection and the probability of detection and correct decision are derived exactly for both phase-coherent and phase-incoherent reception as a function of the threshold level, the signal-to-noise ratio, the common cross-correlation efficient and the size of the signal set M.

OPTIMUM COHERENT DEMODULATION FOR CONTINUOUS MODULATION SYSTEMS
A. J. Viterbi, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 498/508.

. . . Coherent demodulation refers to the recovery of the information signal by operating upon the noise-corrupted received signal with a replica of the carrier signal.

This principle applies simply to amplitude modulation wherein the information signal is multiplied by the carrier signal. Demodulation can be achieved by multiplying the received signal by a replica of the carrier signal.

POWER SPECTRAL DENSITY ESTIMATION WITH A COHERENT MEMORY FILTER (Correspondence)
J. Capon, IEEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 461/462.

. . . The coherent memory filter (CMF) is an active time variable network which provides a means for measuring the spectrum of a signal in real time and with fine resolution. This device can, therefore, be used as a replacement for a bank of filters to estimate the power spectrum of a stationary random process. . . .

MULTIPLE SYNCHRONOUS STORAGE OF PULSED SIGNALS
M. I. Finkel'shteyn, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 10, Oct. 1963, p. 13/20.

. . . Synchronous storage is widely used to achieve optimal extraction of a signal in the form of a packet of equally spaced pulses from a noise background. . . . shows a storage circuit comprising a delay line with a positive feedback loop, the time delay T_d being chosen equal to the pulse-repetition period of the required signal T_n. . . .

COHERENT AND NON-COHERENT DEMODULATION OF ENVELOPE-MODULATED RADIO SIGNALS WITH PARTICULAR REFERENCE TO THE ENHANCED-CARRIER SYSTEM
P. V. Indiresan, et al., Radio Electronic Engr., vol. 25, no. 1, Jan. 1963, p. 65/72.

The ordinary "linear detector" and the coherent demodulator are briefly discussed . . . The synchrodyne and enhanced-carrier systems are regarded as intermediate cases in which the switching is effected by an impure carrier derived from the incoming signal. The enhanced-carrier system, using filters to extract the carrier from the incoming signal, appears to have received little attention in the literature . . .

THE MEAN VALUE OF THE ENVELOPE OF A SINE AND COHERENT WAVE SUPERIMPOSED ON THE NARROW-BAND GAUSSIAN NOISE
B. Leskovar, J. Electronics and Control, vol. 14, no. 1, Jan. 1963, p. 113/120.

. . .The mean value is calculated and plotted as a function of both the sine wave-to-noise and coherent wave-to-noise ratios of the coherent detector input wave. Attention is paid to the mean value of the envelope for various phase angles between the coherent wave and the sine wave plus narrow-band Gaussian noise. The normalized form of the mean value's computed curves suitable for direct application on an additive type of coherent detector is given.

PERFORMANCE OF COHERENT DETECTION SYSTEMS USING DECISION DIRECTED CHANNEL MEASUREMENT
J. G. Proakis, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 64G1, AFESD TDR63 80, 27 June 1963, 24, p. AD 409 819.

A receiver which employs coherent, or synchronous, detection must have a priori knowledge of the phase of the received signal. The receiver acquires this knowledge by performing measurements on the channel. The results of the measurement process is a noisy phase reference which is used by the receiver in the detection processing of the incoming signals. In this report, the effect of using baud decisions to direct the phase measurement process is investigated by means of computer simulation of a coherent communication system employing either orthogonal or phase-reversal signalling. Error rates are given for several signal-to-noise ratios. . . . conclusion . . .error rates . . . less than . . . of corresponding nondecision directed phase measurement schemes at all signal-to-noise ratios; no threshold exists below which a decision directed phase measurement system deteriorates rapidly.

SYNCHRONIZATION OF COHERENT DETECTORS
I. Selin, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 100/109.

The estimation of carrier frequency and subcarrier epoch in a coded- "noise" communication system is discussed. These are the parameters which constitute synchronization of the system. . . . Various electronic detection methods are considered; in particular, an interesting application of sequential detection is described. . . .

COHERENT EXTRACTION OF SIGNALS FROM TURBULENT NOISE
D. H. Tack, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 78/88, 13 refs.

This paper reports the results of some theoretical and experimental studies of the extraction of signals from convecting and decaying fluid dynamic turbulent noise employing an analog correlation receiver. In addition, it presents an extension of the theory of correlator analysis for finite observation times to the case of a linear time-varying delay. . . . Noise of turbulent origin is . . . often encountered in the transmission medium. This paper treats the extraction of signals from a particular type of turbulence, known as boundary layer turbulence . . . generally associated with the flow of viscous fluids such as air or water over rough surfaces. . . . problems involved in the extraction of sonar signals and acoustic noise

signals from flow noise associated with fast submarines. . . .

OPTIMUM POWER DIVISION IN COHERENT COMMUNICATION SYSTEMS
H. L. Van Trees, Lincoln Lab., Mass. Inst. of Tech., Lexington, Feb. 19, 1963, p. 51, 9 p., refs., N63-23350.

. . . optimum way to divide the available energy between the channel measurement and information transfer functions. Specifically considered is a binary symmetric, phase-modulation system operating over a channel which imparts a random phase modulation to the signal and adds Gaussian noise . . . Under a wide variety of conditions, the best strategy is to devote all the available power to modulation, and to obtain the synchronizing information by performing some operation on the incoming signal which removes its dependence on the data.

Related Publications:

AN AUTOMATIC DOPPLER CYCLE COUNTER
B. E. Keiser, East Coast Conf. Aeron. Navig. Electronics, vol. 5, Oct. 1958, p. 223/229.

. . . (ADCC) is a system capable of transforming doppler data from analog to digital form with an accuracy of 0.01 cycle at frequency change rates up to 2000 cps per second, thus permitting precise determination of the path and velocity of test aircraft and missiles . . .

DIGITAL DATA PROCESSING FOR FINITE MEMORY FILTERS
A. J. Monroe, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 49/56.

The theory of continuous optimum time invariant filtering of non-random signals from stationary random noise has been of interest . . . for the past few years. . . . extensions have been made to include either the finite or infinite past history of the input. . . .

DIGITAL METHODS FOR THE EXTRACTION OF PHASE AND AMPLITUDE INFORMATION FROM A MODULATED SIGNAL
R. S. Lawrence, et al., J. Res. Nat. Bur. Stand., vol. 65D, no. 4, July/Aug. 1961, p. 351/356.

. . . three digital methods . . . The first method, the "zero-crossing" method, is economical of computer time and, for modulation which is not too deep and does not contain frequencies near the carrier frequency, accurately recovers the phase and amplitude modulation. The second method, the "filter" method, is more laborious but it gives better accuracy and will operate with deeper and more rapid modulation. The third method, a statistical approach, will work with severely overmodulated signals, but it yields only a statistical summary of the modulation. The methods were designed specifically for analysis of radio-star scintillation records . . .

2.835: Coincidence Methods of Detection (Concidence in Time and/or Amplitude)

Included: Detection of multiple epoch signals; Recirculators; Multiple synchronous storage; Polarity coincidence detectors; Coincident arrangement of detectors; Amplitude selective detection methods; Defruiting methods in radar detection; Polarity coincidence correlator.

Not Included: Coincidence counters for nuclear instrumentation.

Cross References: Coherent detection methods (2.834); Integration techniques in detection systems (2.833); Coherent cycle counter (2.834); Optimal nonlinear filtering (2.813); Detection of sampled transmission systems (2.875); Radar detection theory (2.835); Correlation detection (Sect. 2.82).

Principal Publications:

PERFORMANCE OF PARALLEL AND COINCIDENT ARRANGEMENTS OF DETECTORS
C. W. Helstrom, Westinghouse Research Labs., Research Report 413FF364-R1(412), May 1959, 23 p.

INFLUENCE OF NOISE FLUCTUATIONS ON A DECODING UNIT DURING THE INTERVALS SEPARATING THE PULSES IN A CODE GROUP
L. P. Kuklev, Radio Engng. and Electronics, vol. 4, no. 3, 1959, p. 31/39.

. . . we investigate the problem of the effect of noise fluctuations in radionavigation systems with pulse interval coding. . . . comprises the transmission of n pulses identical in form and duration with a certain definite position of the pulses relative to each other. Decoding of such signals is often carried out with the help of delay lines and coincidence stages by comparing the code intervals in the signal with the delay intervals in the lines which are adjusted for the reception of codes fixed in advance.

A NONLINEAR AMPLITUDE TRACKING TECHNIQUE FOR FILTERING PULSE SIGNALS
W. M. Waters, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 1/5.

A technique is described which utilizes only pulse amplitude as the basis for extracting one pulse train from a mixture of a number of pulse signals. The method is based on a nonlinear circuit having a discriminator-like input-to-output voltage transfer characteristic. . . .

THE ACCUMULATION OF PULSE SIGNALS THE REPETITION FREQUENCY BEING UNSTABLE
M. I. Finkel'shtein, Radio Engng., vol. 15, no. 2, 1960, p. 67/72.

DETECTING SIGNALS BY POLARITY COINCIDENCE
B. M. Rosenheck, Electronics, vol. 33, no. 5, Jan. 1960, p. 67/69.

TRANSPOSITION FREQUENCE-TEMPS POUR LA MESURE D'UNE FREQUENCE INCONNUE (Frequency-time Transformation for the Measurement of Unknown Frequencies) (In French)
R. H. Baumann, Ann. Radioelect., vol. 16, no. 63, Jan. 1961, p. 69/92, 25 refs.

In Part I of this investigation, it was shown that the circulating sinusoidal signals in a closed-loop system, which consists of a delay line and a modulator, are transformed into impulses whose time shift is a measure of the unknown Doppler frequency to be determined. In Part II, the system limitations are considered; more specifically, an imperfect system with spurious signals in the delay line and in the modulator is treated theoretically. This analysis provides a good explanation of the anamolous experimental results described in Part I. In conclusion, several methods are proposed for improving the system stability and for minimizing the undesirable effect of spurious signals. The maximum number of recirculations obtained experimentally with one of these methods was 400, which corresponds to a twenty-fold improvement in the signal-to-noise amplitude ratio, and to the determination of the Doppler frequency to within 0.5%.

COINCIDENCE TECHINQUES FOR RADAR RECEIVERS EMPLOYING A DOUBLE-THRESHOLD METHOD OF DETECTION
K. Endresen, et al., Proc. IRE, vol. 49, Oct. 1961, p. 1561/1567.

MATHEMATICAL EXPECTATION OF THE VOLTAGE AND MEAN NUMBER OF PULSES PER UNIT TIME AT THE OUTPUT OF A COINCIDENCE STAGE
M. V. Maksimov, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 11, 1961, p. 57/65.

. . . a coincidence stage at the input of which are transmitted signals and random pulse interference. Formulas have been obtained which permit the calculation . . . analyzing multichannel radio lines with code separation of channels . . . This code is characterized by a definite number of pulses with invariant amplitude and duration and with spacings between them established in advance. . . .

INSTRUCTION MANUAL FOR BEACON VIDEO DEFRUITING EQUIPMENT FAA/BRD TYPE 2, 3NS9
Airborne Instruments Lab., Deer Park, Long Island, N. Y., Final engineering rept., Rept. no. 7407-1 , Feb. 1961, p. 46, AD 260 860.

. . . The purpose of this equipment is to eliminate any non-synchronous beacon replies from received video signals before they are passed to the decoder. The equipment utilizes three storage tubes to obtain the necessary delay. Defruiting can be performed with jittered PRF systems. A one to one interlace capability is included in the design.

COINCIDENCE TECHNIQUE FOR RADAR RECEIVERS (Correspondence)
V. G. Hansen, Proc. IRE, vol. 50, no. 4, April 1962, p. 480.

DIE UBERLAGERUNG VON IMPULSFOLGEN IN SYSTEMEN MIT EINER SCHWELLE (The Transmission of Impulse Sequences in Systems with a Threshold) (In German)
F. Jenik, Arch. Elekt. Uebertragung, vol. 16, April 1962, p. 173/188.

. . . When two pulse trains of different repetition rates are superimposed, a number of pulses will coincide and will accordingly undergo addition or subtraction; with a threshold system the resultant output pulses can be separated from the other input pulses and are then a train of result pulses. The multiplicative relation between the input repetition rates and the output rate is derived. The cluster-periodical structure of the result sequence is explained and a calculation method is worked out. . . .

A NEW METHOD TO COMPUTE CORRELATION FUNCTIONS
P. Jespers, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S106/107.

. . . extends the method of the computation of the polarity correlation function. The polarities of both signals to be correlated are determined at given instants separated to τ seconds, each one with respect to a varying reference level. Both these levels can occupy any possible value between limits located symmetrically around zero . . .

SPECTRAL DENSITY OF THE VOLTAGE AT THE OUTPUT OF A COINCIDENCE STAGE
M. V. Maksimov, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 3, March 1962, p. 58/66.

THE POLARITY-COINCIDENCE CORRELATOR: A NONPARAMETRIC DETECTION DEVICE
S. S. Wolff, et al., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 5/9.

It is shown that the polarity-coincidence correlator (PCC), a two-input detection device, is nonparametric in its false-alarm rate with respect to a wide class of signal and noise distributions. Operating in fixed distributions, the probability of detection is a nondecreasing function of input SNR. . . .

POLARITY COINCIDENCE CORRELATION DETECTION OF A WEAK NOISE SOURCE
H. Ekre, IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 18/23.

. . . Assuming an input SNR much less than one, and Gaussian input signals and noise with identical normalized power spectra, expressions for the output SNR are derived for the analog and the polarity coincidence correlator, with and without sampling. The loss in attainable SNR due to clipping and sampling is computed for three different input spectra . . .

MULTIPLE SYNCHRONOUS STORAGE OF PULSED SIGNALS

M. I. Finkel'shteyn, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 10, Oct. 1963, p. 13/20.

. . . Synchronous storage is widely used to achieve optimal extraction of a signal in the form of a packet of equally spaced pulses from a noise background. . . . shows a storage circuit comprising a delay line with a positive feedback loop, the time delay T_d being chosen equal to the pulse-repetition period of the required signal T_n. . . .

QUANTIZED STORAGE TUBE COINCIDENCE TECHNIQUES FOR BEACON SYSTEMS

P. G. Holcombe, et al., IEEE Internat. Conv. Rec., Pt. 5, vol. 11, March 1963, p. 141/148.

. . . Many techniques for the suppression of nonsynchronous signals in radar and radar-beacon systems have been investigated. Generally, these techniques have been divided into two categories—those providing fixed storage periods (for example, quartz delay lines) and those providing variable storage periods such as cathode-ray storage tube and digital storage techniques. This paper is primarily concerned with the application of storage tubes to coincidence-type suppression circuits. In this technique, incoming signals are stored for one or more periods and are then compared with subsequent incoming signals. . . . Description of the ATC Radar Beacon System. . . Defruiting Problem . . . The Storage Tube Defruiter . . .

THE CHOICE OF THE NORMALIZATION LENGTH OF PULSES IN THE PRIMARY PROCESSING OF RADAR PULSE PACKETS

Ya. S. Itskhoki, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 12, Dec. 1963, p. 56/65.

The coincidence probability of the pulses of a radar packet, gated by means of a "k-out-of-m" type logic circuit, is determined as a function of the duration of the normalized pulses and for various versions of the processing logic. The relationship obtained is used to derive a formula for determining the optimum duration of the normalized pulses ensuring the lowest value of the the threshold signal. . . .

VARIABLE COINCIDENCE UNIT HASL TYPE TL-9

N. Latner, et al., IEEE Internat. Conv. Rec., Pt. 5, vol. 11, no. 5, March 1963, p. 301/305.

. . . The variable coincidence gate is a multi-function logic unit designed for use with the HASL quarter chassis line of nuclear instrumentation. . . .

USE OF RECIRCULATORS FOR COMPRESSING FREQUENCY-MODULATED PULSES

V. V. Lebedev, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 11, Nov. 1963, p. 60/68.

The possibility of using circulating memory devices (recirculators) for the optimum extraction of a frequency-modulated pulse in noise is considered. A comparison with the usual filters using dispersive delay lines is carried out. . . .

EFFECT OF SEVERAL REGULAR PULSE TRAINS ON A DECODING CIRCUIT WITH DELAY LINE AND COINCIDENCE STAGE

A. R. Livshits, Radiotekhnika i Elektronika, vol. 8, June 1963, p. 930/937, In Russian; Radio Engng. Electronic Phys., vol. 8, June 1963, p. 941/947, 9 refs., Translation, A64-17557.

Presentation of formulas for the duty ratio, the number of pulses, and the average duration in the coincidence train obtained from the action at the decoding circuit of N disturbing regular pulse trains. . . . The problem of the effect of n-regular pulse trains on a decoding circuit with delay line and coincidence stage is solved. Such a problem is stated to arise in practice in investigating multichannel systems for the transmission of information with code division of channels. The N regular trains have a disturbing effect on the signal to which the decoding circuit is tuned. Each train is a periodically repeated code group consisting of n pulses; the time intervals between the pulses are not equal to the time delays between the ends of the delay line, and differ therefrom by at least the duration of the pulses.

MINIMUM-ERROR DEMODULATION OF BINARY PCM SIGNALS

E. F. Smith, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 400/409.

. . . determined for binary pcm waveforms with statistical dependence between the data samples. It is assumed that the demodulation decisions are made one-word-at-a-time, by utilizing an arbitrary number, n, of statistically dependent, received noisy words.

For additive, bandlimited white Gaussian noise, a method is developed for simulating with a digital computer the minimum-error demodulation. . . .

REPRESENTATION AND DETECTION OF MULTIPLE-EPOCH SIGNALS
T.Y. Young, Johns Hopkins U., Carlyle Barton Lab., Baltimore, Md., RADC-TDR-63-142, May 1963, 60 p., 14 refs., N63-16789.

. . . procedure for the detection of the individual epochs of overlapping signals and to represent them properly. . . . may be corrupted with random Gaussian noise of zero mean. . . .

Related Publications:

DISTRIBUTION OF PULSE DURATIONS AT COINCIDENCE - CIRCUIT OUTPUT
V. N. Dymchishin, Radio Engng. and Electronics, vol. 4, no. 6, 1959, p. 70/77.

FAST COINCIDENCE CIRCUIT FOR SLOW PULSES
J. E. Draper, et al., Rev. Sci. Instrum., vol. 31, no. 1, Jan. 1960, p. 49/52.

ADDITION OF TELEGRAPH SIGNALS IN A COMMON RESISTANCE
V. M. Rozov, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 5, 1960, p. 111/120.

A study is made of the case of double reception of telegraph signals with d. c. addition in a common resistance. . . .

DIGITAL METHODS FOR THE EXTRACTION OF PHASE AND AMPLITUDE INFORMATION FROM A MODULATED SIGNAL
R. S. Lawrence, et al., J. Res. Nat. Bur. Stand., vol. 65D, no. 4, July/Aug. 1961, p. 351/356.

. . . three digital methods . . . The first method, the "zero-crossing" method . . . The second method, the "filter" method . . . The third method, a statistical approach . . .

AMPLIFICATION OF LOW POWER PERIODIC SIGNALS
B. A. Mamyrin, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 3, 1961, p. 46/52.

A method of amplifying periodic wide-band low-power signals, and of observing their form at the output, is examined. It is shown that with the indicated method of signal spectrum transformation it is possible to obtain a substantial improvement in the signal-to-noise ratio. . . . The idea of transforming the spectrum of the periodic signal is as follows: a periodic signal reaches the amplifier input through a gating circuit, which passes the signal only during a short-time-interval. . . 2. . . . to transmit samples of that signal . . . 3. Change of signal voltage during transformation. . . . 4. Change of noise voltage due to transformation. . . .

FREQUENZ MESSUNG MIT EINEM DISKRIMINATOR (Frequency Measurement with a Discriminator) (In German)
G. Kosel, Arch. Elekt. Uebertragung, vol. 16, July 1962, p. 359/363.

. . . depends on the principle of the coincidence of two pulse trains of the same repetition rate that are delayed in time with respect to each other. . . .

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN AND IMPULSIVE NOISE
L. Kurz, IRE Internat. Conv. Rec., Pt. 4, vol. 4, March 1962, p. 161/173.

. . . Basically, it is shown that subdividing the decision interval (O, T) and coding each subinterval using optimum waveforms is a more efficient method of combatting the impulse noise than using optimum waveforms in the full decision interval. . . .A non-linear detector suppresses the contributions of subintervals with impulsive noise -i.e., the decision at the receiver is essentially based on the subintervals with no impulsive noise. . . . the concept of an ideal discarding detector is introduced.

INCREASED NOISE IMMUNITY IN THE RECEPTION OF AM SIGNALS BY THE USE OF NONLINEAR FEEDBACK IN THE HIGH-FREQUENCY SECTION OF THE RECEIVER (Translation)
A. A. Gorbachev, Telecommun. Radio Engng., Part II-Radio Engineering, vol. 18, Feb. 1963, p. 36/41, A63-20642.

. . . This method enables the suppression, in radiotelephone and radiobroadcasting receivers, of the effect of pulse interference having a repetition frequency up to tens of thousands cps, and is, to a considerable extent, free of the shortcomings of methods which are currently used for this purpose. . . . Experimental investigations show that the method described, as opposed to the method of blanking the wide-band antenna section of the receiver during the time of action of the interference (for controlling the switching of the HF section of the reciver), nor does it require switching devices or delay lines for the required signal.

CUMULATIVE PROBABILITY OF DETECTION FOR TARGETS APPROACHING A UNIFORMLY SCANNING SEARCH RADAR
J. D. Mallett, Proc. IEEE, vol. 51, no. 4, April 1963, p. 596/601.

. . . This is the probability that a target, approaching the radar at a constant radial velocity, is detected at least once by the time it reaches a given range, as distinguished from the more common blip-scan ratio (a single-scan detection probability). . . . Curves of cumulative detection probability, as a function of normalized range, are given for three different target scintillation models. . . .

PERFORMANCE PREDICTION METHOD FOR A CLASS OF FM-CW RADARS
N. D. Wallace, IEEE Trans. Aerospace, vol. AS-1, no. 2, Aug. 1963, p. 38/45.

. . . the author has used the theory of zero crossings of random processes to analyze the errors due to receiver noise of a triangularly modulated FM-CW Radar. Curves are given that can be used to determine the percentage error in the range measurement as a function of signal-to-noise ratio, provided the shape of the noise spectrum is known. . . . The theory can be used in the preliminary design stages to optimize the receiver design.

REPRESENTATION AND DETECTION OF MULTIPLE-EPOCH SIGNALS
T. Y. Young, Johns Hopkins U. Carlyle Barton Lab., Baltimore, Md., RADC-TDR-63-142, May 1963, 60 p., 14 refs., N63-16789.

2.836: Spectrum Analysis Detection Methods

Included: Comb filters; Banks of parallel filters in detection systems; Sequential redetection of harmonic zones; Harmonic zone detection.

Not Included: Power spectrum evaluation (1); Spectrum analyzers.

Cross References: Optimum linear filter theory (2.812); Dual mode filtering (2.855); Multiple synchronous storage (2.835); Non-parametric estimation techniques in signal detection (2.843).

Principal Publications:

THE GENERAL THEORY OF COMB FILTERS
G. T. Flesher, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 282/295, 14 refs.

This tutorial paper summarizes various aspects of comb filter theory. The periodic frequency response characteristic of a comb filter can be obtained through the use of circuits containing signal delay devices. Transform techniques allow a method to be set up for synthesizing networks giving an arbitrary shape of periodic filter bandpass. Signal integration is defined in the comb filter context. Feedback and non-feedback filter types are compared. . . .

ENHANCEMENT OF PULSE TRAIN SIGNALS BY COMB FILTERS
J. Galejs, IRE Trans. Inform. Th., vol. IT-4, no. 3, Sept. 1958, p. 114/125.

INTERCHANNEL CORRELATION IN A BANK OF PARALLEL FILTERS
J. Galejs, IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 106/114.

AN ANALYSIS OF A TYPE OF COMB FILTER
A. G. J. MacFarlane, Proc. Instn. Elect. Engrs., pt. B, vol. 107, no. 31, Jan. 1960, p. 39/52.

DETECTION OF UNKNOWN SIGNALS IN STRONG NOISE
JPL Res. Summ., vol. 1, no. 36-7, Dec./Jan. 1960, p. 53/54.

. . . it is assumed that the detailed form of the signal is unknown but that a rough knowledge of its power spectrum exists. . . . Any given sample of the input signal can be analyzed exactly, by computer, but the spectrum so found will be only for that particular sample. A different sample will, in general, yield a different spectrum. The central problem of power spectrum measurement lies in the reduction of this variability. . . . Computer programs exist that can quickly find the spectrum of 10^4 data points. But 10^8 data points is another matter. . . . This report is a summary of some research into a method to alleviate this difficulty. . . .

TRANSMISSION OF PULSES THROUGH A COMB FILTER
M. I. Finkel'shteyn, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 1, 1961, p. 23/30.

The transmission of N coherent square pulses through a comb filter is discussed. A method is proposed for determining the envelope of the output pulses. It is shown that in a practical filter, with an increase in the number of pulses the pulse amplitude increases exponentially but is not accompanied by improvement of the pulse shape. . . .

FREQUENCY ESTIMATION FROM A COMB FILTER BANK SYSTEM EMPLOYING LOGARITHMIC DETECTION
R. C. Kavee, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 106/110.

. . . based on a linear combination of the logarithmically detected outputs of two filters in the neighborhood of a local maximum within the filter bank. This estimate is justified and compared with the optimum estimate which can be obtained within a fixed coherent integration interval. An approximate solution is given for the variance and bias error of log-signal-plus-Gaussian noise in a system which has an abrupt threshold for signal-plus noise peaks 10 db or more above the rms noise level. . . . The effect of amplitude quantizing in db per bit is analyzed. Variations between filters are also considered. . . .

A COMB FILTER FOR USE IN TRACKING SATELLITES
R. L. Vitek, Ballistic Research Labs., Aberdeen Proving Ground, Md., BRL memo. rept. no. 1349, Aug. 1961, 75 p., 25 refs., AD 263 500.

The design and evaluation is presented of a 180 element comb filter. . . .

AN ACCURATE DISCRIMINATOR FOR DEMODULATING NOISY PFM TELEMETRY SIGNALS
B. Harris, et al., Rec. Nat. Symp. Space Electronics Telemetry, Oct. 1962, no. 3.3.

. . . consists of a band of relatively closely spaced bandpass filters, each of which is followed by an envelope detector.

IMPROVEMENT IN SIGNAL PERCEPTION BY SEQUENTIAL REDETECTION OF HARMONIC ZONES
A. Weiner, Electronic Defense Labs., Mountain View, Calif., Technical memo. no. EDL-M423, 26 Jan. 1962, 22 p., incl. illus., tables, 6 refs., AD 277 001.

. . . signal perception by sequential harmonic zone redetection . . . Using an IF bandwidth of 90 mc centered about 2.7 mc. the harmonic energy within two harmonic zones in sequence (2 and 2,2) was detected. Perception alarm probabilities was measured. . . . signal perception improves with the number of sequential redetections. . . .

THE PERFORMANCE OF A BANK OF DOUBLE, ISOLATED, SYNCHRONOUSLY-TUNED FILTERS FOR RECOVERING TONE BURST TELEMETRY SIGNALS
S. Wenglin, New York U. Coll. of Engineering, N.Y., Tech. Memo, 22: NASA-CR-50113, Jan. 25, 1962, 7 p., N63-16888.

PULSE-FREQUENCY MODULATION TELEMETRY
R.W. Rochelle, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 438/446.

. . . In the detection process for p.f.m. signals, a set of contiguous unmatched filters is used to enhance the signal/noise ratio. To examine the effects of Rayleigh noise on the output of these filters, the word-error probability is derived as a function of the energy per bit, the noise power density, and the degree of coding. . . .

IMPROVEMENT IN GAUSSIAN SIGNAL PERCEPTION BY DETERMINISTIC SIGNAL INJECTION AND HARMONIC-ZONE DETECTION
A. Weiner, et al., Electronic Defense Lab., Mountain View, Calif., 8 Feb. 1963, 28 p., AD 404 476.

. . . perception of narrowband, Gaussian signals . . . using a reference sine wave, a stiff limiter, and a harmonic-zone filter . . . The comparison of this new technique with energy detection showed equal signal perception at 3-db lower S/N ratios for perception probabilities greater than 0.5 at fixed, false-alarm probabilities of 1/1000, 1/10,000, 1/100,000 and 10 to the minus 6th power.

Related Publications:

A THEOREM ON CROSS CORRELATION BETWEEN NOISY CHANNELS
J. Keilson, et al., IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 77/79.

A REVIEW OF METHODS FOR IMPROVED DETECTION OF PULSES IN NOISE
F. L. Slojkowski, Bell Telephone Labs., Inc., Whippany, N.J., Technical memo. no. MM-60-6412-4, 26 May 1960, AD 251 550.

. . . three most commonly considered methods for improvement in signal detection is presented. Correlation, comb filters and integration techniques are discussed along with the advantages and disadvantages of each.

EXPERIMENTAL RESULUTION IMPROVEMENT RESEARCH
D. G. Corbett, Goodyear Aircraft Corp., Akron, Ohio, Phase rept. task 5 on Filter Derivation, Rept. no. GER-10268S1, 15 Dec. 1961, 68 p., AD 268 701.

A procedure for computing a physically realizable resolution improvement filter with a convolution equation system using space-domain Dirac samples of the sensor aperture is described. . . . It is shown that a resolution improvement filter must contain both positive and negative terms and that the optimum design of a filter is a function of the system input signal to noise ratio.

AMPLIFICATION OF LOW POWER PERIODIC SIGNALS
B. A. Mamyrin, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 3, 1961, p. 46/52.

A method of amplifying periodic wide-band low-power signals, and of observing their form at the output, is examined. It is shown that with the indicated method of signal spectrum transformation it is possible to obtain a substantial improvement in the signal-to-noise ratio. . . . The idea of transforming the spectrum of the periodic signal is as follows: a periodic signal reaches the amplifier input through a gating circuit, which passes the signal only during a short time-interval . . . 2. . . . to transmit samples of that signal . . . 3. Change of signal voltage during transformation. . . . 4. Change of noise voltage due to transformation. . . .

SYNTHESIS AND OFF-LINE EVALUATION OF A MULTICHANNEL FILTER SYSTEM DESIGNED FROM A THEORETICAL MODEL OF SIGNAL AND NOISE FOR THE ENHANCEMENT OF MANTLE P WAVES
R. Baldwin, et al., Texas Instruments Inc., Dallas, 15 Sept. 1963, 116 p., AD 436 039.

A multi-channel filter system was synthesized for Cumberland Plateau Seismological Observatory (CPO) on the basis of a theoretical model of signal and noise. An off-line evaluation was performed by processing actual recorded data from CPO through a computer simulation of the on-line Multiple Array Processor (MAP). . . .

DEVICE FOR SEPARATING NARROW FREQUENCY BANDS FROM A COMPLEX SIGNAL
A. M. Eilenkrig, et al., Foreign Tech. Div., Air Force Systems Command, Wright Patterson Air Force Base, Ohio, 1 July 1963, 4 p., AD 416 754.

. . . made in form of several filtering cells, tuned to the separated frequencies . . . The device described differs from the known ones by the use of band elimination filters and distribution elements, forming a narrow band amplifier. This amplifier assures zero phase displacement on a tuning frequency of the band elimination filter . . .

MULTIPLE SYNCHRONOUS STORAGE OF PULSED SIGNALS
M. I. Finkel'shteyn, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 10, Oct. 1963, p. 13/20.

. . . Synchronous storage is widely used to achieve optimal extraction of a signal in the form of a packet of equally spaced pulses from a noise background. . . . shows a storage circuit comprising a delay line with a positive feedback loop, the time delay T_d being chosen equal to the pulse-repetition period of the required signal T_n. . . .

2.837: Time Analysis Detection Methods

Included: Re-sampling methods for signal detection; Time discrimination for pulse signals; Detection by time-interval measurement; Step detector; Numerical filters for time analysis detection methods; Digital filters for time domain detection methods; Sampling of signals in noise.

Not Included: Pulse duration demodulators; Pulse position demodulator; Digital filter design.

Cross References: Digital correlation detectors (2.824); Statistical signal extraction methods (Sect. 2.84); Detection of sampled transmission systems (2.875); Non-parametric estimation techniques in signal detection (2.843).

Principal Publications:

STEP DETECTION—REDUCING CROSSTALK IN TIME-DIVISION MULTIPLEX SYSTEMS
A. R. Billings, Electronic and Radio Engineer, vol. 35, Dec. 1958, p. 453/455.

. . . A step detector is a device which converts a train of amplitude-modulated pulses into a continuous stepped waveform.

SAMPLE-AND-HOLD CIRCUITS FOR TIME CORRELATION OF ANALOG-VOLTAGE INFORMATION
W. T. Eddins, IRE Nat. Conv. Rec., pt. 5, vol. 6, March 1958, p. 21/25.

OPTIMUM NETWORK FUNCTIONS FOR THE SAMPLING OF SIGNALS IN NOISE
H. S. Heaps, Proc. Instn. Elect. Engrs., pt. C, vol. 105, Sept. 1958, p. 438/443.

A COMPARISON OF RANDOM AND PERIODIC DATA SAMPLING FOR THE DETECTION OF SIGNALS IN NOISE
D. Middleton, IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 234/247.

ENCODER MEASURES RANDOM EVENT TIME INTERVALS
R. J. Kelso, et al., Electronics, vol. 32, no. 20, March 1959, p. 48/51.

NOISE ELIMINATION BY PULSE-SIGNAL TIME-DISCRIMINATION
B. N. Mitiashev, Radio Engng. and Electronics, vol. 4, no. 4, 1959, p. 111/125.

A NON-CLASSIFIED SYSTEM FOR HIGH ACCURACY TIME INTERVAL MEASUREMENTS
H. D. Tanzman, Electronic Industr., vol. 18, Jan. 1959, p. 62/67.

Methods and equipment for measuring time intervals with an accuracy of 0.1 μsec. are known. A system is described here which makes possible measurements with 0.01 μsec. accuracy between events taking place in widely separated locations. Complete design information is given to permit constructing this system.

EFFECTIVE SAMPLING RATES FOR SIGNAL DETECTION; OR CAN THE GAUSSIAN MODEL BE SALVAGED?
I. J. Good, Inform. Control, vol. 3, no. 2, June 1960, p. 116/140.

THEORETICAL BASIS AND PRACTICAL IMPLICATIONS OF BAND-PASS SAMPLING
C. L. Ackerman, et al., Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 1/9.

If the Shannon sampling theorem is extended to the case of band-pass signals, the result is that a sampling rate between 2W and 4W samples per

second suffices for a complete reconstitution of the signal . . . In this paper, the effect of band-pass sampling is studied in a sampled-data correlation system using signal-to-noise processing gain as a performance measure. It is concluded that such alternatives as demodulation or quadrature sampling may be necessary to prevent degradation of system performance when band-pass sampling is employed.

THE EFFECT OF CONVERSION OF PERIODIC SIGNALS BY SAMPLING ON THE SIGNAL-TO-NOISE RATIO
V.A. Vol, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 10, Oct. 1962, p. 1/8.

The passage of a mixture of a signal and noise through a converter which makes the signal discrete during a finite interval is examined. . . . It is shown that, from the point of view of eliminating noise from a signal, quantizing is similar to linear filtering. It is found that the possible increase in signal-to-noise ratio in filtering of a quantized signal is several times lower than the number of mutually dependent values to be read in the signal. . . .

OPTIMUM POWER ESTIMATES WITH SMALL SAMPLES
I. Eisenberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-25, Dec./Jan. 1963, p. 200/205.

Consider the problem of detecting a narrow-band Gaussian signal embedded in independent wide-band white Gaussian noise. Suppose that the shape of the spectrum of the signal is known, but not the amplitude, and that the spectral density of the noise is known (it is flat, of known amplitude). Suppose a short sample of the signal-plus-noise is received. What is the optimum way to measure the power in the signal? For long samples of signal-pulse-noise, the answer is known-matched filtering, matched to the signal spectral shape. This note discusses the case of short samples, where it can not be assumed that the response of filters which would be used is the steady-state response.

Related Publications:

SOME SIMPLIFYING ADDITIONS TO BASIC SAMPLED-DATA THEORY
C.O. Carlson, IRE WESCON Conv. Rec., no. 4, Aug. 1958, p. 197/232.

SYNTHESIS OF SAMPLED-SIGNAL NETWORKS
P.M. Lewis, II, IRE Trans. Circuit Theory, vol. CT-5, March 1958, p. 74/77.

THE FUNDAMENTAL THEOREMS OF INFORMATION THEORY PARTICULARLY IN TELECOMMUNICATIONS (In German)
H. Wolter, Arch. Elekt. Ubertragung., vol. 12, Aug. 1958, p. 335/345.

An ambiguity in the proof of Shannon's sampling theorem and the contradictions involved in the assumption of sharp frequency limits are discussed. . . . determining time function at the input . . . from the time function measured at the output. . . . therefore effectively expand the channel bandwidth to any desired value.

FREQUENCY DOMAIN APPLICATIONS TO DATA PROCESSING
M.A. Martin, IRE Trans. Space Electronics Telemetry, vol. SET-5, March 1959, p. 33/41.

. . . telemetered functions are not measured continuously. To permit time multiplexing, values of these functions are determined only at constant time intervals; it is said that they are sampled at a specified sampling frequency. Smoothing, differentiation and integration of continuous signals are quite familiar. Mathematical tools have been developed which perform similar operations on digitized sampled functions; by analogy, these tools are called numerical filters, or simply filters.

DIGITAL DATA PROCESSING FOR FINITE MEMORY FILTERS
A.J. Monroe, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 49/56.

THE DISTORTION OF SIGNAL ENVELOPE BY A SINUSOIDAL VOLTAGE KEY DETECTOR
V.M. Ravikovich, Radio Engrg., vol. 14, no. 6, p. 35/50.

ON THE ACCURACY OF RESTORING A FUNCTION WITH A FINITE NUMBER OF TERMS OF A KOTEL'NIKOV SERIES
B.S. Tsybakov, et al., Radio Engng. and Electronics, vol. 4, no. 3, 1959, p. 274/275.

SPECIAL PURPOSE ANALYSIS TECHNIQUES
R. Archbald, et al., New York U., Coll. of Engineering, N.Y., Quarterly rept. no. 3, 1 Jan.-31 March 1961, 31 March 1961, 90 p., AD 259 736.

. . . Development of a miniaturized automatic direction finding system. Two different antenna arrays are described which can be used with the direction finder. An experimental program for determining the feasibility of using a general purpose digital computer for signal analysis problems was started. The Packard-Bell Company 250 computer and counter-measures receiving set AN/TLR-1 are the major units explained. A method for using a digital computer to control the operation and interpret the output of a direction finding unit for pulse signals is described. Computer programs to perform the desired system control and data interpretation are developed.

FREQUENZMESSUNG MIT EINEM DISKRIMINATOR (Frequency Measurement with a Discriminator) (In German)
G. Kosel, Arch. Elekt. Uebertragung, vol. 16, July 1962, p. 359/363.

. . . The frequency discriminator described in the paper depends on the principle of the coincidence of two pulse trains of the same repetition rate that are delayed in time with respect to each other. Dimensioning equations are derived and the influence of an interfering noise voltage is studied when a discriminator is operated with continuous sine-wave signals and with pulse-modulated signals. . . .

EXTRAPOLATION (PREDICTION) OF A FUNCTION WITH A LIMITED SPECTRUM FROM ITS DISCRETE VALUES
Y. G. Pollyak, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 11, Nov. 1962, p. 59/67.

The possibility of predicting (extrapolating) a continuous function with a limited frequency spectrum from the results of discrete measurements taken at equal "past" time intervals is established. The sufficient conditions for such extrapolations are formulated. The accuracy of the approximate prediction formulas is discussed. . . .

ASYMPTOTICALLY OPTIMUM QUANTIZERS AND OPTIMUM ANALOG TO DIGITAL CONVERTERS FOR CONTINUOUS SIGNALS (Correspondence)
L.I. Bluestein, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 242/246.

Quantizers are commonly used to match analog data sources to digital devices and channels. Most previous studies consider the source to be noise free; this paper, however, is concerned with the quantization of noisy, continuous signals. Thus we consider the problem of finding a discrete-output transducer whose output is a close replica of the noise-free signal in an appropriate statistical sense. This device is then a zero-memory filter of a rather specialized type. In a previous paper, it was shown that the optimum zero memory filter for noisy quantized signals, under the mean absolute error criterion, is a quantizer. For continuous signals, this is not true . . . two requirements of any quantizer synthesis procedure . . . This communication proposes a technique which satisfies these requirements. . . .

Section 2.84
Statistical Signal Extraction Methods

2.840: Statistical Extraction Methods in General

Included: Combined observation-decision procedures; Integrated signal extraction plus decision methods.

Not Included: Signal processing techniques in general (3A).

Cross References: Optimum linear filtering (2.812); Time analysis methods of detection (2.837).

Principal Publications:

INVESTIGATION OF METHODS FOR IMPROVING THE DETECTABILITY AND IDENTIFICATION OF RADAR SIGNALS BY INFORMATION PROCESSING
G.I. Cohn, et al., Electronics Research Lab., Illinois Inst. of Tech., Chicago, Final rept., 10 Nov. 1960, 285 p., AD 251 566.

Linear integrator output statistics . . . Statistics for statistical detector output, Optimum first-order statistical detector . . . Experimental statistical detector, Experimental results . . .

MULTIPLE MONITORING OF SINGLE EVENTS
G.R. Cooper, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 543/555, 12 refs.

. . . In obtaining accurate missile velocity determination from combined systems composed of ground-based radar plus missile-borne inertial components velocity is obtained both from differentiation of radar position data and from the integration of the acceleration derived from the inertial system. The single event, the missile velocity history is viewed through two independent sensory systems and the two sets of information obtained may be combined, with proper attention to differences in the errors involved, to obtain a single velocity history more accurate than that of either channel considered alone. . . .

BASIC RESEARCH IN PROBABILITY AND STATISTICS OF SEVERAL SAMPLE PROBLEMS
F.C. Andrews, et al., Oregon U., Eugene, Final rept., 1 July 1961 - 30 June 1963, 31 July 1963, 53 p., AD 415 959.

THEORY OF SIGNAL DETECTABILITY. OBSERVATION-DECISION PROCEDURES
T.G. Birdsall, et al., Cooley Electronics Lab., U. of Michigan, Ann Arbor. Technical rept. 136, Jan. 1964, 164 p., AD 429 220.

. . . extended to include observation-decision procedures other than the familiar fixed observation-decision procedure. . . . include predetermined nonsequential procedures and the optimum (Bayes') sequential procedure, deferred decision. . . . if the available output signal-to-noise ratio which one would obtain is small, then sequential procedures consume about 60% as much time as nonsequential procedures and the resultant error probabilities are approximately

the same; if the available output signal-to-noise ratio is on the order of +10 db, then deferred decision and the optimum non-sequential procedure consume about the same amount of time with sequential procedures making less terminal decision errors.

ON NONPARAMETRIC SIGNAL DETECTORS
J.W. Carlyle, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 146/152, 51 refs.

. . . a survey and summary of some of the similar one-input and two-input detection schemes. Particular emphasis is placed on those systems where less than a complete statistical description of the input is required. Such nonparametric detectors offer the advantages of ease of instrumentation and insensitivity to changes in the input statistics . . .

Related Publications:

AN APPROXIMATE METHOD IN SIGNAL DETECTION
W. F. Frieberger, Brown U., Div. of Applied Mathematics, Providence, R.I., 7 Feb. 1962, 6 p., AD 404 972.

A theorem from the theory of Toeplitz forms (ref. 1) is applied to the problem of estimating the best test statistic for the detection of Gaussian signals in Gaussian noise.

SEQUENTIAL DETECTION
D. Middleton, Carlyle Barton Lab., Johns Hopkins U., Baltimore, Md., RADC TDR63 179, Sept. 1963, 77 p., AD 416 724.

Basic problems . . . in particular, those cases where the signal is unknown but the distribution of signal parameters is given or available . . . main attention is given here to the average sampling numbers (ASN) and to the Operating Characteristic Functions (OCF) of these sequential tests . . .

2.841: Special Theories for Statistical Extraction Methods

Included: Discriminant analysis; Discriminability of classes of signals; Theory of correlated samples of signal plus noise; Recognition of classes of signals; Strategies of signal detection; Statistical estimation techniques in general.

Not Included: Fundamentals of mathematical statistics; Performance of random variables (1).

Cross References: Decision theory (Sect. 2.85); Pattern recognition theory (2.260); Search operations in detection systems (2.881).

Principal Publications:

PREDICTION AND FILTERING FOR RANDOM PARAMETER SYSTEMS
F.J. Beutler, IRE Trans. Inform. Th., vol. IT-4, Dec. 1958, p. 166/171.

STATISTICAL ERRORS IN MEASUREMENTS ON AMPLITUDE-DISTORTED GAUSSIAN SIGNALS
D.L. Haas, Res. Lab. Electronics, MIT, Quarterly Progress Rept., April 1958, p. 81/89.

CANONICAL FORMS FOR NONLINEAR STATISTICAL ESTIMATORS
G.D. Zames, MIT, Res. Lab. Quarterly Progress Rept., no. 52, Jan. 1959, p. 91/104.

The optimum predictor, filter, coder, and decision operator are considered for processes that are random and stationary. Discrete processes are studied first, and then Wiener's representation is used for continuous processes in conjunction with a definition of "probability density". In a sense, the method is an extension of that used by Bose.

ON THE PREDICTION OF FORCED-CHOICE AND PHENOMENAL-REPORT THRESHOLDS BY STATISTICAL DETECTION THEORY (Correspondence)
R.H. Lyon, J. Acoust. Soc. Amer., vol. 32, no. 4, April 1960, p. 508.

OPTIMUM DECISION AND SCANNING TECHNIQUES FOR SYNCHRONIZATION
J.Z. Grayum, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 170/178.

Assuming both the communicator and his opponent are using optimum strategies, a "most efficient" method of synchronization requires the application of Wald's sequential probability ratio test. The average likelihood ratio, assuming phase unknown, reveals that the receiver includes a correlator, an envelope detector, a weighting filter, and a scanning program generator. . . .

ON CERTAIN STRATEGIES OF SIGNAL DETECTION USING CLIPPER CROSSCORRELATOR (SINGLE SIGNAL SIZE)
G.P. Patil, et al., Office of Research Administration, U. of Michigan, Ann Arbor, (Technical rept. no. 128, rept. no. 3674-1-T), Oct. 1962, 37 p., incl. illus., tables, 6 refs., AD 288 028.

. . . signal detection . . . using clipper crosscorrelator . . . Four strategies are suggested which arise in a very natural way, and their interrelations are studied. Efficiency of the clipper crosscorrelator in relation to the usual crosscorrelator is defined and investigated in the setup as described.

SOME SMALL SAMPLE PROPERTIES OF CERTAIN STRUCTURAL EQUATION ESTIMATORS
R. E. Quandt, Princeton U., N.J., Research memo. no. 48, 21 Dec. 1962, 69 p., AD 299 553.

ON THE CONDITIONS FOR THE ORTHOGONALITY AND EQUIVALENCE OF GAUSSIAN MEASURES IN THE FUNCTIONAL SPACE
V. G. Alekseev, Minneapolis-Honeywell Regulator Co., Minn., Military Products Group, (1963), 10 p., refs., Transl. into English from Dokl. Akad. Nauk SSSR, Mat. v. 147, no. 4, 1962, p. 751/754, (MH Transl. 423), N64-11569.

. . . is well known that the Gaussian measures in the functional space of samples, corresponding to two different random processes, can be either equivalent or orthogonal. However, the available necessary and sufficient conditions for the equivalence of the Gaussian measures are all not sufficiently effective, in the sense that their testing for concrete processes represents an extremely complicated and as yet unsolved problem . . .

THE VARIANCE OF THE MEAN OF CORRELATED SAMPLES
I. Eisenberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 168/170.

Problem . . . arises in planetary radar, and elsewhere . . .

COMBINATIONS OF LEAST-SQUARES APPROXIMATIONS IN THE CASE OF CORRELATED VARIABLES
P. L. Kadakia, Smithsonian Astrophysical Observatory, Cambridge, Mass., NASA CR-50831, SAO Special Rept. 122, April 2, 1963, 13 p., 6 refs., N63-19543.

The problem of estimating a mean vector of n independent sample mean vectors of the same population or the same physical quantity with their corresponding n variance-covariance matrices (or weight matrices) for which off-diagonal elements are nonzero, e.g., when fitting an equation of polynomial of some degree to a large number of observations by the least squares. The method of solution discussed is based on the statistical estimation theory . . .

ON THE APPLICATION OF DISCRIMINANT ANALYSIS TO IDENTIFICATION IN AERIAL PHOTOGRAPHY
L. N. Kanal, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 416/419.

. . . By "Discriminant Analysis" we mean a body of statistical techniques consisting of multivariate tests of significance, measures of distance between samples, between groups, and between a sample and a group; coordinate transformations and projections; and probabilistic methods for classification. . . .

ON THE PROPERTIES OF SOME SYSTEMS THAT DISTORT SIGNALS—I
I. W. Sandberg, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 2033/2046.

This is the first part of a two-part paper concerned with some generalizations and extensions of the Beurling-Landau-Miranker-Zames theory of recovery of distorted band-limited signals. We present a uniqueness proof that extends Beurling's result and study a class of functional mappings defined on Hilbert space. As an application, we show that the recovery results can be extended to cases in which a known square-integrable corrupting signal is added to the input signal and the result applied to a time-variable device which may be nonlinear. It is proved that an assumption made by the earlier writers is in fact necessary in order that stable recovery be possible. . . .

K RASCHETU KHARAKTERISTIK OBNARUZHENIIA FLUKTUIRUIUSHCHIKH SIGNALOV (On the Calculation of Detection Characteristics of Fluctuating Signals) (In Russian)
R. L. Stratonovich, et al., Moskovskii Universitet, Vestnik, Seriia III-Fizika, Astronomiia, vol. 19, Jan. - Feb. 1964, p. 43/49, 5 refs., A64-17118.

. . . of correlated Gaussian radio signals in a correlated Gaussian noise. Exact expressions are derived for determining the errors of optimal and nonoptimal detectors of fluctuating radio signals. These expressions can also be used as a basis for tabulating the detection characteristics using a high-speed computer.

METHODS FOR THE CLASSIFICATION AND RECOGNITION OF TIME-VARYING SIGNALS
S.S. Viglione, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 430/433.

. . . problem of signature analysis . . . examining a radar return to determine if the incoming object is a decoy or a warhead or a sonar return to distinguish the submarine echo from that of a whale . . . processing technique incorporating data processing features of the neural networks of the higher order animals. The unique feature of such a system is its capability to learn, or adjust, to its task at hand. . . .

Related Publications:

A NEW METHOD OF MEASURING VERY SMALL VARYING ELECTRICAL QUANTITIES (In Russian)
V.S. Voyutskii, Radiotekhnika i Elektronika, vol. 3, no. 2, 1958, p. 340/346.

STABILITY OF CIRCUITS WITH RANDOMLY TIME-VARYING PARAMETERS
J.E. Bertram, et al., IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 260/270.

OPTIMAL FILTERING OF PERIODIC PULSE-MODULATED TIME SERIES
W. A. Janos, IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 67/74.

OPTICAL CORRELATION FOR TERRAIN TYPE DISCRIMINATION
A. Goldstein, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 420/424.

SINGLE SAMPLING INSPECTIONS PLANS WITH SPECIFIED ACCEPTANCE PROBABILITY AND MINIMUM COSTS
A. Hald, Copenhagen U. (Denmark), July 1963, 68 p., AD 416 800.

To design an economical sampling plan it is necessary to know the costs of sampling inspection, the costs of wrong decisions, and the quality distribution of lots submitted for inspection, the prior distribution. Sometimes it is impossible to specify the prior distribution in detail but a vague knowledge is available which means that not enough is known to find the Bayes solution and on the other hand too much is known for the minimax solution to be satisfactory. The problem then is to choose a principle leading to a reasonable solution . . .

LIMITS TO ANIMAL DISCRIMINATION AND RECOGNITION IN A NOISE EXTERNAL ENVIRONMENT
J. L. Stewart, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 116/131.

. . . A theory for neural noise is developed which is shown to specify the limits to animal discrimination and to explain certain observed neural mechanisms. Finally, concepts of optimum detection are employed to specify the ideal animal recognition sensory schema . . .

2.842: Parameter Estimation Techniques for Signal Detection

Included: Bayes' sequential observer; Maximum likelihood estimator; Variance of estimates as performance criterion; Frequency acquisition as a parameter estimation problem; Spectral estimation techniques; Asymptotic distributions of estimators; Sequential estimation; Multiple signal counting; Pulsed signals parameter estimation; Optimum estimation of impulse response; Angular maximum likelihood estimation; Non-stationary estimation of parameters; Parameter identification; Estimation of co-variance functions; Large sample estimation; Simultaneous estimation of two signal parameters; Process parameter estimation.

Not Included: Mathematical fundamentals of statistics.

Cross References: Decision theory (Sect. 2.85); Search operations in detection systems (2.881); Tracking operations in detection systems (2.882); Maximum likelihood deciders (2.852); Sequential estimation techniques (2.854).

Principal Publications:

ON SIGNAL PARAMETER ESTIMATION
E. M. Glaser, et al., IRE Trans. Inform. Th., vol. IT-4, no. 4, Dec. 1958, p. 173/174.

. . . ideas of Statistical Decision Theory are applied to estimate the parameters of signals represented by a linear expansion of orthogonal functions.

A RADAR SCAN THEORY USING A BAYES SEQUENTIAL OBSERVER WITH INCREASING OBSERVATION COSTS
T. Curry, Westinghouse Research Labs., Electronics & Nuclear Physics, Dept., Research Report No. 6-94410-14-R4, Jan. 1959.

THE ASYMPTOTIC DISTRIBUTIONS OF ESTIMATORS OF THE AMOUNT OF TRANSMITTED INFORMATION
Z. A. Lomnicki, et al., Inform. Control, vol. 2, no. 3, Sept. 1959, p. 260/284.

A NOTE ON THE ESTIMATION OF SIGNAL WAVEFORM
D. Middleton, IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 86/89.

. . . representation of the signal process as a linear expansion (M.S.) in complete orthonormal sets, suitable choices of these sets. Examples involving discrete and continuous sampling on a finite interval, with various choices of a priori distributions of signals parameters are described . . .

OPTIMUM DE-CODING SYSTEM FOR THE TRANSMISSION OF THE MAXIMUM NUMBER OF PARAMETER VALUES IN THE PRESENCE OF NON-ADDITIVE NOISE
B. S. Fleishman, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 36/46.

. . . construction of a system of de-coding which for definite types of modulation will ensure that the maximum number of parameter values will be reliably transmitted in the presence of non-additive noise. . . . Kotel'nikov (1) has already solved the problem of optimum parameter reception in the case of channels with additive normal fluctuation noise.

The optimum solution for the same problem has been given in another paper. . . for the more general case of non-additive noise. In these papers, optimum parameter reception is understood to mean the optimum conversion

(de-coding) of the signal at the output which leads to the value of the parameter having the maximum probability being transmitted to the input. . . . In this article a study is made of actual types of modulation which are known to be other than optimum and the problem of how to transmit the maximum number of values of the parameter reliability is solved. . . .

OPTIMUM ESTIMATION OF IMPULSE RESPONSE IN THE PRESENCE OF NOISE
M. J. Levin, IRE Trans. Circuit Theory, vol. CT-7, no. 1, March 1960, p. 50/56. 15 refs.

PARAMETER ESTIMATION THEORY AND SOME APPLICATIONS OF THE THEORY TO RADAR MEASUREMENTS
R. Manasse, Mitre Corp., Bedford, Mass., Technical series rept. no. 3, ESD TDR 62-50, 1 April 1960, 13 p., 8 refs., AD 287 562.

The general theory of parameter estimation is developed using the inverse probability approach. . . . The theory is illustrated by applying it to several radar measurement problems of interest.

AN ADAPTIVE SYSTEM USING PERIODIC ESTIMATION OF THE PULSE TRANSFER FUNCTION
S. C. Bigelow, et al., IRE Internat. Conv. Rec., vol. 4, March 1961, p. 25/38.

OPTIMUM LINEAR FINITE-DIMENSIONAL ESTIMATOR OF SIGNAL WAVEFORMS
T. Kasami, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 206/215.

This paper deals with the linear estimation of noise corrupted signal waveforms, from observation over a specified finite time-interval. Two new features are delineated in this paper: 1) the estimating operator is assumed to be finite-dimensional . . . and 2) the cost of observation and estimation is taken into account . . . As a result, the optimum linear finite-dimensional operator that minimizes the risk . . . is obtained for the case in which a quadratic loss function due to error is adopted. . . .

FREQUENCY ESTIMATION FROM A COMB FILTER BANK SYSTEM EMPLOYING LOGARITHMIC DETECTION
R. C. Kavee, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961 p. 106/110.

THE THEORY OF PULSED SIGNAL MEASUREMENTS
G. W. Preston, IRE Internat. Conv. Rec., vol. 5, March 1961, p. 349/359.

. . . target properties such as the velocity, acceleration, rotation and multiplicity is of considerable interest . . . networks may be designed for measuring target parameters such as these . . . detecting any parameter of a pulse modulated signal . . . work is the counterpart in pulsed modulation theory to Wiener's celebrated work on the theory of the smoothing of stationary time series . . .

APPLICATION OF STATISTICAL ESTIMATION PROCEDURES TO THE IDENTIFICATION PROBLEM
R. P. Wishner, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 47G-2, 3 Nov. 1961, 24 p., AD 266 877.

The method of maximum likelihood parameter estimation is applied to the problem of measuring parameters of an unknown linear filter or control system from input-output data when it is assumed that the output signal is corrupted with an additive Gaussian noise signal . . . Approximate expressions for the parameter estimates and the covariance matrix of the errors in the parameter estimates are obtained in the strong signal case. This analysis also has applications to the adaptive radar problem.

LIMITING ACCURACY OF THE ESTIMATE OF THE SIGNAL PARAMETER DURING RECEPTION IN NORMAL NOISE
Y. I. Kulikov, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 7, July 1962, p. 1/9.

By maximizing the equal-likelihood function, formulas are obtained for the evaluation of the variance of the estimate of the signal parameter during its reception in additive normal noise. . . .

MAXIMUM ACCURACY OF DELAY-TIME MEASUREMENT
Y. I. Kulikov, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 8, Aug. 1962, p. 1/7.

On the basis of the method of the maximum likelihood function, the variances for the delay-time measurement of a radio pulse with random initial phase when received in white and narrow-band normal noise are calculated. The article gives signal forms at the output of an optimal receiver. . . .

SOME SMALL SAMPLE PROPERTIES OF CERTAIN STRUCTURAL EQUATION ESTIMATORS
R. E. Quandt, Princeton U., N. J., (Research memo. no. 48), 21 Dec. 1962, 69 p., AD 299 553.

THE SEQUENTIAL ESTIMATION AND DETECTION OF SIGNALS IN NORMAL NOISE
I. Selin, RAND Corp., Santa Monica, Calif., Memo. no. RM-2994-PR, June 1962, 113 p. incl. illus., 42 refs., AD 276 530.

. . . Two classes of signals are considered: signals which are known exactly, and signals known except for a finite number of parameters.

GENERALIZED RESOLUTION IN RADAR SYSTEMS
H. Urkowitz, et al., Proc. IRE, vol. 50, no. 10, Oct. 1962, p. 2093/2105.

. . . A new concept, "angular dispersion and compression," has been evolved . . . The technique of maximum likelihood estimation has been extended to angular measurement.

FREQUENCY ACQUISITION TECHNIQUES
A. J. Viterbi, JPL Res. Summ., no. 36-14, Feb./March 1962, p. 71/75.

The problem of determining the presence of a sinusoid in additive gaussian noise and of estimating its frequency is of considerable importance . . .
One approach is to assume an arbitrary initial frequency and phase, compare these with the received signal by a phase comparison device, and use the error estimate to correct the initial assumption. . . .

A STATISTICAL THEORY FOR PARAMETER IDENTIFICATION IN PHYSICAL SYSTEMS
A. A. Wolf, et al., J. Franklin Inst., vol. 274, no. 5, Nov. 1962, p. 369/400.

Certain aspects of a theory for white-noise probing of a class of linear and nonlinear systems are presented. Theoretical questions related to the identification problem and to the application of the theory to the determination of system transmission characteristics, and physical parameters, are considered. The extension of the method to the measurement of the correlation functions is treated, together with a possible application of the scheme to adaptive control. The notion of adaptive probe systems and correlators is also developed.

O RASCHETE VEROIATNOSTI "GRUBOI" OSHIBKI PRI DVUKHSHKAL'NOM SPOSOBE IZMERENIIA PARAMETRA SIGNALA (Calculation of the Probability of a "Gross" Error in a Two-Scalar Method For Measuring The Signal Parameter) (In Russian)
V. V. Akindinov, Radiotekhnika i Elektronika, vol. 8, July 1963, p. 1099/1105, A63-24398, A64-17509

. . . reliability of signal parameter estimation in a two-scalar measurement method. The reliability is characterized by a probable falling of the parameter estimation into the first side maximum of the probability function, termed the probability of the gross error.

A METHOD FOR COMPUTING LEAST SQUARES ESTIMATORS THAT KEEP UP WITH THE DATA
A. Albert, et al., Arcon Corp., Lexington, Mass., Feb. 1964, 34 p., AD 434 715.

RAZLICHENIE PARAMETROV SIGNALOV PRI IKH VYDELENII IZ SHUMOV (Discrimination of Signal Parameters During Their Extraction From Noise) (In Russian)
I. A. Bol'shakov, et al., Radiotekhnika i Elektronika, vol. 9, Feb. 1964, p. 201/210, A64-17124.

Presentation of a solution to the problem of optimum Bayes filtration of random varying parameters of similar signals received in a unique mixture against the background noise . . . contains a special device which discriminates the parameters according to the type of their coding in the mixture and character of variation with time.

ON THE ESTIMATION OF STATE VARIABLES AND PARAMETERS FOR NOISY DYNAMIC SYSTEMS
H. Cox, IEEE Trans. Automatic Control, vol. AC-9, Jan. 1964, p. 5/12, 18 refs., A64-15907.

Formulation of the estimation problem to include a large class of discrete-time systems in the presence of random disturbances and measurement noise. . . .

THE VARIANCE OF THE MEAN OF CORRELATED SAMPLES
I. Eisenberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 168/170.

SOME FUNDAMENTAL ASPECTS OF PROCESS-PARAMETER ESTIMATION
P. Eykhoff, IEEE Trans. Automatic Control, vol. AC-8, Oct. 1963, p. 347/357, A64-12535.

Description of methods for estimating the parameters of both linear and nonlinear processes. Parameter estimation schemes are derived through the introduction of a generalized model of the given process. . . .

MAXIMUM LIKELIHOOD ESTIMATION OF PARAMETER CHANGES IN NOISY SIGNALS
R. M. Gagliardi, University of Southern Calif., Engineering Center, Los Angeles, Rept. no. 106, Jan. 1964, 30 p., AD 436 108.

In the detection and tracking of space vehicles, quite often important information is directly associated with changes occurring in the parameters of signals received from the target. . . . optimal receiver . . . for estimating the time of occurence of parameter changes . . . The primary assumption is that the signals and/or the parameters are known a priori.

BETTER DATA PROGRAM
H. Goldstein, General Electric Co., Syracuse, N. Y., Rept. no. 63098 63, 1963, 15 p., AD 407 764.

The General Electric BETTER (Best Estimate Trajectory To Exploit Redundant) data program has been designed to employ the maximum likelihood estimation technique to combine redundant measuring systems observing a vehicle in powered flight. This IBM 7090 computer program uses raw data measured radar positions, timing information, the covariances on the random noise and survey data from each system to precipitate a weighed estimation. . . .

POTENTSIAL'NAIA TOCHNOST'IZMERENIIA V ODNOKANAL'NYKH I MNOGOKANAL'NYKH IZMERITELIAKH PARAMETROV SIGNALA (Potential Precision of Single-Channel and Multi-Instruments for Measuring Signal Parameters) (In Russian)
L. S. Gutkin, Radiotekhnika, vol. 19, March 1964, p. 3/8, 5 refs., A64-17748.

Discussion of the highest theoretically possible precision in the measurement of constant signals and signals varying with time. . . .

LARGE-SAMPLE ESTIMATION OF AN UNKNOWN DISCRETE WAVEFORM WHICH IS RANDOMLY REPEATING IN GAUSSIAN NOISE
M. Hinich, Stanford U., Calif., Tech. Rept. 93; 31 Dec. 1963, 47 p., refs., AD 429 465, N64-16656.

. . . The rate of recurrence of the waveform is a small . . . and the signal-to-noise ratio of the input is quite low. . . . The optimal estimator of autocorrelation is presented . . . Three examples discussed are the general case of white noise, the case of white noise when the discrete waveform has only two components, and the case of Gaussian Markov noise. . . .

NUMERICAL ANALYSIS OF SYSTEM AVAILABILITY AND OF PARAMETER ESTIMATION METHODS
W. J. Howard, et al., Space Technology Labs., Inc., Redondo Beach, Calif., Aug. 1963, 105 p., AD 415 690.

. . . The first part (Parameter Estimation) summarizes the results of a Monte Carlo analysis to determine the feasibility and accuracy of measuring system failure rates, checkout error probabilities, and repair effectiveness from the numbers of systems passing and failing in three consecutive checkouts . . .

THE LEAST SQUARES ESTIMATION OF LINEAR AND NONLINEAR SYSTEM WEIGHTING FUNCTION MATRICES
H. C. Hsieh, Inform. Control, vol. 7, March 1964, p. 84/115, 23 refs., A64-16514.

. . . general approach to the least squares estimation of the weighting function matrix of a linear multivariable system, by means of normal operating records.

THEORY OF THE MEASUREMENT OF RELATIVE DELAY BETWEEN TWO SAMPLES OF AN UNKNOWN SIGNAL
P. W. James, Royal Aircraft Establishment (Gt. Brit), RAE TN no. Rad 834, March 1963, 22 p., AD 410 362.

SOVMESTNAIA OTSENKA AMPLITUDY, FAZY, RASSTOIANIIA I EGO PROIZVODNYKH RADIOLOKATSIONNYMI METODAMI (Simultaneous Estimation of The Amplitude, Phase, and Distance and Its Derivatives by Radar Methods) (In Russian)
S. I. Krasnogorov, Radiotekhnika i Elektronika, vol. 9, Jan. 1964, p. 78/86, A64-15783.

VERY HIGH RESOLUTION TECHNIQUES
A. A. Ksienski, Hughes Aircraft Co., Culver City, Calif., Quarterly rept. no. 6, 15 Sept. - 15 Dec. 1963, 15 Dec. 1963, 96 p., AD 434 727.

. . . approach to radar resolution . . . A general system based upon joint parameter estimation and a zero-one loss function is developed. . . . Various estimation techniques . . . Two alternative designs . . .

LIMITING ACCURACY OF THE SIMULTANEOUS ESTIMATION OF TWO SIGNAL PARAMETERS IN THE PRESENCE OF NORMAL NOISE
Y. I. Kulikov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 1, Jan. 1963, p. 53/61.

Using the maximum value of the probability function, formulas are derived for the calculation of the variance and correlation coefficient for the simultaneous estimation of two radio signal parameters with a random initial phase in the presence of additive correlated normal noise. On the basis of these formulas, the characteristics of the simultaneous evaluation of the delay time and frequency shift for the reception of a bell-shaped radio signal in the presence of white noise are calculated for the cases of no internal frequency modulation and linear frequency modulation. . . .

A NEW METHOD OF LOCATING THE MAXIMUM POINT OF AN ARBITRARY MULTI-PEAK CURVE IN THE PRESENCE OF NOISE
H. J. Kushner, Lincoln Lab., Mass. Inst. of Tech., Lexington, 1963, 11 p., AD 411 969.

A versatile and practical method of searching a parameter space . . . usefulness . . . when the only available information is noise-disturbed samples of the function. . . . The observations are taken sequentially; but, as opposed to the gradient method, the observation may be located anywhere on the parameter interval. A sequence of estimates of the location of the curve maximum is generated. The location of the next

observation may be interpreted as the location of the most likely competitor (with the current best estimate) for the location of the curve maximum. . . .

INVESTIGATION OF ANALOG AND DIGITAL COMMUNICATION SYSTEMS
J. G. Lawton, Cornell Aeronautical Lab., Inc., Buffalo, N. Y., Final rept., Feb. 1962 - Feb. 1963, RADC TDR63 147, May 1963, 175 p., AD 407 343.

The maximum likelihood estimation of FM-modulated signals is investigated. . . . threshold phenomenon in FM reception with an ideal discriminator and postdetection Wiener filter for the case of a random modulation function. . . . bounds on the performance of PCM systems for transmitting analog information . . . compared with theoretical bounds for systems of prescribed complexity. The analysis of the optimization of N-ary digital systems operating over a dispersive channel, which was begun during a previous phase of the contract, is further advanced.

PRIMENENIE TEORII STATISTICHESKIKH RESHENII K ZADACHAM OTSENKI PARAMETROV OB'EKTA (Application of the Theory of Statistical Solutions to Parameter-Evaluation Problems for the Controlled Member) (In Russian)
E. P. Maslov, Avtomatika i Telemekhanika, vol. 24, Oct. 1963, p. 1338/1350, A64-13216.

. . . for the case where the input and output signals of the system are applied to a computer through channels that are subject to random noise. The parameter values obtained for a quadratic loss function are shown to be optimum in the sense of minimum deviation from all the possible non-biased estimates. The results are applied to several examples.

ON THE EFFICIENCY OF THREE-STAGE LEAST-SQUARES ESTIMATION
A. Madansky, RAND Corp., Santa Monica, Calif., Memo. no. RM-3557-PR, March 1963, 15 p., AD 299 572.

ADAPTIVE MINIMUM MSE ESTIMATION (Correspondence)
D. T. Magill, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 289.

. . . to show how minimum mean-square-error (MSE) estimates may be calculated when the parameter(s) describing the quantity being estimated are initially unknown and must be learned with time. . . .

OPTIMAL NON-STATIONARY ESTIMATION OF THE PARAMETERS OF A LINEAR SYSTEM WITH GAUSSIAN INPUTS
D. Q. Mayne, J. Electronics and Control, vol. 14, no. 1, Jan. 1963, p. 101/112.

STATISTICAL FILTERING OF SPACE NAVIGATION MEASUREMENTS
J. E. Potter, et al., American Institute of Aeronautics and Astronautics, Guidance and Control Conference, Cambridge, Mass., Aug. 12-14, 1963, Paper 63-333, 13 p., A63-20665.

. . . designing an estimator which computes the state vector of a space vehicle from redundant navigational measurements. It is shown that under the assumption of linearity all these criteria lead to the same estimator (or filter). If all measurement uncertainties have Gaussian distributions, it is shown that the estimate obtained from optimum filter theory is identical with the maximum likelihood estimate. . . .

MAXIMUM LIKELIHOOD ESTIMATION IN FINITE STATIONARY ERGODIC MARKOV CHAINS AND A STRONG CONVERSE TO THE CODING THEOREM FOR CONTINUOUS MEMORYLESS CHANNELS
U. V. R. Rao, Michigan U., Ann Arbor, 1963, 70 p., refs., N64-17164.

THE MAXIMUM LIKELIHOOD ESTIMATOR FOR A PHASE COMPARISON ANGLE MEASURING SYSTEM (Correspondence)
Y. Ronen, et al., Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1669/1670.

ESTIMATION OF THE COVARIANCE AND AUTO-REGRESSIVE STRUCTURE OF A STATIONARY TIME SERIES
M. C. Schaerf, Stanford U., Calif., Technical Report No. 12, 13 Jan. 1964, 74 p., refs., AD 432 148, N64-16778.

. . . given a finite length of record from a discrete-parameter normal-covariance stationary time series with zero mean . . . estimate the covariance function and other quantities related to it, like the autoregression coefficients . . .

AN INTRODUCTION TO ESTIMATION THEORY FOR FOR DYNAMICAL SYSTEMS
F. C. Schweppe, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. 22G-15, 28 Aug. 1963, 51 p., refs., AD 417 777, N64-16819.

Estimation (filtering) theory for dynamical systems is reviewed. Emphasis is on time-varying systems and nonstationary stochastic processes. The basic ideas for linear systems are presented in an intuitive manner using time-domain techniques and the state-variable concept. Both continuous and discrete time systems are discussed . . .

AN OPTIMAL DATA ASSOCIATION PROBLEM IN SURVEILLANCE THEORY
R. W. Sittler, IEEE Trans. Mil. Electronics, MIL-8, no. 2, April 1964, p. 125/139.

. . . By a method of inverse probability, the optimal data processor is obtained which permits maximum likelihood estimates to be made of the true data-surveillance object association. The maximum likelihood estimator is given in a form

that lends itself to sequential computations performed in real time as the data arrives. . . . Computer implementations are possible. . . .

ESTIMATION OF THE CONSTANT COMPONENT OF A DETECTED PERIODIC SIGNAL MIXED WITH ADDITIVE GAUSSIAN NOISE USING A SEGMENT OF A SINGLE SAMPLE OF FINITE DURATION
A. B. Tatarinov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 6, June 1963, p. 5/14.

Using a single sample of finite duration, the problem of estimation of the mean value of a detected harmonic signal on a background of additive Gaussian noise, mixing with the signal before the detection process, is considered. For linear and square-law detectors, equations are derived for the relative bias of the estimate . . .

THE ACCURACY OF MAXIMUM LIKELIHOOD ANGLE ESTIMATES IN RADAR AND SONAR
H. Urkowitz, IEEE Trans. Mil. Electronics, vol. MIL-8, no. 1, Jan. 1964, p. 39/45.

By extending the results of Kelly, Reed, and Root, formulas are derived for the variances of maximum likelihood estimates of azimuth, and azimuth and elevation, jointly, by dense, discrete and discrete-continuous apertures for the strong signal case. . . .

AN ANALYSIS OF AN APPROXIMATE SEQUENTIAL PROCEDURE FOR INTERVAL ESTIMATION
D. A. Walters, RCA Labs. Div., Radio Corp. of America, Princeton, N. J., Technical note no. 1, July 1963, 101 p., AD 420 806.

An approximate sequential method is presented for interval estimation suitable for hypothesis testing in current research in artificial intelligence, a study of its properties, and a method of choosing parameter values to maximize its effectiveness. . . .

GENERALIZED LEAST SQUARES ESTIMATORS FOR RANDOMIZED FRACTIONAL REPLICATION DESIGNS
S. Zacks, Applied Mathematics and Statistics Labs., Stanford U., Calif., Technical rept. no. 86, 15 March 1963, 28 p., 11 refs., AD 400 398.

. . . The term generalized least-squares estimators is used since the matrices of the normal equations corresponding to these designs are singular. . . The required algebra, and the method of constructing the orthogonal fractional replications is presented.

THE USE OF THE HYPERGEOMETRIC FUNCTION AS PART OF BAYESIAN ESTIMATION OF A TWO STATE MARKOV PROCESS
E. A. Silver, Mass. Inst. of Tech., Cambridge, Technical note no. 2, Jan. 1964, 15 p., AD 428 852.

. . . consider a two state process where one transition probability is known exactly, while the other is assumed Beta distributed. . . . expected values of the steady state probabilities are obtained through the use of the hypergeometric function. . .

OB ODNOI ZADACHE OTSENKI SUSHCHESTVENNYKH PARAMETROV OB'EKTA (A Problem in the Evaluation of the Principal Parameters of an Object) (In Russian)
V. P. Zhivogliadov, et al., Akademiia Nauk SSSR, Izvestiia, Tekhnicheskaia Kibernetika, Jan.-Feb. 1964, p. 174/181, 5 refs., A64-16984.

Discussion of the application of the theory of statistical solutions to the problem of assessing the principal parameters of a system, in the case of incomplete information on the input signal and the system's state. . . algorithm for calculating an unknown parameter of a nonlinear system.

Related Publications:

MULTIPLE SIGNAL COUNTING
W. M. Gersch, Electronics Research Labs., Columbia U., New York, Tech. rept. no. T-1/161, CU-21-61-AF-1971-ERL, 28 July 1961, 160 p., AD 266 940.

. . . The problem is one of parameter estimation, called Multiple Signal counting, which is an idealized model for a radar operating in a multiple signal environment.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE
L. Kurz, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 215/223.

. . . A theory of so-called efficient codes (minimax, equal separation, and nearly equal separation) is developed. . . . It is shown that efficient codes perform better than equidistant codes if the noise is nonwhite. . . The detection scheme used does not require estimation of the signal or the noise levels at the receiver and is thus independent of fading.

A NOTE ON THE FACTORIZATION PROBLEM
T. Kailath, JPL Res. Summ., no. 36-14, Feb./March 1962, p. 75/76.

. . . The factorization problem arises in several fields, some of which are. . . Certain problems of spectral estimation.

CODING FOR SOURCE AND CRITERION
E. C. Posner, et al., JPL Res. Summ., no. 36-14, Feb./March 1962, p. 33.

. . . Coding to make the source random is sometimes called data compression. After

compression, one can use ordinary coding techniques. . . The real difference occurs when error probability is not the right criterion. For example, if the data are to be used for parameter estimation, the variance of the estimate is a proper criterion.

FUNDAMENTAL ACCURACY LIMITATIONS FOR PILOT-TONE TIME-BASE CORRECTIONS
J. A. Develet, Jr., Aerospace Corp., Los Angeles, Calif., Rept. no. TDR 269 9990 3, 10 Feb. 1964, 14 p., AD 430 464.

Wiener filtering concepts are applied. . . addition of a stable sinusoid in a clear area of the signal baseband. After transmission through a medium with varying time delay and additive noise, the pilot tone is recovered by a tracking filter, the output of the tracking filter can be used to estimate the variations in time delay of the transmission medium. . . . theory of parameter estimation. . .

PATTERN RECOGNITION AND DETECTION BY MACHINE Final Report
A. E. Laemmel, Polytechnic Inst. of Brooklyn, N.Y., Microwave Res. Inst., PIBMRI-1130-63, AFCRL-63-98, March 8, 1963, 68 p., 69 refs., N63-21404.

. . . optimum estimation of statistical parameters so as to minimize the probability of incorrect classification, non-Gaussian and nonstationary situations, pattern detection in a continuing time series, and calculation of error probabilities. Some of the work is specifically directed toward the problem of radio station recognition . . .

RANDOM NOISE IN AMPLITUDE COMPARISON MONOPULSE SYSTEMS
J. W. McGinn, Jr., Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 47G-7, AFESD TDR 63-28, 7 Feb. 1963, 26 p., incl. illus., AD 400 113.

. . . the effect of random noise on amplitude comparison monopulse signal processing is studied. The following three factors are determined: (1) the form of the maximum likelihood estimate of angle of arrival in the presence of random noise, (2) the probability density function of such an estimate, and (3) an appropriate measure of the precision of the estimate for the zero angle of arrival condition.

DUAL-MODE FILTERING OF POLYNOMIAL SIGNALS IN NOISE
L. G. Shaw, IEEE Trans. Automatic Control, vol. AC-8, April 1963, p. 136/142, A63-17514.

THE LINEAR PREDICTION OF DETERMINISTIC SIGNALS
S. Zahl, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 222/226.

A method is presented for linear estimations of functionals of deterministic signals containing additive noise. The method is based on statistical decision theory and assumes discrete observations. . . . In this paper . . . restricted to real one-dimensional functions parametrized by a real vector. . . .

2.843: Non-Parametric Estimation Techniques in Signal Detection

Included: Estimation for random processes; Detection of irregularities in stationary processes; Optimum power estimates with small samples; Theory of dichotomics; Estimation of the characteristics of statistical populations; Detection of the peak of an arbitrary spectrum; Discriminating between two Gaussian processes; Non-parametric signal detectors; Hill climbing methods; Slippage problems.

Not Included: General non-parametric statistical theory; Sampling methods (1).

Cross References: Time analysis detection methods (2.837); Spectrum analysis detection methods (2.836).

Principal Publications:

OPTIMUM LINEAR ESTIMATION FOR RANDOM PROCESSES AS THE LIMIT OF ESTIMATES BASED ON SAMPLED DATA
P. Swerling, IRE WESCON Conv. Rec., no. 4, Aug. 1958, p. 158/163.

ASYMPTOTIC BEHAVIOR OF OPTIMUM FIXED-LENGTH AND SEQUENTIAL DICHOTOMIES
E. M. Hofstetter, MIT Quarterly Progress Rept. no. 53, April 1959, p. 117/121.

One of the classical problems of statistics is the determination of the probability distribution of a random variable from measurements made on the variable itself. The simplest, non-trivial version of this problem is the dichotomy — a situation in which the unknown distribution is known to be one of two possible distributions. In this report two of the most important solutions of the dichotomy are described and their performances compared.

DETECTABILITY OF SMALL IRREGULARITIES IN A BROADBAND NOISE SPECTRUM
C. I. Malme, MIT, Res. Lab. Quarterly Progress Rept., no. 52, Jan. 1959, p. 139/142.

SOME RESULTS ON THE PROBLEM OF DISCRIMINATING BETWEEN TWO GAUSSIAN PROCESSES
P. Bello, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 224/233, 22 refs.

. . . an approach termed the "inverse operator" . . . is presented which leads to approximate detector structures via the Neumann series expansion of linear operator theory. . . .

SEQUENTIAL DESIGN OF EXPERIMENTS WITH TWO RANDOM VARIABLES
L. R. Abramson, Columbia U., New York, N.Y., Electronics Research Labs., Tech. Rept. T-2/180, 20 Sept. 1962, 113 p. refs., AD 295 617, N64-15953.

. . . Bayes sequential procedures are studied, and it is proved that a Bayes decision rule always exists . . . The properties of a class of tests, called tandem tests, are studied, and necessary and sufficient conditions for a tandem test to be asymptotically Bayes are found.

A TECHNIQUE FOR THE MEASUREMENT OF THE POWER SPECTRA OF VERY WEAK SIGNALS
R. M. Goldstein, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 2, June 1962, p. 170/173.

. . . designed to distinguish the spectrum of a weak signal which is masked by strong background noise. The method was applied during the Jet Propulsion Laboratory Venus radar experiment to study spectral characteristics of the echo. . . .

SEQUENTIAL TESTS FOR THE MEAN OF A NORMAL DISTRIBUTION IV (Discrete Case)
H. Chernoff, Stanford U., Calif., Technical rept. no. 1, 31 Jan. 1964, 32 p., AD431 814.

The problem of sequentially testing whether the mean of a normal distribution is positive has been approximated by the continuous analogue where one must decide whether the mean drift of a Wiener-Levy process is positive or negative. . . .

ESTIMATING THE CURRENT MEAN OF A NORMAL DISTRIBUTION WHICH IS SUBJECTED TO CHANGES IN TIME
H. Chernoff, et al., Standford U., Calif., Tech. Rept. 91, 31 Oct. 1963, 44 p., refs., AD 425 901, N64-13092.

ESTIMATION IN MIXTURES OF DISCRETE DISTRIBUTIONS
A. C. Cohen, Jr., Georgia U., Athens Inst. of Statistics, Tech. Rept. 12, Aug. 15, 1963, 11 p. refs., N63-23426.

THE VARIANCE OF THE MEAN OF CORRELATED SAMPLES
I. Eisenberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-21, April/ May 1963, p. 168/170.

OPTIMUM POWER ESTIMATES WITH SMALL SAMPLES
I. Eisenberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-25, Dec./Jan. 1963, p. 200/205.

DETECTION OF THE PEAK OF AN ARBITRARY SPECTRUM
L. Kleinrock, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 215/221.

A new procedure is described for determining that frequency at which the spectrum of a signal has its absolute peak. The salient feature of the procedure is that it does not explicitly involve the estimation of the spectrum of the signal itself. . . .

HILL CLIMBING METHODS FOR THE OPTIMIZATION OF MULTIPARAMETER NOISE DISTURBED SYSTEMS
H. J. Kushner, Lincoln Lab., Mass. Inst. of Tech., Lexington, June 1963, 9 p., AD 416 066.

Modifications of the statistical technique of stochastic approximation are used as a means of experimentally optimizing multiparameter systems on which the only available information is obtained from noise perturbed samples of the performance . . .

ON THE NON PARAMETRIC ESTIMATION OF THE PROBABILITY DENSITY
M. R. Leadbetter, Research Triangle Inst., Durham, N.C., Technical rept. no. 11, 24 May 1963, 96 p., AD 415 764.

NON-PARAMETRIC STATISTICS. A DDC REPORT BIBLIOGRAPHY
T. Long (comp), Defense Documentation Center, Alexandria, Va., Bibliography for Jan. 1963-Nov. 1963, Nov. 1963, 1 v., AD 422 850.

A photo bibliography of documents from the statistical literature which deal with non-parametric statistics dated from 1954 through 1963. . . .

CONTINUOUS ESTIMATION OF SEQUENTIALLY CORRELATED RANDOM VARIABLES
C. G. Pfeiffer, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, NASA CR-53016, JPL-TR-32-524, 30 Oct. 1963, 21 p., refs.

ASYMPTOTIC EFFICIENCY OF A CLASS OF c-SAMPLE TESTS
M. L. Puri, Courant Inst. of Mathematical Sciences, New York U., N.Y., Rept. no. IMM NUY314, Nov. 1963, 40 p., AD 428 118.

A c-sample problem is considered by examining the 2-sample problem and generalizing the results obtained by other authors. . . . A number of well known tests are included . . .

ESTIMATION OF THE COVARIANCE AND AUTOREGRESSIVE STRUCTURE OF A STATIONARY TIME SERIES
M. C. Schaerf, Stanford U., Calif., Rept. no. 12, 13 Jan. 1964, AD 432 148.

. . . given a finite length of record from a discrete parameter normal covariance stationary time series with zero mean . . . estimate the

covariance function and other quantities related to it, like the autoregression coefficients. . . .

A BAYESIAN PROCEDURE FOR DETECTION OF SLIPPAGE
F. B. Smith, Jr., Carnegie Inst. of Tech., Pittsburgh, Pa., CIT ORD 16TR8, Feb. 1963, 118 p., AD 405 026.

SPACE-TIME SAMPLING AND LIKELIHOOD RATIO PROCESSING IN ACOUSTIC PRESSURE FIELDS
P. L. Stocklin, J. Brit. Instn. Radio Engrs., vol. 26, no. 1, July 1963, p. 79/91.

LEAST-SQUARES ESTIMATION OF PARAMETERS FOR ASYMPTOTES OF EXTREMES
J. E. Walsh, System Development Corp., Santa Monica, Rept. no. SP1566, 26 Feb. 1964, 21 p., AD 433 836.

Consider a specified one of the largest order statistics of a sample of size n from a continuous population. . . . Development of a nonparametric estimate of the asymptotic distribution for an extreme furnishes the basis for the estimation. . . .

ON TWO-STAGE NON-PARAMETRIC ESTIMATION
E. Y. H. Yen, Minnesota U., Minneapolis, May 1963, 43 p., AD 406 713.

A two-sample, two-stage non-parametric estimation problem is studied. . .

Related Publications:

DETECTION OF RADAR SIGNALS BY DIRECT MEASUREMENT OF THEIR EFFECT ON NOISE STATISTICS
G. I. Cohn, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 821/831.

The fundamental problem involved in the detection of targets by radar methods is that of observing an event at the output of a radar and arriving at a decision as to whether this event was due to target echoes and noise or to noise alone. This paper is concerned with the development of methods for storage and selective readout of radar information in such a manner as to increase the probability of making a correct decision . . . a detection method which is directly responsive to changes in noise statistics caused by the presence of a pulse. . . .

AN APPROXIMATE METHOD IN SIGNAL DETECTION
W. F. Frieberger, Brown U., Div. of Applied Mathematics, Providence, R. I., 7 Feb. 1962, 6 p., AD 404 972.

A theorem from the theory of Toeplitz forms (ref. 1) is applied to the problem of estimating the best test statistic for the detection of Gaussian signals in Gaussian noise.

SEQUENTIAL DETECTION OF GAUSSIAN SIGNALS IN GAUSSIAN NOISE
T. Kailath, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 35/37.

. . . some results are presented on the performance of the optimum receiver in the special example studied in RS 36-13, p. 38/42. The special example treated the detection of one of a set of unknown signals in Gaussian noise. The very limited initial information is supplemented by the use of "learning" observations or labeled samples of each different type of unknown signal. . . . We shall here examine the rate at which the probability of error using the ideal receiver goes down as the number of learning observations increases.

METHOD FOR THE DETERMINATION OF THE OPTIMAL WEIGHTING FUNCTIONS OF DISCRETE FILTERS FOR ONE CLASS OF NON-STATIONARY RANDOM PROCESSES (In Russian)
P. D. Krut'ko, Tekhnicheskaia Kibernetika, Jan.-Feb. 1963, Engineering Cybernetics, Jan.-Feb. 1963, p. 47/53, (Translation), A64-15928.

. . . a method for determining the optimal weighting functions of discrete filters for nonstationary random processes whose correlation functions are given in the form of polynomials of finite powers of the secondary variables. The method eliminates the necessity for solving a system of higher-order algebraic equations.

CANONICAL FORMS FOR ERROR PROBABILITIES IN BINARY BAYES DETECTION
D. Middleton, Air Force Cambridge Research Labs., Bedford, Mass., Nov. 1963, 32 p., AD 427 881.

. . . composite situation involving detection in noise of signals of one general class (S1) vs signals of another general class (S2) . . . The results are general and apply for continuous as well as discrete sampling for nonnormal, nonadditive, and stationary cases . . . Specific use of these canonical relations is illustrated by several examples . . .

JOINT DISTRIBUTIONS WITH PRESCRIBED MOMENTS
E. C. Posner, et al., JPL Space Progr. Summ., vol. 4, no. 37-25, Dec./Jan. 1963, p. 186/194.

In many scientific problems, two random variables, X and Y, have a joint distribution, but only the marginal distributions are known, together with some other information. . . . This article uses the principle of maximum entropy (ref. 37) to pick out one plausible joint distribution from the various possible ones allowed by the marginal distribution and the given cross moments. It is shown that a joint distribution of maximum entropy exists and is unique, under very general conditions. Furthermore, it is shown that this unique joint distribution can be obtained as the solution of a certain nonlinear integral equation. Some indication is given of the proof involved.

2.844: Statistical Classification Theory for Signal Detection

Included: Recognition systems suitable for signal detection.

Not Included: Reconnaissance systems and their problems.

Cross References: Pattern recognition (Sect. 2.26); Map compilation systems (2.482); Phoneme recognition methods (2.360).

Principal Publications:

EXPERIMENTS IN ADAPTIVE PATTERN RECOGNITION
J. S. Bryan, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 174/179.

. . . experiments . . . to supply data concerning the power of some Perceptron-like adaptive pattern recognition systems using linear discriminate functions. . . .

ON THE EFFECTIVENESS OF RECEPTORS IN RECOGNITION SYSTEMS
T. Marill, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 11/17, 22 refs.

. . . the physical sample to be recognized is first subjected to a battery of tests; on the basis of the test results, the sample is then assigned to one of a number of prespecified categories.

The theory of how test results should be combined to yield an optimal assignment has been discussed in an earlier paper. Here, attention is focused on the tests themselves. . . .

Related Publications:

THE VARIANCE OF THE MEAN OF CORRELATED SAMPLES
I. Eisenberger, et al., JPL Space Progr. Summ., vol. 4, no. 37-21, April/ May 1963, p. 168/170.

Problem . . . arises in planetary radar, and elsewhere . . . One has a receiver containing a certain filter. A radar return of mean u is added to receiver noise to create a white Gaussian stochastic process of mean u and variance σ_0^2 . . . The process is passed through a linear filter . . . The resulting function is then sampled periodically. One wishes to estimate u by taking the average of n samples. The question is, what is the variance of this estimate, and in particular, how does the variance decrease with n?

2.845: Moment Detection and Related Methods

Included: Statistical filter theory; Temporal moments; Hausdorff moment problem; Separation of signals with overlapping spectra; Detection of one of several statistically independent signals with identical spectra; Sample rank tests; Moments of order statistics; Two sample problem.

Principal Publications:

ON THE MEAN SQUARE STABILITY OF RANDOM LINEAR SYSTEMS
J. C. Samuels, IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 248/259.

. . . extended to systems containing one or more non-independent parameters. It is shown that the second product moment of the solution satisfies a linear integral equation which can be solved in closed form in some important special cases.

INVESTIGATION OF DIGITAL DATA COMMUNICATION SYSTEMS
J. G. Lawton, Cornell Aeronautical Lab., Inc., Buffalo, N. Y., Rept. no. US-1420-S-1, RADC TR 61-58, 3 Jan. 1961, AD 256 584.

. . . The properties of impulse noise are examined and . . . and the effect of packed codes are investigated. Moment detection, which refers to a decision technique based on the use of temporal moments is investigated both analytically and experimentally.

METHOD OF INCREASING THE SELECTIVITY OF RECEIVERS FOR TWO AM SIGNALS WITH SUPERIMPOSED FREQUENCY SPECTRA
Yu. N. Babanov, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 12, Dec. 1962, p. 45/48.

. . . The presence in the receiving channel of the communication system of powerful oscillations of an interfering station worsens the reception conditions and in to a breakdown in communications. In order to design a system capable of eliminating the harmful effect of the interfering station, we shall make use of the fact that the probability that the carrier frequencies of the desired and interfering stations are coincident is very small.

. . . a system of special IF amplifier stages is effective in eliminating the harmful effect of the signal of the unwanted station. . . .

ON MOMENTS OF ORDER STATISTICS AND QUASI-RANGES FROM NORMAL POPULATIONS
Z. Govindarajulu, Minnesota U., Minneapolis, 29 Jan. 1962, rev. 27 Nov. 1962, 19 p., AD 429 252.

The lower bound on the number of integrals to be evaluated is obtained in order to know the first, second and mixed (linear) moments of the normal order statistics . . . in a sample of size N assuming that these moments are available for sample sizes less than N. . . .

SIMULTANEOUS TRANSMISSION OF TWO STATISTICALLY INDEPENDENT SIGNALS OVER A SINGLE CHANNEL
R. D. Leytes, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 12, Dec. 1962, p. 15/25.

The structural circuit method is used to investigate filtering (the extraction of one of the signals) by a linear filter. White noise is assumed to be present and the filters are assumed to have a bell-shaped frequency characteristic. A mean square criterion is used for estimating the filtering error. . . .

THE ASYMPTOTIC NORMALITY OF TWO TEST STATISTICS ASSOCIATED WITH THE TWO-SAMPLE PROBLEM
S. Blumenthal, Applied Mathematics and Statistics Labs., Stanford U., Calif., Technical rept. no. 85, 28 Feb. 1963, 31 p., 16 refs., AD 400 399.

Proofs are presented for the asymptotic normality of two statistics which have been proposed to test the hypothesis that two samples come from the same parent population.

THE STRUCTURE OF THE SOLUTION SET FOR A GENERALIZED REDUCED HAUSDORFF MOMENT PROBLEM
E. B. Cobb, et al., Mathematics Research Center, U. of Wisconsin, Madison, Technical summary rept. 453, Jan. 1964, 22 p., AD 433 876.

The solution set for a generalized reduced Hausdorff moment problem is shown to be the closure of the convex hull of cumulative distribution functions with small spectra.

PERCENTILE MODIFICATIONS OF TWO SAMPLE RANK TESTS
J. L. Gastwirth, Stanford U., Calif., Technical rept. no. 95, 11 Feb. 1964, 27 p., AD 433 869.

. . . increasing the efficiency of rank tests relative to the best tests for samples from normal distributions without using complicated scoring systems such as the normal scores tests. . . .

RELATIONS AMONG MOMENTS OF ORDER STATISTICS IN SAMPLES FROM TWO RELATED POPULATIONS
Z. Govindarajulu, Case Inst. of Tech., Cleveland, Ohio, Nov. 1963, 5 p., AD 434 303.

It is shown that the moments of order statistics in samples drawn from a population symmetric about zero can be expressed in terms of the moments of order statistics in samples drawn from the population obtained by folding the symmetric population at zero. . . .

Related Publications:

SMALL-SIGNAL RECEPTION BY THE METHOD OF BINARY INTEGRATION (Translation)
V. I. Bunimovich, et al., Radio Engng. Electronic Phys., vol. 11, Nov. 1962, p. 1734/1740, A63-20083.

. . . binary integration with regard to detection of a weak signal which is a stationary, random, Gaussian process against a background of stationary Gaussian noise possessing a spectral density curve of the same shape as that of the signal. The SNR at the output of the binary integration device is plotted as a function of the interrogation frequency at optimum threshold level, and as a function of the threshold level for different interrogation frequencies. . . .

VISUAL PATTERN RECOGNITION BY MOMENT INVARIANTS
M. K. Hu, IRE Trans. Inform. Th., vol. IT-8, no. 2, Feb. 1962, p. 179/187.

EXPERIMENTAL INVESTIGATION OF A METHOD FOR IMPROVING THE SELECTIVITY OF RADIO RECEIVERS FOR OVERLAPPING AM SIGNAL SPECTRA
Yu. N. Babanov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 6, June 1963, p. 27/30, AD 408 846.

Results of experimental investigations on the separation of two AM signals with overlapping frequency spectra in radio receivers are reported. The experimental circuit with which the investigation was performed is given. . . .

ASYMPTOTIC EFFICIENCY OF A CLASS OF c-SAMPLE TESTS
M. L. Puri, Courant Inst. of Mathematical Sciences, New York U., N. Y., Rept. no. IMM NYU314, Nov. 1963, 40 p., AD 428 118.

A c-sample problem is considered by examining the 2-sample problem and generalizing the results obtained by other authors. . . . A number of well known tests are included . . .

A BAYESIAN PROCEDURE FOR DETECTION OF SLIPPAGE
F. B. Smith, Jr., Carnegie Inst. of Tech., Pittsburgh, Pa., CIT ORD 16TR8, Feb. 1963, 118 p., AD 405 026.

. . . procedure . . . for deciding, on the basis of a sample, whether all normal populations in a given family have the same mean, or, as an alternative, that all but one of the populations have a common mean. . . . applied to a typical slippage problem, that where the mean of an unspecified distribution might change in either direction by a fixed known amount. Special attention is given the case where the sample can be drawn from only a single population.

2.846: Post Detection Operations. Smoothing of Detected Signals

Included: A posteriori probability computing methods; Post detection filtering; Limiter following a power law detector; Band pass filter after detector; Slicer and counter after detector; Reconstruction of quantized and sampled signals; Smooth limiters after detectors; Smoothing filters; Smoothing operations; Least-square smoothing; Noise stripping processes after detection.

Not Included: Design of Limiters; Filter construction; Sampling theorems (1); Aliasing error (1); Digital-to-analog converters.

Cross References: Linear optimum filter theory (2.812)

Principal Publications:

LINEAR LEAST-SQUARES SMOOTHING AND PREDICTION WITH APPLICATIONS
S. Darlington, Bell Syst. Tech. J., vol. 37, Sept. 1958, p. 1221/1294.

PROBABILITY DENSITIES OF THE SMOOTHED "RANDOM TELEGRAPH SIGNAL"
W.M. Wonham, et al., J. Electronics and Control, vol. 4, June 1958, p. 567/576.

NONSTATIONARY SMOOTHING AND PREDICTION USING NETWORK THEORY CONCEPTS
S. Darlington, IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 1/13.

THE STATISTICS OF RADAR VIDEO AFTER LINEAR AND NONLINEAR MIXING
P.R. Dax, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 850/859.

In many radar applications, two or more video channels have to be mixed to produce a single channel of information. Two examples are:
(1) The stacked-beam radar where a signal may exist in one out of n beams and where a composite plan picture is required.
(2) The multifrequency radar where a signal may exist simultaneously in all n channels and where maximum signal enhancement is required in the common channel.
In this paper, the statistics of the video after resistance (linear) mixing or diode (peak or trough selection) mixing are derived. . . .

SIGNAL-TO-NOISE RATIOS IN SMOOTH LIMITERS
J. Galejs, IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 79/85.

OPTIMUM LINEAR LEAST-SQUARE SMOOTHING AND PREDICTION
R. Mittra, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 422/430.

. . . discusses the mathematical problem of the design of smoothing and prediction filters for stationary random processes. . .

DIGITAL DATA PROCESSING FOR FINITE MEMORY FILTERS
A.J. Monroe, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 49/56.

. . . This paper is concerned with the analysis and/or synthesis of digital programs to operate on an input signal so as to give some particular desired output. . . . will include ordinary smoothing, smoothing with prediction and differentiation . . . smoothing with prediction and integration. . . .

INFORMATION LOSS ASSOCIATED WITH DECISION-MAKING IN ADDITIVE GAUSSIAN CHANNELS
B. Reiffen, MIT, Res. Lab. Quarterly Progress Rept. #52, Jan. 1959, p. 107/108.

The a posteriori probability computing channel (APPCC). After being perturbed by additive white Gaussian noise, a received signal is crosscorrelated with replicas of each of the possible transmitted signals, and the a posteriori probability of each input event is computed These ℓ a posteriori probabilities or the crosscorrelations from which they are determined are the outputs of the channel.

ON THE POSTDETECTION CORRELATION BETWEEN TWO SINUSOIDAL SIGNALS WITH SUPERIMPOSED CORRELATED NOISE (Correspondence)
K. Blotekjaer, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 271/272.

The problem of measuring autocorrelation and cross-correlation is frequently encountered in experimental analysis. . . . The results of the present paper have also been successfully applied to the analysis of signals from earth satellites. Since most of the signals used in transmission techniques are high-frequency signals with relatively narrow bandwidths, the correlation measurements are most easily performed on the detected signals, whereas for theoretical calculations the correlation between the undetected signals is required. It is therefore of great importance to know the relationship between the correlation before and after detection. It is the purpose of this paper to establish this relationship for a special class of signals, namely signals consisting of a sinusodial component with superimposed narrow-band Gaussian noise. . . .

ON THE APPLICATION OF THE SIGNAL EXTRAPOLATION METHOD UNDER CONDITIONS OF PULSE INTERFERENCE SUPPRESSION
A.A. Gorbachev, et al., Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 8, 1961, p. 49/55.

The article presents a signal extrapolation method accomplished with the help of a power polynomial, as well as some experimental results of its application to the suppression of pulse interference. . . .

SEQUENTIAL DETECTION OF GAUSSIAN SIGNALS IN GAUSSIAN NOISE
T. Kailath, JPL Res. Summ., no. 36-13, Dec./Jan. 1961, p. 38/42.

. . . The ideal receiver . . . computes the set of a posteriori probabilities . . . the various Gaussian processes conditional on the received waveform. In this report the study of the sequential detection of Gaussian signals in Gaussian noise is begun.

LINEAR RECONSTRUCTION OF QUANTIZED AND SAMPLED RANDOM SIGNALS
D.S. Ruchkin, IRE Trans. Commun. Syst., vol. CS-9, no. 9, Dec. 1961, p. 350/355.

THE AMPLITUDE DISTRIBUTION AND FALSE ALARM RATE OF NOISE AFTER POST-DETECTION FILTERING
S. Thaler, et al., Proc. IRE, vol. 49, Feb. 1961, p. 479/485.

A NOTE ON USING CASCADED SIMPLE AVERAGES FOR OBTAINING ACCELERATION INFORMATION (Correspondence)
J. P. O'Donohue, IRE Trans. Circuit Theory, vol. CS-9, no. 2, June 1962, p. 187.

. . . The purpose of this letter is to compare two types of smoothing by cascade simple averages to obtain acceleration information. One technique, termed acceleration criterion, uses smoothed second differences and the other, termed velocity decrement, uses velocity changes per unit time to determine the acceleration. The advantages of the latter technique will be explained.

TWO-DIMENSIONAL SPATIAL FILTERING AND COMPUTERS
W.D. Fryer, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 529/535.

. . . An important class of smoothing filters, with weighting functions approximately Gaussian, is derived and used for illustration. . . .

THE APPLICATION OF INVERSE CONVOLUTION TECHNIQUES TO IMPROVE SIGNAL RESPONSE OF RECORDED GEOPHYSICAL DATA
C.F. George, et al., Proc. IRE, vol. 50, no. 11, Nov. 1962, p. 2313/2319.

The process of restoring signal resolution to data recorded from a sluggish measuring device may be accomplished by appropriate mathematical operations on the data using a large ditigal computer. Smoothing techniques may be applied in the transform domain to derive an inverse convolver to be used in real space. The inverse convolver, a non-physically realizable filter function, when convolved with the output of the device, restores high-frequency components necessary for sharp detail. . . .

ON A METHOD OF SIGNAL EXTRAPOLATION BY POWER SERIES
A.A. Gorbachev, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 7, July 1962, p. 9/12.

A method of extrapolating signals interrupted by pulse interference is examined. The method is based on the use of loops of series-connected RC sections. . . .

OPTIMUM CRITERIA FOR THE DETECTION OF SIGNALS IN NOISE (In Japanese)
T. Inoue, et al., J. Inst. Elect. Commun. Engrs. Japan, vol. 45, no. 5, May 1962, p. 605/612.

. . . Application is made to the basic digital post-detection integration system in which the sampled inputs are fed to a detector followed by a slicer and a counter, and the optimum slice level and optimum count were evaluated by a computer.

PERFORMANCE OF ERROR-REJECTING DETECTORS FOR UNCODED BINARY SIGNALS IN GAUSSIAN NOISE
M.A. Koerner, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 165/169.

The optimum receiver . . . consists of a computer which determines the a posteriori probability of each of the possible signals, and a maximum-liklihood decision device. . . .

EXTRAPOLATION (PREDICTION) OF A FUNCTION WITH A LIMITED SPECTRUM FROM ITS DISCRETE VALUES
Yu. G. Pollyak, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 11, Nov. 1962, p. 59/67.

The possibility of predicting (extrapolating) a continuous function with a limited frequency spectrum from the results of discrete measurements taken at equal "past" time intervals is established. The sufficient conditions for such extrapolations are formulated. The accuracy of the approximate prediction formulas is discussed. . . .

A TELEMETRY IMPROVEMENT STUDY
Philco Corp., Palo Alto, Calif., Technical documentary rept., (Rept. no. WDL-TR1909), 1 Oct. 62, lv. incl. illus. tables, AD 289 875.

. . . Both i-f filtering and post-detection filtering are considered. . . . Results show that such filtering is of marginal value for the particular telemetry signal investigated.

BAND-PASS NONLINEARITIES
N. M. Blachman, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 162/164.

. . . a simple method for analyzing the effect of a nonlinearity sandwiched between band-pass filters, applying it to the case of weak signals when both filters pass the same band of frequencies, and obtaining completely general expressions for the output signal and noise when the output filter passes a harmonic of the input band. . . .

THE USE OF DIGITAL DATA SYSTEMS
L. W. Gardenhire, Proc. Nat. Telem. Conf., May 1963, no. 3—1.

. . . Several methods of interpolating between samples are explained and a new process called computer interpolation is presented which allows for a reduction in required samples by using a computer to look at the correlation between several samples. . . .

DATA SMOOTHING
J. R. Garrett, et al., Radio Corp. of America, Patric AFB, Fla., In AF Missile Test Center New Data Reduction Methods to Improve Range Data, (1963), p. 183/196, N64-15319.

A brief history of smoothing or filtering data is presented, and a type of filter in which the frequency response can be improved without increase in the timespan is described . . .

EXPERIMENTAL INVESTIGATIONS OF THE PEAKS OF THE SMOOTHED ENVELOPE OF QUASI-SINUSOIDAL NOISE
V. T. Goryainov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 3, March 1963, p. 1/8.

DISTRIBUTION OF OVERSHOOT PERIODS FOR THE SMOOTHED ENVELOPE OF QUASI-SINUSOIDAL NOISE
V. T. Goryainov, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 8, Aug. 1963, p. 1/7.

Experimental results are presented showing the average number of overshoots and the distribution of positive or negative overshoot periods in a smoothed envelope comprising the sum of a sinusoidal signal and quasi-sinusoidal noise. The experimental data obtained are compared with results of analytical investigations.

RESTORATION OF TIME FUNCTIONS DISTORTED BY TRANSDUCERS DESCRIBED BY DIFFERENTIAL EQUATIONS
H. H. Grote, Army Electronics Research and Development Agency, Fort Monmouth, N. J., March 1963, 15 p., AD 408 341.

. . . The restoration of signals which have passed through a low-pass filter is demonstrated and shows surprising similarity between the original and the restored time functions. This method is esp cially suited for application on the analog computer.

SVOISTVA OBOBSHCHENNOGO OPERATORA SGLAZHIVANIIA (The Properties of a Generalized Smoothing Operator) (In Russian)
A. V. Gur'ev, et al., Radiotekhnika, vol. 19, Feb. 1964, p. 67/72, A64-15725.

. . . used in the correlation analysis of unsteady random processes . . . The relative accuracy of smoothing, depending on the chosen smoothing interval, is estimated.

APPLICATIONS OF DIGITAL FILTERING TECHNIQUES TO DATA PROCESSING
M. A. Martin, General Electric Co., Philadelphia, Pa., Missile and Space Div., In AF Missile Test Center New Data Reduction Methods to Improve Range Data, 1963, p. 197/223, N64-15320.

. . . Applications of the theory to filters used in smoothing, differentiation, interpolation, and power spectrum analysis of sampled data are discussed. . . .

THRESHOLD DECODING
J. L. Massey, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 5 April 1963, 123 p., AD 407 946.

Two procedures for decoding linear systematic codes, majority decoding and a posteriori probability, are formulated . . .

DISCRETE SMOOTHING FILTERS FOR CORRELATED NOISE
J. D. Musa, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 2121/2151.

OPTIMUM TRIGGER LEVEL FOR A LIMITER FOLLOWING A SQUARE-LAW DETECTOR
T. Nishimura, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 158/160.

PICTURE REGENERATION FROM QUANTIZED DATA
J. G. Raudseps, Ohio State U., Research Foundation, Columbus Antenna Lab., (Rept. 122-19), July 31, 1963, 34 p., 3 refs., N63-22505.

. . . The reduction of the essential information contained in a picture to constant-intensity contours for computer storage and subsequent regeneration by a modified Flexowriter, is reported. Six quantitizing levels were used, and data smoothing methods were developed for both horizontal and vertical scans . . .

SOLUTIONS TO THE LINEAR SMOOTHING PROBLEM
H. E. Rauch, IEEE Trans. Automatic Control, vol. AC-8, Oct. 1963, p. 371/372, A64-12537.

Derivation, for a linear dynamic system, of relations which directly relate the smoothed estimate of the state of the system at a particular time to instantaneous observations of the system. . . .

A TECHNIQUE FOR CALCULATING SMOOTHING AND DIFFERENTIATION COEFFICIENTS
J. P. Sheats, et al., National Aeronautics and Space Administration Marshall Space Flight Center, Huntsville, Ala., Sept. 26, 1962, 28 p., 3 refs., N63-21995.

. . . a least squares procedure for calculating smoothing and differentiation coefficients and a technique for establishing the standard deviations of the data on which the smoothing and differentiation formulas are used.

Related Publications:

AN OUTPUT PREDICTION SYSTEM TO IMPROVE THE PERFORMANCE OF ON-OFF AND SATURATING CONTROL SYSTEMS
J. Mills, Proc. Instn. Elect. Engrs. Pt. B, vol. 108, no. 42, Nov. 1961, p. 667/671.

POLYNOMIAL FILTERING OF SIGNALS
F. W. Nesline, Jr., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 531/542.

. . . Even though this subject has received considerable attention in the literature during the last several decades, there is no reference specific enough to aid the engineer materially in selecting and evaluating a filter for a particular application. The purpose of this paper is to fill this need by presenting the detailed properties of filters that regenerate a signal as a continuous, or as a discrete, polynomial in time. The properties of interest in design and evaluation are presented for polynomial outputs as high as third order. The formulas clearly show the interactions between input parameters, network parameters, and output parameters, and in addition, they eliminate much of the tedious calculation usually associated with the design and evaluation of an optimum filter. . . .

STUDY AND EXPERIMENTAL INVESTIGATION ON SAMPLING RATE AND ALIASING IN TIME-DIVISION TELEMETRY SYSTEMS
D. G. Childers, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 4, Dec. 1962, p. 267/283.

. . . In most applications, especially when the interpolation error must be 1 per cent or better, a minimum samples per cycle of 3 or higher will be required. . . .

SNOW REMOVAL—A NOISE-STRIPPING PROCESS FOR PICTURE SIGNALS
R. E. Graham, IRE Trans. Inform. Th., vol. IT-8, no. 2, Feb. 1962, p. 129/144.

TRUNCATION ERROR OF SAMPLING-THEOREM EXPANSIONS
H. D. Helms, et al., Proc. IRE, vol. 50, Feb. 1962, p. 179/184.

. . . arises in reconstituting a band-limited function by summing over only a finite number (instead of the requisite infinite number) of samples of this function in an appropriate sampling-theorem expansion. Upper bounds are given for the truncation errors of the Cardinal and Fogel sampling expansions and for "self-truncating" versions of these two sampling expansions . . .

SIGNAL FIDELITY IN RADAR PROCESSING
W. A. Penn, IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 204/218.

. . . Degradation of the desired signal due to the statistical fluctuation of the signal itself is also considered. The distinction between predetection integration and post detection processing is made. . . .

EIN ENERGIEKRITERIUM SUR BEWERTUNG VON IMPULSFILTERN (An Energy Criterion for the Analysis of Pulse Filters) (In German)
W. Postl, Arch. Elekt. Uebertragung, vol. 16, July 1962, p. 351/355.

. . . The scale of merit . . . as introduced by O. Herrmann and W. Schussler, has turned out to be a useful criterion for the adequate performance of such devices in multichannel data transmission systems. It can be shown, however, that filters of a high degree are possibly related too favorably by this criterion.

A criterion that may be applied within a wider range, being based on the energy distribution of a single pulse in both the time and frequency spaces, is defined in this paper. . . .

REDUCTION OF QUANTIZING NOISE BY USE OF FEEDBACK
H. A. Spang, III, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 373/380.

. . . using linear feedback around the quantizer to shape the noise spectrum. Each output sample will then contain not only signal information but also information about the errors in the previous samples. Such a system is analyzed for random input signals of a rather general nature. . . . A comparison is made of the mean-square error with and without feedback. . . .

A TWO-STATE MODULATION SYSTEM
A. G. Bose, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 1963, 10 p., AD 423 294.

. . . has the property that the modulating signal can be recovered by lowpass filtering . . . combines aspects of frequency and pulsewidth modulation in a manner that enables its realization in terms of a simple closed-loop system having a nonlinear forward path and a linear passive feedback path. . . .

AN OUTLINE AND DISCUSSION OF THREE PROPOSED METHODS FOR THE DATA ANALYSIS OF RADAR RETURN PULSES
G.W. Evans, II, et al., Stanford Research Inst., Menlo Park, Calif., Memo Rept. 5, Aug. 1963, 36 p., AD 415 906.

This report suggests extensions for the application of the covariance and power spectral density functions and for the finite Fourier transform and conjugate transform . . . for the analysis of radar return pulses when more than one data sample may be extracted from each return pulse.

A DIODE DIGITAL-TO-ANALOG CONVERSION TECHNIQUE
J. Ihnat, Naval Research Lab., Washington, D.C., (NRL rept. no. 5866), 30 Jan. 1963, incl. illus., tables, AD 297 390.

The transformation is approximate since errors are introduced during conversion. Various techniques have been developed to minimize these errors; the most popular ones are the weighted resistor method and the ladder arrangement. The digital-to-analog conversion speed amounted to 20 microseconds for the case considered.

SYNTHESIS OF OPTIMAL FILTERS FOR A FEEDBACK QUANTIZATION SYSTEM
E.G. Kimme, et al., IEEE Trans. Circuit Theory, vol. CT-10, no. 3, Sept. 1963, p. 405/413.

. . . The feedback filter F is assumed to be a tapped delay line, whose top weights are obtained through a rapidly converging iterative procedure on an IBM 7090 automatic computer. . . . passive, lumped parameter predistortion and reconstruction filters are designed.

SYNTHESIS OF CONTINUOUS ANALOG DATA FROM DISCRETE SAMPLE DATA VIA A PB250-TRICE LINK
J.C. McCoy, National Aeronautics and Space Administration Marshall Space Flight Center, Huntsville, Ala., 2 Jan. 1964, 24 p., N64-18101.

A procedure is described for using discrete, widely dispersed measurements of wind velocity to generate continuous curves suitable for use as driving functions in a simulated flight of the Saturn Vehicle. . . The problem is solved by first, on the 7090, fitting the 26 values in each set of measurements with a fifth-order smoothing equation. The 7090 next breaks the smoothing curve into 125 segments of equal width, calculates the slopes of straight lines connecting the end-points of these segments, and records the slopes on tape in PB250 format. With the PB250 acting as interpreter, the TRICE is then used to integrate the slopes with respect to time . . .

Section 2.85
Decision Theory

2.850: General Publications on Decision Theory

Included: Books and surveys on decision theory; Minimum error demodulation in general; Locally optimum detectors; Probabilistic information processing in general.

Not Included: Information theory (1).

Cross References: Statistical signal extraction methods (Sect. 2.84).

Principal Publications:

DETECTION AS A STATISTICAL DECISION PROBLEM (Abstract)
D. Van Meter, IRE Nat. Conv. Rec., March 1958, p. 3.

THE METHOD OF DETERMINING OPTIMUM SYSTEMS USING GENERAL BAYES CRITERIA
V.S. Pugachev, IRE Trans. Circuit Theory, vol. CT-7, no. 4, Dec. 1960, p. 491/505, 18 ref., including many Russian publications.

. . . problems of finding an algorithm of an optimum system designed for detecting or estimating signals in the presence of interferences may be formulated as follows.

ON THE ASYMPTOTIC EFFICIENCY OF LOCALLY OPTIMUM DETECTORS
J. Capon, IRE Trans. Inform. Th., vol. IT-7, no. 2, April 1961, p. 67/71.

A detector examines an unknown waveform to determine whether it is a mixture of signal and noise, or noise alone. The Neyman-Pearson detector . . . is optimum for all values of the signal-to-noise ratio, and its implementation is usually quite complicated . . . it is desired to detect signals which are very weak compared to the noise. The locally optimum detector is defined as one which has optimum properties only for small signal-to-noise ratios. It is proposed as an alternative to the Neyman-Pearson detector. . . .

SIMULATION OF DECISION SYSTEMS, PAPERS AND NOTES
C.M. Festa, et al., Mitre Corp., Bedford, Mass., Rept. no. SR48, 54 p., Jan. 1962, ESD TDR63 424, AD 410 267.

THE STATUS OF STATISTICAL DECISION THEORY
J.C. Hancock, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 763.

. . . applications of this theory to the digital communication problem is briefly reviewed. Systems having multiplicative as well as additive types of disturbances are considered. Assumptions necessary to realize functional receivers are discussed and related to experimental results.

COHERENT DETECTION ON PULSED RADARS
A. Kerdock, Microwave Research Inst., Polytechnic Inst. of Brooklyn, N.Y., Research rept. no. PIBMRI-1103-62, June 1962, 33 p., incl. illus., 4 refs., AD 295 076.

. . . discussed from a statistical decision theory viewpoint. The Neyman Pearson test is applied to two cases . . .

RECENT DEVELOPMENT IN INFORMATION AND DECISION PROCESSES
R. E. Machol and P. Gray, (editors), New York The Macmillan Co., 1962, 197 p.

This book contains twelve papers and constitutes the proceedings of the Symposium on Information and Decision Processes held on April 12-13, 1961, at Purdue University, Lafayette, Ind. . . .

DECISION-MAKING PROCESSES IN PATTERN RECOGNITION
G. S. Sebestyen, New York, The Macmillan Co., 1962, 162 p.

. . . design of practical procedures for solving pattern recognition problems starting from basic decision-theory considerations. . . . not . . . all . . . procedures are directly motivated by decision theory. . . . most seem to have their origins in a common-sense engineering approach to real problems . . . provides additional insight into his common-sense approach by relating it to decision theory or classical statistics. . . . It is this constant feedback between mathematical analysis and engineering design which makes Sebestyen's book so valuable. . . .

PROBABILISTIC INFORMATION PROCESSING BY MEN, MACHINES, AND MAN-MACHINES SYSTEMS
W. Edwards, System Development Corp., Santa Monica, Calif., Rept. no. TM1418 000 01, 13 Aug. 1963, 9 p., AD 428 727.

A discussion is presented of the argument that Bayes's theorem is a normative model for inductive inference. Results of several experiments are presented that indicate that human beings do not behave the way this normative model says they should, the implications of these ideas and findings suggest the design of information processing systems intended for business, military, or governmental use. Research in progress on such systems is described.

LECTURES ON DECISION THEORY
W. Karush, System Development Corp., Santa Monica, Calif., 28 May 1963, 96 p., AD 410 789.

. . . deal with the mathematical theory of decision-making, i.e., with mathematical models of situations in which there is a set of alternative actions, some condition of knowledge concerning the relationship between action and outcome, and an objective of achieving a 'good' or 'best' outcome on the basis of this knowledge.

INFORMATION PROCESSING RELEVANT TO MILITARY COMMAND: SURVEY, RECOMMENDATIONS AND BIBLIOGRAPHY VOLUME II (BIBLIOGRAPHY APPENDIX)
A. E. Murray, et al., Cornell Aeronautical Lab., Inc., Buffalo, N.Y., Final rept., ESD TDR63 349, 1963, AD 418 176.

. . . consists of a set of bibliography cards referencing the most recent works in artificial intelligence, pattern recognition, and decision making . . .

MATHEMATICAL SPECIFICATIONS OF GOALS FOR DECISION PROBLEMS
R. Radner, California U., Berkeley, Technical rept. no. 14, June 1963, 71 p., AD 413 363.

. . . The problem of how to formulate and solve a decision is itself a decision problem. Determining optimal procedures for searching for an optimum is discussed.

THE EMPIRICAL BAYES APPROACH TO TESTING STATISTICAL HYPOTHESES
H. Robbins, Columbia U., New York, Rept. no. CU-34-63-Nonr-26659-MS, 30 Jan. 1963, 28 p., 13 refs., AD 298 886.

METHODS OF THRESHOLD SIGNAL RECEPTION IN THE PRESENCE OF NOISE
J. Seidler, Foreign Tech. Div., Air Force Systems Command, Wright Patterson AFB, Ohio, 7 Oct. 1963, 139 p., AD 424 402.

. . . Analysis is based on decision functions theory . . . Consideration is given to the reception of signals transmitting discrete, continuously varying, or multidimensional (multiplexed) messages. Reception of radio and radar signals is discussed in more detail . . . The relationship between the conventional concept of signal to noise ratio and the concepts of decision theory are discussed.

Related Publications:

CERTAIN RELATIONSHIPS IN OPTIMUM SYSTEMS FOR DETECTING SIGNALS (Continuation)
L. S. Gutkin, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 4, 1960, p. 34/43.

. . . The detection of pulse packets . . .
If all the pulses in the packet are coherent one with another (i.e., rigidly inter-connected in phase) and consequently their coherent summation is possible, then all the formulae in Part I remain

true if the energy of the signal is understood to mean the energy of the whole packet of n pulses . . .

a. Binary detection . . .
b. Optimum system for m-alternative discrimination and detection. . . .

STATISTICAL THEORY OF SIGNAL DETECTION
C.W. Helstrom, New York, Pergamon Press, 1960, 364 p.

MAXIMUM INTERFERENCE RESISTANCE OF SYSTEMS WITH DISCRETE SIGNALS
N. L. Teplov, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 4, 1960, p. 44/60.

. . . in the presence of coherent and non-coherent reception. . . . takes into account the correlation of instantaneous value of interference. The "limiting excesses of the signal above the interference" correspond to maximum interference resistance. . . . Functions are formulated for an ideal receiver which will achieve maximum interference resistance. Use is made of the simplest method of analysis, namely signal and interference amplitude envelopes (skirting). . . .

A NOTE ON REALIZATION OF DECISION NETWORKS USING SUMMATION ELEMENTS
P.M. Lewis, II, Inform. Control, vol. 4, no. 2/3, Sept. 1961, p. 282/290.

Frequently engineering considerations place limitations on the size of decision making systems and on the resources of the system designer. The pertinent high order probability distributions may be unknown and it may not be possible to measure and/or store these distributions in their entirety; some type of approximation is then necessary. One type of approximation that has been studied previously involves measuring and storing several of the lower order component distributions and using these to approximate the high order distribution, using the criterion of maximum entropy. . . .

CONSTRUCTION AND DECISION DETECTION OF BINARY INFORMATION
B.W. Russell, Proc. Nat. Aerosp. Electronics Conf., May 1961, p. 302/306.

. . . definition of "information" . . . description of a simple Pulse Code Modulation communication system . . . derives basic signal power, bandwidth, information rate and error loss factor relationships . . .

A COMPUTER-AUGMENTED TECHNIQUE FOR THE DESIGN OF LIKELIHOOD-RADIO RECEIVERS
T.G. Birdsall, et al., Cooley Electronics Lab., U. of Michigan, Ann Arbor, Technical rept. no. 130, 3674-3-T, Oct. 1962, 36 p., incl. illus., tables, 9 refs., AD 292 161.

Standard approximation methods of design of detection receivers are reviewed, and a method based on fitting curves calculated on a high-speed computer is presented. This computer-augumented technique is applied to the design problem of a signal distorted by a sign-preserving, rapidly varying transmission gain.

ELEMENTARY STATISTICAL DECISION THEORY
H. Chernov and L. Moses, Moscow, Sovetskoye Radio, 1962, 408 p.

. . . presented in accessible and attractive form with a wealth of clear and interesting examples. . . . should be of considerable interest to a wide circle of specialists. . . .

MINIMUM-ERROR DEMODULATION OF BINARY PCM SIGNALS
E.F. Smith, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 400/409.

. . . determined for binary pcm waveforms with statistical dependence between the data samples. It is assumed that the demodulation decisions are made one-word-at-a-time, by utilizing an arbitrary number, n, of statistically dependent, received noisy words.

For additive, bandlimited white Gaussian noise, a method is developed for simulating with a digital computer the minimum-error demodulation. . . .

2.851: Analytical Background of Decision Theory

Included: General Bayes' criterion; Bayes' inverse probability theorem; Ideal observer criterion; Optimal decision functions; Multiple observers; Quanification theory; Wald criterion; Neyman-Pearson criterion; Inductive probability as a decision criterion; Extreme value theory; Multiple input model; Equal likelihood function; Bayes' procedure for the detection of slippage; Decision demons; Demon in the box; Paired comparison schedule; Optimum decision rules; Optimum threshold setting.

Not Included: Information theory (1).

Cross References: Detection under multipath conditions (2.873); Asymptotic forms of detectors (2.811); Threshold setting for null zone detection methods (2.853); Cumulative decision techniques (2.854).

Principal Publications:

APPLICATION OF COMPARISON OF EXPERIMENTS TO RADAR DETECTION AND CODING PROBLEMS
N. M. Abramson, Stanford Electronics Labs., Stanford U., California, Technical Report No. 41, July 1958, 85 p., AD 201 444.

COMPARISON OF THE OPTIMAL PROPERTIES OF THE WALD AND NEYMAN-PEARSON CRITERIA
S. A. Aivazian, Theory Prob. Appl., vol. 4, no. 1, 1959, p. 83/87.

MULTIPLE OBSERVERS, MESSAGE RECEPTION, AND RATING SCALES
L. R. Decker, et al., J. Acoust. Soc. Amer., vol. 31, no. 10, Oct. 1959, p. 1327/1328.

Two sets of decision rules were employed to select among the responses of three observers. . . . Confidence ratings substantially improved the selection of the correct message reception in the absence of response agreement among observers.

SIGNAL/NOISE RATIO IN PULSE-CODE MODULATION SYSTEMS —USE OF THE IDEAL OBSERVER CRITERION
J. W. R. Griffiths, J. Brit. Instn. Radio Engrs., vol. 19, March 1959, p. 183/186.

CALCULATION OF OPTIMUM THRESHOLD LEVEL FOR COMBINATIONS OF DETECTORS AND INHIBITORS
C. W. Helstrom, Westinghouse Research Labs., Research Report 412FF366-R1, June 1959, 29 p.

ON A CLASS OF OPTIMAL DECISION FUNCTIONS FOR A BINOMIAL FAMILY OF DISTRIBUTIONS
I. N. Kovalenko, Theory Prob. Appl., vol. 4, no. 1, 1959, p. 95/99.

OPTIMAL PROPERTIES IN THE STATISTICAL THEORY OF RECEPTION (Correspondence)
H. Lass, et al., IRE Trans. Inform. Th., vol. IT-5, no. 3, Sept. 1959, p. 138/139.

. . . applications of the Bayes' inverse probability theorem to the problem of optimum receiver design.

A PROOF METHOD FOR QUANTIFICATION THEORY: ITS JUSTIFICATION AND REALIZATION
P. C. Gilmore, IBM J. Res. Developm., vol. 4, no. 1, Jan. 1960, p. 28/35.

. . . a method for proving that a sentence of quantification theory is logically true. . . . provides a decision procedure over a subclass of the sentences of quantification theory. . . . includes all syllogisms. . . . program for the IBM 704 Data Processing Machine is outlined . . .

OPTIMUM SYSTEM THEORY USING A GENERAL BAYES CRITERION
V. S. Pugachev, IRE Trans. Inform. Th., vol. IT-6, no. 1, March 1960, p. 4/7.

An extension of the general method of obtaining an optimum system developed by the author is given to include the case of nonlinear dependence of the observed function on signal parameters. The method affords effective determining of optimum systems designed for the detection and reproduction of signals in the presence of noise using various practically adequate criteria.

A NOTE OF OPTIMUM LINEAR MULTI-VARIABLE FILTERS
R. J. Kavanagh, Proc. Instn. Elect. Engrs., Pt. C, vol. 108, no. 14, Sept. 1961, p. 412/417.

The explicity solution for the optimum linear physically realizable multi-variable filter involves the factorization of a power-spectra matrix into two matrices, one having all its poles in the left-half p-plane and the other having all its poles in the right-half p-plane. No general method of accomplishing this factorization has previously been available. This note contributes a method of factorizing any power-spectra matrix in the required manner. As a result, the explicity solution for the optimum filter is obtainable in a number of cases not previously solvable without resort to implicity methods. . . . In the course of deriving the factorization method two interesting results will be developed. The first is a general method of converting a set of cross-correlated signals to an equal number of incoherent white-noise signals. The second concerns the converse problem, i.e., that of converting a set of incoherent white-noise signals to an equal number of signals with a desired power-spectra matrix. In both cases it will be shown that the desired transformation may always be effected by means of a physically realizable linear multi-variable system. . . .

SOME RESULTS ON NEW CLASSES OF MATCHED FILTERS
D. Middleton, Rand Corp., Santa Monica, Calif., Rept. no. RM-2625, 12 July 1961, 34 p., AD 261 027.

. . . the design criterion is the automatic decision process that occurs when the signals are detected or measured in noise. . . . conceived theoretically, and the approach is indicated to their deisgn and construction for actual use.

ON SINGULAR AND NONSINGULAR OPTIMUM (BAYES) TESTS FOR THE DETECTION OF NORMAL STOCHASTIC SIGNALS IN NORMAL NOISE
D. Middleton, IRE Trans. Inform. Th., vol. IT-7, no. 2, April 1961, p. 105/113.

ON THE STATISTICAL DETECTION PROBLEM FOR MULTIPLE SIGNALS
J. B. Thomas, et al., Rome Air Development Center, Griffiss Air Force Base, N.Y., Rept. no. RADC TN 61-182, Nov. 1961, 16p., AD 268 753.

The problem of detecting signals in noise is considered for the multiple input model, where each of the inputs can contain one of many possible signals. The detection procedure for this model becomes, in general, the testing of multiple hypotheses. Two detection criteria are examined for choosing among multiple hypotheses and it is found that, for both criteria, the decision is based on the likelihood functions for the various signals. Systems for computing likelihood ratios are examined in detail for the multiple input case. A multidimensional matched filter is considered and its relationship to the likelihood ratios is shown. Optimum signals are determined for the two-hypothesis problem.

ON THE DETECTION AND ESTIMATION PROBLEM FOR MULTIDIMENSIONAL GAUSSIAN RANDOM CHANNELS
J. K. Wolf, Rome Air Development Center, Griffiss Air Force Base, N.Y., RADC-TR-61-214, Nov. 1961, 26 p., AD 268 492.

. . . Such a channel is characterized by the property that a deterministic input results in a set of received waveforms which are sample functions of Gaussian processes. For the detection problem, a receiver is found which operates on the set of received waveforms and gives as outputs, voltages proportional to the logarithm of the likelihood functions of the possible transmitted signals. For the estimation problem, it is assumed that the intelligence-carrying signal is itself a sample function of a Gaussian process and a mathematical description is presented of a receiver which has as its output the maximum a posteriori estimate of this signal. Examples are presented in which optimum receivers are found for both the detection and estimation problem.

EXTREME-VALUE THEORY APPLIED TO FALSE-ALARM PROBABILITIES (Correspondence)
T. L. Fine, et al., IRE Trans. Inform. Th., vol. IT-8, no. 3, April 1962, p. 259.

INDUCTIVE PROBABILITY AS A DECISION CRITERION FOR COMMUNICATION SYSTEMS
B. Harris, New York U., Coll. of Engineering, N.Y., Scientific rept. no. 9, AFCRL 62-71, 15 Jan. 1962, 47 p., incl. illus., 15 refs., AD 275 602.

OPTIMUM CRITERIA FOR THE DETECTION OF SIGNALS IN NOISE (In Japanese)
T. Inoue, et al., J. Inst. Elect. Commun. Engrs., Japan, vol. 45, no. 5, May 1962, p. 605/612.

The statistical treatment of the detection of sinusoidal signals in noise is briefly reviewed. Measurements according to the binary decision (signal or noise) principle based on observation of N sampled inputs inevitably involve some risk of error. Optimum criteria for minimizing this risk are here deduced from Wald's statistical decision function. . . . Application is made to the basic digital post-detection integration system in which the sampled inputs are fed to a detector followed by a slicer and a counter, and the optimum slice level and optimum count were evaluated by a computer.

LIMITING ACCURACY OF THE ESTIMATE OF THE SIGNAL PARAMETER DURING RECEPTION IN NORMAL NOISE
Ye. I. Kulikov, Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 7, July 1962, p. 1/9.

By maximizing the equal-likelihood function, formulas are obtained for the evaluation of the variance of the estimate of the signal parameter during its reception in additive normal noise. . . .

REMARKS ON AND REVISIONS OF SOME EARLIER RESULTS IN TWO RECENT PAPERS (Correspondence)
D. Middleton, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 385/387.

. . . The principal difficulties appear in the author's first paper. . . . D. Middleton, "On singular and non-singular optimum Bayes tests for the detection of normal stochastic signals in normal noise" . . .

ADAPTIVE DECISION ELEMENTS TO IMPROVE THE RELIABILITY OF REDUNDANT SYSTEMS
W. H. Pierce, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 124/131, 16 refs.

. . . Redundant but unreliable binary or analog signals are used most effectively when each signal's error probability is used to compute a statistical estimate of the correct signal. When errors in the inputs are independent, the statistical estimates can be made by simple summing circuits. Adaptive circuits are proposed which give the most reliable inputs the largest weights. . . .

ERROR ANALYSIS OF A STATISTICAL DECISION METHOD
R. Albrecht, et al., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1963, p. 34/38.

For the recognition of patterns as members of certain classes it is assumed that the probability distributions of certain characteristic features are known. For a decision based on the maximum likelihood criterion bounds on the statistical error are derived. In the case of normally distributed and statistically independent features these bounds are evaluated. . . .

THEORY OF SIGNAL DETECTABILITY. OBSERVATION-DECISION PROCEDURES
T. G. Birdsall, et al., Cooley Electronics Lab., U. of Michigan, Ann Arbor, Technical rept. 136, Jan. 1964, 164 p., AD 429 220.

. . . extended to include observation-decision procedures other than the familiar fixed observation-decision procedure. . . . include prede termined nonsequential procedures and the optimum (Bayes') sequential procedure, deferred decision. . . . if the available output signal-to-noise ratio which one would obtain is small, then sequential procedures consume about 60% as much time as nonsequential procedures and the resultant error probabilities are approximately the same; if the available output signal-to-noise ratio is on the order of +10 db, then deferred decision and the optimum non-sequential procedure consume about the same amount of time with sequential procedures making less terminal decision errors.

RAZLICHENIE PARAMETROV SIGNALOV PRI IKH VYDELENII IZ SHUMOV (Discrimination of Signal Parameters During their Extraction from Noise) (In Russian)
I. A. Bol'shakov, et al., Radiotekhnika i Elektronika, vol. 9, Feb. 1964, p. 201/210, A64-17124.

Presentation of a solution to the problem of optimum Bayes filtration of random varying parameters of similar signals received in a unique mixture against the background noise . . . contains a special device which discriminates the parameters according to the type of their coding in the mixture and character of variation with time.

DECISION THEORY SOLUTIONS FOR NONLINEAR DEVICES (Correspondence)
D. B. Brick, IEEE Trans Inform. Th., vol. IT-9, no. 3, July 1963, p. 205/206.

Relationships are derived showing that the optimum processor for a process that has been transformed by a memoryless nonlinear device is of the same form as that for the original untransformed process if we replace the measured values of the process by their inversely transformed values.

In the response of Lumicon, Vidicon, or Image Orthicon TV Systems, it is not unusual to operate in the nonlinear region. . . . Since the actual characteristics of the TV systems are pseudo-logarithmic in shape, a specialization to a log characteristic and Gaussian noise is made at the end of this communication. Optimality is specified in terms of minimum risk. . . .

PAIRED-COMPARISON EXPERIMENTS INVOLVING FIVE RESPONSE CLASSES
W. A. Glenn, Research Triangle Inst., Durham, N. C., Technical rept. no. 3, Rept. no. SU74, 29 March 1963, 21 p., AD 416 050.

. . . For example, the treatments may be two blends of coffee and the comparison consists of selecting the blend with the better flavor . . . involves the pairwise comparisons of two or more treatments by one or more judges. It is proposed to extend the method of Glenn and David to cover paired-comparison experiments involving five response classes . . . a tie . . . a mile preference . . . a strong preference . . .

AN IBM 650 PROGRAM FOR A COMPLETE PAIRED COMPARISON SCHEDULE (PARCOPLET-2-21)
H. Gulliksen, Educational Testing Service, Princeton, N. J., May 30, 3 p., AD 418 264.

The method of paired comparisons and the law of comparative judgment provides a calling method with accurate checks on the goodness of fit of the data to the theory. An IBM 650 program has been prepared that will handle a complete paired comparison schedule for any number of objects up to and including 21 . . .

A BAYESIAN APPROACH TO SOME BEST POPULATION PROBLEMS
I. Guttman, et al., Wisconsin, U. Madison, Technical rept. no. 15, Feb. 1963, 20 p., AD 410 291.

DECISION PROCEDURES FOR FINITE DECISION PROBLEMS UNDER COMPLETE IGNORANCE
B. Harris, et al., Mathematics Research Center, U. of Wisconsin, Madison, Technical summary rept. 445, Jan 1964, 34 p., AD 433 878.

. . . there exists a family of decision procedures, each of which satisfies all required properties. An algorithm for determining optimal strategies is given. . . .

STUDIES IN FUNCTIONAL EQUATIONS OCCURRING IN DECISION PROCESSES
T. E. Harris, et al., RAND Corp., Santa Monica, Calif., Report no. P382, 18 March 1963, 62 p., AD 422 825.

Certain problems are considered which arise from a study of the Bayes' decision making model. The Markov process associated with this model is considered and existence and continuity, as well as a functional equation, are obtained for the limit distribution . . .

IDEALIZED AND PRACTICAL PANDEMONIUM
S. F. Kozubovs'kyy, Joint Publications Research Service, Washington, D. C., JPRS-17432, OTS-63-21043, Feb. 1, 1963, 14 p. refs., Transl. into English from Avtomatyka (Kiev) v. 7, no. 4, 1962, N64-10475.

. . . The data or images which must be distinguished are fed to the input of the instrument. To each possible image which belongs to a certain number, there corresponds a functional block

(subprogram) which is imagined to be in the form of a demon in a box . . . Each demon calculates the degree of his resemblance to the image . . . The upper "decision demon" selects the image that belongs to the demon whose output signal is the greatest . . . was tested by setting up the task of dintinguishing the dots and dashes of letters of the Morse-code alphabet.

A METHOD OF DIGITAL SIGNALLING IN THE PRESENCE OF ADDITIVE GAUSSIAN AND IMPULSIVE NOISE
L. Kurz, IRE Internat. Conv. Rec., Pt. 4, vol. 4, March 1962, p. 161/173.

. . . Basically, it is shown that subdividing the decision interval (O, T) and coding each subinterval using optimum waveforms is a more efficient method of combatting the impulse noise than using optimum waveforms in the full decision interval. . . .

DECISION PROCESSES IN COMMUNICATION THEORY
D. Middleton, Middleton (David), Concord, Mass., In: Md. U. Proc. of the Space Communications Inst., Md. U., College Park, June 23-28, 1963, 1963, p. 74/76, refs., N64-17200.

Two principal classes of decision . . . are distinguished: (a) signal detection . . . (b) signal extraction . . . Detection is recognized as the communication equivalent of hypothesis testing in statistical theory, whereas extraction is the counterpart of statistical estimation . . .

CANONICAL FORMS FOR ERROR PROBABILITIES IN BINARY BAYES DETECTION
D. Middleton, Air Force Cambridge Research Labs., Bedford, Mass., AFCRL 63 561, Nov. 1963, 32 p., AD 427 881.

. . . composite situation involving detection in noise of signals of one general class (SI) vs signals of another general class (S2) . . . The results are general and apply for continuous as well as discrete sampling for nonnormal, nonadditive, and stationary cases . . . Specific use of these cannonical relations is illustrated by several examples . . .

DECISION RULES BASED ON FAILURE-RESTORATION PROCESSES
R. Radner, System Development Corp., Santa Monica, Calif., Rept. no. SP1530 000 00, 3 Jan. 1964, 49 p., AD 437 770.

. . . proposes a class of rules, called here maximum-likelihood-ratio rules, suggested by the Newman-Pearson theory of hypothesis testing. . . . presents mathematical examples of peacetime and wartime failure-restoration processes.

INFORMATION PATTERN, LEARNING STRUCTURE, AND OPTIMAL DECISION RULE
M. Sakaguchi, Inform. Control, vol. 6, no. 3, Sept. 1963, p. 218/229.

MARKOVIAN DECISION PROCESSES WITH UNCERTAIN TRANSITION PROBABILITIES OR REWARDS
E.A. Silver, Center for Operations Research, Mass. Inst. of Tech., Cambridge, Technical rept. no. 1, Aug. 1963, 256 p., AD 417 150.

In most Markov process studies to data it has been assumed that both the transition probabilities and rewards are known exactly. . . . purpose of this thesis . . . to study the effects of relaxing these assumptions to allow more realistic models of real world situations.

A BAYESIAN PROCEDURE FOR DETECTION OF SLIPPAGE
F.B. Smith, Carnegie Inst. of Tech., Pittsburgh, Pa., Technical Report No. 8, Feb. 1963, 123 p., 13 refs., N63-15840.

. . . deciding, on the basis of a sample, whether all normal populations in a given family have the same mean, or, as an alternative, that all but one of the populations have a common mean. . . .

ON THE STATISTICAL DETECTION PROBLEM FOR MULTIPLE SIGNALS
J.B. Thomas, et al., IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 274/280.

. . . each of the inputs can contain one of many possible signals. The detection procedure for this model becomes, in general, the testing of multiple hypotheses. Two detection criteria are examined for choosing among multiple hypotheses and it is found that, for both criteria, the decision is based on the likelihood functions for the various signals.

Systems for computing ratios are examined for the multiple input case. A multidimensional matched filter is considered and its relationship to the likelihood ratios are shown. Optimum signals are determined for the two-hypothesis problem.

BAYES THEOREM AND THE USE OF PRIOR KNOWLEDGE IN REGRESSION ANALYSIS
G.C. Tiao, et al., Wisconsin U., Madison, Technical rept. no. 14, Jan. 1963, 31 p., AD 409 435.

OPTIMAL THRESHOLD AND LEVEL SELECTION FOR QUANTIZING DATA
R.C. Titsworth, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, 196/200.

When a random process is quantized, there are generally two sets of parameters which must be considered: (1) The actual set of values, of levels . . . (2) The set of boundaries, or thresholds . . .

This note investigates optimum selection of these parameters.

RESEARCH IN COMPUTER DECISION PROCESS
G. O. Young, et al., University of Southern Calif., Los Angeles, Final rept., USCEC Rept. no. 98 101, Aug. 1963, 94 p., AD 419 695.

. . . two separate parts . . . The first is concerned with optimization criteria in systems design; the second deals with the identification problem for nonlinear systems.

FIRST CONGRESS ON THE INFORMATION SYSTEM SCIENCES. SESSION 4. JOINT MAN-COMPUTER DECISION PROCESSES
MITRE Corp., Bedford, Mass., Rept. no. SS4, ESD TDR 63 474 4, Feb. 1964, 118 p., AD 432 169.

. . . involves choosing one of a number of alternatives after simultaneously evaluating the several characteristics which distinguish the alternatives. . . . results of experiments conducted with human subjects to determine how decision-making performance varies with the number of characteristics presented in a complex decision problem. . . .

Related Publications:

FINITE AUTOMATA AND THEIR DECISION PROBLEMS
M. O. Rabin, et al., IBM J. Res. Developm., vol. 3, no. 2, April 1959, p. 114/125.

Finite automata are considered in this paper as instruments for classifying finite tapes. Each one-tape automaton defines a set of tapes, a two-tape automaton defines a set of pairs of tapes, et cetera. . . .

AMOUNT OF DECIDING AND DECISIONARY EFFORT
I. J. Good, Inform. Control, vol. 4, no. 2/3, Sept. 1961, p. 271/281.

. . . explicata are obtained for (1) the net amount of deciding contained in a mental event, F, in favor of an act or of a class of acts; (2) the decisionary effort contained in F, with respect to a class of acts. . . . It is found, for example, that much deciding can be done effortlessly, and on the other hand a small amount of deciding can consume a lot of effort. . . . A by-product of the discussion is a contribution to the axiomatics of what Kullback calls the "divergence" between two probability distributions. . . . The meanings of "decision" and "conclusion" are briefly considered. . . .

SEMI-MARKOVIAN CONTROL SYSTEMS
R. A. Howard, Mass. Inst. of Tech., Cambridge, Technical rept. no. 3, Dec. 1963, 57 p., AD 434 242.

. . . a statistical model useful in analyzing a wide variety of common problems, problems in the areas of maintenance, replacement, marketing, finance, and inventory control. The basis for the present model is a decision model developed for strictly Markov processes, characterized as processes in which the main interest is on state transitions rather than on the time required for a transition. . . . development of the semi-Markov process which allowed the time between transitions to be a random variable conditional on the transition made. . . . the decision model can be extended to the semi-Markov process. . . .

ASYMPTOTIC FORMS OF DETECTORS OF SIGNALS IN NOISE
W. L. Root, Mathematics Research Center, U. of Wisconsin, Madison, Feb. 1964, 39 p., AD 437 292.

. . . The first result is . . . an approximation, asymptotically correct as the observation interval becomes infinite, to . . . the optimum detector for sure signals in Gaussian noise. . . . has previously only been justified heuristically. The second result . . . a detector of noise-like signals in noise which has the merit of minimizing asymptotically a certain bound on the errors from among a wide class of quadratic detectors, specified in a completely practical way. . . .

MINIMUM-ERROR DEMODULATION OF BINARY PCM SIGNALS
E. F. Smith, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 400/409.

. . . determined for binary pcm waveforms with statistical dependence between the data samples. It is assumed that the demodulation decisions are made one-word-at-a-time, by utilizing an arbitrary number, n, of statistically dependent, received noisy words. . . .

2.852: Maximum Likelihood Deciders and Related Problems

Included: Optimum demodulator for Poisson processes; Likelihood ratio receiver; Largest-of selection method; Bayes' risk theory; Optimum threshold setting; Largest-of-n selection; M-out-of-n decision method; Bayes' detection; Normalized periodogram detector.

Not Included: Higher order data transmission systems (1).

Cross References: Correlation detectors (Sect. 2.82); Bayes' inverse probability theorem (2.851); Bayes' induction theorem (2.855); Maximum likelihood estimation (2.842).

Principal Publications:

MAXIMUM LIKELIHOOD DETECTION OF HAMMING CODED MESSAGES
W. Altar, Westinghouse Res. Lab. Res. Rept. 8-1040-R12, March 1958, 23 p.

OPTIMUM THRESHOLD FSK COMMUNICATION WITH DECISION REJECTION
D. Middleton, Air Force Command & Develop. Div., Air Research & Develop. Command, Bedford, Mass., Rept. no. AFCRC TR 60-137, April 1960, AD 245 725.

Optimum incoherent threshold detection of general FSK signals in formal noise is examined, where the new feature of decision rejection, as well as decision acceptance, is used. Structure of the optimum threshold system is given, and the error and rejection probabilities associated with the Bayes risk are computed for general signals and arbitrary baud lengths. It is shown, in particular, that for the same error probabilities in either state it is possible to have a smaller input signal level with rejection than without it, the rejection probabilities being non zero, of course, with a consequent reduction in information rate. Besides a detailed examination of the binary rejection cases, the theory of the multiple alternative detection process with decision rejection is also outlined.

ON THE APPROXIMATION TO LIKELIHOOD RATIO DETECTORS LAWS (THE THRESHOLD CASE)
H. Blasbalg, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p 194/195.

WIDE-BAND CARRIER COMMUNICATIONS. VOLUME IV. RANDOM SIGNAL CODING FOR FINITE MESSAGE SETS
T. L. Grettenberg, Lockheed Aircraft Corp., Sunnyvale, Calif., Technical rept. on Communications, Rept. no. 6-90-61-59, June 1961, 65 p., AD 264 328, supersedes Stanford Electronics Labs., Rept. no. TR 2004-3, AD 262 357.

The divergence between statistical hypotheses is used as a criterion for selection of a finite transmitter alphabet in a communication system. The members of the transmitter alphabet are sample functions from one of a finite set of normally distributed random processes. The receiver uses a maximum-likelihood decoding procedure, and the probability of error is evaluated for this receiver for a class of codes having orthogonal covariance functions.

A CODING CRITERION FOR CONTINUOUS CHANNELS DERIVED FROM LIKELIHOOD ESTIMATION
T. L. Grettenberg, Lockheed Aircraft Corp., Sunnyvale, Calif., Rept. LMSD-894811, March 1961, 34 p., AD 257 868, Supersedes Stanford Electronics Labs., Stanford U., Technical rept. 2004-1, AD 253 548.

FURTHER RESULTS ON THE DETECTABILITY OF KNOWN SIGNALS IN GAUSSIAN NOISE
H. C. Martel, et al., Bell Syst. Tech. J. vol. 40, no. 2, March 1961, p. 423/451.

. . . performance of a maximum likelihood detector operating on a finite set of discrete measurements of the stimulus as the set becomes large. The stimulus is either signal plus noise or noise alone. . . .

LIKELIHOOD DETECTION OF SMALL SIGNALS IN STATIONARY NOISE
P. Rudnick, J. Appl. Phys., vol. 32, no. 2, Feb. 1961, p. 140/143.

An approximation to the liklihood ratio which may be used in the detecting a small signal in stationary noise is derived. The result contains only low-order moments of the signal and only stationary properties of the noise; hence it is applicable without change of form to any sufficiently long observation period. In the Gaussian case, with the signal also stationary and both signal and noise power spectra continuous, the result represents passage through a linear Eckart filter, followed by square-law detection and equal-weight smoothing.

A COMPUTER-AUGMENTED TECHNIQUE FOR THE DESIGN OF LIKELIHOOD-RADIO RECEIVERS
T. G. Birdsall, et al., Cooley Electronics Lab., U. of Michigan, Ann Arbor, Technical rept. no. 130; 3674-3-T, Oct. 1962, 36 p., incl. illus. tables, 9 refs., AD 292 161.

Standard approximation methods of design of detection receivers are reviewed, and a method based on fitting curves calculated on a high-speed computer is presented. This computer-augmented technique is applied to the design problem of a signal distorted by a sign-preserving, rapidly varying transmission gain.

ON THE DETECTION OF A RANDOMLY DISTORTED SIGNAL IN GAUSSIAN NOISE
L. Halsted, et al., Michigan U., Ann Arbor, Technical rept. no. 129; Rept. no. 3674-2-T, Oct. 1962, 38 p., incl. illus., 8 refs., AD 291 982.

. . . designing a likelihood ratio receiver for detection of a signal that has been distorted by a randomly varying transmission loss and subsequently masked by an additive Gaussian noise . . . evaluated for the two-input samples case using a digital computer . . .

PERFORMANCE OF ERROR-REJECTING DETECTORS FOR UNCODED BINARY SIGNALS IN GAUSSIAN NOISE
M. A. Koerner, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec.-Jan. 1962, p. 165/169.

The optimum receiver . . . consists of a computer which determines the a posteriori probability of each of the possible signals, and a maximum-likelihood decision device.

ON THE PROBABILITY OF ERROR FOR LARGEST-OF SELECTION (Correspondence)
H. Ward, Proc. IRE, vol. 50, Jan. 1962, p. 93/94.

DISTRIBUTION OF THE NORMALIZED PERIODOGRAM DETECTOR
R.P. Wishner, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 342/349.

The detection problem for a radar receiver whose input signal is range-sampled Doppler-modulated sine waves in Gaussian noise of constant but unknown intensity is considered. The probability distribution for the likelihood ratio detector for this input is derived by applying a sequence of transformations. The distribution is a function of the signal-to-noise ratio and the error in the Doppler estimate. . . . This problem also has applications to a problem in diversity reception.

LARGEST OF N SELECTION SYSTEMS AFFECTED BY MULTIPATH TIME SPREADING (Correspondence)
J. Dumanian, Proc. IEEE, vol. 51, no. 2, Feb. 1963, p. 390.

Several authors have considered the error probabilities in detecting a signal when the transmitted signal is one of N orthogonal waveforms. . . . In this note . . . the received signal is Gaussian noise in Gaussian noise. Moreover, in this description it is assumed that the time duration of the received signal is greater than the reciprocal of the signal bandwidth. . . .

MAXIMUM-LIKELIHOOD DETECTION IN A BINARY CHANNEL WITH MEMORY
R.A. Gonsalves, et al., Northeastern U., Boston, Mass., Scientific Report No. 4, AFCRL-63-313, July 1963, 42 p., refs., AD 425 602, N64-12610.

. . . for binary signals transmitted sequentially over a channel with memory . . . The channel memory is assumed short enough so that there is intersymbol interference between adjacent symbols only . . . With the aid of a simplifying assumption, upper and lower bounds of the per symbol error probability are derived. These bounds check reasonably well with the results of a digital "Monte Carlo" experiment.

INVESTIGATION OF ANALOG AND DIGITAL COMMUNICATION SYSTEMS
J.G. Lawton, et al., Cornell Aeronautical Lab., Inc., Buffalo, N.Y., Griffiss AFB, N.Y., Rome Air Development Center, Final Report, Feb. 1962-Feb. 1963, RADC-TDR-63-147, May 1963, 187 p., 26 refs., N63-17933.

. . . Maximum likelihood reception of FM signals. . . threshold effects in FM receivers . . . transmission of analog information over a digital channel . . . comparison of digital data systems . . . dispersive channels. Optimization . . .

A NOTE ON BAYES DETECTION OF SIGNALS
F.C. Ogg, Jr., IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 57/60.

The general Bayes decision rule is derived, showing that the best decision rule is always the single decision with smallest expected cost. The likelihood function detector for multiple signal classes is extended to include overlapping signal classes which occur in adaptive detection and in detection of stochastic signals. Specification of a multiple-signal detector in terms of its error probabilities is discussed, and generalizations of the Ideal Observer and the Neyman-Pearson detector are obtained.

OPTIMUM DECODING AT LOW SIGNAL-TO-NOISE RATIOS
E.C. Posner, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 155-156.

. . . It is shown that if bit-by-bit detection is used, and if the expected number of bits in error is to be minimized, then maximum likelihood decoding is not optimum at low signal-to-noise ratios. . . .

M-OUT-OF-N DECISION LOGIC
M. Raship, Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 131/141.

A formal algebra is developed for the analysis and synthesis of switching networks made up of m-out-of-n decision elements. An m-out-of-n decision element is described by a threshold function in which the weights are fixed at unity, and the threshold is a positive integer . . .

AN OPTIMUM DEMODULATOR FOR POISSON PROCESSES; PHOTON SOURCE DETECTORS
B. Reiffen, et al., Proc. IEEE, vol. 51, no. 10, Oct. 1963, p. 1316/1320.

The optimum demodulator for time-varying Poisson processes is derived from consideration of the likelihood ratio. In the case of high background level radiation, it has been found that the optimum signal processing is cross-correlation. . . .

PRINCIPLES OF SYSTEMATIC CODING FOR ERROR CORRECTION
B.W. Russell, Electronic Warfare Div., Air Force Avionics Lab., Aeronautical Systems Div., Wright-Patterson Air Force Base, Ohio, Rept. for Jan. 1962-March 1963, June 1963, 56 p., AD 411 767.

. . . The importance and salient features of maximum likelihood detection are stressed. . . .

OPTIMIZATION OF SIGNALS
F.C. Schweppe, Lincoln Lab., Mass. Inst. of Tech., Lexington, Group rept. no. 64 4, ESD TDR 64 18, 16 Jan. 1964, 49 p., AD 430 345.

. . . A communication problem of deciding which of M signals was transmitted and a radar problem of deciding the range rate of a target are used as examples.

TABULATION OF THE PROBABILITY OF DETECTION AND CORRECT DECISION AMONG M ALTERNATIVES FOR PHASE-INCOHERENT RECEPTION
D. Shnidman, Air Force Cambridge Research Labs., Bedford, Mass., AFCRL 63 374, Sept. 1963, 31 p., AD 424 731.

THE PROBABILITY OF ERROR FOR LARGEST-OF-SELECTION BY NUMERICAL INTEGRATION (Correspondence)
R.C. Sommer, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 236.

An article by Ward . . . was recently published. It may be of interest that a similar analysis had been performed at New York University for evaluating various PFM (pulse-frequency modulation) space telemetry schemes. . . .

A LIMIT FOR THE PROBABILITY OF ERROR FOR LARGEST-OF-SELECTION (Correspondence)
F.G. Splitt, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 494/496.

In some recent communications Ward and Sommer discuss the problems associated with the computation of the error probability for largest-of selection when a noncoherent detection process is employed by the receiver. These problems have also been studied during the course of an investigation of multiple-time shift-keyed (T_mSK) transmissions at Northwestern University. It is the purpose of this communication to derive an expression for the limiting form of the probability of error as the number of channels or slots approach infinity. . . . groups or blocks of m (consecutive) digits are replaced by one of 2^m orthogonal sinusoidal functions. When frequency is utilized as the orthogonal modulation parameter there results a multiple-frequency shift-keyed (F_mSK) transmission. When the orthogonality is based on time, there results a multiple-time shift-keyed (T_mSK) transmission. . . .

Related Publications:

OPTIMUM SYSTEM THEORY USING A GENERAL BAYES CRITERION
V.S. Pugachev, IRE Trans. Inform. Th., vol. IT-6, no. 1, March 1960, p. 4/7.

STATISTICAL CONSIDERATIONS IN ELEMENT VALUE SOLUTIONS
R.S. Berkowitz, et al., IRE Trans. Mil. Electronics, vol. MIL-6, no. 3, July 1962, p. 282/288.

. . . The method presented is an iteration one using maximum likelihood estimation techniques at each stage, the iteration accounting for the nonlinearity of equations used with respect to the element value unknowns.

BAYES' OPTIMUM FILTERS DERIVED USING WIENER CANONICAL FORMS
D.B. Brick, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S35/46.

Canonical forms and circuit structures are derived for Bayes' optimum decision rules utilizing Wiener-like functionals. . . . The structures derived consist of orthogonal filter sets (usually Laguerre filters) followed by combinations of $_v$th-law-devices (Hermite polynomial generators of the Laguerre coefficients), amplifiers of specified gains, and then summing and division circuits . . . many forms of previously synthesized Bayes' structures. . . . have been valid primarily for processes obeying Gaussian or other special statistics and/or for the limiting cases of small or large signal-to-noise ratios. In many cases, they have involved the use of so-called Bayes' matched filters followed by zero-memory quadratic (or non-linear) and finite-memory linear operations. . . .

EXPERIMENTAL EVALUATION OF AN OPTIMUM DETECTOR FOR FSK TRANSMISSION THROUGH A RAYLEIGH FADING CHANNEL
E.E. Cossette, et al., Rome Air Development Center, Griffiss Air Force Base, N.Y., Rept. no. RADC TDR 62-554, Nov. 1962, 22 p., incl. illus., 6 refs., AD 291 892.

STATISTICAL PROPERTIES OF THE DICON RECEIVER
J.A. Dumanian, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 52 G-2, AFESD TDR 62-85, 2 March 1962, 11 p., illus., 3 refs., AD 275 278.

A STATISTICAL ANALYSIS OF THE SYNCHRONIZATION OF A BINARY RECEIVER (Correspondence)
H. Kaneko, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 498/501.

. . . In this paper, a very special case of the synchronization problem is considered. The information-bearing signal is a rectangular waveform and is transmitted through a channel perturbed by a stationary white Gaussian noise. A sinusoidal synchronizing signal is assumed to be transmitted separately from the information-bearing signals and is also perturbed by an independent noise. The Bayes receiver is considered for the detection of the information-bearing signal, and a synchronizer with a narrow-band filter and an ideal phase detector is assumed. . . .

IMPROVEMENT OF ENERGY DETECTION AS A RESULT OF CHANNEL SUBDIVISION (Correspondence)
J.A. Knudson, Proc. IEEE, vol. 51, no. 6, June 1963, p. 955.

It has been shown that an energy detector can be calibrated to read likelihood ratio, thus, for that class of signals identified by their energy content alone, the energy detector becomes an optimum receiver. . . . the original bandwidth B is divided into L equal-width subchannels making the individual channel bandwidth B/L cps . . .

PERFORMANCE ANALYSIS FOR THE COHERENT MULTIRECEIVER IN SPECULAR AND RANDOM MULTICHANNELS
W.C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 154/156.

The multireceiver combines, at the conclusion of each signaling interval, samples taken from both the matched filter and square law detector outputs (Fig. 6). Under the . . . assumptions . . . that the signals are assumed to be selected from an equal energy signaling alphabet which occurs with equal probability, the detection system is optimum in the a posteriori probability computing sense (ref. 9).

CANONICAL FORMS FOR ERROR PROBABILITIES IN BINARY BAYES DETECTION
D. Middleton, Air Force Cambridge Research Labs., Bedford, Mass, AFCRL 63 561, Nov. 1963, AD 427 881.

. . . composite situation involving detection in noise of signals of one general class (S1) vs signals of another general class (S2) . . . The results are general and apply for continuous as well as discrete sampling for nonnormal, nonadditive, and stationary cases . . . Specific use of these canonical relations is illustrated by several examples . . .

2.853: Null Zone Detection Methods

Included: Detection systems for erasure channels; Null reception analysis; Erasure fill-in techniques; Error rejecting detectors; Slave threshold devices; Multi-threshold detection systems; Canceling interval; Threshold decoding; Uncertainty regions; Null detectors; Null zone envelope detection; Controlled threshold devices.

Not Included: Channel models (1); Threshold logic design.

Cross References: Error detecting codes (2.772); Paired comparison experiments (2.851).

Principal Publications:

EXPERIMENTAL NULL-ZONE RECEPTION SYSTEMS
D. Hoffman, New York U. Coll. of Engineering, N.Y., Scienfific rept. no. 6, 15 Jan. 1958-14 Jan. 1959, Rept. no. AFCRC TN-59-152, Jan. 1959, 63 p., AD 212 259.

AN ESTIMATE OF THE STABILITY OF SLAVE THRESHOLD DEVICES
I.B. Kogan, et al., Radio Engng., vol. 14, no. 10, 1959, p. 82/92.

EXTENSION OF NULL-RECEPTION ANALYSIS TO BINARY COMMUNICATION SYSTEMS EMPLOYING ENVELOPE DETECTION, INCLUDING FSK
J.J. Metzner, et al., New York U., Coll. of Engrg., Scientific Report No. 8, AFCRC TN-59-562, July 1959, 20 p., AD 226 363.

OPTIMUM THRESHOLD FSK COMMUNICATION WITH DECISION REJECTION
D. Middleton, Air Force Command and Control Develop. Div., Air Research and Develop. Command, Bedford, Mass., Rept. no. AFCRC TR 60-137, April 1960, AD 245 725.

Optimum incoherent threshold detection of general FSK signals in formal noise is examined, where the new feature of decision rejection, as well as decision acceptance, is used. Structure of the optimum threshold system is given, and the error and rejection probabilities associated with the Bayes risk are computed for general signals and arbitrary baud lengths. . . .

CODED, DIVERSIFIED, RAYLEIGH-FADED BINARY SYMMETRIC THRESHOLD CHANNELS
Research Lab. of Electronics, MIT, Cambridge, Tech. rept. 384, 4 Dec. 1960, 32 p., AD 264 722.

The expressions for the probabilities associated with a Rayleigh-faded channel with null-zone detecting and diversity used are derived . . .

ON THE USEFULNESS OF INTRODUCING A CANCELLING INTERVAL
L.F. Borodin, et al., Radio Engng: Transl. of Radiotekhnika, vol. 17, no. 3, March 1962, p. 34/44.

. . . increasing the probability of accurate reception of a correcting code . . . Necessary and sufficient conditions are formulated for the usefulness of introducing the cancellation interval. Simple estimates are obtained for the cancellation intervals maximize the probability of correct reception and minimize the probable error. . . .

ERASURE FILL-IN FOR BINARY ERASURE CHANNEL
A. L. Duquette, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 64/66.

The concept of the binary erasure channel was first introduced by Elias (Ref. 8). Utilizing the properties of modulo 2 arithmetic, an analog of the Gauss-Jordan procedure (Ref. 9) may be employed . . .

An alternate decoding procedure for the binary erasure channel is given here which, for ceratin cyclic codes, has obvious advantages.

METHOD AND MERIT OF BINARY CODING FOR ANALOG CHANNELS
I. M. Jacobs, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 765/773.

. . . In this paper, we consider the improvement in rate and signal-to-noise ratio offered by coding and decoding for three values of detector quantization; $Q = 2$ (binary detection), $Q = 3$ (ternary or null-zone detection), and $Q = \infty$ (continuous or unquantized detection). A qualitative insight is then provided into convolutional encoding and sequential decoding as one means, adaptable to any value of Q, for realizing these gains.

LOGIC OF CONTROLLED THRESHOLD DEVICES
H. F. Klock, et al., Case Inst. of Tech., Cleveland Ohio, RADC-TDR-62-498, Dec. 1962, 187 p., 26 refs., N63-16944.

PERFORMANCE OF ERROR-REJECTING DETECTORS FOR UNCODED BINARY SIGNALS IN GAUSSIAN NOISE
M. A. Koerner, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 165/169.

The optimum receiver . . . consists of a computer which determines the a posteriori probability of each of the possible signals, and a maximum-likelihood decision device.

. . . in simply choosing the most probable signal we disregard the information regarding the probability of the alternate possibilities. The following analysis indicates a technique for employing this additional information to improve the performance of the binary channel.

ERROR PROBABILITIES FOR EQUICORRELATED M-ARY SIGNALS UNDER PHASE-COHERENT RECEPTION
A. H. Nuttall, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 305/314, 72 refs.

. . . derived in the form of previously untabulated single and double integrals. These integrals are amenable to to computer evaluation for arbitrary M. Two modes of reception are considered. In the first, one of M equal energy equiprobable signals is known to be transmitted during a symbol interval of T seconds through a nonfading channel with additive white Gaussian noise. . . . the cross-correlation coefficients between all the signals are equal. The probability of correct decision in both phase-coherent and phase-incoherent reception is derived exactly, as a function of the signal-to-noise ratio, the common cross-correlation coefficient, and the size of the signal set M. In the second mode of reception, the only difference is that a threshold is incorporated in the receiver. The probability of false detection and the probability of detection and correct decision are derived exactly for both phase-coherent and phase-incoherent reception as a function of the threshold level, the signal-to-noise ratio, the common cross-correlation efficient and the size of the signal set M.

THE MAJORITY DECISION ELEMENT AS A NULL DETECTOR (Correspondence)
R. C. Sommer, Proc. IRE, vol. 50, no. 12, Dec. 1962, p. 2518.

. . . It has been shown that even for unidirectional systems, null-zone reception is capable of increasing the information rate . . . it has been shown to provide a useful decision mechanism for decision-feedback systems. These treatments were based on null-zone detectors which, in the uncoded case, consisted of dividing the possible received signals into three zones. . . For the coded case the detectors were based on the properties of the code. This brief presentation considers the use of multiple receptions and a majority decision element as a null detector.

ON THE CHOICE OF BINARY CODES AND THRESHOLDS (Correspondence)
C. V. Freiman, Proc. IEEE, vol. 51, no. 3, March 1963, p. 478.

A GEOMETRIC TEST-SYNTHESIS PROCEDURE FOR A THRESHOLD DEVICE
P. Kaszerman, Inform. Control, vol. 6, no. 4, Dec. 1963, p. 381/398.

A Boolean function may be defined as a mapping from the vertices of an n-dimensional hypercube whose vertices are n-tuples of "1" and "-1" to (0, 1). A threshold function is then a Boolean function whose "1" or "TRUE" vertices are separable from the "0" or "FALSE" vertices by a hyperplane. Using this geometric representation, one may show that a threshold device realization may be approximated as follows: Form the vector sum of the TRUE vertices. The components of the resultant vector can then serve as the weights. The threshold is approximated by 2^{n-1} minus the number of TRUE vertices. . . .

RELIABILITY IMPROVEMENT OF DIGITAL COMMUNICATION USING REDUNDANCY IN UNCERTAINTY REGION RECEPTION
L. Kurz, New York U. Coll. of Engineering, N.Y., Scientific rept. no. 13, AFCRL Rept. no. 63 187, June 1963, 78 p., AD 414 370.

. . . utilizing the redundancy of the transmittible language to improve the reliability of a

digital communication system disturbed by additive non-white gaussian noise. . . . systems using orthogonal and binary digit codes . . . uncertainty region at the receiver. . . . an extension and generalization of null-zone reception previously applied to the improvement of binary transmission in the presence of white gaussian or peak-limited noise. . . . it is shown that communication links using orthogonal digit coding afford greater reliability than corresponding links using binary digit coding. . . .

THRESHOLD DECODING
J. L. Massey, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, 5 April 1963, 123 p., AD 407 946, N64-14111.

Two procedures for decoding linear systematic codes, majority decoding and a posteriori probability decoding, are formulated . . . linear transformation of the parity-check equations of the code into "orthogonal parity checks." The decoding decisions are then made on the basis of the values assumed by these orthogonal parity checks . . . It is shown that threshold decoding can be applied effectively to convolutional codes up to approximately 100 transmitted bits in length over an interesting range of rates. Very simple decoding circuits are presented for such codes. It is shown that threshold decoding is applicable to certain low-rate block codes, and that a generalization of the method is applicable to several other classes of block codes . . .

NULL-ZONE ENVELOPE DETECTION IN BINARY SYSTEMS
J. J. Metzner, et al., IEEE Trans. Commun. Electranics, no. 66, May 1963, p. 219/227, 12 refs.

. . . The effects of applying the null-zone decision mechanism to two types of envelope-detection systems are investigated, and comparisons are made with previous results for synchronous-detection systems. It is demonstrated conclusively that, just as for the synchronous system, null-zone reception offers a means of improving the information rate of a uni-directional system.

CUMULATIVE DECISION TECHNIQUES FOR ERROR-FREE COMMUNICATION SYSTEMS
J. J. Metzner, et al., New York U., N.Y., Fourteenth Scientific Report, NYU TR-400-82, AFCRL-63-330, July 15, 1963, 101 p., 13 refs., N63-21472 and also AD 417 230.

LOGICHESKIE VOSMOZHNOSTI REAL'NYKH POROGOVYKH ELEMENTOV (Possible Applications of Realizable Threshold Elements in Logical Design) (In Russian)
M. A. Rozenblat, et al., Akademiia Nauk SSSR, Izvestiia, Tekhnicheskaiia Kibernetika, Jan.-Feb. 1964, p. 50/64, 10 refs., A64-16974.

. . . presence of a zone in which the output signal of the threshold element is not uniquely defined . . . the conditions for the realization of threshold functions . . . are defined. The results of the analysis are applied to several examples in logical design.

Related Publications:

ERROR PROBABILITIES FOR NON-ORTHOGONAL M-ARY SIGNALS UNDER PHASE-COHERENT AND PHASE-INCOHERENT RECEPTION
A. H. Nuttall, Litton Systems, Inc., Waltham Mass., Technical rept. no. TR-61-1-BF), 15 June 1961, 153 p., AD 261 182.

. . . derived in the form of previously untabulated single and double integrals. Two modes of reception are considered. In the first . . . no fading and only one path is available for communication (no multipath). In the second . . . a threshold is incorporated in the receiver. If the largest correlation value is less than the threshold, a decision is made that no signal was transmitted; if the largest correlation value exceeds the threshold, the signal corresponding to that particular correlation value is decided to have been transmitted. . . .

MULTI-THRESHOLD DIGITAL DATA TRANSMISSION SYSTEMS, THEIR ADVANTAGES AND POSSIBLE OPERATIONAL MODES
A. Brothman, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 488/497.

ON THE SYNTHESIS OF THRESHOLD DEVICES
P. Kaszerman, New York U., N.Y., Rept. no. TR 400 84, Sept. 1963, 139 p., AD 437 294.

. . . A threshold function is defined as a Boolean function whose TRUE vertices are separable from the FALSE vertices by a hyperplane. It is shown that the vertices of the above hypercube lie on the surface of a hypersphere and are distributed uniformly over the surface of this hypersphere. . . .

BINARY DECISION FEEDBACK WITH ENVELOPE DETECTION
J. J. Metzner, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 227/239.

The performance of discarding and of cumulative decision-feedback systems employing null-zone reception is evaluated for two common types of envelope detection. . . .

2.854: Sequential Detection Methods

Included: Sequential decoding; Sequential estimation; Sequential analysis; Sequential search theory; List decoding; List detection; Automatic path-finding in the maze; Probabilistic decoding methods; Probability filters; Coherent sequential detection; Cumulative decision techniques; FCT = forced continuation testing; Range sampled sequential detection system; Sequential processors; Incoherent sequential detection; Square law sequential detector.

Not Included: Sequential machines in general; Automata; Switching theory; Signal processors (3A).

Cross References: Codes for sequential operations (2.752); Parameter estimation techniques (2.752); Parameter estimation techniques (2.842); Non-parametric estimation techniques (2.843); Search operations in detection theory (2.881); Coherent detection in general (2.834).

Principal Publications:

ZERO ERROR CAPACITY FOR LIST DETECTION
P. Elias, MIT Res. Lab. Electronics, Quart. Progress Rept., Jan. 1958, p. 88/90.

LIST DECODING
J. M. Wozencraft, MIT Res. Lab. Electronics, Quart. Progress Rept., Jan. 1958, p. 90/95.

THE APPLICATION OF SEQUENTIAL ANALYSIS TO BINARY COMMUNICATION SYSTEMS WITH A RAYLEIGH DISTRIBUTION OF SIGNAL INTENSITY FLUCTUATIONS
A. E. Basharinov, et al., Radio Engng. and Electronics, vol. 4, no. 2, 1959, p. 1/9.

EXPERIMENTAL RESULTS IN SEQUENTIAL DETECTION
H. Blasbalg, IRE Trans. Inform. Th., vol. IT-5, no. 2, June 1959, p. 41/51.

. . . it is shown that the Wald Theory of Sequential Analysis agrees well with experiment for the important case of Bernoulli Detection even when the excess over the boundaries at the termination of an experiment is neglected. . . . Experimental curves of the Operating Characteristic (OC) and Average Sample Number (ASN) Functions for several sets of parameters are given.

. . . The practical use of these detectors for parameter estimation is discussed.

AUTOMATIC PATH-FINDING IN THE MAZE (In German)
R. Eier, et al., Elektronische Rechenanlagen, vol. 1, Feb. 1960, p. 23/31.

The necessary informations, for goal seeking as well as for repeating the way or finding back to the start, must be stored and then may be applied by a suited program. . . .

SEPARATE SIGNAL FROM NOISE WITH PROBABILITY FILTERS
W. L. Still, Control Engng., vol. 7, no. 3, March 1960, p. 147/151.

DYNAMIC PROGRAMMING, SEQUENTIAL ESTIMATION AND SEQUENTIAL DETECTION PROCESSES
R. Bellman, et al., Proc. Nat. Acad. Sci., vol. 47, no. 3, March 1961, p. 338/341.

A SEQUENTIAL DETECTION SYSTEM FOR THE PROCESSING OF RADAR RETURNS
Aaron A. Galvin, Proc. IRE, vol. 49, Sept. 1961, p. 1417/1423.

SEQUENTIAL DETECTION OF GAUSSIAN SIGNALS IN GAUSSIAN NOISE
T. Kailath, JPL Res. Summ., no. 36-13, Dec./Jan. 1961, p. 38/42.

SEQUENTIAL ANALYSIS WITH APPLICATIONS TO RADAR DETECTION
J. Proakis, Electronic Systems Lab., Mass. Inst. of Tech., Cambridge, (Rept. no. ESL-R-116), Aug. 1961, 128 p. AD 263 571.

AN INVESTIGATION OF SEQUENTIAL DECODING
W. R. Wadden, et al., RCA Rev., vol. 22, no. 3, Sept. 1961, p. 522/542.

. . . presents theoretical results on the associated average number of decoding steps and the probability of error. Simulation studies of this decoding scheme are currently being performed on a digital computer.

SEQUENTIAL DECODING
J. M. Wozencraft and B. Reiffen, Mass., The Technology Press of MIT and New York, John Wiley and Sons, Inc., 1961, 74 p.

. . . reports on important research carried out at MIT and Lincoln Lab. during the past four years in the area of error-correcting codes. It is based on the doctoral theses of the authors and on work by M. Horstein and R. G. Gallagher. . . .

SEQUENTIAL PHENOMENA IN PSYCHOPHYSICAL JUDGMENTS: A THEORETICAL ANALYSIS
R. C. Atkinson, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 155/162.

. . . analysis of psychophysical detection experiments designed to assess the limit of a human observer's level of sensitivity. A mathematical theory of the detection process is introduced that, in contrast to previous theories, provides an analysis of the sequential effects observed in psychophysical data. Two variations of the detection task are considered: information feedback situation the subject is given information concerning the correctness of his responses, whereas in the no-feedback situation he is not. . . .

METHODS OF STATISTICAL SEQUENTIAL ANALYSIS, WITH APPLICATIONS TO RADIO ENGINEERING (In Russian)
A. Y. Basharinov and B. S. Fleyshman, Moscow, Soviet Radio Press, 1962, 353 p.

. . . examines problems in the theory of statistical sequential analysis relationships used to calculate indices for decision procedures in simple (two-alternative) and complex situations.

The desirability of using sequential analysis to solve several statistical problems in radio engineering is supported by the great effectiveness of sequential procedures in comparison with other well-known statistical procedures. Examples are given of the application of sequential analysis to problems of extraction of signals from noise, process-control problems, theory of scanning, reliability control, etc. . . .

A RANGE-SAMPLED SEQUENTIAL DETECTION SYSTEM
C. W. Helstrom, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 43/47.

SEQUENTIAL DETECTION OF GAUSSIAN SIGNALS IN GAUSSIAN NOISE
T. Kailath, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 35/37.

SEQUENTIAL DETECTION IN RADAR WITH MULTIPLE RESOLUTION ELEMENTS
M. B. Marcus, et al., IRE Trans. Inform. Th., vol. IT-8, no. 3, April 1962, p. 237/245.

. . . the difficulties of obtaining analytical results for multiple-resolution-element sequential radars are discussed. Most of the results of this paper were obtained by simulation. Included are interesting results which suggest that truncation is not necessary for the tests which were considered.

SEQUENTIAL DECODING FOR DISCRETE INPUT MEMORYLESS CHANNELS
B. Reiffen, IRE Trans. Inform. Th., vol. IT-8, no. 3, April 1962, p. 208/220.

THE SEQUENTIAL ESTIMATION AND DETECTION OF SIGNALS IN NORMAL NOISE
I. Selin, (Memo. no. RM-2994-PR), June 1962, 113 p., incl. illus., 42 refs., AD 276 530.

. . . Two classes of signals are considered: signals which are known exactly, and signals known except for a finite number of parameters.

CODING AND DECODING FOR TIME-DISCRETE AMPLITUDE-CONTINUOUS MEMORYLESS CHANNELS
J. Ziv, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 199/205.

. . . A scheme for constructing a discrete signal space, for which sequential encoding-decoding methods are possible for the general continuous memoryless channel, is described. Random code selection from a finite ensemble, with each code word sequentially generated from a small number of basic waveforms, is considered. . . . The application of sequential decoding to the continuous asymmetric channel, and a new decoding scheme for convolutional codes, successive decoding, are considered. . . . We consider the quantization at the receiver, and its effects on probability of error and receiver complexity.

THEORY OF SIGNAL DETECTABILITY. OBSERVATION-DECISION PROCEDURES
T. G. Birdsall, et al., Cooley Electronics Lab., U. of Michigan, Ann Arbor. Technical rept. 136, Jan. 1964, 164 p., AD 429 220.

. . . includes predetermined nonsequential procedures and the optimum (Bayes') sequential procedure . . .

AN INVESTIGATION OF THE FANO SEQUENTIAL DECODING ALGORITHM BY COMPUTER SIMULATION
G. Blustein, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 62G5, AFESD TDR 63 88, 12 July 1963, 35 p., AD 412 632.

A NOTE ON SEQUENTIAL DECODING APPLIED TO LARGE ALPHABET INCOHERENT CHANNELS - R COMP DETERMINATION
M. H. Check, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 65G6, AFESD TDR63 77, 31 May 1963, AD 410 883.

. . . investigation of the computation cutoff rate for such channels. . . the meaning of 'incoherent' will be made precise presently. Suppose one of 1 orthogonal and equal energy bandpass signals is sent over a channel perturbed by additive white Gaussian noise. The prior probability of all signals is assumed equal.

The received signal is detected by a bank of 1 filters matched to the 1 waveforms. The envelopes of the filter outputs are formed and are sampled at the appropriate time. This detection procedure is optimum if the receiver does not have knowledge of the RF phase of the signal, and if the RF phase, whatever it is, is constant over the signalling interval. A decoder has available to it the 1 analog outputs. A decision on the largest of these destroys information. Accordingly, if coding is to be used, it is appropriate to view the 1 analog outputs as a vector which may be operated on by a decoder.

SINTEZ OPTIMAL'NOGO FIL'TRA DLIA SIGNALOV, IZMENIAIUSHCHIKH STATISTICHESKIE SVOISTVA V POSLEDOVATEL'NYE INTERVALY VREMENI (Synthesis of an Optimal Filter for Signals with Statistical Properties Successively Varying with Time) (In Russian)
I. B. Chelpanov, Avtomatika i Telemekhanika, vol. 24, Oct. 1963, p. 1331/1336, A64-13215.

. . . design of a filter that is optimum with respect to minimum mean square error, for the case where the statistical properties of both the useful signal and the noise signal are subject to abrupt changes at definite instants of time. The signal properties are given in the form of matrices of correlation functions. The problem is reduced to the solution of a system of integral equations of the first type. This solution is obtained by the Zadeh-Ragazzini method.

SEQUENTIAL TESTS FOR THE MEAN OF A NORMAL DISTRIBUTION III (SMALL t)
H. Chernoff, Applied Mathematics and Statistics Labs., Stanford Univ., Calif., Rept. no. TR90, 21 Oct. 1963, 53 p., AD 424 788.

Asymptotic expansions are derived for the behavior of the optimal sequential test of whether the unknown drift mu of a Wiener-Levy process is positive oı negative for the case where the process has been observed for a short time. . . .

FCT. A NEW SEQUENTIAL DETECTION METHOD FOR MULTIPLE-RESOLUTION-ELEMENT RADAR
G. M. Dillard, Navy Electronics Lab., San Diego, Calif., Research Report (1 Jan.-1 Sept. 1963), (NEL-1201) 25 Oct. 1963, 32 p., refs., AD 429 307, N64-17363.

Simulation of the FCT (forced continuation testing) mode in processing binomially quantized radar-receiver output voltage gave data that agreed well with exact, computed results. . .

A HEURISTIC DISCUSSION OF PROBABILISTIC DECODING
R. M. Fano, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 64/74.

A NEW APPROACH TO SEQUENTIAL DETECTION IN PHASED ARRAY RADAR SYSTEMS
H. M. Finn, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 2, Feb. 1963, no. 4-3, 12 refs.

A new class of radar detection and modes designated as Energy-Variant sequential detection modes has been developed for the detection of both non-fluctuating and fluctuating target types. The transmitted energies and detection thresholds are design degrees of freedom used to accomplish a minimization of the average power required to perform a specified surveillance mission. . . .

A CONDITION FOR OPTIMALITY IN SEQUENTIAL SIGNAL DETECTION
K. B. Gray, California U., Los Angeles, Rept. no. WP46; RR88, Dec. 1963, 8 p., AD 433 124.

A COMPARISON OF TWO SCHEMES INVOLVING A DECISION AND TRANSMISSION THROUGH A NOISY CHANNEL
A. K. Joshi, et al., Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 14/22.

. . . a comparison of two decision schemes involving transmission through a noisy channel has been made by using the technique of sequential analysis (in particular the sequential probability ratio test) . . . The first scheme consists of performing a sequential test for two hypotheses (or two information sources) and then transmitting the decision (as to which information source is transmitting) over a binary symmetric channel. The second scheme consists of first transmitting the data over the binary symmetric channel and then performing the sequential test at the output of the channel . . .

A SEQUENTIAL TEST FOR RADAR DETECTION OF MULTIPLE TARGETS (Correspondence)
W. B. Kendall, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 51/53.

PERFORMANCE OF THE BIASED SQUARE-LAW SEQUENTIAL DETECTOR IN THE ABSENCE OF SIGNAL
W. B. Kendall, RAND Corp., Santa Monica, Calif., (RM-3759-PR), July 1963, 30 p., 10 refs., N63-19402.

G. E. Albert's general sequential test. . . performance. . . as the solutions of integral equations. . .

COMPLETELY COHERENT SEQUENTIAL DETECTION WITH APPLICATION TO SEARCH RADAR
W. B. Kendall, RAND Corp., Santa Monica, Calif., RM-3757-PR, July 1963, 64 p., 9 refs., N63-18976, AD 411 644.

A QUALITATIVE DESCRIPTION OF SEQUENTIAL DECODING
I. L. Lebow, Lincoln Lab., Mass. Inst. of Tech., Lexington, AFESD TDR 63 91, 12 July 1963, 27 p., AD 413 949.

. . . discussion. . . directed toward the non-specialist in information theory. Both the Wozencraft and Fano algorithms are included. The description of sequential decoding is preceded by a summary of the general problem of probabilistic coding and decoding.

CUMULATIVE DECISION TECHNIQUES FOR ERROR-FREE COMMUNICATION SYSTEMS
J. J. Metzner, et al., New York U. Coll. of Engineering, N. Y., AFCRL Rept. 63 330, 15 July 1963, lv, AD 417 230.

Efforts concerned the exploration of practicable methods by which the efficiency of error-free, fail-safe, digital communication systems operating over real channels can be raised to yield information rates closer to channel capacity. Emphasis was on cumulative decision techniques. A feedback policy is described which makes the system completely compatible with the cumulative process. . . . including systems employing binary, null-zone, and continuous-level reception. Some numerical results are presented of certain characteristics of two of the proposed cumulation methods . . .

SEQUENTIAL DETECTION
D. Middleton, Carlyle Barton Lab., Johns Hopkins U., Baltimore, Md., RADC TDR63 179, Sept. 1963, 77 p., AD 416 724.

SEQUENTIAL SEARCH AND DETECTION THEORY IN THE PRESENCE OF A MULTIPLICITY OF HYPOTHESES
E. C. Posner, et al., JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 164/176.

In previous SPS's, a probabilistic model for initial angle acquisition of a satellite was considered (RS 36-10, Vol. I, p. 15/16; SPS 37-16, Vol. IV. p. 48/50; SPS 37-21, Vol. IV, p. 152/154). This article presents the final results of this research project.

EXACT DISTRIBUTION FUNCTIONS OF TEST LENGTH FOR SEQUENTIAL PROCESSORS WITH DISCRETE INPUT DATA
J. G. Proakis, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 182/191.

In studies of sequential detection of radar signals, the parameter of primary interest is the length of the sequential test, denoted by n. Since this test length is a random variable, moments and/or probability distribution functions of n are desirable. A procedure is described. . . for obtaining exact probability distribution functions. . . and exact average values of n . . .

A SEQUENTIAL TEST FOR THE PRESENCE OF A SIGNAL IN ONE OF k POSSIBLE POSITIONS (Correspondence)
I. S. Reed, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 286/288.

. . . results on the design and evaluation of a sequential radar to detect the presence and estimate the range of a target. . . .

SEQUENTIAL DECODING ON A CHANNEL WITH SIMPLE MEMORY
J. E. Savage, Lincoln Lab., Mass. Inst. of Tech., Lexington, Group rept. no. 1964 5, ESD TDR 64 42, 2 April 1964, 23 p., AD 437 163.

A model for a binary channel with additive Markovian noise is presented. The behavior of the Sequential Decoding cutoff rate. . . for this channel is studied under various degrees of memory. . . .

THE INCOHERENT SEQUENTIAL DETECTION OF A SINE WAVE IN WHITE NOISE (Correspondence)
I. Selin, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 92/93.

This communication reports a problem incurred in trying to obtain the probability density function (p.d.f.) of the ending time of the continuous sequential test for the presence in white noise of a sine wave known except for carrier phase. . . .

SOME TOPICS IN SEQUENTIAL DETECTION AND ESTIMATION
I. Selin, RAND Corp., Santa Monica, California, Feb. 1963, 12 p., (Rept. no. P-2711), AD 297 922.

CODING AND DECODING FOR TIME-DISCRETE AMPLITUDE-CONTINUOUS MEMORYLESS CHANNELS
J. Ziv, Massachusetts Inst. of Tech., Cambridge Research Lab. of Electronics, (RLE-TR-399) 31 Jan. 1963, 108 p., refs., AD 299 016, N64-18366.

A scheme for constructing a discrete signal space, for which sequential encoding-decoding methods are possible for the general continuous memoryless channel, is described. . . .

CONSTANT-WEIGHT COUNTERS AND DECODING TREES
W. H. Kautz, IRE Trans. Electronic Computers, vol. EC-9, no. 2, June 1960, p. 231/244.

SUCCESSIVE DECODING SCHEME FOR MEMORYLESS CHANNELS
J. Ziv, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 97/104.

Related Publications:

ERROR CORRECTING CODES FROM LINEAR SEQUENTIAL CIRCUITS
M. Abramson, Stanford Electronics Labs., Stanford U., Calif., (Technical rept. no. 2002-1), 13 June 1960, 20 p., 25 refs., AD 239 777.

SEQUENCE DETECTION USING ALL-MAGNETIC CIRCUITS
H. D. Crane, IRE Trans. Electronic Computers, vol. EC-9, no. 2, June 1960, p. 155/160.

METHOD AND MERIT OF BINARY CODING FOR ANALOG CHANNELS
I. M. Jacobs, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 765/773.

The reception of coded signals is conveniently considered as two steps, detection and decoding, the first largely analog and the second largely digital. . . .

In this paper, we consider the improvement in rate and signal-to-noise ratio offered by coding and decoding for three values of detector quantization; $Q = 2$ (binary detection), $Q = 3$ (ternary or null-zone detection), and $Q = \infty$ (continuous or unquantized detection). A qualitative insight is then provided into convolutional encoding and sequential decoding as one means, adaptable to any value of Q, for realizing these gains.

PERFORMANCE OF ERROR-REJECTING DETECTORS FOR UNCODED BINARY SIGNALS IN GAUSSIAN NOISE
M. A. Koerner, JPL Space Progr. Summ., vol. 4, no. 37-19, Dec./Jan. 1962, p. 165/169.

The optimum receiver. . . consists of a computer which determines the a posteriori probability of each of the possible signals, and a maximum-likelihood decision device.

. . . in simply choosing the most probable signal we disregard the information regarding the probability of the alternate possibilities. The following analysis indicates a technique for employing this additional information to improve the performance of the binary channel.

EFFICIENT ERROR-LIMITING VARIABLE-LENGTH CODES
P. G. Neumann, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 292/304.

. . . Variable-length codes recursively defined by certain sequential machines are investigated. It is seen that the recursive definition may be used to control error propagation as well as to provide a conceptually simple decoding procedure. . . . Methods for obtaining efficient codes are discussed, and examples are given.

ERROR-LIMITING CODING USING INFORMATION-LOSSLESS SEQUENTIAL MACHINES
P. G. Neumann, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 108/115, 16 refs.

An information-lossless sequential machine is essentially a machine whose input sequence may be recovered from knowledge of its output sequence. A situation is considered in which such a machine is used as the encoder for a communication system. . . . This paper investigates the effects of transient errors in such a system and shows that there are encoders for which the decoder is incorrect. . . Each such encoder has input sequences which resynchronize the encoder following errors, as well as output sequences which resynchronize the decoder. . . .

TRANSIENT SOLUTIONS FOR 3-STATE DISCRETE TIME MARKOV PROCESSES
E. A. Silver, Mass. Inst. of Tech., Cambridge, Technical note no. 1 July 1963, 55 p., AD 417 221, AD 417 151.

2.855: Adaptive Decision Systems

Included: Learning filters for pattern recognition; Self-optimizing decision systems; Self-organizing detection systems.

Not Included: Automata; Learning systems; Design of adaptive filters; Bionics (3B).

Cross References: Adaptive operations in communications systems (2.930); Pattern recognition (2.260).

Principal Publications:

ADAPTIVE BINARY DETECTORS
R. F. Daly, Stanford Electronics Labs., Stanford U., Calif., Rept. 2003-2, 26 June 1961, AD 258 861.

A sequential binary detection problem is considered in which it is required to detect the presence of absence of a stochastic signal in each member of a sequence of observations perturbed by additive noise. . . .

USING BAYES' INDUCTION THEOREM TO ESTIMATE PROBABILITIES IN A COMMUNICATION CHANNEL
S. D. Stearns, Dikewood Corp. Albuquerque, N. Mex., (Rept. DTN-1013-1), RADC TN 61-207, 2 July 1961, 31 p., AD 265 847.

LEARNING FILTERS FOR OPTIMUM PATTERN RECOGNITION
D. Braverman, IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 280/285.

. . . An optimum adaptive system is obtained for the identification of pattern samples which are the sum of a fixed unknown signal, determined by the pattern of the sample, plus Gaussian noise. The system learns the unknown signals from a set of pattern samples, called learning sample, which have been identified with absolute certainty.

. . . apply the techniques of statistical decision theory. . . define the automatic recognition problem. . .

ADAPTIVE DECISION ELEMENTS TO IMPROVE THE RELIABILITY OF REDUNDANT SYSTEMS
W. H. Pierce, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 124/131, 16 refs.

. . . Redundant but unreliable binary or analog signals are used most effectively when each signal's error probability is used to compute a statistical estimate of the correct signal. When errors in the inputs are independent, the statistical estimates can be made by simple summing circuits. Adaptive circuits are proposed which give the most reliable inputs the largest weights. . . .

PATTERN RECOGNITION BY AN ADAPTIVE PROCESS OF SAMPLE SET CONSTRUCTION
G. S. Sebestyen, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 82/91.

ADAPTIVE DECISION SYSTEMS - I
R. Smallwood, et al., Air Force Cambridge Research Labs., Bedford, Mass., AFCRL Cambridge memo no. 13; Technical memo no. 62 14, 27 Dec. 1962, 16 p., AD 419 478.

. . . automated decision system to operate on data from a single channel. . . . A noisy signal is obtained upon which random events impose a signature which has some characteristics that are constant from event to event. The goal is to detect the occurrence of an event by the presence of these characteristics signatures and with as little time lag as possible. . . . can be broken down into two problems: (1) The parameter problem—(2) the Decision problem—. . . the optimum decision system will vary with the parameters used. The question arises then, as to whether a decision system can be built that will change its properties and thereby adapt to any data parameters chosen. . . .

PATTERN RECOGNITION WITH SELF-ORGANIZING MACHINES
A. C. Foreman, Air Force Inst. of Tech., Wright-Patterson AFB, Ohio, Aug. 1963, 90 p., AD 419 094.

Most of the pattern-recognition self-organizing machines can be classified as adjustable-weight threshold-logic machines, statistical-switching machines, or correlation machines. A noisy pattern is a pattern that varies slightly from a model pattern that the machine has been taught. Computer simulations of a typical machine. . . indicate that the noisy pattern recognition capabilities are poor for statistical-switching machines, good for threshold-logic machines, best for correlation type machines. A proposed correlation self-organizing machine is simple, learns in one step, and recognizes noisy patterns accurately.

ADAPTIVE RECEPTION OF SIGNALS WITH UNKNOWN GAIN AND DELAY
J. C. Hancock, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 54/65.

Assuming unknown channel gain and unknown channel delay we derive a set of delay estimators . . . The estimating filter output is the true path delay plus a noise term that is Gaussian when the additive channel noise is Gaussian. . . . Any of these delay estimators can be incorporated into an adaptive M-ary receiver which uses the noisy estimates in a manner that would be optimum if the measurements were precise. . . .

ADAPTIVE TECHNIQUES FOR THE OPTIMIZATION OF BINARY DETECTION SYSTEMS
H. J. Kushner, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 107/117.

. . . for the problem of the experimental optimization of maximum signal-to-noise ratio binary detectors which operate in a partially unknown environment. Two approaches are taken and compared in detail. The first involves the use of statistical estimates of the unknown quantities that are obtained by the appropriate averaging operations. The second, and more interesting, approach makes use of the methods of stochastic approximation to develop a convergent iterative process on the parameters of the adaptive filter. The iterates converge to the optimum values in mean square and with probability one. . . .

MULTI-PARAMETER SELF-OPTIMIZING SYSTEMS USING CORRELATION TECHNIQUES
K. S. Narendra, et al., Cruft Lab., Harvard U., Cambridge, Mass., Tech. rept. no. 413, 5 June 1963, 20 p., AD 413 402.

A class of self-optimizing systems is described which continually alters its parameters to reduce a mean-square performance criterion. The change in each parameter is determined from an error gradient in parameter space computed by cross-correlation methods which are independent of signal spectra and require no test signal or parameter perturbation. Application of this technique to both open-loop and closed-loop systems are included, and it is shown that a combination of such self-optimizing systems is a possible solution to the adaptive control problem.

MULTIPARAMETER SELF-OPTIMIZING SYSTEMS USING CORRELATION TECHNIQUES
K. S. Narendra, et al., IEEE Trans. Automatic Control, vol. AC-9, Jan. 1964, p. 31/38, 8 refs., A64-15910.

. . . systems which continually alter their parameters to reduce a mean-square performance criterion. The change in each parameter is determined from an error gradient in parameter space computed by cross-correlation methods which are independent of signal spectra and require no test signal or parameter perturbation. Applications of this technique to both open-loop and closed-loop systems are included. . . Computer simulation results are included to demonstrate the practicality of the proposed systems.

DUAL-MODE FILTERING OF POLYNOMIAL SIGNALS IN NOISE
L. G. Shaw, Western Electronic Show and Convention, San Francisco, Calif., Aug. 22-25, 1961, IEEE Trans. Automatic Control, vol. AC-8, April 1963, p. 136/142, A63-17514.

. . . procedure for finding the best (minimum mean-square error) filter of a class of dual-mode (adaptive) filters when the input consists of a sample from an ensemble of fixed-order polynomials plus "almost white" noise.

THE DETECTION OF MULTIPLE UNKNOWN SIGNALS BY ADAPTIVE FILTERS
J. W. Smith, Johns Hopkins U., Carlyle Barton Lab., Baltimore, Md., May 1963, 133 p., 13 refs., N63-16514.

. . . class of filters discussed includes two types previously described in the literature, and one new type designed explicitly for operating in a multiple waveform environment. The new structure processes the data in a nonlinear fashion and effectively sets up a narrow decision region about the estimate of the waveform. . . .

Related Publications:

USE OF CROSSCORRELATION IN AN ADAPTIVE CONTROL SYSTEM
G. W. Anderson, et al., Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 34/45.

Section 2.87
Detection Theory for Special Communications Applications

2.870: Detection Theory of Special Signals in Specified Channels

Included: Matching of signal waveforms; Transmission channel and detection systems.

Not Included: Channel characteristics (1); Signal waveforms (1).

Cross References: Correlation detection methods (Sect. 2.82).

Principal Publications:

THE THEORY OF OPTIMUM NOISE IMMUNITY
V.A. Kotel'nikov, New York, McGraw-Hill Book Co. Inc., 1959, 140 p.

. . . first English-language account of Dr. Kotel'nikov's 1947 doctoral dissertation at the Molotov Energy Institute. . . . interesting addition to . . . the statistical theory of signal detection . . . a study of considerable historical interest.

SIGNALS WITH MAXIMUM AND MINIMUM PROBABILITY OF DETECTION
V.A. Kotel'nikov, Radio Engrg. and Electronics, vol. 4, no. 3, 1959, p. 5/11.

THE PROBABILITY DENSITY OF THE OUTPUT OF A FILTER WHEN THE INPUT IS A RANDOM TELEGRAPHIC SIGNAL: DIFFERENTIAL-EQUATION METHOD
J.A. McFadden, IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 228/233.

ON THE DETECTION OF STOCHASTIC SIGNALS IN ADDITIVE NORMAL NOISE
D. Middleton, Lincoln Lab., MIT, Lexington, 28 Dec. 1960, AD 250 287.

Optimum detection of FSK and on-off normal stochastic signals in additive normal noise backgrounds is examined. (AD 112 385) . . . A specific example of weak-signal operation involving 2 narrow-band FSK noise signals is considered . . . the degradation of performance because of spectral overlap between signal channels is computed. Also included in the present study is a general treatment of colored-noise backgrounds, as well as specialization to the white-noise cases, and a short discussion of on-off vs. FSK operation in the threshold situation.

CORRECTION TO "ON THE DETECTION OF STOCHASTIC SIGNALS IN ADDITIVE NORMAL NOISE - PART I" (Correspondence)
D. Middleton, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 412.

DISCUSSION ON "OPTIMUM COMBINATION OF PULSE SHAPE AND FILTER TO PRODUCE A SIGNAL PEAK UPON A NOISE BACKGROUND"
D.A. Bell (communicated on), Proc. Instn. Elect. Engrs., Pt. C, vol. 108, no. 14, Sept. 1961, p. 531/532.

Heaps, H.S.: Monograph No. 407 E, October 1960 (see 108C, p. 153).

OPTIMUM COMBINATION OF PULSE SHAPE AND FILTER TO PRODUCE A SIGNAL PEAK UPON A NOISE BACKGROUND
H.S. Heaps, Proc. Instn. Elect. Engrs. Pt C, vol. 108, no. 13, March 1961, p. 153/158.

. . . generation of a signal pulse for transmission through a propagating medium and its subsequent detection as a single peak after it is received upon a noise background. It is supposed that the propagating medium behaves as a linear filter and that the noise background is independent of the signal. The pulse is conveniently described as consisting of a central portion attached to a leading edge and a trailing edge. It is found that for a given length of central portion there is an optimum combination of transmitted pulse shape and predetection filter. The results are compared with those arising from the use of certain non-optimum systems, and it is found that the optimum system leads to a significantly high signal/noise ratio. The results of the paper imply that for the range of parameters considered it is advantageous to transmit a succession of short pulses of a determined form rather than a single smooth pulse. . . .

ON THE OPTIMUM DETECTION OF DIGITAL SIGNALS IN THE PRESENCE OF WHITE GAUSSIAN NOISE — A GEOMETRIC INTERPRETATION AND A STUDY OF THREE BASIC DATA TRANSMISSION SYSTEMS
E. Arthurs, et al., IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 336/372.

. . . a geometric interpretation of the detection problem is presented on a tutorial level. . . . this technique is used to derive the optimum detector for each of three basic data transmission systems: m-level Phase Shift Keyed, m-level Amplitude Shift Keyed and m-level Frequency Shift Keyed. Corresponding probability of error curves are derived, compared and discussed with reasonable detail. . . .

THE RELATIVE EFFICIENCIES OF VARIOUS BINARY DETECTION SYSTEMS
R.O. Rowlands, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 185/189.

. . . This paper attempts to fill the need of the engineer who is designing a signal detection system and who wants a rough idea of the relative merits of the various basic detection methods that are availabe. Five common binary detection systems are analyzed and formulas are derived for the signal-to-noise ratios required to give the same probabilities or error in each system. The effects of varying the duration of the signal and the bandwidth of the noise are discussed for each system, and the region is defined within which the detectability of the signal is improved by clipping. . . . 1. Ideal Correlator . . . 2. Square-Law Detector . . . 3. Two-Channel Correlator . . . 4. Sign Correlator . . . 5. Two-Channel Sign Correlator. . . .

Related Publications:

A NOTE ON THE WORD ERROR PROBABILITY ASSOCIATED WITH A SEQUENCE OF DIGITS HAVING UNEQUAL ERROR PROBABILITIES (Correspondence)
F.G. Splitt, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 492/493.

. . . in cases where the interference is nonstationary or where a quantized frequency modulation (QFM) transmission is perturbed by colored noise, the digit error probabilities will be unequal. These unequal digit error probabilities lead to cumbersome expressions for the probability distribution function for the number of ones in the error sequence and the word error probability. It is to the simplification of these problems that this note is addressed. . . .

2.871: Detection Under Special Noise Conditions

Included: Detection in non-Gaussian noise; Detection in impulse noise; Detection in nonstationary noise; Detection in the presence of stochastic disturbances; Detection of non-Gaussian processes in non-Gaussian noise; Detection in colored noise.

Not Included: Statistical characteristics of impulse noise (1); Channels with pulsive disturbances (1).

Cross References: Optimum nonlinear filter theory (2.813).

Principal Publications:

LEAST SQUARES FILTERING AND PREDICTION OF NONSTATIONARY SAMPLED DATA
B. Friedland, Inform. Control, vol. 1, Dec. 1958, p. 297/313.

THE SUPPRESSION OF PULSE INTERFERENCE BY NON-LINEAR TRANSFORMATION OF THE FORM OF THE FREQUENCY SPECTRUM
A.A. Gorbachev, Radio Engng., vol. 13, no. 1, 1958, p. 72/80.

SOME EXPERIMENTAL STUDIES OF SIGNAL DETECTION IN NONSTATIONARY BACKGROUND NOISE
T.R. Williams, Princeton Univ. Dept. of Electrical Engineering, March 1958, 22 p., AD 155 081.

DETECTION OF SIGNALS IN NON-GAUSSIAN NOISE
D.L. Clark, Lincoln Lab. MIT - Lexington, Group Rept. No. 47-36, Dec. 1959, 15 p., AD 232 332.

ON THE DETECTION OF SIGNALS IN NONSTATIONARY NOISE BY PRODUCT ARRAYS
J.B. Thomas, et al., J. Acoust. Soc. Amer., vol. 31, April 1959, p. 453/462.

Two detection systems having multiple inputs each consisting of nonstationary noise and a stationary random signal are analyzed and compared on a signal-to-noise ratio basis. In both systems the inputs are divided into two groups and the sum of each group is formed.

AN EXPERIMENTAL STUDY OF DETECTION IN NONSTATIONARY NOISE
T.R. Williams, et al., Princeton U., N.J., April 1959, 5 p., AD 232 677, Reprint from Commun. and Electronics, Nov. 1959, 5 p.

DETECTION OF SIGNALS IN NON-GAUSSIAN NOISE-COMPUTATION RESULTS FOR THE RATIO DETECTOR SYSTEM
J.W. McGinn, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 47G-0015, 3 April 1961, 20 p., incl. illus., AD 254 035.

. . . the ratio detector is a simplified version of a normalized periodogram detector. A ranking of the detection performance of the three systems studied so far would place the performance of the ratio system roughly midway between the linear and limiting systems.

DETECTION OF SIGNALS IN COLORED NOISE
B. Harris, New York U. Col. of Engineering, N.Y., NASA CR-50348; Tech. Memo. 25, May 1, 1962, 39 p., N63-17231.

DETECTION OF NON-GAUSSIAN PROCESSES IN NON-GAUSSIAN NOISE
F.C. Ogg, Jr., Johns Hopkins U. Carlyle Barton Lab., Baltimore, Md., RADC TDR 63 192, June 1963, 37 p., 4 refs., N63-18647 and also AD 408 986.

OPTIMAL CONTROL OF SYSTEMS WITH STOCHASTIC DISTURBANCES
R. Sussman, Electronics Research Lab., U. of Calif., Berkeley, 25 Nov. 1963, 69 p., AD 430 078.

. . . a Linear System which is disturbed by white (or Linear Markov) additive noises . . . The Cost Function used is quadratic. It is proved that the Optical Controller is a linear function of the observations only if both noises are Gaussian. . . . While the Optimal Linear Controller requires the updating of only the mean and the variance, the n-th order Polynomial Controller requires the updating of the 2n first moments. These results can also be applied to Optimal Filtering.

2.872: Detection in Channels with Non-Additive Noise

Included: Noisy nonlinearities; Nonlinear operators in detection theory.

Not Included: Nonlinear distortions in channels (1); Frequency translations in communications channels (1).

Cross References: Optimum nonlinear filter theory (2.813).

Principal Publications:

OPTIMUM DE-CODING SYSTEM FOR THE TRANSMISSION OF THE MAXIMUM NUMBER OF PARAMETER VALUES IN THE PRESENCE OF NON-ADDITIVE NOISE
B.S. Fleishman, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 8, 1960, p. 36/46.

OPTIMIZATION OF SOME NOISY NONLINEAR SYSTEMS
R.O. Harger, Institute of Science and Tech., U. of Michigan, Ann Arbor, Rept. 2900-290-T, Oct. 1961, 82 p., AD 265 554.

The presence of noisy nonlinearities in the transmission of signals in a system whose function is either signal recovery (estimation) or signal detection is considered. The system is composed of a nonlinear operator followed inseparably by an additive stochastic noise source and interspersed between two linear time-invariant filters. For the estimation function, two types of signal are considered: a sinusoidal signal of random phase; and a more general stochastic signal of second-order stationarity . . . The postfilter gain is determined by matched-filter theory, and it is shown that prefilter gain should be infinite.

Related Publications:

AN EXPERIMENTAL STUDY OF DETECTION IN NONSTATIONARY NOISE
T.R. Williams, et al., Princeton U., N.J., April 1959, 5 p., Reprint from Commun. and Electronics, Nov. 1959, 5 p., AD 232 677.

2.873: Detection Under Multipath Conditions

Included: Detection in fading channels; Reception through non-selective slow fading; Detection methods for multipath channels; RAKE anti-multipath detection system; Adaptable receiver for detection of signals under selective fading; Factorization problem in multipath communications systems; Coherent multi-channel detector; Coherent multi-receiver; Random noise carrier system; Matched filter anti-multipath detector.

Not Included: Design of diversity combiners; Characteristics of fading channels (1); Spread spectrum communications systems (1).

Cross References: Diversity operations (Sect. 2.62); Adaptive communications systems (2.930); Correlation detection methods (Sect. 2.82); Coherent detection methods (2.834); Matched filter detection systems (2.823).

Principal Publications:

THE APPLICATION OF THE THEORY OF SIGNAL DETECTABILITY TO SIGNALS WITH UNKNOWN POLARIZATION AND PHASE
R. Manasse, MIT Lincoln Lab, Group Report 32-25, Aug. 1956.

SOME COMMUNICATIONS APPLICATIONS OF DETECTION THEORY
W. B. Davenport, Jr., IRE Nat. Conv. Rec., March/April 1958.

Summary—Two specific systems are discussed. The first system, called RAKE, the second system, called MAUDE, is designed to automatize the reception of hand sent Morse code signals.

A COMMUNICATION TECHNIQUE FOR MULTIPATH CHANNELS
G. D. Hulst, Proc. IRE, vol. 46, Nov. 1958, p. 1882.

A COMMUNICATION TECHNIQUE FOR MULTIPATH CHANNELS
R. Price, et al., Proc. IRE, vol. 46, March/1958, p. 555/570.

ERROR PROBABILITIES FOR BINARY SYMMETRIC IDEAL RECEPTION THROUGH NONSELECTIVE SLOW FADING AND NOISE
G. L. Turin, Proc. IRE, vol. 46, Sept. 1958, p. 1603/1719.

PRELIMITING BANDPASS FILTERING ON FADING RADIO CIRCUITS
C. Buff, IRE Trans. Commun. Syst., vol. CS-7, May 1959, p. 42/46.

On channels subject to multipath propagation, minimum-loss, flat-topped filters create serious transient effects which add greatly to the error rate in data transmission. Because of adjacent channel requirements, an over-all Gaussian response is not applicable. A practical solution is considered to be a rounded-top filter composed of a series of synchronous-tuned single circuits in cascade. Observations on an independent side band (ISB) telegraph circuit. A threefold improvement in the error rate of 45-baud printer operation.

POTENTIAL NOISE SUPPRESSION FOR INDEFINITE SIGNAL PHASE
L. M. Fink, Radio Engng., vol. 14, no. 1, 1959, p. 54/69.

. . . optimum criteria of receiving discrete messages in the presence of noise when the initial phase of the high-frequency carrier is a random quantity. The minimum error probabilities are calculated and methods of realizing the potential noise suppression are determined.

POTENTIAL NOISE SUPPRESSION UNDER CONDITIONS OF SIGNAL FADING
L. M. Fink, Radio Engng., vol. 14, no. 9, p. 1/14.

FREQUENCY SHIFTS IMPROVE PULSE COMMUNICATIONS
J. L. Hollis, Electronics, vol. 32, no. 19, June 1959, p. 66/69.

New technique overcomes multipath problems in long-range pulse transmission. Transmitter and receiver simultaneously shift frequency so that receiver is sensitive only to the transmission arriving by the shortest path.

AN EXPERIMENTAL EQUIPMENT TO REDUCE TELEPRINTER ERRORS IN THE PRESENCE OF MULTIPATH
J. L. Hollis, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 185/188.

. . . A comonly used four-channel multiplex system has a bit length of 6.7 milliseconds and is thus seriously affected by differences in path delay greater than approximately 3 milliseconds. . . . This paper describes a method of. . . synchronously shifting the frequency of the transmitter and receiver following transmission of each bit. The receiver is thus responsive to the signalling element propagated by the shortest path and rejects the long path signals by filter selectivity. . . . The compatibility of the anti-multipath equipment with existing equipment and the ability to reduce the error rate substantially, under conditions of ground-scatter multipath propagated by the F layer, have been successfully demonstrated. . . .

APPLICABILITY OF MULTIPATH PROTECTION TO METEOR BURST COMMUNICATIONS
T. G. Knight, IRE Trans. Commun. Syst., vol. CS-7, no. 3, Sept. 1959, p. 209/210.

This paper investigates past methods of improving the duty cycle of meteor scatter communications links in the presence of multipath distortion and suggests using a technique, for further improvement, which has proved useful at HF frequencies. . . .

STUDIES OF COMMUNICATION CHANNELS
S. Chang, et al., Electronics Research Lab., Northeastern U., Boston, Mass., Scientific rept. no. 3, pt. 2, AFCRC TN 60-574, vol. 2, 17 May 1960, 46 p., incl. illus., AD 242 674.

. . . (3) Feedback systems for the reduction of multipath distortion have been evaluated. . . .

TIME-VARYING CHANNELS WITH DELAY SPREAD
P. E. Green, Jr., In: Radio Waves and Circuits; Proceedings of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 208/224; Discussion, p. 225/226, 21 refs., A64-10835.

. . . results on two topics, (1) the characterization of time-varying linear communication channels (or radar targets) having a spread of propagation delays . . . (2) the design of optimum receivers for detecting or distinguishing between signals propagated by such media. It has proved useful to model the channel as a tapped delay line in which each individual tap output undergoes a random time variation before being added to the other tap outputs to form the channel output. . . . particular emphasis on Price's formulation of a class of receivers that are optimum at small input signal-to-noise ratios.

INVERSE IONOSPHERE
G. D. Hulst, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 3/9.

. . . A device to eliminate this particular form of distortion is. . . described, using a sensing technique, a logical matrix, and a signal restoration network. . . . Specific restoration networks are described for several typical ionosphere multipath conditions.

QUESTIONS OF POTENTIAL INTERFERENCE RESISTANCE WHEN THE SIGNAL FADES
D. C. Klovskii, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 5, 1960, p. 24/35.

Criteria are obtained for single coherent and non-coherent reception of discrete messages for an ideal receiver in the presence of fluctuating interference and rapid smooth fadings of the signal. The probability density of the envelope of the signal reaching the receiver is assumed to be distributed according to the generalized Rayleigh law. . . . The minimum probability of faulty reception is calculated for certain classes of systems. . . .

NEW SYSTEM DEFEATS MULTIPATH EFFECT
G. A. Scheer, Electronic Industr., vol. 19, May 1960, p. 150/153.

A FREQUENCY STEPPING SCHEME FOR OVERCOMING THE DISASTROUS EFFECTS OF MULTIPATH DISTORTION ON HIGH-FREQUENCY FSK COMMUNICATION CIRCUITS
A. R. Schmidt, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 44/47.

. . . it is practical to employ four-channel time division multiplex systems under multipath conditions that would otherwise render them useless.

A MATCHED FILTER COMMUNICATION SYSTEM FOR MULTIPATH CHANNELS
S. M. Sussman, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 367/373.

. . . underlying principles are based on the Rake system. . . . employs complex lumped-parameter networks to generate and receive a pair of long-duration, broadband signals representing Mark and Space respectively.

COMMUNICATION THROUGH RANDOMLY VARYING MEDIA
G. L. Turin, In: Radio Waves and Circuits; Proceedings of Commission VI on Radio Waves and Circuits during the XIIIth General Assembly of URSI, London, Sept. 1960, Edited by Samuel Silver, New York, Elsevier Publishing Co., 1963, p. 201-207, 10 refs., A64-10834.

Summary of several results concerning communication through a fading, noisy, multi-diversity channel. In particular, the form of the optimum receiver for such a channel is outlined. The behavior of the error probability for this receiver is discussed for the binary case, for various types of fading and orders of diversity. A special case is a frequency-shift telegraph channel.

DIGITAL METHODS FOR THE EXTRACTION OF PHASE AND AMPLITUDE INFORMATION FROM A MODULATED SIGNAL
R. S. Lawrence, et al., J. Res. Nat. Bur. Stand., vol. 65-D, no. 4, July/Aug. 1961, p. 351/356.

A description is given of three digital methods which have been used to recover amplitude and phase information from a modulated sinusoidal signal sampled at equal intervals of not more than one-sixth of a period. The first method, the "zero-crossing" method, is economical of computer time and, for modulation which is not too deep and does not contain frequencies near the carrier frequency, accurately recovers the phase and amplitude modulation. The second method, the "filter" method, is more laborious but it gives better accuracy and will operate with deeper and more rapid modulation. The third method, a statistical approach, will work with severely overmodulated signals, but it yields only a statistical summary of the modulation. The methods were designed specifically for analysis of radio-star scintillation records but they may be applied to many other modulated signals.

ERROR PROBABILITIES FOR NON-ORTHOGONAL M-ARY SIGNALS UNDER PHASE-COHERENT AND PHASE-INCOHERENT RECEPTION
A. H. Nuttall, Litton Systems, Inc., Waltham, Mass., (Technical rept. no. TR-61-1-BF), 15 June 1961, 153 p., AD 261 182.

ON THE DESIGN OF A HIGHLY RELIABLE HF DIGITAL COMMUNICATION SYSTEM. PROBLEMS, DESIGN PROCEDURES AND THE DESCRIPTION OF A PROPOSED DESIGN
K. Otten, National Cash Register Co., Dayton, Ohio, Rept. 3-45, Oct. 1961, 38 p., AD 269 891.

. . . Use of a demodulation technique which utilizes, rather than rejects, multipath signal contributions. . . .

PERFORMANCE OF A RAKE SYSTEM OVER THE ORBITAL DIPOLE CHANNEL
P. Bello, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 46/53.

STUDY OF ADAPTABLE COMMUNICATIONS SYSTEMS
D. A. Chesler, Sylvania Electric Products, Inc., Waltham, Mass., Final rept., (Rept. no. F-1008-1) (RADC TDR 62-314), 14 June 1962, 293 p., incl. illus., tables, refs., AD 286 504.

. . . One investigation demonstrates the utility of a rake-type system for orbital dipole channels. The rake system studied is a generalization of the conventional rake system and has the advantage of allowing analog as well as digital modulation.

A COMMUNICATION ANALYSIS OF HIGH FREQUENCY IONOSPHERIC SCATTERING
G. Einarsson, Research Lab. of Electronics, Mass. Inst of Tech., Cambridge, Technical rept. no. 400, 15 March 1962, 76 p., AD 416 605.

A communication scheme for random multipath channels is investigated. During predetermined intervals the transmitter sends a sounding signal that the receiver uses to predict the behavior of the channel during the intermediate time when communication is performed. It is assumed that the channel varies slowly, and that the additive noise in the receiver is low. The possibility of representing a multipath channel as a time-variant filter is investigated. A sampling theorem for linear bandpass filters is derived, and the results that can be expected when it is used to represent a single fluctuating path with Doppler shift are discussed.

HIGH FREQUENCY RADIO DATA TRANSMISSION THROUGH MULTIPATH DISTURBANCE
J. C. Hansen, Mitre Corp., Bedford, Mass., (Technical memo. no. TM-3359) (ESD TDR 62-327), 13 Sept. 1962, 18 p., incl. illus., 14 refs., AD 290 538.

There exists an urgent requirement to increase the reliability of high frequency radio communications. A degradation of performance can occur during periods of high signal strength due to multipath distrubance. This phenomenon, along with a number of proposed methods of solution, are described.

COMMUNICATION THROUGH RANDOM MULTIPATH MEDIA
D. P. Harris, Stanford Electronics Labs., Stanford U., Calif., (Technical rept. no. 1002-2), April 1962, 89 p., incl. illus., 24 refs., AD 291 447.

TECHNIQUES FOR INCOHERENT SCATTER COMMUNICATION
D. P. Harris, IRE Trans. Commun. Syst., vol. CS-10, no. 2, June 1962, p. 154/160.

. . . a class of digital communication systems that employ sinusoidal pulse-transmissions with frequency-shift or time-position-shift modulation, or a combination of these techniques. The magnitudes of the shifts are to be selected such that the received waveforms, (corresponding to different possible transmitted-pulse positions) can be observed independently . . .

A NOTE ON THE FACTORIZATION PROBLEM
T. Kailath, JPL Res. Summ., no. 36-14, Feb./March 1962, p. 75/76.

. . . The factorization problem arises in several fields, some of which are. . . c. Simplification of the structure of certain ideal receiver configurations arising in multipath communications. . . .

In this note we shall discuss how this problem arises in multipath communication and show how a partial solution to the factorization problem may be obtained.

EFFECTS OF FADING ON QUADRATURE RECEPTION OF ORTHOGONAL SIGNALS
G. Lieberman, RCA Rev., vol. 23, no. 3, Sept. 1962, p. 353/395.

. . . An analysis of effects of fading, frequency instability, and noise on quadrature reception of orthogonal signals is given. . . The analysis includes effects of the shape of the spectrum of the fading carrier. The model assumes nonselective fading consisting of a specular component superposed on a Gaussian-process random component. The measure of error probability performance used consists of quantiles of error probability as well as the mean probability of error.

RECOVERY OF INFORMATION TRANSFERRED INTO PHASE MODULATION IN IONOSPHERIC WAVE PATHS
M. Mancianti, et al., Pisa U. (Italy), Final rept., 1 Feb. 1961/31 Jan. 1962, AFCRL 62-547, Feb. 1962, 37 p., incl. illus., 11 refs., AD 282 960.

. . . information. . . originally impressed onto a signal as amplitude modulation, has been changed to phase modulation by travelling through the ionosphere. . . at least partial recovery . . . by means of a double homodyne detector was studied. . .

HIGH FREQUENCY DIGITAL COMMUNICATION SYSTEM
National Cash Register Co., Dayton, Ohio. Quarterly progress engineering rept. no. 5, 1 June/31 Aug. 1962, NCR rept. no. 3-5Q, 15 Oct. 1962, 101 p., incl. illus., AD 287 485.

. . . system that provides highly reliable operation in the presence of multipath propagation and doppler shift. . . . operation of the circuits used in the control and coding equipment. . . .

VERFAHREN ZUR BESEITIGUNG AUFTRETENDER ECHOS BEI BELIEBIGEN ZEITVORGANGEN (A Method for Eliminating the Existing Echoes for any Time Function) (In German)
H. G. Enke, Nachrichtentech. Z., vol. 16, Sept. 1963, p. 464/468, 18 refs., A63-24423.

. . . The group delay difference between the signal and echoes is determined from measurements of the auto-correlation function and the cross-correlation function, respectively. Elimination of the echoes is accomplished by feedback of an amplifier via group delay sections.

OPTIMUM PERFORMANCE OF SELF-ADAPTIVE SYSTEMS OPERATING THROUGH A RAYLEIGH-FADING MEDIUM
J. C. Hancock, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 443/453, 19 refs.

. . . problem of communicating through the Rayleigh-Fading-Multipath channel with additive noise. The a posteriori probabilities necessary for specifying different receiver modes for various forms of a priori channel knowledge are derived. System performance is analyzed and computed for several modes of operation and the results presented in graphical form, allowing one to determine the importance of making measurements on the unknown channel state. . . .

DETECTION OF FADING TARGETS IN NOISE: THE CASE IN WHICH THE FADING IS NEITHER FAST NOR SLOW
P. W. James, Royal Aircraft Establishment (Gt. Brit.), RAE TN RAD 828, Jan. 1963, 40 p., AD 406 158.

. . . with particular reference to the case when the signal fading period is (a) less than the post-detection integration time, and (b) greater than the time interval over which the noise, after multiplication by an appropriate reference waveform, is predictable. . . The theory leads to expressions for detection probabilities for arbitrary fading rate. Some numerical results are presented in the form of graphs showing how the diversity gain arising out of the signal fluctutation varies with fading rate.

A RAKE SYSTEM FOR LUNAR RELAY COMMUNICATIONS
S. Kasowski, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 197/214, 15 refs.

PERFORMANCE ANALYSIS FOR THE COHERENT MULTIRECEIVER IN SPECULAR AND RANDOM MULTI-CHANNELS
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 154/156.

The multireceiver combines, at the conclusion of each signaling interval, samples taken from both the matched filter and square law detector outputs (Fig. 6). Under the. . . assumptions . . . that the signals are assumed to be selected from an equal energy signaling alphabet which occurs with equal probability, the detection system is optimum in the a posteriori probability computing sense (Ref. 9).

AN INTEGRAL EQUATION ARISING IN MULTICHANNEL COMMUNICATION PERFORMANCE CHARACTERISTICS
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 156/158.

Suitable for specifying the performance characteristic for a non-coherent multilink communication system employing two correlated equiprobable, equal-energy signals, . . . The result is, in fact, a generalization of a result obtained by Helstrom (Ref. 16) and includes results obtained by Turin (Ref. 17), Lindsey (SPS 37-20, Vol. IV), Reiger (Ref. 18), and Pierce (Ref. 19) as special cases. . . . The waveforms transmitted into the multi-channels are presumed to be perturbed by Rician Fading and additive white Gaussian noise. . . Cross-correlation or matched filter quadratic envelope detection is used.

A NOTE ON THE COHERENT MULTI-CHANNEL DETECTOR
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 180/184.

An integral solution is presented which has application to the singly noncentral F-distribution with 2 deg. of freedom for the chi-squared variate and 1 deg for the denominator; in terms of detection theory the integral specifies the error rate for a coherent correlation receiver which is connected to a channel that may assume one of several statistical forms.

USE OF A TIME-DELAY CORRELATOR IN SOLVING AN ACOUSTIC MULTI-PATH PROBLEM (Correspondence)
A. G. Ratz, Proc. IEEE, vol. 51, no. 1, Jan. 1963, p. 239.

FEATURES OF OPTIMUM RECEPTION OF A PULSED SIGNAL IN LONG-DISTANCE TROPOSPHERIC PROPAGATION OF RADIO WAVES
I. G. Tratas, Radiotekhnika i Elektronika, vol. 8, April 1963, p. 546/551, In Russian; Radio Engineering and Electronic Physics, vol. 8, April 1963, p. 590/594, Translation, A64-15212.

CONDITIONS OF MAXIMUM NOISE IMMUNITY OF SYSTEMS WITH ACTIVE SPACING INTERVAL AND INDETERMINATE SIGNAL PHASE
I. A. Tsikin, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 7, July 1963, p. 1/11.

OPTIMUM POWER DIVISION IN COHERENT COMMUNICATION SYSTEMS
H. L. Van Trees, Lincoln Lab., Mass. Inst. of Tech., Lexington, Feb. 19, 1963, 51 p., 9 refs., N63-23350.

. . . Specifically considered is a binary symmetric, phase-modulation system operating over a channel which imparts a random phase modulation to the signal and adds Gaussian noise. . .

Related Publications:

APPLICATION OF INFORMATION THEORY TO VARIABLE RATE SCATTER COMMUNICATION
H. Blasbalg, Second National Symposium Global Commun. St. Petersburg, Fla., Dec. 1958, p. 1/35.

MEAN ABSOLUTE VALUE AND STANDARD DEVIATION OF THE PHASE OF A CONSTANT VECTOR PLUS A RAYLEIGH-DISTRIBUTED VECTOR
J. R. Johler, et al., J. Res. Nat. Bur. Stand., vol. 1962, May 1959, p. 183/186.

SOME THOUGHTS ON MODULATION AND DEMODULATION FOR THE NEEDLES CHANNEL PART I
R. Price, Lincoln Lab., Mass. Inst. of Tech., Lexington, Group rept. no. 34-86, 15 April 1959, 18 p., AD 262 922.

A highly random model for the Needles channel is adopted, and the application of detection theory yields a cross-correlator-radiometer receiver that is near-optimal at low-S/N in the channel. Relationships to the Rake system are discussed. It is concluded that under certain conditions desirable waveforms for the Needles channel are sinusoids employed in a manner that circumvents intersymbol interference. . . .

A MATCHED FILTER DETECTION SYSTEM FOR COMPLICATED DOPPLER SHIFTED SIGNALS
R. M. Lerner, IRE Trans. Inform. Th., vol. IT-6, no. 3, June 1960, p. 373/385.

PHASE-SHIFT KEYING IN FADING CHANNELS
H. B. Voelcker, Proc. Instn. Elect. Engrs., pt. B, vol. 107, no. 31, Jan. 1960, p. 31/38.

THE DICON SYSTEM
R. S. Berg, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, (Technical rept. no. 251), 31 Oct. 1961, 28 p., AD 267 536.

. . . pertubations are expected to be due principally to Doppler shift, Doppler spread and multipath delay. Since the fluctuation and multipath times may be of the same order, a noncoherent detection scheme is used.

A COMPARISON OF FREQUENCY-SHIFT ANTI-MULTIPATH SIGNALING TECHNIQUES FOR DIGITAL COMMUNICATION SYSTEMS
W. B. Jones, Jr., IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 83/87.

WIDTH OF THE PASSBAND IN SINGLE AND SPACED RECEPTION OF THE SIGNALS IN LONG DISTANCE TROPOSPHERIC PROPAGATION OF ULTRA SHORT WAVES
A. S. Nemirovskii, Telecommunications, no. 5, Oct. 1961, p. 501/512.

THE ECONOMICAL DESIGN OF RADIO COMMUNICATION SYSTEMS BY MATCHING THE MESSAGE URGENCY TO THE FADING CONDITIONS
L. P. Yeh, IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1961, p. 288/291.

A matched-traffic technique is proposed to control the hourly traffic volume so that the capacity of the system is designed only to carry the urgent messages that require immediate transmission at the desired reliability.

A SIMPLE ADAPTABLE RECEIVER WITH PILOT TONES FOR ANALOG TRANSMISSION THROUGH A SELECTIVE FADING CHANNEL
D. A. Chesler, Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 163/169.

MULTIPATH AND SCATTER COMMUNICATION TECHNIQUES
D. P. Harris, IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 161, 16 refs.

. . . results of an investigation of random-multipath-and scatter-communication channels and of communication techniques applicable to such channels. The limiting bounds imposed on the performance of adaptive matched-filter receiver techniques by channel-sounding errors are evaluated for a wide range of behavior in practical multipath-channel models. . . .

DESIGN OF RELIABLE LONG-DISTANCE AIR-TO-GROUND COMMUNICATION SYSTEMS INTENDED FOR OPERATION UNDER SEVERE MULTIPATH PROPAGATION DISTURBANCES
K. W. Otten, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 67/78.

A survey of the principal methods of improving the reliability of long-range digital communication systems. . . Special modulation techniques as well as redundant transmission of pulses, redundant in time and in carrier frequency, are described as methods to counteract the effects of multipath distortion in connection with the proper special demodulation and diversity reception techniques. . . . for an air-to-ground communication system, in which Doppler shift has to be considered in addition to the multipath distortion, high reliability can be obtained if quantized frequency modulation (QFM) and time redundancy are properly applied. . . .

DISTORTION OF SIGNALS TRANSMITTED THROUGH THE IONOSPHERE
R. L. Greenspan, MITRE Corp., Bedford, Mass., Rept. no. W5810, ESD TDR 63 289, Aug. 1963, 23 p., AD 415 013.

. . . The effect of the ionosphere on signal transmission is obtained by inversion of a Fourier integral, and the relevance of group velocity, signal velocity, and time delay concepts is examined. The dispersions decreases the output signal of a typical UHF correlation receiver by less than 3 db for normal ionospheric conditions.

ADAPTIVE RECEPTION OF SIGNALS WITH UNKNOWN GAIN AND DELAY
J. C. Hancock, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 54/65.

APPROXIMATE DETERMINATION OF THE DISTRIBUTION FUNCTION OF FADE LENGTHS BELOW THRESHOLD LEVEL FOR THE ENVELOPE OF THE SUM OF A DETERMINISTIC SIGNAL AND GAUSSIAN STATIONARY NOISE
B. R. Levin, et al., Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 5, May 1963, p. 20/26.

The distribution function of the axis-crossing intervals for the envelope of the sum of a sinusoidal signal and Gaussian noise by the first-approximation curve for noise alone when the intervals are small and by an exponential curve when the intervals are too large is approximated. . . . compared with known experimental data as well as with Rice's approximation method. . . .

2.874: Detection with Noisy Memory

Included: Detection of completely specified signals with a noisy version of the signal.

Cross References: Correlation detection (Sect. 2.82).

Principal Publications:

DETECTION OF A SIGNAL SPECIFIED EXACTLY WITH A NOISY STORED REFERENCE SIGNAL
T. G. Birdsall, Research Inst., U. of Michigan, Ann Arbor, Technical Report No. 93, Report No. 2803-1-T, AFOSR TN-59-909, Sept. 1959, 22 p., AD 229 517.

. . . optimization problem of detecting the presence of a signal in a background of white Gaussian noise, under the restriction that the signal is specified exactly but the receiver memory contains only a noisy version of the signal. . . .

Related Publications:

EVALUATING EFFICIENCY OF DATA STORAGE METHODS IN DETERMINING THE TIME POSITION OF WEAK PULSE SIGNALS
B. N. Mityashev, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 2, 1961, p. 50/61.

By example of a system with one threshold the author evaluates the efficiency of data storage methods in determining the time position of a group of weak pulse signals with coherent and incoherent high-frequency storage. . . . The advisability of using limiters in multi-channel storage systems is emphasized. . . .

2.875: Detection Theory for Sampled Communications Systems

Included: Theory of optimum detection for pulse communications systems.

Not Included: Design of pulse demodulators; Sampled modulation methods (1); Pulse code modulation (1); Sampling techniques (1).

Cross References: Time analysis detection methods (2.837).

Principal Publications:

EFFICIENCY AND RECIPROCITY IN PULSE-AMPLITUDE MODULATION: PART I, PRINCIPLES
K.W. Cattermole, Proc. Instn. Elect. Engrs., Pt. B, vol. 105, Sept. 1958, p. 449/462.

A METHOD OF INCREASING THE ACCURACY OF PULSE DEMODULATION
B.I. Mitiashev, Radio Engrg., vol. 13, no. 5, 1958, p. 78/90.

AUTOMATIC DIGITAL READOUT SYSTEM FOR TELEMETRY
E.J. Telander, Proc. Nat. Symp. Telem., no. 5.1, Sept. 1958.

Data Collection and Reduction system for PPM/AM, PWM/FM and FM/FM telemetry.

FREQUENCY DOMAIN APPLICATIONS TO DATA PROCESSING
M.A. Martin, IRE Trans. Space Electronics Telem., vol. SET-5, March 1959, p. 33/41.

. . . telemetered functions are not measured continuously. To permit time multiplexing, values of these functions are determined only at constant time intervals; it is said that they are sampled at a specified sampling frequency. Smoothing, differentiation and integration of continuous signals are quite familiar. Mathematical tools have been developed which perform similar operations on digitized sampled functions; by analogy, these tools are called numerical filters, or simply filters.

TELEMETRY DEMODULATOR USING MODIFIED "AND" GATE
L. Weisman, Electronics, vol. 32, no. 20, Feb. 1959, p. 54/57.

Input circuit to pulse-position telemetry demodulator is a modified two-input semiconductor diode AND gate. A quasifeedback-type link between transmitting and receiving equipments compensates variation parameters.

EXPERIMENTAL INVESTIGATION OF THE EFFECT OF NOISE SUPPRESSIONS IN THE SAMPLED DATA METHOD OF AMPLIFICATION
G.S. Anufriyev, et al., Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 9, 1961, p. 10/18.

ON THE APPROACH OF A FILTERED PULSE TRAIN TO A STATIONARY GAUSSIAN PROCESS
P. Bello, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 144/149.

. . . output of a narrow-band filter when the input is wide-band non-Gaussian noise of a certain class, and the bandwidth of the narrow-band filter approaches zero. The non-Gaussian input consits of a train of pulses having identical waveshapes, but random amplitudes and phases.

EXTRAPOLATION (PREDICTION) OF A FUNCTION WITH A LIMITED SPECTRUM FROM ITS DISCRETE VALUES (Translation)
I.G. Polliak, Telecommun. Radio Engng., Pt. II - Radio Engng., vol. 17, Nov. 1962, p. 59/67, 12 refs., A63-16488.

. . . useful in the design and analysis of sampled-data systems in communications and remote control, as well as in numerical analysis.

Related Publications:

FILTERING SAMPLED FUNCTIONS
E.D. Fullenwider, et al., U.S. Naval Ordnance Lab., Corona, Calif., July 1956, Tech. Memo 64-104.

HIGH SPEED PULSE AMPLITUDE DISCRIMINATOR
F.J. Farley, Rev. Sci. Instrum., vol. 29, July 1958, p. 595/596.

TELEMETERING RECEIVING STATION TIME PULSE DETECTOR
J. Star, IRE Nat. Conv. Rec., vol. 6, no. 5, March 1958, p. 43/49.

Section 2.88
Detection Theory for Related Applications

2.881: Search Operations and Detection Systems

Included: Optimum sync search procedures; Identification problems in signal detection; Expected search times; Frequency acquisition of received signals; Conditional frequency uncertainty; Sequential search theory; Random search methods; Defective coin problem.

Not Included: Synchronization subsystems.

Cross References: Synchronization codes (2.124); Discriminant analysis (2.841).

Principal Publications:

OPTIMUM SEARCH FOR OBJECTS HAVING UNKNOWN ARRIVAL TIMES
N. Blachman, et al., Electronic Defense Lab., Mountain View, Calif., Engrg. rept. no. EDL-E30, Sept. 1958, 25 p., AD 208 306.

THE EFFECT OF NOISE UPON A METHOD OF FREQUENCY MEASUREMENT
T. B. Pickard, IRE Trans. Inform. Th., vol. IT-4, June 1958, p. 83/88.

ON VARIOUS VERSIONS OF THE DEFECTIVE COIN PROBLEM
R. Bellman, et al., Inform. Control, vol. 4, no. 2/3, Sept. 1961, p. 118/131.

The problem of ascertaining the minimum number of weighings which suffice to determine the defective coin in a set of N coins of the same appearance, given an equal arm balance and the information that there is precisely one defective coin present, is well known. . . . The problem in the case where there are known to be two or more defective coins is far more complex because we cannot draw any simple definite conclusions at the end of a single test. . . . The purpose of this paper is to indicate a systematic way in which the theory of dynamic programming can be used to provide a computational solution to the determination of optimal and suboptimal testing policies. . . .

SEARCH PROCEDURES MINIMIZING EXPECTED SEARCH TIME
E. C. Posner, et al., JPL. Res. Summ., vol. 1, no. 36-10, June/July 1961, p. 15/16.

A study has been made of search procedures for finding a satellite in a noisy sky. The parts of the sky in which the satellite is known to be is assumed composed of A disjoint cells (A=about 50 in practice), each cell the size of the area of sky that the narrowest antenna beam can search. In this summary, only single-sideband transmission and white guassian noise will be discussed.

OPERATIONS RESEARCH ON RECOGNITION. THE GENERALIZED SEARCH PROCESS
R. D. Turner, Advanced Electronics Center, General Electric Co., Ithaca, N. Y., Scientific rept. no. 2, Nov. 1961, lv., AD 266 874.

OPTIMAL SEARCH PROCEDURES FOR ACQUISITION OF A SINGLE TARGET
N. Zierler, JPL Res. Summ., no. 36-8, Feb./March 1961, p. 52.

RAPID ACQUISITION OF DOPPLER FREQUENCIES
W. Ewanus, et al., IRE Internat. Conv. Rec., Pt. 5, vol. 10, March 1962, p. 32/48.

INCOHERENT FREQUENCY AND ANGULAR ACQUISITION OF A SPACE VEHICLE BEACON
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-17, Aug./Sept. 1962, p. 87/91.

The problem of simultaneously estimating or measuring the carrier frequency and the position of a space vehicle is difficult to formulate in terms of what is known a priori. For simplicity, we first consider the problem of acquiring the vehicle's angular position and later, the combined acquisition problem.

EXPECTED SEARCH TIMES
E. C. Posner, et al., JPL Space Progr. Summ., vol. 4, no. 37-16, June/July 1962, p. 48/50.

A space probe is known to be radiating or reflecting from one of many "cells" into which the sky has been divided. An antenna search is instituted. The signal detected from a cell that is empty is a normally distributed random variable of mean 0 and variance inversely proportional to the search (or integration) time. In

this summary, an exact answer is derived to the . . . problem for the idealized case of two cells . . .

It will be necessary to consider first the case of discrete intervals of search time, and then let the length of the intervals approach zero.

SEARCH PROCEDURES FOR A SATELLITE BEACON OF UNKNOWN FREQUENCY AND POSITION
A. J. Viterbi, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 43/46.

A STATISTICAL THEORY FOR PARAMETER IDENTIFICATION IN PHYSICAL SYSTEMS
A. A. Wolf, et al., J. Franklin Inst., vol. 274, no. 5, Nov. 1962, p. 369/400.

ASSESSMENT OF THE NOISE IMMUNITY OF THE AUTOMATIC PULSE RANGEFINDER IN THE SIGNAL-SEARCHING MODE OF OPERATION
M. P. Bobnev, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 5, May 1963, p. 57/65.

(See also AD 422 871).

ON THE NARROW BEAM COMMUNICATION SYSTEM ACQUISITION PROBLEM
J. S. Greenberg, IEEE Trans. Mil. Electronics, vol. MIL-8, no. 1, Jan. 1964, p. 28/39.

It is desired to establish a communication link between two separate transmit-receive terminals, each having narrow beamwidths and specified uncertainity as to relative angular locations. To achieve the communication link the narrow beams must point directly at each other. The purpose of this paper is to determine the search or acquisition time required by the two terminals to achieve the desired state of knowledge whereby the transmit-receive beams of both terminals are pointed in the required directions, signals are mutually recognized and the communication link is thereby established. . . .

ANALYSIS OF AN OPTIMUM SYNC SEARCH PROCEDURE
C. Gumacos, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 89/99.

Synchronization of communications receivers can require lengthy sync search procedures. In order to establish theoretical guideposts for evaluating synchronization systems, an idealized model is assumed in which: 1) Sync exists in one, and only one, of large number of discrete time cells, 2) the a priori probability distribution of sync position is known and 3) samples taken from any time cell are normally distributed. . . .

ACQUISITION TIME AND ERROR RATES USING THE ENERGY DETECTOR
W. C. Lindsey, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 176/179.

The problem of acquiring the angular position and carrier frequency of a space vehicle is discussed; and included, as a special case, is the error analysis and average acquisition time associated with one particular type of detector.

O RATSIONAL'-NOM PLANIROVANII OPERATSII POISKA (Rational Planning of Search Operations) (In Russian)
I. V. Liubatov, Akademiia Nauk SSSR, Izvestiia, Tekhnicheskaia Kibernetika, Jan.-Feb 1964, p. 94/100, A64-16976.

EKSTREMAL'-NOE REGULIROVANIE NEPRERYVNYKH MNOGOPARAMETRICHESKIKH SISTEM METODOM SLUCHAINOGO POISKA (Optimizing Control of Continuous Multiparameter Systems by the Method of Random Search) (In Russian)
V. A. Mutsenieks, et al., Akademiia Nauk SSSR, Izvestiia, Tekhnicheskaia Kibernetika, Jan.-Feb. 1964, p. 101/110, A64-16977.

EXACT EXPRESSIONS FOR EXPECTED SEARCH TIMES
E. C. Posner, et al., JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 152/154.

In RS 36-10, Vol. I, pp. 15/16 and SPS 37-16, Vol. IV, pp. 48/50, the problem of searching for a space probe with a radar antenna was discussed. RS 36-10, Vol. I, pp. 15/16 considered only a restricted class of strategies, and SPS 37-16, Vol. IV, pp. 48/50 only the case in which the uncertainty of the probe's position was confined to two radar beam widths, or "cells". . . . the search procedure under consideration throughout this note will be the one which always looks at the most likely cell.

OPTIMAL SEARCH PROCEDURES
E. C. Posner, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 157/160.

This paper sets up a restricted class of search procedures for a satellite lost in a region of the sky. The satellite must be found by a radar search. The procedures under consideration allow the use of a preliminary search,

which may be done with a wider beam than is required for the final search. The purpose of the preliminary search is to obtain a ranking of the various portions of the sky, so that the final search can examine the more likely regions of the sky first. It is shown that a preliminary search can reduce the expected search time . . .

SEQUENTIAL SEARCH AND DETECTION THEORY IN THE PRESENCE OF A MULTIPLICITY OF HYPOTHESES
E. C. Posner, et al., JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 164/176.

In previous SPS's, a probabilistic model for initial angle acquisition of a satellite was considered (RS 36-10, Vol. I, pp 15/16 SPS 37-16, Vol. IV, 48/50; SPS 37-21, Vol. IV, pp 152/154). This article presents the final results of this research project.

CONDITIONAL FIRST PASSAGE TIMES IN COMMUNICATION THEORY
E. C. Posner, et al., JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 195/201.

. . . extends results in SPS 37-21, Vol. IV. We consider . . . the expected time for a continuous-parameter one-dimensional Markov process with continuous sample functions to first leave a bound interval, given that the sample function leaves from a given one of the two boundary points. We generalize the problem . . . This model is applicable to a wide variety of search problems including radar search for satellites, two-way channels, etc. Finally, we consider a new application of the single-process case to cycle-skipping in phase-locked loops.

FREQUENCY ACQUISITION BY SWEPT OSCILLATOR TECHNIQUES
A. J. Viterbi, JPL Space Progr. Summ., vol. 4, no. 37-21, April/May 1963, p. 149/152.

In RS 36-14, Vol. I, pp. 71/75, the problem of determining the approximate frequency of a sinusoid in the presence of additive Gaussian noise was considered, and an optimum receiver for the purpose was analyzed. . . . Since the equipment requirements are generally prohibitive, an alternate mechanization which requires only one such device and performs the function serially may be preferable, even though it multiplies the overall observation time by a factor of WT.

CONDITIONAL FREQUENCY UNCERTAINTY IN SPACECRAFT ACQUISITION
E. A. Yerman, JPL Space Progr. Summ., vol. 4, no. 37-24, Oct./Nov. 1963, p. 192/195.

In attempting to acquire a signal from a spacecraft whose position is not known due to uncertainties in its trajectory . . . search in both frequency and angle must be performed. Present search procedures sweep a band of maximum frequency uncertainty, around the center frequency, and this maximum uncertainty is found as a function of time. This study shows, using a particular launch model, that the length of the frequency uncertainty interval at injection can be reduced . . . by a factor of about 2 for a representative trajectory.

PROBLEM OF SEARCH IN A SYSTEM WITH FINITE NUMBER OF POSITIONS
K. S. Zigangirov, Joint Publications Research Service, Washington, D. C., In its Transl. on USSR Electron, 12 April 1963, p. 13/24, refs, N64-11835.

Related Publications:

DETECTION OF A PULSED SINUSOID IN NOISE AS A FUNCTION OF FREQUENCY
D. M. Green, et al., J. Acoust. Soc. Amer., vol. 31, no. 11, Nov. 1959, p. 1446/1452.

ON THE AVERAGING OF REDUNDANT MEASUREMENTS FOR MAXIMUM PRECISION
M. L. Eaton, Pacific Missile Range, Point Mugu, Calif., PMR TM 63 12, 11 Jan. 1963, 30 p., AD 420 844.

A method is derived for obtaining a weighted average of several redundant measurements of a common vector quantity so as to obtain the estimate of the vector with minimum error "variance". . . . the method is applied to a specific submarine-locating problem, where the submarine's position is to be estimated by use of hydrophones and a depth sensor. . . .

ON THE APPLICATION OF DISCRIMINANT ANALYSIS TO IDENTIFICATION IN AERIAL PHOTOGRAPHY
L. N. Kanal, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 416/419.

AN OPTIMAL DATA ASSOCIATION PROBLEM IN SURVEILLANCE THEORY
R. W. Sittler, IEEE Trans. Mil. Electronics, vol. MIL-8, no. 2, April 1964, p. 125/139.

. . . By a method of inverse probability, the optimal data processor is obtained which permits maximum likelihood estimates to be made of the true data-surveillance object association. The maximum likelihood estimator is given in a form that lends itself to sequential computations performed in real time as the data arrives. . . . Computer implementations are possible. . . .

THE ANALYSIS OF MULTIPLE SIGNAL DATA
J. W. Smith, IEEE Trans. Inform. Th., vol. IT-10, No. 3, July 1964, p. 208/214.

2.882: Tracking Operations and Detection Theory

Included: Frequency tracking methods; Phase tracking methods; Delay lock tracking.

Not Included: Design of phase tracking loops; Signal tracking subsystems; Delay lock loop design.

Cross References: Radar detection theory (2.883); Frequency acquisition problems (2.881); Frequency search operations (2.881).

Principal Publications:

PROBABILITY OF CONTINUOUS TRACKING IN THE PRESENCE OF RANDOM NOISE
F. E. Alzofon, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 519/527.

EIN IMPULSSCHWEBUNGSVERFAHREN FUR GENAUE FREQUENZ- UND PHASEN-MESSUNGEN UND PHASENSTARRE FREQUENZTRANSFORMATION (A Pulse Frequency Conversion System for Accurate Frequency and Phase Measurement and for Phaselock Frequency Transformation) (In German)
G. Becker, Frequenz, vol. 12, March 1958, p. 82/90.

RADAR TARGET ANGULAR SCINTILLATION IN TRACKING AND GUIDANCE SYSTEMS BASED ON ECHO SIGNAL PHASE FRONT DISTORTION
D. D. Howard, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 840/849.

The slope of the phase front of the echo signal from a finite size complex target is shown to be identical to the angular errors caused in tracking radars by angular scintillation or target angle noise. . . .

ZUSAMMENSTELLUNG UND VERGLEICH BEKANNTER VERFAHREN ZUR AUFFINDUNG PERIODISCHER PULSE BEI ANWESENHEIT VON GERAUSCHEN (Survey and Comparison of Methods to Find Periodical Pulse Sequences in the Presence of Noise) (In German)
D. Haubig, Hochfrequenztech. u. Elekt. Akust., vol. 69, no. 3, June 1960, p. 94/103.

AN APPROACH TO THE STUDY OF AUTOMATIC TARGET TRACKING
L. Pode, Commun. and Electronics, vol. 46, Jan. 1960, p. 806/811.

TARGET TRACK CORRELATION WITH A SEARCH MEMORY
E. C. Joseph, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 255/261.

DELAY-LOCK TRACKING OF BINARY SIGNALS
J. J. Spilker, Jr., IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 1, March 1963, p. 1/8.

. . . The delay-lock discriminator is a nonlinear feedback system which employs a form of cross correlation in the feedback loop and continuously estimates the relative delay between a reference signal and a delayed version of that signal which is perturbed with additive noise. Binary maximal-length, shift-register sequences are used as the signal because they can easily be regenerated with any desired delay and they possess desirable autocorrelation functions. . . . performance in the presence of additive Gaussian noise is discussed. Computations are made of the effect of amplitude-limiting the received data on the system noise performance. . . .

Related Publications:

MINIMUM ENERGY TRIGGERING SIGNALS
L. A. Beattie, Proc. IRE, vol. 46, April 1958, p. 751/757.

. . . optimization of the function of time which is used for triggering so as to minimize the energy required of the triggering signal.

PHASE-LOCK LOOP DESIGN FOR COHERENT ANGLE-ERROR DETECTION IN THE TELSTAR SATELLITE TRACKING SYSTEM
W. L. Nelson, Bell Syst. Tech. J., vol. 42, no. 5, Sept. 1963, p. 1941/1975.

The function of the angle-error detector is to provide pointing-error signals to the ground antenna control system, which allows operation in the autotrack mode once the satellite beacon has been acquired. The limitations on the accuracy of this system imposed by noise, phase jitter and Doppler effects are evaluated and the optimum design in terms of minimum mean-square error is developed. Design examples are given for both the horn-reflector antenna autotrack system and the precision tracker antenna system.

RADAR TRACKING ACCURACY IMPROVEMENT BY MEANS OF PULSE-TO-PULSE FREQUENCY MODULATION
W. P. Birkemeier, et al., Commun. and Electronics, vol. 81, No. 64, Jan 1963, p. 571/575.

PULSE POSITION MODULATION CODE FOR THE IMPROVEMENT OF DOPPLER SHIFT MEASUREMENT
L. A. Wan, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 192/195.

. . . for improving Doppler measurement by pulsed radar with respect to Woodward's expression of Doppler ambiguity . . . The code of pulse positions is shown to be analytically obtained from the difference between the required ambiguity expression and that of a constant pulse-repetition frequency signal. . . .

2.883: Radar Signal Detection Theory

Included: Detection of fluctuating targets; Statistical theory of target detection; Resolution of radar signals; Range resolution; Ambiguity function; Multiple target resolution; Detection methods for chirp radar; Angular radar solution.

Not Included: Radar systems design; Satellite tracking radars; Spreak spectrum modulation techniques (1); Pulse compression techniques (1).

Cross References: Ranging codes (2.123); Correlation detection (Sect. 2.82).

Principal Publications:

A RADAR DETECTION PHILOSOPHY
W.M. Siebert, IRE Trans. Inform. Th., vol. IT-2, no. 3, Sept. 1956, p. 219/220.

THE APPLICATION OF "COMPARISON OF EXPERIMENTS" TO DETECTION PROBLEMS
N. Abramson, IRE Nat. Conv. Rec., March 1958, p. 22/26.

Recently developed topic in the theory of statistical decisions, application to radar detection.

DETECTION OF RADAR SIGNALS BY DIRECT MEASUREMENT OF THEIR EFFECT ON NOISE STATISTICS
G.I. Cohn, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 821/831.

BANDWIDTH CONSERVATION IN PULSE MODULATED RADARS
R.A. Rosien, et al., IRE Nat. Conv. Rec., vol. 6, no. 8, March 1958, p. 139/154.

SOME APPLICATIONS OF DETECTION THEORY TO RADAR
W.M. Siebert, IRE Nat. Conv. Rec., March 1958, p. 5/14.

This tutorial paper considers the problems of radar detector design in terms of statistical decision theory.

DETECTION OF MOVING RADAR TARGETS IN CLUTTER
L.H. Zetterberg, Inform. Control, vol. 1, Dec. 1958, p. 314/333.

ACCURACY OF A MONOPULSE RADAR
D.K. Barton, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 179/186.

THE EFFECTS OF NOISE ON A STACKED BEAM HEIGHT FINDING RADAR
R.A. Enstrom, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 3, June 1959, p. 192/195.

MULTIPLE TARGET RESOLUTION OF MONOPULSE VERSUS SCANNING RADARS
S.F. George, et al., Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 814/823.

The lack of information on the multiple target resolution characteristics of operational radars prompted a study of the inherent angle resolving powers and angle error sensitivities of the most prevalent tracking systems: amplitude comparison monopulse, conical scan, and two forms of sequential lobing. . . .

THE ANALYSIS OF PULSED RADAR SIGNALS IN NOISE
C.W. Helstrom, Westinghouse Research Labs., Research Report 8-1259-R10, Jan. 1959, 47 p.

A COMPARISON BETWEEN PULSE AND FREQUENCY-MODULATION ECHO-RANGING SYSTEMS
L. Kay, J. Brit. Instn. Radio Engrs., vol. 19, Feb. 1959, p. 105/117.

A general theory of the operation of frequency-modulation systems has been developed which can be applied to either Asdic or Radar, and the information obtained from such a system is compared with that from a conventional pulse system and a multipulse system.

RADAR RECEIVER SYSTEM
W.M. Stone, et al., Trans. IRE Inform. Th., vol. IT-5, March 1959, p. 9/11.

Expressions for the detection probabilities associated with the output of filter-square law detector-filter radar receivers are presented for practical filter systems and with a slowly varying Rayleigh distributed signal amplitude.

A COMPARISON OF THE METHODS OF RADAR RECEPTION FROM THE POINTS OF VIEW OF INFORMATION THEORY
F.P. Tarasenko, Radio Engrg., vol. 14, no. 7, 1959, p. 88/98.

SIGNAL DETECTION AGAINST A BACKGROUND OF NORMAL NOISE AND RANDOM REFLECTIONS
V.D. Zubakov, Radio Engrg. Electronics, vol. 4, no. 1, 1959, p. 42/59.

This article is devoted to the theory of optimum detection of radar signals in the presence of noise and reflections from local objects distributed at random. Stray reflections are represented as a random process for a train of main pulses.

THE OPTIMUM FALSE ALARM PROBABILITY FOR RADAR SYSTEMS
J.F. Bartram, East Coast Conf. Aerosp. Navig. Electronics, vol. 7 Oct. 1960, no. 2.1.4.

. . . method . . . for maximizing radar detection performance at a given signal-to-noise ratio . . . performance is defined as the amount of information flowing out of the radar into the computer. . . .

SYSTEM EVALUATION OF LOW-NOISE RADAR SENSITIVITY
S. Charton, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 4, June 1960, p. 234/241.

. . . recent reductions in receiver noise level by variable reactance amplifiers, masers, etc. have resulted in externally-originating and internally-originating noise levels of the same order of magnitude. Thus, a careful evaluation of the external noise environment must be made in order to determine system sensitivity. . . . external noise . . . from . . . atmospheric oxygen . . . water vapor . . . galaxy, radio stars . . . Warm earth radiation . . . certain assumptions concerning terrain, antenna pattern, ground cover . . . little experimental data has been presented to justify these estimates. Therefore, it was decided to make experimental measurments on representative antennas and sites in order to check the validity of the theoretical estimates. . . .

LIMITATIONS OF ANGULAR RADAR RESOLUTION
E. Eichler, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 4, June 1960, p. 249/252.

Angular radar resolution, its limits, and means for reaching or overcoming them are reviewed. The subject is linked to optical diffraction theory and to the resolution problem and the sampling theorem of communication. . . .

THE CORRELATION FUNCTIONS AND ENERGY SPECTRA OF FM RADAR SIGNALS
S.E. Fal'kovich, Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 12, 1960, p. 16/24.

. . . assumption that the duration T of the signal is the same as the duration of . . . the modulation period . . . it is supposed that the signal can be regarded as a frequency-modulated oscillation . . .

THE DETECTION OF RADAR ECHOES IN NOISE
E.J. Kelly, et al., J. Soc. Indust. Applied Math., vol. 8, no. 2, June 1960, p. 309/341.

A STATISTICAL THEORY OF TARGET DETECTION BY PULSED RADAR
J.I. Marcum, IRE Trans. Inform. Th., vol. IT-6, no. 2, April 1960, p. 59/144, Rand Research Memo RM-754, Dec. 1, 1947.

PROBABILITY OF DETECTION FOR FLUCTUATING TARGETS
P. Swerling, IRE Trans. Inform. Th., vol. IT-6, no. 2, April 1960, p. 269/308.

A STATISTICAL THEORY OF TARGET DETECTION BY PULSED RADAR
IRE Trans. Inform. Th., vol. IT-6, no. 2, April 1960, p. 65/67.

THEORETICAL ACCURACY OF RADAR MEASUREMENTS
IRE Trans. Aerospace Navig. Electronics, vol. ANE-7, no. 4, Dec. 1960, p. 123/129.

RANGE-ONLY TARGET CORRELATION
D.F. Allen, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 430/436.

A large number of targets can be simultaneously tracked with a single beam or monopulse radar using only range measurements and a single target tracking loop. Similar capabilities are exhibited for track-while-scan and multi-beam arrays. The technique utilizes inherently higher granularity in range compared with angle measurements to eliminate noise and to correlate target returns. State-of-the-art digital logic and a limited stored program computer can be specified for real-time correlation in presently realizable radar systems. . . . The Range-Only Target Correlator has been successfully simulated on the IBM 704 computer. . . .

GROUND CLUTTER AND ITS CALCULATION FOR AIRBORNE PULSE DOPPLER RADAR
S.D. Coleman, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 409/415.

RECEPTION OF RADAR SIGNALS WITH FLUCTUATION BACKGROUND NOISE (In Russian)
S.E. Fal'kovich, Moscow, Sovetskoye Radio, 1961, 312 p.

. . . is devoted to the statistical determination of the potential possibilities of radar systems and to design questions of radar receivers for reception under noisy conditions. The main part of the book is concerned with a revision of previously published materials. Part of the material is the author's own work. . . . detection of stationary targets, accuracy in the reading of coordinates, detection of moving targets, theory of simplified radar lines, some design questions of radio receiving equipment. . . .

THE OUTPUT SPECTRAL DENSITY OF A DETECTOR OPERATING ON A F.M.C.W RADAR SIGNAL IN THE PRESENCE OF BAND-LIMITED WHITE NOISE
J. Lait, et al., Proc. Instn. Elect. Engrs., Pt. C, vol. 108, no. 13, March 1961, p. 197/207.

A method of analysis suggested by Lawson and Uhlenbeck is used to examine the interaction between reference signal, echo and noise in the detector stage of a frequency-modulated c.w. radar receiver. . . . a method of approximation . . . restrictions on system parameters for which the approximations are valid.
Expressions for spectral density are derived separately for both quadratic and linear detectors, and the questions of optimum predetector bandwidth is examined. Finally, the authors consider how signal/noise ratio will be affected by choice of bandwidth in stages which follow the detector. . . .

THE INDETERMINACIES OF MEASUREMENTS USING PULSES OF COHERENT ELECTROMAGNETIC ENERGY
R. Madden, Proc. Instn. Elect. Engrs., Pt. C, vol. 108, no. 13, March 1961, p. 247/251.

. . . radar for the measurement of velocity and acceleration of objects . . . further perfection of equipment and further development of measuring techniques may not yield an increase in the quality of measurements because of the limitations inherent in the pulses themselves. In this paper, consideration will be given to the limitations which stem from well-established physical principles which, in more recent times, appear to have received less attention than they deserve. . . .

THE USE OF PULSE CODING TO DISCRIMINATE AGAINST CLUTTER
R. Manasse, Lincoln Lab., Mass., Inst. of Tech., Lexington, Group rept. no. 312-12, rev. 1, June 1961, 16p., AD 260 230.

ON THE OPTIMUM RANGE RESOLUTION OF RADAR SIGNALS IN NOISE
N.J. Nilsson, IRE Trans. Inform. Th., vol. IT-7, no. 4, Oct. 1961, p. 245/253.

. . . problem in distinguishing between different possible target configurations. Radar reception systems which perform optimum range resolution are . . . designed using the principles of statistical decision theory. . . . carried out for a squared-error loss function . . . Such a system is capable of simultaneously deciding the number of targets present, their spatial positions (ranges) and their relative amplitudes. The analysis also includes a discussion of an optimum device for the resolution of distributed (clutter-like) targets. . . .

LIMITATIONS ON DYMANIC RANGE AND MULTI-TARGET RESOLUTION FOR A SEARCH OR TRACK RADAR
W.L. Rubin, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 425/429.

POST-WAR DEVELOPMENTS IN CONTINUOUS-WAVE AND FREQUENCY-MODULATED RADAR
W.K. Saunders, IRE Trans. Aerospace Navig. Electronics, vol. ANE-8, no. 1, March 1961, p. 7/19, 52 refs.

. . . survey of trends . . . with emphasis on systems designed to operate to short range. . . . systems which use a single local oscillator power. . . . various methods of analysis which may be used to study these systems. . . . Some information of a practical nature on microphonism, nonlinearties, feed-thru, and saturation . . . A bibliography . . .

OUTLINE OF THE PRINCIPLES OF CW RADAR (In Russian)
A.S. Vinitskiy, Moscow, Sovetskoye Radio, 1961, 496 p.

A brief and accessible outline of the theoretical principles of CW radar . . . A systematic analysis . . . initial concepts and relations which are common to CW as well as pulsed radars; a number of new concepts (almost coherent functions, reduced time scale, etc.) is introduced and the classification of radar signals and methods of their reception is made more precise on their basis. . . . radar problems of a single target under CW radiation, including the principles of radar using the Doppler effect, the peculiarities of circuits and operational regions of FM radars . . . questions of detection of many targets, the series and parallel analysis of range spectra, range search and strobing in FM radars. . . . intended for radio specialists . . .

BRIGHTNESS DISCRIMINATION OF SIGNALS IN THE PRESENCE OF BACKGROUND NOISE
I.L. Zelmanovich, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 8, 1961, p. 78/84.

A decrease in the operating range of radar stations in the presence of atmospheric particles (clouds) is caused mainly by echo-signals reflected from said obstacles. In order to counteract the masking properties of rain (clouds), receivers are used which exhibit a logarithmic response . . . and transmitters having circular polarization. . . . The above-mentioned methods are less effective in the case of non-spherical particles (snowflakes). Somewhat better discrimination of the target signal over the background noise may be obtained by using a display for a minimum excess of signal over the noise . . . a discussion on the functional dependence of signal brightness discrimination when background noise is present on threshold contrast. . . .

A QUANTITATIVE EXAMINATION OF THE RADAR RESOLUTION PROBLEM
J.L. Allen, Lincoln Lab., Mass. Inst. of Tech., Lexington, Technical rept. no. 281, AFESD TDS 62-269, Sept. 1962, 41 p., AD 295 573.

SYSTEM PERFORMANCE IN THE PRESENCE OF STOCHASTIC DELAYS
W.M. Brown, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 206/214.

. . . With the advent of sophisticated data-processing systems using high time band-width products, it becomes necessary to consider the effects of stochastic delays. Depending on the particular application, the mathematical process to be considered is either a stochastic process of a stochastic process or a function of a stochastic process. . . .

THE EFFECT OF OBSTACLES ON THE ACCURACY OF CONICAL SCAN RADAR
J. Callahan, et al., Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 247/253.

IMPROVED AUTOMATIC DETECTION FOR RADAR
J.W. Caspers, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 1, Feb. 1962, p. 78.

Ability to discriminate between signals and noise is a basic need in radar systems. . . . Statistical theory . . . optimum methods of data processing . . . sequential probability ratio test . . .

ANALYSIS OF SIGNAL PROCESSING DISTORTION IN RADAR SYSTEMS
J.V. DiFranco, et al., IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 219/227.

. . . A measure of the loss in performance is obtained by the development of a modified radar "uncertainty function" which results from the presence of time-and frequency-domain distortions in the system. Losses due to the major sources of distortion are evaluated and several compensation techniques discussed. . . .

HIGH-RESOLUTION AND LONG-RANGE TECHNIQUES FOR RADAR APPLICATIONS. AN ANNOTATED BIBLIOGRAPHY
G.R. Evans, Lockheed Aircraft Corp., Sunnyvale, Calif., AD 273 074.

OPTIMUM DETECTION OF A RADAR SIGNAL WHEN SEVERAL RECEIVING CHANNELS ARE USED
V.B. Fedorov, Radio Engng: Transl. of Radioteckhnika, vol. 17, no. 9, Sept. 1962, p. 58/66.

. . . problem of detecting, against a background of set noise and interference, a signal arriving simultaneously through several information channels of a radar system with a multilobe coverage pattern. An expression is obtained for the mutual correlation factor of interference in the individual receiving channels. It is shown that the problem of optimum reception when several information channels are used may be reduced to a problem of optimum reception according to the data of one channel by altering the magnitude of the signal and the noise level in a definite manner. . . . 3. Optimum Signal Processing . . . considers the problem of the optimum processing of a signal, taking into account the presence of K information channels, for the . . . idealized model. . . .

MONOPULSE RESOLUTION IMPROVEMENT APPLIED TO THE AIR TRAFFIC CONTROL PROBLEM (Letter to the Editor)
R. Garcia, et al., IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 2, June 1962, p. 118.

A TECHNIQUE FOR THE MEASUREMENT OF THE POWER SPECTRA OF VERY WEAK SIGNALS
R.M. Goldstein, IRE Trans. Space Electronics Telemetry, vol. SET-8, no. 2, June 1962, p. 170/173.

. . . designed to distinguish the spectrum of a weak signal which is masked by strong background noise. The method was applied during the Jet Propulsion Laboratory Venus radar experiment to study spectral characteristics of the echo. . . .

EFFECTS OF PHASE ERRORS ON PULSE-COMPRESSION SYSTEMS (Correspondence)
H.L. Groginsky, et al., IRE Trans. Inform. Th., vol. IT-8, no. 4, July 1962, p. 321/322.

. . . phase-error tolerances for a wide class of pulse-compressions systems. . . . degradation of the ambiguity function for systems in which the phase error is either stochastic or deterministic.

A RANGE-SAMPLED SEQUENTIAL DETECTION SYSTEM
C.W. Helstrom, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 43/47.

Sequential analysis has been applied to detecting a radar target of unknown range by sampling the receiver output at instants separated by a Nyquist interval and conducting a sequential test at each sampling time. . . . In a sequential test of alternative hypotheses measurements are taken only until the choice of one hypothesis or the other can be made with a specified reliability. The theory of such tests was developed by Wald and applied to signal detection by Bussgang and Middleton and by Blasbalg. . . .

PROBABILITY OF DETECTION OF A RADAR PULSE TRAIN HAVING A NON-RECTANGULAR WAVEFORM ENVELOPE (Translation)
Iu. M. Kazarinov, Telecommun. Radio Engng., Part II — Radio Engng., vol. 17, Nov. 1962, p. 77/80, A63-16490.

Extension of a method for . . . rectangular envelope, to include a pulse train with non-rectangular envelope. . . .

SIGNAL FIDELITY IN RADAR PROCESSING
W.A. Penn, IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 204/218.

Usually in a radar signal-processing scheme, the primary consideration is the geometrical resolution of the system, or, if a particular measurement is desired, the accuracy of the system. . . . Usually, beyond these simple criteria, the matter of signal amplitude fidelity is not particularly stressed. In many processes, however, signal fidelity can be an important consideration in evaluating the over-all effect on the observer. In this paper the loss of information caused by signal interference in correlation or matched filter techniques is evaluated in an approximate manner. This is related to the invariance of the total integral of the Woodward ambiguity function. Degradation of the desired signal due to the statistical fluctuation of the signal itself is also considered. The distinction between pre-detection integration is made. . . . Finally . . . comments are made on the philosophy of providing adequate gray-level rendition in radar displays. Attention is given to reconciling the dynamic ranges of the display and the signals, and to the number of resolvable gray levels available in the signal. . . .

A LINEAR TRANSFORMATION OF THE AMBIGUITY FUNCTION PLANE (Correspondence)
F. B. Reis, IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 59.

RADAR RESOLUTION OF CLOSELY SPACED TARGETS
W. L. Root, IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 197/204.

. . . analysis of the problem of the resolvability of two radar targets which are located close together, in the sense that any parameters of the targets being measured (e.g., range, range rate, range acceleration, azimuth, azimuth rate, etc.) are close together . . . and it is assumed there is additive noise of arbitrary but known spectral shape. . . .

ANGLE ESTIMATION ACCURACY WITH A MONOPULSE RADAR IN THE SEARCH MODE
S. Sharenson, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 3, Sept. 1962, p. 175/179.

. . . The effects of narrow-band Gaussian receiver noise on the sum and differeace signals are considered. An asymptotic expansion for the angle estimate is derived which converges for SNR's of 12 db or greater. . . .

CIRCLE DIAGRAM APPLIED TO MONOPULSE
D. Thunqvist, IRE Trans. Commun. Syst., vol. CS-10, no. 3, Sept. 1962, no. 246/257.

Quite a lot of reports . . . have been published . . . The analysis has mostly been confirmed to pure amplitude sensing or pure phase sensing. If amplitude and phase are allowed to vary simultaneously the general formulas will be rather lengthy. The situation is suggestive of transmission line calculus where the usefulness of the Smith chart is well known.

In a slightly modified form this chart is a convenient aid in analyzing the influence of various parameters in the most common monopulse systems. . . .

THE EFFECTS OF NOISE THROUGH AN ANALOG INTEGRATOR WHICH INTEGRATES WITH RESPECT TO AN ARBITRARY VARIABLE
P. R. Westlake, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 3, Sept. 1962, p. 151/158.

THE EFFECTS OF NOISE THROUGH A RECTANGULAR-INTEGRATION PROCESS AND SOME SAMPLED SPECTRAL-DENSITY METHODS
P. R. Westlake, IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 3, Sept. 1962, p. 159/175.

DISTRIBUTION OF THE NORMALIZED PERIODOGRAM DETECTOR
R. P. Wishner, IRE Trans. Inform. Th., vol. IT-8, vol. 6, Oct. 1962, p. 342/349.

SIGNAL DETECTION UNDER NOISE INTERFERENCE IN A GAME SITUATION
L. H. Zetterberg, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 47/52, 11 refs.

With application to radar and data transmission, a game situation is studied where one player selects a suitable receiving filter, and the other a function describing the noise power density under restriction of a fixed total amount of power. The payoff function is a signal to noise ratio. . . .

PROBLEMS IN RADAR STATISTICAL THEORY (In Russian)
P. A. Bakut, I. A. Bal'shakov, et al., Moscow, Sovetskoye Radio, 1963, 424 p.

. . . a monograph on the statistical theory of radar. There are two volumes. The first sets out mainly problems of display theory, and the second, problems of radar measurements together with problems of target discrimination. A study is made of methods of analysis and synthesis of radar systems . . . intended for readers with a knowledge of the basic ideas of probability theory and the theory of random processes. . . .

SOME LIMITING FACTORS IN RADAR MEASUREMENT ACCURACY
F. C. Bequaert, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 79/82.

. . . discusses . . . these limitations, particulary for those radars observing objects entering the earth's atmosphere. A method is given for determining the effects of higher order time derivatives upon measurement accuracy as the measurement time is increased. . . . A method is then described for graphically presenting the radar system errors as function of observation

time. The use of such graphs in system analysis and synthesis is briefly discussed. . . .

EFFECTS OF PHASE ERRORS ON THE AMBIGUITY FUNCTION
W. M. Brown, et al., IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 118/123.

RADARS — THEORIES MODERNES (Radar, Modern Theories) (In French)
M. Carpentier, Paris, France, Dunod, 1963, 165 p.

. . . the book of a teacher in which the new ideas which, since 1947, have led to the realization of "modern radars" are soundly exposed. Among these are correlation radars, noise modulated radars, radars using pulse compression and Chirp radars, pulse radars using random frequency, Doppler radars, etc. . . .

DEGRADATION EFFECTS OF ARBITRARY PHASE ERRORS ON HIGH-RESOLUTION RADAR PERFORMANCE
D. K. Cheng, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 434/437.

DIGITAL DATA PROCESSING CONSIDERATIONS IN RADAR
P. J. Child, Radio and Electronic Engineer, vol. 27, Jan. 1964, p. 75/83, 13 refs., A64-14765.

FUNDAMENTAL ACCURACIES IN THE SIMULTANEOUS MEASUREMENT OF TRANSVERSE AND RADIAL TRAJECTORIES OF RADAR TARGETS
J. J. Connolly, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 64/68.

REAL-TIME MEASUREMENT AND CORRECTION OF PHASE DISTORTION IN HIGH-FIDELITY RADARS
J. DeLorenzo, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 96/103.

. . . Phase distortion causes variations in the radar uncertainty function, that, in many cases, degrade the resolution capability of the system. This paper briefly describes the characteristics of the common forms of distortion in practical systems and deals with the analytical and experimental results of phase measurements using a multiplier-type phase-error detector. The relationship of this device to active correlators and uncertainty function plotters will be described. A discussion of real-time correction of phase distortion with experimental results also is included. . . .

MINIMIZATION OF ATMOSPHERIC TURBULENCE EFFECTS ON HIGH-RESOLUTION SYNTHETIC APERTURE SYSTEMS
D. M. Diamond, Illinois U., Urbana Coordinated Science Lab., Sept. 1963, 69 p., refs., AD 426 965, N64-19404.

A method of processing the received signals in a synthetic aperture radar system to remove the effects of atmospheric turbulence is proposed. An appropriate mathematical model of the synthetic system and the manner in which it is affected by atmospheric turbulence is developed. The model thus developed is used as the basis for a processing procedure that matches the first few terms of a Fourier series to the phase error effect caused by the atmospheric turbulence. Several examples of a computer simulation are used to illustrate the results of such processing.

A NEW APPROACH TO SEQUENTIAL DETECTION IN PHASED ARRAY RADAR SYSTEMS
H. M. Finn, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 2, Feb. 1963, p. 4-3/12, 12 refs.

AN ESTIMATE OF THE NUMBER OF TARGETS IN A RADAR RETURN
W. Gersch, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 86/90.

THE LIMIT OF RADAR RANGE RESOLUTION FOR A DISTRIBUTED TARGET (Correspondence)
W. Gersch, Proc. IEEE, vol. 51, no. 12, Dec. 1963, p. 1787/1788.

SIGNAL SELECTION IN COMMUNICATION AND RADAR SYSTEMS
T. L. Grettenberg, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 265/275.

A criterion for selecting a finite set of transmitter signals for a continuous communication channel is proposed. The "optimum" signal sets using this criterion are selected to maximize the minimum divergence between hypothesis pairs being tested at the receiver. . . .

A NEW TECHNIQUE FOR SIMULTANEOUS RADAR OBSERVATION OF MULTIPLE TARGETS WITHIN A BROAD SURVEILLANCE REGION
H. L. Groginsky, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 82/95, 21 refs.

. . . for extracting information from a multielement array antenna in a manner which provides simultaneous observation of multiple targets within the antenna coverage region.

This technique is an innovation in antenna practice, since for the first time, it makes available an output for each target in the system surveillance region, which is the same as if the array had been phased to point at the target. It can do this simultaneously for any number of targets in the surveillance region. In this respect, the proposed technique is similar to a preformed beam system; however, the beams available in this system continuously fill the surveillance region.

A NOTE ON THE REALIZATION OF AMBIGUITY FUNCTIONS
R. O. Harger, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 4, Dec. 1963, p. 127/130.

DYNAMIC RADAR CROSS-SECTION PREDICTIONS
J.R. Huynen, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 7, Sept. 1963, p. 83/85.

For many practical applications, one wishes to know the measured radar cross-section of a given object if the object is placed in an arbitrary, but known, position relative to the radar observer. In many instances the radar is known to be horizontally or vertically or, in some cases, circularly polarized. . . . it has been common practice to obtain laboratory measurements of the object at horizontal and vertical polarizations for various cuts of angular orientation of the object . . . The question arises whether this technique is satisfactory for predicting the return with linear polarization . . . The inadequacy of the conventional technique is . . . apparent, but substitution of a better technique has thus far not taken place. . . .

THE CHOICE OF THE NORMALIZATION LENGTH OF PULSES IN THE PRIMARY PROCESSING OF RADAR PULSE PACKETS
Ya.S. Itskhoki, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 12, Dec. 1963, p. 56/65.

The coincidence probability of the pulses of a radar packet, gated by means of a "k-out-of-m" type logic circuit, is determined as a function of the duration of the normalized pulses and for various versions of the processing logic. The relationship obtained is used to derive a formula for determining the optimum duration of the normalized pulses ensuring the lowest value of the threshold signal. . . .

A RANDOM ACCELERATION MODEL FOR FILTERING POLYNOMIAL-LIKE SIGNALS
L. Jones, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 28G3, AFESD TDR63 567, 25 Oct. 1963, 15 p., AD 423 431.

Random type models for filtering discrete time, polynomial-like signals from noise are discussed. The particular model analyzed is a second-degree polynomial with the acceleration (second derivative) considered to be a random process. The optimum filter corresponding to this model is derived. . . .

A SEQUENTIAL TEST FOR RADAR DETECTION OF MULTIPLE TARGETS (Correspondence)
W.B. Kendall, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 51/53.

THE REDUCTION OF ANGLE-OF-ARRIVAL SCINTILLATION BY A FREQUENCY SHIFTING TECHNIQUE
L.H. Kosowsky, et al., Proc. Nat. Electronics Conf., vol. 19, Oct. 1963, p. 52/71.

The measurement of the angle-of-arrival of radiation from a distributed group of scatterers has been accomplished by a variety of radar techniques, e.g., a phase interferometer (1)*, an amplitude monopulse radar (2), and a phase monopulse radar (3) . . . It has been shown (4), that the observed scintillations are due to the perturbation in the wavefront resulting from the granularity of the distributed target . . . The classic two reflector problem, which has been used in the past to illustrate angle scintillation, is found to produce an angular error which is a sharply tuned function of frequency whose maximum value and bandwidth, are determined by the intensity ratio of the two radiators. A periodic shifting of the transmitted frequency about its nominal value, produces a series of angle-of-arrival pulses*, whose shape is related to the a frequency response function. . . .

PHASE COMPENSATION OF DIODE DETECTORS AT THE ENVELOPE FREQUENCY
V.P. Kovrigin, Radio Engng: Transl. of Radiotekhnika, vol. 18, no. 5, May 1963, p. 51/56.

. . . in recent years, the solution of a number of navigational problems has involved the use of various phase-measuring radio equipment . . . in which the measurement of a phase difference is carried out at a comparatively low modulation frequency, while the carrier frequency consists as a rule of oscillations in the microwave band. . . . Diode detectors are most often used to extract the envelope from the signals received. . . . variable phase shifts . . . would result in the occurrence of errors in the measurements of the phase angle . . .

SOVMESTNAIA OTSENKA AMPLITUDY, FAZY, RASSTOIANIIA I EGO PROIZVODNYKH RADIOLOKATSIONNYMI METODAMI (Simultaneous Estimation of the Amplitude, Phase, and Distance and its Derivatives by Radar Methods) (In Russian)
S.I. Krasnogorov, Radiotekhnika i Elektronika, vol. 9, Jan. 1964, p. 78/86.

COMMUNICATION AND RADAR — SECTION B. Radar Waveform Selection
R.M. Lerner, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 246/248.

INSTANTANEOUS SPECTRA AND AMBIGUITY FUNCTIONS (Correspondence)
M.J. Levin, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1964, p. 95/97.

A formulation of the "instantaneous spectrum" of a waveform is described which is a modification of that originally considered by Page and extended by Turner. It is shown that this function is the double Fourier transform of the complex-conjugate of the ambiguity function and has other interesting properties. . . .

CUMULATIVE PROBABILITY OF DETECTION FOR TARGETS APPROACHING A UNIFORMLY SCANNING SEARCH RADAR
J.D. Mallett, et al., Proc. IEEE, vol. 51, no. 4, April 1963, p. 596/601.

. . . This is the probability that a target, approaching the radar at a constant radial

velocity, is detected at least once by the time it reaches a given range, as distinguished from the more common blip-scan ratio (a single-scan detection probability). . . . Curves of cumulative detection probability, as a function of normalized range, are given for three different target scintillation models. . . .

THE DETECTION OF CHIRPED RADAR SIGNALS BY MEANS OF ELECTRON SPIN ECHOES
W. B. Mims, Proc. IEEE, vol. 51, no. 8, Aug. 1963, p. 1127/1134.

. . . In a typical system the transmitted pulse is subjected to a linear frequency sweep and extends over a considerable period of time. When this waveform returns from the scattering object, a device in the receiver delays the earlier portions in such a way that all the received energy is concentrated into a short pulse . . . One way of obtaining the differential delay of frequency components is by passing the received signal through a dispersive network. An alternative scheme involving the generation of electron spin echoes is suggested here. It is readily adaptable to waveforms having a variety of frequency sweeping functions, and it offers the possibility of operating with exceptionally high time compression factors. . . .

RADAR DETECTION
W. L. Rubin, et al., Electro-Technology, vol. 73, April 1964, p. 63/90, 10 refs., A64-16648.

Theoretical study of the problems of radar detection with emphasis on the detection of a radar pulse in a noisy environment. . . . To simplify system calculations, a set of graphs of statistical radar performance is presented. . . .

METHODS OF THRESHOLD SIGNAL RECEPTION IN THE PRESENCE OF NOISE
J. Seidler, Foreign Tech. Div., Air Force Systems Command, Wright-Patterson AFB, Ohio, 7 Oct. 1963, 139 p., AD 424 402.

. . . Analysis is based on decision functions theory . . . Consideration is given to the reception of signals transmitting discrete, continuously varying, or multidimensional (multiplexed) messages. Reception of radio and radar signals is discussed in more detail . . . The relationship between the conventional concept of signal to noise ratio and the concepts of decision theory are discussed.

ESTIMATION OF THE RELATIVE DELAY OF TWO SIMILAR SIGNALS OF UNKNOWN PHASES IN WHITE GAUSSIAN NOISE
I. Selin, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 189/191.

A frequent problem in radar . . . The envelopes of the two signals are similar because they are echoes from the same coherent radar transmitter. This problem is identical to that of estimating the relative delay of one path with respect to another in a two-path communication channel. . . .

THE ANALYSIS OF MULTIPLE SIGNAL DATA
J. W. Smith, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 208/214.

. . . Problems which fit into the board category described are: 1) Radar detection in a multiple emitter environment . . .

AUTOMATISCHE AUSWERTUNG DIGITALISIERTER RADARSIGNALE (Automatic Evaluation of Digitized Radar Signals) (In German)
W. Storz, et al., Nachrichtentech. Z. vol. 16, Dec. 1963, P. 643/648, A64-13724.

Demonstration that for equal error probability and equal echo-signal-to-noise ratio the probability of detecting an aircraft by a digital detector is not substantially reduced when the radar video signal in front of the detector is digitized in unity bits. . .

AN ACCURACY STUDY OF A DOPPLER NAVIGATION SYSTEM ASSUMING TIME-STATIONARY RANDOM INPUT ERRORS
C. J. Styers, IEEE Trans. Aerospace Navig. Electronics, vol. ANE-10, no. 1, March 1963, p. 2/17.

. . . analysis . . . finding the rms position error of a Doppler navigation system when the input to the system is composed of random velocity errors. Statistical techniques of time-stationary random processes are used to represent the input velocity. Results show that system errors expressed as a per cent of distance traveled are shown to decrease with increasing distance traveled. . . . .

THE ACCURACY OF MAXIMUM LIKELIHOOD ANGLE ESTIMATES IN RADAR AND SONAR
H. Urkowitz, IEEE Trans. Mil. Electronics, vol. MIL-8, no. 1, Jan. 1964, p. 39/45.

By extending the results of Kelly, Reed, and Root, formulas are derived for the variances of maximum likelihood estimates of azimuth, and azimuth and elevation, jointly, by dense, discrete and discrete-continuous apertures for the strong signal case. . . .

PERFORMANCE PREDICTION METHOD FOR A CLASS OF FM-CW RADARS
N. D. Wallace, IEEE Trans. Aerospace, vol. AS-1, no. 2, Aug. 1963, p. 38/45.

. . . the author has used the theory of zero crossings of random processes to analyze the errors due to receiver noise of a triangularly modulated FM-CW Radar. Curves are given that can be used to determine the percentage error in the range measurement as a function of signal-to-noise ratio, provided the shape of the noise spectrum is known. . . . The theory can be used in the preliminary design stages to optimize the receiver design.

THE PANCHROMATIC PRINCIPLE IN OPTICAL FILTERING
R. E. Williams, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 227/234.

The panchromatic optical correlator is a coherent correlator which uses a slightly broadened light spectrum to correlate simultaneously a number of receiver channels against a continuous range of Doppler distortions of the transmitted signal. . . . A strong need exists in active search and surveillance systems for simultaneous multi-channel signal processing capability. . . . a number of signal processing techniques have been proposed in recent years . . . The panchromatic optical correlator is one attempt to satisfy a particular requirement of high data rate receivers matched to the transmitted waveform. . . .

Related Publications:

RADIOLOKATSIONNAIA AVTOMATIKA (Automatic Radar Systems) (In Russian)
E.'A. Krogius, Leningrad, Izd. Voen. Krasnoznam., Akad. Sviazi, 1959, 301 p.

. . . fundamentals of regulation theory . . . design calculations on radar systems . . . small amount of theory. . . . contents of the textbook conform to the programme of the Academies' courses. . . .

THE THEORY AND DESIGN OF CHIRP RADARS
J.R. Klauder, et al., Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 745/808.

THE DESIGN OF RADAR SIGNALS HAVING BOTH HIGH RANGE RESOLUTION AND HIGH VELOCITY RESOLUTION
J.R. Klauder, Bell Syst. Tech. J., vol. 39, no. 4, July 1960, p. 809/820.

SUMMARY OF THE PRELIMINARY STUDY OF THE APPLICABILITY OF THE ORDER SYSTEM TECHNIQUES TO THE TRACKING OF PASSIVE SATELLITES
Electronics Research Labs., Columbia Univ., New York, Final rept., Rept. nos. CU2 600 RD, F157, 11 Feb. 1960, 154 p., AD 419 772.

The results of a study of the problems of coherent integration and frequency estimation in a CW Doppler earth satellite tracking system are presented. . . . incorporating the coherent signal processor known as the Circulating Memory Filter (CMF) into the satellite tracking system. . . .

VIDEO INTEGRATION IN RADAR AND SONAR SYSTEMS
D.C. Cooper, et al., J. Brit. Instn. Radio Engrs., vol. 21, no. 5, May 1961, p. 421/433, 14 refs.

The performance of some basic integration systems is analyzed, and the effect of beam pattern on their performance is considered. A new system is described employing two delay loops which, in general, will give a small improvement in threshold detection and furthermore has a number of practical advantages. . . .

EFFECTS OF PHASE-MODULATION ERRORS ON PULSE COMPRESSION SIGNALS
C.E. Cook, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 174/184.

THE EFFECTS OF NORMALLY DISTRIBUTED RANDOM PHASE ERRORS IN SYNTHETIC ARRAY GAIN PATTERNS
C.A. Greene, et al., IRE Trans. Mil. Electronics, vol. MIL-6, no. 2, April 1962, p. 130/139.

A NEW APPROACH TO RADAR CROSS-SECTION MEASUREMENTS
J. R. Huynen, IRE Internat. Conv. Rec., Pt. 5, vol. 10, March 1962, p. 3/11.

AMPLITUDE MODULATED CW RADAR
O.K. Nilssen, et al., IRE Trans. Aerospace Navig. Electronics, vol. ANE-9, no. 4, Dec. 1962, p. 250/254.

. . . a radar system in which a measure of range is obtained as the phase difference between amplitude modulations on the transmitter and echo signals. Significant features of this AM radar system are simplicity and capability of accurately measuring very short ranges. For instance, an experimental unit ranges from zero to 50 feet with maximum error of six inches. . . .

NOTE ON THE EXISTENCE OF PERFECT MAPS
I.S. Reed, et al., IRE Trans. Inform. Th., vol. IT-8, no. 1, Jan. 1962, p. 10/12.

OPTIMUM WEIGHTING FUNCTIONS FOR THE DETECTION OF SAMPLED SIGNALS IN NOISE
J. Capon, IEEE Trans. Inform. Th., vol. IT-10, no. 2, April 1964, p. 152/159.

VISUAL DISPLAYS OF INTEGRATED VIDEO WAVEFORMS
D.C. Cooper, J. Brit. Instn. Radio Engrs., vol. 25, no. 3, Mar. 1963, p. 277/285.

ON THE AVERAGING OF REDUNDANT MEASUREMENTS FOR MAXIMUM PRECISION
M.L. Eaton, Pacific Missile Range, Point Mugu, Calif., PMR TM 63 12, 11 Jan. 1963, 30 p., AD 420 844.

THE PORTRAYAL OF BODY SHAPE BY A SONAR OR RADAR SYSTEM
A. Freedman, J. Brit. Instn. Radio Engrs., vol. 25, no. 1, Jan. 1963, p. 51/64.

OPTIMAL SEARCH PROCEDURES
E.C. Posner, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 157/160.

EXACT DISTRIBUTION FUNCTIONS OF TEST LENGTH FOR SEQUENTIAL PROCESSORS WITH DISCRETE INPUT DATA
J.G. Proakis, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 182/191.

A MODERN TACTICAL RADAR
J.R. Vadus, Sperry Engineering Review, vol. 16, Spring 1963, p. 2/9, A63-17580.

. . . V-beam digital data processing capabilities. . . . provide a multimission capability . . . three-dimensional sensor in an air-defense system.

DIVISION 2.9
CONTROLLED COMMUNICATIONS SYSTEMS

The last division of this volume contains references to a special class of communications systems which will be of great importance in future space communications systems. The compilers of this bibliography placed a number of considerably different approaches to efficient communications techniques under the name "controlled communications systems." These techniques have been investigated in connection with Earth-based communications links. They all have one thing in common: At least one parameter of the link specifications is automatically adjusted to match the variable channel characteristics in real time.

Section 2.92 deals with the large class of feedback communications systems. They are presently under investigation in the form of two-way communications links, where each terminal keeps the other terminal constantly informed about the quality of its reception. The transmitter in each terminal is controlled in such a way that both links operate most of the time as close to the instantaneous capacity of the link as the quality of the transmission medium will permit. There are many methods for achieving this. The oldest is the so-called ARQ (automatic repetition request) procedure and subdivision 2.926 deals specifically with this method.

Section 2.93 (subdivision 2.930) discusses the general principles of adaptive operations in communications systems. This section, by necessity, will overlap with other sections in this other divisions, depending on how narrowly or how broadly one interprets the term adaptive. Because of this indefinite terminology the compilers desisted from further breaking down the class of adaptive communications operations. The reader should be aware that many adaptive operations require feedback links (2.920) for their execution and that most of the special variable parameter techniques of section 2.95 are based on adaptive operations.

Section 2.94 singles out one particular engineering problem in controlled (adaptive) methods, the problem of sensing the changes of the variable to which the system should be adapted. In communications this will usually be a statistical variable and statistical sensing techniques will be required for observing this variable. Again it was advisable to single out the oldest of such sensing techniques, ionospheric sounding techniques (2.946).

Section 2.95, as mentioned above, describes in various subdivisions specialized adaptive methods which control primarily the operations of one particular parameter of the link. This may be the transmitter power (2.952), the bandwidth (2.953), the data format (rate, redundancy) (2.954) or the signal waveform (modulation method) (2.955). The small number of references in these subdivisions indicate that such specialized applications of adaptive techniques are still in their infancy. However it is in these practical applications that space communications systems hope to benefit in the future.

The last section (2.98) include those references to integrated adaptive systems which do not exactly fit the definition of any of the other subdivisions.

2.900: Controlled Communications Systems in General

Included: Theory of end-point control problems; General control theory of two-way channels; Adaptive communications with feedback in general; Network problems with controlled links.

Not Included: Theory of control systems; Theory of feedback systems; Theory of large communications networks.

Cross References: Feedback communications systems (2.920); Adaptive operations in communications systems (2.930); Transportation lag in feedback communications systems (2.920).

Principal Publications:

COMPUTER DIRECTED COMMUNICATIONS
R. F. Filipowsky, Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 251/257.

THE INFORMATION CAPACITY OF CHANNELS WITH GENERAL AND SELECTIVE FADING
I. A. Obseevich, et al., Radio Engng: Transl. of Radiotekhnika, vol. 15, no. 12, 1960, p. 1/10, 14 ref.

Approximate methods are given for calculating the information capacity of multi-path radio channels with strong (Rayleigh) and weak (Gauss) general fading. They are also applicable to selective fading. The information capacity of a channel in the presence of feedback is calculated.

LECTURES ON COMMUNICATION SYSTEM THEORY
E. J. Baghdady, (editor), New York, McGraw-Hill Book Co., Inc., 1961.

. . . The book is essentially a collection of papers resulting from the MIT summer program (1959) on "Reliability Long-Range Radio Communication." The 18 authors are recognized authorities in their respective specialities, and the reader can appreciate the effort required to edit the contributed material into the 23 chapters which make up the book. . . .

SEQUENTIAL PHENOMENA IN PSYCHOPHYSICAL JUDGMENTS: A THEORETICAL ANALYSIS
R. C. Atkinson, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 155/162.

. . . analysis of psychophysical detection experiments designed to assess the limit of a human observer's level of sensitivity. A mathematical theory of the detection process is introduced that, in contrast to previous theories, provides an analysis of the sequential effects observed in psychophysical data. Two variations of the detection task are considered: in the information feedback situation the subject is given information concerning the correctness of his responses, whereas in the the no-feedback situation he is not. . . .

ON INSTANTANEOUS ENTROPY
W. H. Foy, Jr., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 267/274.

. . . In many communication and control problems . . . the quantities of interest come from a class of signals. We can assign a probability distribution over function space, and the entropy of this distribution measures our uncertainty as to the occurrence of any given signal in the class. In many other problems, on the other hand, we are interested in the value of some function at a particular instant. A probability distribution is assigned over the function values, and the "instantaneous entropy" of this distribution measures our uncertainty as to the instantaneous function value. This interpretation finds useful application to a long list of problems in communication, data-processing, guidance and control. . . . We shall be concerned in this paper with the instantaneous entropy of continuously distributed quantities. . . .

A STUDY OF HIGH FREQUENCY COMMUNICATION IMPROVEMENT TO OVERCOME THE IMPACT OF MINIMUM SOLAR ACTIVITY
L. H. King, Jansky and Bailey Div., Atlantic Research Corp., Wash. D. C., Final rept. on Volume 1-2, July 1962, 46 p. incl. illus., tables., 29 refs., AD 282 144.

. . . probable effects of the solar cycle minimum on the Defense Communications System (DCS) . . . three phases . . . One consisted of the accumulation, reduction, and analysis of data to determine the anticipated impact of the solar cycle minimum on selected trunks of the DCS. Phase Two consisted of the accumulation and evaluation of data on fully developed currently available means of reducing the anticipated impact, and the effectiveness and relative costs of implementation. Phase Three consisted of a review of state-of-the-art developments which may lead to improved high-frequency communication systems within the next five years. This final report summarized the results obtained in the three phases of the program.

ADAPTIVE COMMUNICATION WITH FEEDBACK
L. S. Schwartz, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 764.

. . . some of the ways in which adaptive communications may be employed. There may be control at the receiver, at the transmitter, and at both jointly by means of feedback. . . . Adjustments may be made from inductive observations on received signals, permitting estimates to be formed of error probabilities. Decision threshold settings may then be altered until these probabilities attain specified values. . . .

This paper discusses methods for achieving: (1) adaptive control in receivers without feedback; (2) adaptive control in communication systems with a feedback loop from the receiver to the transmitter; and (3) adaptive control in systems employing both an adaptable receiver and a feedback loop from the receiver to the transmitter. . . .

CODING FOR AND DECOMPOSITION OF TWO-WAY CHANNELS
F. Jelinek, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1963, p. 5/17.

The present topic was first considered by Shannon. For the most part, he treated the discrete memoryless case, although one of his coding theorems applies also to discrete channels with finite memory. In this paper we shall restrict our attention to the discrete, memoryless two-way channel . . . It consists of two terminals, each of which has an input and an output. . . . The channel operates synchronously . . . Under certain natural restrictions, the binary two-way channel can be canonically decomposed into an interconnection of pairs of oppositely oriented memoryless one-way channels connected in cascade to special channels that are noiseless whenever the signal transmitted in the opposite direction is an appropriate one. Three distinct categories are defined into which the totality of all binary channels can be partitioned. . . .

LOSS IN INFORMATION TRANSMISSION THROUGH TWO-WAY CHANNELS
F. Jelinek, Inform. Control, vol. 6, no. 4, Dec. 1963, p. 337/371.

Analysis of a transducer-channel combination as a derived two-way channel whose inputs are the strategy functions and whose outputs are the outputs of the underlying channel. Expressions for the information transmission rate through the two directions of the derived channel are developed and are compared to the expressions for the average information about outputs of the equivalent signal sources, transmitted through the underlying two-way channel . . . A condition on the transmission probabilities makes it possible to define a class of lossless channels. Similarly, another class is defined having the property that, regardless of the strategy code used, the information transmitted through the derived channel will be strictly less than the information transmitted through the underlying channel. The consequences of the above results on the random selection of message codes are discussed.

DELAY IN DATA TRANSMISSION THROUGH SIMPLE NETWORKS: STEADY STATE CHARACTERISTICS WITH INFINITE NODAL STORAGE
B. J. Moriarty, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 25G19, 6 June 1963, 40 p., AD 408 250.

. . . single constant rate source of data communication with a single sink of data, via a set of fault-liable HF links which are connected to relay stations equipped with storage facilities. Methods of transmission are used between nodes which effectively result in a node ceasing to transmit when a link becomes faulty and only resuming when a link returns to its normal condition. Thus data will queue at a node when the outgoing link is faulty, and all data reaching the sink is error-free. The network has been simulated on a digital computer using the recorded link behavior of two existing HF RTTY links. The probability distributions have been obtained for the queues that arise at the nodes and for the total delay involved in transmitting data from the source to the sink.

MULTIPARAMETER SELF-OPTIMIZING SYSTEMS USING CORRELATION TECHNIQUES
K. S. Narendra, et al., IEEE Trans. Automatic Control, vol. AC-9, Jan. 1964, p. 31/38, 8 refs., A64-15910.

. . . systems which continually alter their parameters to reduce a mean-square performance criterion. The change in each parameter is determined from an error gradient in parameter space computed by cross-correlation methods which are independent of signal spectra and require no test signal or parameter perturbation. Applications of this technique to both open-loop and closed-loop systems are included . . . Computer simulation results are included to demonstrate the practicality of the proposed systems.

Related Publications:

RELIABILITY MONITORING BY OPTIONAL STOPPING SAMPLING
N. R. Garner, Seventh Mil.-Ind., Missile and Space Reliability Symp., NAS, North Island, Calif., 18-21 June 1962, p. 441/446, 3 refs., N63-17299.

. . . This procedure allows testing to continue until k defects are observed. At this time one of three decisions is made. If the number of trails is too small, testing is stopped and an engineering change is required. . . . If the number of runs is neither too small nor to large, a new sequence of testing begins. . . . The mathematical model is discussed, cumulative probabilities are given so that control charts can be established, and an example is presented. This method may find application in adaptive communications systems. (See N63-17266).

ON THE STABILITY ANALYSIS OF A TWO-WAY CONTROLLED CARRIER TRANSMISSION SYSTEM
N. J. Bershad, Air Force Cambridge Research Labs., Bedford, Mass., AFCRL 63 586, Dec. 1963, 9 p., AD 428 435.

A mathematical model of a linear controlled-carrier tropospheric communication system is analyzed for tropospheric gain variations with a white-noise power spectral density. The stability of the first moment of the impulse response of the closed loop control system is determined as a function of the linear controllers and the statistical characteristics of the troposphere.

A GENERAL MINIMUM PRINCIPLE FOR END-POINT CONTROL PROBLEMS
S. Katz, J. Electronics and Control, 1st Series, vol. 16, Feb. 1964, p. 189/222, 7 refs., A64-14914.

Formulation, in general terms, of a very broad class of endpoint control problems, and development for their solution of general procedures in the calculus of variations . . . The state of the system being controlled is described by an abstract vector in a suitable linear space; the evolution of the system state with time is described in terms of an operator on the state vector; the measure of system performance to be maximized or minimized is taken as a functional of the final state. . . .

Section 2.92
Communications Loops

2.920: Feedback Communications Systems

Included: Binary decision feedback; Transportation lag in feedback communications systems; Multi-threshold devices in feedback communications systems; Noisy delayed decision feedback; Null zone reception feedback systems; Reliable fail-safe binary communications; Information feedback systems; Digital feedback communications systems; Two-way communications by means of feedback; Coded binary decision feedback systems; Cumulative binary decision feedback systems; SECO feedback communications systems; Sequential transmission using noiseless feedback.

Not Included: Comparison of modulation methods (1); Statistical characteristics of communications channels (1); Feedback systems theory in general; Control systems; Servo systems.

Cross References: Null zone decision theory (2.853); Theory of multi-threshold devices (2.853); Special error detecting codes for feedback systems(2.782); Error-free data transmission systems (2.926); ARQ (automatic repeat request) techniques (2.926); Sequential detection systems (2.854 .

Principal Publications:

THEORY OF INFORMATION FEEDBACK SYSTEMS
S. S. Chang, IRE Trans. Inform. Th., vol. IT-2, no. 3, 1956, p. 29/40.

CUMULATIVE BINARY DECISION-FEEDBACK SYSTEMS
S. S. Chang, et al., Proc. Nat. Electronics Conf., vol. 14, Oct. 1958, p. 1044/1057.

Discarding feedback systems operate by rejecting the information in any excessively ambiguous message and requiring its repetition. However, when a great reduction in error probability is demanded, the information lost in the discards becomes excessive. Cumulative binary decision feedback overcomes this difficulty by integrating the received sequence of repeats until sufficient information is accumulated to permit a decision to be made with acceptable error probability . . . also examined as a means of maintaining reliability in the presence of varying signal strength. Its superiority . . . in the presence of fast fading, as encountered in scatter-multipath propagation, is demonstrated.

BINARY COMMUNICATION FEEDBACK SYSTEMS
B. Harris, et al. Commun. and Electronics, vol. 40, Jan. 1959, p. 960/969.

AN OPTIMUM SELF-SYNCHRONIZED SYSTEM
S. S. Chang, et al., New York U. Coll. of Engineering, N. Y., 8 June 1960, AD 242 919.

. . . A specific modulation scheme is discussed and analyzed to serve as a transmission scheme to be used in feedback communication system. One optimum scheme for transmission in the presence of additive noise is binary PSK using a modified equal-weight Reed Code and synchronous detection. This technique also permits the synchronizing carrier at the receiver to be generated from the message signal itself, so that phase drifts due to multipath and doppler can be automatically and correctly compensated for.

CODED BINARY DECISION-FEEDBACK COMMUNICATION SYSTEMS
J. J. Metzner, et al., IRE Trans. Commun. Syst., vol. CS-8, no. 2, June 1960, p. 103/113.

CODED FEEDBACK COMMUNICATION SYSTEMS
J. J. Metzner, et al., Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 250/257.

. . . employing long codes with feedback, correcting only very small numbers of errors, and utilizing a new technique which effectively prevents any type of disturbance in the feedback channel from harming system reliability. The resulting system yields excellent reliability, "fails safe" . . . and operates at a relatively high per-symbol-information rate. This approach is particularly effective in precisely those situations where less efficient procedures fail - namely, when severe burst-type noise or heavy fading is encountered. . . .

RELIABLE FAIL-SAFE BINARY COMMUNICATION
J. J. Metzner, et al., New York U. Coll. of Engineering, N. Y., Scientific rept. no. 2, AFCRL TN 60-791, 10 July 1960, AD 245 253.

. . . employing long codes with feedback, correcting only very small numbers of errors, and utilizing a new technique which effectively prevents any type of disturbance in the feedback channel from harming system reliability. The resulting system yields excellent reliability, "fails safe" (an error probability of 10^{-10} when the signal-to-noise ratio falls to zero, for instance), and operates at a relatively high per-symbol information rate. . . . when severe burst-type noise or heavy

fading is encountered. The cost of this performance is far less than that of comparable unidirectional systems. . . .

THE DESIGN OF AN "ERROR-FREE" DATA TRANSMISSION SYSTEM FOR TELEPHONE CIRCUITS
B. Reiffen, et al., Lincoln Lab., MIT, Lexington, 22 Dec. 1960, AD 248 637.

. . . easily implemented codes can detect essentially all errors occurring in digital data sent over toll grade telephone circuits. A two-way communications system is described which uses these codes to detect the occurrence of errors and requests a retransmission of any data in error. . . . The philosophy that guided the design of this system can be applied to other media where high noise bursts or low signal levels occur infrequently.

IMPROVEMENT OF TWO-WAY COMMUNICATION BY MEANS OF FEEDBACK
S. S. Chang, IRE Internat. Conv. Rec., vol. 4, March 1961, p. 88/104.

SYNCHRONIZATION OF DECISION FEEDBACK SATELLITE TELEMETRY SYSTEMS
B. Harris, et al., New York U. Coll. of Engineering N. Y., Technical Memorandum No. 8, March 21, 1961, 7 p., N63-18318.

. . . the receiving site commands the bird to repeat those portions of the transmission which are deeply embedded in the system noise. Various ways of synchronizing the feedback and direct channels are considered, so that the proper portion of the message is repeated, and the receiver can identify the repeated material.

SEQUENTIAL TRANSMISSION USING FEEDBACK
M. Horstein, IRE Internat. Conv. Rec., vol. 4, March 1961, p. 105.

ON MAKING INFORMATION FEEDBACK FAIL-SAFE
J. J. Metzner, New York U., Coll. of Engineering, N. Y., Scientific report no. 8, AFCRL 62-25, 15 Dec. 1961, 45 p., incl. illus., 9 refs., AD 274 025.

. . . decision policies . . . decision and information feedback . . . binary decision made for individual digits . . .

SOME RECENT DEVELOPMENTS IN DIGITAL FEEDBACK COMMUNICATION SYSTEMS
L. S. Schwartz, IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 51/57.

. . . reports the rejection to the transmitter . . . the transmitter subsequently repeats the message. . . . feedback channel to be error-free.

IMPROVEMENT OF TWO-WAY COMMUNICATION BY MEANS OF FEEDBACK
L. S. Schwartz, et al., New York U. Coll. of Engineering, N. Y., Scientific rept. no. 5, 15 March 1961, 55 p., incl. illus., tables, 20 refs., AD 259 141.

. . . General synthesis technique is presented for feedback systems with block codes. . . . Decision feedback is the basic and most desirable form to use for simultaneous communication in both directions. Compound and information feedback should play supplementary roles and should be called upon only to speed up to transmission one direction if the other channel is not in use for message transmission. The improvement of feedback systems over unidirectional systems can be readily estimated for channels with independent errors. However, the improvement is much greater under fading situations (or long burst errors). . . . The methods discussed are general and versatile enough to cope with practically any situation.

THEORETICAL STUDY OF ON-OFF TRANSMISSION OVER GAUSSIAN MULTIPLICATIVE CIRCUITS
P. A. Bello, et al., Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 76/92.

. . . performance of an . . . "intermittent" binary communication system employing forward and feedback channels with statistically independent flat fading. . . .

STUDY OF ADAPTABLE COMMUNICATIONS SYSTEMS
D. Chesler, Sylvania Electric Products, Inc., Waltham, Mass., Final rept., Rept. no. F-1008-1, RADC TDR 62-314, 14 June 1962, 293 p., incl. illus., tables, refs., AD 286 504.

. . . covering both adaptable receivers and repeat-request feedback systems using error-detection codes. . . .

SOME RECENT ADVANCES IN ADAPTIVE DIGITAL SPACE TELEMETRY SYSTEMS
B. Harris, et al., Proc. Nat. Telem. Conf., no. 10-5, May 1962.

. . . three techniques for improving the reliability of digital space telemetry systems: 1) decision feedback, 2) information feedback, and 3) power control. . . .

AN ITERATIVE-CODE COMMUNICATIONS SYSTEM WITH NOISY DELAYED DECISION FEEDBACK
I. M. Jacobs, et al., Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 37/45.

. . . provides the attractive possibilities of realizing high data-rate transmission at arbitrarily low error probabilities while providing good adaptation to time-varying channel statistics.

The "cost" is a feedback channel with (typically) a rate requirement approximating 1/3 of the forward channel rate plus a relatively large bulk storage at transmitter and receiver. Decoder complexity is minimal. . . .

A TRANSPORTATION LAG CIRCUIT FOR ANALOGUE COMPUTATION
R. E. King, J. Brit. Instn. Radio Engrs., vol. 24, no. 2, Aug. 1962, p. 111/115.

. . . An example is shown which has a transportation lag of 32 ms and a maximum frequency of operation of 150 c/s. . . . Situations in which transportation lags occur in physical systems are numerous. In feedback control systems they are often met with to the detriment of stability. . . . In simulating physical processes on electronic analogue computers it is often therefore necessary to incorporate such transportation lags. . . .

THE AN/GSC-5 ( ) DIGITAL COMMUNICATIONS SYSTEM
R. G. Matteson, et al., Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 155/162.

. . . may operate in any one of three error correction modes—"None", "Wait for Acknowledgement", and "Continuous" . . . All error correction is accomplished by decision feedback. . . .

CODED FEEDBACK COMMUNICATION SYSTEMS
J. J. Metzner, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 643/647.

. . . employing long codes with feedback, correcting only small numbers of errors, and utilizing appropriate feedback techniques. The resulting system yields essentially error-free performance under all conditions, is relatively efficient, and compares very favorably in cost. . . .

THE ESTIMATION PROBLEM IN NULL-ZONE RECEPTION FEEDBACK SYSTEMS
J. J. Metzner, et al., New York U., Coll. of Engineering, N. Y., Scientific rept. no. 11, 15 Aug. 1962, 137 p., incl. illus., tables, 26 refs., AD 290 325.

When signal-strength correlation is appreciable over as few as ten digits, overall system performance is only slightly less efficient than would be attained with exact knowledge of the channel conditions. Methods of minimizing the undesirable effects of impulsive and burst-type noise are discussed.

SECO: A SELF-REGULATING ERROR CORRECTING CODER-DECODER
K. E. Perry, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S128/135.

SECO is an efficient engineering realization of a coding-decoding scheme designed to use variable redundancy and feedback in a two-way communication system to increase the rate of information transfer between users connected by a channel having a slowly time-varying capacity. . . . The decoding computer is designed to detect channel errors with very high probability and to correct as many of these as it can, subject to the current channel condition and decoder state. When a detected error cannot be corrected easily, the decoder stops and uses the feedback channel to request retransmission at a lower information rate. . . .

FEEDBACK COMMUNICATION SYSTEMS
L. S. Schwartz, New York U., Coll. of Engineering, N. Y., Summary scientific rept. for 14 Nov. 1962, AFCRL 62-921, 14 Nov. 1962, 20 p., 26 refs., AD 292 119.

The contents of eleven scientific reports are described . . . coded . . . feedback communication systems . . . signal theory . . . communication system performance. . . .

BEAM TAGGING DIVERSITY
R. T. Adams, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 233.

Abstract only . . . The composite signal is analyzed at the receiver to obtain phase-control information, which is relayed to the transmitting site for controlling the individual signals. . . .

MULTI-THRESHOLD DIGITAL DATA TRANSMISSION SYSTEMS, THEIR ADVANTAGES AND POSSIBLE OPERATIONAL MODES
A. Brothman, et al., Proc. Internat Telem. Conf., vol. 1, Sept. 1963, p. 488/497.

. . . In binary digital data systems, there is an ever increasing need to transmit data at maximum speed and maximum security. . . . This paper urges: (1) the appending of a quaternary decision logic to the conventional binary digital receiving modem; and (2) the exploitation of the greater information capabilities of such a decision logic to enhance data correction capabilities and to develop rational feedback control over coding and bit rate. . . .

SEQUENTIAL TRANSMISSION USING NOISELESS FEEDBACK
M. Horstein, IEEE Trans. Inform. Th., vol. IT-9, no. 3, July 1963, p. 136/143.

A sequential continuous-transmission system employing a binary symmetric forward channel (but which is suitable for use with any discrete memoryless forward channel) and a noiseless feedback channel is described. Its error

exponent is shown to be substantially greater than the optimum block-code error exponent at all transmission rates less than channel capacity. The average value and the first-order probability distribution of the effective constraint length, found by simulating the system on an IBM 709 computer, are also given. . . .

CUMULATIVE DECISION TECHNIQUES FOR ERROR-FREE COMMUNICATION SYSTEMS
J. J. Metzner, et al., New York U., N. Y., Fourteenth Scientific Report, AFCRL-63-330; NYU TR-400-82, July 15, 1963, 101 p., 13 refs., N63-21472.

. . . foundation for a continuing exploration of practicable methods by which the efficiency of error-free, fail-safe, digital communication systems operating over real channels can be raised to yield information rates closer to channel capacity . . . new feedback policy . . . including systems employing binary, null-zone, and continuous-level reception. Some numerical results are presented, including calculations obtained with an IBM 1620 computer of certain characteristics of two of the proposed cumulation methods . . .

BINARY DECISION FEEDBACK WITH ENVELOPE DETECTION
J. J. Metzner, et al., IEEE Trans. Commun. Electronics, no. 66, May 1963, p. 227/239.

The performance of discarding and of cumulative decision-feedback systems employing null-zone reception is evaluated for two common types of envelope detection. Compared with a synchronous phase-detection system, of course, the envelope-detection systems necessarily suffer somewhat. . . . Nevertheless, feedback is again shown to permit an unlimited trade-off between error probability and transmission time.

FEEDBACK FOR ERROR CONTROL AND TWO-WAY COMMUNICATION
L. S. Schwartz, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 49/56.

. . . considers the usefulness of feedback relative to coding, the kind of feedback system to use, the advantages of combining feedback with coding and the characteristics of a system that results therefrom. . . . effectiveness of block codes plus feedback in combatting burst-type noise. . . . a brief discussion of existing feedback systems using some of these principles. . . .

IMPROVEMENT OF COHERENT COMMUNICATION OVER THE GAUSSIAN CHANNEL BY ERROR-FREE DECISION FEEDBACK
A. J. Viterbi, JPL Space Progr. Summ., vol. 4, no. 37-23, Aug./Sept. 1963, p. 179/180.

It is shown that, in uncoded digital telemetry over the Gaussian channel employing two antipodal signals to represent the binary symbols, it is possible to reduce the transmitted power by a factor of approximately 4 (6 db) at any specified error probability by a sequential procedure wherein decisions are transmitted in the reverse direction over an error-free feedback channel.

ASYMPTOTIC ERROR CODING BOUNDS FOR THE BINARY SYMMETRIC CHANNEL WITH FEEDBACK
E. J. Weldon, Jr., Florida U., Engineering and Industrial Experiment Station, Gainesville, Scientific rept. no. 1, AFCRL Rept. no. 63 122, 1 April 1963, 122 p., 10 refs., AD 412 793, N63-18274.

Various asymptotic upper and lower bounds are calculated for linear (parity check) codes used with the Binary Symmetric Channel (BSC) with feedback. The feedback channel is taken to be noiseless and capable of instantaneous transmission. . . . The bounds calculated herein indicate that the best variable-length code has a higher probability of erroneous decoding than the best fixed-length code in which the feedback is used to vary the number of information symbols per word. They also indicate that the best code used without feedback has a higher probability of erroneous decoding than the best code used with decision feedback, which in turn has a higher probability of erroneous decoding than the best code used with information feedback.

Related Publications:

STUDIES OF COMMUNICATION CHANNELS
S. Chang, et al., Electronics Research Lab., Northeastern U. (Boston, Mass.), Scientific rept. no. 3, pt. 2, AFCRC TN 60-574, vol. 2, 17 May 1960, 46 p., incl. illus., AD 242 674.

. . . The following topics are discussed . . . Feedback systems for the reduction of multipath distortion have been evaluated. . . .

COMMUNICATION THROUGH RANDOM MULTIPATH MEDIA
D. P. Harris, Stanford Electronics Labs., Stanford U., Calif, Technical rept. no. 1002-2, April 1962, 89 p., incl. illus., 24 refs., AD 291 447.

. . . comparisons . . . of the performance potentials of different communication techniques. Bounds on the communication rate possible with an adaptive matched-filter receiving technique are obtained as functions of the channel-sounding effort, the signal characteristics, and the channel characteristics. . . .

THEORETICAL INVESTIGATION OF DUAL RATE TRANSMISSIONS OVER GAUSSIAN MULTIPLICATIVE CIRCUITS
Sylvania Electric Products, Inc., Waltham, Mass., Final rept., Rept. no. F-1004-1, AFCRL-62-198, 12 April 1962, 127 p., incl. illus., tables, 12 refs., AD 278 139.

The simplest form of a variable data rate communication system, an on-off system, which in the ideal case has been shown to be almost as good as the continuously variable rate system is detailed. The effects of Rayleigh fading and additive Gaussian noise in both the forward and feedback channels are studied.

HIGH FREQUENCY DIGITAL COMMUNICATION SYSTEM
National Cash Register Co., Dayton, Ohio, Quarterly progress engineering rept. no. 5, 1 June-31 Aug. 1962, NCR rept. no. 3-5 Q, 15 Oct. 1962, 101 p., incl. illus., AD 287 485.

. . . system that provides highly reliable operation in the presence of multipath propagation and doppler shift. . . . operation of the circuits used in the control and coding equipment. . . .

SOME TYPES OF OPTIMAL CONTROL OF STOCHASTIC SYSTEMS
S. E. Dreyfus, RAND Corp., Santa Monica, Calif., Memo RM3726PR, July 1963, 29 p., AD 419 392.

. . . Under various assumptions concerning the information available to the controller, different optimal control rules result. . . . the vast superiority of feedback over open-loop control is demonstrated.

CUMULATIVE DECISION TECHNIQUES FOR ERROR-FREE COMMUNICATION SYSTEMS
J. J. Metzner, et al., IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 153.

Abstract Only . . . It is presently known that essentially error-free digital communication can be attained on real channels by employing long codes in conjunction with feedback to obtain repetition of unacceptable received code words. However, if the channel conditions are too often below a fairly well-defined threshold, the amount of repetition required drives the accepted-message rate well below the actual capacity of the channel.

This paper first discusses some cumulative decision techniques which show promise of remedying this difficulty. . . . The several methods are evaluated and compared with respect to the gain in efficiency of channel utilization and other practical considerations. It is shown that the cumulative procedure is theoretically more efficient than the alternative of varying the data rate according to channel conditions, and that it should also be easier to implement in many situations. . . .

2.926: Methods with Automatic Repeat Request

Included: Error-free communications methods; ARQ procedures; Automatic message repetition in data links; Insert method for repeat transmissions; Rapidatas' synchronous system with message repetitions.

Not Included: Teletype equipment; Storage equipment.

Cross References: Feedback communications systems in general (2.920); Special codes for ARQ operation (2.782); SECO system (2.920); Integrated error-free communications system (2.980).

Principal Publications:

AN AUTOMATIC SELF-VERIFYING, SELF-CORRECTING, DATA TRANSMISSION SYSTEM
I. Flores, IRE Trans. Telem, Remote Contr. vol. TRC-1, no. 3, Aug. 1955, p. 5/7.

. . . to transmit information over a two- or three-wire system for distances of up to a mile or more. The information to be handled is in the form of numerical data . . . The heart of this system is the rotary stepping switch.

CONSTANT-RADIO CODE AND AUTOMATIC-RQ ON TRANSOCEANIC HF RADIO SERVICES
J.B. Moore, IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 72/75.

Historical development, of present-day commercial teleprinter services . . . A general description of the Automatic-RQ method and system — rather than specific designs—is given . . . growth, in the international services, is illustrated by that of TEX (Overseas Teleprinter Exchange) service.

THE USE OF GROUP CODES IN ERROR DETECTION AND MESSAGE RETRANSMISSION
W.R. Cowell, IRE Trans. Inform. Th., vol. IT-7, no. 3, July 1961, p. 168/171.

APPLICABILITY OF CODING TO RADIO TELETYPE CHANNELS
A.B. Fontaine, Lincoln Lab., MIT Lexington, Rept. 25G-3, 27 Oct. 1961, 6 p., AD 266 827.

Approximately 300 hours of radio teletype data were analyzed . . . to determine the applicability of coding theory to radio teletype channels. . . . error detect and repeat schemes with about 10% redundancy will reduce the probability of error to a negligible amount.

RELIABLE DATA TRANSMISSION THROUGH NOISY MEDIA — A SYSTEMS APPROACH
C.M. Melas, Commun. and Electronics, vol. 80, no. 57, Nov. 1961, p. 501/504.

. . . Transmission errors can be corrected either by adding redundancy bits to the information to generate an error correcting code, or by automatically retransmitting the message when erroneously received. The relative merits of the two techniques are discussed in terms of both error control and systems compatibility. A class of powerful and easily implemented cyclic error detection and correction codes was recently developed which, in combination with automatic retransmission, should give effective error protection. . . .

THE DESIGN OF AN ERROR-FREE DATA TRANSMISSION SYSTEM FOR TELEPHONE CIRCUITS
B. Reiffen, et al., Commun. and Electronics, vol. 80, no. 55, July 1961, p. 224/231.

Recent experimental results verify that easily implemented codes can detect essentially all errors occurring in digital data sent over toll-grade telephone circuits. . . . request a retransmission . . . The feedback logic is detailed herein, and the buffer required to adapt the system to various data sources is discussed. Extrapolated experimental results indicate an average delivery rate in each direction of approximately 7/8 the modem (modulation system) bit rate with a mean time to error of several hundred years. . . . The Bose-Chaudhuri codes used in the test were the 511, 493, the 255, 239, and the 127, 113. . . .

ERROR PROBABILITY AND TRANSMISSION SPEED ON CIRCUITS USING ERROR DETECTION AND AUTOMATIC REPETITION OF SIGNALS
H.C.A. Van Duuren, IRE Trans. Commun. Syst., vol. CS-9, March 1961, p. 38/50.

COMPUTER SIMULATION OF THE USE OF GROUP CODES WITH RETRANSMISSION ON A GILBERT BURST CHANNEL
W.R. Cowell, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 577/585.

A study of error control by coding was made by Monte-Carlo simulation of a burst-noise channel on an IBM (International Business Machines) 7090. Using short group codes, comparisions were made between correction and detection with retransmission. Also, the effect of interleaving the code words was studied. Error detection with retransmission showed a consistently better performance than error correction and the time division resulting from interleaving was effective in combatting burst type error patterns. . . .

EXPERIMENTAL DATA TRANSMISSION SYSTEM FOR SWITCHED TELEPHONE LINES
H. Marko, et al., Elect. Commun., vol. 37, no. 3, 1962, p. 238/251.

. . . the system must be able to cope with noise caused by rotary selectors as well as with short-time interruptions not uncommon in carrier-system channels. . . . The return path of the (basically duplex) telephone line can be utilized for backward signals, such as proceed to send or repeat. . . . Frequency modulation has been favored because of its simplicity of equipment and adjustment and the minor effects of changes in signal-to-noise ratio. . . .

ON FSK PARITY CHECKING (Correspondence)
N.M. Blachman, IEEE Trans. Inform. Th., vol. IT-9, no. 2, April 1963, p. 121/123.

. . . compares the error probabilities for a fixed-information-transmission-rate FSD channel, with and without one parity-checking bit per word, for various word lengths, any word whose parity does not check at the receiver being retransmitted.

ON REPEATING A DIGITAL MESSAGE TO INCREASE THE PROBABILITY OF CORRECT RECEPTION
H. Dym, Mitre Corp., Bedford, Mass., Rept. no. TM3389, ESD TDR 63 239, July 1963, 38 p., AD 412 918.

The theoretical aspects are considered relative to the repetition of messages as a means of error detection and correction, where, on the average, less than 50% of the digits received are in error, and reception reliability is obtained at the expense of a lower data rate. Two repetition schemes, fixed and sequential, are considered . . . Comparision is made of such repetition schemes with more sophisticated techniques, e.g., those involving optimum coding.

QUEUEING CHARACTERISTICS OF A TELEPHONE DATA TRANSMISSION SYSTEM WITH FEEDBACK
A.B. Fontaine, IEEE Trans. Commun. Electronics, no. 68, Sept. 1963, p. 449/455.

. . . Experimental error data were used to measure the queueing characteristics of a simulated detect and repeat telephone data transmission system operating with a constant rate source. The maximum queue varied considerably as a function of the telephone circuit error sample and data system. . . . queues of more than

100,000 bits were found. Measurements were also made of the frequency of exceeding a buffer which was smaller than the maximum queue.

"THE RAPIDATA S" SYNCHRONOUS SYSTEM FOR THE HIGH SPEED TRANSMISSION OF INTELLIGENCE (In French)
A. Girinsky, et al., Onde Electr. vol. 43, no. 431, Feb. 1963, p. 186/198.

This method of transmission is a synchronous type using frequency modulation. It is suitable for use on telephone circuits . . . Reliability of transmission is ensured by an automatic device for the detection of errors which transmits the intelligence in block form and obtains the repetition of any among them which are disturbed. Auxiliary equipment makes it possible to check the operation of the device and to extract the statistical information on errors. . . .

CUMULATIVE DECISION TECHNIQUES FOR ERROR-FREE COMMUNICATION SYSTEMS
J.J. Metzner, et al., New York U., Coll. of Engineering, N.Y., AFCRL Rept. 63 330, 15 July 1963, lv., AD 417 230.

Efforts concerned the exploration of practicable methods by which the efficiency of error-free, fail-safe, digital communication systems operating over real channels can be raised to yield information rates closer to channel capacity. Emphasis was on cumulative decision techniques. A feedback policy is described which makes the system completely compatible with the cumulative process. . . . including systems employing binary, null-zone, and continuous-level reception. Some numerical results are presented of certain characteristics of two of the proposed cumulation methods . . .

COMPARISON OF THE 3-OUT-OF-7 ARQ WITH BOSE-CHAUDHURI-HOCQUENGHEM CODING SYSTEMS
M. Nesenbergs, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 202/212.

The performance of coding schemes can be expressed by two criteria; the useful transmission rate R, and output character-error probability P. Both quantities are expressed in a form applicable to a binary forward channel coupled with an arbitrary feedback channel. . . . If the element errors are independent of each other a purely error-correcting arrangement looks attractive. If the errors are correlated (i.e., occure in bursts), error detection holds more promise. . . .

REAL-CHANNEL ASPECTS OF AN ERROR-FREE DATA TRANSMISSION SYSTEM FOR TOLL-GRADE TELEPHONE CIRCUITS
W.G. Schmidt, IEEE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 69/72.

A feedback communications system . . . The coding technique employed promises an ultra-low data error rate capability . . . reliability can only be assured when considerable attention is also given to the problems associated with bit and block synchronization. . . . many thousands of hours of actual on-line testing. The effects of impulse and random noise are outlined, the hazards of long-term circuit dropouts are detailed and some solutions to these problems presented. . . . Utilizing the results of the error-detection code study by Fontaine and Gallager, a feedback system logic was designed around the use of the (255,231) Hocquenghem-Bose-Chaudhuri codes. . . . certain characteristics of real-channel operation . . . cannot be simulated on a computer . . . The modulation system used for purposes of these tests is a differentially coherent 1200 bit-per-second phase-reversal system which uses internal coding for purposes if enabling the regeneration of the BIT TIMING and BLOCK START signals at the receiver. . . .

AN INSERT SYSTEM FOR USE WITH FEED-BACK COMMUNICATION LINKS (Correspondence)
R.D. Stuart, IRE Trans. Commun. Syst., vol. CS-11, no. 1, March 1963, p. 142/143.

. . . When a channel suffers from burst noise . . . efficient use of the channel is made by using an error detection code in conjunction with a feedback link. . . . In a "go-back" system the receiver ignores anything received after detection of the error and the transmitter goes back to the word received in error . . . Obviously more efficient use could be made of the channel if only the word received in error had to be retransmitted, any subsequent words correctly received being preserved at the receiver and the missing word inserted in the correct place when properly received. . . .

Related Publications:

THE NOISE-PROOF FEATURE OF THE HAMMING CODE (In Russian)
G.A. Shastova, Radiotekhnika i Elektronika, vol. 3, 1958, p. 24/37.

A comparision is made between the noise-proof feature of the information transmission by the Hamming code, by the simple binary code and by the code with repetitition and parity check.

NOTES ON TRANSMISSION OF DATA AT 750 BAUDS OVER PRACTICAL CIRCUITS
P.A. Chittenden, Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 22/28.

. . . conclusions that . . . the assessment of the quality of a data path based on an average number of digit errors is unrealistic, and that error detection with repetition is . . . an equally effective . . . method . . .

CODING FEEDBACK COMMUNICATION SYSTEMS
J.J. Metzner, et al., Proc. Nat. Electronics Conf., vol. 16, Oct. 1960, p. 250/257.

. . . employing long codes with feedback, correcting only very small numbers of errors, and utilizing a new technique which effectively prevents any type of disturbance in the feedback channel from harming system reliability. The resulting system yields excellent reliability, "fails safe" . . . and operates at a relatively high per-symbol-information rate. This approach is particularly effective in precisely those situations where less efficient procedures fail - namely, when severe burst-type noise or heavy fading is encountered. . . .

STUDY OF ADAPTABLE COMMUNICATIONS SYSTEMS
D. Chesler, Sylvania Electric Products, Inc., Waltham, Mass. Final rept., Rept no. F-1008-1, RADC TDR 62-314, 14 June 1962, 293 p., incl. illus. tables, refs., AD 286 504.

. . . covering both adaptable receivers and repeat-request feedback systems using error-detection codes. The study on error-detecting codes deals with a multi-stage error-detection repeat-request system in which the receiver performs error detection on small blocks of binary digits and requests a repeat of each block in which an error is detected. . . . Optimum thresholds are determined for use in dual-rate transmission over fading channels in conjunction with error-detection coding. The remaining studies deal with adaptable receivers. One investigation demonstrates the utility of a rake-type system for orbital dipole channels. The rake system studied is a generalization of the conventional rake system and has the advantage of allowing analog as well as digital modulation.

OPTIMUM ERROR DETECTION CODES FOR NOISELESS DECISION FEEDBACK
I. Jacobs, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 359/371, 18 refs.

Iterative error-detection codes are applied to a decision-feedback communication system employing a noisy binary-symmetric forward channel and a noise-free feedback channel. The optimum (maximum information rate) code is shown to be one in which only a single parity check is made at each stage of the iteration. This code is referred to as the SPC code. For this code, the probability of an undetected error P_M tends to zero algebraically, rather than exponentially, with block length. However, the complexity of the necessary decoder grows only as log log $1/P_M$, a drastic improvement over the log $1/P_M$ growth encountered in error-correction systems. . . .

CODED FEEDBACK COMMUNICATION SYSTEMS
J.J. Metzner, et al., Commun. and Electronics, vol. 80, no. 58, Jan. 1962, p. 643/647.

. . . employing long codes with feedback, correcting only small numbers of errors, and utilizing appropriate feedback techniques. The resulting system yields essentially error-free performance under all conditions, is relatively efficient, and compares very favorably in cost. . . .

RETRANSMISSION ERROR CONTROL
T.G. Kuhn, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 186/201.

. . . discusses . . . the use of vertical and horizontal block parity checks. . . . provides a level of error rate performance which is far better than that which can be expected from the equipment into which it must operate. For instance, for a random bit error probability of 10^{-4}, a 22 x 22 bit block yields an output error rate of $4.4(10)^{-14}$, with an efficiency of 87 per cent. . . . An analysis is presented which determines the parameters for optimum performance for both random and bunched errors. . . .

COMPARISION OF SIGNALLING EFFICIENCY IN WIDEBAND COMMUNICATION SYSTEMS
J.W. Ye, Mitre Corp., Bedford, Mass., Rept. no. TM3851, ESD TDR63 437, Oct. 1963, 15 p., AD 422 599.

Section 2.93

2.930: Adaptive Operations in Communications Systems

Included: Definition of adaptivity; Adaptable receiver with pilot tones; Signal design techniques in adaptive links; Adaptive circuits in decision systems; Self-adaptive data compression; Adaptive learning processes in communications systems; Application of adaptive antenna systems; Adaptive route selection; Adaptive communications filter; Adaptive waveform recognition system.

Not Included: Re-entry communications links; Adaptive control systems; Learning processes in general; Automata; Bionics (3B); Adaptive reliability techniques; Antenna theory; Theory of large communications networks; Filter theory; Matched filter detection systems (1); Adaptive memory systems (3A).

Cross References: Decision theory (Div. 2.8); Data compression methods (Div. 2.2); Adaptive error correction procedures (2.954); SECO, adaptive feedback system (2.920); Systems with special variable communications parameters (Sect. 2.95).

Principal Publications:

DYNAMIC PROGRAMMING AND ADAPTIVE PROCESSES—I: MATHEMATICAL FOUNDATION
R. Bellman, et al., RAND Corp., Santa Monica, Calif., Rept. no. P1416, 3 July 1958, rev. 6 Feb. 1959, 23 p., AD 423 467.

A foundation is laid for a mathematical theory of a significant class of decision processes which have not as yet been studied in any generality. These processes. . . arise in practically all parts of statistical study. . . engulf the field of operations research, and play a paramount role in the current theory of stochastic control processes of electronic and mechanical origin. All three of these domains merge in the consideration of the problems of communication theory. . . .

FUNCTIONAL EQUATIONS IN ADAPTIVE PROCESSES AND RANDOM TRANSMISSION
R. Bellman, et al., IRE Trans. Circuit Theory, vol. CT-6, May 1959, p. 271/282.

By imbedding a complex physical process under consideration within an appropriate class of processes and expressing the functional relationships among the members of the class, it is frequently possible to obtain insights into the structure of the original process which would not be feasible through consideration of that process alone. By way of illustration, transmission through random media. Still other applications which have been made in modulation theory, communication theory, and network analysis are briefly sketched.

ADVANCED TELEMETRY SYSTEM DEVELOPMENT
A. Egger, Space Technology Labs., Inc., Los Angeles, Calif., Semiannual rept., 1 Jan.-30 June 1960, Rept. no. STL/TR-60-0000-09192, 30 June 1960, 38 p., AD 267 855.

. . . studies leading to. . . adaptive and analytical telemetry systems in which the information efficiently utilizes the data channel capacity. . . .

LINK ERROR CONTROL AND NETWORK ROUTE SELECTION
R. C. Amara, et al., IRE Trans. Commun. Syst., vol. CS-9, no. 9, Dec. 1961, p. 328/334.

On a link basis, character reliability can be increased using decision feedback for error control. A method is then given for determining the optimal message route between each origin and destination—

ADAPTIVE BINARY DETECTORS
R. F. Daly, Stanford Electronics Labs., Stanford U., Calif., Rept. 2003-2, 26 June 1961, 25 p., AD 258 861

A sequential binary detection problem is considered in which it is required to detect the presence or absence of a stochastic signal in each member of a sequence of observations perturbed by additive noise. The problem is formulated so that the decision rule for the (kl) observation depends on a memory function of the previous k observations. . . . A time-varying linear predictor of the unknown signal is introduced as the memory function, and a binary detector with a variable structure depending on the linear predictor is discussed.

ADVANCED TELEMETRY SYSTEM STUDIES
A. Egger, Space Technology Labs., Los Angeles, Calif., Rept. no. STL/TR-60-0000-19430, 31 Jan. 1961, AD 255 510.

. . . applications of conformal (adaptive) telemetry systems and a description of a prototype conformal unit designed and constructed to demonstrate feasibility of the concept, together with a complete PCM telemetry system designed to operate with the conformal unit.

ADAPTIVE TECHNIQUES FOR LONG RANGE TRANSMISSION OF PULSE CODE MODULATION TELEMETRY DATA
D. H. Ellis, et al., Dynatronics, Inc., Orlando, Fla., Final rept., June 1960-May 1961, ASD TR 61-198, Aug. 1962, 244 p., incl. illus., tables, refs., AD 288 076.

. . . long range transmission of PCM telemetry data. . . . optimization of system information capacity, selection of an optimum R. F. link, and investigations of format compromises, to attain the maximum information rate possible over a wide range of transmission path lengths, and a variety of data requirements. The type of modulation (phase) for the R. F. link is shown by theoretical analysis to be superior to any other. A system design and engineering model development program has been completed. Results of test performed on the model verify the feasibility of the engineering design.

PRINCIPAL ELEMENTS OF ADAPTIVE COMMUNICATION SYSTEMS
R. F. Filipowsky, et al., Natl. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 266/273.

A general discussion of all conceivable parameters in large scale communication networks which may be used in adaptive operations. A fundamental model for an adaptive terminal is included.

SIGNAL DETECTION BY ADAPTIVE FILTERS
E. M. Glaser, IRE Trans. Inform. Th., vol. IT-7, no. 2, April 1961, p. 87/98.

. . . giving increased attention to detection systems which are able to adjust their own structure so as to be optimum for the particular detection problem of the moment. This paper

describes a system which is capable of adapting and optimizing its response to the class of pulse signals whose individual pulses are less than T seconds in duration.

DIGITAL SIMULATION OF AN ADAPTIVE WAVEFORM RECOGNITION SYSTEM
C. V. Jakowatz, Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 234/246.

Earlier reports describe an adaptive Waveform Recognition System which modifies itself with experience in such a manner as to become a matched filter for an unknown input waveform. The input waveform is randomly occurring and mixed with additive Gaussian noise. The original experimental work on such systems was done in an analog fashion, and dealt with low dimension signals. The system reported on here has been simulated on the 7090 computer for multiple adaptive waveform recognition, which can deal with several signals of high dimension, and thereby become a classification system (Signal times dimension being (10^4) . . .

THE LINK CONNECTION AS AN ADAPTIVE MATCHED FILTER
N. A. Liskov, Cornell U. School of Electrical Engineering, Ithaca, N. Y., Technical rept. no. 66; Research rept. no. EE 509, 30 Aug. 1961, 42 p., 4 refs., AD 270 847.

. . . Link amplifier with variable transconductances between its grid and plate delay lines, can be used as an adaptive matched filter. On the assumption that the unknown input signal is fixed and repeats every T seconds for a number of cycles, it is shown that the optimum adjustment procedure is to set each transconductance equal to the average of the corresponding input sample of signal plus noise. Several types of averagers are discussed and the RC averager is chosen as the most desirable. An electronically controled, linear, variable-gain amplifier and several sampling systems are suggested for the actual instrumentation of the adaptive matched filter.

AN APPROACH TO SELF-ADAPTIVE TELEMETRY SYSTEMS
M. A. Lowy, Proc. Nat. Telem. Conf., May 1961, p. 10-1/10-10.

General survey of adaptive techniques in TM.

USING BAYES' INDUCTION THEOREM TO ESTIMATE PROBABILITIES IN A COMMUNICATION CHANNEL
S. D. Stearns, Dikewood Corp., Albuquerque, N. Mex., rept. DTN-1018-1, RADC TN 61-207, 2 July 1931, 31 p., AD 265 847.

. . . inferring the values of a finite set of probabilities of which nothing is at first known . . . application of Bayes' Theorem results in a reasonable measure of the amount of learning which takes place during the process of inference. If this measure of learning is acceptable, one can specify in advance the maximum and minimum amounts to be learned after the receipt of a given number of samples (or symbols at the receiver in a communication channel).

AN ADAPTIVE COMMUNICATIONS FILTER (Correspondence)
C. S. Weaver, Proc. IRE, vol. 49, Oct. 1961, p. 1587/1588.

Filter for unknown repetitive signals.

SIGNAL AND DATA-PROCESSING ANTENNAS
G. O. Young, IRE Trans. Mil. Electronics, vol. MIL-5, no. 1, April 1961, p. 94/102.

. . . This paper treats the antennas as an information processing device, and applies the concepts of modern information theory to the design of antennas and to the optimization of their performance. The principal optimization criterion employed is maximization of information or data rate.

A SIMPLE ADAPTABLE RECEIVER WITH PILOT TONES FOR ANALOG TRANSMISSION THROUGH A SELECTIVE FADING CHANNEL
D. A. Chesler, Rec. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 163/169.

. . . the purpose of an adaptable receiver is to undo the signal distortion due to the channel and to minimize the effect of additive noise. An adaptable receiver is studied whose adaptation is by means of N variable complex gains (amplitude and phase) and in which the limited information about the present channel conditions is provided by M pilot tones. A method is derived for obtaining the present "optimum" values of the N complex gains from the present values of the complex envelopes of the M filtered pilot tones. . . .

STUDY OF ADAPTABLE COMMUNICATIONS SYSTEMS
D. A. Chesler, Sylvania Electric Products, Inc., Waltham, Mass., Final rept., Rept. no. F-1008-1, RADC TDR 62-314, 14 June 1962, 293 p., incl. illus., tables, refs., AD 286 504.

. . . covering both adaptable receivers and repeat-request feedback systems using error-detection codes. The study on error-detecting codes deals with a multi-stage error-detection repeat-request system in which the receiver performs error detection on small blocks of binary digits and requests a repeat of each block in which an error is detected. . . . Optimum thresholds are determined for use in dual-rate transmission over fading channels in conjunction with error-detection coding. The remaining

studies deal with adaptable receivers. One investigation demonstrates the utility of a rake-type system for orbital dipole channels. The rake system studied is a generalization of the conventional rake system and has the advantage of allowing analog as well as digital modulation.

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATIONS SYSTEMS. PART III. A WIDEBAND ADAPTIVE COMMUNICATION SYSTEM
J. C. Hancock, et al., Purdue U., School of Electrical Engineering, Lafayette, Ind., Final tech. rept., June 1961-June 1962 on Improved Information Transfer Efficiency of Wideband Systems, ASD TDR 62-611, pt. 3, July 1962, 218 p., incl. illus., 60 refs., AD 284 452.

. . . capable of monitoring the medium through which it must perform while simultaneously transmitting information and continuously adjusting its modes of operation so as to optimize its performance with respect to a performance criterion chosen a priori. Statistical methods are applied to the adaptive communication problem. Communicating through a random multipath channel with additive noise is considered. . . . A major conclusion taken from these expressions is that the probability of error in no case depends directly on the channel gain, but rather is a function of the total average energy received from all propagation modes.

COMMUNICATION THROUGH RANDOM MULTIPATH MEDIA
D. P. Harris, Stanford Electronics Labs., Stanford U., Calif., Technical rept. no. 1002-2, April 1962, 89 p., incl. illus., 24 refs., AD 291 447.

. . . Bounds on the communication rate possible with an adaptive matched-filter receiving technique are obtained as functions of the channel-sounding effort, the signal characteristics, and the channel characteristics. . . .

ADAPTIVE DECISION ELEMENTS TO IMPROVE THE RELIABILITY OF REDUNDANT SYSTEMS
W. H. Pierce, IRE Internat. Conv. Rec., Pt. 4, vol. 10, March 1962, p. 124/131, 16 refs.

. . . Redundant but unreliable binary or analog signals are used most effectively when each signal's error probability is used to compute a statistical estimate of the correct signal. When errors in the inputs are independent, the statistical estimates can be made by simple summing circuits. Adaptive circuits are proposed which give the most reliable inputs the largest weights. . . .

ERROR PROBABILITIES FOR ADAPTIVE MULTICHANNEL RECEPTION OF BINARY SIGNALS
R. Price, Lincoln Lab., Mass. Inst. of Tech., Lexington, Technical rept. no. 258, AFESD TDR 62-129, 23 July 1962, 58 p., incl. illus., table, 34 refs., AD 284 651.

. . . adaptive receiver that is part of a multichannel communication system over which binary data are conveyed. In the adaptive receiver, noisy measurements are made of presumably nonvarying channel signal strengths and phase shifts. The measurements are then applied to the signal processing in a manner that would be optimum if the measurements were perfect. Signaling in each channel is accomplished by means of a pair of equal-energy waveforms that are orthogonal or opposites, and all channels are affected by mutually independent white Gaussian noises of identical intensities. . . . One major conclusion is that the error probability does not depend directly on the signal strengths or phase shifts in the various channels, but instead is a function of the total average power received over all channels, exclusive of the noise. . . . A by-product of the analysis is the error expression for the special case of nonadaptive multichannel reception of nonorthogonal signals.

ERROR PROBABILITIES FOR ADAPTIVE MULTICHANNEL RECEPTION OF BINARY SIGNALS
R. Price, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 305/316, 18 refs.

. . . two slightly different forms of an adaptive receiver. . . Each channel has a non-dispersive non-fading propagation path and additive white gaussian noise that is independent of, and equal in intensity to, the other channel noises. Either phase-independent orthogonal signaling (such as FSK) or phase-reversal-comparison signaling is employed to convey to the receiver both the message and information about the path strengths and phases. The receiver measures the path parameters and applies the results to the detection processing as though they were perfectly accurate. . . The distribution of the received signaling energy among the channels is immaterial. . . .

ERROR PROBABILITIES FOR ADAPTIVE MULTICHANNEL RECEPTION OF BINARY SIGNALS: ADDENDUM (Correspondence)
R. Price, IRE Trans. Inform. Th., vol. IT-8, no. 6, Oct. 1962, p. 387/389.

Exact results have been given. . . R. Price, "Error Probabilities for Adaptive Multichannel Reception of Binary Signals," IRE Trans. on Information Theory, vol. IT-8, p. 305/316, Sept. 1962. . . . The purpose

of the present letter is to take cognizance of a convenient approximation to this error probability that was given some time ago by Sussman in a slightly different context, and to examine its accuracy. . . .

A DIGEST OF ADAPTIVE SYSTEMS
V. C. Rideout, et al., Cornell Aeronautical Lab., Inc., Buffalo, N.Y., Rept. no. ID-1384-P-2, 1 March 1962, 15 p., illus., AD 281 719.

. . . An attempt is made to define and classify adaptive systems in such a way that meaningful comparisons may be made. In particular, a useful semi-tabular form is given, upon which 30 proposed adaptive systems are entered.

A SURVEY ON ADAPTIVE SYSTEMS WITH A DYNAMIC CHARACTERISTIC ADJUSTMENT
R. S. Rutman, Minneapolis-Honeywell Regulator Co., St. Petersburg, Fla., Honeywell Military Products Group, Sept. 1962, 50 p., refs., Transl. into English from Avtomat i. Telemekh. (Moscow), v. 23, no. 5, p. 661/684 (MH-Transl. 393), N64-14752.

A classification is presented of adaptive systems that are concerned with maintaining a performance index, and a survey is given of periodicals, books, and conference materials on adaptive systems with a dynamic characteristic adjustment. Basic principles and methods for their realization are selected for the construction of this type of system. The materials are generalized and systematized according to the most important criteria; the algorithms of the self-adjustment and the methods for determining the dynamic characteristics.

ADAPTIVE COMMUNICATION WITH FEEDBACK
L. S. Schwartz, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 764.

. . . some of the ways in which adaptive communications may be employed. There may be control at the receiver, at the transmitter, and at both jointly by means of feedback. . . . Adjustments may be made from inductive observations on received signals, permitting estimates to be formed of error probabilities. Decision threshold settings may then be altered until these probabilities attain specified values. . . .

This paper discusses methods for achieving: (1) adaptive control in receivers without feedback; (2) adaptive control in communication systems with a feedback loop from the receiver to the transmitter; and (3) adaptive control in systems employing both an adaptable receiver and a feedback loop from the receiver to the transmitter. . . .

AN ADAPTIVE COMMUNICATION TECHNIQUE
L. Schwartzman, Proc. Nat. Aerospace Electronics Conf., vol. 10, May 1962, p. 92/97.

An antenna design which permits cooperative operation between a ground station and a satellite is presented. Athesa (Automatic Three Dimensional Electronic Scanning Antenna System) can, on an automatic closed-loop basis, maintain its entire aperture in a uniform phase relationship as seen at the satellite, in spite of high velocities (large Doppler shifts), large ratios of maximum to minimum range, and anomalous atmospheric propagation.

ADAPTIVE DECISION SYSTEMS - I
R. Smallwood, et al., Air Force Cambridge Research Labs., Bedford, Mass., AFCRL Cambridge memo no. 13; Technical memo no. 62 14, 27 Dec. 1962, 16 p., AD 419 478.

. . . automated decision system to operate on data from a single channel. . . . A noisy signal is obtained upon which random events impose a signature which has some characteristics that are constant from event to event. The goal is to detect the occurrence of an event by the presence of these characteristics signatures and with as little time lag as possible. . . . can be broken down into two problems: (1) The parameter problem — (2) the Decision problem—. . . the optimum decision system will vary with the parameters used. The question arises then, as to whether a decision system can be built that will change its properties and thereby adapt to any data parameters chosen. . . .

ADAPTIVE COMMUNICATION FILTERING
C. S. Weaver, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 169/178.

. . . It is assumed that either the noise or the signal is completely unknown and only the spectrum or autocorrelation function of the other is known. It is desired to filter according to a mean-square error criteria. . . . filters. . . may be realized physically by the use of tapped delay lines, or they may be constructed as part of a digital computer program. On the computer they are capable of real-time filtering of many types of signals. Measurements taken of signal and noise give the information needed to adjust—in a straightforward manner—the filter parameters. . . .

THE CONCEPT OF SELF-ADAPTIVE DATA COMPRESSION
D. R. Weber, et al., Rec. Nat. Symp. Space Electronics Telemetry, no. 4.1, Oct. 1962.

. . . reviews the broad aspects of data compression as a means for improving the

efficiency of PCM telemetry. . . . attention . . . to redundancy removal methods. . . importance of the higher-order techniques. Results from analysis of actual telemetry data are presented briefly, showing the effectiveness of higher-order redundancy relative to sampling efficiency. Buffer requirements. . . other benefits from self-adaptive data compression, such as selective sampling, variable accuracy, and data priority control. . .

THEORETICAL INVESTIGATION OF DUAL RATE TRANSMISSIONS OVER GAUSSIAN MULTIPLICATIVE CIRCUITS
Sylvania Electric Products, Inc., Waltham, Mass., Final rept., Rept. no. F-1004-1, AFCRL-62-198, 12 April 1962, 127 p., incl. illus., tables, 12 refs., AD 278 139.

The simplest form of a variable data rate communication system, an on-off system, which in the ideal case has been shown to be almost as good as the continuously variable rate system is detailed. The effects of Rayleigh fading and additive Gaussian noise in both the forward and feedback channels are studied.

BEAM TAGGING FOR CONTROL OF ADAPTIVE TRANSMITTING ARRAYS
R. T. Adams, IEEE Trans. Antennas Propagation, vol. AP-12, March 1964, p. 224/227, 6 refs., A64-16613.

. . . Conventionally, self-focusing or steering of an adaptive array has always been controlled by signal measurements made in the receiving mode. By the use of beam tagging, a transmitting array can be made adaptive. The signal from each array element is tagged with identifying modulation, and a single sample from the far field can then be analyzed to find control information for the set of transmitting-element phases and amplitudes. The technique can be used with two-way arrays or with arrays used solely for transmitting. . . .

CONTROL MEASUREMENT IN THE PRESENCE OF NOISE. II
J. Dawkins, J. Electronics and Control, 1st Series, vol. 15, Sept. 1963, p. 255/268, A63-22428.

. . . results are generalized to include continuously measured quantities and the simultaneous estimating of many parameters. They provide means for designing multidimensional adaptive filters, and for determining the state variables of partially observable linear systems.

ADAPTIVE ENCODING FOR LANGUAGE COMPRESSION
J.W. Falter, Proc. Nat. Aerospace Electronics, Conf., May 1963, p. 92/98.

ADAPTIVE RECEPTION OF SIGNALS WITH UNKNOWN GAIN AND DELAY
J. C. Hancock, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 54/65.

Assuming unknown channel gain and unknown channel delay we derive a set of delay estimators . . . The estimating filter output is the true path delay plus a noise term that is Gaussian when the additive channel noise is Gaussian. . . . Any of these delay estimators can be incorporated into an adaptive M-ary receiver which uses the noisy estimates in a manner that would be optimum if the measurements were precise. . . .

ON THE USEFULNESS OF SIGNAL DESIGN TECHNIQUES IN ADAPTIVE TELEMETRY LINKS
J. C. Hancock, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 322/327.

. . . The usefulness of signal design techniques in adaptive communication systems is investigated with primary emphasis on the intersymbol interference problem. . . . Comparisons are made between systems which have been designed to have no intersymbol interference and those which simply use 'guard' spaces as protection . . . Applying signal design concepts to eliminate intersymbol interference in a communication channel entails a-priori knowledge of the impulse response of the channel, and this in itself is a major task for most time varying links. . . . we first investigate the advantages of signal design techniques if this a-priori information is known. . . .

OPTIMUM PERFORMANCE OF SELF-ADAPTIVE SYSTEMS OPERATING THROUGH A RAYLEIGH-FADING MEDIUM
J. C. Hancock, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 443/453, 19 refs.

. . . problem of communicating through the Rayleigh-Fading-Multipath channel with additive noise. The a posteriori probabilities necessary for specifying different receiver modes for various forms of a priori channel knowledge are derived. System performance is analyzed and computed for several modes of operation and the results presented in graphical form, allowing one to determine the importance of making measurements on the unknown channel state. . . .

COMMUNICATION THROUGH RANDOM MULTIPATH MEDIA
D. P. Harris, Lockheed Aircraft Corp., Sunnyvale, Calif., 6 July 1963, 96 p., AD 410 286.

. . . some specific techniques for communicating through noisy, randomly time-varying multipath channels are considered . . . Bounds on the communication rate possible with an adaptive matched-filter receiving technique are obtained as functions of the channel-sound effort, the signal characteristics, and the

channel characteristics. The performance characteristics of a class of radiometric signal detection techniques that require no channel sounding provisions are analyzed . . .

GETTING THE MOST OUT OF AEROSPACE TELEMETRY
A. Hauptschein, et al., Electronics, vol. 36, Sept. 27, 1963, p. 23/29, A63-25088.

Comparison of adaptive transmission systems which can vary power or bandwidth, or both, to cope with changing environmental conditions and to increase efficiency. . . . several adaptive and nonadaptive systems are compared in terms of energy savings, total information capacity, error probability, and practical system requirements. Bidirectional systems or feedback systems are suggested.

ADAPTIVREGELSYSTEME MIT SINUSTEST-SIGNALEN (Adaptive Control System With Harmonic Test Signals) (In German)
E. Kollmann, VDI - Forschungsheft no. 499, 1963, 40 p., A64-13472.

Investigation of a class of adaptive control systems, which provides information about the varying system parameters by means of harmonic test signals. The nonlinearities necessary to evaluate the response of the test signals and to adjust the parameters of the fundamental control circuit can be linearized with respect to the adaptive control circuit . . . Several adaptive systems which control the time constants of the amplification factors of the fundamental system were tested on an analog computer and explored in their dynamic behavior. . . . a special two-parameter adaptive control system was established in which the amplification of the fundamental circuit and the frequency of the test signal are the controlled variables. . . .

ADAPTIVE TECHNIQUES FOR THE OPTIMIZATION OF BINARY DETECTION SYSTEMS
H.J. Kushner, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 107/117.

. . . for the problem of the experimental optimization of maximum signal-to-noise ratio binary detectors which operate in a partially unknown environment. Two approaches are taken and compared in detail. The first involves the use of statistical estimates of the unknown quantities that are obtained by the appropriate averaging operations. The second, and more interesting, approach makes use of the methods of stochastic approximation to develop a convergent iterative process on the parameters of the adaptive filter. The iterates converge to the optimum values in mean square and with probability one. . . .

INVESTIGATIONS OF ADAPTIVE DETECTION TECHNIQUES
J.G. Lawton, et al., Cornell Aeronautical Lab., Inc., Buffalo, N.Y., Annual Rept. Aug. 1962 - Aug. 1963, Rept. no. RM1744 S1, Nov. 1963, 71 p., AD 426 915.

. . . situations under which use of an adaptive detection system may be desirable . . . analysis of a one-dimensional nonparametric system . . . simplifying assumptions . . . noise is gaussian . . . Experimental results, obtained by means of a digital computer. Are found to agree fairly well with the approximate theory . . .

DELAY IN DATA TRANSMISSION THROUGH SIMPLE NETWORKS: STEADY STATE CHARACTERISTICS WITH INFINITE NODAL STORAGE
B.J. Moriarty, Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 25G19, 6 June 1963, 40 p., AD 408 250.

. . . single constant rate source of data communicating with a single sink of data, via a set of fault-liable HF links which are connected to relay stations equipped with storage facilities. Methods of transmission are used between modes which effectively result in a node ceasing to transmit when a link becomes faulty and only resuming when a link returns to its normal condition. Thus data will queue at a node when the outgoing link is faulty, and all data reaching the sink is error-free. The network has been simulated on a digital computer using the recorded link behavior of two existing HF RTTY links. The probability distributions have been obtained for the queues that arise at the nodes and for the total delay involved in transmitting data from the source to the sink.

ANALYSIS OF OPTIMIZING CONTROL SYSTEMS USING FUNDAMENTAL ADAPTATION CONCEPTS
L. Pun, In: 1st International Symposium on Optimizing and Adaptive Control, Proceedings, Pittsburgh, Pa., Instrument Society of America, International Headquarters, 1963, p. 137/145, A63-21797.

. . . The concepts of adaption, optimization, and learning are examined, and a consistent set of expressions is deduced from this examination. . . .

ADAPTIVE COMMUNICATION WITH SOUNDING SIGNALS IN RANDOM CHANNELS
C.K. Rushforth, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 102/106.

. . . describes a communication system which utilizes a sequence of reference or sounding signals to adapt itself to a random linear channel. A particular set of signals is considered, each of which is partitioned into a reference or sounding signal and a message signal . . .

AN ADAPTIVE INFORMATION TRANSMISSION SYSTEM EMPLOYING MINIMUM REDUNDANCY WORD CODES
E.S. Schwartz, Armour Research Foundation, Chicago, Ill., Final rept. on Phase 1 &2, 1 Feb. 1961-1 April 1963, ASD TDR62 265, p. 2, 1 June 1963, 241 p., AD 404 463.

. . . experimental model of an adaptive information transmission system employing minimum-redundancy word codes . . . Flow charts of computer programs . . . Compression ratios for processed messages were determined and the effectiveness of a modified split-dictionary format providing for word decomposition and synthesis was studied. . . . knowledge concerning the statistics of word and letter frequencies can be effectively utilized in the design of an efficient system. A procedure for determining when dictionary changes are required is outlined.

THE DETECTION OF MULTIPLE UNKNOWN SIGNALS BY ADAPTIVE FILTERS
J.W. Smith, John Hopkins U. Carlyle Barton Lab., Baltimore, Md., May 1963, 133 p., 13 refs., N63-16514.

. . . class of filters discussed includes two types previously described in the literature, and one new type designed explicitly for operating in a multiple waveform environment. The new structure processes the data in a nonlinear fashion and effectively sets up a narrow decision region about the estimate of the waveform. . . .

A PHSE-LOCKED RECEIVING ARRAY FOR HIGH-FREQUENCY COMMUNICATIONS USE
D.E. Svoboda, IEEE Trans. Antennas Propagation, vol. AP-12, March 1964, p. 207/215, A64-16611.

Discussion of an automatically phased HF receiving array that employs separate RF amplifiers for each element and IF signal combination. The array corrects essentially all phase errors between the distant transmitter and the point where the received signals are combined. The phase errors include those due to the propagation path, array element motion, near-field obstructions, and the instabilities in electronic equipment and RF cables. The array also corrects phase shifts due to changes in angle of arrival, thus giving it the ability to automatically track a desired signal. . . . A six-element experimental array is described with a technique for measuring patterns, and measured array patterns are compared with calculated patterns.

ON THE DEFINITION OF ADAPTIVITY (Correspondence)
L.A. Zadeh, Proc. IEEE, vol. 51, no. 3, March 1963, p. 469/470.

In recent years, the notion of an adaptive system has come to play an important role in the theories of communication and control. Nevertheless, it is difficult to find a satisfactory explanation, much less precise definition, of this notion in the literature. . . . The present note has . . . objective of characterizing not the mechanism of adaptivity buts its external manifestations. . . .

1ST INTERNATIONAL SYMPOSIUM ON OPTIMIZING AND ADAPTIVE CONTROL PROCEEDINGS
L.E. Bollinger (editor), Symposium Sponsored by the International Federation of Automatic Control, Theory Committee, Rome, Italy, April 26-28, 1962, Pittsburgh, Pa., Instrument Society of America, International Headquarters, 1963, 311 p., A63-21788.

. . . general feedback control problems, dynamic programming for direct optimization systems, adaptive information processing . . . Also considered are the physical and linguistic evolution in self-organizing systems, and learning matrices for binary and nonbinary signals. . . .

Related Publications:

ON COMMUNICATION PROCESSES INVOLVING LEARNING AND RANDOM DURATION
R. Bellman, et al., Rand Corp., Santa Monica, Calif., rept. P-1194, 23 Jan. 1958, AD 244 750.

. . . problems within the framework of multistage processes of stochastic type, and as such may be treated by the theory of dynamic programming. The relations between utility and capacity, in Shannon's sense, are indicated. The problem of how to treat communication problems involving the use of a channel whose statistical properties are not completely known, and those involving processes of random duration is discussed. These are special cases of still more general problems in prediction theory. The aim throughout the report is to show how quite general processes can be treated in unitary fashion by the functional equation technique of dynamic programming.

ON COMMUNICATION PROCESSES INVOLVING LEARNING AND RANDOM DURATION
R. Bellman, et al., IRE Nat. Conv. Rec., March 1958, p. 16/21.

ON THE PHILOSOPHY OF ADAPTIVE CONTROL FOR PLANT ADAPTIVE SYSTEMS
M. Margolis, et al., Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 27/33.

. . . describes a very general approach to the design of process adaptive systems . . . process adaptive control is discussed as a logical extension of the basic concepts of feedback theory.

. . . use of a learning model whose form is the same as the physical process and whose parameters are continually adjusted so that the model and process behave as much alike as possible. The parameter's of the model are used to set the parameters of the controller for the overall control of the system.

COMMUNICATION APPLICATIONS OF INFORMATION THEORY
B. L. Basore, Dikewood Corp., Albuquerque, N. Mex., Rept. DRF-1004, RADC TR 61-107, Final rept., 29 Dec. 1960, 37 p., AD 257 983.

A mathematical model of communication in a situation in which learning occurs . . . the equivocation measuring the uncertainty about what message was transmitted is greater in a learning situation than in the case covered by conventional communication theory . . . this increase is more than the amount of information which may be learned from the one transmission about the statistical description of the transmitter's message set.

A UNIVERSAL NON-LINEAR FILTER, PREDICTOR AND SIMULATOR WHICH OPTIMIZES ITSELF BY A LEARNING PROCESS
D. Gabor, et al., Proc. Instn. Elect. Engrs., vol. 108, no. 40 - Pt. B, July 1961, p. 422/438.

. . . consisting of a universal non-linear filter, which is a highly adaptable analogue computer, together with a training device. The analogue machine has 18 input quantities from which it can compute in about 2. 5 millisec 94 terms of a polynomial, each term containing products and powers of the input quantities, with adjustable coefficients, and can form their sum. . . .

VARIABLE BANDWIDTH FM TRANSMISSION SYSTEM
J. E. Palmer, et al., RCA Defense Electronic Products, Camden, N.J., RADC TR 61-124, 30 April 1961, 143 p., 43 refs., AD 259 090.

. . . A system is proposed in which data rate would be varied by adjusting the transmitted bandwidth in accordance with the prevailing conditions. . . .

ANOTHER METHOD FO OPTIMUM PROCESSING OF A RECEIVED SIGNAL IN THE PRESENCE OF NOISE
F. P. Tarasenko, Radio Engng: Transl. of Radiotekhnika, vol. 16, no. 2, 1961, p. 7/13.

. . . It is shown that with slight modification the quadrature detector may (in the case of ergodic signals) operate without prior data concerning the amplitude and phase of the effective signal. In this case, it begins to operate as a square-law detector, and then its properties asymptotically approach those of a synchronous detector. . . .

APPLICATION OF STATISTICAL ESTIMATION PROCEDURES TO THE IDENTIFICATION PROBLEM
R. P. Wishner, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Rept. no. 47G-2, 3 Nov. 1961, 24 p., AD 266 877.

. . . This analysis also has applications to the adaptive radar problem.

APPLICATION OF TECHNIQUES FOR STATISTICAL COMMUNICATION THEORY IN UNDERWATER ACOUSTICS
D. Middleton, Raytheon Co., Portsmouth, R.I., Quarterly status rept. 2 for Sept. 1961, Rept. R155, Sept. 1961, 32 p., AD 266 138.

. . . analytical solutions of selected passive sonar problems by use of the techniques of statistical communication theory . . . (1) The characteristics of the adaptive nonparametric-type detector functional when used to detect both gaussian and non-gaussian signals in either gaussian or non-gaussian noise; (2) The characteristics of the detector for noise-like signals in the presence of impulse-type background noise . . . The practical implementation of the adaptive detector was considered. A design was obtained which could process 1000 data samples and 3000 noise samples taken at a 2-kc rate, in real time. The detector outputs would be available with 1/2 sec of the epoch of the final data sample. A research report describing the status of the analysis on optimal array detection systems is appended to this report.

LEARNING TO RECOGNIZE PATTERNS IN A RANDOM ENVIRONMENT
N. Abramson, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S58/63.

This paper deals with the optimal use of a sequence of prior observations in order to recognize patterns. . . . the results may be applied to patterns of a visual, aural or electromagnetic origin. . . . the use of prior observations for pattern recognition may be described as a process of learning the statistical characteristics of the patterns involved. . . . The optimum systems are shown to consist of banks of generalized correlators. . . .

THE SELF-REPRODUCING SYSTEM
W. R. Ashby, International Symposium on Biosimulation, 1st, Proceedings, Locarno, Switzerland, June 29 - July 5, 1960, In: Aspects of the Theory of Artificial Intelligence, New York, Plenum Press, Inc., 1962, p. 9/18, A63-17871.

. . . a system so constructed that if there occurs within it a certain form (or property, or pattern, or recognizable quality generally), then a dynamic process occurs, involving the whole system. The dynamic process is of such a nature that eventually we can recognize, in the system, further forms closely similar to the original. . . .

SELF-ORGANIZING MODELS — THEORY AND TECHNIQUES
E. B. Carne, Proc. Nat. Aerospace Electronics Conf., vol. 10, May 1962, p. 499/508.

IMPROVED UTILIZATION OF TELEMETRY CAPACITY
B. D. Cobb, et al., Army Missile Command, Guidance and Control Lab., Redstone Arsenal, Ala., RG-TR-62-3, June 29, 1962, 44 p., N63-16843.

. . . attempt is made to develop a figure of merit . . . Data bandwidth reduction and transmitter bandwidth utilization are considered as separate problems. . . . potential of adaptive techniques is discussed. Several recommendations for the immediate improvement of utilization are outlined.

PRINCIPLES OF SELF-ORGANIZATION: TRANSACTIONS OF THE UNIVERSITY OF ILLINOIS SYMPOSIUM ON SELF-ORGANIZATION
H. Von Foerster and G. W. Zopf, Jr., editors, New York, 22, Pergamon Pres, Inc., 1962, 526 p.

. . . An outstanding feature of the book is the well presented discussion which follows a large number of the papers. The Symposium was attended by many of the outstanding and experienced workers in the field; the cross-fire of their comments, criticisms, and examples adds new dimension to each paper. . . .

RELIABILITY MONITORING BY OPTIMAL STOPPING SAMPLING
N. R. Garner, Seventh Mil.-Ind. Missile and Space Reliability Symp., NAS, North Island, Calif., 18-21 June 1962, (1962), p. 441/446, 3 refs., N63-17299.

. . . This procedure allows testing to continue until k defects are observed. At this time one of three decisions are made. If the number of trials is too small, testing is stopped and an engineering change is required. If the number of trials is too large, then a new reliability plateau has been achieved. If the number of runs is neither too small nor too large, a new sequence of testing begins. . . . The mathematical model is discussed, cumulative probabilities are given so that control charts can be established, and an example is presented. This method may find application in adaptive communications systems.

LEARNING PHENOMENA IN NETWORKS OF ADAPTIVE SWITCHING CIRCUITS
M. E. Hoff, Jr., Stanford Electronics Lab., Stanford U., Calif., Technical rept. no. 1554-1, SEL-62-090, ASD TDR 62-767, July 1962, 85 p., incl. illus., tables, 15 refs., AD 288 894.

A practical adaptive (trainable) switching circuit, consisting of an adjustable switching circuit together with a circuit realizing an adjustment procedure, is described. The adjustable switching circuit used has as its output a quantized linear weighted sum of the inputs; the adjustment procedure, known as the minimum-mean-square-error method, consists of iteratively connecting the various input states to the adjustable circuit and making weight changes for each input state based on the circuits response to that input state. . . .

SEQUENTIAL DETECTION OF GAUSSIAN SIGNALS IN GAUSSIAN NOISE
T. Kailath, JPL Space Progr. Summ., vol. 4, no. 37-15, April/May 1962, p. 35/37.

. . . some results are presented on the performance of the optimum receiver in the special example studied in RS 36-13, p. 38/42. The special example treated the detection of one of a set of unknown signals in Gaussian noise. The very limited initial information is supplemented by the use of "learning" observations or labeled samples of each different type of unknown signal. . . . We shall here examine the rate at which the probability of error using the ideal receiver goes down as the number of learning observations increases.

THE CASE FOR ADAPTIVE CONTROLS
M. A. Ostaard, et al., Presented at the 21st Meeting of the Flight Mech. Panels of AGARD, Paris, 6-10 July 1962, July 1962, 30 p., 22 refs., N63-19036.

This paper attempts to show that adaptive control systems are practical, that they have lived up to expectations, and that they represent a significant advance over the conventional linear control systems. A typical flight-control problem for re-entry vehicles is described . . .

SECO: A SELF-REGULATING ERROR CORRECTING CODER-DECODER
K. E. Perry, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S128/135.

SECO is an efficient engineering realization of a coding-decoding scheme designed to use variable redundancy and feedback in a two-way communication system to increase the rate of information transfer between users connected by a channel having a slowly time-varying capacity. . . .

COMMUNICATION PROCESSES IN RANDOM MULTIPATH CHANNELS
C. K. Rushforth, Stanford Electronics Labs., Stanford U., Calif., Rept. no. SEL-62-063, Technical rept. no. 2004-5, April 1962, 31 p., incl. illus., 11 refs., AD 276 688.

. . . channels whose exact nature is not known a priori . . . Two criteria . . . the probability of error and the divergence between statistical hypotheses. . . . The adaptive behavior of a receiver is considered with memory making a sequence of observations. It is shown for a particular case that the optimum receiver evolves from one using estimates of the channel output to the classical matched filter or correlation detector using a known channel output.

CAPABILITIES AND LIMITATIONS OF SOME ADAPTIVE TECHNIQUES
E. B. Stear, et al., Proc. Nat. Aerospace Electronics Conf., vol. 10, May 1962, p. 644/660.

. . . study of adaptive control techniques in general and adaptive flight control techniques in particular.
. . . three techniques; will be classified as High-Gain, Error Switching, and Model-Reference.
Good Bibliography

STRUCTURALLY HOMOGENEOUS ADAPTIVE SYSTEMS
R. M. Stewart, Proc. Nat. Aerospace Electronics Conf., vol. 10, May 1962, p. 509/514.

A SELF-ORGANIZING CONTROL SYSTEM BASED ON CORRELATION TECHNIQUES AND SELECTIVE REINFORCEMENT
D. N. Streeter, et al., Cruft Lab., Harvard U., Cambridge, Mass., Technical rept. no. 359, 20 July 1962, 36 p., illus., 20 refs., AD 291 498.

. . . The relation between learning, adaptation, and self-organization in control systems and in animals is discussed. A system capable of synthesizing its controllers without explicit knowledge of the process or the spectra of the inputs is described. The synthesis is based on the cross-correlation between a signal representing the desired output state and the various components of the tentative input signal. . . . Results of computer simulation of the system are presented. . . .

BEAM TAGGING DIVERSITY
R. T. Adams, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 233.

Abstract only . . . The composite signal is analyzed at the receiver to obtain phase-control information, which is relayed to the transmitting site for controlling the indivdual signals.
When used to combine a set of transmitted signals in space diversity, beam-tagging yields an advantage equivalent to the array-gain of the set of transmitting antennas. . . .

ADAPTIVE CONTROL VIA QUASILINEARIZATION AND DIFFERENTIAL APPROXIMATION
R. Bellman, et al., RAND Corp., Santa Monica, Calif., Rept. no. RM3928PR, Nov. 1963, 19 p., AD 422 713.

. . . The potential military and commercial applications of such devices are impressive. The aim of this Memorandum is to show that the basic system identification and state determination problems can be viewed, mathematically, as nonlinear multipoint boundary value problems. They can be resolved, computationally, via use of quasilinearization and differential approximation. The net result is that we now possess straightforward and effective procedures for designing wide classes of adaptive controllers.

GRAPHICAL DATA PROCESSING RESEARCH STUDY AND EXPERIMENTAL INVESTIGATION
A. E. Brain, Stanford Research Inst., Menlo Park, Calif., Final rept., 1 April 1960 - 31 May 1963, Rept. no. 12, June 1963, 43 p., AD 417 859.

A small experimental learning MINOS I was developed in order to evaluate the feasibility of this type of machine for categorizing graphical data from maps, charts and aerial photographs. A much larger machine MINOS II has recently been constructed, including an optical preprocessor which provides a good match between the raw data and the learning machine . . . MINOS II uses a magnetic weight with second-harmonic read-out. Competitive weights use multiaperture magnetic cores, and magnetostrictive delay lines. The learning machine contains two layers of threshold logic. Training is by "majority-rule" logic . . .

A NEW CONCEPT IN ARTIFICIAL INTELLIGENCE
J. P. Choisser, et al., Rome Air Development Center, Griffiss Air Force Base, N. Y., RADC TDR63 228, May 1963, 6 p., AD 409 111, N63-18170.

. . . CHILD (Cognitive Hybrid Intelligent Learning Device). CHILD is a self-adaptive learning machine which was conceived, designed, and constructed at the Information Processing Lab., Rome Air Development Center. . . .

A MODULATION METHOD FOR MODEL REFERENCE ADAPTIVE CONTROL SYSTEMS
R. C. Dorf, et al., IEEE Internat. Conv. Rec., Pt. 2, vol. 11, March 1963, p. 146/153.

. . . Adaptation is achieved by reduction of the difference between the response of the control system and the response of a reference model to the same input signal. Theoretical and simulation studies of the effectiveness of an adaptive loop which adjust a parameter in the control system were accomplished. A new modulation method has been devised to achieve this parameter control. This method utilizes a high frequency modulation of the model output signal and results in a rapid, yet stable, adaptive loop. The effects of noise and certain nonlinearities in the system have been investigated. . . .

MAGNETO-PLASMAS AND RE-ENTRY RADIO BLACKOUT
S. T. Fisher, Proc. IEEE, vol. 51, no. 7, July 1963, p. 1029/1030.

. . . By using RHCP waves and a variable magnetic field it should be possible to optimize transmission through the sheath. The proposed

method is to monitor the reflection coefficient of the transmitting antenna and continuously to adjust the magnetic field for minimum reflected power. . . .

A GROUP INTERACTION EXPERIMENT
M. M. Flood, System Development Corp., Santa Monica, Calif., Rept. no. TM1512, 1 Oct. 1963, 34 p., AD 428 494.

. . . (GRIT) experiment, conducted by the use of an on-line time-sharing information processing system developed at the System Development Corporation. . . . pairs of subjects interact as partners in a non-constant sum negotiation game. . . . Discusses stochastic learning models adequate for parameter estimation and goodness-of-fit testing purposes . . . might eventually provide the basis for much more effective design and management of units having command and control functions.

ADAPTIVE CONTROL SYSTEMS: AN ANNOTATED BIBLIOGRAPHY
J. B. Goldmann (comp.), Lockheed Aircraft Corp., Sunnyvale, Calif., Special Biblio., SB63 60, 2 75 63 1, AD 433 807.

. . . application . . . to communications systems, automatic reconnaissance techniques, detection of weak signals in noise, and reliability enhancement are the areas of interest emphasized in this annotated bibliography. . . . covers the period 1960 - July 1963.

INCREASED NOISE IMMUNITY IN THE RECEPTION OF AM SIGNALS BY THE USE OF NONLINEAR FEEDBACK IN THE HIGH-FREQUENCY SECTION OF THE RECEIVER (Translation)
A. A. Gorbachev, Telecommun. Radio Engng. Part II-Radio Engng., vol. 18, Feb. 1963, p. 36/41, A63-20642.

. . . This method enables the suppression, in radiotelephone and radiobroadcasting receivers, of the effect of pulse interference having a repetition frequency up to tens of thousands cps, and is, to a considerable extent, free of the shortcomings of methods which are currently used for this purpose.. . . . Experimental investigations show that the method described, as opposed to the method of blanking the wide-band antenna section of the receiver during the time of action of the interference (for controlling the switching of the HF section of the receiver), nor does it require switching devices or delay lines for the required signal.

ADAPTIVE SYSTEM CONTROLLERS USING DELAY ELEMENTS
M. H. Hamza, In: 1st International Symposium on Optimizing and Adaptive Control, Proceedings, Pittsburgh, Pa., Instrument Society of America, International Headquarters, 1963, p. 267/275, A63-21804.

. . . where a compensator using delay elements is used under changing environmental conditions, it may not be necessary to vary the values of the delays, although some of the compensator parameters must still be varied.

A DIGITAL WIDE-BAND NONLINEAR RECEIVER CAPABLE OF NEAR OPTIMUM RECEPTION IN THE PRESENCE OF NARROW-BAND INTERFERENCE
J. C. Hancock, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 3, Sept. 1963, p. 272/279.

In a wide-band communication system the additive disturbances in the channel are less likely to be white Gaussian nose than in narrow-band links. . . . illustrates how linear receivers can be made more optimum by incorporating a nonlinear transformation which precedes detection. Narrow-band AM stations are assumed to be the only additive disturbance in the channel. Adaptive techniques are also suggested . . .

THEORY OF ADAPTIVE MECHANISMS Final Report
M. K. Hu, et al., Griffiss AFB, N.Y., RADC, RADC-TDR-63-334, Dec. 1963, 110 p., refs., AD 429 935, N64-15814.

USTROISTVO SLEDIASHCHEE ZA OTNOSHENIEM SIGNAL/SHUM (A System Based On The Signal-to-Noise Ratio) (In Russian)
G. I. Levitan, et al., Elektrosviaz', vol. 18, March 1964, p. 5/16, 6 refs., A64-17641.

. . . methods for constructing systems whose output voltage is determined by the ratio of signal to the fluctuating noise at the input. Two types of such systems are described in detail. The basic theoretical prerequisities are considered, together with the results of experimental investigations conducted for the case of a frequency-manipulated signal. Some recommendations are presented for the construction of the system's circuits.

A CLASSIFICATION OF LEARNING TASKS IN CONVENTIONAL LANGUAGE
E. E. Miller, Wright-Patterson AFB, Ohio, Behavioral Sciences Lab., Final Report, AMRL-TDR-63-74, July 1963, 20 p., 7 refs., N63-22594.

. . . Learning tasks are categorized by applying the definitional criteria sequentially. Major categories are perceptual-motor, discovery, understanding, perceptual judgment, and memorizing . . .

AN ADAPTIVE PROCEDURE FOR CONTROLLING UNDEFINED LINEAR PROCESSES
K. S. Narendra, et al., Cruft Lab., Harvard U., Cambridge, Mass., 8 Nov. 1963, 35 p., AD 434 895.

. . . causes a reduction of the mean-square error of a linear stationary random process,

without explicity knowledge of the characteristics of the process. The procedure involves recursive simultaneous adjustment of an arbitrary number of parameters in a feedback compensator. . . .

ADAPTIVE OPTIMAL CONTROL OF NON-LINEAR PROCESSES
A.E. Pearson, Conference sponsored by the American Institute of Chemical Engineers, New York, American Institute of Chemical Engineers, 1963, p. 80/90, In: Joint Automatic Control Conference, 4th University of Minnesota, Minneapolis, Minn., June 19-21 1963, Preprints of Technical Papers, A64-11183.

Analysis of Kulikowski's formulation of the adaptive optimal control problem. . . . Methods are suggested for using certain a priori information . . . Various practical considerations associated with the required identification are discussed, and the operations of the adaptive optimal controller are briefly summarized.

RANDOM ACCESS STATIONARY SATELLITE RELAY COMMUNICATION SYSTEM
Z. Prihar, Rec. Nat. Space Electronics Symp., no. 3.4, 1963.

. . . Queuing (waiting line) problems . . . alternative multiple access methods . . . substitution of an adaptive system . . .

FERRIELECTRICS AND THEIR APPLICATION IN SOLID-STATE DEVICES AS AN ADAPTIVE CONTROL
C.F. Pulvari, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 254/260.

The basic properties of the recently discovered ferrielectrics, which are essentially degenerate antiferroelectrics exhibiting ferroelectric properties, will be discussed. . . . A new device which operates similar to the transfluxor and represents an electrostatically controlled circuit impedance with stored settings will be discussed. This device called the "transpolarizer" represents one of the most interesting recent achievements in the semiconductor field. . . . by the application of a control signal, it can be changed from a ferroelectric capacitor into a linear capacitor and can assume any intermediate polarization level between these two limits . . . Now, for the first time, it is possible to utilize the combination of electrically controlled resistance, inductance and capacitance in circuit design. . . . extremely useful in the fields of pattern recognition, trainable computers and adaptive control. . . .

AN ADAPTIVE-PREDICTIVE MODEL FOR NON-LINEAR PROCESSES WITH TWO-LEVEL INPUTS
R. Roy, et al., Conference sponsored by the American Institute of Chemical Engineers, New York, American Institute of Chemical Engineers, 1963, p. 204/210, In: Joint Automatic Control Conference, 4th, University of Minnesota, Minneapolis, Minn., June 19-21 1963, Preprints of Technical Papers, A64-11190

Extension of a previously described method by which the class on nonlinear processes with switched two-level inputs and finite settling times could be identified and an adaptive model of the process constructed. The new theory is presented in sufficiently general form to encompass the problem of prediction of the output of a process. The prediction involves an identification of both the process and its input signal. . . . The results of a computer study of the model are presented.

INFORMATION PATTERN, LEARNING STRUCTURE, AND OPTIMAL DECISION RULE
M. Sakaguchi, Inform. Control, vol. 6, no. 3, Sept. 1963, p. 218/229.

In Section I various types of information structures in individual decision-making under uncertainty are discussed. A quantity which measures the value of information structure is proposed. In Section II the team decision problem is considered. Finally, in Section III we consider the mutlistage decision process with learning and we shall try to evaluate the effect of the learning structure and compute it by the technique of dynamic programming. . . .

ADAPTIVE MEMORY RESEARCH
G. Sebestyen, Griffiss AFB, N.Y., Inform. Processing Lab., RADC-TDR-63-371, Nov. 1963, 88 p., refs., AD 427 825, N64-14309.

. . . state-of-the-art of automatic pattern recognition techniques and related hardware developments, with special emphasis on the use of the various adaptive memories reported in recent literature . . . The relationship between pattern recognition problems and Air Force intelligence problems . . . machine learning and recognition techniques . . . major activities in automatic photographic data processing (target recognition) conducted in various laboratories of the United States . . .

THE ANALYSIS OF MULTIPLE SIGNAL DATA
J.W. Smith, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 208/214.

This paper discusses the automatic processing of data containing multiple signals. In particular, filters which modify their structures in order to recognize initially unknown waveforms in Gaussian noise and an unknown signal environment are investigated experimentally. . . . The results demonstrate the possibility of using filters of the new type for automatically processing data although the relevant waveforms may be unknown a priori. . . . Problems which fit into the broad category described are: 1) Radar detection in a multiple emitter environment; 2) Multiple signal communications systems such as hand-sent Morse code; 3) Medical or reconnaissance data.

CYBERNETICS. A DDC REPORT BIBLIOGRAPHY
E.E. Thompson (comp.), Defense Documentation Center, Alexandria, Va., Bibliography for 1953-Sept. 1963, Oct. 1963, lv., AD 419 462.

Annotated bibliography of 227 documents catalogued by DDC from 1953 to the present (includes and supersedes ARB-13,453, dated December 1962) . . .

USE OF MODEL-REFERENCE ADAPTIVE CONTROL TO ACHIEVE A SPECIFIED PERFORMANCE
H.P. Whitaker, Massachusetts Inst. of Tech., Cambridge Instrumentation Lab., April 1963, 20 p., 11 refs., N63-23106.

. . . enables a system to change its compensation parameters in a closed-loop manner so as to achieve a specified performance. Fundamentally, the model is the specification of the desired response of the system, based on engineering judgment identifying what constitutes acceptable performance . . . The possibilities of using the model-reference concept (1) in a learning adaptive system, (2) for response limitation, and (3) to identify vehicle characteristics are examined.

THEORY AND APPLICATION OF ADAPTIVE CORRELATION AND PROBABILITY FUNCTION SYSTEMS
A.A. Wolf, et al., IEEE Paper no. 63-594, Feb. 1963, 15 p.

Section 2.94
Sensing Methods in Controlled Communications

2.940: Statistical Sensing Techniques for Adaptive Communications

Included: Transpolarizer as adaptive sensing element; Special counting devices as statistical sensors; Optimum estimation of impulse noise; Impulse response sensing; Statistical speech detectors; Signal waveform identifiers; Transmitted reference techniques; Signal-to-noise sensors; Intersymbol interference sensing; Delay distortion sensors.

Not Included: Experimental evaluation of statistical populations (1); Statistical sensing in communications channels (1); Delay distortions in communications channels (1).

Cross References: Speech compaction methods (Sect. 2.3); Speech pattern recognition (2.360); Ionospheric sounding techniques (2.946).

Principal Publications:

USE OF CROSSCORRELATION IN AN ADAPTIVE CONTROL SYSTEM
G.W. Anderson, et al., Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 34/45.

The measurement of system impulse response by means of crosscorrelation is discussed. The use of periodic excitation and the effect of external disturbances are considered. Several methods of applying impulse response measurements to self-adaptive systems are described . . . The mechanization of a practical crosscorrelator is also discussed.

TRANSITION-RATE DISCRIMINATORS
J.D. Holland, Elect. Commun., vol. 35, no. 4, 1959, p. 261/265.

Telegraph signalling waveforms consist of a series of mark-space or space-mark transitions that represent points at which the rate of change of information is a maximum. The number of transitions that occur over a given period for an error-free message depends on the signalling speed. If the message is disturbed by noise the transition rate increases . . . The difference in transition rate between an error-free message and one perturbed by noise can be detected, and the information used to provide a utilization voltage. Circuits have been developed for this purpose, known as transition-rate discriminators . . .

STATISTICAL ERROR CONTROL OF A REALIZABLE BINARY SYMMETRIC CHANNEL
I.S. Reed, Lincoln Lab., Mass. Inst. of Tech., Lexington, Nov. 1959, 13 p., AD 241 453.

. . . It is shown how the statistics of a channel can be measured as the message is being received. . . .

OPTIMUM ESTIMATION OF IMPULSE RESPONSE IN THE PRESENCE OF NOISE
M.J. Levin, IRE Trans. Circuit Theory, vol. CT-7, no. 1, March 1960, p. 50/56, 15 refs.

. . . In the fields of communication and control there sometimes arises the problem of determining the characteristics of a time-invariant linear system from records of its input and output during a limited interval of time. . . . the postulate that random noise is superimposed upon the system output appears to lead to estimates of practical value. This paper considers only the estimation of impulse response, and it should be noted that if the interest is really in the frequency response or transfer function of the system, then different procedures are applicable.

ON THE IDENTIFICATION OF LINEAR PROCESSES (Correspondence)
W.W. Lichtenberger, IRE Trans. Circuit Theory, vol. CT-7, no. 1, March 1960, p. 78/79.

. . . A current problem in the field of adaptive control systems is the rapid identification of the process under control. . . . One useful characteristic of a linear process is its impulse response. This can be measured in several ways, of which a most useful one has been attributed to Y.W. Lee.

LEARNING TO RECOGNIZE PATTERNS IN A RANDOM ENVIRONMENT
N. Abramson, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S58/63.

This paper deals with the optimal use of a sequence of prior observations in order to recognize patterns. . . . the results may be applied to patterns of a visual, aural or electromagnetic origin. . . . the use of prior observations for pattern recognition may be described as a process of learning the statistical characteristics of the patterns involved. . . . The optimum systems are shown to consist of banks of generalized correlators. . . .

A SIMPLE ADAPTABLE RECEIVER WITH PILOT TONES FOR ANALOG TRANSMISSION THROUGH A SELECTIVE FADING CHANNEL
D.A. Chesler, Proc. Nat. Commun. Symp., vol. 8, no. 10, Oct. 1962, p. 163/169.

. . . the purpose of an adaptable receiver is to undo the signal distortion due to the channel and to minimize the effect of additive noise. An adaptable receiver is studied whose adaptation is by means of N variable complex gains (amplitude and phase) and in which the limited information about the present channel conditions is proved by M pilot tones. A method is derived for obtaining the present "optimum" values of the N complex gains from the present values of the complex envelopes of the M filtered pilot tones. . . .

ON INSTANTANEOUS ENTROPY
W.H. Foy, Jr., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 267/274.

. . . In many communication and control problems . . . the quantities of interest come from a class of signals. We can assign a probability distribution over function space, and the entropy of this distribution measures our uncertainty as to the occurrence of any given signal in the class. In many other problems, on the other hand, we are interested in the value of some function at a particular instant. A probability distribution is assigned over the function values, and the "instantaneous entropy" of this distribution measures our uncertainty as to the instantaneous function value. This interpretation finds useful application to a long list of problems in communication, data-processing, guidance and control. . . . We shall be concerned in this paper with the instantaneous entropy of continuously distributed quantities. . . .

CONTROL OF INDUSTRIAL PROCESSES BY ELECTRONIC COUNTING
D.J. Hancock, Proc. Instn. Radio Engrs. Australia, vol. 23, no. 12, Dec. 1962, p. 701/712, 85 refs.

. . . It is shown that electronic counting systems can overcome the disadvantages of mechanical systems and provide facilities not otherwise available. . . . A comprehensive bibliography is included. . . .

MEASUREMENTS ON TIME-VARIANT COMMUNICATION CHANNELS
T. Kailath, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 229/236.

. . . problems of measuring the characteristics of time-variant communication channels. . . . the use of such media as tropo-scatter links, meteor trails, auroral belt, and orbital-chaff channels makes the assumption of slow changes unsatisfactory. . . . The . . . signals . . . pass through a (linear or nonlinear) filter. A, for example the ionosphere or an underwater link. There is also an additive noise, n, usually due to front end receiver noise or to co-channel interference. The measurement problem is to determine the parameters of the filter, A, by input-output operations on the channel. That is, we put in suitable probing signals . . . and make appropriate computations on the output . . . in order to calculate the filter parameters. There is also, of course, the problem of determining the characteristics of the additive noise . . .

TASI QUALITY — EFFECT OF SPEECH DETECTORS AND INTERPOLATION
H. Miedema, et al., Bell Syst. Tech. J., vol. 41, no. 4, July 1962, p. 1455/1473.

. . . tests made to select design parameters for the speech detectors in the TASI system. Results of subjective tests carried out to determine maximum permissible loading of TASI circuits during busy hours are also described . . . observations indicate that TASI is a more satisfactory method of increasing transatlantic cable capacity than alternate methods, such as the use of 2-kc channel banks.

ERROR PROBABILITIES FOR ADAPTIVE MULTICHANNEL RECEPTION OF BINARY SIGNALS
R. Price, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 305/316, 18 refs.

. . . two slightly different forms of an adaptive receiver . . . Each channel has a

non-dispersive non-fading propagation path and additive white gaussian noise that is independent of, and equal in intensity to, the other channel noises. Either phase-independent orthogonal signaling (such as FSK) or phase-reversal-comparison signaling is employed to convey to the receiver both the message and information about the path strengths and phases. The receiver measures the path parameters and applies the results to the detection processing as though they were perfectly accurate . . . The distribution of the received signaling energy among the channels is immaterial. . . .

ADAPTIVE COMMUNICATION FILTERING
C.S. Weaver, IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. 169/178.

. . . It is assumed that either the noise or the signal is completely unknown and only the spectrum or autocorrelation function of the other is known. It is desired to filter according to a mean-square error criteria. . . . filters . . . may be realized physically by the use of tapped delay lines, or they may be constructed as part of a digital computer program. On the computer they are capable of real-time filtering of many types of signals. Measurements taken of signal and noise give the information needed to adjust — in a straightforward manner — the filter parameters. . . .

BEAM TAGGING DIVERSITY
R.T. Adams, IEEE Internat. Conv. Rec., Pt. 8, vol. 11, March 1963, p. 233.

Abstract only . . . Diversity combining is normally regarded as part of the receiving process. If the individual transmitted signals are suitably tagged, however, combining can be performed in the transmission medium. The composite signal is analyzed at the receiver to obtain phase-control information, which is relayed to the transmitting site for controlling the individual signals.
When used to combine a set of transmitted signals in space diversity, beam-tagging yields an advantage equivalent to the array-gain of the set of transmitting antennas. . . .

O POMEKHOZASHCHISHCHENNOSTI SIGNALOV AMPLITUDNOI MANIPULIATSII PRI ZAMIRANIAKH (Concerning the Noiseproof Characteristics of Amplitude-Manipulated Signals, in the Presence of Fading) (In Russian)
M.F. Bakhareva, et al., Radioteknika i Elektronika, vol. 8, April 1963, p. 539/545, A63-19873.

Discussion of the noiseproof features of binary-code signals transmitted by the method of amplitude "manipulation" with fading present. It is assumed that the limit level of the transmitter decoding unit is not constant but that it "traces" the SNR according to the law of optimum control. Noiseproof characteristics, averaged over the Rayleigh fading are calculated as a function of SNR, with allowance for the law of optimum control.

FUNDAMENTAL ACCURACY LIMITATIONS FOR PILOT-TONE TIME-BASE CORRECTION
J.A. Develet, Jr., Aerospace Corp., Los Angeles, Calif., Rept. no. TDR269 9990 3, 10 Feb. 1964, 14 p., AD 430 464.

Wiener filtering concepts are applied . . . addition of a stable sinusoid in a clear area of the signal baseband. After transmission through a medium with varying time delay and additive noise, the pilot tone is recovered by a tracking filter, the output of the tracking filter can be used to estimate the variations in time delay of the transmission medium. . . . theory of parameter estimation . . .

MESURE PERMANENTE DU FACTEUR DE BRUIT D'UN EMETTEUR RECEPTEUR RADAR EN FONCTIONNEMENT (Permenent Measurement of the Noise Figure of a Radar Transmitter-Receiver in Operation (In French)
B. Gouars, Annales de Radioelectricite, vol. 18, July 1963, p. 238/247, A64-12376

Description of a device for the continuous measurement of noise figure in a radar transmitter-receiver in actual operation . . . A description of the operation of the various circuits which make up the Noise Figure Meter F.B. 340 is provided. . . .

OPTIMUM PERFORMANCE OF SELF-ADAPTIVE SYSTEMS OPERATING THROUGH A RAYLEIGH-FADING MEDIUM
J.C. Hancock, et al., IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 443/453, 19 refs.

. . . problem of communicating through the Rayleigh-Fading-Multipath channel with additive noise. The a posteriori probabilities necessary for specifying different receiver modes for various forms of a priori channel knowledge are derived. System performance is analyzed and computed for several modes of operation and the results presented in graphical form, allowing one to determine the importance of making measurements on the unknown channel state. . . .

ADAPTIVE RECEPTION OF SIGNALS WITH UNKNOWN GAIN AND DELAY
J.C. Hancock, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 54/65.

Assuming unknown channel gain and unknown channel delay we derive a set of delay estimators . . . The estimating filter output is the true path delay plus a noise term that is Gaussian when the additive channel noise is Gaussian. . . . Any of these delay estimators can be incorporated into an adaptive M-ary

receiver which uses the noisy estimates in a manner that would be optimum if the measurements were precise. . . .

ON THE USEFULNESS OF SIGNAL DESIGN TECHNIQUES IN ADAPTIVE TELEMETRY LINKS
J.C. Hancock, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 322/327.

. . . Applying signal design concepts to eliminate intersymbol interference in a communication channel entails a-priori knowledge of the impulse response of the channel, and this in itself is a major task for most time varying links. . . .

TIME-VARIANT COMMUNICATIONS CHANNELS
T. Kailath, Stanford Electronics Labs., Stanford Univ., Calif., Rept. nos. SEL 63 106, TR 7050 1, Aug. 1963, 19 p., AD 420 482.

. . . broken down into five areas — methods of channel representation, methods for measuring the instantaneous and average behavior of the channel, the derivation of suitable receiver structures for communication over such channels, the evaluation of the performance of such receivers, and studies of signal selection and coding techniques to increase the speed and reliability of communication.

ADAPTIVE TECHNIQUES FOR THE OPTIMIZATION OF BINARY DETECTION SYSTEMS
H.J. Kushner, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 107/117.

. . . for the problem of the experimental optimization of maximum signal-to-noise ratio binary detectors which operate in a partially unknown environment. Two approaches are taken and compared in detail. The first involves the use of statistical estimates of the unknown quantities that are obtained by the appropriate averaging operations. The second, and more interesting, approach makes use of the methods of stochastic approximation to develop a convergent iterative process on the parameters of the adaptive filter. The iterates converge to the optimum values in mean square and with probability one. . . .

ESTIMATION OF A SYSTEM PULSE TRANSFER FUNCTION IN THE PRESENCE OF NOISE
M.J. Levin, Lincoln Lab., Mass. Inst. of Tech., Lexington, 1963, 7 p., AD 411 832.

. . . Some adaptive control systems carry out measurements of plant parameters during normal operation. In communication systems an analogous situation arises in the utilization of time-varying channels (1). Often the application of a special test signal is undesirable so the information must be obtained from ordinary input output data. The presence of random noise and instrumentation errors can render many measurment schemes ineffective. Statistical estimation theory provides powerful methods for dealing with this type of problem. Some of these methods are applied to the estimation of the pulse transfer function of a linear system.

USTROISTVO SLEDIASHCHEE ZA OTNOSHENIEM SIGNAL/SHUM (A System Based on the Signal-to-Noise Ratio) (In Russian)
G.I. Levitan, et al., Elektrosviaz', vol. 18, March 1964, p. 5/16, 6 refs., A64-17641.

. . . methods for constructing systems whose output voltage is determined by the ratio of signal to the fluctuating noise at the input. Two types of such systems are described in detail. The basic theoretical prerequisities are considered, together with the results of experimental investigations conducted for the case of a frequency-manipulated signal. Some recommendations are presented for the construction of the system's circuits.

ADAPTIVE DIGITAL COMMUNICATION FOR A SLOWLY VARYING CHANNEL
G. Lieberman, IEEE Trans. Commun. Electronics, no. 65, March 1963, p. 44/51.

. . . The adaptation is accomplished by providing the receiver with the capability of measuring signal-to-noise ratio, and controlling the transmitted signal energy by means of a feedback loop. . . .

ON THE EFFECTIVENESS OF RECEPTORS IN RECOGNITION SYSTEMS
T. Marill, et al., IEEE Trans. Inform. Th., vol. IT-9, no. 1, Jan. 1963, p. 11/17, 22 refs.

. . . the physical sample to be recognized is first subjected to a battery of tests; on the basis of the test results, the sample is then assigned to one of a number of prespecified categories.
The theory of how test results should be combined to yield an optimal assignment has been discussed in an earlier paper. Here, attention is focused on the tests themselves . . .

PILOT WAVEFORM INSERTION IN TELEVISION SIGNALS
J.B. Potter, Proc. Instn. Radio Engrs., Australia, vol. 24, no. 9, Sept. 1963, p. 685/690.

The provision of pilot-type monitoring and control facilities in television systems by the use of continuous test signal insertion in television signals is discussed with regard to the benefit to be obtained, the equipment required and the possibility of future extensions to the presently available facilities. Recommendations as to the test waveforms to be used and their application in television systems are also made. . . . in the installation of any point-to-point

communication system . . . equipment to provide continuous monitoring of system performance in the presence of traffic. . . .

FERRIELECTRICS AND THEIR APPLICATION IN SOLID-STATE DEVICES AS AN ADAPTIVE CONTROL
C. F. Pulvari, IEEE Trans. Mil. Electronics, vol. MIL-7, no. 2/3, April/July 1963, p. 254/260.

. . . A new device which operates similar to the transfluxor and represents an electrostatically controlled circuit impedance with stored settings will be discussed. This device called the "transpolarizer" represents one of the most interesting recent achievements in the semiconductor field. . . . by the application of a control signal, it can be changed from a ferroelectric capacitor into a linear capacitor and can assume any intermediate polarization level between these two limits . . . Now, for the first time, it is possible to utilize the combination of electrically controlled resistance, inductance and capacitance in circuit design. . . . extremely useful in the fields of pattern recognition, trianable computers and adaptive control. . . .

ERROR-CONTROL CODING IN DIGITAL TELEMETRY SYSTEMS
L.D. Rudolph, et al., Proc. Nat. Telem. Conf., no. 10-4, May 1963.

. . . provide error rate monitoring for closed-loop adaptive operation or to give an indication of confidence in the incoming data. . . .

TRANSMITTED-REFERENCE TECHNIQUES FOR RANDOM OR UNKNOWN CHANNELS
C.K. Rushforth, IEEE Trans. Inform. Th., vol. IT-10, no. 1, Jan. 1963, p. 39/42.

. . . A particular set of signals is chosen, each member of which is partitioned into a known reference or sounding signal and a message signal. The channel is assumed to be linear, and is divided into a multiplicative and an additive portion. The multiplicative portion is assumed to have the same response to both message and reference components, while the additive noises associated with these components are assumed to be independent. The channel outputs and the additive noises are further assumed to be Gaussian. . . .

ADAPTIVE COMMUNICATION WITH SOUNDING SIGNALS IN RANDOM CHANNELS
C.K. Rushforth, IEEE Internat. Conv. Rec. Pt. 4, vol. 11, March 1963, p. 102/106.

. . . describes a communication system which utilizes a sequence of reference or sounding signals to adapt itself to a random linear channel. A particular set of signals is considered, each of which is partitioned into a reference or sounding signal and a message signal . . .

INFORMATION PATTERN, LEARNING STRUCTURE, AND OPTIMAL DECISION RULE
M. Sakaguchi, Inform. Control, vol. 6, no. 3, Sept. 1963, p. 218/229.

In Section I various types of information structures in individual decision-making under uncertainty are discussed. A quantity which measures the value of information structure is proposed. . . .

THE ANALYSIS OF MULTIPLE SIGNAL DATA
J.W. Smith, IEEE Trans. Inform. Th., vol. IT-10, no. 3, July 1964, p. 208/214.

This paper discusses the automatic processing of data containing multiple signals. In particular, filters which modify their structures in order to recognize initially unknown waveforms in Gaussian noise and an unknown signal environment are investigate experimentally. . . . The results demonstrate the possibility of using filters of the new type for automatically processing data although the relevant waveforms may be unknown a priori. . . . Problems which fit into the broad category described are: 1) Radar detection in a multiple emitter environment; 2) Multiple signal communications systems such as hand-sent Morse code; 3) Medical or reconnaissance data.

REPRODUCING DISTRIBUTIONS FOR MACHINE LEARNING
J.D. Spragins, Jr., Stanford Electronics Labs., Stanford U., Calif., Technical rept. no. 6103 7; 63 099, Nov. 1963, 102 p., AD 431 994.

A model is proposed for learning the nature and value of an unknown parameter, or unknown parameters, in a probability distribution which forms part of a body of statistics related to some system or process. . . . The learning process . . . is shown to be technically feasible if the a priori and a posteriori distributions are of the same form with the learning accomplished by calculating new parameters for these distributions. . . .

Related Publications:

AN INTERSYMBOL ADJUSTMENT METHOD OF DISTORTION COMPENSATION
E.D. Gibson, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 5, June 1961, p. 196/207.

This paper describes a device capable of simultaneously compensating for both amplitude and delay distortion. Within wide limits, any amplitude-versus-frequency curve and any differential-delay-versus-frequency curve can be obtained simultaneously from this device, called the ISIC (Intersymbol Interference

Corrector) is well suited for use as an equalizer of digital or analog transmission systems, a highly adjustable filter, or a laboratory instrument. The ISIC is continuously and easily adjustable, stable and reliable. . . .

ADAPTIVE SYSTEM IDENTIFICATION BY STATE VARIABLE OPERATIONS
H.M. Estes, Proc. Nat. Electronics Conf., vol. 18, Oct. 1962, p. 19/27.

A new method is established for the measurement of changes in response characteristics of a class of linear systems due to the effects of time and environment. The basis of the method lies in the fact that any state variable of the system may be related to some reference state vector of the system by a proper linear transformation. This transformation will, in general, be a function of the parameters chosen to describe the response characteristics of the system.
. . . Writing the transformation equations relating these quantities yields a set of nonlinear equations whose solutions are the desired values of the system response parameters . . .

AN IMPULSE NOISE CANCELLER (Correspondence)
W.L. Black, IEEE Trans. Commun. Syst., vol. CS-11, no. 4, Dec. 1963, p. 506.

. . . If the pulses occur infrequently and are sufficiently narrow, the disturbance they produce is one of two spectrally adjacent channels can be used to cancel the disturbance they produce in the other. The system described . . . was designed to perform this cancellation, was built, and was tested. . . .

INFORMATION CAPACITY OF FADING CHANNELS UNDER CONDITIONS OF INTENSE INTERFERENCE
J.P. Costas, Proc. IEEE, vol. 51, no. 3, March 1963, p. 451/461.

. . . such systems must receive and process two distinct types of information. The first, and quite obvious, type of information concerns the intelligence signal which is provided as an output from the receiving terminal of the system. The second, and much less obvious, type of information concerns medium variations. . . . This paper is concerned with the limiting case of very small channel SNR's that are below the level required for analysis of the medium at the receiver. . . . The mathematical approach used is sufficiently general to permit inclusion of random system variations (such as oscillator phase) as part of the medium variations and hence the results are believed to be applicable to a wide variety of communication situations including deep-space probe telemetry.

SELECTION AND RANKING PROCEDURES AND ORDER STATISTICS FOR THE BINOMIAL DISTRIBUTION
S.S. Gupta, Applied Mathematics & Statistics Labs., Stanford Univ., Calif., Technical rept. no. 68, 24 Sept. 1963, 115 p., AD 421 011.

Some work on selection and ranking procedures for binomial populations are described. . . . Order statistics from the binomial distribution are discussed and some new tables of moments and cumulative distribution function of these order statistics are described.

AUTOMATIC PICTURE DETAIL DETECTION IN THE PRESENCE OF RANDOM NOISE
M.H. Kubba, Proc. IEEE, vol. 51, no. 11, Nov. 1963, p. 1518/1523.

. . . intended to be a companion to the paper in this issue by Cherry, et al., entitled, "An Experimental Study of the Possible Bandwidth Compression of Visual Image Signals". . . . concerns particularly that part of the visual signal compression process carried out by the "picture detail detector". The purpose of this detector is to make a continuous running examination of a scanned video signal, in real time and to make successive decisions concerning the location of essential sample points. These points are the boundaries between successive step functions which adequately represent a reduced form of the picture suitable for encoding in a compression scheme. . . .

ADAPTIVE MINIMUM MSE ESTIMATION (Correspondence)
D.T. Magill, IEEE Trans. Inform. Th., vol. IT-9, no. 4, Oct. 1963, p. 289.

. . . to show how minimum mean-square-error (MSE) estimates may be calculated when the parameter(s) describing the quantity being estimated are initially unknown and must be learned with time. . . .

2.946: Ionospheric Sounding Techniques

Included: Oblique incidence ionospheric sounder; CURTS = commom user radio transmission sounding system; Portable ionosonde; Multipath structure sensing systems; Frequency sounding techniques; FM backscatter sounding; Ionospheric ray tracing; Polarization tracing equipment; Polarimeters.

Not Included: Ionospheric propagation characteristics; Statistical characteristics of HF communications channels (1); Characteristics of scatter communications links (1); Interference caused by ionospheric sounders.

Cross References: Statistical sensing techniques for adaptive communications (2.940); Polarization programming methods (2.955).

Principal Publications:

DOWNCOMING RADIO WAVES
J.R. Wait, Electronic and Radio Engineer, vol. 36, March 1959, p. 106/107.

. . . to outline a scheme for measuring the angle of arrival, azimuth, and polarization of a downcoming radio wave. Despite the existence of extensive literature 1,2,3,4,5 on the subject of polarization errors in direction finders and related subjects, there does not seem to have been a method available for analyzing the characteristics of an arbitrary downcoming plane wave from measurements made on the ground.

FM BACKSCATTER SOUNDING AS A MEANS FOR MONITORING PROPAGATION CONDITIONS DURING SHORT-WAVE BROADCASTS
R.B. Fenwick, et al., IRE Internat. Conc. Rec., Pt. 1, vol. 10, no. 1, March 1962, p. 136/144.

. . . Employment of megawatt power levels in shortwave broadcasting, the declining sunspot cycle, and the growing number of broadcasters competing fro spectrum space make it increasingly desirable for transmitter personnel to know when unusually low MUF's prevent a given broadcast from reaching its destination. . . . Backscatter sounding is known to be a satisfactory means for determining propagation conditions along the transmission path, but owing to the practical problems of integrating such sounding into broadcasting operations, has not been appreciably used as yet. It is shown that application of the FM ranging principle to backscatter sounding is feasible, permitting the broadcasting carrier itself to be used for sounding purposes without disturbance to transmitter operating conditions or appreciable annoyance to the distant listener. . . .

SYSTEM CONCEPTS FOR A COMMON-USER RADIO TRANSMISSION SOUNDING SYSTEM (CURTS)
R.G. Gould, et al., Stanford Research Inst., Menlo Park, Calif., Final rept., Oct. 1962, 241 p., incl. illus. tables, 12 refs., AD 288 102.

A Common-User Radio Transmission Sounding System (CURTS) is studied. It is demonstrated that oblique ionospheric sounders can find usable frequencies during periods of a disturbed ionosphere and that usable frequencies can be predicted with high accuracy for periods of a quarter of an hour or more during times of average magnetic activity. . . . A systems operational concept for use of sounders is described and analyzed. . . . Problems that have arisen during field tests are discussed . . .

MULTIPATH AND SCATTERED COMMUNICATION TECHNIQUES
D.P. Harris, Lockheed Aircraft Corp., Sunnyvale, Calif., Tech. rept. on Flight Sciences, rept. no. 6-90-62-42, May 1962, 10 p., incl. illus., 16 refs., AD 275 343.

. . . The performance characteristics of a class of incoherent communication techniques that required no channel-sounding provisions are considered. . . .

FREQUENCY SOUNDING TECHNIQUES FOR HF COMMUNICATIONS OVER AURORAL ZONE PATHS
G.W. Jull, et al., Proc. IRE, vol. 50, no. 7, July 1962, p. 1676/1682.

. . . evidence that systematic oblique incidence channel sampling transmissions are valuable for improving the reliability of air-ground HF communications when propagation conditions are marginal . . . results from air-ground radio communications trials supplemented by frequency sounding transmissions over flight paths of up to 1260 nautical miles into auroral zone latitudes from a ground station in Nova Scotia. . . .

LOW-NOISE RECEIVER FOR AN IONOSPHERIC STATION (Translation)
I.V. Markov, et al., Geomagnetism and Aeronomy, vol. 2, no. 3, 1962, p. 454/457, A64-13110.

Description of the design of an improved receiver for a panoramic ionospheric station, developed at the Bonch-Bruevich Leningrad Electrotechnical Institute of Communication. The basic circuit of the low-noise receiver consists of input filters, a conversion cascade circuit, a new type of braod-band transformer, a tube selection unit, and a lumped-selection filter . . . Its actual sensitivity proved to be better than 1 μv at a noise/signal ratio of 3 . . . The dynamic range of the receiver was 56 db. . . . Use of the receiver for more than two years at Voyeykovo showed that sporadic layers are observed 80% of the operating time, in contrast to other stations, also located in the Leningrad region. . . .

SOME PRELIMINARY RESULTS FROM AN OBLIQUE INCIDENCE STEP SOUNDER LINK
W.R. Vincent, et al., Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 1, Feb. 1962, p. 280.

Since July 1961 . . . duplex Philips oblique sounder system between Palo Atlo, California and Fort Monmouth, New Jersey. The path is being used to study HF propagation as it applies to communication systems. . . .

EXPLORATORY PROGRAMMING STUDIES FOR IONOSPHERIC RAY TRACING
Electronic Associates, Inc., Princeton, N.J., Final rept., 8 Oct. 1962, 31 p., AD 412 487.

The development of preliminary analog computer programs for the solution of the two dimensional electromagnetic ray path equations is discussed. . . . Circuit diagrams, typical computer output plots, and the specialized forms of the equations used at low frequencies (5 kc.) and high frequencies (14 meg.) are included.

LOW FREQUENCY SWEEP GROUP HEIGHT AND POLARIZATION RECORDS
J. D. Hardy, Ionosphere Research Lab., Penn. State U., University Park, Scientific rept. no. 179, Rept. for 5 March-22 Aug. 1962 on Ionospheric Research, AFCRL 63-256, 15 Feb. 1963, 220 p., incl. illus., 3 refs., AD 401 184.

. . . covering the . . . range of 100-1000 kc . . . Its purpose is determination of the structure of the lower ionosphere. Included in these data are the preliminary results of a stepped frequency experiment. These appear to be the only such records being obtained in the world at this time.

AN ANALYSIS OF THE INTERFERENCE POTENTIAL OF AN OBLIQUE IONOSPHERIC SOUNDER
H. Kimball, IIT Research Inst., Chicago, Ill., ECAC TDR 63 6; ESD TDR 63 4, Aug. 1963, 28 p., AD 417 357.

. . . effects of potential HF interference which might be produced by an ionospheric sounder operated between Navy communication stations near Washington, D.C. and Honolulu, Hawaii. The sounder uses a transmitter and receiver at each station and emits pulses of differing widths, at varying repetition rates, and with center frequencies distributed at selected points across the 2-32 mc band. The analysis considered interference to telephony, telegraphy, and facsimile, those being the three types of service predominate in that band. . . .

THE USE OF PULSE COMPRESSION IN MULTIPATH MEASUREMENTS
F. M. Lightfoot, et al., Rec. Nat. Commun. Symp., vol. 9, Oct. 1963, p. 319/324.

The determination of multipath interference is frequently important in the optimization of communication system design. Standard sounding techniques are compared with a pulse compression method from the standpoint of path resolution and in the requisite signal-to-noise ratio. . . .

HF COMMUNICATION EFFECTS SIMULATION: INSTRUMENTATION AND OPERATION OF THE FIELD EXPERIMENT
R. A. Shepherd, Stanford Research Inst., Menlo Park, Calif., Interim rept. 3, Dec. 1963, 103 p., AD 434 554.

. . . examined with oblique-incidence ionosphere sounders which collect propagation data between 4 and 64 Mc. . . .

AN IMPROVED LOW FREQUENCY SWEEP POLARIMETER
S. Weisbrod, et al., Ionosphere Research Lab., Penn State U., University Park, Rept. on Ionospheric research, Scientific rept. no. 182, AFCRL 63-290, 1 April 1963, 30 p., incl. illus., 3 refs., AD 401 674.

. . . describes an improved version of a low-frequency polarimeter which is used in conjunction with the low-frequency sweep studies at the Ionospheric Research Laboratory.

PORTABLE IONOSONDE FOR H. F. COMMUNICATION TESTS
J. Brit. Instn. Radio Engrs., vol. 25, no. 5, May 1963, p. 460.

. . . for continuous rapid determination of the optimum wavelength for long range h.f. radio communication has recently been developed by EMI-Cossor Electronics Ltd., Halifax, Nova Scotia. . . .

A VIDEO SIGNAL ENHANCER FOR USE WITH OBLIQUE-INCIDENCE IONOSPHERIC SOUNDERS
D. C. Coll, et al., Defense Research Telecommunications Establishment, (Canada), DRTE 1127, Jan. 1964, 16 p., AD 434 874.

. . . concerned with a post-detection, RC, range gate signal enhancer developed to improve the performance of oblique-incidence, sweep-frequency, ionospheric sounders. The enhancer utilizes the energy available from the multiplicity of sounding pulses that are transmitted on each frequency, together with the coherence of pulse-to-pulse amplitude, to increase the signal-to-noise ratio available to display devices. . . . its performance in the presence of wideband HF interference has been shown to be very good.

Related Publications:

ORBITAL SCATTER CHANNEL PROPAGATION EXPERIMENT
P. R. Drouilhet, et al., Lincoln Lab., Mass. Inst. of Tech., Lexington, Tech. rept. no. 292, ESD TDR 62-280, 21 Dec. 1962, 24 p., 7 refs., AD 401 311.

. . . essential characteristics for channels of this type may be expressed in terms of the channel 'scattering function', which exhibits the average character of the time and Doppler smearing of the medium. . . . can be measured by observing the channel with a coherent bistatic pulsed radar.

A COMMUNICATION ANALYSIS OF HIGH FREQUENCY IONOSPHERIC SCATTERING
G. Einarsson, Research Lab. of Electronics, Mass. Inst. of Tech., Cambridge, Technical rept. no. 400, 15 March 1962, 76 p., AD 416 605.

A communication scheme for random multipath channels is investigated. During predetermined intervals the transmitter sends a sounding signal that the receiver uses to predict the behavior of the channel during the intermediate time when communication is performed. It is assumed that the channel varies slowly, and that the additive noise in the receiver is low. The possibility of representing a multipath channel as a time-variant filter is investigated. A sampling theorem for linear bandpass filters is derived, and the results that can be expected when it is used to represent a single fluctuating path with Doppler shift are discussed.

MULTIPATH AND SCATTER COMMUNICATION TECHNIQUES
D.P. Harris, IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 161, 16 refs.

. . . results of an investigation of random-multipath-and scatter-communication channels and of communication techniques applicable to such channels. The limiting bounds imposed on the performance of adaptive matched-filter receiver techniques by channel-sounding errors are evaluated for a wide range of behavior in practical multipath-channel models. . . .

THE REDUCTION OF LOCAL RADIO INTERFERENCE CAUSED BY H.F. IONOSPHERIC SOUNDING EQUIPMENT
V.A. Harrison, J. Brit. Instn. Radio Engrs., vol. 23, no. 2, Feb. 1962, p. 145/149.

Ionospheric measurements commonly involve the use of high-power pulse-modulated transmission in the h.f. spectrum and can cause severe interference in nearby receivers. The use of short bursts of pulses instead of continuous transmissions has virtually eliminated interference caused during absorption measurements and the use of horizontal, terminated, folded dipoles with other precautions has minimized interference during vertical incidence soundings. . . .

ADAPTIVE COMMUNICATION WITH SOUNDING SIGNALS IN RANDOM CHANNELS
C.K. Rushforth, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 102/106.

. . . describes a communication system which utilizes a sequence of reference or sounding signals to adapt itself to a random linear channel. A particular set of signals is considered, each of which is partitioned into a reference or sounding signal and a message signal . . .

Section 2.95
Special Variable Parameter Techniques

2.952: Adaptive Methods with Variable Transmitter Power

Included: Controlled carrier transmission; Two-way controlled carrier transmissions; Transmitter power control; Transmission programming for energy conversion; Automatic power level control; Variable energy adaptive digital communications.

Not Included: Comparison of various modulation methods (1).

Cross References: Adaptive operations in communications systems (2.930).

Principal Publications:

AUTOMATIC CONTROL OF POWER IN A SCATTER COMMUNICATIONS SYSTEM
G.S. Axelby, et al., Proc. Nat. Symp. Telem., Sept. 1958, no. 6.2, See Also: IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 48/56.

APPLICATION OF AUTOMATIC LEVEL CONTROL IN TROPOSPHERIC SSB COMMUNICATION SYSTEMS
A.J. Vadasz, IRE WESCON Conv. Rec., Sept. 1958, p. 69/75.

BASIC ANALYSIS ON CONTROLLED CARRIER OPERATION OF TROPOSPHERIC SCATTER COMMUNICATION SYSTEMS
L.P. Yeh, IRE Nat. Conv. Rec., Pt. 8, vol. 6, March 1958, p. 261/283.

TRANSMITTER POWER CONTROL IN TWO-WAY COMMUNICATIONS SYSTEM
G.S. Axelby, et al., IRE Trans. Commun. Syst., vol. CS-8, no. 1, March 1960, p. 48/56.

TRANSMISSION PROGRAMMING FOR ENERGY CONSERVATION IN SPACE COMMUNICATIONS
N.S. Potter, IRE Internat. Conv. Rec., Pt. 8, vol. 10, March 1962, p. 132/130.

. . . analytic and quantitative study . . . of the programming of transmitter power output to minimize the energy consumption required to maintain a specified minimal information rate from an astronautical vehicle to a terrestrial receiving system over the trajectory of the former. . . .

SPECTRUM ECONOMY THROUGH CONTROLLED TRANSMITTER POWER LEVELS
A.A. Barrios, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 2, Feb. 1963, no. 3-6.

Abstract Only
. . . based on a mathematical analysis of the radio frequency interference problem and suggests a technique for evaluating spectrum economy when transmitter power emission levels are controlled. . . . a probability of interference model is derived for co-channel and adjacent frequency channel assignments. Interfering transmitters are considered to be distributed in a random fashion within specified constraints. The effects of terrain variations, based on a statistical terrain model are also considered. The results show that a significant savings in spectrum can be achieved through control of transmission levels in a military communications area.

ON THE STABILITY ANALYSIS OF A TWO-WAY CONTROLLED CARRIER TRANSMISSION SYSTEM
N.J. Bershad, Air Force Cambridge Research Labs., Bedford, Mass., Data Sciences Lab., AFCRL-63-586, Dec. 1963, 16 p., refs., AD 428 435, N64-16803.

A mathematical model of a linear controlled-carrier tropospheric communication system is analyzed for tropospheric gain variations with a white-noise power spectral density. The stability of the first moment of the impulse response of the closed-loop control system is determined as a function of the linear controllers and the statistical characteristics of the troposphere.

ADAPTIVE DIGITAL COMMUNICATION FOR A SLOWLY VARYING CHANNEL
G. Lieberman, IEEE Trans. Commun. Electronics, no. 65, March 1963, p. 44/51, 26 refs.
A theoretical analysis of variable-energy adaptive digital communication is given for a slowly-varying channel. The adaptation is accomplished by providing the receiver with the capability of measuring signal-to-noise ratio, and controlling the transmitted signal energy by means of a feedback loop. Theoretical gains achievable with adaptation are calculated in terms of reductions in required mean transmitter ener-energy as a function of a signal-fading parameter for different probabilities of unsatisfactory operation.

SIMULATION EXPERIMENTS IN TWO-WAY CONTROLLED CARRIER TRANSMISSION
R.J. Massa, Air Force Cambridge Research Labs., Bedford, Mass., AFCRL-63-159, May 1963, 49 p., 12 refs., N63-19806.

. . . power reductions due to controlled carrier transmission, and the results of an analog computer simulation demonstrating various as-aspects of controlled carrier operation are cussed. In addition, communication performance improvements in tropospheric scatter systems that may be obtained through the use of controlled carrier are cited, and related to corresponding improvements obtained with diversity and coding.

SIMULATION EXPERIMENTS IN TWO-WAY CONTROLLED CARRIER TRANSMISSION
R.J. Massa, Air Force Cambridge Research Labs., Bedford, Mass., AFCRL 63 159, Rev. Oct. 1963, 45 p., AD 423 708.

. . . power reductions due to controlled carrier transmission . . . results of an analog computer simulation demonstrating various aspects of controlled carrier operation . . . communication performance improvements in tropospheric scatter systems that may be obtained through the use of controlled carrier are cited, and related to corresponding improvements obtained with diversity and coding.

THE REDUCTION OF ENERGY CONSUMPTION IN DEEP SPACE COMMUNICATIONS THROUGH TRANSMITTER PROGRAMMING
N.S. Potter, IRE Trans. Commun. Syst., vol. CS-10, no. 4, Dec. 1962, p. 441/448.

. . . programming of transmitter power output to minimize the energy consumption required to maintain a specified minimal information rate from an astronautical vehicle to a terrestrial receiving system over the trajectory of the vehicle. . . . trajectories . . . include an idealized, rectilinear trajectory, deep-space probe with variable terminal ranges, and solar circular orbits at variable radii in the plane of the ecliptic. . . .

Related Publications:

A NEW APPROACH TO SEQUENTIAL DETECTION IN PHASED ARRAY RADAR SYSTEMS
H.M. Finn, Conf. Proc. Nat. Winter Conv. Mil. Electronics, vol. 2, Feb. 1963, p. 4-3/12, 12 refs.

A new class of radar detection and modes designated as Energy-Variant sequential detection modes has been developed for the detection of both non-fluctuating and fluctuating target types. The transmitted energies and detection thresholds are design degrees of freedom used to accomplish a minimization of the average power required to perform a specified surveillance mission. . . .

USTROISTVO, SLEDIASHCHEE ZA OTNOSHENIEM SIGNAL/SHUM (A System Based on the Signal-to-Noise Ratio) (In Russian)
G.I. Levitan, et al., Elektrosviaz', vol. 18, March 1964, p. 5/16, 6 refs., A64-17641.

. ... methods for constructing systems whose output voltage is determined by the ratio of signal

to the fluctuating noise at the input. Two types of such systems are described in detail. The basic theoretical prerequisites are considered, together with the results of experimental investigations conducted for the case of the frequency-manipulated signal. Some recommendations are presented for the construction of the system's circuits.

2.953: Adaptive Methods with Variable Bandwidth

Included: Variable bandwidth amplifiers; Variable bandwidth FM transmission systems.

Not Included: Frequency modulation methods (1); Spectra of modulated waveforms (1).

Cross References: Detection theory (Div. 2.8); Feedback communications systems (2.920).

Principal Publications:

VARIATION OF BANDWIDTH WITH MODULATION INDEX IN FREQUENCY MODULATION
M.S. Corrington, Proc. IRE, vol. 35, Oct. 1947, p. 1013/1020.

A METHOD OF IMPROVING RECPETION IN FM COMMUNICATIONS
H.D. Hern, et al., IRE WESCON Conv. Rec., no. 8, Aug. 1958, p. 46/52.

. . . proportionally reducing the receiver bandwidth when the input signal level drops toward the level which would normally produce the threshold effect.

VARIABLE BANDWIDTH FM TRANSMISSION SYSTEM
J. Bordogna, et al., Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 310/317.

. . . application . . . in general and in FM tropospheric scatter . . . will significantly reduce interference and fuel consumption by allowing the reduction of required transmitter power while maintaining reliability . . .

CONCEPT OF A VARIABLE—BANDWIDTH MILITARY SATELLITE SYSTEM
H.P. Hutchinson, Nat. Commun. Symp. Rec., vol. 7, Oct. 1961, p. 93/94.

VARIABLE BANDWIDTH FM TRANSMISSION SYSTEM
J.E. Palmer, et al., RCA Defense Electronic Products, Camden, N.J., RADC TR-61-124, 30 April 1961, 143 p., 43 refs., AD 259 090.

An important trend in modern communications is toward adaptation of some parameters of a system in order to improve or optimize system performance. . . . A system is proposed in which data rate would be varied by adjusting the transmitted bandwidth in accordance with the prevailing conditions. . . . Efficient use of the communications channel, especially in systems such as forward propagation tropospheric scatter where the received signal power varies over a wide range. By utilizing the variable bandwidth technique, a constant signal-to noise ratio is maintained at the input of a receiver detector. Detailed investigations are included of several diversity systems, feedback loop stability, effects of errors in measurement and transmission of the control signal, effects of system delay, tape machine design and overall system configuration. Results indicate that addition of the variable bandwidth scheme to present fixed bandwidth systems can offer at least a 12 db improvement in performance. The use of variable bandwidth transmission to compensate for changes in path length, atmospheric attenuation and antenna nonisotropism in satellite communication systems is also discussed.

2.954: Adaptive Methods with Variable Data Format

Included: Statistical error control; Variable rate sampling for adaptive communications; Variable word length PCM; Variable rate communications links; Dual rate transmission methods; Variable length binary encoding.

Not Included: Sampling theories (1); Asynchronous sampling methods (1).

Cross References: Protective coding methods (Div. 2.7); Feedback communications systems (2.920); ARQ procedures (2.926); Asynchronous multiplexing (2.533); SECO system (2.920).

Principal Publications:

APPLICATION OF INFORMATION THEORY TO VARIABLE RATE SCATTER COMMUNICATION
H. Blasbalg, Second National Symposium on Global Comm., St. Petersburg, Fla., Dec. 1958, p. 1/35.

VARIABLE-LENGTH BINARY ENCODINGS
E.N. Gilbert, et al., Bell Syst. Tech. J., vol. 38, no. 4, July 1959, p. 933/967.

. . . of the sort which could be used for the storage or transmission of information. Some of these, such as the prefix and finite delay properties, deal with the time delay with which circuits can be built to decipher the encodings. The self-synchronizing property deals with the ability of the deciphering circuits to get in phase automatically with the enciphering circuits. Exhaustive encodings have the property that all possible sequences of binary digits can occur as messages.

STATISTICAL ERROR CONTROL OF A REALIZABLE BINARY SYMMETRIC CHANNEL
I.S. Reed, Lincoln Lab., Mass. Inst. of Tech., Lexington, Nov. 1959, 13 p., AD 241 453.

. . . It is shown how the statistics of a channel can be measured as the message is being received. A confidence level acceptance or rejection criterion is presented which is based on these measurements. In order to accomplish this aim, a phone line channel is studied. . . . binary symbols are distinguished from one another by 180° phase reversals of a carrier . . . noise . . . occurs in bursts . . . no a priori knowledge of the expected noise power. . . .

OPTIMUM CONTROL THROUGH TUNED SAMPLING
J.T. Tou, Proc. Nat. Electronics Conf., vol. 15, Oct. 1959, p. 290/298.

. . . A sampled-data control system contains one or more samplers which may operate with different sampling rates. The sampling rate may be either constant or variable. It is found that the control system exhibits optimum performance if the variable-rate sampler is properly "tuned." The system stability may be improved by selecting a suitable variable rate for the sampler. It is shown in this paper that when the cyclic-variable sampling rate is varied the stability boundary describes a curve which is concave downward, exhibiting a peak between two limiting values of the cyclic rate. Furthermore, when the system is subjected to a stochastic input, the mean-square error can be reduced to a minimum by "tuning" the variable-rate sampler to an optimum rate. The optimizing feature of tuned sampling may be utilized to achieve self-optimization of control systems.

A PROPOSED VARIABLE DATA RATE COMMUNICATION TECHNIQUE
J.E. Palmer, Proc. Nat. Commun. Symp., vol. 6, Oct. 1960, p. 205/212.

THEORETICAL PERFORMANCE BOUNDS FOR VARIABLE DATA RATE TRANSMISSIONS ON FADING CIRCUITS
J.N. Pierce, Air Force Cambridge Research Labs., Bedford, Mass., AFCRL-959, Nov. 1961, 9 p., AD 269 796.

. . . a means of counteracting adverse effects of fading. Theoretical bounds on attainable improvements are derived as a guideline to more exhaustive studies. It is shown that relatively simple suboptimum systems offer virtually as good performance as the most elaborate system.

STUDY OF ADAPTABLE COMMUNICATIONS SYSTEMS
D. Chesler, Sylvania Electric Products, Inc., Waltham, Mass., Final rept., Rept. no. F-1008-1, RADC TDR 62-314, 14 June 1962, 293 p., incl. illus., tables, refs., AD 286 504.

. . . Optimum thresholds are determined for use in dual-rate transmission over fading channels in conjunction with error-detection coding. . . .

VARIABLE WORD LENGTH PCM IN GROUND STATIONS
R.G. Cumings, Proc. Nat. Telem. Conf., no. 13-5, May 1962.

A NEW DIGITAL MATCHED FILTER COMMUNICATION TECHNIQUE
G.E. Goode, Conf. Proc. Nat. Conv. Mil. Electronics, vol. 6, June 1962, p. 371.

Abstract . . . Operational aspects . . . showing . . . (1) a normal redundancy mode whereby a set of codes is used . . . (2) a maximum redundancy mode in which only one code and its complement are used . . . advantage of a digital matched filter communication system of being resistive to jamming from other similar systems operating on or near the same frequency. . . .

INFORMATION TRANSFER EFFICIENCY OF WIDEBAND COMMUNICATIONS SYSTEMS. PART III. A WIDEBAND ADAPTIVE COMMUNICATION SYSTEM
J.C. Hancock, et al., Purdue U., School of Electrical Engineering, Lafayette, Ind., Final tech. rept., June 1961 - June 1962 on Improved Information Transfer Efficiency of Wideband Systems, ASD TDR 62-611, pt. 3, July 1962, 218 p., incl. illus., 60 refs, AD 284 452.

. . . capable of monitoring the medium through which it must perform while simultaneously transmitting information and continuously adjusting its modes of operation so as to optimize its performance with respect

to a performance criterion chosen a priori. Statistical methods are applied to the adaptive communication problem. Communicating through a random multipath channel with additive noise is considered. . . . A major conclusion taken from these expressions is that the probability of error in no case depends directly on the channel gain, but rather is a function of the total average energy received from all propagation modes.

A NOTE ON LEARNING SIGNAL DETECTION
M. Kac, IRE Trans. Inform. Th., vol. IT-8, no. 2, Feb. 1962, p. 126/128.

. . . This paper considers a threshold detector operating on noisy binary pulses. It is shown that an adaptive error-correction procedure can bring the threshold to the point of equal false alarm and missed detection probabilities.

ERROR PROBABILITIES FOR ADAPTIVE MULTICHANNEL RECEPTION OF BINARY SIGNALS
R. Price, Lincoln Lab., Mass. Inst. of Tech., Lexington, Technical rept. no. 258, AFESD TDR 62-129, 23 July 1962, 58 p., incl. illus., table, 34 refs., AD 284 651.

. . . adaptive receiver that is part of a multichannel communication system over which binary data are conveyed. In the adaptive receiver, noisy measurements are made of presumably nonvarying channel signal strengths and phase shifts. The measurements are then applied to the signal processing in a manner that would be optimum if the measurements were perfect. Signaling in each channel is accomplished by means of a pair of equal-energy waveforms that are orthogonal or opposites, and all channels are affected by mutually independent white Gaussian noises of identical intensities. . . . One major conclusion is that the error probability does not depend directly on the signal strengths or phase shifts in the various channels, but instead is a function of the total average power received over all channels, exclusive of the noise. . . . A by-product of the analysis is the error expression for the special case of nonadaptive multichannel reception of non-orthogonal signals.

THEORETICAL INVESTIGATION OF DUAL RATE TRANSMISSIONS OVER GAUSSIAN MILTIPLICATIVE CIRCUITS
Sylvania Electric Products, Inc., Waltham, Mass., Final rept., Rept. no. F-1004-1, AFCRL-62-198, 12 April 1962, 127 p., incl. illus., tables, 12 refs., AD 278 139.

The simplest form of a variable data rate communication system, an on-off system, which in the ideal case has been shown to be almost as good as the continuously variable rate system is detailed. The effects of Rayleigh fading and additive Gaussian noise in both the forward and feedback channels are studied.

COMPARISON OF SIGNALLING EFFICIENCY IN WIDEBAND COMMUNICATION SYSTEMS
J.W.F. Ye, Mitre Corp., Bedford, Mass., Rept. no. TM3851, ESD TDR63 437, Oct. 1963, 15 p., AD 422 599.

. . . comparing the system performance improvement in a coded correlation communication system under heavy jamming environment for the following forms of message encoder and decoder: (1) simple reduction of the transmission rate, (2) simple reduction of the same symbol, and (3) application of error-correcting codes. The error-correcting codes were found to perform uniformly better than the other two schemes. . . . .

Related Publications:

ADAPTIVE TELEMETRY FORMAT GENERATOR
R.E. Gottfried, et al., Proc. Nat. Telem. Conf., vol. 2, no. 10-1, May 1962.

. . . The great utility of time multiplexed formats for use in telemetry, communications, and data processing has been well established over the years. . . . The majority of telemetry formats . . . are fixed according to some prearranged sampling plan. . . . This practice has often resulted in great transmission inefficiency . . . excessive sampling results in redundance. . . . This paper describes a format generation technique which is believed to have great simplicity in terms of implementation and operational usage. The device which results can be controlled by command or self-adaptive means. . . .

SECO: A SELF-REGULATING ERROR CORRECTING CODER-DECODER
K.E. Perry, et al., IRE Trans. Inform. Th., vol. IT-8, no. 5, Sept. 1962, p. S128/135.

SECO is an efficient engineering realization of a coding-decoding scheme designed to use variable redundancy and feedback in a two-way communication system to increase the rate of information transfer between users connected by a channel having a slowly time-varying capacity. . . . The decoding computer is designed to detect channel errors with very high probability and to correct as many of these as it can, subject to the current channel condition and decoder state. When a detected error cannot be corrected easily, the decoder stops and uses the feedback channel to request retransmission at a lower information rate. . . .

ON THE CHOICE OF BINARY CODES AND THRESHOLDS (Correspondence)
C.V. Freiman, Proc. IEEE, vol. 51, no. 3, March 1963, p. 478.

. . . example illustrates the fact that, when designing error-correcting codes for memoryless binary channels with controllabel decision thresholds, best performance is not always realized by choosing the threshold which maximizes channel capacity. . . .

RETRANSMISSION ERROR CONTROL
T.G. Kuhn, IEEE Trans. Commun. Syst., vol. CS-11, no. 2, June 1963, p. 186/201.

. . . discusses . . . the use of vertical and horizontal block parity checks. . . . provides a level of error rate performance which is far better than that which can be expected from the equipment into which it must operate. For instance, for a random bit error probability of 10^{-4}, a 22 x 22 bit block yields an output error rate of $4.4(10)^{-14}$, with an efficiency of 87 per cent. . . . An analysis is presented which determines the parameters for optimum performance for both random and bunched errors. . . . .

ADAPTIVE TECHNIQUES FOR THE OPTIMIZATION OF BINARY DETECTION SYSTEMS
H.J. Kushner, IEEE Internat. Conv. Rec., Pt. 4, vol. 11, March 1963, p. 107/117.

. . . for the problem of the experimental optimization of maximum signal-to-noise ratio binary detectors which operate in a partially unknown environment. Two approaches are taken and compared in detail. The first involves the use of statistical estimates of the unknown quantities that are obtained by the appropriate averaging operations. The second, and more interesting, approach makes use of the methods of stochastic approximation to develop a convergent iterative process on the parameters of the adaptive filter. The iterates converge to the optimum values in mean square and with probability one. . . .

ASYMPTOTIC PERFORMANCE CHARACTERISTICS FOR MULTIRECEIVER COMMUNICATIONS THROUGH THE RICIAN MULTICHANNEL
W.C. Lindsey, Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, JPL-TR-32-400, April 30, 1963, 21 p., 19 refs., N63-18387.

Ideal . . . characteristics . . . for the coherent adaptive multireceiver and the noncoherent multireceiver. The transmitter for the system selects for transmission one of two equiprobable, equal-energy correlated waveforms. The selected waveform is transmitted into the Rician fading multichannel with additive gaussian noise superposed at the receiver end. The multichannel may take on one of four forms, i.e., it may change from one of a completely random nature to that of a completely fixed nature.

2.955: Adaptive Methods with Variable Signal Waveforms

Included: Polarization programming methods; Adaptive signal design techniques; Function modeling experiments.

Not Included: Signal theory (1); Data systems with orthogonal waveforms (1); Higher order alphabet systems (1).

Cross References: Polarization tracing equipment (2.946).

Principal Publications:

STUDY AND INVESTIGATION OF POLARIZATION PROGRAMMING. VOLUME II: POLARIZATION SYSTEMS ANALYSIS
R.S. Berkowitz, et al., Pennsylvania U., Philadelphia Moore School of Electrical Engineering, Griffiss AFB, N.Y., RADC, Moore School Rept. 64-02, RADC-TDR-63-396, Vol. 2., Jan. 1964, 72 p., refs., AD 430 249, N64-15818.

The choice of frequency range based upon preservation of polarization is discussed . . . factors that can lead to depolarization at higher frequencies are mentioned . . . polarization effects that take place in propagation via the ionosphere, with some emphasis on future applications to satellite communication. The troposcatter propagation factors affecting a polarization programing system are presented. A general mathematical description of polarized waves of all types and of their transmission channel is given . . . antenna considerations. It is concluded that the application of polarization programing to an over-the-horizon troposcatter link seems to be feasible, and that with all factors considered it should lie in the range of 1 to 10 kmc.

FUNCTION MODELING EXPERIMENTS
R.O. Duda, et al., Stanford Research Inst., Menlo Park, Calif., Technical rept., Dec. 1963, 67 p., AD 427 018.

. . . capabilities and the limitations of trainable machines for use in function modeling . . . In the simpler experiments the data used for training were noise-free . . . In the prediction experiments, random fluctuations in the data limited performance . . . Viewed as a statistical procedure, this technique is essentially a non-parametric procedure that can be efficiently performed by a special purpose computer of the type currently being constructed for pattern recognition problems.

ON THE USEFULNESS OF SIGNAL DESIGN TECHNIQUES IN ADAPTIVE TELEMETRY LINKS
J.C. Hancock, et al., Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 322/327.

. . . The usefulness of signal design techniques in adaptive communication systems is investigated with primary emphasis on the intersymbol interference problem. . . . Comparisons are made between systems which have been designed to have no intersymbol interference and those which simply use "guard" spaces as protection . . . Applying signal design concepts to eliminate intersymbol interference in a communication channel entails a-priori knowledge of the impulse response of the channel, and this in itself is a major task for most time varying links. . . . we first investigate the advantages of signal design techniques if this a-priori information is known. . . .

THE DETECTION OF MULTIPLE UNKNOWN SIGNALS BY ADAPTIVE FILTERS
J.W. Smith, Carlyle Barton Lab., Johns Hopkins U., Baltimore, Md., May 1963, 133 p., AD 405 629.

Filters which modify their structure in order to recognize initially unknown waveforms in Gaussian noise are investigated experimentally. . . . two types previously described in the literature and one new type . . . The new structure processes the data in a nonlinear fashion and effectively sets up a narrow decision region about the estimate of the waveform. Results are given in the form of learning curves which show the effects of correct and incorrect decisions.

Related Publications:

DERIVATION OF A MULTIPLE OF A VARIABLE FREQUENCY (In French)
V. Gavreau, et al., C.R. Acad. Sci., vol. 249, no. 20, Nov. 1959, p. 2026/2028.

A MAGNETIC VARIABLE GAIN COMPONENT FOR ADAPTIVE NETWORKS
H.S. Crafts, Stanford Electronics Labs., Stanford U., Calif., Rept. no. SEL-62-147, Technical Rept., no. 1851-2, ASD TDR 62-1011, Dec. 1962, 64 p., incl. illus., AD 299 836.

A new magnetic variable-gain component for adaptive logic circuits is described. . . . consists of a pair of tapewound cores which are driven from an RF power source.

. . . An adaline adaptive pattern classifier with 16 inputs was constructed using the second-harmonic magnetic variable-gain components for the variable weights . . .

LEARNING MATRICES FOR BINARY AND NON-BINARY SIGNALS
K. Steinbuch, In: 1st International Symposium on Optimizing and Adaptive Control, Proceedings, Pittsburgh, Pa., Instrument Society of America, International Headquarters, 1963, p. 69/87, A63-21793.

Derivation of an organic circuit principles for the simulation of organic learning processes. Basically two types of circuits are discussed, those for which binary and those for which non-binary patterns are to be processed; learning matrices (a matrix which determines the most similar pattern to a given set of events which is a maximum likelihood detection) for each of these cases are discussed . . .

Section 2.98
Special Applications

2.980: Special Applications of Controlled Communications Techniques

Included: LOGICOM (a digital communications system); Integrated error-free communications system; Matched traffic communications system.

Not Included: Adaptive problems in large communications networks.

Cross References: Error-free communications links with ARQ procedures (2.926).

Principal Publications:

LOGICOM: A DIGITAL COMMUNICATION SYSTEM
D.C. Coll, Defense Research Telecommunications Establishment (Canada), DRTE rept. no. 1055, Feb. 1961, AD 254 313.

. . . was used as a demonstration of: information source coding, error detection and correction through use of redundant coding for transmission, burst transmission, and visual display of received message. LOGICOM was constructed with the use of logic modules.

THE ECONOMICAL DESIGN OF RADIO COMMUNICATION SYSTEMS BY MATCHING THE MESSAGE URGENCY TO THE FADING CONDITIONS
L.P. Yeh, IRE Trans. Commun. Syst., vol. CS-9, no. 3, Sept. 1961, p. 288/291.

A matched-traffic technique is proposed to control the hourly traffic volume so that the capacity of the system is designed only to carry the urgent messages that require immediate transmission at the desired reliability.

AN INTEGRATED "ERROR-FREE" COMMUNICATION SYSTEM
J. C. Hansen, IEEE Trans. Space Electronics Telemetry, vol. SET-9, no. 3, Sept. 1963, p. 92/98.

. . . a system is proposed which combines the functions of command, synchronization, range, and range rate on the two-way radio link. Extreme reliability of information transfer is achieved by employing "comma-free" words which have been coded for error detection. . . . The coding is such that synchronization obtains the same high degree of reliability as the information. . . . the system offers relative ease of implementation common to the class of cyclic codes. . . .

Related Publications:

ANALYSIS OF COHERENT TWO-WAY DOPPLER COMMUNICATION SYSTEM
JPL Res. Summ., vol 1 , no. 32-2, Feb./March, 1960, p. 23/26.

. . . consisting of a ground transmitter, a spacecraft transponder, and a ground receiver . . . Independent noises are assumed to enter both receivers (spacecraft and ground) simultaneously. The effects on the threshold sensitivity of the ground receiver and the measurement of two-way doppler phase are calculated as a function of the noise entering the vehicle spacecraft and the spacecraft receiver bandwidth. . . .

THE MARINER (VENUS 1962) FLIGHT TELECOMMUNICATIONS SYSTEM
J. N. Bryden, Proc. Internat. Telem. Conf., vol. 1, Sept. 1963, p. 498/508.

. . . provided 2-way doppler, automatic angle tracking, command, and telemetry functions. Two-way doppler is achieved by the spacecraft transponder receiver, which receives at a frequency of 89- Mc and, when in lock, transmits the telemetry carrier signal at exactly 96/89ths of this frequency giving a transmitted frequency of 960 Mc. . . . The command and telemetry systems make use of identical modulation and detection methods. Each employs two subcarriers, related in frequency by a ratio of 2/1. The data subcarrier frequency is biphase modulated according to the state of the binary data information, and the synchronization subcarrier is biphase modulated by cyclic pseudo-random code. . . .

SUBJECT INDEX

The terms in the following index were taken directly from the subject contents of the individual subdivisions in the volume. The terms listed under "Included," as well as selected section and subdivision titles, were considered for inclusion in the index.

Multi-noun terms are presented in two ways: 1) the full term is listed in alphabetical order of the first noun, e.g., "aliasing error"; and 2) the full expressions are permuted or separated so as to provide multiple listings of a single expression, e.g., "error, aliasing". General usage of the technical terms is followed in the permuting process; combinations of words which fail to make technical sense are not included.

In instances where a particular term is not located in the index, the user should refer to the table of contents. When used in conjunction, the table of contents and index will enable the user to locate the proper section or subdivision and, in turn, the pertinent citations.

As a general rule, if a proper name, e.g., Fourier, identifies a theory, process, etc., the name has been included in the index. Words and expressions that denote general concepts, e.g., systems, problems, technologies and techniques, methods, etc., have not been included in the index.

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