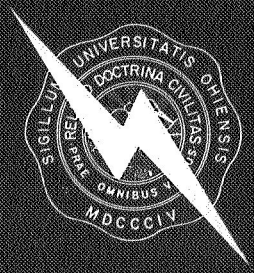
ELECTRICAL ENGINEERING RESEARCH

FINAL TECHNICAL REPORT

ACTIVE FUNCTION SYNTHESIS UTILIZING MODELING AND SCALING PROCEDURES

EER-10-25 September 30, 1969



Ohio University ATHENS
RESEARCH INSTITUTE

FINAL TECHNICAL REPORT

on

ACTIVE FUNCTION SYNTHESIS UTILIZING MODELING AND SCALING PROCEDURES

TECHNICAL REPORT NO. EER-10-25

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Author	Wai-Kai Chen, Principal Investigator Associate Professor Department of Electrical Engineering Ohio University Athens, Ohio 45701
Monitor	Dr. W. W. Happ, Chief Automated Techniques Branch Electronics Research Center Cambridge, Massachusetts 02139

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1. Summary

The objective of the investigation is to increase the usefulness and effectiveness in applying dimensional analysis to modeling and scaling procedures used by aerospace and electronics engineers.

The principal purpose of dimensional analysis from the engineering point of view is the arrangement of the variables of a physical relation so that, without destroying the generality of the relationship, it may be more easily determined experimentally. The method is particularly valuable when the number of variables is very large. Thus, the complexity and extent of an experiment may be greatly simplified by this approach.

In order to avoid undesired duplication of effort and to serve as an aid to others who may engage in similar research and to help those interested in or working in the field to become aware of what has been published, two complete bibliographies on the theory and applications of dimensional analysis were assembled during the literature search phase of the project[1,2]. Part of the bibliography will be published in the JOURNAL OF THE FRANKLIN INSTITUTE[3].

Present techniques of dimensional analysis provide procedures of judicious grouping of variables associated with a physical phenomenon to form dimensionless products of variables. A FORTRAN program has recently been developed by NASA for the computation of B-numbers, dimensionless products of variables, from the laws of physics[4]. Since the set of B-numbers in general is not unique, additional constraints can be imposed upon. Such a set of constraints may be termed as optimization criteria of the system. Some of these constraints such as to maximize the number of zeros and to minimize the sum of the absolute values of all the elements

have been proposed by Happ[5]. These criteria are chosen so that the formulas associated with a physical phenomenon are in their "simplest" form. Otherwise, they are completely arbitrary. The problem was only partially solved by Happ by means of an exhaustive procedure: Using the columns of a complete B-matrix as a basis, a large number of B-matrices are generated. They are then compared with one another to obtain an "optimized" one. Thus, it is not known if the "optimized" B-matrix is really optimal.* Because of this, the existing computer program developed by NASA can only evaluate problems with up to 15 variables and 10 dimensions[6].

During the past year our study of dimensional analysis has convinced us that a complete set of B-numbers (pi-numbers) itself contains enough information as to which linear combinations should be formed to obtain the optimized ones. Based on this property, an efficient algorithm has been developed which generates a complete optimized set of B-numbers from any complete set of B-numbers. The details of the technical justifications will be published in a Special Issue of the JOURNAL OF THE FRANKLIN INSTITUTE entitled, "Dimensional Analysis, Similarity and Similitude, and Structural Modeling," scheduled to appear in the fall[7]. The algorithm may also be used to generate all the complete optimized sets of B-numbers, and it is non-exhaustive and efficient and is readily adaptable for a digital computer.

It has also been shown[7,8] that the set of dimensionless products of the variables associated with a physical phenomenon is invariant with respect to the choice of the reference dimensions. Thus, in computing a complete set of dimensionless products we may use any appropriate set of dimensions as rendered feasible by the problem at hands as the reference dimensions. Once an appropriate set of reference dimensions has been chosen,

* Two counterexamples have been found.

the dimensional matrix associated with a physical phenomenon can easily be set up. The generation of a complete set of dimensionless products amounts to computing a complete B-matrix from the dimensional matrix. For this purpose, a simple and systematic procedures has been included[7,8].

REFERENCES

1. H. C. Li and W. K. Chen, "Dimensional analysis: a bibliography," Tech. Rept. No. EER-10-19, Dept. of Elec. Engrg., Ohio Univ., Athens, January, 1969.
2. I. C. Goyal and W. K. Chen, "A complete bibliography on dimensional analysis," Tech. Rept. No. EER-10-24, Dept. of Elec. Engrg., Ohio Univ., Athens, July, 1969.
3. T. J. Higgins, W. K. Chen, and W. W. Happ, "A bibliography on dimensional analysis," J. Franklin Institute, to appear.
4. A. D. Sloan and W. W. Happ, "Computer program for dimensional analysis," NASA Rept. ERC/CQD 68-621, August, 1968.
5. W. W. Happ, "Computer-oriented procedures for dimensional analysis," J. Appl. Phys., Vol. 38, pp. 3918-3926, 1967.
6. A. D. Sloan and W. W. Happ, "Matrix methods of dimensional analysis," NASA Rept. ERC/CQD 68-623, September, 1968.
7. W. K. Chen, "Algebraic theory of dimensional analysis," J. Franklin Inst., Vol. 287, 1969, to appear.
8. W. K. Chen, "Algebraic theory of dimensional analysis," Tech. Rept. EER-10-22, Dept. of Elec. Engrg., Ohio Univ., Athens, April, 1969.

2. Grant Activities

A. Technical papers

1. H. C. Li and W. K. Chen, "Dimensional analysis: a bibliography," Tech. Rept. No. EER-10-19, Dept. of Elec. Engrg., Ohio Univ., Athens, January, 1969.
2. I. C. Goyal and W. K. Chen, "A complete bibliography on dimensional analysis," Tech. Rept. No. EER-10-24, Dept. of Elec. Engrg., Ohio Univ., Athens, July, 1969.
3. W. K. Chen, "Algebraic theory of dimensional analysis," J. Franklin Institute, Vol. 287, 1969, to appear.
4. W. K. Chen, "Algebraic theory of dimensional analysis," Tech. Rept. No. EER-10-22, Dept. of Elec. Engrg., Ohio Univ., Athens, April, 1969.

B. Related technical activities

1. W. K. Chen, "An efficient algorithm in dimensional analysis," Tech. Brief, NASA, March, 1969.
2. W. K. Chen, Book Review "An Introduction to Dimensional Analysis for Engineers," by J. F. Douglas, 1969, to appear in the J. of the Franklin Institute, Vol. 287, 1969.

C. Graduate students who benefited from this grant

1. H. C. Li, M.S. student, to be completed.
2. I. C. Goyal, M.S. Student, to be completed.