(E00-10205) DESIGN SPECIFICATION FOR SECONDARY ERROR SOURCES MULTI-TEMPORAL BAYES CLASSIFIER (Lockheed Electronics Co.) 13 p HC A02/MF A01 CSCL 05B

N30-23764

Unclas
G3/43 00205

0205
ASA CR-
160636

DESIGN SPECIFICATION

FOR

SECONDARY ERROR SOURCES

MULTI-TEMPORAL BAYES CLASSIFIER

Job Order 71-695

(TIRF 77-0058)

Prepared by

Lockheed Electronics Company, Inc.

Systems and Services Division

Houston, Texas

Contract NAS 9-15200

For

EARTH OBSERVATIONS DIVISION

SPACE AND LIFE SCIENCES DIRECTORATE

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

December 1977

LEC- 11677

JSC- 13823

DESIGN SPECIFICATION

FOR

SECONDARY ERROR SOURCES

MULTI-TEMPORAL BAYES CLASSIFIER

Job Order 71-695

(TIRF 77-0058)

Prepared By

P. J. Aucoin, Jr.
P. J. Aucoin, Jr.
Lockheed Electronics Company

APPROVED BY

Philip L. Krumm
P. L. Krumm, Supervisor
Applications Software Section

B L Carroll
B. L. Carroll, Manager
LACIE Development and Evaluation Dept.

Prepared By

Lockheed Electronics Company, Inc.

For

Earth Observations Division

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

December 1977

LEC- 11677

CONTENTS

1. SCOPE

This document contains a design specification for software to implement a multi-temporal Bayes classifier. This classifier uses multi-temporal pixel data in combination with transition probabilities to correct for misregistration and crop planting changes.

Implementation will be on the Purdue-LARS computer system. It will be incorporated into the EOD-LARSYS system as an add-on processor.

2. APPLICABLE DOCUMENTS

- Final Design Specification for EOD-LARSYS Procedure 1, Houston, Texas, August 1977, JSC-12742, LEC-10417.
- Job Order 63-1347-1695
- TIRF
- J. R. Welch and K. G. Salter, "A Context Algorithm for Pattern Recognition and Image Interpretation", IEEE Trans. SML, Vol. SMC-1, No. 1, pp. 24-30, January 1971.

3. SYSTEM DESCRIPTION

3.1 HARDWARE DESCRIPTION

N/A

3.2 SOFTWARE DESCRIPTION

The Multi-temporal Bayes classifier will proceed along the following computational lines.

Input Cards: Control card data, including number of acquisitions, subsets of acquisitions for classification output and error output, sun angle correction, unit and file numbers, channels selected.

Pixel Fields to be classified.

A-priori probabilities of categories.

Transitional probabilities.

Test fields for error computation.

Input Files: A multi-acquisition MSS data tape.
Set of conditional probability density estimates $f(z^{(i)}|c_j)$, j = category number, i = acquisition number, for pixels z contained in the pixel fields on MAPTAP or DSTTAP files. (MAPTAP input will provide the various inputs needed to compute $f(z^{(i)}|c_j)$ as a multi-normal distribution.)

The pixel fields to be classified must be contained in the fields on MAPTAP or DSTTAP. Also, the number of acquisitions available from MAPTAP or DSTTAP must be at least as large as the number called for under the card input.

Classification will proceed according to the method described in this section. Results will be outputted in EOD-LARSYS MAPTAP file format for selected subsets of acquisitions.

Error computations will proceed according to the method to be described in this section. Printer output of these computations will be presented for selected subsets of acquisitions.

Prior to classification, the estimates

$$\{f(z^{(i)}|c_j)\} \quad i=1,\ NA,\ j=1,\ NOCAT$$

will be extracted from DSTTAP files or MAPTAP files.

In the case of DSTTAP files provided, there must be at least NA files available. The channels specified in control card CHANNEL must match those specified in DSTTAP files.

In the case of MAPTAP files, the estimates $\{f(z^{(i)}|c_j)\}$ will be built from multi-normal information (covariance matrices, mean vectors). The channels specified in control card CHANNEL must be included in the MAPTAP file aggregate.

COMPUTATIONAL PROCEDURE FOR CLASSIFICATION:

For classification on the first acquisition of any pixel $z^{(1)}$ in the test field described under (3), select the category j which maximizes

$$F1_j(z)=f(z^{(1)}|c_j^{(1)})P(c_j^{(1)})$$

For 2 acquisitions, select the category j which maximizes

$$F2_j(z) = \sum_i f(z^{(1)}|c_i^{(1)})f(z^{(2)}|c_j^{(2)})P(c_i^{(2)}|c_j^{(1)})P(c_j^{(1)})$$

For 3 acquisitions, select the category k to maximize

$$F3_k(z) = \sum_i \sum_j f(z^{(1)}|c_i^{(1)}) f(z^{(2)}|c_j^{(2)}) f(z^{(3)}|c_k^{(3)}) * P(c_k^{(3)}|c_j^{(2)} c_i^{(1)}) P(c_j^{(2)}|c_i^{(1)}) P(c_i^{(1)})$$

For 4 acquisitions, select the category ℓ to maximize

$$F4_\ell(z) = \sum_i \sum_j \sum_k f(z^{(1)}|c_i^{(1)}) f(z^{(2)}|c_j^{(2)}) f(z^{(3)}|c_k^{(3)}) * f(z^{(4)}|c_\ell^{(4)}) P(c_\ell^{(4)}|c_i^{(1)} c_j^{(2)} c_k^{(3)}) * P(c_k^{(3)}|c_i^{(1)} c_j^{(2)}) P(c_j^{(2)}|c_i^{(1)}) P(c_i^{(1)})$$

Output MAPTAPs are required.

Error Calculations

These will be based on the test pixel fields.

Bayes risk option:

Compute the number of test pixels N. Then, for a particular number of acquisitions NA, NA=1, 2, 3 or 4, an estimate of the Bayes risk is

$$R_{BE}(NA) = 1 - \frac{1}{N} \sum_{i=1}^{N} \left[\frac{\max\limits_{\ell} \; FNA_\ell(z_i)}{\sum\limits_{\ell}^{NC} FNA(z_i)} \right]$$

$$z_i \text{ refers to } \begin{bmatrix} z_i^{(1)} \\ z_i^{(2)} \\ \vdots \\ z_i^{(NA)} \end{bmatrix}$$

Misclassified Pixel Count Option:

Compute the number of test pixels N. For the NAth acquisition, compare the classification (input) of each test pixel with that of the NAth assignment made by the multi-temporal Bayes procedure described above.

Count the pixels where this differs. Dividing this count by N yields $R_{BE}(NA)$.

3.2.1 LINKAGES

The Multi-temporal Bayes classifier will use the FORTRAN IV-G compiler, IBM system routines, EOD-LARSYS utility routines and EOD-LARSYS common blocks GLOBAL, ISOLNK, and INFORM. A new common block MULBAY will be provided for transfer of information among subprograms.

3.2.2 INTERFACES

The Multi-temporal Bayes classifier will require an MSS input file for pixel radiance value input.

It will be invoked from the MONTOR routine of EOD-LARSYS upon encounterin a control card of the form $MULBAY. Back-to-back runs with the DISPLAY processor of EOD-LARSYS will be possible.

3.2.3 INPUTS

a. Processor Card

<u>Keyword</u>

$MULBAY

b. New Control Cards

Keyword	Parameter	Function
CATNAM	category $name_1$,... category $name_{NOCAT}$	Names of categories. These names must match those on MAPTAP or DSTTAP.
CHANNEL	$C_1,\ldots,C_{NOFET2}$	Selected channels.
NCPASS	N (Default: N=4)	Number of channels per pass.

NOTE: From this channel information, the number of acquisitions NA will be computed.

Keyword	Parameter	Function
SUNANG	TAPE or $n_1,\ldots,n_{NA}$	If tape specified, sunangles will be extracted from the header of the MSS data tape (Universal format).
NASUB	$n_1,\ldots,n_{SUB}$	Subset of integers 1,2,..., NA for print of classification maps and error results.
DATAFI	INPUT/UNIT=N,FILE=M (Default: N=3,M=1) (Not required if DSTTAP input specified)	MSS Data Tape unit and file numbers.
FORMAT	U or L	Universal or LARSYS
MAPTAP	OUTPUT/UNIT=N,FILE=M (Default: N=2,M=2)	Unit number and beginning file number of classification map file.
MAPTAP	INPUT/UNIT=N,FILE=M (Default: N=2,M=1)	Unit number and beginning file number of classification map file.

Keyword	Parameter	Function
DSTTAP	INPUT/UNIT=N,FILE=M (Default: None)	Unit number and beginning file number of classification map file.
APRIOR	$P_1,\ldots,P_{NOCAT}$ (Default: None)	A-priori values for each category
ERROR	BAYES or COUNT	Select error computation.
END		Terminates control card input.

c. Field Cards

Field cards will be handled as in EOD-LARSYS, except that DESIGN header cards will include SAMPLE and TEST designators.

Sample fields for classification will be user input. Test fields for error computation will be user supplied (optional).

3.2.4 OUTPUTS

MAPTAP files will be outputted.

3.2.5 STORAGE REQUIREMENTS

TBD

3.2.6 DESCRIPTION

The following list of subprograms will constitute the building blocks of the Multi-temporal Bayes classifier.

Subprogram	Function
MULBAY	Main driver.
SET16	Will read control cards.
RDDAT	Will read pixel fields (sample and test), establish field vertices, extract pixel radiance values from MSS data tape, perform sun angle correction. NOTE: If DSTTAP input, radiance values are not required.
EXTRAC	Set up $\{f(z^{(i)}\|c_j)\}$
CLSSAM	Will perform sequential classification of sample fields.
CLSTST	Will perform sequential classification of test fields.
ERRBAY	Will compute Bayes error.

Subprogram	Function
ERRCNT	Will compute count error.
RDDST	Will read DSTTAP.
RDMAP	Will read MAPTAP.
WTRMAP	Will write MAPTAP.
PRERR	Will print error computation.
PRMAP	Will print classification map.