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**RECOG: A POLYALGORITHM FOR THE ANALYSIS OF
GENERALIZED DATA SETS. AN OPERATOR'S MANUAL**

L. A. Cox, Jr., R. H. Pritchard, and C. F. Bender

April 9, 1975

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GENERALIZED DATA SETS. AN OPERATOR'S MANUAL*

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INTRODUCTION

With UCID-16443, issued in December of 1973, the polyalgorithm RECOG was made available for general use within the Lawrence Livermore Laboratory. Since that time extensive efforts have been made to make RECOG both more efficient, more powerful, and more "usable." This document attempts to describe the theory and operations of the RECOG system. We hope that with this report potential users will be able to efficiently apply the system to their own particular problems with a minimum of effort.

Often one finds that an "off-the-shelf" algorithm ALMOST--but not quite--meets the requirements of the researcher. This document strives to familiarize the potential user with the methodology, conventions, and philosophy which underlie the RECOG program, so that any necessary modifications can be made easily and RECOG can be customized as individual problems dictate.

PATTERN RECOGNITION

One of the branches of the science of Artificial Intelligence is Pattern Recognition. This is rapidly developing area combining Computer Science and Applied Mathematics has shown great promise in providing a general approach to solutions of diverse data analysis problems. A general statement of the type of problem which pattern recognition attempts to solve is as follows:

*This work was performed under the auspices of the U. S. Energy Research & Development Administration.

"... given a set of objects and a list of measurements made on these objects, is it possible to find and/or predict a property of the objects which is not directly measurable but is known to be related by some unknown relationship?..."*

The polyalgorithm described in this document attempts to answer that question for specific data sets. We have striven to preserve and foster the capability for RECOG to answer not only "YES," but also "NO" when such a response is warranted. When intelligently employed, RECOG will act upon a data set in such a way that it becomes apparent if useful information (beyond that already discerned) is contained in the data set.

A variety of processing techniques are used to look at the data so that informed decisions may be made about the data. The problem which RECOG faces has been described as being roughly parallel to determining the shape of a multivariate function in many-dimensional space, given a number of functional values in that space. Of course, it is not clear what the functional form is or what the proper choice of variables ought to be. These are the essential questions that RECOG strives to answer.

PROGRAMMING CONVENTIONS

RECOG was written in FORTRAN IV, which essentially conforms to USASI FORTRAN, X3.9-1966, the standard features of the United States of America Standards Institute FORTRAN report. It has been written primarily for use on Control Data Corporation 6000 and 7000 series computers, but is essentially statement-for-statement compatible with IBM FORTRAN IV-G and UNIVAC FORTRAN. Some program modules take advantage of the CDC machine 60 bit word length (14 significant figures in single precision); however, in some cases, easy conversion to double precision has been included should these portions of the code be run on other machines.

*B. R. Kowalski and C. F. Bender, J. Am. Chem. Soc. 94, 3632 (1972).

While the versions run by the authors take advantage of large amounts of locally available fast memory, a general purpose library of data handling routines allows the program to be run with virtually any size scientific machine with only minor modifications of some utility routines. Parameters giving fast memory allocation may be specified at compile time and the program will automatically adjust, and employ slow (disk) storage as required. In addition, should overlaying of the code be required, each verb or processor section (as described below) has been written so that these segments are overlayable, with only the control segments and data handling structure being resident continuously.

Programming has been such that generality has been preserved in virtually every case. Versions of RECOG are now running on machines employing various Operating Systems and hardware of the IBM, CDC, and UNIVAC companies. We have consciously tried to minimize the problems inherent in transitioning between machines.

For use on LLL's CDC 6000/7000 series machines, we have adopted the following file conventions. The primary input file is called PATIN, and the secondary input files are called TAPE2 (binary) and ALTIN (BCD). The primary output file is called FXRADPBXYZ. The plotting routines, although designed to use LLL's DD80 (CRT) plotting system, are amenable to the more familiar and universally available CALCOMP software.

In the following pages, we will describe the most comprehensive system now operational. Not all of the features incorporated will be applicable to facilities using different hardware or different operating systems. In the cases of the most evident differences, the peculiarity and its probable solution have been indicated.

THE RECOG STRUCTURE

RECOG analyzes pattern sets by applying various techniques to them. The use of "verbs" in the input stream allows the user a great deal of flexibility

in the data analysis procedure. For example, the format for the verb input is as follows:

INPUT (A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	----	VERB (left justified).

Upon the recognition of a valid verb in the input file, RECOG will jump to a first level subroutine, which will (in general) set up the data structures and working space which will be required in the following calculations. The first level subroutine then calls a second level routine which does the bulk of actual processing. Additional levels of subroutines are called as required, and upon completion of the desired processing sequence, control is returned to the executive (main program) for processing of the next verb command.

Verbs are grouped into functional areas, depending upon their intended purpose.

These groups are as follows:

- I. PATTERN ANALYSIS. These routines are used to evaluate the usefulness of the measurements. These steps should be the first analysis applied to a pattern recognition problem. Correlations between variables often reveal interesting information on the types of tests performed, and sometimes early indications of the applicability of pattern recognition methods may be inferred at this stage of the analysis. The verbs in this section are:

CORR	p. 10
CORRPP	p. 11

- II. DATA PREPROCESSING. The subroutines in this section are used to change the representation of the patterns in pattern space. Such changes often make features more easily discernible and enhance classification. The verbs in this section are:

AUTO	p. 7
KHPRE	p. 21
NVS	p. 28
SELECT	p. 35
SLT	p. 37

- III. DISPLAY ROUTINES. The subroutines which make up the verbs in this section are used to display the multi-dimensional pattern space in

two dimensions. Many of these subroutines, if not all, require the use of software/hardware unique to LLL. The verbs included in this section are:

HISTO	p. 18
NLM	p. 26
PLOTVS	p. 31
PLTSPEC	p. 32
2DPLOT	p. 44

- IV. SPECTRAL ANALYSIS ROUTINES. The verbs and software of this section are used to analyze and preprocess spectral and spectral-like (i.e., digitized curves) patterns. The verbs of this section are:

AUTOCORR	p. 8
DERIV	p. 12
FOURIER	p. 14
HADAMARD	p. 16
NORMSPEC	p. 27
SMOOTH	p. 38
XMOMENT	p. 42
YMOMENT	p. 43

- V. SUPERVISED LEARNING ROUTINES. These routines are used to classify unknown samples by applying rules which were developed using a set of known samples. Verbs included are:

BUTLER	p. 9
KNEAR	p. 22
LEAST	p. 23
MULTCL	p. 24
PARZ	p. 29

- VI. UNSUPERVISED LEARNING ROUTINES. These routines seek to find meaningful clusters of patterns. Verbs are:

HIER	p. 17
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- VII. UTILITY ROUTINES. Routines in this section control input, output, plotting data set manipulation etc. Some require either special LLL hardware or software. Verbs of this section include:

END	p. 13
GIVE	p. 15
INPUT	p. 19
KEEP80	p. 20
NEW	p. 25
PATMERGE	p. 30
PRINT	p. 33
PUNCH	p. 34
TMDS	p. 39
TTYOFF	p. 40
TTYON	p. 41

These functional verbs are described in the following pages, both from an operator's point of view, and in terms of the actual algorithm and software employed. Appendix A contains examples of input decks and resulting output from RECOG.

DEFINITIONS AND NOMENCLATURE

Before proceeding into a discussion of the various algorithms and their properties, a brief summary of the basic nomenclature and definitions is in order.

Input data consists of a collection of NP objects for which NV measurements have been recorded. This tabulated data is called a "pattern," and is denoted by the vector $\tilde{x}_j$.

$$\tilde{x}_j = \begin{pmatrix} x_{1j} \\ x_{2j} \\ x_{3j} \\ x_{4j} \\ \vdots \\ x_{NVj} \end{pmatrix} \quad j = 1, 2, \dots, NP$$

A pattern space is a collection of these patterns:

$$\tilde{X} = (\tilde{x}_1, \tilde{x}_2, \dots, \tilde{x}_{NP})$$

Patterns and pattern spaces are input and operated upon by RECOG in a variety of ways. A summary of RECOG verb usage and operations may be found in the following section.

DESCRIPTION: Autoscaling is applied to the variables in order to equally weight each variable. The new variables are defined by

$$Y_{ij} = (x_{ij} - \bar{x}_i) / \sigma_i$$

where

$$\sigma_i^2 = \sum_{j=1}^{NP} (x_{ij} - \bar{x}_i)^2$$

$$\bar{x}_i = \frac{1}{NP} \sum_{j=1}^{NP} x_{ij}$$

The new variables Y_{ij} can also be weighted with class information by setting

$$Y'_{ij} = w_i^{(\text{code})} Y_{ij}$$

There are five weighting codes available. Code 0 sets $w_i^{(0)} = 1$ for all i , that is, $Y'_{ij} = Y_{ij}$. Code 1 defines $w_i^{(1)}$ as the absolute value of the correlation coefficient between the predicted property and variable i (see discussion of CORRPP). Code 2 weights according to the degree of interclass separation

$$w_i^{(2)} = \sum_{j \in C_1, l=1, \dots, (NC-1)} \sum_{k \in C_J, J=l+1, \dots, NC} (x_{ij} - x_{ik})^2$$

Here the notation means that the first sum is over all patterns in Class 1, and the second sum is over all patterns in Class J, where $J > 1$. Code 3 defines

$$w_i^{(3)} = \left[\sum_{\substack{j > k \\ j, k \in C_1, l=1, \dots, NC}} (x_{ij} - x_{ik})^2 \right]^{-1}$$

that is, the degree of intraclass clustering. Code 4 does both 2 and 3 simultaneously:

$$w_i^{(4)} = w_i^{(2)} / w_i^{(3)}$$

INPUT (2A10, 5X, 15)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set X .
11-20	A	---	Name of output pattern set Y ; if this field is blank, the new set will simply replace the old set.
26-30	I	0	Weighting code as described above.

DESCRIPTION:

This routine gives the autocorrelation spectrum:

$$Y_{lj} = \frac{\sum_{i=1}^{NV-l} X_{ij} X_{i+l,j}}{\sum_{i=1}^{NV} X_{ij}^2} \quad l = 1, 2, \dots, k$$

The new pattern set will have k variables.

INPUT (2A10, 15)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set X
11-20	A	---	Name of output pattern set Y -- must not be blank
21-25	I	10	k--must be < NV

DESCRIPTION:

This routine is a non-linear estimator for continuous functions.*

$$P_j = \frac{\sum_{k=1}^{NT} w_{jk} P_k}{\sum_{k=1}^{NT} w_{jk}} \quad (j=1, \dots, NP)$$

where

$$w_{jk} = 1 / (1 + A d_{jk})$$

$$d_{jk} = \left[\sum_{i=1}^{NV} (x_{ij} - x_{ik})^2 \right]^B$$

and P_j is the predicted property for the j^{th} pattern.

INPUT (A10, 15, 2F10.0)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set.
11-10	I	0	Non-zero gives leave-one-out statistics for the training set.
16-25	F	1.0×10^4	A in above formula.
26-35	F	0.5	B in above equation.

*G. Butler, Allstate Research Center, Menlo Park, CA. (private communication).

DESCRIPTION:

The correlation matrix C is calculated for correlations among all the variables, where

$$c_{ik} = \frac{1}{\sigma_i \sigma_k} \sum_{j=1}^{NP} (x_{ij} - \bar{x}_i)(x_{kj} - \bar{x}_k)$$

$$\sigma_i^2 = \sum_{j=1}^{NP} (x_{ij} - \bar{x}_i)^2$$

$$\bar{x}_i = \frac{1}{NP} \sum_{j=1}^{NP} x_{ij}$$

Non-diagonal elements of C are ordered on $|c_{ik}|$ and printed, provided their value is ≥ 0.50 .

INPUT (A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.

DESCRIPTION:

The correlation coefficients for all variables with the predicted property P are calculated and ordered on absolute value, where

$$c_i = \frac{1}{\sigma_i \sigma_P} \sum_{j=1}^{NP} (x_{ij} - \bar{x}_i) (P_j - \bar{P})$$

$$\sigma_i^2 = \sum_{j=1}^{NP} (x_{ij} - \bar{x}_i)^2$$

$$\sigma_P^2 = \sum_{j=1}^{NP} (P_j - \bar{P})^2$$

$$\bar{x}_i = \frac{1}{NP} \sum_{j=1}^{NP} x_{ij}$$

$$\bar{P} = \frac{1}{NP} \sum_{j=1}^{NP} P_j$$

INPUT (A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.

DESCRIPTION:

Takes the derivative of each spectrum by

$$Y_{ij} = X_{i+1,j} - X_{ij}$$

which, of course, assumes that $\Delta x = 1$. The number of variables (NV) is reduced by one. Higher-order derivatives may be obtained by calling the routine again.

INPUT (2A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set $\tilde{X}$.
11-20	A	---	Name of output pattern set $\tilde{Y}$; if blank, $\tilde{X}$ is replaced by $\tilde{Y}$.

VERB: <u>END</u>	TYPE: <u>UTILITY</u>	PAGE 13
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DESCRIPTION:

An end card terminates a RECOG run.

DESCRIPTION:

This routine creates a new pattern set consisting of the Fourier expansion series coefficients

$$Y_{ij} = a_{i-1}^j \quad i = 1, 2, \dots (n+1)$$

where $n = 2 \lfloor NV/2 \rfloor$ and

$$a_0^j = \sum_i x_{ij} / \frac{NV(NV+1)}{2}$$

...

$$a_{n-1}^j = \sum_i x_{ij} \sin n\tau_i / \sum_i (\sin n\tau_i)^2$$

$$a_n^j = \sum_i x_{ij} \cos n\tau_i / \sum_i (\cos n\tau_i)^2$$

$$\tau_i = 2\pi \left(\frac{i-1}{NV-1} \right)$$

The new pattern set has $(n+1)$ variables.

INPUT (2A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set X.
11-20	A	---	Name of output pattern set Y--must not be blank.

VERB: GIVE	TYPE: UTILITY ROUTINE	PAGE 15
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DESCRIPTION:

This verb sends printer output files to the primary output device.

(Currently microfiche at LLL.)

DESCRIPTION:

This routine creates a new pattern set consisting of the coefficients in the Walsh function* expansion series

$$y_{ij} = b_{i-1}^j \quad i = 1, 2, \dots (n + 1)$$

where $n = 2 \lfloor NV/2 \rfloor$ and

$$b_0^j = \sum_i x_{ij} / \frac{NV(NV + 1)}{2}$$

$$b_{n-1}^j = \sum_i x_{ij} \text{sal}(n, t_i) / \sum_i (\text{sal}(n, t_i))^2$$

$$b_n^j = \sum_i x_{ij} \text{cal}(n, t_i) / \sum_i (\text{cal}(n, t_i))^2$$

$$t_i = (i-1)/(NV-1)$$

The new pattern set has $(n + 1)$ variables.

INPUT (2A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set $\tilde{X}$.
11-20	A	---	Name of output pattern set $\tilde{Y}$ --must not be blank.

*See B. R. Kowalski and C. F. Bender, Anal. Chem. 45, 2334 (1973).

DESCRIPTION:

Clusters of patterns are formed based upon one of the three similarity coefficients

$$1. S_{jk} = 1 - (d_{jk} / \max(d_{jk}))$$

where

$$d_{jk} = \left[\sum_{i=1}^{NV} (x_{ij} - x_{ik})^2 \right]^{1/2}$$

$$2. S_{jk} = (1 + c_{jk})/2$$

where

$$c_{jk} = \frac{1}{\sigma_j \sigma_k} \sum_{i=1}^{NV} (x_{ij} - \bar{x}_j)(x_{ik} - \bar{x}_k)$$

$$\sigma_j^2 = \sum_{i=1}^{NV} (x_{ij} - \bar{x}_j)^2$$

$$\bar{x}_j = \frac{1}{NV} \sum_{i=1}^{NV} x_{ij}$$

$$3. S_{jk} = (1 + x_{jk}^+ / |x_j| |x_k|) / 2$$

Patterns or clusters are connected by maximizing the similarity coefficient S_{jk} with (1) one particular member of a cluster or (2) the average similarity coefficient over the cluster.

INPUT (A10,415, F10.0)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.
11-15	I	1	Similarity code (see above.)
16-20	I	0	Connection code (see above); zero gives 1 and 2.
21-25	I	0	Minimum number of clusters.
26-30	I	0	Non-zero gives plot and analysis after each connection
31-40	F	0.01	Plots and analysis will be given after this specified change in similarity.

DESCRIPTION:

For specified variables or the predicted property, histograms are generated which indicate their distribution within the pattern set. The range of the variable is divided into sub-ranges, and the number of occurrences of each sub-range is plotted. (LLL system dependent.)

INPUT

PATTERN SET IDENTIFICATION (A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.

HISTOGRAM SPECIFICATION (215, A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-5	I	---	Variable number; - 1 gives predicted property.
6-10	I	6	Number of Sub-ranges.
11-20	A	Blank	Name of variable for plot label.

A blank card is used to terminate HISTO.

DESCRIPTION:

The parameters and patterns (i.e., the matrix X) for a given pattern set are defined.

INPUT

PATTERN DEFINITION CARD (A10, 415)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set (must be new and unique).
11-15	I	---	Number of variables per pattern (NV).
16-20	I	---	Number of patterns (NP).
21-25	I	---	Number of classes (NC) (should be at least one).
26-30	I	---	Number of patterns in the <u>training set</u> (NT). If negative, the first NT patterns will constitute the training set; otherwise, the (NP-NT) <u>unknown</u> ordinal pattern numbers will be read in the format (2013). (On alternate input file if Option 2 is selected--see below).

INPUT FORMAT CARD (8A10).

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-80	A	---	Format for pattern input in the form $(F_1, F_2, \dots, F_{NV}, B, C, D)$ where the F_k 's are the formats for the pattern values X_j (<u>must</u> be floating point numbers), B is a floating point format for the predicted property, C is an alphanumeric format for the class name (usually A1-A4), and D is the format (alphanumeric) for the name of the pattern.

If the first three characters on this card are BIN, the patterns will be read off the binary file assigned to Unit 2 (i.e., TAPE2). The unformatted read is

READ (2) (X(I,J), I=1, NV), P, CL, NAME

where X is the pattern matrix, P the predicted property, CL the class name, and NAME the pattern name. If the first three characters of the Input Format Card are BCD, then the patterns will be read off the BCD file assigned to Unit 1 (called ALTIN). In this case, the user must read in two additional formats $F1 = (F_1, F_2, \dots, F_{NV})$ and $F2 = (B, C, D)$ as described above. The formatted read from ALTIN is

READ (1, F1) (X(I, J), I=1, NV)

READ (1, F2) P, CL, NAME

After the patterns are read in, the (NP-NT) unknown pattern numbers are read in from ALTIN in the format (2013). (If $NT > 0$.)

VERB: KEEP 80

TYPE: UTILITY ROUTINE

PAGE 20

DESCRIPTION:

This verb is used to retain a plot file on disc under the name HOLDX, for TMDS or special handling (LLL only).

DESCRIPTION:

New variables are defined which diagonalize the scatter matrix $\tilde{S}$, where

$$S_{ik} = \sum_{j=1}^{NP} x_{ij} x_{kj}$$

and

$$\tilde{y}_j = \tilde{c}^+ \tilde{x}_j$$

$$\tilde{S} \tilde{c} = \lambda \tilde{c}$$

This technique is often called the Karhunen-Loève transformation. It can be used to reduce the number of variables by selecting only the first few columns of the transformation matrix of eigenvectors $\tilde{c}$. These new variables have decreasing variance.

INPUT (2A10, 15)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set X.
11-20	A	---	Name of output set Y; if blank, input is replaced.
21-25	I	NV	Number of variables to be retained in the output pattern set. The output pattern set <u>must</u> have a new name if the number of variables is to be changed.

DESCRIPTION:

For a given pattern $X_{\sim j}$ in the training set the K smallest distances

$$d_{jk} = \sum_{i=1}^{NV} (x_{ij} - x_{ik})^2$$

are calculated and retained, where $K = 1, 2, \dots, 7$. The pattern is then classified by a majority vote of its nearest neighbors. The "leave-one-out" technique can be used to determine the reliability of the classifiers.

INPUT. (A10, 15)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.
11-15	I	0	Zero gives "leave-one-out" statistics.

DESCRIPTION:

This routine determines a linear weight vector by a least squares solution to the equation

$$\tilde{X}^+ \tilde{W} = \tilde{P}$$

where $\tilde{P}$ is the vector of the predicted property. The above is solved by premultiplication by $\tilde{X}$,

$$(\tilde{X} \tilde{X}^+) \tilde{W} = \tilde{X} \tilde{P}$$

which can be solved using standard linear equation techniques. The weight vector $\tilde{W}$ can then be used to predict P_j for unknown patterns.

INPUT (A10, 15, F10.0)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set $\tilde{X}$
11-15	I	0	Zero prints only classifications of unknown patterns, whereas nonzero gives full output.
16-25	F	0.	Tolerance ($\pm$) for "hit" or "miss" of predicted property.

DESCRIPTION:

For each class, weight vectors are constructed which separate that class from each other class. In this way, $(NC*(NC-1)/2)$ weight vectors are defined. The weight vectors are then applied to the entire pattern space, and the patterns are classified based upon a majority vote. If the classes are linearly separable, a pattern will receive $(NC-1)$ votes for the proper class and a few votes for all the other classes. For non-separable data sets, three answers are possible: (1) a classification in which the number of votes is $(NC-1)$ (the best case); (2) a classification based upon a simple majority; or (3) no classification (tie). Currently, there are three modes of weight vector selection; Mode 1 uses the least square (i.e., SLT) technique, Mode 2 uses least square followed by a feedback correction technique, and Mode 3 uses the BUTLER non-linear separator.

INPUT (A10, 415, 2F10.0)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.
11-15	I	0	Nonzero gives plot of classifications (2DPL0T).
16-20	I	1	Mode for weight vector selection.
21-25	I	0	Nonzero gives leave-one-out statistics.
26-30	I	1	Number of feedbacks.
31-40	F	1.0×10^4	A in BUTLER.
41-50	F	0.5	B in BUTLER.

DESCRIPTION:

This causes a complete purge of all existing pattern sets and a reinitialization of mass storage allocation. It should be the first verb used in the input stream and may be used to "clean the slate" and begin working on a completely separate data set.

DESCRIPTION:

Non-linear optimization techniques are used to display the NV-dimensional data in two dimensions. The optimization minimizes the function

$$f = \sum_{j>k}^{NP} (d_{jk}^* - d_{jk})^2 (d_{jk})^K$$

where

$$d_{jk} = \left[\sum_{i=1}^{NV} (x_{ij} - x_{ik})^2 \right]^{1/2}$$

and

$$d_{jk}^* = \left[(x_j - x_k)^2 + (y_j - y_k)^2 \right]^{1/2}$$

The current version uses a contra-gradient technique for the minimization.

INPUT (A10, 315, F10.0)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.
11-15	I	0	Value of K.
16-20	I	250	Number of cycles (N) in iteration (-N gives initial random guess for (x_i, y_i) , otherwise the Karhunen-Loève transformation is used.
21-25	I	0	Nonzero gives a plot after every cycle; otherwise only a final plot is given.
26-36	F	10^{-5}	Δf minimization criterion.

(LLL system dependent.)

DESCRIPTION:

This routine normalizes a spectrum to unit area:

$$Y_{ij} = X_{ij} / \sum_i X_{ij}$$

INPUT (2A10)

)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input patterns set X
11-20	A	---	Name of output pattern set Y; if blank, X is replaced by Y

DESCRIPTION:

New variables are defined as products and transgenerations of variables from the input data set. Products (selection code 1) are formed as

$$X_{ik}^i = \prod_m X_{im}^{P_m} \cdot X_{in}^{P_n}$$

where P_q is the power of the q-th variable in the product. Transgeneration available are

<u>Function</u>	<u>Selection code (see below)</u>
SQRT	-1
ALOG	-2
EXP	-3

INPUT

Pattern set information (2A10, 215)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set, X.
11-20	A	---	Name of output pattern set Y; if this field is blank, the new set will simply replace the old set.
21-25	I	NV	Number of variables in output pattern set.
26-30	I	2	Maximum number of variables in a product.

Variable definition cards

Card 1 (215)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-5	I	---	Selection code, blank card terminates pattern set generation.
6-10	I	---	Number of variables in product of variables, or variable number of transgeneration.

Card 2 (used only for product generation)(1615)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-5	I	---	Variable number in product.
6-10	I	---	Power for above variable.
11-15	I	---	Variable number in product.
16-20	I	---	Power for above variable.

DESCRIPTION:

For each class, probability density functions are estimated. These functions are the sum of kernel functions placed around each sample point. The functions are normalized by the number of samples in each class. Unknowns are classified according to the function that has the largest value. Leave-one-out statistics are used on the training set to determine classifier reliability. The input pattern set must be autoscaled.

INPUT (A10, F10.0, 15)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.
11-10	F	0.2	Shape parameter--standard deviation of probability distribution.
21-25	I	0	Nonzero gives probability density function estimates for all samples in the training set.

DESCRIPTION:

Variables from a number of pattern sets are merged to form a new pattern set.

INPUT

Card 1: Output pattern set identification . . . (A10, 15)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of output pattern set (must not be blank).
11-15	I	---	Maximum number of variables.

Card 2: Input pattern set identification . . . (A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of next input pattern set (merge is terminated by blank card).

Card 3: Variable selection . . . (15)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-5	I5	---	Variable number to be selected; blank terminates merge from current pattern set.

Cards 2 and 3 are repeated as necessary.

DESCRIPTION:

One variable can be plotted against another variable or the predicted property.
(LLL system dependent.)

INPUT

Pattern set information (A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set X.

Plot definition card(s) (15, A10, 15, A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-5	I	0	Variable number of x; if negative predicted property will be used. A zero entry terminates plotting.
6-15	A	---	Name of x-variable to appear in plot.
16-20	I	---	Variable number for y; if negative, predicted property will be used.
21-10	A	---	Name of y-variable to appear on the plot.

DESCRIPTION:

This routine makes line plots of selected spectra (patterns). (LLL system dependent.)

INPUT (A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.

INPUT (15)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-5	I	0	Pattern (spectrum) number to be plotted; blank or zero terminates plotting.

DESCRIPTION:

This verb will cause the writing of an entire pattern set onto the RECOG output file.

INPUT (A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.

VERB: PUNCH

TYPE: UTILITY ROUTINE

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DESCRIPTION:

This verb will write a pattern set on the RECOG punch file.

INPUT (A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.

DESCRIPTION:

New variables are defined which are ordered on an attribute and may be uncorrelated with one another.

The available attributes are:

- 1 Same as autoscale code 1
- 2 Same as autoscale code 2
- 3 Same as autoscale code 3
- 4 Same as autoscale code 4
- 11 Optimize performance of KNN classifier
- 12 Optimize performance of MULTCL (mode 1)
- 13 Optimize performance of MULTCL (mode 2)
- 14 Optimize performance of MULTCL (mode 3)
- 15 Optimize performance of PARZ
- 16 Optimize performance of LEAST
- 17 Optimize performance of BUTLER

Note that a training **set** must exist. The program assumes that the pattern set has been autoscaled.

Three selection codes are available. Code 1 simply selects variables as ordered on the attribute. For Code 0, the selected variable is "uncorrelated" to the remaining variables by taking linear combinations of the selected variable (i) and each of the remaining variables (k) in question. The particular combination (k') is determined by requiring the scatter between i and k' to be zero:

$$\tilde{k}' = c_i \tilde{i} + c_k \tilde{k}$$

$$S_{ik'} = \sum_{j=1}^{NP} x_{ij} x_{k'j} = 0$$

The coefficients c_i and c_k are determined by the condition above and the requirement that $S_{kk'} = 1$. Since the pattern set has been autoscaled, $S_{ii} = S_{kk} = 1$, and the coefficients are uniquely defined. Existing variables are dropped if the scatter $S_{ik} > 0.99$ before uncorrelating. Finally, selection Code 2 uses the Code 1 order of variables for selecting new variables from the original ones.

INPUT (315, A10, 215, 2F10.0, F5.0)

SELECT (Cont'd.)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set X .
11-20	A	---	Name of output pattern set Y ; if blank the new set replaces the old set.
21-25	I	NV	Number of variables to be retained.
26-30	I	0	Selection Code (see above).
31-35	I	1	Attribute Code.
36-45	A	---	Name of scratch pattern set; output pattern set is used as a default.
46-50	I	1	K for KNN optimization.
51-55	I	1	Number of feedbacks for code 13.
56-65	F	1.0×10^4	BUTLER parameter A.
66-75	F	0.5	BUTLER parameter B.
76-80	F	0.02	Sigma for PARZ.

DESCRIPTION:

New variables are defined which separate one class from each other class. The new variables are generated by the transformation which defines an interclass separation plane. For each pair of classes $C_1, C_J, 1 > J$, a column vector Q^{IJ} is defined for the patterns contained in the two classes, where

$$Q_j^{IJ} = +1 \text{ if } \tilde{x}_j \text{ is in } C_1$$

$$-1 \text{ if } \tilde{x}_j \text{ is in } C_J$$

The linear transformation A^{IJ} is found by the least squares solution to

$$\tilde{x}' A^{IJ} = Q^{IJ}$$

Here $\tilde{x}'$ denotes only the pattern space spanned by the members of the classes C_1 and C_J . The $(NC * (NC-1))/2$ transformations A^{IJ} are then applied to the full pattern set to create the same number of new variables $((NC * (NC-1))/2)$.

INPUT (2A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set.
11-20	A	---	Name of output set; <u>cannot</u> be blank.

DESCRIPTION:

This routine performs an n-point smoothing operation of degree k on each spectrum using the method of convoluting integers (A. Savitsky and M. J. E. Golay, Anal. Chem. 36, 1627 (1964)). It is equivalent to obtaining each $((n + 1)/2)^{\text{th}}$ point from a least-squares fit of the n points to a polynomial of degree k. Options include n = 5, 7, 9, 11, k = 2, 3; n = 7, 9, 11, k = 4, 5.

The number of variables (NV) is reduced by (n - 1).

INPUT (2A10, 215)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set X.
11-20	A	---	Name of output pattern set Y; if blank, X is replaced by Y.
21-25	I	7	n
26-30	I	2	k

VERB: TMDS	TYPE: UTILITY ROUTINE	PAGE 39
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DESCRIPTION:

Used for on-line display of all plotted output (LLL-7600-TMDS only).

VERB: TTYOFF

TYPE: UTILITY ROUTINE

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DESCRIPTION:

Used for interactive operating mode, disconnects teletype as principle input/
output device (LLL only).

VERB: TTYON

TYPE: UTILITY ROUTINE

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DESCRIPTION:

Used for interactive operating mode, verb activates teletype input/output version of RECOG (LLL only).

DESCRIPTION:

This routine gives the first k X-moments of the spectrum

$$y_{\ell j} = \frac{\sum_{i=1}^{NV} (i - \bar{i})^{\ell} x_{ij}}{\sum_{i=1}^{NV} x_{ij}} \quad \ell = 1, 2, \dots, k$$

The new pattern set will have k variables.

INPUT (2A10, 15)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set $\tilde{X}$.
11-20	A	---	Name of output pattern set $\tilde{Y}$ --must not be blank.
21-25	I	10	k

DESCRIPTION:

This routine gives the first k (non-vanishing) Y-moments of the spectrum

$$Y_{\ell j} = \frac{1}{NV} \sum_{i=1}^{NV} (X_{ij} - \bar{X}_j)^{\ell+1} \quad \ell = 1, 2, \dots, k$$

The new pattern set will have k variables.

INPUT (2A10, 15)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of input pattern set X.
11-20	A	---	Name of output pattern set Y--must not be blank.
21-25	I	10	k

DESCRIPTION:

A two-dimensional representation of the pattern set is defined by the linear transformation (Karhunen-Loève) which diagonalizes the scatter matrix. The two eigenvectors corresponding to the two largest eigenvalues are retained. The "x" and "y" of the plot are thus

$$x_j = \tilde{c}_1^+ \tilde{x}_j$$

$$y_j = \tilde{c}_2^+ \tilde{x}_j$$

where

$$\tilde{S} \tilde{c} = \tilde{\lambda} \tilde{c}$$

and

$$\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_{NV}$$

$$S_{ik} = \sum_{j=1}^{NP} x_{ij} x_{kj}$$

INPUT (A10)

<u>Cols.</u>	<u>Type</u>	<u>Default</u>	<u>Description</u>
1-10	A	---	Name of pattern set.

(LLL system dependent.)

THE FOLLOWING CARDS ARE FOR USE WITH THE ORDER O/S

*ID 266CGW
 * XEQ RECOG2
 * PRINT TEST
 * DUMP OCT
 * DATA PATIN

CHECK

RECOG

BX Y04000001

BEGIN RECOG INPUT

KEEP80
 INPUT
 RAW DATA 10 75 4 -45
 (10F6.0, F3.0, 1X, A2, A10)

CARDS 10-84 ARE INPUT DATA CARDS
 AND APPEAR HERE IN THE INPUT STREAM.

PRINT
 RAW DATA
 CORR
 RAW DATA
 CORRFP
 RAW DATA
 AUTO
 RAW DATA AUTO
 KHPRE
 AUTO KHT-3 3
 SELECT
 AUTO SEL-31 3 0 1
 SELECT
 AUTO SEL-32 3 0 2
 SELECT
 AUTO SEL-33 3 0 3
 SELECT
 AUTO SEL-34 3 0 4
 SELECT
 SLT
 AUTO SLT
 2DPLOT
 RAW DATA
 2DPLOT
 AUTO
 2DPLOT
 KHT-3
 2DPLOT
 SEL-31
 2DPLOT
 SEL-32
 2DPLOT
 SEL-33
 2DPLOT
 SEL-34
 MULTCL
 RAW DATA 1 1
 MULTCL
 AUTO 1 1
 MULTCL
 KHT-3 1 1
 MULTCL
 SEL-31 1 1
 MULTCL
 SEL-32 1 1
 MULTCL
 SEL-33 1 1
 MULTCL
 SEL-34 1 1
 MULTCL
 SLT 1 1
 KNEAR
 RAW DATA
 KNEAR
 AUTO
 KNEAR
 KHT-3
 KNEAR
 SEL-31
 KNEAR
 SEL-32
 KNEAR
 SEL-33
 KNEAR
 SEL-34
 KNEAR
 SLT
 PARZ
 RAW DATA 1
 PARZ
 AUTO 1
 PARZ
 KHT-3 1
 PARZ
 SEL-31 1
 PARZ
 SEL-32 1
 PARZ
 SEL-33 1
 PARZ
 SEL-34 1

I. INPUT LISTING

KEEP80
INPUT
RAW DATA 10 75 4 -45
(10F6.0, F3.0, IX.A2.A10)

1069.	375.	51.	959.	429.	42.	100.	51.	47.	128.	1	1	101K-1A
1173.	417.	54.	961.	441.	47.	135.	55.	60.	145.	1	1	201K-1B
1164.	404.	56.	916.	446.	42.	120.	50.	49.	140.	1	1	301K-2
1030.	373.	59.	920.	487.	38.	128.	53.	50.	138.	1	1	401K-3A
1077.	373.	55.	888.	455.	38.	97.	51.	54.	145.	1	1	501K-1C
1080.	403.	53.	919.	442.	41.	133.	60.	45.	155.	1	1	601K-1D
1020.	360.	59.	883.	473.	43.	119.	40.	50.	134.	1	1	701K-3B
1050.	396.	56.	924.	482.	48.	140.	74.	71.	157.	1	1	801K-4R
1100.	373.	53.	910.	477.	51.	137.	61.	50.	152.	1	1	901K-4S
1105.	257.	10.	940.	431.	40.	121.	20.	53.	73.	2	2	102BL-1
1210.	276.	10.	966.	430.	44.	117.	20.	44.	73.	2	2	202BL-2
1205.	291.	10.	975.	420.	43.	115.	25.	58.	73.	2	2	302BL-3
920.	215.	6.	650.	435.	37.	122.	15.	65.	75.	2	2	402
1100.	267.	10.	910.	500.	49.	145.	25.	65.	95.	2	2	502BL-6
1100.	200.	10.	872.	515.	49.	145.	30.	60.	65.	2	2	602BL-7
860.	102.	7.	722.	418.	33.	115.	20.	55.	53.	2	2	702BL-8
952.	131.	37.	320.	430.	34.	118.	25.	65.	165.	3	3	103SH-1
933.	120.	36.	321.	414.	31.	125.	10.	59.	163.	3	3	203SH-15
999.	129.	30.	343.	445.	34.	121.	15.	52.	161.	3	3	303SH-51
973.	136.	30.	333.	418.	35.	111.	10.	53.	147.	3	3	403SH-6B
885.	110.	32.	294.	382.	27.	95.	15.	55.	134.	3	3	503SH-2
920.	127.	37.	337.	455.	30.	109.	15.	47.	151.	3	3	603SH-3
090.	122.	33.	315.	380.	34.	106.	15.	60.	155.	3	3	703SH-5
840.	135.	42.	320.	405.	31.	100.	10.	55.	197.	3	3	803SH-13
1720.	392.	50.	890.	344.	64.	97.	48.	50.	181.	4	4	124ANA-1
1525.	270.	54.	850.	345.	65.	83.	47.	60.	203.	4	4	224ANA-2
1565.	374.	54.	813.	295.	59.	88.	42.	49.	187.	4	4	324ANA-3
1705.	441.	66.	835.	310.	66.	91.	44.	42.	187.	4	4	424ANA-4
1690.	294.	60.	945.	367.	62.	91.	39.	50.	192.	4	4	524ANA-5
1630.	314.	54.	934.	340.	67.	95.	33.	30.	220.	4	4	624ANA-6
1635.	405.	50.	860.	311.	56.	83.	47.	60.	154.	4	4	724ANA-7
1635.	385.	55.	845.	290.	62.	85.	47.	50.	196.	4	4	824ANA-8
1490.	310.	54.	850.	320.	66.	71.	27.	47.	184.	4	4	924ANA-9
1720.	425.	50.	893.	316.	65.	93.	33.	44.	192.	4	4	1024ANA-10
1560.	269.	56.	915.	350.	64.	96.	47.	52.	194.	4	4	1124ANA-11
1705.	333.	55.	1010.	345.	74.	94.	45.	61.	217.	4	4	1224ANA-12
1700.	360.	55.	945.	355.	60.	100.	47.	50.	183.	4	4	1324ANA-13
1675.	342.	56.	920.	360.	61.	91.	49.	59.	215.	4	4	1424ANA-14
1695.	358.	57.	920.	347.	67.	93.	42.	71.	192.	4	4	1524ANA-15
1645.	327.	65.	940.	322.	69.	88.	44.	60.	208.	4	4	1624ANA-16
1620.	305.	55.	835.	295.	59.	87.	22.	60.	203.	4	4	1724ANA-17
1615.	337.	50.	890.	320.	66.	92.	43.	66.	212.	4	4	1824ANA-18
1675.	325.	62.	930.	350.	66.	89.	50.	63.	224.	4	4	1924ANA-19
1685.	353.	59.	875.	318.	60.	91.	41.	60.	203.	4	4	2024ANA-20
1600.	316.	54.	915.	347.	83.	82.	52.	66.	208.	4	4	2124ANA-21
660.	114.	9.	511.	404.	26.	110.	25.	50.	55.	2	02	112BLAV7
863.	183.	8.	626.	452.	34.	121.	15.	50.	70.	2	02	212BLAV15
1100.	320.	53.	320.	460.	45.	120.	57.	50.	142.	1	01	111K HVL
1100.	209.	7.	783.	426.	41.	109.	15.	57.	67.	2	02	312BLAV5
1050.	195.	45.	865.	400.	36.	97.	10.	50.	160.	1	01	21129938
920.	127.	39.	475.	420.	34.	98.	5.	60.	156.	3	03	11325099
900.	115.	37.	310.	440.	34.	100.	30.	60.	175.	3	03	21325101A
920.	130.	41.	350.	450.	34.	110.	20.	62.	157.	3	03	31329101B
1010.	357.	65.	900.	455.	42.	112.	65.	55.	145.	1	01	311130960
780.	140.	12.	605.	415.	35.	130.	15.	50.	70.	2	02	412131519
920.	320.	60.	830.	440.	33.	110.	43.	60.	143.	1	01	411131530

680.	105.	10.	450.	400.	31.	127.	15.	57.	87.	2	02	5121
775.	110.	35.	327.	337.	34.	93.	15.	65.	132.	3	03	41369534
1000.	194.	58.	965.	460.	42.	125.	30.	60.	145.	1	01	51169535
935.	131.	38.	360.	420.	37.	105.	10.	85.	150.	3	03	51369536
890.	115.	37.	272.	384.	32.	117.	15.	50.	150.	3	03	6135H1170
1000.	135.	35.	333.	383.	32.	100.	15.	50.	135.	3	03	7135HV18
930.	131.	32.	342.	389.	28.	100.	10.	55.	140.	3	03	8135H1110
680.	156.	36.	375.	388.	37.	103.	15.	53.	143.	3	03	9135H1113
680.	437.	33.	315.	390.	34.	110.	10.	60.	167.	3	03	10135H1118
970.	133.	40.	310.	398.	36.	115.	15.	65.	160.	3	03	11135HV12
919.	131.	39.	433.	392.	35.	108.	15.	54.	150.	3	03	12135HV24
932.	147.	37.	316.	393.	32.	122.	28.	56.	174.	3	03	13135H1154
970.	140.	40.	336.	394.	36.	118.	15.	61.	160.	3	03	14135H11K5
1000.	145.	41.	350.	394.	33.	125.	15.	48.	170.	3	03	15135H1115
970.	133.	40.	310.	390.	36.	115.	15.	65.	160.	3	03	16135HV12
930.	140.	36.	333.	395.	33.	100.	10.	65.	170.	3	03	17135H1110
960.	139.	35.	323.	395.	52.	103.	10.	55.	145.	3	03	18135H1113
990.	142.	38.	405.	400.	37.	122.	15.	60.	155.	3	03	19135HV14
919.	133.	35.	317.	408.	35.	120.	15.	58.	190.	3	03	20135H1177

PRINT
 RAW DATA
 CORR
 RAW DATA
 CORPPP
 RAW DATA
 AUTO
 RAW DATA AUTO 1
 AUTO
 RAW DATA AUTO 2
 AUTO
 RAW DATA AUTO 3
 AUTO
 RAW DATA AUTO 4
 AUTO
 AUTO
 KHPRE
 AUTO
 AUTO
 RAW DATA AUTO
 SELECT
 AUTO
 AUTO
 RAW DATA AUTO
 SLT
 AUTO SLT DATA
 AUTO
 SLT DATA
 ZPLOT
 SLT DATA
 HISTO
 RAW DATA
 1 10 VAP 1
 2 10 VAP 2
 5 10 VAP 5

NLIH
 SLT DATA
 AUTO
 SLT DATA
 HIER

SLT DATA
 KNEAR
 SLT DATA
 LEHST
 SLT DATA
 MULTCL
 SLT DATA
 STOP

II. PRINTED OUTPUT

```

KEEP00      COMPLETE IN      0.14 SECONDS
INPUT        COMPLETE IN      0.43 SECONDS
PRINTING PATTERN SET RAW DATA
PATTERN 1 101K-1A 1 1.000000E+00 4.200E+01 1.000E+02 5.100E+01 4.700E+01 1.280E+02
1.069E+03 3.750E+02 5.100E+01 9.580E+02 4.290E+02 4.200E+01 1.000E+02 5.100E+01 4.700E+01 1.280E+02
PATTERN 2 201K-1B 1 1.000000E+00 4.700E+01 1.350E+02 5.500E+01 6.000E+01 1.450E+02
1.173E+03 4.170E+02 5.400E+01 9.610E+02 4.410E+02 4.700E+01 1.350E+02 5.500E+01 6.000E+01 1.450E+02
PATTERN 3 301K-2 1 1.000000E+00 4.200E+01 1.200E+02 5.800E+01 4.500E+01 1.400E+02
1.164E+03 4.040E+02 5.600E+01 9.160E+02 4.460E+02 4.200E+01 1.200E+02 5.800E+01 4.500E+01 1.400E+02
PATTERN 4 401K-3A 1 1.000000E+00 3.000E+01 1.200E+02 5.300E+01 5.800E+01 1.300E+02
1.030E+03 3.730E+02 5.900E+01 9.200E+02 4.970E+02 3.000E+01 1.200E+02 5.300E+01 5.800E+01 1.300E+02
PATTERN 5 501K-1C 1 1.000000E+00 3.000E+01 9.700E+01 5.100E+01 5.400E+01 1.450E+02
1.077E+03 3.730E+02 5.500E+01 8.880E+02 4.550E+02 3.000E+01 9.700E+01 5.100E+01 5.400E+01 1.450E+02
PATTERN 6 601K-1D 1 1.000000E+00 4.100E+01 1.330E+02 6.000E+01 4.500E+01 1.550E+02
1.080E+03 4.030E+02 5.300E+01 9.190E+02 4.420E+02 4.100E+01 1.330E+02 6.000E+01 4.500E+01 1.550E+02
PATTERN 7 701K-3B 1 1.000000E+00 4.300E+01 1.190E+02 4.000E+01 5.000E+01 1.340E+02
1.020E+03 3.600E+02 5.900E+01 8.830E+02 4.730E+02 4.300E+01 1.190E+02 4.000E+01 5.000E+01 1.340E+02
PATTERN 8 801K-4R 1 1.000000E+00 4.800E+01 1.400E+02 7.400E+01 7.100E+01 1.570E+02
1.050E+03 3.960E+02 5.600E+01 9.240E+02 4.620E+02 4.800E+01 1.400E+02 7.400E+01 7.100E+01 1.570E+02
PATTERN 9 901K-4B 1 1.000000E+00 5.100E+01 1.370E+02 6.100E+01 5.800E+01 1.520E+02
1.100E+03 3.730E+02 5.300E+01 9.100E+02 4.770E+02 5.100E+01 1.370E+02 6.100E+01 5.800E+01 1.520E+02
PATTERN 10 102BL-1 2 2.000000E+00 4.000E+01 1.210E+02 2.000E+01 5.300E+01 7.300E+01
1.100E+03 2.570E+02 1.000E+01 9.400E+02 4.310E+02 4.000E+01 1.210E+02 2.000E+01 5.300E+01 7.300E+01
PATTERN 11 202BL-2 2 2.000000E+00 4.400E+01 1.170E+02 2.000E+01 4.400E+01 7.300E+01
1.210E+03 2.760E+02 1.000E+01 9.650E+02 4.300E+02 4.400E+01 1.170E+02 2.000E+01 4.400E+01 7.300E+01
PATTERN 12 302BL-3 2 2.000000E+00 4.300E+01 1.150E+02 2.500E+01 5.800E+01 7.300E+01
1.205E+03 2.910E+02 1.000E+01 9.750E+02 4.200E+02 4.300E+01 1.150E+02 2.500E+01 5.800E+01 7.300E+01
PATTERN 13 402 2 2.000000E+00 3.700E+01 1.220E+02 1.500E+01 6.500E+01 7.500E+01
9.200E+02 2.150E+02 6.000E+00 8.500E+02 4.350E+02 3.700E+01 1.220E+02 1.500E+01 6.500E+01 7.500E+01
PATTERN 14 502BL-6 2 2.000000E+00 4.000E+01 1.450E+02 2.500E+01 6.500E+01 9.500E+01
1.100E+03 2.670E+02 1.000E+01 9.100E+02 4.100E+02 4.000E+01 1.450E+02 2.500E+01 6.500E+01 9.500E+01
PATTERN 15 602BL-7 2 2.000000E+00 4.900E+01 1.450E+02 3.800E+01 6.800E+01 6.500E+01
1.190E+03 2.800E+02 1.000E+01 8.720E+02 4.100E+02 4.900E+01 1.450E+02 3.800E+01 6.800E+01 6.500E+01
PATTERN 16 702BL-8 2 2.000000E+00 3.300E+01 1.150E+02 2.000E+01 5.500E+01 5.300E+01
0.600E+02 1.020E+02 7.000E+00 7.220E+02 4.100E+02 3.300E+01 1.150E+02 2.000E+01 5.500E+01 5.300E+01
PATTERN 17 103SH-1 3 3.000000E+00 3.400E+01 1.180E+02 2.500E+01 6.500E+01 1.650E+02
9.520E+02 1.310E+02 3.700E+01 3.200E+02 4.300E+02 3.400E+01 1.180E+02 2.500E+01 6.500E+01 1.650E+02
PATTERN 18 203SH-15 3 3.000000E+00 3.100E+01 1.250E+02 1.800E+01 5.900E+01 1.630E+02
9.330E+02 1.200E+02 3.600E+01 3.210E+02 4.100E+02 3.100E+01 1.250E+02 1.800E+01 5.900E+01 1.630E+02
PATTERN 19 303SH-51 3 3.000000E+00 3.400E+01 1.210E+02 1.500E+01 5.200E+01 1.610E+02
9.990E+02 1.290E+02 3.800E+01 3.430E+02 4.400E+02 3.400E+01 1.210E+02 1.500E+01 5.200E+01 1.610E+02
PATTERN 20 403SH-68 3 3.000000E+00 3.600E+01 1.110E+02 1.800E+01 5.300E+01 1.470E+02
9.750E+02 1.360E+02 3.800E+01 3.370E+02 4.100E+02 3.600E+01 1.110E+02 1.800E+01 5.300E+01 1.470E+02
PATTERN 21 503SH-2 3 3.000000E+00 2.700E+01 9.500E+01 1.500E+01 5.500E+01 1.340E+02
8.850E+02 1.100E+02 3.200E+01 3.540E+02 3.820E+02 2.700E+01 9.500E+01 1.500E+01 5.500E+01 1.340E+02
PATTERN 22 603SH-3 3 3.000000E+00 3.000E+01 1.050E+02 1.500E+01 4.700E+01 1.510E+02
9.200E+02 1.270E+02 3.700E+01 3.370E+02 4.550E+02 3.000E+01 1.050E+02 1.500E+01 4.700E+01 1.510E+02
PATTERN 23 703SH-5 3 3.000000E+00 3.400E+01 1.060E+02 1.500E+01 6.000E+01 1.550E+02
8.900E+02 1.220E+02 3.300E+01 3.150E+02 3.800E+02 3.400E+01 1.060E+02 1.500E+01 6.000E+01 1.550E+02
PATTERN 24 803SH-13 3 3.000000E+00 3.100E+01 1.000E+02 1.000E+01 5.500E+01 1.970E+02
8.400E+02 1.330E+02 4.200E+01 3.200E+02 4.030E+02 3.100E+01 1.000E+02 1.000E+01 5.500E+01 1.970E+02
PATTERN 25 124ANA-1 4 4.000000E+00 6.400E+01 9.700E+01 4.800E+01 5.000E+01 1.010E+02
1.720E+03 3.920E+02 5.800E+01 8.950E+02 3.440E+02 6.400E+01 9.700E+01 4.800E+01 5.000E+01 1.010E+02
PATTERN 26 224ANA-2 4 4.000000E+00 6.500E+01 8.300E+01 4.700E+01 6.000E+01 2.030E+02
1.525E+03 2.700E+02 5.400E+01 8.600E+02 3.450E+02 6.500E+01 8.300E+01 4.700E+01 6.000E+01 2.030E+02
PATTERN 27 324ANA-3 4 4.000000E+00 5.900E+01 8.600E+01 4.200E+01 4.900E+01 1.870E+02
1.965E+03 3.740E+02 5.400E+01 8.130E+02 2.950E+02 5.900E+01 8.600E+01 4.200E+01 4.900E+01 1.870E+02
PATTERN 28 424ANA-4 4 4.000000E+00 6.400E+01 9.100E+01 4.400E+01 4.200E+01 1.070E+02
1.785E+03 4.410E+02 6.500E+01 8.350E+02 3.100E+02 6.400E+01 9.100E+01 4.400E+01 4.200E+01 1.070E+02
PATTERN 29 524ANA-5 4 4.000000E+00

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PATTERN 30 2.940E+03 6.000E+01 3.100E+02 3.070E+02 6.700E+01 5.100E+01 3.900E+01 3.800E+01 1.930E+02
PATTERN 31 1.310E+03 5.400E+01 9.340E+02 3.200E+02 6.700E+01 5.300E+01 3.300E+01 3.600E+01 2.200E+02
PATTERN 32 4.050E+02 5.000E+01 9.600E+02 3.110E+02 5.840E+01 8.300E+01 4.700E+01 6.000E+01 1.500E+02
PATTERN 33 3.650E+02 3.900E+01 8.450E+02 2.500E+02 3.200E+01 8.500E+01 4.700E+01 4.500E+01 1.900E+02
PATTERN 34 3.100E+02 5.400E+01 8.570E+02 3.200E+02 6.000E+01 7.100E+01 2.700E+01 4.700E+01 1.840E+02
PATTERN 35 4.250E+02 3.000E+01 8.970E+02 3.100E+02 6.500E+01 5.300E+01 3.300E+01 4.400E+01 1.920E+02
PATTERN 36 2.690E+02 5.600E+01 9.150E+02 3.500E+02 6.400E+01 5.600E+01 4.700E+01 5.200E+01 1.940E+02
PATTERN 37 3.330E+02 5.500E+01 1.010E+03 3.450E+02 7.400E+01 5.400E+01 4.500E+01 6.100E+01 2.170E+02
PATTERN 38 3.600E+02 5.500E+01 9.450E+02 3.550E+02 6.000E+01 1.000E+02 4.700E+01 5.300E+01 1.830E+02
PATTERN 39 3.420E+02 5.600E+01 9.200E+02 3.600E+02 5.100E+01 5.100E+01 4.500E+01 5.900E+01 2.150E+02
PATTERN 40 3.500E+02 5.700E+01 9.200E+02 3.470E+02 6.700E+01 5.300E+01 4.200E+01 7.100E+01 1.900E+02
PATTERN 41 3.270E+02 6.500E+01 9.400E+02 3.230E+02 5.900E+01 8.600E+01 4.400E+01 5.000E+01 2.000E+02
PATTERN 42 3.850E+02 5.900E+01 9.350E+02 2.950E+02 5.900E+01 8.700E+01 2.200E+01 6.000E+01 2.030E+02
PATTERN 43 3.370E+02 5.000E+01 8.500E+02 3.200E+02 6.600E+01 9.200E+01 4.800E+01 6.600E+01 2.120E+02
PATTERN 44 3.250E+02 6.200E+01 9.300E+02 3.500E+02 6.600E+01 8.900E+01 5.000E+01 6.300E+01 2.240E+02
PATTERN 45 3.530E+02 5.900E+01 8.750E+02 3.180E+02 5.000E+01 9.100E+01 4.100E+01 5.000E+01 2.030E+02
PATTERN 46 3.160E+02 5.400E+01 9.130E+02 3.470E+02 8.300E+01 8.200E+01 5.700E+01 6.600E+01 2.050E+02
PATTERN 47 1.140E+02 9.000E+00 5.340E+02 4.040E+02 2.600E+01 1.100E+02 2.500E+01 5.000E+01 5.500E+01
PATTERN 48 1.830E+02 8.000E+00 6.260E+02 4.520E+02 3.400E+01 1.210E+02 1.500E+01 5.800E+01 7.000E+01
PATTERN 49 3.900E+02 5.500E+01 9.200E+02 4.600E+02 4.500E+01 1.200E+02 5.700E+01 5.800E+01 1.420E+02
PATTERN 50 3.000E+02 7.000E+00 7.830E+02 4.260E+02 4.100E+01 1.050E+02 1.500E+01 5.700E+01 6.700E+01
PATTERN 51 1.950E+02 4.400E+01 8.650E+02 3.700E+02 3.600E+01 3.700E+01 1.000E+01 5.600E+01 1.600E+02
PATTERN 52 1.270E+02 3.300E+01 4.750E+02 4.300E+02 3.400E+01 5.600E+01 5.000E+00 6.000E+01 1.550E+02
PATTERN 53 1.190E+02 3.700E+01 3.100E+02 4.400E+02 3.400E+01 1.080E+02 3.000E+01 1.750E+02
PATTERN 54 1.380E+02 4.100E+01 3.570E+02 4.500E+02 3.400E+01 1.100E+02 2.000E+01 6.200E+01 1.570E+02
PATTERN 55 3.570E+02 6.500E+01 9.200E+02 4.550E+02 4.200E+01 1.120E+02 6.500E+01 5.500E+01 1.450E+02
PATTERN 56 1.400E+02 1.200E+01 6.090E+02 4.130E+02 3.500E+01 1.130E+02 1.590E+01 5.000E+01 7.000E+01
PATTERN 57 3.200E+02 5.000E+01 8.300E+02 4.400E+02 3.300E+01 1.100E+02 4.300E+01 6.000E+01 1.430E+02
PATTERN 58 1.850E+02 1.000E+01 4.630E+02 4.000E+02 3.100E+01 1.270E+02 1.500E+01 5.700E+01 8.700E+01
PATTERN 59 1.100E+02 3.400E+01 3.270E+02 3.370E+02 3.400E+01 9.200E+01 1.500E+01 6.500E+01 1.320E+02
PATTERN 60 1.100E+02 3.400E+01 3.270E+02 3.370E+02 3.400E+01 9.200E+01 1.500E+01 6.500E+01 1.320E+02

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PATTERN 61 1.310E+02 3.800E+01 3.600E+02 4.200E+02 3.700E+01 1.050E+02 1.000E+01 8.500E+01 1.500E+02
PATTERN 62 1.190E+02 3.700E+01 2.720E+02 3.340E+02 3.200E+01 1.170E+02 1.500E+01 5.000E+01 1.600E+02
PATTERN 63 1.350E+02 3.600E+01 3.350E+02 3.300E+02 3.200E+01 1.000E+02 1.500E+01 5.000E+01 1.300E+02
PATTERN 64 1.310E+02 3.200E+01 3.420E+02 3.850E+02 2.920E+01 1.000E+02 1.000E+01 5.500E+01 1.490E+02
PATTERN 65 1.560E+02 3.600E+01 2.790E+02 3.830E+02 3.100E+01 1.030E+02 1.500E+01 5.300E+01 1.470E+02
PATTERN 66 1.370E+02 3.500E+01 3.150E+02 3.800E+02 3.400E+01 1.100E+02 1.000E+01 6.000E+01 1.670E+02
PATTERN 67 1.330E+02 4.000E+01 3.100E+02 3.900E+02 3.500E+01 1.150E+02 1.500E+01 6.500E+01 1.800E+02
PATTERN 68 1.310E+02 3.600E+01 4.350E+02 3.920E+02 3.500E+01 1.080E+02 1.500E+01 5.400E+01 1.500E+02
PATTERN 69 1.470E+02 3.700E+01 3.180E+02 3.930E+02 3.200E+01 1.220E+02 2.000E+01 5.600E+01 1.740E+02
PATTERN 70 1.400E+02 4.000E+01 3.380E+02 3.940E+02 3.500E+01 1.180E+02 1.500E+01 6.100E+01 1.600E+02
PATTERN 71 1.460E+02 4.100E+01 3.600E+02 3.940E+02 3.320E+01 1.250E+02 1.500E+01 4.800E+01 1.700E+02
PATTERN 72 1.330E+02 4.000E+01 3.180E+02 3.900E+02 3.500E+01 1.150E+02 1.500E+01 6.500E+01 1.500E+02
PATTERN 73 1.400E+02 3.600E+01 3.350E+02 3.950E+02 3.300E+01 1.000E+02 1.000E+01 6.500E+01 1.700E+02
PATTERN 74 1.300E+02 3.500E+01 3.230E+02 3.950E+02 3.200E+01 1.030E+02 1.000E+01 5.500E+01 1.450E+02
PATTERN 75 1.420E+02 3.800E+01 4.850E+02 4.000E+02 3.700E+01 1.220E+02 1.500E+01 6.000E+01 1.550E+02
PATTERN 76 1.330E+02 3.500E+01 3.170E+02 4.060E+02 3.500E+01 1.200E+02 1.500E+01 5.000E+01 1.900E+02

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CLASS 1 IS CALLED 1
CLASS 2 IS CALLED 2
CLASS 3 IS CALLED 3
CLASS 4 IS CALLED 4

TRAINING PATTERN IDS FOLLOW

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
41	42	43	44	45																

CLASS 1 CONTAINS 5 PATTERNS IN TRAINING SET
CLASS 2 CONTAINS 7 PATTERNS IN TRAINING SET
CLASS 3 CONTAINS 8 PATTERNS IN TRAINING SET
CLASS 4 CONTAINS 21 PATTERNS IN TRAINING SET

PS-INT COMPLETE IN 0.56 SECONDS

RAW DATA

1	1.00000																			
2	1.07257	2			1.00000															
3	1.05600	3	2		0.57897	3	3	1.00000												
4	1.07010	4	2		0.88374	4	3	0.37724	4					1.00000						
5	1.06610	5	2		0.10794	5	3	-0.37479	5	4			-0.07563	5	5	1.00000				
6	1.03400	6	2		0.70737	6	3	0.55673	6	4			0.68211	6	5	-0.59705	6	6	1.00000	
7	1.05828	7	2		-0.18057	7	3	-0.44355	7	4			-0.12853	7	5	-0.61747	7	6	-0.55125	
8	1.00000																			
9	1.05505	8	2		0.35111	8	3	0.53349	8	4			0.76751	8	5	-0.02757	8	6	0.59779	
10	1.06113	9	2		1.00000															
11	1.06843	9	2		-0.19339	9	3	-0.03733	9	4			-0.13042	9	5	0.08154	9	6	0.00000	
12	1.06103	9	2		-0.07518	9	3	1.00000												
13	1.06115	10	2		0.27815	10	3	0.14113	10	4			0.07405	10	5	-0.55000	10	6	0.07500	


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10 10 1.000000
CORRELATION IN CORRELATION
1 1 0.73500 1 0.73500 8 2 0.25414 7 5 0.31747 10 3 0.31113 6 4 0.75251
2 1 0.72500 6 2 0.70237 6 4 0.70237 5 1 -0.66040 5 1 -0.66040
3 1 0.60755 7 1 -0.53828 8 6 0.59770 10 5 -0.59770 10 5 -0.59770
10 5 0.57926 3 2 0.57926 10 7 -0.57423 6 3 0.56372 8 1 0.53396 7 6 -0.55126
PPPP COMPLETE IN 0.23 SECONDS
VARIABLE-ADJUSTED PROPERTY ANALYSIS FOR RAW DATA
1 1 0.74141 2 2 -0.03731 3 3 0.34155 4 4 -0.04215 5 5 -0.06823 6 6 0.65367
2 1 0.79100 8 8 -0.14673 9 9 0.07277 10 10 0.68548
DATA ON ADJUSTED VALUE OF CC
1 3 0.66023 2 7 -0.73100 3 1 0.74141 4 10 0.68548 5 6 0.65367 6 3 0.34155
2 3 -0.14673 8 3 0.07277 9 4 -0.05215 10 2 -0.03731
PPPP COMPLETE IN 0.09 SECONDS
AUTOSCALED RAW DATA WILL BE STORED IN AUTO WEIGHT CODE
FOR VARIABLE 1 XB= 1.1594000E+03 X2= 2.7497364E+03 WEIGHT= 1.5047660E+00
FOR VARIABLE 2 XB= 2.4722667E+02 X2= 9.5758297E+02 WEIGHT= 9.0721575E-01
FOR VARIABLE 3 XB= 4.1640000E+01 X2= 1.4743568E+02 WEIGHT= 7.0239484E-01
FOR VARIABLE 4 XB= 6.6652000E+02 X2= 2.3570848E+03 WEIGHT= 8.4746270E-01
FOR VARIABLE 5 XB= 3.9773333E+02 X2= 4.5404258E+02 WEIGHT= 1.0733208E+00
FOR VARIABLE 6 XB= 4.4800000E+01 X2= 1.1902941E+02 WEIGHT= 1.0040747E+00
FOR VARIABLE 7 XB= 1.0009333E+02 X2= 1.3934973E+02 WEIGHT= 6.6380323E-01
FOR VARIABLE 8 XB= 3.0173333E+01 X2= 1.5055480E+02 WEIGHT= 1.6191884E-01
FOR VARIABLE 9 XB= 5.6773333E+01 X2= 6.4491446E+01 WEIGHT= 9.1871087E-01
FOR VARIABLE 10 XB= 1.5294667E+02 X2= 3.7152360E+02 WEIGHT= 2.2383346E+00
AUTO COMPLETE IN 0.11 SECONDS
AUTOSCALED RAW DATA WILL BE STORED IN AUTO WEIGHT CODE
FOR VARIABLE 1 XB= 1.1594000E+03 X2= 2.7497364E+03 WEIGHT= 1.7041613E+00
FOR VARIABLE 2 XB= 2.4722667E+02 X2= 9.5758297E+02 WEIGHT= 1.5391639E+07
FOR VARIABLE 3 XB= 4.1640000E+01 X2= 1.4743568E+02 WEIGHT= 1.9602500E+05
FOR VARIABLE 4 XB= 6.6652000E+02 X2= 2.3570848E+03 WEIGHT= 4.8218937E+07
FOR VARIABLE 5 XB= 3.9773333E+02 X2= 4.5404258E+02 WEIGHT= 8.3871320E+06
FOR VARIABLE 6 XB= 4.4800000E+01 X2= 1.1902941E+02 WEIGHT= 3.1427900E+05
FOR VARIABLE 7 XB= 1.0009333E+02 X2= 1.3934973E+02 WEIGHT= 4.9100100E+05
FOR VARIABLE 8 XB= 3.0173333E+01 X2= 1.5055480E+02 WEIGHT= 1.1497910E+06
FOR VARIABLE 9 XB= 5.6773333E+01 X2= 6.4491446E+01 WEIGHT= 4.3196000E+04
FOR VARIABLE 10 XB= 1.5294667E+02 X2= 3.7152360E+02 WEIGHT= 8.9862240E+06
AUTO COMPLETE IN 0.31 SECONDS
AUTOSCALED RAW DATA WILL BE STORED IN AUTO WEIGHT CODE
FOR VARIABLE 1 XB= 1.1594000E+03 X2= 2.7497364E+03 WEIGHT= 1.3941268E-08
FOR VARIABLE 2 XB= 2.4722667E+02 X2= 9.5758297E+02 WEIGHT= 2.2335489E-07
FOR VARIABLE 3 XB= 4.1640000E+01 X2= 1.4743568E+02 WEIGHT= 1.6272599E-05
FOR VARIABLE 4 XB= 6.6652000E+02 X2= 2.3570848E+03 WEIGHT= 9.0695108E-03
FOR VARIABLE 5 XB= 3.9773333E+02 X2= 4.5404258E+02 WEIGHT= 2.9346795E-07
FOR VARIABLE 6 XB= 4.4800000E+01 X2= 1.1902941E+02 WEIGHT= 6.2068405E-05
FOR VARIABLE 7 XB= 1.0009333E+02 X2= 1.3934973E+02 WEIGHT= 4.7234201E-06
FOR VARIABLE 8 XB= 3.0173333E+01 X2= 1.5055480E+02 WEIGHT= 2.5815845E-06
FOR VARIABLE 9 XB= 5.6773333E+01 X2= 6.4491446E+01 WEIGHT= 6.3079543E-05
FOR VARIABLE 10 XB= 1.5294667E+02 X2= 3.7152360E+02 WEIGHT= 2.4505511E-07
AUTO COMPLETE IN 0.31 SECONDS
AUTOSCALED RAW DATA WILL BE STORED IN AUTO WEIGHT CODE
FOR VARIABLE 1 XB= 1.1594000E+03 X2= 2.7497364E+03 WEIGHT= 2.3759170E+00
FOR VARIABLE 2 XB= 2.4722667E+02 X2= 9.5758297E+02 WEIGHT= 3.5693739E+00
FOR VARIABLE 3 XB= 4.1640000E+01 X2= 1.4743568E+02 WEIGHT= 3.183361E+00
FOR VARIABLE 4 XB= 6.6652000E+02 X2= 2.3570848E+03 WEIGHT= 4.3732217E+00
FOR VARIABLE 5 XB= 3.9773333E+02 X2= 4.5404258E+02 WEIGHT= 2.4613545E+00
FOR VARIABLE 6 XB= 4.4800000E+01 X2= 1.1902941E+02 WEIGHT= 2.1705749E+00
FOR VARIABLE 7 XB= 1.0009333E+02 X2= 1.3934973E+02 WEIGHT= 2.3192040E+00
FOR VARIABLE 8 XB= 3.0173333E+01 X2= 1.5055480E+02 WEIGHT= 2.9682827E+00
FOR VARIABLE 9 XB= 5.6773333E+01 X2= 6.4491446E+01 WEIGHT= 2.7247840E+00
FOR VARIABLE 10 XB= 1.5294667E+02 X2= 3.7152360E+02 WEIGHT= 2.7247840E+00

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FOR VARIABLE 10 XB= 1.5294667E+02 X2= 3.7152360E+02 WEIGHT= 2.2383346E+00
AUTO COMPLETE IN 0.38 SECONDS
AUTOSCALED AUTO WILL BE STORED IN AUTO WEIGHT CODE -0
FOR VARIABLE 1 XB= 1.1720100E+14 X2= 2.3750170E+03 WEIGHT= 1.0000000E+00
FOR VARIABLE 2 XB= 1.2759760E+14 X2= 3.5693739E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 3 XB= 2.0011600E+15 X2= 3.1898361E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 4 XB= 6.2917731E+15 X2= 4.3732217E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 5 XB= 4.0356287E+15 X2= 2.4613545E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 6 XB= 2.0724163E+15 X2= 2.1705749E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 7 XB= 1.1131836E+15 X2= 2.3192040E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 8 XB= 8.1238119E+15 X2= 2.9682827E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 9 XB= 2.7059836E+15 X2= 2.7247840E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 10 XB= 6.8804222E+15 X2= 2.2383346E+00 WEIGHT= 1.0000000E+00
AUTO COMPLETE IN 0.09 SECONDS
K-L TRANSFORMATION ON AUTO STORING RESULTS IN AUTO RETAINING 10 VARIABLES
100.000 PERCENT SCATTER RETAINED
5.251939E+00 2.478423E+00 1.081521E+00 8.301904E-01 2.945452E-01 1.744321E-01 1.284490E-01 6.938496E-02
5.596997E-02 3.472058E-02
PPPP COMPLETE IN 0.46 SECONDS
AUTOSCALED RAW DATA WILL BE STORED IN AUTO WEIGHT CODE -0
FOR VARIABLE 1 XB= 1.1594000E+03 X2= 2.7497364E+03 WEIGHT= 1.0000000E+00
FOR VARIABLE 2 XB= 2.4722667E+02 X2= 9.5758297E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 3 XB= 4.1640000E+01 X2= 1.4743568E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 4 XB= 6.6652000E+02 X2= 2.3570848E+03 WEIGHT= 1.0000000E+00
FOR VARIABLE 5 XB= 3.9773333E+02 X2= 4.5404258E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 6 XB= 4.4800000E+01 X2= 1.1902941E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 7 XB= 1.0009333E+02 X2= 1.3934973E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 8 XB= 3.0173333E+01 X2= 1.5055480E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 9 XB= 5.6773333E+01 X2= 6.4491446E+01 WEIGHT= 1.0000000E+00
FOR VARIABLE 10 XB= 1.5294667E+02 X2= 3.7152360E+02 WEIGHT= 1.0000000E+00
AUTO COMPLETE IN 0.10 SECONDS
SELECTION OF VARIABLES FROM AUTO STORING IN AUTO AND RETAINING 10 RETAINING CODE IS -0
VARIABLE 1 WAS 3 CC= -0.66823
VARIABLE 2 WAS 1 CC= -0.26774
VARIABLE 3 WAS 1 CC= -0.43602
VARIABLE 4 WAS 1 CC= -0.09751
VARIABLE 5 WAS 3 CC= -0.05863
VARIABLE 6 WAS 10 CC= -0.06993
VARIABLE 7 WAS 9 CC= -0.05126
VARIABLE 8 WAS 6 CC= -0.03995
VARIABLE 9 WAS 4 CC= -0.03218
VARIABLE 10 WAS 8 CC= -0.01749
AUTO COMPLETE IN 0.42 SECONDS
AUTOSCALED RAW DATA WILL BE STORED IN AUTO WEIGHT CODE -0
FOR VARIABLE 1 XB= 1.1594000E+03 X2= 2.7497364E+03 WEIGHT= 1.0000000E+00
FOR VARIABLE 2 XB= 2.4722667E+02 X2= 9.5758297E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 3 XB= 4.1640000E+01 X2= 1.4743568E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 4 XB= 6.6652000E+02 X2= 2.3570848E+03 WEIGHT= 1.0000000E+00
FOR VARIABLE 5 XB= 3.9773333E+02 X2= 4.5404258E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 6 XB= 4.4800000E+01 X2= 1.1902941E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 7 XB= 1.0009333E+02 X2= 1.3934973E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 8 XB= 3.0173333E+01 X2= 1.5055480E+02 WEIGHT= 1.0000000E+00
FOR VARIABLE 9 XB= 5.6773333E+01 X2= 6.4491446E+01 WEIGHT= 1.0000000E+00
FOR VARIABLE 10 XB= 1.5294667E+02 X2= 3.7152360E+02 WEIGHT= 1.0000000E+00
AUTO COMPLETE IN 0.10 SECONDS
AUTO SLT AND STORED IN SLT DATA
AUTO COMPLETE IN 0.51 SECONDS
AUTOSCALED SLT DATA WILL BE STORED IN SLT DATA WEIGHT CODE -0
FOR VARIABLE 1 XB= 4.0878234E-01 X2= 6.2111595E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 2 XB= 5.7750000E+00 X2= 6.7159000E+00 WEIGHT= 1.0000000E+00

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FOR VARIABLE 3 XB= 8.900700E-01 XZ= 7.5397403E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 4 XB= 1.0001907E-01 XZ= 5.4501827E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 5 XB= 2.5004011E-01 XZ= 5.6653710E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 6 XB= -1.3005000E-01 XZ= 6.9725764E+00 WEIGHT= 1.0000000E+00
AUTO COMPLETE IN 0.06 SECONDS
3-DIMENSIONAL PLOTTING OF SLT DATA
PERCENTAGE RETAINED 87.418
REPLOT COMPLETE IN 0.52 SECONDS
HISTOGRAM FOR PATTERN SET RPL DATA
PLOTS COMPLETE IN 3.27 SECONDS
NLM IN SLT DATA -0 350 -0 1.000E-04
PERCENTAGE RETAINED 87.418
ITERATION 1 1.54553E+00 2.58545E+00 4.75146E-01
ITERATION 2 1.45081E+00 1.94333E+00 6.23654E-02
ITERATION 3 1.43150E+00 1.45061E+00 1.32534E-02
ITERATION 4 1.42573E+00 1.43150E+00 4.04236E-03
ITERATION 5 1.42464E+00 1.42573E+00 7.60261E-04
ITERATION 6 1.42443E+00 1.42464E+00 1.47672E-04
ITERATION 7 1.42432E+00 1.42443E+00 8.26783E-05
ITERATION 8 1.42431E+00 1.42432E+00 7.75801E-06
NLM COMPLETE IN 17.95 SECONDS
AUTOSCALED SLT DATA WILL BE STORED IN SLT DATA WEIGHT CODE -0
FOR VARIABLE 1 XB= -5.6169292E-15 XZ= 1.0000000E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 2 XB= 4.0264080E-16 XZ= 1.0000000E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 3 XB= 1.1555941E-14 XZ= 1.0000000E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 4 XB= 5.2853426E-15 XZ= 1.0000000E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 5 XB= 4.5741189E-15 XZ= 1.0000000E+00 WEIGHT= 1.0000000E+00
FOR VARIABLE 6 XB= -2.2737368E-15 XZ= 1.0000000E+00 WEIGHT= 1.0000000E+00
AUTO COMPLETE IN 0.06 SECONDS
INTERPOLATED LEARNING FOR SLT DATA 1 -0 4 -0 1.00E-02

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MAXI-CONNECTION
AFTER CONNECTING 71 WITH 66 THERE ARE 74 CLUSTERS 1.00000E+00
AFTER CONNECTING 39 WITH 29 THERE ARE 73 CLUSTERS 9.99828E-01
AFTER CONNECTING 19 WITH 17 THERE ARE 72 CLUSTERS 9.99759E-01
AFTER CONNECTING 12 WITH 11 THERE ARE 71 CLUSTERS 9.99726E-01
AFTER CONNECTING 8 WITH 4 THERE ARE 70 CLUSTERS 9.99606E-01
AFTER CONNECTING 43 WITH 11 THERE ARE 69 CLUSTERS 9.99485E-01
AFTER CONNECTING 60 WITH 17 THERE ARE 68 CLUSTERS 9.99458E-01
AFTER CONNECTING 68 WITH 47 THERE ARE 67 CLUSTERS 9.99404E-01
AFTER CONNECTING 58 WITH 18 THERE ARE 66 CLUSTERS 9.99317E-01
AFTER CONNECTING 17 WITH 15 THERE ARE 65 CLUSTERS 9.99311E-01
AFTER CONNECTING 61 WITH 58 THERE ARE 64 CLUSTERS 9.99309E-01
AFTER CONNECTING 31 WITH 25 THERE ARE 63 CLUSTERS 9.99285E-01
AFTER CONNECTING 30 WITH 28 THERE ARE 62 CLUSTERS 9.99148E-01
AFTER CONNECTING 16 WITH 15 THERE ARE 61 CLUSTERS 9.99129E-01
AFTER CONNECTING 13 WITH 12 THERE ARE 60 CLUSTERS 9.99108E-01
AFTER CONNECTING 8 WITH 7 THERE ARE 59 CLUSTERS 9.99035E-01
AFTER CONNECTING 55 WITH 55 THERE ARE 58 CLUSTERS 9.98997E-01
AFTER CONNECTING 34 WITH 25 THERE ARE 57 CLUSTERS 9.98971E-01
AFTER CONNECTING 13 WITH 13 THERE ARE 56 CLUSTERS 9.98929E-01
AFTER CONNECTING 54 WITH 13 THERE ARE 55 CLUSTERS 9.98924E-01
AFTER CONNECTING 35 WITH 2 THERE ARE 54 CLUSTERS 9.98878E-01
AFTER CONNECTING 9 WITH 3 THERE ARE 53 CLUSTERS 9.98833E-01
AFTER CONNECTING 40 WITH 33 THERE ARE 52 CLUSTERS 9.98748E-01
AFTER CONNECTING 21 WITH 20 THERE ARE 51 CLUSTERS 9.98734E-01
AFTER CONNECTING 46 WITH 35 THERE ARE 50 CLUSTERS 9.98683E-01
AFTER CONNECTING 5 WITH 2 THERE ARE 49 CLUSTERS 9.98679E-01
AFTER CONNECTING 35 WITH 11 THERE ARE 48 CLUSTERS 9.98675E-01
AFTER CONNECTING 21 WITH 19 THERE ARE 47 CLUSTERS 9.98633E-01
AFTER CONNECTING 12 WITH 11 THERE ARE 46 CLUSTERS

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AFTER CONNECTING 26 WITH 18 THERE ARE 45 CLUSTERS 9.98578E-01
AFTER CONNECTING 41 WITH 11 THERE ARE 44 CLUSTERS 9.98541E-01
AFTER CONNECTING 39 WITH 11 THERE ARE 43 CLUSTERS 9.98325E-01
AFTER CONNECTING 26 WITH 24 THERE ARE 42 CLUSTERS 9.98314E-01
AFTER CONNECTING 16 WITH 14 THERE ARE 41 CLUSTERS 9.98312E-01
AFTER CONNECTING 8 WITH 2 THERE ARE 40 CLUSTERS 9.98291E-01
AFTER CONNECTING 16 WITH 14 THERE ARE 39 CLUSTERS 9.98342E-01
AFTER CONNECTING 28 WITH 19 THERE ARE 38 CLUSTERS 9.98300E-01
AFTER CONNECTING 38 WITH 10 THERE ARE 37 CLUSTERS 9.98295E-01
AFTER CONNECTING 16 WITH 13 THERE ARE 36 CLUSTERS 9.98280E-01
AFTER CONNECTING 11 WITH 10 THERE ARE 35 CLUSTERS 9.98134E-01
AFTER CONNECTING 27 WITH 2 THERE ARE 34 CLUSTERS 9.98103E-01
AFTER CONNECTING 18 WITH 13 THERE ARE 33 CLUSTERS 9.98090E-01
AFTER CONNECTING 19 WITH 13 THERE ARE 32 CLUSTERS 9.98064E-01
AFTER CONNECTING 31 WITH 10 THERE ARE 31 CLUSTERS 9.97940E-01
AFTER CONNECTING 15 WITH 13 THERE ARE 30 CLUSTERS 9.97498E-01
AFTER CONNECTING 25 WITH 10 THERE ARE 29 CLUSTERS 9.97444E-01
AFTER CONNECTING 13 WITH 12 THERE ARE 28 CLUSTERS 9.97123E-01
AFTER CONNECTING 4 WITH 2 THERE ARE 27 CLUSTERS 9.97000E-01
AFTER CONNECTING 25 WITH 9 THERE ARE 26 CLUSTERS 9.96673E-01
AFTER CONNECTING 4 WITH 2 THERE ARE 25 CLUSTERS 9.96595E-01
AFTER CONNECTING 12 WITH 10 THERE ARE 24 CLUSTERS 9.96535E-01
AFTER CONNECTING 12 WITH 10 THERE ARE 23 CLUSTERS 9.96401E-01
AFTER CONNECTING 13 WITH 10 THERE ARE 22 CLUSTERS 9.96097E-01
AFTER CONNECTING 3 WITH 2 THERE ARE 21 CLUSTERS 9.95836E-01
AFTER CONNECTING 6 WITH 4 THERE ARE 20 CLUSTERS 9.95796E-01
AFTER CONNECTING 18 WITH 8 THERE ARE 19 CLUSTERS 9.95769E-01
AFTER CONNECTING 16 WITH 6 THERE ARE 18 CLUSTERS 9.95675E-01
AFTER CONNECTING 17 WITH 6 THERE ARE 17 CLUSTERS 9.95472E-01
AFTER CONNECTING 10 WITH 3 THERE ARE 16 CLUSTERS 9.95450E-01
AFTER CONNECTING 2 WITH 1 THERE ARE 15 CLUSTERS 9.95152E-01
AFTER CONNECTING 14 WITH 10 THERE ARE 14 CLUSTERS 9.95042E-01
AFTER CONNECTING 3 WITH 2 THERE ARE 13 CLUSTERS 9.94928E-01
AFTER CONNECTING 5 WITH 4 THERE ARE 12 CLUSTERS 9.93377E-01
AFTER CONNECTING 10 WITH 2 THERE ARE 10 CLUSTERS 9.92855E-01
AFTER CONNECTING 9 WITH 1 THERE ARE 9 CLUSTERS 9.92735E-01
AFTER CONNECTING 8 WITH 4 THERE ARE 8 CLUSTERS 9.92725E-01
AFTER CONNECTING 3 WITH 2 THERE ARE 7 CLUSTERS 9.92528E-01
AFTER CONNECTING 5 WITH 4 THERE ARE 6 CLUSTERS 9.93217E-01
AFTER CONNECTING 6 WITH 5 THERE ARE 5 CLUSTERS 9.81919E-01
AFTER CONNECTING 5 WITH 1 THERE ARE 4 CLUSTERS 9.76002E-01

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1	1	2	2	3	3	4	4	5	5	6	1	7	1	8	1	9	1	10	2
11	1	2	1	3	2	4	1	2	15	2	16	2	17	3	19	3	19	3	20
21	3	22	3	23	3	24	4	35	4	36	4	37	4	38	4	39	4	40	4
41	4	42	4	43	4	44	4	45	4	46	4	47	4	48	4	49	4	50	1
51	3	52	3	53	3	54	1	55	2	56	1	57	2	58	3	59	1	60	3
61	2	62	3	63	3	64	3	65	3	66	3	67	3	68	3	69	3	70	3
71	3	72	3	73	3	74	3	75	3	76	3	77	3	78	3	79	3	80	3

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OCCUPANCY FOR CLUSTER 1
1 2 3 4 5 6 7 8 9 48 50 54 56 59
OCCUPANCY FOR CLUSTER 2
10 11 12 13 14 15 16 46 47 49 55 57
OCCUPANCY FOR CLUSTER 3
17 18 19 20 21 22 23 24 31 32 33 34 35 36 37 38 39 40 41 42 43 44
OCCUPANCY FOR CLUSTER 4
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44

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CENTROID CONNECTION

AFTER CONNECTING	71 WITH	66 THERE ARE	74 CLUSTERS	1.00000E+00
AFTER CONNECTING	39 WITH	29 THERE ARE	73 CLUSTERS	9.99828E-01
AFTER CONNECTING	19 WITH	17 THERE ARE	72 CLUSTERS	9.99758E-01
AFTER CONNECTING	12 WITH	11 THERE ARE	71 CLUSTERS	9.99726E-01
AFTER CONNECTING	8 WITH	4 THERE ARE	70 CLUSTERS	9.99686E-01
AFTER CONNECTING	39 WITH	9 THERE ARE	69 CLUSTERS	9.99489E-01
AFTER CONNECTING	55 WITH	13 THERE ARE	68 CLUSTERS	9.99458E-01
AFTER CONNECTING	61 WITH	41 THERE ARE	67 CLUSTERS	9.99404E-01
AFTER CONNECTING	51 WITH	13 THERE ARE	66 CLUSTERS	9.99317E-01
AFTER CONNECTING	58 WITH	53 THERE ARE	65 CLUSTERS	9.99309E-01
AFTER CONNECTING	57 WITH	25 THERE ARE	64 CLUSTERS	9.99260E-01
AFTER CONNECTING	24 WITH	22 THERE ARE	63 CLUSTERS	9.99148E-01
AFTER CONNECTING	10 WITH	9 THERE ARE	62 CLUSTERS	9.99108E-01
AFTER CONNECTING	7 WITH	6 THERE ARE	61 CLUSTERS	9.99035E-01
AFTER CONNECTING	50 WITH	8 THERE ARE	60 CLUSTERS	9.99031E-01
AFTER CONNECTING	45 WITH	44 THERE ARE	59 CLUSTERS	9.98997E-01
AFTER CONNECTING	44 WITH	9 THERE ARE	58 CLUSTERS	9.98924E-01
AFTER CONNECTING	27 WITH	2 THERE ARE	57 CLUSTERS	9.98878E-01
AFTER CONNECTING	31 WITH	25 THERE ARE	56 CLUSTERS	9.98803E-01
AFTER CONNECTING	49 WITH	9 THERE ARE	55 CLUSTERS	9.98676E-01
AFTER CONNECTING	44 WITH	36 THERE ARE	54 CLUSTERS	9.98630E-01
AFTER CONNECTING	48 WITH	42 THERE ARE	53 CLUSTERS	9.98601E-01
AFTER CONNECTING	21 WITH	18 THERE ARE	52 CLUSTERS	9.98514E-01
AFTER CONNECTING	41 WITH	32 THERE ARE	51 CLUSTERS	9.98470E-01
AFTER CONNECTING	36 WITH	5 THERE ARE	50 CLUSTERS	9.98376E-01
AFTER CONNECTING	38 WITH	11 THERE ARE	49 CLUSTERS	9.98367E-01
AFTER CONNECTING	23 WITH	6 THERE ARE	48 CLUSTERS	9.98134E-01
AFTER CONNECTING	41 WITH	8 THERE ARE	47 CLUSTERS	9.98093E-01
AFTER CONNECTING	14 WITH	13 THERE ARE	46 CLUSTERS	9.98064E-01
AFTER CONNECTING	13 WITH	7 THERE ARE	45 CLUSTERS	9.97912E-01
AFTER CONNECTING	33 WITH	26 THERE ARE	44 CLUSTERS	9.97783E-01
AFTER CONNECTING	43 WITH	39 THERE ARE	43 CLUSTERS	9.97699E-01
AFTER CONNECTING	32 WITH	3 THERE ARE	42 CLUSTERS	9.97694E-01
AFTER CONNECTING	33 WITH	32 THERE ARE	41 CLUSTERS	9.97601E-01
AFTER CONNECTING	36 WITH	11 THERE ARE	40 CLUSTERS	9.97573E-01
AFTER CONNECTING	20 WITH	16 THERE ARE	39 CLUSTERS	9.97521E-01
AFTER CONNECTING	37 WITH	34 THERE ARE	38 CLUSTERS	9.97138E-01
AFTER CONNECTING	30 WITH	27 THERE ARE	37 CLUSTERS	9.96862E-01
AFTER CONNECTING	36 WITH	30 THERE ARE	36 CLUSTERS	9.96653E-01
AFTER CONNECTING	23 WITH	3 THERE ARE	35 CLUSTERS	9.96277E-01
AFTER CONNECTING	10 WITH	7 THERE ARE	34 CLUSTERS	9.96097E-01
AFTER CONNECTING	30 WITH	28 THERE ARE	33 CLUSTERS	9.96061E-01
AFTER CONNECTING	27 WITH	26 THERE ARE	32 CLUSTERS	9.95988E-01
AFTER CONNECTING	28 WITH	6 THERE ARE	31 CLUSTERS	9.95979E-01
AFTER CONNECTING	20 WITH	6 THERE ARE	30 CLUSTERS	9.95979E-01
AFTER CONNECTING	25 WITH	19 THERE ARE	29 CLUSTERS	9.95682E-01
AFTER CONNECTING	17 WITH	14 THERE ARE	28 CLUSTERS	9.95460E-01
AFTER CONNECTING	15 WITH	9 THERE ARE	27 CLUSTERS	9.95003E-01
AFTER CONNECTING	7 WITH	3 THERE ARE	26 CLUSTERS	9.94925E-01
AFTER CONNECTING	17 WITH	11 THERE ARE	25 CLUSTERS	9.94600E-01
AFTER CONNECTING	17 WITH	16 THERE ARE	24 CLUSTERS	9.94593E-01
AFTER CONNECTING	13 WITH	11 THERE ARE	23 CLUSTERS	9.94339E-01
AFTER CONNECTING	18 WITH	9 THERE ARE	22 CLUSTERS	9.93894E-01
AFTER CONNECTING	13 WITH	5 THERE ARE	21 CLUSTERS	9.93623E-01
AFTER CONNECTING	17 WITH	14 THERE ARE	20 CLUSTERS	9.93331E-01
AFTER CONNECTING	6 WITH	2 THERE ARE	19 CLUSTERS	9.92773E-01
AFTER CONNECTING	10 WITH	8 THERE ARE	18 CLUSTERS	9.91146E-01
AFTER CONNECTING	12 WITH	1 THERE ARE	17 CLUSTERS	9.90241E-01

AFTER CONNECTING	10 WITH	6 THERE ARE	16 CLUSTERS	9.90230E-01
AFTER CONNECTING	11 WITH	7 THERE ARE	15 CLUSTERS	9.90065E-01
AFTER CONNECTING	10 WITH	9 THERE ARE	14 CLUSTERS	9.89818E-01
AFTER CONNECTING	11 WITH	9 THERE ARE	13 CLUSTERS	9.89189E-01
AFTER CONNECTING	8 WITH	4 THERE ARE	12 CLUSTERS	9.88535E-01
AFTER CONNECTING	10 WITH	1 THERE ARE	11 CLUSTERS	9.88092E-01
AFTER CONNECTING	0 WITH	0 THERE ARE	10 CLUSTERS	9.84294E-01
AFTER CONNECTING	6 WITH	4 THERE ARE	9 CLUSTERS	9.83687E-01
AFTER CONNECTING	3 WITH	2 THERE ARE	8 CLUSTERS	9.81819E-01
AFTER CONNECTING	5 WITH	2 THERE ARE	7 CLUSTERS	9.75693E-01

1	1	2	2	3	3	4	4	5	5	6	6	7	7						
1	2	2	2	3	3	4	4	5	5	6	6	7	7	8	2	9	2	10	5
11	5	12	5	13	3	14	5	15	5	16	5	17	7	18	7	19	7	20	7
21	7	22	7	23	7	24	7	25	4	26	4	27	4	28	1	29	4	30	4
31	4	32	4	33	4	34	4	35	4	36	4	37	4	38	4	39	4	40	4
41	4	42	4	43	4	44	4	45	4	46	3	47	3	48	2	49	5	50	6
51	7	52	7	53	7	54	2	55	3	56	2	57	3	58	7	59	6	60	7
61	7	62	7	63	7	64	7	65	7	66	7	67	7	68	7	69	7	70	7
71	7	72	7	73	7	74	7	75	7										

OCCUPANCY FOR CLUSTER

1	2	3	4	5	6	7	8	9	48	54	56								
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OCCUPANCY FOR CLUSTER

13	46	47	55	57															
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OCCUPANCY FOR CLUSTER

25	26	27	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
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OCCUPANCY FOR CLUSTER

10	11	12	14	15	16	49													
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OCCUPANCY FOR CLUSTER

50	59																		
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OCCUPANCY FOR CLUSTER

17	18	19	20	21	22	23	24	51	52	53	58	60	61	62	63	64	65	66	67
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AFTER CONNECTING

68	69	70	71	72	73	74	75	3 THERE ARE	6 CLUSTERS	9.55056E-01									
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AFTER CONNECTING

1	1	2	2	3	3	4	4	5	5	9.54855E-01									
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1	1	2	1	3	1	4	1	5	1	6	1	7	1	8	1	9	1	10	4
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11	4	12	4	13	4	14	4	15	4	16	4	17	3	18	3	19	3	20	3
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21	3	22	3	23	3	24	3	25	5	26	5	27	5	28	5	29	5	30	5
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31	5	32	5	33	5	34	5	35	5	36	5	37	5	38	5	39	5	40	5
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41	5	42	5	43	5	44	5	45	5	46	4	47	4	48	1	49	4	50	2
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51	3	52	3	53	3	54	1	55	4	56	1	57	4	58	3	59	2	60	3
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61	3	62	3	63	3	64	3	65	3	66	3	67	3	68	3	69	3	70	3
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71	3	72	3	73	3	74	3	75	3										
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OCCUPANCY FOR CLUSTER

1	2	3	4	5	6	7	8	9	48	54	56								
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OCCUPANCY FOR CLUSTER

50	59																		
----	----	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

OCCUPANCY FOR CLUSTER

17	18	19	20	21	22	23	24	51	52	53	58	60	61	62	63	64	65	66	67
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

OCCUPANCY FOR CLUSTER

68	69	70	71	72	73	74	75	15	16	46	47	48	55	57					
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	--	--	--	--	--

OCCUPANCY FOR CLUSTER

25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

AFTER CONNECTING

1	1	2	2	3	3	4	4	5	4	6	4	7	4	8	4	9	4	10	2
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----	---

11	2	12	2	13	2	14	2	15	2	16	2	17	1	18	1	19	1	20	1
----	---	----	---	----	---	----	---	----	---	----	---	----	---	----	---	----	---	----	---

21	1	22	1	23	1	24	1	25	3	26	3	27	3	28	3	29	3	30	3
----	---	----	---	----	---	----	---	----	---	----	---	----	---	----	---	----	---	----	---

10	3	32	3	33	3	34	3	35	3	36	3	37	3	38	3	39	3	40	3
11	3	42	3	43	3	44	3	45	3	46	2	47	2	48	4	49	2	50	4
12	1	52	1	53	1	54	4	55	2	56	4	57	2	58	1	59	4	60	1
13	1	62	1	63	1	64	1	65	1	66	1	67	1	68	1	69	1	70	1
14	1	72	1	73	1	74	1	75	1										
OCCUPANCY FOR CLUSTER																			
17	18	19	20	21	22	23	24	51	52	53	58	60	61	62	63	64	65	66	67
68	69	70	71	72	73	74	75												
OCCUPANCY FOR CLUSTER																			
10	11	12	13	14	15	16	45	47	49	55	57								
OCCUPANCY FOR CLUSTER																			
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44

[illegible]

```

      4      0      0      0      0      0
***** COMPLETE IN 1.07 SECONDS
***** FITTING ON PATTERN SET SLT DATA
***** NEXT PLOT FOLLOWS
*****
X=399E+00 -1.3854E+00 -0.5637E-01 7.2347E+00 3.0672E+00 1.5592E+00 2.7957E+00
 45  46      2.00000      1.93011
 47  47      2.00000      1.93943
 48  48      1.00000      1.11929

```

43	43	2.00000	2.17087
50	50	1.00000	2.24458
51	51	3.00000	2.76267
52	52	3.00000	2.93505
53	53	3.00000	2.02681
54	54	1.00000	1.02541
55	55	2.00000	1.99859
56	56	1.00000	1.01609
57	57	2.00000	2.00585
58	58	3.00000	2.97620
59	59	1.00000	1.69241
60	60	3.00000	3.09679
61	61	3.00000	3.11049
62	62	3.00000	3.42455
63	63	3.00000	3.13055
64	64	3.00000	2.96543
65	65	3.00000	3.21200
66	66	3.00000	3.31879
67	67	3.00000	2.54030
68	68	3.00000	2.94397
69	69	3.00000	3.18929
70	70	3.00000	3.13211
71	71	3.00000	3.31038
72	72	3.00000	3.06124
73	73	3.00000	3.40424
74	74	3.00000	3.19617
75	75	3.00000	2.92940

P8= 2.911111E+00 P2= 7.97775
LEAST COMPLETE IN 0.11 SECONDS

MULTICLASS LINEAR LEARNING ON SLT DATA SEP 16 16 23 3 2 SEP

46	46	Q2	2	SEP
47	47	Q2	2	SEP

47	47	Q2	2	SEP
48	48	Q1	1	SEP

49	49	Q2	2	SEP
50	50	Q1	1	SEP

50	50	Q1	1	SEP
51	51	Q3	3	SEP

52	52	Q3	3	SEP
53	53	Q3	3	SEP

53	53	03	3	SEP
54	54	01	1	SEP

54	54	Q1	1	52P
55	55	Q2	2	52P
56	56	Q3	3	52P
57	57	Q4	4	52P
58	58	Q5	5	52P
59	59	Q6	6	52P
60	60	Q7	7	52P
61	61	Q8	8	52P
62	62	Q9	9	52P
63	63	Q10	10	52P
64	64	Q11	11	52P
65	65	Q12	12	52P
66	66	Q13	13	52P
67	67	Q14	14	52P
68	68	Q15	15	52P
69	69	Q16	16	52P
70	70	Q17	17	52P
71	71	Q18	18	52P
72	72	Q19	19	52P
73	73	Q20	20	52P
74	74	Q21	21	52P
75	75	Q22	22	52P
76	76	Q23	23	52P
77	77	Q24	24	52P
78	78	Q25	25	52P
79	79	Q26	26	52P
80	80	Q27	27	52P
81	81	Q28	28	52P
82	82	Q29	29	52P
83	83	Q30	30	52P
84	84	Q31	31	52P
85	85	Q32	32	52P
86	86	Q33	33	52P
87	87	Q34	34	52P
88	88	Q35	35	52P
89	89	Q36	36	52P
90	90	Q37	37	52P
91	91	Q38	38	52P
92	92	Q39	39	52P
93	93	Q40	40	52P
94	94	Q41	41	52P
95	95	Q42	42	52P
96	96	Q43	43	52P
97	97	Q44	44	52P
98	98	Q45	45	52P
99	99	Q46	46	52P
100	100	Q47	47	52P
101	101	Q48	48	52P
102	102	Q49	49	52P
103	103	Q50	50	52P
104	104	Q51	51	52P
105	105	Q52	52	52P
106	106	Q53	53	52P
107	107	Q54	54	52P
108	108	Q55	55	52P
109	109	Q56	56	52P
110	110	Q57	57	52P
111	111	Q58	58	52P
112	112	Q59	59	52P
113	113	Q60	60	52P
114	114	Q61	61	52P
115	115	Q62	62	52P
116	116	Q63	63	52P
117	117	Q64	64	52P
118	118	Q65	65	52P
119	119	Q66	66	52P
120	120	Q67	67	52P
121	121	Q68	68	52P
122	122	Q69	69	52P
123	123	Q70	70	52P
124	124	Q71	71	52P
125	125	Q72	72	52P
126	126	Q73	73	52P
127	127	Q74	74	52P
128	128	Q75	75	52P
129	129	Q76	76	52P
130	130	Q77	77	52P
131	131	Q78	78	52P
132	132	Q79	79	52P
133	133	Q80	80	52P
134	134	Q81	81	52P
135	135	Q82	82	52P
136	136</			

56	56	Q1	1	SEP
57	57	Q2	2	SEP

57	57	02	2	SEP
58	58	03	3	SEP

59	59	Q1	1	SEP
60	60	Q3	7	SEP

60	60	Q3	3	SEP
61	61	Q3	3	SEP

61	61	63	3	SFP
62	62	63	3	SFP
63	63	63	3	SFP

63	67	Q3	3	SEP
64	64	Q3	3	SEP

64	64	03	3	SEP
65	65	03	3	SEP

66	65	03	3	0000
67	67	02	3	0000

67	67	03	67	03
68	68	03	68	03

096

70	70	03	3	28
71	71	03	3	29

71	71	03	3	SEP
72	72	03	7	SEP

73	73	03	3	SEP
74	74	03	3	SEP

74	74	03		
75	75	03		


```

NUMBER OUT OF 45 IN THE TRAINING SET
CLASS 1 0
CLASS 2 3
CLASS 3 0
CLASS 4 0
TIME TO COMPLETE IN 0.32 SECONDS
MINIMUM WORD STOP
FEEDBACK COMPLETE IN 59.46 SECONDS

```

III. PLOTTED OUTPUT

10. NO. PLOT FOR SLT DATA

CLASSIFICATION FOR SLT DATA USING ABLE

CLASSIFICATION FOR SLT DATA - BMDP DISPLAY

CLASSIFICATION FOR SLT DATA USING KLB

HIER-PPXI WITH 4 CLUSTERS

HIER-SUM WITH 4 CLUSTERS

Distribution - LLL

K. Booth, L-73
L. Cox, L-28
C. Cox, Jr./R. Pritchard/C. Bender, L-404 (50)
G. Dorough, L-82
K. Ernst, L-404
J. Frazer, L-401
V. Hampel, L-380
L. Hrubesh, L-404
G. Michaels, L-73
S. Root, L-401
H. Rizzo, L-402
C. Wetherell, L-607
M. Zosel, L-60
TID (5)

External Distribution

Col. G. J. Freyer
AFWL
Kirtland AFB, New Mexico 87117

Lt. P. W. Cockerham
AFML/DOY
Wright-Patterson AFB, Ohio 45433

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