EARTH RESOURCES LABORATORY

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CHOICE: 36 BAND FEATURE SELECTION SOFTWARE
WITH APPLICATIONS TO MULTISPECTRAL PATTERN RECOGNITION
BY: W.C. JONES

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FEATURE SELECTION SOFTWARE WITH
APPLICATIONS TO MULTISPECTRAL PATTERN
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LYNDON B. JOHNSON SPACE CENTER
CHOICE: 36 Band Feature Selection Software

with Applications to Multispectral Pattern Recognition

BY: W.C. Jones
ABSTRACT

Often a pattern recognition system is broken into two parts—feature selection and classification. This note deals with feature selection. In 1971, the Earth Resources Laboratory (ERL) received a version of the Purdue pattern recognition software (LARSYSA). ERL was preparing to process the very large quantities of data as output by the Bendix 24 channel scanner. Eppler's Digital Table Look-up Classifier (DTL) was being implemented at ERL primarily because of its speed advantage. The Purdue feature selection program was quite useful but was limited to twelve features (or channels) and did not select channel subsets in a manner suggested by Eppler to be used with his table look-up classifier. He suggested using a different subset of channels for each material (class), i.e., the subset which is best suited for detecting a particular material.

Feature selection software has been developed at ERL that is capable of inputting up to 36 channels and selecting channel subsets according to several criteria based on divergence. One of the criterion used is compatible with the table look-up classifier requirements. The software indicates which channel subset best "separates" (based on average divergence) each class from all other classes. The software employs an exhaustive search technique, and designing the software such that computer time did not become prohibitive was a major goal. A typical task to select the "best" 4 of 22 channels for 12 classes takes 9 minutes on a Univac 1108 computer.
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</table>
INTRODUCTION

A pattern recognition system is often broken into two parts - feature selection and classification. This note deals with feature selection. (For a much more detailed discussion of pattern recognition and feature selection, see [1, 11, 12].) In 1971, the Earth Resources Laboratory (ERL) received a version of the pattern recognition software LARSYSAA. This software was originally developed by the Laboratory for Application of Remote Sensing (LARS) at Purdue University. The system is well-known and is described by Landgrebe [8] and Ratcliff [16].

ERL was preparing to process the very large quantities of data as output by the Bendix 24 channel scanner [19]. Eppler's Digital Table Look-up Classifier (DTL) was being implemented at ERL primarily because of its speed advantage [4]. The LARSYSAA feature selection program ($SELECT) was quite useful, but it was limited to 12 channels and did not rank the channel subsets in a manner suggested by Eppler, i.e., by the four channels which were best suited for detecting a particular material (class). It was necessary to develop feature selection software which would handle more than 12 channels and would rank them in a manner more compatible with the DTL. This software - CHOICE - is coded completely in Fortran V and runs on a Univac 1108 computer. The maximum number of classes and channels are currently set at 32 and 24 respectively and the program uses less than 32K, i.e., 32,000 Univac 1108 computer words. These limits are not fixed. More details can be found in the discussions under Computation Time and Core.
FEATURE SELECTION

A brief description of the notions of pattern recognition and feature selection as they are often applied in processing multispectral scanner data follows.

A series of \( n \) measurements are made on an object. This series could be composed of measurements of intensity of spectral radiation in \( n \) bands (channels) of a multispectral scanner. A series of measurements on an object can be considered an \( n \)-dimensional observation vector. Given \( m \) multivariate normal populations (classes), we are to decide to which class the observation vector most likely belongs. In general, it is not practical to use all \( n \) measurements in making this decision (classification) because of computer time constraints. We want to select some subset \( k \) of \( n \) channels which will enable us to classify the data in an accurate manner. Often there are many subsets to choose from. For example, the DTL requires that \( k=4 \) and in working with 24 channel scanner data, there are more than 10,000 possible channel subsets - \( \binom{24}{4} \). We use divergence to help us choose a channel subset.

DIVERGENCE

All of the criteria used by CHOICE are based on divergence. The application of divergence to feature selection was proposed by Marill and Green [10], and an interesting discussion on the subject is given by Fu [11]. Divergence is given a very general definition by Kullback [7] and is based on considerations from information theory. Kullback argues that divergence is an appropriate "distance" between arbitrary distributions and asserts it to be "a measurement of the difficulty of discriminating" between two distributions [7, 10]. In the case of two multivariate normal populations with
equal covariance matrices, it can be shown that the probability of classification error is a monotonically decreasing function of divergence [11]. In the less restricted case of more than two populations with unequal covariance matrices, there is experimental support for using divergence [10].

Criteria based on divergence have come under attack because they have not been explicitly expressed in terms of probability of error in the more general cases. Further, specific examples can be cited where the average pairwise divergence criterion does not yield the minimum probability of error [6, 15]. Although these criticisms are valid, criteria based on divergence have proved to be a useful guide in working with multispectral scanner data and in attempting to improve classification results.

In the case of several multivariate normal populations (classes), the pairwise divergence between class $i$ and class $j$ reduces to:

$$J_{ij} = \frac{1}{2} \text{tr}\{(K_i - K_j)(K_j^{-1} - K_i^{-1})\} + \frac{1}{2} \text{tr}(u_i - u_j)^T(K_i^{-1} + K_j^{-1})(u_i - u_j)$$

(1)

where:

- tr - trace
- $T$ - transpose
- $u_i$ - $k \times 1$ mean vector of class $i$
- $K_i$ - $k \times k$ covariance matrix of class $i$
- $K_i^{-1}$ - inverse of the covariance matrix of class $i$

CHOICE actually computes the quantity $D_{ij}$, where $D_{ij} = 2(J_{ij})$.

Figure 1 illustrates some simple examples of class pairs and their associated divergences. The data from which these statistics were calculated were acquired by an aircraft borne 12 channel multispectral scanner.
Figure 1. Statistics calculated from actual data (flight line C-1). Note the relation between a large value of pairwise divergence and good separability.
This flight line (Flight line C-1) was flown June 28, 1966 for LARS and has been widely reported on [2, 9]. In Figure 1, probability density functions \( f_i(x) \) are plotted for four classes in the single channel case (channel 1). The mean response of channel 1 for soybeans (170.0) is the average reading of this channel as it "looked at" those soybean fields which were used in training the pattern recognition algorithm. The channel readings for a class are usually assumed to be normally distributed about the class's mean response. Thus, given the mean response and the standard deviation of these responses for soybean training fields, the probability density function for soybeans can be graphed. Figure 1 illustrates, and the pairwise divergence (\( Y_A = 3.1 \)) indicates, that channel 1 would not be a "good" channel to discriminate rye from alfalfa. However, it would be a "good" channel to separate soybeans from red clover as evidenced by the figure and by \( SR=56.9 \).

**CRITERIA**

Assume that we are given \( n \) channels and are asked to choose a subset \( k \) of these, where \( k < n \), by some criterion. CHOICE ranks the channel subsets by five separate criteria. The first two of these are the same as those available with $SELECT$. Unfortunately, there is no one criterion that is always "best". Thus, the software presents several rankings to the investigator. An example of these channel subset rankings with \( k=4 \) for each criterion is given in the Appendix under Example of Output. Data from Flight Line C-1 was used in producing this output and is also listed in the Appendix under Example of Input Data. Following is a description of the five criteria used by CHOICE:

Criterion 1: Maximizing the arithmetic mean of the pairwise divergences. The average pairwise divergence for a given channel set can be computed by
\[ \text{Div}_{\text{avg}} = \frac{1}{m(m-1)} \sum_{j=1}^{m-1} \sum_{i=j+1}^{m} \text{Di}, \text{ where } m \text{ is the number of classes} \]

This average is computed for all \( \binom{n}{k} \) possible subsets. The channel subsets which yield the largest averages are saved and printed.

Criterion 2. Maximizing the minimum pairwise divergence.

The minimum pairwise divergence for a given channel set is given by

\[ \text{Div}_{\text{min}} = \min \{ \text{Di} \}, i=1, m-1; j=i+1, m \]

The minimum is computed for all \( \binom{n}{k} \) subsets. Those subsets which produce the largest minimums are saved and printed.

Criterion 3. Maximizing the average divergence by class.

This is the criterion used at ERL most often in conjunction with the table look-up. Since the DTL can be run with a different set of channels for each class, this criterion is used to help decide which subset of channels best separates a class from all other classes. The average divergence for class \( j \) for a given channel set is computed by

\[ \text{Div}_{\text{avg}} (\text{class } j) = \frac{1}{m-1} \sum_{i=1}^{m} \text{D}_{ij}, i \neq j. \]

The class average is computed for all classes for each channel set. This is repeated for all possible channel sets. The channel subset which yields the largest average for each class is saved and printed.

Criterion 4. Maximizing the geometric mean of the pairwise divergences.

It seems reasonable to expect the difference between a divergence of 10 and 30 to be more important than the difference between a divergence of 50 and 70 even though the delta in both cases is 20. For example, in the one-dimensional two-class case with variances equal to one, we get the following:
<table>
<thead>
<tr>
<th>D_{ij}</th>
<th>Average Probability of Classification Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>13.14%</td>
</tr>
<tr>
<td>30</td>
<td>2.62</td>
</tr>
<tr>
<td>50</td>
<td>.62</td>
</tr>
<tr>
<td>70</td>
<td>.15</td>
</tr>
</tbody>
</table>

Criterion 4 gives more weight for an improvement in separation from 10 to 30 than for an improvement from 50 to 70. The more widely available criterion 1 considers these improvements of equal value. The geometric mean is computed for each channel subset as follows:

$$\text{Div}_{\text{geo}} = \frac{1}{m(m-1)^{m-1}} \prod_{j=1}^{m-1} \prod_{i=j+1}^{m} D_{ij}$$

This mean is computed for all possible subsets $^{(n)} \binom{k}$ and those channel subsets which yield the largest geometric means are saved and printed.

Criterion 5. Maximizing the pairwise divergence for each class pair. $D_{ij}$ is computed for each $\binom{n}{k}$ subset of channels. That channel set which yields the maximum divergence for each class pair is saved and printed. This is most useful in working with hard-to-separate classes. In the worst case, it will indicate to the investigator that no matter which channel set is selected, it will not be possible to separate the two classes. In less severe cases, it will indicate the most separability to be expected and which channel set will provide it. (This assumes that the channels will not be transformed. See discussion under Uses and [14].)

**COMPUTATION TIME**

There has been some discussion that it is not feasible to do an exhaustive search when the number of channels is large [2, 17]. By incorporating some efficiencies, we have found we can routinely process 24
channel scanner data using the exhaustive search technique. A typical task to select the "best" 4 of 22 channels for 12 classes takes 9 minutes on a Univac 1108 computer.

In order to handle more than 12 channels in a timely manner, we decided it would be necessary to rewrite the feature selection software and not just modify LARSYSAA. There were two key changes which accounted for considerable time-savings.

1. Input/Output

    No input/output (I/O) is done during the exhaustive search loop. Because of their generality, Fortran formatted read and write commands are quite expensive in both throughput and in execution time. CHOICE circumvents doing an I/O after each set of divergence calculations by immediately testing whether this channel set ranks in the top group of channel sets for each criterion. Each group is made up of those sets which have exceeded all the preceding channel sets in maximizing a particular criterion. If the set is not ranked in any top group, it is discarded. If it is top-ranked, then the channel set is saved using a bit manipulation function. With this technique only one 36 bit Univac 1108 word is required to store a channel set. (Hence the limitation of 36 channels.) At this point the pairwise divergences are discarded in order to conserve core. The search is continued until all possible subsets have been considered. At the completion of the search, the divergences for those top-ranked channel sets (which usually number less than 50) are recomputed and printed.

2. Matrix Inversion

    In a case where we have 12 classes and are asked to select the best 4 of 22 channels, we must perform over 85,000 matrix inversions, and these comprise a significant portion of the total computation time. A procedure
based on the bordering technique [5] was incorporated into CHOICE to invert
the lower triangular matrices. This procedure takes advantage of the fact
that the matrices are symmetric. In a test, this procedure was about five
times as fast as the more general and widely used matrix routine MINV.
MINV uses the Gauss-Jordan reduction technique and does not capitalize on
the symmetry of the matrices.

An empirical formula which can be used to roughly estimate the computa-
tion (CPU) time of CHOICE in minutes is:

\[
\text{time} = \frac{n \choose k \choose m}{50,000}
\]

where \( n \) = total number of channels
\( k \) = number of channels in subset to be chosen
\( m \) = number of classes

Take, for example, the theoretically important two-class case. Let us
estimate the time to choose the best 4 of 36 measurements.

\[
\text{time} = \frac{36 \choose 4 \choose 2}{50,000}
\]

\[
\text{time} = 1.2 \text{ minutes}
\]

CORE

CHOICE was written such that its core allocation can be easily changed
for different applications by changing parameter cards.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Meaning</th>
<th>Current Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>( m )</td>
<td>maximum number of classes</td>
<td>32</td>
</tr>
<tr>
<td>( n )</td>
<td>maximum number of channels</td>
<td>24</td>
</tr>
<tr>
<td>( k )</td>
<td>maximum size of best subset</td>
<td>12</td>
</tr>
<tr>
<td>Parameter</td>
<td>Meaning</td>
<td>Current Setting</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>-----------------</td>
</tr>
<tr>
<td>s</td>
<td>maximum number of show requests(^1)</td>
<td>10</td>
</tr>
<tr>
<td>P(_1)</td>
<td>maximum number of top-ranked sets to print for criteria 1 and 2</td>
<td>20</td>
</tr>
<tr>
<td>P(_2)</td>
<td>maximum number of top-ranked sets to print for criteria 3</td>
<td>10</td>
</tr>
</tbody>
</table>

The following formula can be used to calculate the amount of core required (in U1108 words).

\[
\text{Core} = 10,500 + m[n+n(n+1)/2+k+k(k+1)/2+4]+k(s+1)+n(n-1)(p_1+4)/2+4p_2
\]

All parameters must be greater than or equal to one. The number of channels must be less than or equal to 36, and the number of classes must be greater than or equal to 2.

**USES**

Just as with the LARSYSA separability processor, there are several areas in which the investigator may find CHOICE useful in processing multi-spectral data.

1) The primary purpose of the program is to indicate which subset of measurements might best be used in deciding to which of several classes an unknown element belongs.

2) The program can indicate those classes which cannot be separated with the given set of measurements, no matter which subset we choose. For example, CHOICE may indicate that white sand and concrete look spectrally very similar when observed from space under certain illumination conditions. The investigator must decide whether to group

\(^1\)A show request refers to a request by an investigator to see the pairwise divergence printed for a channel set of interest--one that is not necessarily top-ranked.
these materials into one class or to drop the materials from the classification.

3) Training fields for the same class can often be quite different spectrally. A decision must be made as to which training fields can be pooled into one population and which cannot. CHOICE can aid in this decision by indicating whether the two training fields are spectrally "close" or not. "Closeness" would be indicated by relatively low pairwise divergences.

4) Recently there has been developed a feature selection technique that seems very promising [13, 14]. Basically this technique determines a linear transformation $Bx$ which can be used to reduce the dimension of the data from $n$ to $k$ where $n$ is greater than $k$. This technique determines a $k$ by $n$ matrix $B$ which maximizes the so called $B$-average divergence. (One disadvantage of this technique is that it is currently limited to 9 classes.) It is recommended that the best $k$ of $n$ channels be chosen as the initial guess for the $B$ matrix [3]. This is done in order to increase the probability that the maximum found iteratively will be the global maximum. It seems that CHOICE could be quite useful in initializing $B$, especially when $n$ is greater than 12.

SUMMARY

In this note, feature selection software (CHOICE) was described. CHOICE was developed mainly to enable processing 24 channel scanner data and to rank the channel subsets in a manner more compatible with the table look-up
classifier. A brief justification of the use of divergence was given. The criteria used by CHOICE in ranking the various channel subsets were described. Computer time and core allocation were discussed. Finally, some of the ways the program has been used at ERL were given. The appendix gives an example of a CHOICE computer run with real data. It also provides a description of the software including logic flow and Fortran listings.
References


8. Landgrebe, D.A. and staff. LARS Information note 091968, "LARSYSAA, A Processing System for Airborne Earth Resources Data", Purdue University, Lafayette, Indiana.


Examples of Output

Task: Select the "best" 4 of 12 channels for 9 classes.
(data is from flight line C-1)

Computation time: 35 seconds
Criterion 1: Maximizing the arithmetic mean of the pairwise divergences. (top two sets).
DISPLAY OF CHANNELS RANKED ACCORDING TO AVERAGE PAIR-WISE DIVERGENCE.

CHANNELS: 1 9 11 12
AVERAGE PAIR-WISE DIVERGENCE: 442.0
MINIMAL PAIR-WISE DIVERGENCE: 22.8

RATIO OF THIS CHANNEL SET WITH CHANNEL SET YIELDING MAXIMUM PERCENT SEPARATION: .33

AVERAGE DIVERGENCE BY CLASS...
AVERAGE INTERCLASS DIVERGENCE FOR CLASS S = 173.702
AVERAGE INTERCLASS DIVERGENCE FOR CLASS C = 268.075
AVERAGE INTERCLASS DIVERGENCE FOR CLASS O = 180.512
AVERAGE INTERCLASS DIVERGENCE FOR CLASS M = 303.655
AVERAGE INTERCLASS DIVERGENCE FOR CLASS R = 654.247
AVERAGE INTERCLASS DIVERGENCE FOR CLASS A = 696.094
AVERAGE INTERCLASS DIVERGENCE FOR CLASS Y = 206.235
AVERAGE INTERCLASS DIVERGENCE FOR CLASS X = 1165.065
AVERAGE INTERCLASS DIVERGENCE FOR CLASS E = 339.305

PAIR-WISE DIVERGENCE
<table>
<thead>
<tr>
<th>CS</th>
<th>OS</th>
<th>OC</th>
<th>WC</th>
<th>WD</th>
<th>RS</th>
<th>RC</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.1</td>
<td>76.4</td>
<td>76.6</td>
<td>102.4</td>
<td>224.5</td>
<td>110.9</td>
<td>209.5</td>
<td>100.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AS</th>
<th>AC</th>
<th>AO</th>
<th>AW</th>
<th>AR</th>
<th>YS</th>
<th>YC</th>
<th>YR</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.7</td>
<td>219.7</td>
<td>75.0</td>
<td>86.4</td>
<td>96.4</td>
<td>50.1</td>
<td>752.3</td>
<td>24.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EA</th>
<th>ES</th>
<th>EC</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>239.5</td>
<td>346.8</td>
<td>325.3</td>
<td>24.6</td>
</tr>
</tbody>
</table>

CHANNELS: 6 9 11 12
AVERAGE PAIR-WISE DIVERGENCE: 429.7
MINIMAL PAIR-WISE DIVERGENCE: 24.6

RATIO OF THIS CHANNEL SET WITH CHANNEL SET YIELDING MAXIMUM PERCENT SEPARATION: .38

AVERAGE DIVERGENCE BY CLASS...
AVERAGE INTERCLASS DIVERGENCE FOR CLASS S = 137.740
AVERAGE INTERCLASS DIVERGENCE FOR CLASS C = 259.026
AVERAGE INTERCLASS DIVERGENCE FOR CLASS O = 171.964
AVERAGE INTERCLASS DIVERGENCE FOR CLASS M = 330.097
AVERAGE INTERCLASS DIVERGENCE FOR CLASS R = 647.225
AVERAGE INTERCLASS DIVERGENCE FOR CLASS A = 609.260
AVERAGE INTERCLASS DIVERGENCE FOR CLASS Y = 199.801
AVERAGE INTERCLASS DIVERGENCE FOR CLASS X = 1165.065
AVERAGE INTERCLASS DIVERGENCE FOR CLASS E = 339.305

PAIR-WISE DIVERGENCE
<table>
<thead>
<tr>
<th>CS</th>
<th>OS</th>
<th>OC</th>
<th>WC</th>
<th>WD</th>
<th>RS</th>
<th>RC</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>87.4</td>
<td>64.9</td>
<td>75.5</td>
<td>188.8</td>
<td>391.3</td>
<td>121.4</td>
<td>225.2</td>
<td>82.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AS</th>
<th>AC</th>
<th>AO</th>
<th>AW</th>
<th>AR</th>
<th>YS</th>
<th>YC</th>
<th>YR</th>
</tr>
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<tbody>
<tr>
<td>819.7</td>
<td>340.3</td>
<td>929.8</td>
<td>201.2</td>
<td>3190.0</td>
<td>3190.0</td>
<td>233.4</td>
<td>145.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EA</th>
<th>ES</th>
<th>EC</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>3190.0</td>
<td>145.6</td>
<td>337.7</td>
<td>281.5</td>
</tr>
</tbody>
</table>

18
Criterion 2: Maximizing the minimum pairwise divergence. (top two sets)
### Display of Channel Combinations Ranked According to Minimum Pair-Wise Divergence

<table>
<thead>
<tr>
<th>Channels:</th>
<th>1 0 10 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Pair-Wise Divergence</td>
<td>304.4</td>
</tr>
<tr>
<td>Minimum Pair-Wise Divergence</td>
<td>35.6</td>
</tr>
</tbody>
</table>

The ratio of this channel set with the channel set yielding maximum percent separation is .22.

#### Average Divergence by Class...

<table>
<thead>
<tr>
<th>Class</th>
<th>Average Interclass Divergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>132.384</td>
</tr>
<tr>
<td>C</td>
<td>323.847</td>
</tr>
<tr>
<td>O</td>
<td>336.477</td>
</tr>
<tr>
<td>W</td>
<td>244.477</td>
</tr>
<tr>
<td>R</td>
<td>311.805</td>
</tr>
<tr>
<td>A</td>
<td>423.008</td>
</tr>
<tr>
<td>Y</td>
<td>190.141</td>
</tr>
<tr>
<td>X</td>
<td>376.956</td>
</tr>
<tr>
<td>E</td>
<td>320.109</td>
</tr>
</tbody>
</table>

#### Average Pair-Wise Divergence

<table>
<thead>
<tr>
<th>Channels:</th>
<th>1 0 10 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Pair-Wise Divergence</td>
<td>305.2</td>
</tr>
<tr>
<td>Minimum Pair-Wise Divergence</td>
<td>34.1</td>
</tr>
</tbody>
</table>

The ratio of this channel set with the channel set yielding maximum percent separation is .13.

#### Average Divergence by Class...

<table>
<thead>
<tr>
<th>Class</th>
<th>Average Interclass Divergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>135.850</td>
</tr>
<tr>
<td>C</td>
<td>321.952</td>
</tr>
<tr>
<td>O</td>
<td>336.666</td>
</tr>
<tr>
<td>W</td>
<td>230.257</td>
</tr>
<tr>
<td>R</td>
<td>395.266</td>
</tr>
<tr>
<td>A</td>
<td>490.099</td>
</tr>
<tr>
<td>Y</td>
<td>196.095</td>
</tr>
<tr>
<td>X</td>
<td>546.950</td>
</tr>
<tr>
<td>E</td>
<td>303.221</td>
</tr>
</tbody>
</table>

#### Average Pair-Wise Divergence
Criterion 3: Maximizing the average divergence by class

1. Summary print. For example, channel set (1, 8, 11, 12) yields the largest average divergence for class Rye (Y)-223. Also, if this set is used, Bare Soil (X) has an average divergence of 924 from all other classes.

2. Expanded print. The first set is (1, 8, 11, 12); the "best" set for detecting Rye. The second set is (1, 9, 11, 12); the "best" set for detecting bare soil.
Matrix of divergences for channel set yielding the maximum separation of a class from all other classes

<table>
<thead>
<tr>
<th>Features</th>
<th>S</th>
<th>C</th>
<th>O</th>
<th>W</th>
<th>R</th>
<th>A</th>
<th>Y</th>
<th>X</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 9 11 12 S</td>
<td>174</td>
<td>268</td>
<td>180</td>
<td>304</td>
<td>654</td>
<td>696</td>
<td>206</td>
<td>1165</td>
<td>339</td>
</tr>
<tr>
<td>1 9 11 12 C</td>
<td>174</td>
<td>268</td>
<td>180</td>
<td>304</td>
<td>654</td>
<td>696</td>
<td>206</td>
<td>1165</td>
<td>339</td>
</tr>
<tr>
<td>1 9 11 12 O</td>
<td>174</td>
<td>268</td>
<td>180</td>
<td>304</td>
<td>654</td>
<td>696</td>
<td>206</td>
<td>1165</td>
<td>339</td>
</tr>
<tr>
<td>1 9 11 12 W</td>
<td>163</td>
<td>247</td>
<td>152</td>
<td>346</td>
<td>499</td>
<td>518</td>
<td>204</td>
<td>743</td>
<td>347</td>
</tr>
<tr>
<td>1 9 11 12 R</td>
<td>174</td>
<td>268</td>
<td>180</td>
<td>304</td>
<td>654</td>
<td>696</td>
<td>206</td>
<td>1165</td>
<td>339</td>
</tr>
<tr>
<td>1 9 11 12 A</td>
<td>127</td>
<td>220</td>
<td>157</td>
<td>243</td>
<td>649</td>
<td>706</td>
<td>182</td>
<td>1133</td>
<td>323</td>
</tr>
<tr>
<td>1 9 11 12 Y</td>
<td>165</td>
<td>235</td>
<td>166</td>
<td>261</td>
<td>559</td>
<td>607</td>
<td>223</td>
<td>924</td>
<td>363</td>
</tr>
<tr>
<td>1 9 11 12 X</td>
<td>174</td>
<td>268</td>
<td>180</td>
<td>304</td>
<td>654</td>
<td>696</td>
<td>206</td>
<td>1165</td>
<td>339</td>
</tr>
<tr>
<td>1 9 11 12 E</td>
<td>160</td>
<td>244</td>
<td>146</td>
<td>287</td>
<td>409</td>
<td>517</td>
<td>203</td>
<td>751</td>
<td>367</td>
</tr>
</tbody>
</table>

Diagonal

174 268 180 304 654 696 206 1165 339
**CHANNELS:** 1 8 11 12

**AVERAGE PAIR-WISE DIVERGENCE:** 391.4

**MINIMUM PAIR-WISE DIVERGENCE:** 23.7

**RATIO OF THIS CHANNEL SET WITH CHANNEL SET YIELDING MAXIMUM PERCENT SEPARATION:** .24

**AVERAGE DIVERGENCE BY CLASS:**

<table>
<thead>
<tr>
<th>Class</th>
<th>Average Divergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>164.967</td>
</tr>
<tr>
<td>C</td>
<td>353.160</td>
</tr>
<tr>
<td>O</td>
<td>163.692</td>
</tr>
<tr>
<td>W</td>
<td>281.203</td>
</tr>
<tr>
<td>R</td>
<td>558.932</td>
</tr>
<tr>
<td>Y</td>
<td>923.967</td>
</tr>
<tr>
<td>E</td>
<td>352.898</td>
</tr>
</tbody>
</table>

**PAIR-WISE DIVERGENCE**

<table>
<thead>
<tr>
<th>Class</th>
<th>C =</th>
<th>G =</th>
<th>O =</th>
<th>S =</th>
<th>W =</th>
<th>Y =</th>
<th>E =</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>172.1</td>
<td>270.6</td>
<td>96.3</td>
<td>257.7</td>
<td>RC = 100.4</td>
<td>RC = 76.1</td>
<td>RC = 612.7</td>
</tr>
<tr>
<td>C</td>
<td>24.9</td>
<td>156.0</td>
<td>246.0</td>
<td>32.6</td>
<td>YC = 50.5</td>
<td>YC = 422.1</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>295.3</td>
<td>2301.1</td>
<td>221.6</td>
<td>344.0</td>
<td>EC = 241.0</td>
<td>EC = 446.2</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>769.6</td>
<td>50.7</td>
<td>410.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CHANNELS:** 1 9 11 12

**AVERAGE PAIR-WISE DIVERGENCE:** 443.0

**MINIMUM PAIR-WISE DIVERGENCE:** 23.8

**RATIO OF THIS CHANNEL SET WITH CHANNEL SET YIELDING MAXIMUM PERCENT SEPARATION:** .33

**AVERAGE DIVERGENCE BY CLASS:**

<table>
<thead>
<tr>
<th>Class</th>
<th>Average Divergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>173.702</td>
</tr>
<tr>
<td>C</td>
<td>256.025</td>
</tr>
<tr>
<td>O</td>
<td>180.312</td>
</tr>
<tr>
<td>W</td>
<td>303.635</td>
</tr>
<tr>
<td>R</td>
<td>654.247</td>
</tr>
<tr>
<td>Y</td>
<td>206.233</td>
</tr>
<tr>
<td>E</td>
<td>598.094</td>
</tr>
<tr>
<td>A</td>
<td>1185.083</td>
</tr>
<tr>
<td>X</td>
<td>3285.305</td>
</tr>
</tbody>
</table>

**PAIR-WISE DIVERGENCE**

<table>
<thead>
<tr>
<th>Class</th>
<th>C =</th>
<th>G =</th>
<th>O =</th>
<th>S =</th>
<th>W =</th>
<th>Y =</th>
<th>E =</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>202.4</td>
<td>324.5</td>
<td>110.9</td>
<td>RC = 100.3</td>
<td>RC = 90.3</td>
<td>RC = 674.6</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>25.0</td>
<td>117.5</td>
<td>204.3</td>
<td>YC = 37.9</td>
<td>YC = 92.6</td>
<td>YC = 423.3</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>299.6</td>
<td>3241.7</td>
<td>629.2</td>
<td>EC = 629.2</td>
<td>EC = 409.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>723.9</td>
<td>49.6</td>
<td>376.6</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

23
Criterion 4: Maximizing the geometric mean of the pairwise divergences. This criterion is also referred to as "per cent separation".
DISPLAY OF CHANNEL COMBINATIONS RANKED ACCORDING TO MAXIMUM PERCENT SEPARATION.

CHANNELS = 1 6 9 12
AVERAGE PAIR-WISE DIVERGENCE = 355.5
MINIMUM PAIR-WISE DIVERGENCE = 27.9
RATIO OF THIS CHANNEL SET WITH CHANNEL SET YIELDING MAXIMUM PERCENT SEPARATION = 1.00

AVERAGE DIVERGENCE BY CLASS...
AVERAGE INTERCLASS DIVERGENCE FOR CLASS S = 165.568
AVERAGE INTERCLASS DIVERGENCE FOR CLASS C = 241.099
AVERAGE INTERCLASS DIVERGENCE FOR CLASS O = 148.228
AVERAGE INTERCLASS DIVERGENCE FOR CLASS W = 343.142
AVERAGE INTERCLASS DIVERGENCE FOR CLASS A = 506.152
AVERAGE INTERCLASS DIVERGENCE FOR CLASS Y = 208.093
AVERAGE INTERCLASS DIVERGENCE FOR CLASS X = 760.625
AVERAGE INTERCLASS DIVERGENCE FOR CLASS E = 517.945

PAIR-WISE DIVERGENCE
CS = 27.9 OC = 74.6 OC = 96.4 WC = 246.1 WC = 404.3 VC = 111.7 RC = 214.0 RC = 109.2 RO = 88.2 RW = 646.8
AS = 187.4 AC = 76.4 AO = 133.3 AR = 742.2 AR = 37.8 YS = 120.2 YC = 196.6 YR = 71.7 YW = 204.2 YR = 396.7
VA = 356.7 XS = 244.3 XC = 650.9 XE = 502.3 XW = 290.4 XR = 1045.9 YE = 1556.9 XE = 292.2 ES = 210.1 EC = 377.1
EO = 147.6 ED = 99.4 ER = 710.6 EA = 608.7 EE = 56.4 EX = 303.7

CHANNELS = 1 6 9 11
AVERAGE PAIR-WISE DIVERGENCE = 356.5
MINIMUM PAIR-WISE DIVERGENCE = 27.6
RATIO OF THIS CHANNEL SET WITH CHANNEL SET YIELDING MAXIMUM PERCENT SEPARATION = .69

AVERAGE DIVERGENCE BY CLASS...
AVERAGE INTERCLASS DIVERGENCE FOR CLASS S = 162.926
AVERAGE INTERCLASS DIVERGENCE FOR CLASS C = 246.946
AVERAGE INTERCLASS DIVERGENCE FOR CLASS O = 151.437
AVERAGE INTERCLASS DIVERGENCE FOR CLASS W = 346.474
AVERAGE INTERCLASS DIVERGENCE FOR CLASS A = 409.120
AVERAGE INTERCLASS DIVERGENCE FOR CLASS Y = 203.546
AVERAGE INTERCLASS DIVERGENCE FOR CLASS X = 742.910
AVERAGE INTERCLASS DIVERGENCE FOR CLASS E = 347.346

PAIR-WISE DIVERGENCE
CS = 27.9 OC = 81.2 OC = 91.2 WC = 249.4 WC = 404.3 VC = 110.3 RC = 214.0 RC = 109.2 RO = 96.2 RW = 655.7
AS = 371.7 AC = 60.0 AO = 112.5 AR = 722.5 AR = 30.1 YS = 117.5 YC = 203.0 YR = 64.8 YW = 196.7 YR = 364.5
VA = 351.0 XS = 241.1 XC = 654.2 XE = 502.3 XW = 205.7 XR = 1721.5 YE = 1657.6 XE = 292.2 ES = 223.4 EC = 419.4
EO = 156.2 ED = 80.4 ER = 729.6 EA = 721.9 EE = 53.1 EX = 364.0
Criterion 5: Maximizing the pairwise divergence for each class pair.
DISPLAY OF CHANNEL COMBINATIONS YIELDING MAXIMUM PAIR-WISE DIVERGENCE.

<table>
<thead>
<tr>
<th>CLASS</th>
<th>MAX</th>
<th>AVG</th>
<th>CHANNELES</th>
</tr>
</thead>
<tbody>
<tr>
<td>BI</td>
<td>36.5</td>
<td>332.2</td>
<td>6 9 10 11</td>
</tr>
<tr>
<td>BS</td>
<td>53.1</td>
<td>504.4</td>
<td>6 10 11</td>
</tr>
<tr>
<td>CB</td>
<td>122.3</td>
<td>304.4</td>
<td>2 6 10 11</td>
</tr>
<tr>
<td>CG</td>
<td>255.6</td>
<td>242.2</td>
<td>1 6 9 10</td>
</tr>
<tr>
<td>WC</td>
<td>441.0</td>
<td>332.8</td>
<td>6 9 10 11</td>
</tr>
<tr>
<td>BD</td>
<td>121.4</td>
<td>429.7</td>
<td>6 9 11 12</td>
</tr>
<tr>
<td>RS</td>
<td>326.6</td>
<td>262.9</td>
<td>1 6 11 12</td>
</tr>
<tr>
<td>RC</td>
<td>157.2</td>
<td>295.2</td>
<td>1 6 10 12</td>
</tr>
<tr>
<td>RO</td>
<td>106.7</td>
<td>322.2</td>
<td>6 9 11 12</td>
</tr>
<tr>
<td>RW</td>
<td>700.0</td>
<td>429.7</td>
<td>6 9 11 12</td>
</tr>
<tr>
<td>AS</td>
<td>219.7</td>
<td>429.7</td>
<td>6 9 11 12</td>
</tr>
<tr>
<td>AC</td>
<td>125.1</td>
<td>205.2</td>
<td>1 6 10 12</td>
</tr>
<tr>
<td>AO</td>
<td>115.2</td>
<td>220.2</td>
<td>2 6 9 10</td>
</tr>
<tr>
<td>AV</td>
<td>299.4</td>
<td>337.3</td>
<td>2 6 9 11</td>
</tr>
<tr>
<td>AR</td>
<td>36.2</td>
<td>304.4</td>
<td>1 6 10 11</td>
</tr>
<tr>
<td>TB</td>
<td>173.2</td>
<td>165.5</td>
<td>1 2 7 8</td>
</tr>
<tr>
<td>TC</td>
<td>273.6</td>
<td>177.7</td>
<td>1 2 6 10</td>
</tr>
<tr>
<td>TO</td>
<td>71.7</td>
<td>355.1</td>
<td>1 6 9 12</td>
</tr>
<tr>
<td>YW</td>
<td>233.8</td>
<td>292.5</td>
<td>6 7 9 10</td>
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<tr>
<td>YR</td>
<td>439.8</td>
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<tr>
<td>YA</td>
<td>458.6</td>
<td>461.4</td>
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<tr>
<td>XB</td>
<td>361.3</td>
<td>416.6</td>
<td>6 9 11 12</td>
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<tr>
<td>XC</td>
<td>303.3</td>
<td>403.7</td>
<td>9 10 11 12</td>
</tr>
<tr>
<td>WD</td>
<td>494.4</td>
<td>442.6</td>
<td>5 9 14 13</td>
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<tr>
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<td>333.3</td>
<td>295.2</td>
<td>1 6 10 12</td>
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<td>8 9 11 12</td>
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<tr>
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<td>3378.5</td>
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<td>6 9 11 12</td>
</tr>
<tr>
<td>XT</td>
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<td>1 8 11 12</td>
</tr>
<tr>
<td>ED</td>
<td>205.2</td>
<td>301.4</td>
<td>1 2 6 11</td>
</tr>
<tr>
<td>EC</td>
<td>469.3</td>
<td>351.4</td>
<td>1 6 9 11</td>
</tr>
<tr>
<td>ED</td>
<td>163.7</td>
<td>391.4</td>
<td>1 6 11 12</td>
</tr>
<tr>
<td>EW</td>
<td>105.1</td>
<td>264.4</td>
<td>6 7 10 12</td>
</tr>
<tr>
<td>EX</td>
<td>818.2</td>
<td>332.9</td>
<td>2 7 9 11</td>
</tr>
<tr>
<td>EA</td>
<td>526.5</td>
<td>332.5</td>
<td>2 6 9 11</td>
</tr>
<tr>
<td>ET</td>
<td>82.4</td>
<td>262.1</td>
<td>2 6 10 12</td>
</tr>
<tr>
<td>EX</td>
<td>453.2</td>
<td>319.1</td>
<td>1 6 10 11</td>
</tr>
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</table>
Show Requests
**DISPLAY OF CHANNEL COMBINATIONS REQUESTED BY 4SHOWS** cards.

<table>
<thead>
<tr>
<th>CHANNELS</th>
<th>AVERAGE PAIR-WISE DIVERGENCE</th>
<th>MINIMUM PAIR-WISE DIVERGENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 9 11 12</td>
<td>443.0</td>
<td>25.8</td>
</tr>
</tbody>
</table>

**RATIO OF THIS CHANNEL SET WITH CHANNEL SET YIELDING MAXIMUM PERCENT SEPARATION:** .33

**AVERAGE DIVERGENCE BY CLASS:**

<table>
<thead>
<tr>
<th>CLASS</th>
<th>AVERAGE INTERCLASS DIVERGENCE FOR CLASS B =</th>
<th>AVERAGE INTERCLASS DIVERGENCE FOR CLASS C =</th>
<th>AVERAGE INTERCLASS DIVERGENCE FOR CLASS D =</th>
<th>AVERAGE INTERCLASS DIVERGENCE FOR CLASS E =</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>173.702</td>
<td>268.075</td>
<td>185.312</td>
<td>332.827</td>
</tr>
</tbody>
</table>

**PAIR-WISE DIVERGENCE**

| CS= 26.1 | OS= 78.4 | GS= 76.6 | WS= 202.4 | VC= 324.3 | RC= 110.9 | YS= 209.5 | RS= 100.3 | 90.3 | 674.6 |
| AS= 164.7 | AC= 09.2 | AC= 92.2 | AP= 733.0 | AQ= 25.8 | YR= 111.5 | YS= 204.3 | YQ= 37.9 | YP= 92.6 | 65.5 |
| YS= 409.2 | X8= 346.8 | X8= 921.4 | YQ= 804.1 | XR= 299.6 | 82.6 | 626.8 | XA= 3201.7 | XA= 321.5 | EX= 220.2 | EC= 409.2 |
| EX= 151.0 | ES= 31.5 | ER= 747.5 | ER= 725.9 | EX= 49.6 | EX= 378.6 | |

**CHANNELS | AVERAGE PAIR-WISE DIVERGENCE | MINIMUM PAIR-WISE DIVERGENCE |**

| 6 9 10 11 | 332.2 | 26.2 |

**RATIO OF THIS CHANNEL SET WITH CHANNEL SET YIELDING MAXIMUM PERCENT SEPARATION:** .04

**AVERAGE DIVERGENCE BY CLASS:**

<table>
<thead>
<tr>
<th>CLASS</th>
<th>AVERAGE INTERCLASS DIVERGENCE FOR CLASS B =</th>
<th>AVERAGE INTERCLASS DIVERGENCE FOR CLASS C =</th>
<th>AVERAGE INTERCLASS DIVERGENCE FOR CLASS D =</th>
<th>AVERAGE INTERCLASS DIVERGENCE FOR CLASS E =</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>136.941</td>
<td>254.047</td>
<td>133.205</td>
<td>471.094</td>
</tr>
</tbody>
</table>

**PAIR-WISE DIVERGENCE**

| CS= 36.9 | OS= 61.3 | GS= 105.8 | WS= 208.6 | VC= 441.0 | RC= 112.4 | YS= 167.0 | RS= 104.8 | 106.7 | 604.0 |
| AS= 149.3 | AC= 102.8 | AC= 105.9 | AP= 753.5 | AQ= 26.2 | YR= 53.7 | YS= 164.4 | YQ= 56.9 | YP= 206.6 | 339.3 |
| YS= 339.7 | X8= 233.1 | X8= 675.8 | XQ= 376.7 | XR= 172.9 | XR= 150.2 | YR= 1764.6 | XR= 149.6 | ES= 165.8 | EC= 401.2 |
| EX= 131.0 | ES= 70.2 | ER= 770.6 | ER= 759.6 | EX= 53.6 | EX= 299.7 | |
Software Description
## Overview

<table>
<thead>
<tr>
<th>Routine</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHOICE</td>
<td>Main program. Coordinates subroutine calls.</td>
</tr>
<tr>
<td>INPUT</td>
<td>Inputs and lists data cards.</td>
</tr>
<tr>
<td>DIVERG</td>
<td>Computes divergences, does exhaustive search, and saves top-ranked sets.</td>
</tr>
<tr>
<td>DISPLA</td>
<td>Displays top channel sets.</td>
</tr>
<tr>
<td>DIV</td>
<td>Recomputes pairwise divergences for those top-ranked sets to be displayed.</td>
</tr>
</tbody>
</table>
Univac 1108 Exec 8 Stream

@RUN,P RUNID,ACCOUNTNO,PROJECTID,3,100

@ASG,T CHOICE,T,11848 . MAGNETIC TAPE CONTAINING PROGRAM FILE

@COPIN CHOICE. . TRANSFER PROGRAM FILE TO DRUM

@FREE CHOICE. . RELEASE TAPE

@XQT TLO003 . EXECUTE CHOICE'S ABSOLUTE ELEMENT

  data cards

@FIN . RUN COMPLETED

See: Example of Input Data
Fortran Listing
CHOICE
FOR: A CHOICE

FOR 94L-06/12-08'42 (2,0)

MAIN PROGRAM

STORAGE USED: CODE (1) 000026 DATA (G) 000011 BLANK COMMON (2) 000000

COMMON BLOCKS:

0003 UNITS 000002
0004 MAX 000005
0005 INP 025416
0006 INV 005514
0007 YDIJ 015735

EXTERNAL REFERENCES (BLOCK, NAME)

0010 INPUT
0011 DIVERG
0012 DISPLAY
0013 MINDS
0014 MDIS
0015 NDIS
0016 NDIS
0017 NDIS

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0000 000002 100F 0001 000001 1556 0003 1 000000 CARD 0005 02403 CHAR 0005 02443 D1J
0004 000001 MAXCLS 0004 000002 NBEST 0005 024204 M1J 0004 000004 MPRT 0004 000005 MSHO
0005 000000 NCLASS 0005 024201 NCL 0005 024200 NH 0005 024245 MPRT
0006 024249 NROW 0003 1 000001 PRINT 0005 024246 SHW 0006 005500 VEC 0005 1 000050 VERS
0007 015733 ZAVG 0007 015692 ZCIVG 0005 001400 ZCIVG 0007 000000 Z00 0005 000000 ZINV
0004 000000 ZMADIZ 0007 015730 ZMADIZ 0007 000000 ZMADIZ 0007 000000 ZMEAN 0007 D15734 ZMIN
0008 004000 ZMADIZ 0007 015690 ZMADIZ 0007 000000 ZMDIZ
0008 004050 ZMADIZ 0007 015700 ZMADIZ 0007 000000 ZMDIZ
0009 000000 ZMADIZ 0007 015700 ZMADIZ 0007 000000 ZMDIZ

001000 1* C
001001 2* C
001002 2* C
001003 2* C
001004 2* C
001005 2* C
001006 2* C
001007 2* C
001008 2* C
001009 2* C
001010 2* C
001011 2* C
001012 2* C
001013 2* C
001014 2* C

C. JONES NASA/ERL

JONES
DIMENSION ZCOV(SUMA,MAXCLA) HOLDS COVARIANCES (LOWER TRIANGLE) FOR EACH CLASS.
PARAMETER PCTPRR=10 NO. OF COMBO'S RANKED BY PERCENT TO BE PRINTED
DIMENSION VEC(MBESTA) HOLDS UNIQUE COMBINATION OF FEATURES (CHANNELS)
COMMON /INV/INV.ZV,VEC INVERSION ARRAYS
DIMENSION ZINV(RSUMA,MAXCLA) HOLDS INVERSE COVARIANCE MATRICES FOR EACH CLASS
DIMENSION ZV(MBESTA,MAXCLA) WORKING ARRAY USED WHEN COMPUTING INVERSE BY BORDERING METHOD.
PARAMETER DSM=(MAXCLA-1)*MAXCLA/2 "MAXCLA" COMBO'S TAKEN TO AT A TIME
DIMENSION ZDIJ(0RINT,2) WORKING BUFFER FOR INTERCLASS DIVERGENCE DIJ'S RANLED BY PERCENT,PCW
PARAMETER MPRINT=20 MAXIMUM NO. PRINT REQUESTS TO BE HONORED
DIMENSION ZMDIJ(DS,3) HOLDS MAX. DIJAVG. DIJPACKED CHANNEL PCW
DIMENSION ZMCDIJ(MAXCLA,2) HOLDS MAX. DIJ FOR CLASS,PCW
DIMENSION ZMADIJ(MMIN,2) HOLDS MAX. AVG. DIJ,PCW FOR NO. PRINT REQUEST
DIMENSION ZMCIJ(CRM),PCTFRT) DIJ'S RANLED BY PERCENT,PCW
DIMENSION ZCAVG(MAXCLA) WORK ARRAY USED TO FIND LARGEST CLASS AVG. DIJ
DIMENSION ZDIJ(DSLH) HOLDS CHARACTER COMBO'S FOR DIJ PAIRS
DIMENSION VERS(2) LAST TIME ANY CHANGE TO PROGRAM
DATA VERS/Apr 4",", 1973"/
DATA CARD/5/ CARD READER UNIT
DATA PRINT/6/ PRINTER UNIT
WRITE(PRINT,100) VERS PRINT VERSION NO.
FORMAT("O",RAS,"O")
CALL INPUT GET MEANS,COVARIANCES,NO. OF MEASUREMENTS (CHANNELS), NO. OF CLASSES,DIMENSION OF "BEST" SUBSET, DISPLAY INFO.
CALL DIVERG COMPUTE DIVERGENCE FOR ALL COMBINATIONS AND SAVE THOSE OF INTEREST
CALL DISPLAY OUTPUT SEPARATIONS
STOP
END

END OF COMPIULATION NO DIAGNOSTICS.
SUBROUTINE INPUT
ENTRY POINT 000020

STORAGE USED: CODE (1) 000354 DATA (0) 000284 BLANK COMMON (2) 000020

COMMON BLOCKS:
0003 UNITS 000002
0004 MAX 000003
0005 NR 003416
0006 NINV 005514
0007 YDIJ 015735

EXTERNAL REFERENCES (BLOCK, NAME)
0010 . NEDUS
0011 NICE3
0012 NEDUS
0013 NEDRS
0014 NEDUS
0015 NEDRS

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

FOR A INPUT, INPUT
FOR B1L-06-12-08-44 (2,0)

SUBROUTINE INPUT
ENTRY POINT 000020

STORAGE USED: CODE (1) 000354 DATA (0) 000284 BLANK COMMON (2) 000020

COMMON BLOCKS:
0003 UNITS 000002
0004 MAX 000003
0005 NR 003416
0006 NINV 005514
0007 YDIJ 015735

EXTERNAL REFERENCES (BLOCK, NAME)
0010 . NEDUS
0011 NICE3
0012 NEDUS
0013 NEDRS
0014 NEDUS
0015 NEDRS

STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)
PARAMETER NMMA=MAX2, MAX NO. OF MEASUREMENTS (CHANNELS), CAN INCREASE.
PARAMETER MBIESTA=12, MAX NO. OF MEASUREMENTS IN "BEST" SUBSET
PARAMETER RMS1=MBIESTA+1, SUM OF 1,2,...,NO. IN "BEST" SUBSET
PARAMETER RMS12=MBIESTA+1, SUM OF 1,2,...,MAX NO. MEASUREMENTS
COMMON/UNITSCARD,PRINT I/O UNITS-CARD READER, PRINTER
COMMON MAR/MOM,MAXCLS,MBEST,MSHO,PRINT MAXIMUM
COMMON SINF, ZMEAN,ZCOV,NM,NC,
*BEST,CHAR,FRMT,HDIM,NSHOW,SHOW,DIJ INPUT
DIMENSION ZMEAN(NMSMA,MAXCLA) HOLDS MEANS FOR EACH MEASUREMENT, CLASS
DIMENSION ZCOV(NMSMA,MAXCLA) HOLDS COVARIANCES (LOWER TRIANGLE)
C FOR EACH CLASS.
PARAMETER PCFCLASS=15, NO. OF COMBO'S RANKED BY PERCENT TO BE PRINTED
DIMENSION VEC(MBIESTA) HOLDS UNIQUE COMBINATION OF FEATURES (CHANNELS)
COMMON /INVZYINV,ZY,VEC INVERSION ARRAYS
DIMENSION ZINV(RMS1,MAXCLA) HOLDS INVERSE COVARIANCE MATRICES
FOR EACH CLASS
DIMENSION ZV(MBIESTA,MAXCLA) WORK ARRAY USED WHEN COMPUTING
INVERSE BY BORDING METHOD.
PARAMETER DLUMAX=MAXCLA/2 "MAXCLA" COMBO'S TAKEN TWO AT A TIME
DIMENSION DIJ(MAXSUM) WORKING BUFFER FOR INTERCLASS DIVERGENCE
DIMENSION CHAR(MBIESTA) HOLDS CHARACTER REPRESENTATION OF CLASSES
COMMON MPRT/121,IE12,121I2,121N12
PARAMETER PRNT=IO, "PROGRAM" TO BE PRINTED
PARAMETER MPRINT=MPRINT, "PROGRAM" TO BE PRINTED
PARAMETER MAXCLS=MAXCLA, "BEST" SUBSET IS COMPLETED.
DIMENSION DIJU(MAXCLA), JU=MIN. PRINT REQUESTS
DIMENSION MSWO-MS, "BEST" CLASSES TAKEN 2 AT A TIME * 1 WORD
DIMENSION DIIU(LCSSUM,PCF) DIJ'S RANKED BY PERCENT,PCF
DIMENSION DIIU(LCSSUM,PCFPR) DIJ'S RANKED BY PERCENT,PCF
DIMENSION DIJU(LCSSUM,PCFPR) WORK ARRAY USED TO FIND LARGE CLASS AVG, DIJ
DIMENSION DIJU(LCSSUM) HOLDS CHARACTER COMBO'S FOR DIJ PAIRS
END
READ(CARD,10) NM,NL,NBEST NO. MEASUREMENTS,NL,CLASSES,SUBSET RANK
FORMAT(12,2X,12,2X,12) CHANNEL,XX CLASSES=XX BEST=XX
MAXCLS=MAXCLA GET MAX. CLASSES FROM PARAMETER STATEMENT
MOMSMT=MOMS THE DITTO FOR MAX. NO. MEASUREMENTS
SUBSUMA DITTO FOR SUM OF 1,2,...,NO. MEASUREMENTS
MBEST=MBEST DITTO FOR NO. OF MEANS IN "BEST"
MOMSMT=MOMS THE DITTO FOR MAX. SHOW REQUESTS
MBEST=MBEST DITTO FOR MAX. PRINT REQUESTS
MOMSMT=MOMS THE DITTO FOR SUM OF 1,2,...,NO. IN "BEST"
FORMAT(12) X, "BEST" SUBSET ALLORED=", 13, " ATTEMPTED INUT (TOTAL=", 10, 12, 13,
* NO. MEASUREMENTS ALLORED=", 13, " ATTEMPTED INUT=", 10, 12, 13,
* MAX. RANK SUBSET ALLORED=", 13, " ATTEMPTED INUT=", 10, 12, 13)
WRITE(PRINT,IO) MOMSMT,INHM,MAXCLS,NM,MBEST,NO. ERROR
FORMAT(20) X, "ERROR" EXIT
DO 40 J=1,NL INDEX THRU CLASSES, READ MEANS
READ(CARD,50) (ZMEAN(K,1),K=1,NL) MEANS
READ(CARD,50) (ZCOV(K,1),K=1,NL) COVARIANCES
FORMAT(5X,5E15.8) NO. POINTS IN LOWER TRIANGLE COV., MATRIX SUM 1,2,1,"NN
READ(CARD,50) (ZCOV(K,1),K=1,NL) COVARIANCES
READ(LCARD,50) (ZMEAN(K,1),K=1,NL) MEANS
00213  260  C  READ IN CHARACTER REPRESENTATIONS OF CLASSES

00222  270  READ (CARD,PD) (CHAR(J),J=1,NCL)  CLASSES:0,...

00230  290  FORMAT(1X,36(1X,A))

00231  294  N01  INITIALIZE INDEX FOR D1J CHARACTER PAIR

00232  300  DO 95 1=2,NCL  THE I OF D1J

00255  310  K=1  THE J IS ALWAYS SMALLER THAN THE I

00236  320  DO 95  J=1,NCL  THE J OF D1J

00241  330  D1J(INCHAR(J))  GET FIRST CHAR OF CLASS PAIR

00242  340  FLC0(6,6,D1J(99))  FLC0(6,6,CHAR(J))  GET AND PACK 2*ND CHAR. IN CLASS PAIR

00243  350  55  BUMP PAIR INDEX

00246  360  READ(CARD,RO) NFR1,NCL,NSCW  PRINT=XX,MAX D1J=XXXX,NO. SHOW=XX

00253  370  80  FORMAT(6X,12,X,15,10X,I2)  NO. OF COMBO'S TO PRINT, MAXIMUM INTERCLASS

00255  380  C  DIVERGENCE ALLOWED, NO. OF SPECIAL SHOW COMBINATIONS REQUESTED.

00255  390  C  READ IN CHARACTER PAIR REQUESTS

00254  410  IF(NFR1.LE.,NFR1)  GO TO 90  NO. OF PRINT REQUESTS EXCEEDED MAX,

00256  420  WRITE(PRINT,91) NFR1,NFR1,NFR1,YES, PRINT WARNING

00260  430  91  FORMAT(1X,N20,,15,014,*, TOO LARGE, MAXIMUM

00263  440  440  *)  ALLOWED IS*,12, *= PRINT REQUESTS SET TO MAX.*

00264  440  440  *)  NLPRINT  SET PRINT REQUESTS TO MAXIMUM

00265  460  90  IF(NSM1W.LE.HSJO)  IF(NPRT.LE.

00267  470  WRITE(PRINT,93) NSCW,NSCW,NSCW,YES, PRINT WARNING

00274  480  93  FORMAT(*D NO. OF SHOW REQUESTS=,15,014,*, TOO LARGE, MAXIMUM

00278  490  490  *)  ALLOWED IS*,12, *= SHOW REQUESTS SET TO MAX.*

00279  490  490  *)  NLPRINT  SET SHOW REQUESTS TO MAXIMUM

00279  500  500  NSMWFHID  GET AND SHOW REQUESTS TO MAXIMUM

00276  510  92  IF(NSK,J,NSOW,NSOW,NSOW)  ANY SHOW CARDS

00300  520  92  IF(NSM1W,NSOW,NSOW,YES)  ANY SHOW CARDS

00303  530  92  DO 94 J=1,NSOW  INDEX THRU SHOW CARDS

00303  530  92  READ(CARD,95) (SHOW(J),J=1,NSOW) CHANNELS=01,03,10,...

00311  540  95  FORMAT(6X,84(1X,12))

00312  550  94  CONTINUE

00319  560  99  WRITE(PRINT,100)

00316  570  100  FORMAT(155,*, INTERPRETATION OF CARD INPUT*)

00316  570  100  PRINT CHANNELS,CLASSES,BEST CHANNELS

00317  590  600  WRITE(PRINT,110)N4,NCL,NBEST

00324  600  110  FORMAT(10 CHANNELS=,12,* CLASSES=,12,* BEST=,12)

00325  610  610  WRITE(PRINT,115)

00327  620  115  FORMAT(10 INPUT MEANS*)

00330  630  120  DO 120 J=1,NCL  INDEX THRU CLASSES

00333  640  120  WRITE(PRINT,125) (MEAN(K,J),K=1,N4) PRINT MEANS

00342  650  123  FORMAT(5X,5E15.8)

00343  660  123  PTsw=29(PH+1)*NO. POINTS IN LOWER TRIANGLE COV. MATRIX

00344  670  123  WRITE(PRINT,126)

00346  680  126  FORMAT(10 INPUT CORRANCE*)

00347  690  126  DO 130 J=1,NCL  INDEX THRU CLASSES

00347  690  130  WRITE(PRINT,135) (COV.W(J,J),K=1,PTsw) PRINT UPPER TRIANGLE COV.

00361  710  135  FORMAT(5X,5E15.8)

00362  720  135  WRITE(PRINT,136) (CHAR(J),J=1,NCL) PRINT CLASSES

00365  750  156  FORMAT(10 INPUT CLASSES =,36(1X,A1))

00374  744  150  WRITE(PRINT,150)NFR1,MEAS,SHOW  PRINT=XX MAX. DI=XXX NO. SHOW=XX

00376  750  150  FORMAT(*D NO. OF PRINT=,12,* MAX DI=*,15,*, NO. SHOW=*,12)

00377  760  150  IF(NSM1W,NSOW,YES) RETURN ANY SHOW CARDS

00401  770  150  DO 125 J=1,NSOW  INDEX THRU SHOW CARDS

00404  780  155  WRITE(PRINT,160) SHOW(J,J),J=1,NSOW) BIST CHANNELS

00413  790  160  FORMAT(*D SHOW CHANNELS=* 24(1X,12))

00434  800  160  RETURN
SUBROUTINE DIVERG ENTRY POINT 00174F

STORAGE USED CODE (1) 001774 DATA (0) 000529 BLANK COMMON (2) 000000

COMMON BLOCKS

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<td>INV</td>
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EXTERNAL REFERENCES (BLOCK, NAME)

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<td>NERD3</td>
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STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

<table>
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<th>BLOCK</th>
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<tr>
<td>0004</td>
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</tr>
</tbody>
</table>
00105 10* * INCLUDE SPEC LIST PARAMETERS, DIMENSIONS, COMMON
00123 4* C DIMENSION CMAX=32 MAX NO. OF CLASSES CAN
00141 4* C INCREASE IF NEEDED.
00159 4* C PARAMETER NSUMA=24 MAX NO. OF MEASUREMENTS (CHANNELS) CAN INCREASE.
00177 4* C PARAMETER NBESTA=12 MAX NO. OF MEASUREMENTS IN "BEST" SUBSET
00195 4* C PARAMETER SUMA(NSUMA+1)HDESTA=2 SUM OF 1,2,...,NO. IN "BEST" SUBSET
00213 4* C PARAMETER SUM(NSUMA+1)HOMINAL=2 SUM OF 1,2,...,MAX. NO. MEASUREMENTS
00231 4* C COMMON/UNITS/CARD, PRINT 1/0 UNITS-CARD READER, PRINTER
00249 4* C COMMON MAX/CLASS, MAXCLS, REGI. NO., PRINT MAXIMUS
00267 4* C COMMON NSF/MEAN, ZEAN, ZCN, ZCL,
00285 4* C MINelaide. OF MILLER (SUB) SUB INPUT
00303 4* C DIMENSION ZMEAN(NSUMA,MAXCLA) HOLDS MEANS FOR EACH MEASUREMENT, CLASS
00321 4* C DIMENSION ZCOV(SUMA,MAXCLA) HOLDS COVARIANCES (LOWER TRIANGLE)
00339 4* C DIMENSION ZINV(SUMA,MAXCLA) HOLDS INVERSE COVARIANCE MATRICES
00357 4* C DIMENSION ZINV(RSUMA,MAXCLA) HOLDS INVERSE COVARIANCE MATRICES FOR EACH CLASS.
00375 4* C DIMENSION ZV(NSUMA,MAXCLA) WORKING ARRAY USED WHEN COMPUTING
00393 4* C INVERSE BY BORDERING METHOD.
00411 4* C DIMENSION DSUM (MAXCLA+1)MAXCLA=2 "MAXCLA" CO-SO'S TAKEN TWO AT A TIME
00430 4* C DIMENSION ZDUMA(NSUMA+1)10000 CLASS DIVERSION
00448 4* C dimension CR IBAX (MAXCLA) HOLDS CHARACTER REPRESENTATION OF CLASSES
00466 4* C COMMON /V01/ 10 MAX, ZDUMA, ZMDUMA, ZMDJ.
00484 4* C ZMDUMA = (MBESTA) WORKING BUFFER FOR INTERCLASS DIVERGENCE
00502 4* C PARAMETER MAXIMA=100 MAX NO. OF SHOW REQUESTS HONORED
00520 4* C DIMENSION SNOW (MEISTA,HNSNOW) HOLDS CHANNEL COMBO'S REQUESTED
00538 4* C PARAMETER PRINRED=2 MAX NO. OF PRINT REQUESTS TO BE HONORED
00556 4* C DIMENSION ZDIJ(SUMA,3) HOLDS MAX. DJ, AVG. DJ, DJ, PAIRED CHANNEL.
VEC(NBEST) = VEC(NBEST) - 1 EXCEPT FOR LAST COMPONENT

DO 20 J=1,NBEST GIVE ME NEXT UNIQUE COMBINATION

JR(INBEST) = JR(INBEST) + 1 INCREMENT NBEST TH COMPONENT MOST OFTEN

J3 = J2 + 1 TELLS ME IF I INCREMENTED THE NBEST TH COMPONENT LAST

VEC(J3) = VEC(J3) + 1 INCREMENT J3 TH COMPONENT

IF(J3.GT.NBEST) GO TO 40 IS THIS NBEST TH COMPONENT

DO 30 JJ = J3,NBEST NO, INITIALIZE NEXT LEVEL

VEC(JJ) = VEC(JJ - 1) SET HIGHER ORDER TO LOWER ORDER COMP. + 1

DO 40 IF(VEC(NBEST).LE.NM) GO TO 20 CONTINUE

CONTINUE

RETURN

CC#PUTATICNS CON

THE INPUT

SEE

THIS

JCNES

50

AND

COMPUTES INVERSE FOR "NCL" MATRICES BY BORDERING TECHNIQUE

THIS ALGORITHM PERFORMS MATRIX INVERSION ON A SYMMETRIC MATRIX.

SEE "STATISTICAL COMPUTATIONS ON A DIGITAL COMPUTER" BY HEWERLE, PG 75

THE INPUT MATRIX IS "ZCOV" IN LOWER TRIANGLE FORM

THE INVERSE OF "ZCOV" IS STORED IN "ZINV" IN LOWER TRIANGLE FORM.

THIS PROCEDURE RESTRICTS ITSELF TO THE 200 SERIES

A AND TO INTERNAL FLAGS STARTING WITH "*"

201 DO 221 XCL=1,NCL REDUCE COV. MATRIX FOR EACH CLASS

202 XI=0 COUNTS WHERE I AM IN REDUCED COV. MATRIX

203 DO 221 XCL=1,NBEST REDUCED MATRIX OF RANK "NBEST"

204 XI=VEC(XC) RETRIEVE LOGICAL ROW INDEX

205 DO 221 XI=1,XC COLUMN INDEX FOR REDUCED LOWER TRIANGLE MATRIX

206 XI=VEC(XC) RETRIEVE LOGICAL COLUMN INDEX

207 XCT=XI XI (XI-1)/2+XI CONVERT TO LOWER TRIANGLE INDEXING SCHEME

208 XCT=XCT+1 BUMP POINTER IN REDUCED COVARIANCE ARRAY

209 ZINV(XCT,XCL) = ZCOV(XCT,XCL) REDUCE COVARIANCE MATRIX FOR EACH CLASS

NOW COMPUTE INVERSE

DO 220 XCL=1,NCL COMPUTE INVERSE FOR EACH CLASS

XST=1 FLAGS FIRST ROW ERROR

IF(ABS(ZINV(1,XCL)).LT.0.00001) GO TO 220 WILL I BE

DIVIDING BY ZERO

ZINV(1,XCL) = 1.0/ZINV(1,XCL) NO, TAKE RECIPROCAL

DO 220 XI=2,PBEST INDEX THRU ROWS

DO 220 XI=1,XK INITIALIZE WORK ARRAY TO ZERO

ZV(X1,XCL) =0

XMX=X-1 UPPER ROW LIMIT

DO 220 XI=1,XM INDEX THRU ROWS

DO 220 XI=1,XI INDEX THRU COLUMNS

XI= (XI-1)*XI/2+XI COMPUTE LOWER TRIANGLE INDEX FOR (I,J)

XI= (XI-1)*XI/2+XI DITO FOR (K,J)

ZV(X1,XCL) = ZV(X1,XCL) + ZINV(X1,XCL) * ZINV(X1,XCL) COLUMN WORK VECTOR

IF(X1=1) ZDD=0, ZCN=0 AS I THRU COMPUTING WORK VECTOR

XI=(XI-1)*XI/2+XI DITO FOR (J,I)

XLM=X+1 NO, COMPUTE LOWER LIMIT AND CONTINUE

DO 220 XM=X,XL MULTIPY THE KM TH ROW BY THE XM TH COLUMN

XJ= (XJ-1)*XJ/2+XJ COMPUTE LOWER TRIANGLE INDEX FOR (K,J)

XJ= (XJ-1)*XJ/2+XJ DITO FOR (J,K)

ZV(X1,XCL) = ZV(X1,XCL) + ZINV(X1,XCL) * ZINV(X1,XCL) COLUMN WORK VECTOR

CONTINUE GO TO NEXT ROW

DO 220 XJ=1,XM GO THRU XJ TH COLUMN OF THE KM TH ROW

XJ=(XJ-1)*XJ/2+XJ COMPUTE LOWER TRIANGLE INDEX (LTI) FOR (K,J)

CONTINUE

ZV(X1,XCL) = ZV(X1,XCL) + ZINV(X1,XCL) * ZINV(X1,XCL) COLUMN WORK VECTOR
DO ZINV(IXK,KXK)=I.0/(ZINV(XK,KXK)-ZV(XK,KXK)) .LT. .00001) GO TO 230  WILL 1

C BE DIVIDING BY ZERO

ZINV(XK,KXK)=I.0/(ZINV(XK,KXK)-ZV(XK,KXK)) INVERSE OF ELEMENT (K,K)

DO SYP XJ1, XH INDEX THRU ROWS

DO SYP XJS1, XJ INDEX THRU COLUMNS

XI=(XJ-1)*XJ/2+XI LTI FOR (J,1)

XK=(XK+1)*XK/2 LTI FOR (K,K)

DO ZINV(XJ1,XJ) INVERSE OF THE XJTH ROW AND XIITH COLUMN

CONTINUE GO TO NEXT ROW

CONTINUE GO TO NEXT CLASS

GO TO 240 SKIP ERMOR PRINT

C PROBLEMS ON ATTEMPTING TO INVERT MATRIX

WRITE(PRINT,231)

FORMAT(1,8E15.8) PRINT THE ROW

ZPRINT(KK)=ZCCK(KK,KK) RETRIEVE NEXT

C ELEMENT IN ROW FROM BIG MATRIX

WRITE(PRINT,236) ZPRINT(KK),KK=1,XXC PRINT THE ROW

C ELEMENT IN ROW FROM BIG MATRIX

WRITE(PRINT,236) ZPRINT(KK),KK=1,XXC PRINT THE ROW

CONTINUE GO PRINT NEXT ROW

IF(XF.EQ.0.1) WRITE(PRINT,237) TEST ERROR FLAG

IF(XF.EQ.0.12) WRITE(PRINT,238) TEST ERROR FLAG

WRITE(PRINT,239) XCL

WRITE(PRINT,239) XCL

FORMAT* THIS SUB-MATRIX IS LOCATED IN THE"K,15,"TH,

WRITE(PRINT,239) XCL

WRITE(PRINT,239) XCL

C TRIANGLE INDEXES

WRITE(PRINT,245) XCL

WRITE(PRINT,245) XCL

RETURN D FATAL ERROR. GET DUMP.
THIS PROCEDURE COMPUTES INTERCLASS DIVERGENCE AS FOLLOWS... 

\[ D_{ij} = \sqrt{\sum_{k=1}^{m} (\frac{1}{N_i} \sum_{x \in S_i} (x - \mu_i))^2 + (\frac{1}{N_j} \sum_{x \in S_j} (x - \mu_j))^2} \]

WHERE \( N_i \) AND \( N_j \) ARE THE NUMBERS OF POINTS IN CLASSES \( i \) AND \( j \), RESPECTIVELY.

\( \mu_i \) AND \( \mu_j \) ARE THE MEAN POINTS OF CLASSES \( i \) AND \( j \), RESPECTIVELY.

\( S_i \) AND \( S_j \) ARE THE SETS OF POINTS IN CLASSES \( i \) AND \( j \), RESPECTIVELY.

\( m \) IS THE NUMBER OF DIMENSIONS.

\[ D_{ij} = \sqrt{\frac{1}{N_i} \sum_{x \in S_i} (x - \mu_i)^2 + \frac{1}{N_j} \sum_{x \in S_j} (x - \mu_j)^2} \]

FOR INTERCLASS DIVERGENCE.

\[ D_{ij} = \sqrt{\frac{1}{N_i} \sum_{x \in S_i} (x - \mu_i)^2 + (\mu_j - \mu_i)^2} \]

FOR INTERCLASS DIVERGENCE.

\[ D_{ij} = \sqrt{\frac{1}{N_j} \sum_{x \in S_j} (x - \mu_j)^2 + (\mu_i - \mu_j)^2} \]

FOR INTERCLASS DIVERGENCE.

\[ D_{ij} = \sqrt{\frac{1}{N_i} \sum_{x \in S_i} (x - \mu_i)^2 + \sum_{k=1}^{m} \frac{1}{N_j} \sum_{y \in S_j} (y - \mu_j)^2} \]

FOR INTERCLASS DIVERGENCE.

\[ D_{ij} = \sqrt{\frac{1}{N_j} \sum_{x \in S_j} (x - \mu_j)^2 + \sum_{k=1}^{m} \frac{1}{N_i} \sum_{y \in S_i} (y - \mu_i)^2} \]

FOR INTERCLASS DIVERGENCE.
IF(J,60,VEG(J)) FLD(J,J,1,2PCW)=1 NO, TURN ON BIT
LNL+1 LOOK AT NEXT CHANNEL IN SET
IF (L,61,NEST) GO TO 85 HAVE I SETフラグ FOR ALL CHANNELS IN SET
CONTINUE NO, GO TO NEXT CHANNEL
C COMPUTE CAPPED AVERAGE DIVERGENCE
ZAVG=0 INITIALIZE AVG. DIVERGENCE
ZMDI(J) GET MAX. DJ ALLOWED IN AVG. COMPUTATION
DO 110 J=1,PAIRS INDEX THRU CLASS PAIRS
IF(ZDI(J,J).LT.ZM) ZAVG=ZAVG+ZDI(J,2) DJ .LT. MAX
IF(ZDI(J,J).GE.ZM) ZAVG=ZAVG+ZM DJ .GE. TO MAX DJ
CONTINUE GO ADD NEXT DIVERGENCE
ZAVG=ZAVG/PAIRS COMPUTE AVG. DJ
C NOW SEE IF THIS CONBO. YIELDS THE LARGEST DJ YET FOUND
DO 85 J=1,PAIRS INDEX THRU THE POSSIBLE DIJ'S
IF(ZDI(J,J).LE.ZMDI(J,2)) GO TO 85 IS THIS BIGGEST
CONTINUE
C DIJ I'M FOUND
ZMDI(J,J)=ZDI(J,J) YES, SAVE IT
ZMDI(J,J)=ZDI(J,J)+ZAVG SAVE ASSOCIATED AVERAGE DIVERGENCE
ZMDI(J,J)=ZMDI(J,J)+ZPCW SAVE CHANNEL CONBO. YIELDING THIS
DO 80 J=1,PAIRS INDEX THRU CLASS PAIRS
ZMDI(J,J)=ZMDI(J,J)+ZDI(J,2) IF(ZDI(J,J).LT.ZMDI(J,J)) J+1
DO 80 J=1,PAIRS INDEX THRU CLASS PAIRS
DO 90 J=1,NRT,THRU CHANNEL INDEX
ZHN=000000 INITIALIZE TO LARGE NO. IN SEARCH FOR MIN. DIJ
DO 80 J=1,PAIRS INDEX THRU CLASS PAIRS
C O.K., NOW COMPUTE AVERAGE BY CLASS
DO 90 J=1,NRCL,THRU CLASSES
ZCAVG(J)=0 INITIALIZE FOR AVG. COMP.
LOW-NCL-1 NO. OF PAIRS TO SUM FOR EACH CLASS
ZCAVG(J,J)=ZCAVG(J,J)+ZDI(J,2) INDEX THRU DIJ'S FOR THIS CHANNEL CONBO.
DO 80 J=1,NCL THE 1 OF THE DIJ
UP=J-1 UPPER LIMIT ON J
DO 85 J=1,UP THE J OF THE DIJ
NEXT Classe
ZCAVG(J,J)=ZCAVG(J,J)+ZDI(J,2) GO TO NEXT DIJ
ZCAVG(J,J)=ZCAVG(J,J)+ZPCW COMPUTE SUM FOR J'TH CLASS
DO 90 J=1,NRCL,THRU CLASSES
ZCAVG(J,J)=ZCAVG(J,J)+ZDI(J,2) GO TO NEXT DIJ
ZCAVG(J,J)=ZCAVG(J,J)+ZPCW COMPUTE AVG. DJ FOR CLASS
DO 90 J=1,NRCL,THRU CLASSES
ZCAVG(J,J)=ZCAVG(J,J)+ZDI(J,2) COMPUTE AVG. DJ FOR J'TH CLASS
DO 90 J=1,NRCL,THRU CLASSES
ZCAVG(J,J)=ZCAVG(J,J)+ZDI(J,2) COMPUTE AVG. DJ FOR J'TH CLASS
DO 90 J=1,NRCL,THRU CLASSES
DO 110 J=1,PAIRS INDEX THRU CLASSES
IF(ZCAVG(J,J).LT.ZMDI(J,J,2)) J=1,PAIRS INDEX THRU CLASSES
DO 110 J=1,PAIRS INDEX THRU CLASSES
DO 110 J=1,PAIRS INDEX THRU CLASSES
ZMDI(J,J,1)=ZCAVG(J,J) YES, SAVE IT
ZMDI(J,J,1)=ZMDI(J,J,1)+ZCAVG(J,J) YES, SAVE IT
ZMDI(J,J,1)=ZMDI(J,J,1)+ZPCW ALSO SAVE COMBINATION OF CHANNELS THAT PRODUCED IT
CONTINUE GO CHECK NEXT CLASS AVG.
C CHECK IF THIS CONBO. IS IN THE TOP *NFRIT* POSITIONS AS RANKED BY
C MAXIMUM AVERAGE DIVERGENCE AND BY MAXIMUM MINIMUM INTERCLASS DIVERGENCE
IF(ZCAVG,J,J).LE.ZMDI(J,J,1,1)) GO TO 90 IS AVG. DJ IN TOP *NFRIT*
DO 91 J=1,NFRT YES, RANK IT AND SAVE IT
DO 91 J=1,NFRT YES, RANK IT AND SAVE IT
DO 91 J=1,NFRT YES, RANK IT AND SAVE IT
IF(ZCAVG,J,J).LE.ZMDI(J,J,1,1)) GO TO 91 IS THIS AVG. DJ .LT. J'TH SAVED AVG.
J=1 J=1 YES, COPY ALL J POSITIONS TO J+1 POSITION
DO 90 J=1,NFRT,J,J-1 INDEX THRU MAX. DIJ'S THAT ARE SMALLER THAN ZAVG
ZMDI(J,J,J)=ZMDI(J,J,J)+ZDI(J,2) MOVE SMALLER MAX. DJ'S DOWN IN RANK
ZMDI(J,J,J)=ZMDI(J,J,J)+ZDI(J,2) ALONG WITH THEIR CHANNEL WORDS
ZMDI(J,J,J)=ZMDI(J,J,J)+ZPCW SAVE CHANNELS THAT PRODUCED IT
ZMDI(J,J,J)=ZMDI(J,J,J)+ZPCW SAVE CHANNELS THAT PRODUCED IT
ZMDI(J,J,J)=ZMDI(J,J,J)+ZPCW SAVE CHANNELS THAT PRODUCED IT
ZMDI(J,J,J)=ZMDI(J,J,J)+ZPCW SAVE CHANNELS THAT PRODUCED IT
ZMDI(J,J,J)=ZMDI(J,J,J)+ZPCW SAVE CHANNELS THAT PRODUCED IT
CONTINUE GO TEST NEXT SMALLER SAVED DIJ
CONTINUE GO TEST NEXT SMALLER SAVED DIJ
CONTINUE GO TEST NEXT SMALLER SAVED DIJ
00677  90   DO 94 J=I,NPRT  YES, RANK IT AND INSERT IT
00702  91   IF(ZMIN.LE.ZMMDIJ(J,J))  GO TO 94  IS THIS MIN. DIJ GT. J' TH SAVED MIN
00704  92   J=J+1  YES, COPY ALL J RANKED ELEMENTS TO J+1 ST RANK
00708  93   DO 95 J=I,NPRT  INDEX THRU MAX-MIN DIJ'S THAT ARE SMALLER THAN ZMIN
00710  94   2MMDDIJ(J,J)=2MMDDIJ(J,J-1)  REDUCE RANK OF J' TH MIN DIJ
00711  95   95  ZMMDIJ(I,1)=ZMMDIJ(I-1,1)  ALONG WITH ITS ASSOCIATED CHANNELS
00713  96   ZMMDIJ(J,1)=ZMIN  INSERT NEW MAX-MIN
00714  97   ZMMDIJ(J,2)=ZFCW  ALONG WITH ITS ASSOCIATED CHANNELS
00715  98   GO TO 93  GO SEE IF PERCENT SEPARATION IS TOPS
00716  99   CONTINUE  GO TEST NEXT SMALLER SAVED MIN
00720 100   IF(PCTPRT.LE.0)  GO TO 96  DO I SAVE MAX. PERCENTAGE DIJ'S
00722 101   DO 98 J=1,PAIRS  YES, INDEX THRU CLASS PAIRS FOR DIJ LIMITS
00725 102   IF(ZDIJ(J).LE.0)  RETURN 0 NEGATIVE DIJ NOT ALLOWED
00727 103   IF(ZDIJ(J).GT.ZMJ)  ZDIJ(J)=ZMJ  MAX. DIJ ALLOWED IN SEPARATION COMP.
00731 104   IF(ZDIJ(J).LT.I1)  ZDIJ(J)=I1  MIN. DIJ ALLOWED IN SEPARATION COMP.
00733 105   CONTINUE  CHECK LIMITS ON NEXT CLASS PAIR
00735 106   ZPCT=1.  INITIALIZE PERCENT SEPARATION RATIO
00738 107   DO 97 J=1,PAIRS  YES, INDEX THRU CLASS PAIRS
00741 108   IF(ZPCT.GT.1.E+35)  GO TO 96  AVOID MULTIPLY CNERFLOC
00745 109   ZPCT=ZPCT(ZCIJ(J,PCTPRT)/ZDIJ(J))  CALC. RATIO CF NEW DIJ TO SAVED PCT
00748 110   IF(ZPCT.GE.1)  GO TO 96  IS PCT SEPARATION .GT. LOWEST RANK SAVED
00751 111  DO 100 JJ=J+1,PAIRS  YES, COPY ALL J RANKED SETS INTO J+1 RANK
00754 112   ZDIJ(II,I)=ZMMDIJ(II,I)  REDUCE RANK CF I TH PCT SEP.
00758 113   DO 101 II=I,PAIRS  YES, COPY ALL J RANKED SETS INTO J+1 RANK
00761 114   ZFDIJ(J,J)=ZMMDIJ(J,J)  REDUCE RANK OF J' TH PCT SEP.
00764 115   DO 102 II=I,PAIRS  YES, COPY ALL J RANKED SETS INTO J+1 RANK
00767 116   ZFDIJ(J,J)=ZMIN  INSERT NEW MAX-MIN
00770 117   ZFDIJ(J,2)=ZFCW  ALONG WITH ITS ASSOCIATED CHANNELS
00773 118   GO TO 96  FINISHED CHECKS.  GO GET ANOTHER UNIQUE CHANNEL COMBO.
00776 119   CONTINUE  GO CALC. PCT SEP RATIO FOR NEXT LOWER SET
00779 120   END  OF  COMPILATION  NO  DIAGNOSTICS.
SUBROUTINE DISPLA
ENTRY POINT 001531

STORAGE USED:
GAME(1) 001545 DATA(0) 000460 BLANK COMMON(2) 000000

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STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

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51
SUBROUTINE DISPLA

THIS SUBROUTINE RECOMPUTES DIVERGENCE FOR THOSE CHANNEL COMBINATIONS

DETERMINED TO BE IMPORTANT AND OUTPUTS THEM TO UNIT "PRINT"

INCLUDE SPEC, LIST PARAMETERS, DIMENSIONS, COMMON

IMPLICIT INTEGER(A-Z)

PARAMETERS MAXCLASS=2 MAX NO. OF CLASSES CAN

INCREASE IF NEEDED

PARAMETER NSUM=2 MAX NO. OF MEASUREMENTS IN "BEST" SUBSET

PARAMETER NSUM2 MAX NO. OF MEASUREMENTS IN "BEST" SUBSET

PARAMETER SUMA(NSUM+1):SUMA2 SUM OF 1, 2, ..., NO. IN "BEST" SUBSET

PARAMETER SUMA(NSUM+1):SUMA2 SUM OF 1, 2, ..., MAX NO. MEASUREMENTS

COMMON/UNIT/UNIT, PRINT I/O UNITS-CARD READER, PRINTER

COMMON MAXCLASS, MAXCLASS, MAXCLASS, NSUM, NSUM, PRINT MAXMAX

COMMON VEC(M3ESTA) VECMAX(M3ESTA)

COMMON/UNIT/UNIT, UNIT, UNIT, UNIT

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DIMENSION VEC(M3ESTA) VECMAX(M3ESTA)
00150  106  11111115  PRIN=1  POINTS AT "SHOW" CARD 1
00151  110  2  DO 3  J=1,NBSET  INDEX THRU "SHOW" CHANNELS
00154  120  3  VEC(J)*SHOW(J,II)  GET CHANNELS FOR DIV. COMPUTATION
00156  125  CALL  DIV  COMPUTE DIVERGENCE
00157  130  GO TO 4  PRINT OUT RESULTS
00160  150  5  I=II+1  BUMP SHOW CARD COUNTER
00161  155  IF(I<ST,NSHOW)  GO TO 1  AM I THRU WITH "SHOW" CARDS
00163  160  GO TO 2  NO, GET NEXT ONE
00164  164  1  II=II  COUNTS MAXIMUM INTERCLASS DIV. AVG.
00165  170  190  PRIN=2  FLAG TELLS TO PRINT MAX. INTERCLASS DIV. AVG.
00166  200  6  I=I  COUNTS CHANNELS IN SUBSET FOUND
00167  210  DO 7  J=1,N4  INDEX THRU TOTAL NO. CHANNELS
00172  220  K=1ABS(J-I)  AVOID NEGATIVE ZERO
00173  230  IF(FILK(K,1,Z,DIJ,J,R),EQ.0)  GO TO 7  IS THIS MAX. DIV. AVG. CHANNEL
00175  240  IF(I=ST,NEST)  RETURN 0  YES, ERROR IF MORE CHANNELS THAN IN SUBSET
00177  250  VEC(I,J)=J  SAVE CHANNEL OF INTEREST FOR DIVERGENCE CALC.
00180  260  260  II=II+1  BUMP CHANNEL COUNTER
00181  270  7  CONTINUE  GO SEE IF NEXT CHANNEL IN SUBSET
00182  280  CALL  DIV  COMPUTE DIVERGENCE
00184  290  GO TO 4  PRINT RESULTS
00185  300  10  II=II+1  BUMP MAX. DIV AVG. COUNTER
00186  310  310  IF(I=ST,NEST)  GO TO 6  AM I THRU WITH DIV AVG.
00189  320  GO TO 6  NO, GET NEXT ONE
00190  325  PRIN=3  FLAG TELLS TO PRINT MAX. MIN. DIJ
00191  330  II=II+1  COUNTS MAX. MIN. DIJ'S PRINTED
00192  340  13  I=I  COUNTS CHANNELS IN SUBSET FOUND
00193  350  150  DO 9  J=1,N4  INDEX THRU TOTAL NO. CHANNELS
00197  360  K=1ABS(J-I)  AVOID =0
00198  370  IF(FILK(K,1,Z,DIJ,J,R),0)  GO TO 9  IS THIS MAX. MIN. CHANNEL
00200  380  290  IF(I=ST,NEST)  RETURN 0  YES, ERROR IF MORE CHANNELS THAN IN SUBSET
00202  390  400  VEC(I,J)=J  SAVE CHANNELS OF INTEREST FOR DIV. CALC.
00203  410  II=II+1  BUMP CHANNEL COUNTER
00205  420  9  CONTINUE  GO SEE IF NEXT CHANNEL IN SUBSET
00206  430  CALL  DIV  COMPUTE DIVERGENCE
00208  440  GO TO 4  PRINT RESULTS
00210  450  11  II=II+1  BUMP MAX. MIN. PRINT COUNTER
00211  460  IF(I<ST,NEST)  GO TO 12  AM I THRU WITH MAX. MIN.
00213  470  GO TO 12  NO, GET NEXT ONE
00215  480  PRIN=4  FLAG TELLS ME I AM ON MAX. PERCENT
00216  490  II=II+1  COUNTS WHICH MAX. PERCENT ON
00218  500  15  I=I  COUNTS CHANNELS IN SUBSET FOUND
00219  510  DO 14  J=1,N4  INDEX THRU TOTAL NO. CHANNELS
00220  520  K=1ABS(J-I)  AVOID =0
00221  530  IF(FILK(K,1,Z,DIJ,J,R),EQ.0)  GO TO 14  IS THIS MAX. PERCENT ON
00223  540  540  IF(I<ST,NEST)  RETURN 0  YES, ERROR IF MORE CHANNELS THAN IN SUBSET
00225  550  550  VEC(I,J)=J  SAVE CHANNELS OF INTEREST FOR DIV. CALC.
00227  560  190  I=I+1  BUMP CHANNEL COUNTER
00228  570  14  CONTINUE  GO SEE IF NEXT CHANNEL IN SUBSET
00230  580  CALL  DIV  COMPUTE DIVERGENCE
00232  590  GO TO 4  PRINT RESULTS
00234  600  16  II=II+1  BUMP MAX. PERCENT PRINT COUNTER
00235  610  IF(I<ST,NEST)  GO TO 17  AM I THRU WITH MAX. PERCENT PRINT
00237  620  GO TO 15  NO, GET NEXT ONE
00239  630  17  I=I  COUNTS WHICH CLASS AVERAGE PRINT ON
00240  640  PRIN=5  FLAG TELLS ME TO PRINT DIJ AVERAGES BY CLASS
00241  650  21  I=1  COUNTS CHANNELS IN SUBSET FOUND
00243  660  660  DO 10  J=1,N4  INDEX THRU TOTAL NO. OF CHANNELS
I0271 079  
I0272 064  IF(FIELD(I,J,2,NEXT)=J+1), GOTO 18,  18  THIS MAX. CLASS CHANNEL
I0274 065  IF(J.GT.NBEST) RETURN 0  YES, ERROR IF MORE CHANNELS THAN IN SUBSET
I0276 070  VEC(I,J)=I  SAVE CHANNEL OF INTEREST FOR DIV. CAL.
I0278 018  I=I+1  BUMP CHANNEL COUNTER
I0280 072  CONTINUE  GO SEE IF NEXT CHANNEL IS IN SUBSET
I0282 073  CALL DIV  COMPUTE DIVERGENCE
I0284 070  GO TO 4  PRINT RESULTS
I0286 019  I=I+1  BUMP CLASS AVERAGE PRINT COUNTER
I0288 070  IF(I.GT.NBEST) GO TO 20  AM I THRU MAX. CLASS  DJ? PRINT
I0290 076  GO TO 21  NO, GO GET NEXT ONE
I0292 018  J=J+1  TEST MAXIMUM NO. OF CLASSES
I0294 070  IF(NCLASS.GT.J) GO TO 20  TEST MAXIMUM NO. OF BEST CHANNELS
I0296 070  I=I+1  COUNTS LINE OF PRINT ON
I0300 081  PRINT  FLAGS TELL ME TO PRINT MAX. AVG. INTERCLASS DIVERGENCE
I0302 082  P=1  INITIALIZE P
I0304 073  I=I+1  COUNTS CHANNELS IN SUBSET FOUND
I0306 086  IF(J.GT.NBEST) GO TO 71  IS THIS MAX. CLASS
I0308 087  C CHANNEL
I0310 086  IF(J.GT.NBEST) RETURN 0  YES, ERROR IF MORE CHANNELS
I0312 089  C THAN IN SUBSET
I0314 090  VEC(I,J)=I  SAVE CHANNELS OF INTEREST FOR DIV. CAL.
I0316 091  I=I+1  BUMP CHANNEL COUNTER
I0318 072  CONTINUE  GO SEE IF NEXT IS IN SUBSET
I0320 073  CALL DIV  COMPUTE DIVERGENCE
I0322 070  DO 79 J=I,NCLASS  INDEX THRU TOTAL NO. OF CHANNELS
I0324 070  K=ABS(J-I)  AVOID -0
I0326 086  IF(FIELD(I,J,NEXT)=J+1), GOTO 71  THIS MAX. CLASS
00624  1810  29  WRITE(PRINT,33) MAX. AVG. DIJ BY CLASS
00626  1820  33  WRITE(PRINT,34) DISPLAY OF CHANNEL COMBINATIONS RANKED ACCORDING*,
00628  1830  4* TO MAXIMUM AVERAGE DIVERGENCE BY CLASS*/(/)
00627  1840  40  GO TO 24  PRINT CHANNEL DATA
00630  1850  30  FORMAT(141,* DISPLAY OF CHANNEL COMBINATIONS YIELDING MAXIMUM*,
00632  1870  4* PAIR-WISE DIVERGENCE*,*/)
00633  1880  40  WRITE(PRINT,41) PRINT FIRST LINE OF SUBHEADING
00635  1890  40  WRITE(PRINT,42) PRINT SECOND LINE OF SUBHEADING
00636  1900  41  FORMAT(* CLASS MAX. AVG. *)
00637  1910  42  FORMAT(* PAIR DIJ CHANNELS*,*/)
00640  1920  24  GO TO 24  PRINT CHANNEL DATA
00641  1930  24  IF(PRINT.GT.5) GO TO 29 IS THIS MAX DIJ PRINT
00644  1940  36  WRITE(PRINT,44) (VEC(J),J=1,NBEST) NO. PRINT CHANNELS
00652  1950  44  FORMAT(* CHANNELS*,2413,/) 
00653  1960  45  WRITE(PRINT,45) ZACV PRINT AVG. DIJ
00656  1970  45  FORMAT(AVERAGE PAIR-WISE DIVERGENCE=',F8.1,/) 
00655  1960  46  WRITE(PRINT,46) ZMIN PRINT MIN. DIJ
00662  1990  46  FORMAT(MINIMUM PAIR-WISE DIVERGENCE=',F8.1,/) 
00663  2000  46  ZPT=1 INITIALIZE RATIO MULTIPLIER TO ONE
00664  2010  47  DO 47 J=1,NBEST INDEX THRU CLASS PAIRS
00665  2020  47  ZPTF=ZPTF-ZDI(J) ZPTF(J)=ZPTF(J-1) CALC. RATIO OF THIS DIJ TO MAX. SET
00671  2030  48  WRITE(PRINT,48) ZPTF-YIELDING PERCENT MAX. 4*
00674  2040  48  ZPT=ZPT+1 RATIO OF THIS CHANNEL SET WITH CHANNEL SET*,
00675  2050  48  DO 49 J=1,NCL INDEX THRU CLASSES
00700  2060  49  ZCAGF(J)=0 INITIALIZE CLASS AVG. MATRIX
00702  2070  49  LOFF=NCL-1 NO. OF PAIRS TO SUM FOR EACH CLASS
00703  2080  49  M=0 INDEX THRU DIJS FOR THIS CHANNEL COMBO.
00704  2090  49  DO 50 J=1,NCL INDEX THRU 1'S OF DIJ
00705  2100  50  UP=1-1 UPPER LIMIT ON J
00710  2110  50  DO 50 J=1,UP THE J OF THE DIJ
00713  2120  51  M=U+1 GO TO NEXT DIJ
00714  2130  52  ZCAGF(J)=ZCAGF(J)+ZDI(J,M) COMPUTE SUM FOR 1' TH CLASS
00715  2140  53  ZCAGF(J)=ZCAGF(J)+ZDI(J,M) COMPUTE SUM FOR J' TH CLASS
00720  2150  50  DO 51 J=1,NCL THRU CLASSES
00723  2160  51  ZCAGF(J)=ZCAGF(J)/ACM COMPUTE AVG. DIJ FOR CLASS
00725  2170  52  WRITE(PRINT,52) SUBR FOR CLASS AVG. PRINT
00727  2180  52  FORMAT(AVERAGE DIVERGENCE BY CLASS*,*) 
00730  2200  53  WRITE(PRINT,53) CHAR(J),ZCAGF(J),J=1,NCL) PRINT CLASS CHARACTERS,AVG.
00737  2210  53  ZF=0 AVERAGE INTERCLASS DIVERGENCE FOR CLASS *,A1,* = *,F10,3)
00740  2220  54  WRITE(PRINT,54) 
00742  2230  54  FORMAT(100,* PAIR-WISE DIVERGENCE*)
00743  2240  54  WRITE(PRINT,50) (DIJ(J),DIJ(J+1),J=1,Pairs)
00752  2250  56  WRITE(PRINT,56) FORMAT(1X,10(IX,A2,="",F8.1))
00753  2260  56  IF(INCL(0,T,J)) WRITE(PRINT,90) GO TO NEXT PAGE
00756  2270  90  FORMAT(H1,/) 
00757  2280  90  SP(15,5,2) WRITE(PRINT,92) SKIP A FEW LINES
00762  2290  99  FORMAT(H1,/) 
00766  2300  99  FORMAT(H1,/) 
00768  2310  99  GO TO 4(X,10,11,16,191) FINISHED PRINTING THIS SET, GO GET NEXT ONE
00769  2320  99  C PRINT OUT CLASS PAIR MAX DIJ, AVG DIJ, AND CHANNELS
00774  2330  99  DO 39 (VEC(J),J=1,NBEST)
00775  2340  39  WRITE(PRINT,40) ZDI(J),ZDI(J+1),ZDI(J+2), (VEC(J),J=1,NBEST)
00776  2350  39  FORMAT(1X,A2,F9.1,F8.1,2413)
00777  2360  39  GO TO 22 GO GET NEXT MAX DIJ TO PRINT
00777  2360  39  END

END OF COMPILED NO DIAGNOSTICS.

56
SUBROUTINE DIV

C THIS SUBROUTINE COMPUTES DIVERGENCE AND PARAMETERS NEEDED BY DISPLAY

C FOR A GIVEN SET OF CHANNELS

INCLUDE SPECLIST PARAMETERS, DIMENSIONS, COMMON

C IMPLICIT INTEGER(A-Z) ALL INTEGER EXCEPT Z

PARAMETER MAXCLA=32 MAX. NO. OF CLASSES, CAN

C INCREASE IF NEEDED.

PARAMETER HSOMA=24 MAX. NO. OF MEASUREMENTS (CHANNELS), CAN INCREASE.

PARAMETER HNESTA=12 MAX. NO. OF MEASUREMENTS IN "BEST" SUBSET

PARAMETER SUMA=(HOMA+1)*HNESTA/2 SUM OF 1,2,...,NO. IN "BEST" SUBSET

PARAMETER SUMS=(HOMA+1)*HOMA/2 SUM OF 1,2,...,MAX NO. MEASUREMENTS

COMMON/UNITS/CD,PRINT I/O UNITS, CARD READER, PRINTER

COMMON MAX/MOM,X,M,X1,MEANT,NS,PRINT MAXIMUM

COMON ZJ/V, ZM, ZK, N, NCL,

C INPUT

C DIMENSION ZNEASTA(HOMA,MAXA) HOLDS MEANS FOR EACH MEASUREMENT, CLASS

C DIMENSION ZCOV(SUMA,MAXCLA) HOLDS COVARIANCES (LOWER TRIANGLE)

C DIMENSION ZMEAN,ZCOV,NM,NCL,

C FOR EACH CLASS.

C RESTA=10 NO. OF COMBO'S RANKED BY PERCENT TO BE PRINTED

C DIMENSION VEC(HNESTA) HOLDS UNIQUE COMBINATION OF FEATURES (CHANNELS)

C COMMON ZINV(ZINV,ZJ,V,M,J,VEC) INVERSION ARRAYS

C DIMENSION ZINV(HOMA,MAXCLA) HOLDS INVERSE COVARIANCE MATRICES

C FOR EACH CLASS

C DIMENSION ZXYNEASTA(MAXCLA) WORKING ARRAY USED WHEN COMPUTING

C INVERSE BY BORDERING METHOD.

C DIMENSION ZDIJ(ZDIJ) WORKING BUFFER FOR INTERCLASS DIVERGENCE

C DIMENSION ZCHAR(MAXCLA) HOLDS CHARACTER REPRESENTATION OF CLASSES

C COMM VI ZDIJ ZDIJ,zDIJ,zDIJ,zDIJ, zDIJ,

C DIMENSION ZDIJ(ZDIJ) (DIM/3) WORK ARRAYS TO FIND LARGEST CLASS AVG. DIJ

C DIMENSION ZDIJ(ZDIJ) WORK ARRAY USED TO FIND LARGEST CLASS AVG. DIJ

C DIMENSION ZDIJ(ZDIJ) HLD CHARACTER COMBO'S FOR DIJ PAIRS

C END

C DIMENSION ELSUMA PRINT BUFFER, HOLDS ELEMENTS

C OF COVARIANCE MATRIX ON ERROR.

C DIMENSION ELSUMA PRINT BUFFER, HOLDS ROW

C OF COVARIANCE MATRIX ON ERROR.

C ENCLUE VMLIST PROCEDURE INVERTS COVARIANCE MATRIX FOR ALL CLASSES

C COMPUTES INVERSE FOR "NCL" MATRICES BY BORDERING TECHNIQUE

C THIS ALGORITHM PERFORMS MATRIX INVERSION ON A SYMMETRIC MATRIX.

C SEE "STATISTICAL COMPUTATIONS ON A DIGITAL COMPUTER" BY MENDELE, PG 73

C THE INPUT MATRIX IS "ZCOV" IN LOWER TRIANGLE FORM

C THE INVERSE OF "ZCOV" IS STORED IN "ZINV" IN LOWER TRIANGLE FORM.

C THIS PROCEDURE RESTRICTS ITSELF TO THE 200 SERIES
C AND TO INTERNAL FLAGS STARTING WITH "I"

DO 221 XC=1,NBEST  REDUCE COV. MATRIX FOR EACH CLASS

XCT=0 COUNTS WHERE I AM IN REDUCED COV. MATRIX

DO 221 XC=1,NBEST  REDUCED MATRIX OF RANK "BEST"

XI=VEC(XC) RETRIEVE LOGICAL ROW INDEX

DO 221 X=1,NC COLUMN INDEX FOR REDUCED LOWER TRIANGLE MATRIX

XJ=VEC(X) RETRIEVE LOGICAL COLUMN INDEX

XIND=X+(I-1)/2+XJ  CONVERT TO LOWER TRIANGLE INDEXING SCHEME

XCT=XT  BLIND POINTER IN REDUCED COVARIANCE ARRAY

DO 221 ZINV(XCT,XCL)=ZCOV(XCT,XCL) REDUCE COVARIANCE MATRIX FOR EACH CLASS

C NOW COMPUTE INVERSE

DO 222 X=1,NBEST COMPUTE INVERSE FOR EACH CLASS

XI=1,NC 0.00001) GO TO 230 WILL I BE

C DIVIDING BY ZERO

ZINV(X,I)=C0.0IZINV(X,I,XCL) NO, TAKE RECIPROCAL

DO 201 X=1,NC INDEX THRU ROWS

DO 202 XI=1,XC INITIALIZE WORK ARRAY TO ZERO

ZINV(XIT,XCL)=0

DO 203 X=1,NCL UPPER ROW LIMIT

DO 204 XI=1,XC INDEX THRU ROWS

DO 205 XI=1,XC INDEX THRU COLUMNS

XCL=(XI-1)*XI/2+XJ COMPUTE LOWER TRIANGLE INDEX FOR (I,J)

XCL=(XI+1)*XI/2+XJ DITTO FOR (K,J)

ZV(XI,XCL)=ZV(XI,XCL)+ZINV(XI,XCL)ZINV(XJ,XCL) COLUMN WORK VECTOR

IF(XI-XM) 205,203,205 AM I THRU COMPUTING WORK VECTOR

DO 203 X=1,NCL NO, COMPUTE LOWER LIMIT AND CONTINUE

DO 204 XI=1,XC INDEX THRU COLUMNS

DO 205 XI=1,XC INDEX THRU ROWS

XCL=(XI-1)*XI/2+XJ COMPUTE LOWER TRIANGLE INDEX FOR (K,J)

XJ=(XI-1)*XI/2+XJ DITTO FOR (J,I)

ZV(XJ,XCL)=ZV(XJ,XCL)+ZINV(XJ,XCL)ZINV(XJ,XCL) COLUMN WORK VECTOR

DO 206 XI=1,XC GO TO NEXT ROW

DO 207 XI=1,XC GO THROUGH XI'TH COLUMN OF THE XI'TH ROW

DO 208 XI=1,XC COMPUTE LOWER TRIANGLE INDEX (LTI) FOR (K,J)

XCL=(XI-1)*XI/2 LTI FOR (K,J)

XRK=(XK-1)*XK/2 LTI FOR (K,K)

XRK=(XK+1)*XK/2 LTI FOR (K,K)

IFABS(ZINV(XK,XCL)-ZV(XK,XCL)) .LT. .00001) GO TO 230 I BE

C DIVIDING BY ZERO

ZINV(XK,XCL)=ZINV(XK,XCL)-ZV(XK,XCL) INVERSE OF ELEMENT (K,K)

ZINV(XK,XCL)=ZINV(XK,XCL)-ZV(XK,XCL) INVERSE OF ELEMENT (K,K)

DO 207 ZINV(XK,XCL)=ZINV(XK,XCL)-ZV(XK,XCL) (J,J) INV

DO 209 ZINV(XK,XCL)=ZINV(XK,XCL)-ZV(XK,XCL) (K,J) INV

DO 209 ZINV(XK,XCL)=ZINV(XK,XCL)-ZV(XK,XCL) INV

CONTINUE GO TO NEXT ROW

CONTINUE GO TO NEXT CLASS

GO TO 240 SKIP ERROR PRINT

C PROBLEMS ON ATTEMPTING TO INVERT MATRIX

C

WRITE(PRINT,231)

FORMAT (1H1,"***ERROR*** ON ATTEMPT TO COMPUTE INVERSE",1)

* OF THE FOLLOWING SUB-MATRIX",11)
WRITE(PRINT,238)
00305 101 232 FORMAT(" THE DIAGONAL ELEMENTS CANNOT BE ZERO.",/)
00306 101 * NO TWO ROWS CAN BE THE SAME.",/)
00306 101 WRITE(PRINT,235) (VEC(X),XC=1,NBEST) PRINT FEATURES
00314 101 233 FORMAT(1X,11,T15S)
00315 101 XL=0 COUNTS ELEMENTS IN LOWER TRIANGLE MATRIX
00316 101 DO 234 XC=1,NBEST INDEX THRU NO. CHANNELS IN SUBSET
00317 101 X=VEC(XC) GET ROW INDEX IN BIG COV. MATRIX
00318 101 DO 235 XD=1,XC INDEX THRU COLUMNS
00321 101 235 IF(XJ.EQ.X) PRINT ERRор MESSAGE 1
00322 101 XJ=VEC(XD) GET COL. INDEX IN BIG COV. MATRIX
00323 101 IF(XJ.EQ.X) K=K+1 COMPUTE WHERE F...L ARE IN LOWER TRIANGLE
00324 101 IF(XJ.EQ.X) L=XL+1 BUMP COUNTER FOR NO. ELEMENTS IN LOWER TRIANGLE
00327 101 235 WRITE(PRINT,235)XCL ELX(XL) XCL SAVE LOWER TRIANGLE INDEX
00330 101 235 ZPRINT(XD)=ZCNV(KIND,XCL) RETRIEVE NEXT
00331 101 C ELEMENT IN ROW FROM BIG MATRIX
00333 101 236 WRITE(PRINT,236) (ZPRINT(X),XI=1,XC) PRINT THE ROW
00341 101 236 FORMAT(1X,11,T15S)
00342 101 236 CONTINUE "GO PRINT NEXT ROW"
00344 101 237 IF(OF.EQ.1) WRITE(PRINT,237) TEST ERROR FLAG
00347 101 237 FORMAT("0 ERROR OCCURRED ON FIRST ROW",/)
00350 101 237 IF(OF.EQ.2) WRITE(PRINT,238) TEST ERROR FLAG
00353 101 237 FORMAT("0 ERROR DID NOT OCCUR ON FIRST ROW",/)
00354 101 237 WRITE(PRINT,235)XCL
00357 101 239 FORMAT(" THIS SUB-MATRIX IS LOCATED IN THE,13,31STH").
00357 101 C COVARIANCE MATRIX, *
00360 101 WRITE(PRINT,241) CHAR(XCL)
00363 101 EL1 FORMAT(" THIS COVARIANCE MATRIX IS FOR CLASS *,A2,
00363 101 WRITE(PRINT,241) (CHAR(X),XI=1,XC) PRINT LOWER
00364 101 C TRIANGLE INDEXES
00367 101 243 FORMAT(" CHECK ELEMENTS-",2514)
00379 101 WRITE(PRINT,244) (ZCNV(X),XI=1,XC) PRINT BIG MATRIX
00384 101 244 FORMAT(1X,11,T15S)
00400 101 240 RETURN IF FATAL ERROR, GET DUMP.
00404 101 240 CONTINUE CONTINUATION TO SKIP ERROR PRINT
00404 111 END INCLUDE DIJ.LIST PROCEDURE TO COMPUTE DIJ FOR ALL CLASSES
00405 111 C THIS PROCEDURE COMPUTES INTERCLASS DIVERGENCE AS FOLLOWS...
00405 111 C THIS PROCEDURE COMPUTES INTERCLASS DIVERGENCE AS FOLLOWS...
00405 111 C IN-MEAN VECTOR OF ITH CLASS
00405 111 C DIJ-INTERCLASS DIVERGENCE BETWEEN CLASSES I AND J
00405 111 C IN-TRACE. IE SUM OF DIAGONAL ELEMENTS
00405 111 C IN-COVARIANCE MATRIX OF ITH CLASS
00405 111 C N-RANK OF MATRIX
00405 111 C DIJ-TRIANGLE (K,J,K) = 0.5*TR(K,J,K,J)+TR(J,K,I,J)
00405 111 C THIS PROCEDURE RESTRICTS ITSELF TO STATEMENTS IN THE 320 SERIES
00405 111 C AND INTERNAL VARIABLES STARTING WITH W.
00408 111 X=0 POINTS TO WHERE I AM IN INTERCLASS DIVERGENCE ARRAY
00408 111 DO 300 WA=-2,XCL "I" OF THE DIJ CALC. IE. CLASS I.
00408 111 WI=WA-1 "I" OF THE DIJ CALC. IE. CLASS J.
00408 111 WC=W+1 READY FOR NEXT DIJ CALC.
00408 111 WIJ=I+1 INITIAlIZE SUM
00408 111 Z=0 "I" OF THE DIJ CALC. IE. CLASS J.
00408 111 WS=W+1 READY FOR NEXT DIJ CALC.
00408 111 ZDZ=I+1 "I" OF THE DIJ CALC. IE. CLASS I.
00408 111 DO 300 WI=1,NBEST LOGICAL RANG OF COV. AND INVERSE COV. MATRIX
00421 111
IF(ZDL(AH(J),LT.2)) ZDL(AH(J),EQ.2) MIN DIJ ALLOWED IN FCT SEPARATION COMP.

INDIJ(CALC.) = MIN DIJ ALLOWED IN FCT SEPARATION COMP.

IF(ZDL(AH(J),GT.2)) ZDL(AH(J),EQ.2) MIN DIJ ALLOWED IN FCT SEPARATION COMP.

INDIJ(CALC.) = MIN DIJ ALLOWED IN FCT SEPARATION COMP.

RETURN

END

END OF COMPILED DATA NO DIAGNOSTICS.
Input Data Deck
(from flight line C-1)

This deck was input to produce the Example of Output.
COVAR 11916456+03 91153415+01 19565242+02 14858625+02 18413299+02
COVAR 44470342+02 50299419+02 35527575+02 65790864+02 30366692+02
COVAR 69153946+02 66374119+02 48931422+02

PRINT=10 MAX 01J=30000 NO. SHOW=03

CHANNELS=01,09,11,12

CHANNELS=06,09,10,11

CHANNELS=01,06,10,11
Input Deck Description

Please refer to pages 61-64 as an example of a typical input deck.

Card 1
Field 1. n - the number of input channels (measurements). In this case, n=12.
Field 2. m - The number of classes (populations). In this case, m=9.
Field 3. k - The size of the "best" subset. The task is to pick the "best" k of n channels. In this case, k=4.
Format: This card is read with the following format: (9X,I2,9X,I2,6X,I2)

Cards 2-4 These cards contain the mean readings for the n channels of class 1. Field 1 is the mean response for the first channel; ..., field 12 is the mean response for the twelfth channel. Three cards are required to hold the data for 12 channels.
Format: (5X,5E15.8)

Cards 5-28 These cards contain the mean readings for the n channels of classes 2 through m. In this case, three cards are required per class.
Format: (5X,5E15.8)

Cards 29-44 These cards contain the lower triangular covariance matrix for class 1. (Since the matrix is symmetric, it is only necessary to read the lower triangular portion).
Field 1 - The variance of channel 1 for class 1
Field 2 - The covariance of channels 2 and 1 for class 1
Field 3 - The variance of channel 2 for class 1
Field 4 - The covariance of channels 3 and 1 for class 1
Field 5 - The covariance of channels 3 and 2 for class 1
... Field n(n+1)/2 - The variance of channel n for class 1
From this, it can be seen that there are 78 fields per class in the 12 channel case and that there are 16 cards/class.
Format: (5X,5E15.8)
Cards 45-172 These cards contain the lower triangular covariance matrices for classes 2 through m. The fields are encoded in a similar to those for cards 29-44. There are 16 cards/class in this case.
Format: (5X,5E15.8).

Card 173 A symbol associated with each class. These symbols should be in the same order as the class statistics they represent, i.e., symbol 1 represents class 1, ..., symbol m represents class m.
Format: (7X,36(1X,A1)).

Card 174 Field 1. The number of top ranked channel sets to be printed for criteria, 1, 2, and 3.
Field 2. The maximum pairwise divergence to be allowed by the program in its criteria tests. If a divergence is greater than this maximum, then it is set to it.
Field 3. The number of specific channel combinations asked to be displayed, i.e., the number of "show" requests. If there are no show requests, this field should be set to zero.
Format: (6X,I2,9X,I5,10X,I2)

Cards 175-177 The specific channel combinations the investigator would like to have displayed. For example, the investigator has requested to see set (1, 9, 11, 12). There should be the same number of these cards as was specified in field 3 of card 174.
Format: (8X,24(1X,I2)).