An Investigation of a Nine State EMG Pattern Recognition Classifier for a Prosthetic Arm

by

J. Winston Brown

A thesis
presented to the University of Manitoba
in partial fulfillment of the
requirements for the degree of
Masters of Science
in
Electrical Engineering

Winnipeg, Manitoba

AN INVESTIGATION OF A NINE STATE EMG PATTERN RECOGNITION CLASSIFIER FOR A PROSTHETIC ARM

BY

J. WINSTON BROWN

A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

ABSTRACT

In the design of a myoelectric prosthetic limb classifier, it is highly desirable to obtain myoelectric signals which contain the most discriminating information available. This thesis investigates the classifier success rate for three different muscle site configurations. The first configuration involves only two myoelectric channels with electrodes placed across the biceps and triceps muscles. The second and third involve four channels. The second configuration used four equally spaced channels around the upper arm. The third placed a channel each across the biceps, triceps, anterior deltoid and posterior deltoid muscle.

To reduce the amount of conscious control the patient must exert in order to use a multifunctional arm, the techniques of pattern recognition were applied to features of the the myoelectric signals. Linear discriminant analysis was used to classify between the nine possible motions of: wrist pronation/supination, elbow flexion/extension, humeral rotation in/out, arm extension/retraction and the resting state.

The results show that the four channel configurations provide far more successful classifiers than those for the

two channel configurations tested. It was found that the transformation of the feature space via the logarithm function helped to increase the classifier success rate. The deltoid, biceps and triceps channels produced the best classifier for two subjects with the success rates of 86.7% and 92.0%. The four upper arm channels produced better classification for the third subject. The success rate was 86.2%.

ACKNOWLEDGEMENTS

I wish to thank my thesis director, Prof. E. Shwedyk, for his direction and helpful suggestions in this research. Thanks are also extended to Prof. S. Balakrishnan for the design of the strain gage bridge used in the motion jig.

This work has been supported by grants from Health and Welfare, Canada, and NSERC, Canada.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter I

INTRODUCTION

Since research began in the field of externally powered prosthetic hands/arms, the method of controlling the devices has been a major concern. The function of the controller is to provide an interface between the person who wishes to have the device perform a particular action and the device itself [1]. The user must generate information for the controller's classifier. The classifier uses the information to choose a state for the controller to implement. Obviously, the difficulty of the problem increases significantly as the number of distinct controller states increases.

One of the approaches to this design problem has been to make use of the electrical signals generated by the muscles themselves when they are contracted. The choice of the muscles to be used and the method of making use of these muscle signals also varies considerably.

One possible "simple" controller would be a two state controller; a single function state (eg. prehension) and a rest state. A single muscle, such as the biceps muscle, could be chosen as the controlling muscle. One way of choosing the function state would be to test the muscle signal (electromyographic signal, or simply EMG) variance, against a threshold value. Other statistics of the signal could be and have been considered. If the threshold value is exceeded (ie. the controlling muscle has been contracted to at least a set minimum required amount of force) the function state is chosen by the classifier. Conversely, if the variance is less, the rest state is chosen and the device does nothing. In a similar fashion, controllers with three and five state classifiers have been designed [2-7].

This approach to the classifier design is dependent on the user being able to successfully exert a consistent force in the controlling muscle within all the force ranges. Thus, the limit to the number of states possible is the maximum number of force ranges the user is able to properly use. The user's ability to control the muscle force can be significantly increased with training.

To further expand the number of useable states, it is possible to use more than a single muscle. Again, training is required in order to increase the success rate of the classifier. Unfortunately, as the number of thresholds and the number of muscles used increases, the success of the classifier while in actual use decreases.

Reasonable success has been obtained with a single muscle, three state classifier. Scott [8] has found that the three state classifier is essentially error free. The success of the five state classifier is not as good. Richard [6] has shown that with visual feedback, laboratory error rates of 5 to 10 percent can be had with a five state classifier after proper training. McKenzie [9] obtained less successful results. He found error rates of 18 to 60 percent.

Beyond the above level of complexity, the amount of concentration required of the user is extremely high. Even with extreme concentration, more complex classifiers still suffer significantly from incorrect state choices. In order to expand the role of the classifier to many states, it appears that a modified or new approach to the design problem must be taken.

This thesis investigates one approach to the multi-state classifier. The controller state classifier designed allowed the following nine states: elbow flexion/extension, wrist supination/pronation, humeral rotation inward/outward, arm extension/retraction and the rest state. The chosen method for state decision making was based on pattern recognition theory. This allowed the user to control the device by attempting to perform the actual motion desired. If the user wished to wrist pronate, he/she simply attempted to wrist pronate. The other states were activated in a similar manner.

Another important aspect is the choice of muscles from which the required controlling information is obtained. This aspect was tested, in part, by using three different muscle site configurations.

The theory, method of implementation and the evaluation of this classifier are the topics of discussion in the following chapters.

Chapter II

BACKGROUND

2.1 OBJECTIVES

The motions provided by the developed classifier had to allow reasonable motion versatility. Of equal importance was the ability to successfully classify the subject's desired motion. In order to do this, it was necessary to design for a suitable choice of motions and also provide suitable EMG channels which would provide the signal information for choosing these motions.

2.2 THE CHOICE OF CONTROLLER MOTIONS

The prime function of the device is to provide as wide a variety of motion capability as is reliably possible. This variety is also a prime parameter of the decision success rate. A tradeoff exists: versatility versus success rate. For the purposes of this study, motions were primarily restricted to basic single movements.

Most arm motions can be broken down into the basic single movements of: various modes of finger motion, forearm (wrist) supination/pronation, wrist flexion/extension, wrist abduction/adduction, elbow flexion/extension, humeral inward/outward rotation, shoulder flexion/extension, and shoulder abduction/adduction [10].

Since the design is for a mid to low above elbow amputation, many of the above motions are not required by the device since they are still available in the amputated limb. For others, it is highly unlikely that great success could be obtained in providing these motions. The shoulder motions remain considerably intact. Therefore they fall into the former group. The finger motions and possibly some of the wrist motions lie within the latter group.

Of the wrist movements possible, abduction/adduction and flexion/extension can be compensated for with other arm and shoulder movements. Many hand movements require the use of wrist pronation/supination. This movement is not easily compensated for. Also of major use is a person's ability to reach out, i.e. extension/retraction. Thus the latter four movements are included in the choice of desired motions for these reasons.

With these considerations, the desired motions are wrist pronation/supination, elbow flexion/extension, humeral inward/outward rotation and arm extension/retraction. These eight motions along with a resting state provide significant prosthetic device versatility.

2.3 THE CHOICE OF EMG CHANNELS

One of the prime requirements of a good classifier is an acceptable success rate. Since EMG signals are the source of classifier information, an attempt to increase the classifier decision success may involve using more EMG signals. If the decision quality increases, the extra signals contain useful controlling information. Unfortunately, as always, there is a tradeoff. With an increase in the number of EMG channels comes increased cost, power consumption and computing requirements. Technological advancements may reduce the importance of these considerations. A problem not so easily solved is the decreasing amount of extra discriminating information available by using additional EMG channels. With these points in mind, a maximum of four possible channels was established as a restriction. Consideration of more numerous channels may be of value based in part on the results of this four channel research. It should also be noted that equipment restrictions also made the choice of four EMG channels appropriate.

Previously, it was stated that three different EMG electrode configurations were tested. One configuration involved two channels. These were the biceps and triceps muscles. The two other configurations used four channels. The first involved the biceps and triceps muscles with the remaining two channels being placed between the biceps and triceps muscles. This resulted in four channels approximately equally spaced around the upper arm. This was similar to the approach of Doerschuk [11] and Dening [12] who equally spaced the four channels around the lower arm.

The other configuration was derived from applied kinesiology considerations. Table 2.1 shows a muscle action table for the upper extremities. The chart shows which muscles are involved in different movements as either prime movers or assistant movers [10] [13]. From this chart, muscles are chosen which are used in the motions the classifier is to recognize. It is also beneficial if the individual muscles chosen are primarily used to produce different motions from those of the other chosen muscles. In this manner, the pattern recognition technique used should have a greater chance of success of separating the motions into their separate groups. Muscles which provide stability of the arm or shoulder during motions should also be considered, but with great care. They may or may not show feature differences for each of the desired motions. From the practical standpoint of placing electrodes on the chosen muscles, it is wise to choose subcutaneous muscles. On this basis, the muscles chosen were: biceps, triceps, deltoid anterior and deltoid posterior.

TABLE 2.1

Upper Limb Muscle Action Table

Muscles	Wrist				
	Grip	Flexion	Extension	Abduction	Adduction
Flexor Pollicis Longus	x	x			
Adductor Pollicis	x				
Abductor Digiti Quinti	x				
Abductor Pollicis Brevis	x				
Abductor Pollicis Longus	x				
Lumbricalis					
Flexor Digitorum Profundus	x	x			
Flexor Pollicis Brevis	x				
Flexor Digitorum Sublimis	x	x			
Flexor Carpi Ulnaris		x			x
Flexor Carpi Radialis		x		x	
Palmaris Longus		x			
Extensor Carpi Radialis Brevis			x	x	
Extensor Carpi Radialis Longus			x	x	
Extensor Carpi Ulnaris			x		x
Extensor Digiti Quinti			x		
Extensor Digitorum Communis	x		x		
Extensor Indicis	x		x		
Extensor Pollicis Longus	x		x		
Extensor Pollicis Brevis					
Supinator					
Pronator Quadratus					
Anconeus					
Pronator Teres					
Brachialis					
Brachioradialis					
Biceps					
Triceps					

x - prime mover or assistive mover

TABLE 2.1

Upper Limb Muscle Action Table (continued)

Muscles	**Lower Arm**		**Elbow**	
	Medial Rotation	**Lateral Rotation**	**Flexion**	**Extension**
Flexor Pollicis Longus				
Adductor Pollicis				
Abductor Digiti Quinti				
Abductor Pollicis Brevis				
Abductor Pollicis Longus				
Lumbricalis				
Flexor Digitorum Profundus				
Flexor Pollicis Brevis				
Flexor Digitorum Sublimis			x	
Flexor Carpi Ulnaris			x	
Flexor Carpi Radialis			x	
Palmaris Longus			x	
Extensor Carpi Radialis Brevis				x
Extensor Carpi Radialis Longus				x
Extensor Carpi Ulnaris				x
Extensor Digiti Quinti				
Extensor Digitorum Communis				x
Extensor Indicis				
Extensor Pollicis Longus				
Extensor Pollicis Brevis				
Supinator			x	
Pronator Quadratus		x		
Anconeus	x			x
Pronator Teres	x			x
Brachialis			x	
Brachioradialis			x	
Biceps		x	x	
Triceps				x

x - prime mover or assistive mover

TABLE 2.1

Upper Limb Muscle Action Table (continued)

Muscles	**Shoulder**					
	Flexion	**Extension**	**Abduction**	**Adduction**	**Medial Rotation**	**Lateral Rotation**
Biceps	x		x		x	
Coracobrachialis	x		x			
Deltoid (Anterior)	x		x		x	
Deltoid (Middle)			x			
Deltoid (Posterior)		x	x			x
Pectoralis Major (Clavicular)	x			x	x	
Pectoralis Major (Sternal)	x	x		x	x	
Latissimus Dorsi		x		x	x	
Infraspinatus		x				x
Teres Major		x		x	x	
Teres Minor		x				x
Triceps (Long Head)		x		x		
Supraspinatus			x			
Subscapularis				x	x	
Levator Scapulae						
Trapezius I						
Trapezius II						
Trapezius III						
Trapezius IV						
Subclavius						
Serratus Anterior						
Rhomboideus Major						
Rhomboideus Minor						
Pectoralis Minor						

x - prime mover or assistive mover

TABLE 2.1

Upper Limb Muscle Action Table (continued)

Muscles	**Shoulder Girdle**					
	Elevation	**Depresssion**	**Abduction**	**Adduction**	**Upward Rotation**	**Downward Rotation**
Biceps						
Coracobrachialis						
Deltoid (Anterior)						
Deltoid (Middle)						
Deltoid (Posterior)						
Pectoralis Major (Clavicular)						
Pectoralis Major (Sternal)						
Latissimus Dorsi						
Infraspinatus						
Teres Major						
Teres Minor						
Triceps (Long Head)						
Supraspinatus						
Subscapularis						
Levator Scapulae	x					
Trapezius I	x					
Trapezius II	x			x	x	
Trapezius III				x		
Trapezius IV		x		x	x	
Subclavius		x				
Serratus Anterior			x		x	
Rhomboideus Major				x		x
Rhomboideus Minor				x		x
Pectoralis Minor		x	x			x

x - prime mover or assistive mover

2.4 THE CLASSIFICATION OF MOTION STATES

Given the two or four channels of EMG signals and the eight desired motions (plus a "rest" state), choosing a method of getting the desired choice of motions from the signals is the major concern. As previously indicated, the theory of pattern recognition is of use. Wirta [14], Saridis [15] and Herberts [16] [17], as well as others have also made significant use of this theory. Wirta started with fourteen EMG channels to attempt to choose between flexion/extension, pronation/supination and humeral medial/lateral rotation. He finally reduced the number of EMG channels to eight. Saridis used the two biceps/triceps EMG channels to do the same. Herberts used three channels placed on muscles in the lower arm. He concentrated on wrist and finger motions.

The method in which the user indicates the desired motion to the artificial limb classifier is quite natural. The user goes about obtaining the desired motions by attempting to use the lost limb as if it were still there. It is the job of the classifier to take the EMG signals generated by these natural motions and make the correct choice as to what motion was "performed" by the existing muscles.

It should be noted that it is possible to translate chosen movements into movements not given in the classifier state choices, i.e. an unnatural mapping of user movements to the produced artificial limb movements. For example, when the classifier chooses humeral rotation inward, the controller could have the prosthetic device perform finger flexion. This would allow for the use of device motions that would otherwise be unavailable.

The interface between the user motions and the classifier is the EMG signal. To provide the classifier with EMG signal information, features were calculated based on the signals. For three calculated features and four channels, a twelve dimensional feature space was generated. The signals produced points in this multi-dimensional space.

Pattern recognition techniques attempt to find how points in a feature space can be grouped in order to characterize each of the desired motion states. The feature space can be transformed in an attempt to provide greater separability of the motion states (nine states in this research). Tou and Gonzalez [18] and Andrews [19] discuss many of these pattern recognition techniques.

A conceptually simple but still an effective technique was to separate the states via linear boundaries. Of course these linear boundaries were most likely the sub-optimal case. But the simplicity of linear equations and the capability of transforming the feature space to increase the quality of state separation made this choice quite attractive. This was the technique used in this study. For similar reasons, Wirta [14], Saridis [15], and Herberts [16] [17] did the same. Tatsuoka [20] has described this method of discriminant analysis.

When this technique is applied to a set of actual EMG signals whose desired motion state is known, a linear equation is generated for each of the possible states. When a classifier decision is needed, the current EMG signal feature values are substituted into these equations. The state associated with the equation which has the greatest value is chosen as the desired state.

The choice of which EMG signal features should be used is not clear. Heuristic choices were made. If the signal is assumed to be a zero mean Gaussian signal, as is sometimes done, then the second moment (the variance) is the only significant feature. All odd moments disappear and all higher order even moments are functions of the second moment [21]. On this basis, the second moment was chosen as one of the features to be used. To account for some of the non Gaussian properties, the absolute value of the third moment was also chosen. The third feature was chosen to be the average zero-crossing rate. The average zero-crossing rate can be interpreted as an estimate of the frequency of an "equivalent" sine wave [22]. Thus the three features used for this research were: the average variance, the average absolute value of the third moment and the average number of zero crossings. The features were estimated over a fifty millisecond time period.

Wirta [14] used the single feature of the average absolute value of the signal magnitude. Saridis [15] used the signal zero crossings, variance and the absolute value of several other higher order moments. The choice of which features and how many should be used is still a topic of discussion and research.

Having chosen the desired device motions, EMG electrode configurations, and the classifier decision method, the design of the classifier is complete. The implementation and testing are the remaining steps.

Chapter III

EXPERIMENTAL METHOD

The research was divided into two separate parts: the first being the development of the EMG prosthetic controller classifier while the second is the actual implementation and evaluation of the same. Common to both of these parts however, is the need for subject generated EMG signals. Due to the fact that the classifier and its success in use is highly dependent on the EMG signals used, substantial effort was devoted to obtaining highly reproduceable signals.

3.1 EMG SIGNAL GENERATION

The sampled EMG signals had several dependent factors. The factors of major consideration were: electrode position and application, the manner in which the major muscles were employed to produce the desired "motion" and the signal amplification and sampling.

3.1.1 Electrode Placement and Application

As previously discussed, three different electrode configurations were tested. The two channel biceps/triceps configuration was obtained directly from the other two configurations. (The information from the two remaining electrodes was simply ignored for the purposes of the two channel configuration.) Thus, only EMG signal sampling was needed for two sets of muscle electrode configurations.

The difference in the electrical potentials of two EMG electrodes produced a channel of EMG signal. A single ground electrode was used for a reference voltage for the EMG channels. The ground electrode was located at a "distant" and "nonactive" region of the subject's arm. The general location of electrode placement was governed by the electrode configuration desired. For the electrodes which were to be placed across a particular muscle, each pair of electrodes (ie. one channel) was lined up along the axis of the limb with a spacing of approximately five to eight centimeters, depending on the actual length of the muscle of interest. It was desireable to have a significant portion of the muscle between the electrodes while still having both electrodes located on the muscle itself.

The application of the electrodes to the skin was of great importance since the electrodes were to stay in constant contact with the skin for extended periods of time. The choice of a stretchy bandage adhesive tape proved to give the best results. Silver disc electrodes (type E5 SH by the Grass Instrument Company) were used with an electrode gel.

3.1.2 Motion Data Generation

When people use their limbs to produce some motion or action, resistance to a certain muscle or group of muscles is met. The method of using the limb is modified once resistance has been met so that other muscles may be recruited to help. In order to prevent the desired motion from including other compensating muscle action, a motion isolation jig was built which aids the subject in using only the muscles directly needed to perform the particular motion of interest. The jig considerably restricted arm movement to a single axis of rotation/translation. Figures 3.1 through 3.8 show the jig while in use for each of the different motions.

Figure 3.9 is a picture of the motion isolation jig itself. For stability, the jig was securely bolted to a lab table. A threaded metal post was screwed into the either the base plate of the jig or into the crossbar of the upper portion of the jig frame depending upon the motion to be performed. A strain gage bridge was adhesively attached to the base of the post. The handle gripped by the test subject was connected to the top of the post via a cable. The method of using the jig is shown in the figures indicated above.

To facilitate high signal reproduceability, the motions were each executed with the same constant force. A strain gage bridge was attached to the jig at a point through which the full motion force was applied. The force indicated by the strain gage bridge was displayed on an oscilloscope. Another flat trace, which was the subject's target level, was also displayed on the scope. The person performing the motion was asked to apply sufficient controlled force during the motion so that the force trace overlapped the target trace. This required force amounted to approximately ten to twenty percent of the persons maximum force capability. Higher force levels were not used since it was desireable to avoid muscle fatigue. Also, the chosen level approximates the level of force that would normally be used in the activities of everyday life.

It should be noted that the angle at which the cable transferred the force from the motion jig handle to the central jig post was of importance. The strain gage bridge was designed to measure the force of the bending moment of the central post. The vertical force, which would elongate the post, was not measured. Noting this condition, great efforts were made to ensure that the motions were repeated with the same angle between the cable and the central post. This kept the vertical force constant for each repetition of a given motion. Thus, the force components for the motions were reproduceable, as was required.

Three different subjects were used in this research. All three were males and in their early twenties. None had any upper limb disability. Each individual performed all sixteen motions (eight of which were rest states). The rest states were defined as the subject being prepared to perform each of the individual motions (i.e. having placed the arm in the proper position and holding the jig handle) but applying no force. The EMG signals were recorded under these conditions. Each of the eight rest states was performed four times and the eight motions were performed twelve times. (The data occurring prior to the calculated motion starting point were not used for the classifier steps. In the case of the rest states, all the data were used. Thus, it was appropriate to record fewer rest state "motions".) This produced one hundred and twenty-eight three second recordings per subject.

NOTICE/AVIS

PAGE(S) 22-26 IS/ARE EST/SONT Colour photos

PLEASE WRITE TO THE AUTHOR FOR INFORMATION, OR CONSULT THE ARCHIVAL COPY HELD IN THE DEPARTMENT OF ARCHIVES AND SPECIAL COLLECTIONS, ELIZABETH DAFOE LIBRARY, UNIVERSITY OF MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.

VEUILLEZ ECRIRE A L'AUTEUR POUR LES RENSEIGNEMENTS OU VEUILLEZ CONSULTER L'EXEMPLAIRE DONT POSSEDE LE DEPARTEMENT DES ARCHIVES ET DES COLLECTIONS SPECIALES, BIBLIOTHEQUE ELIZABETH DAFOE, UNIVERSITE DU MANITOBA, WINNIPEG, MANITOBA, CANADA, R3T 2N2.

Figure 3.1: Subject Performing Wrist Pronation

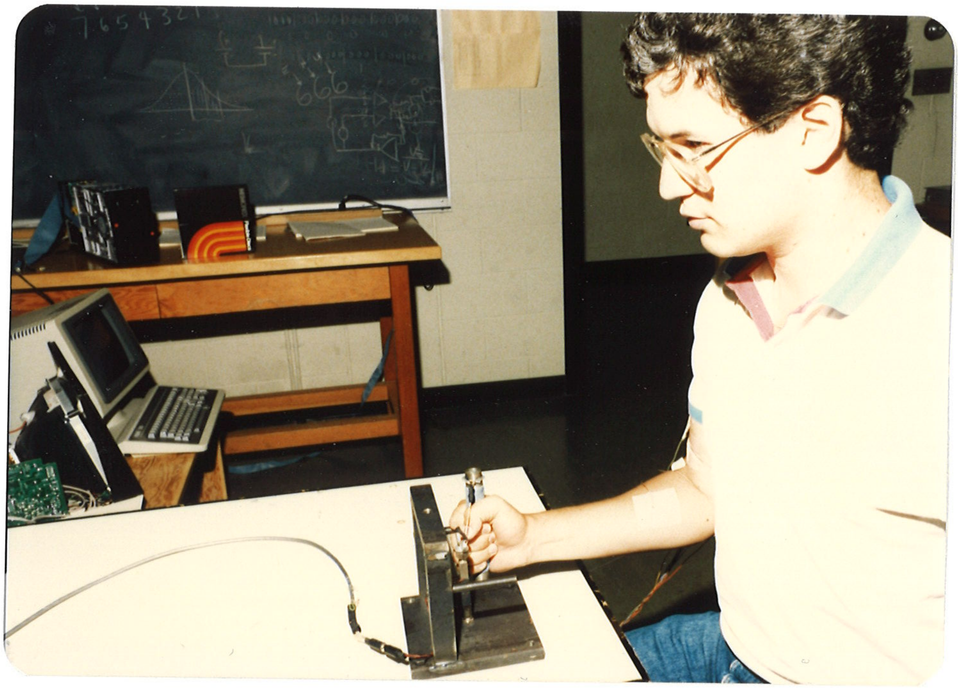


Figure 3.2: Subject Performing Wrist Supination

Figure 3.3: Subject Performing Humeral Rotation Inward

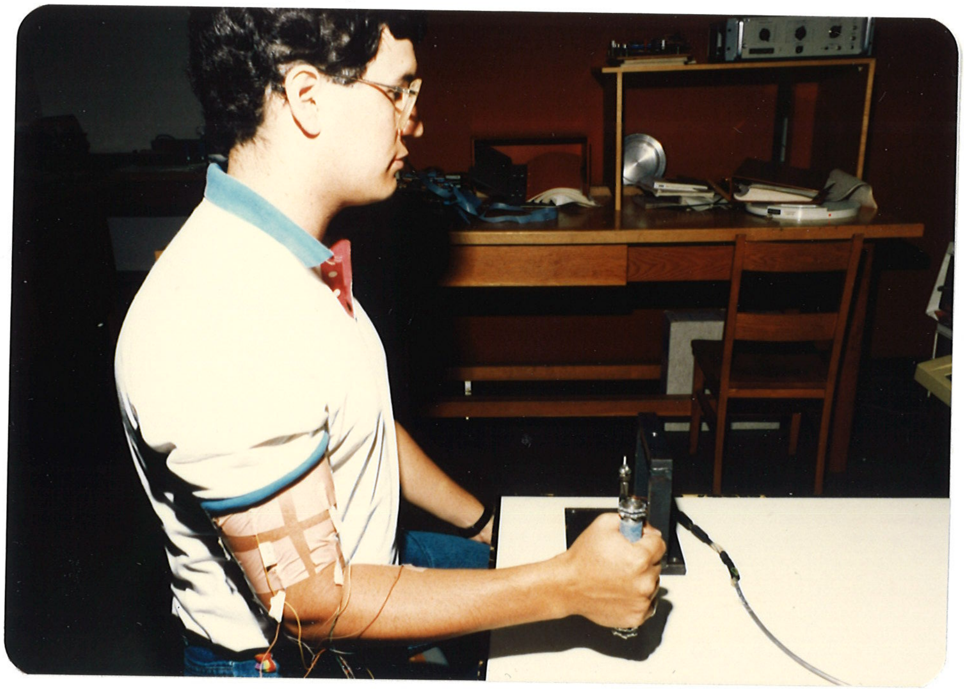


Figure 3.4: Subject Performing Humeral Rotation Outward

Figure 3.5: Subject Performing Elbow Flexion

Figure 3.6: Subject Performing Elbow Extension

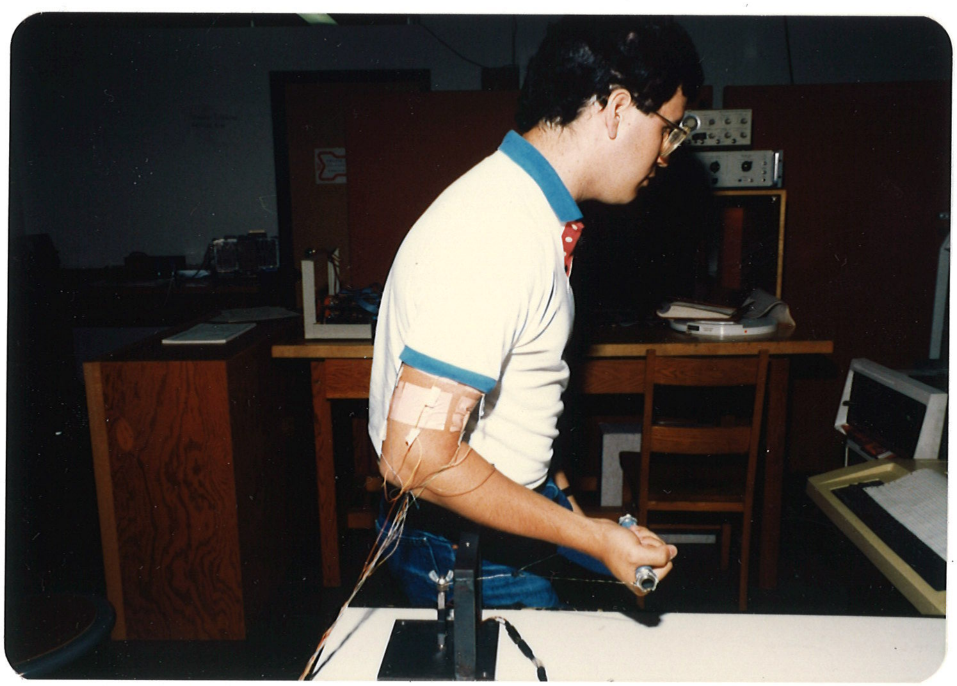


Figure 3.7: Subject Performing Arm Extension

Figure 3.8: Subject Performing Arm Retraction

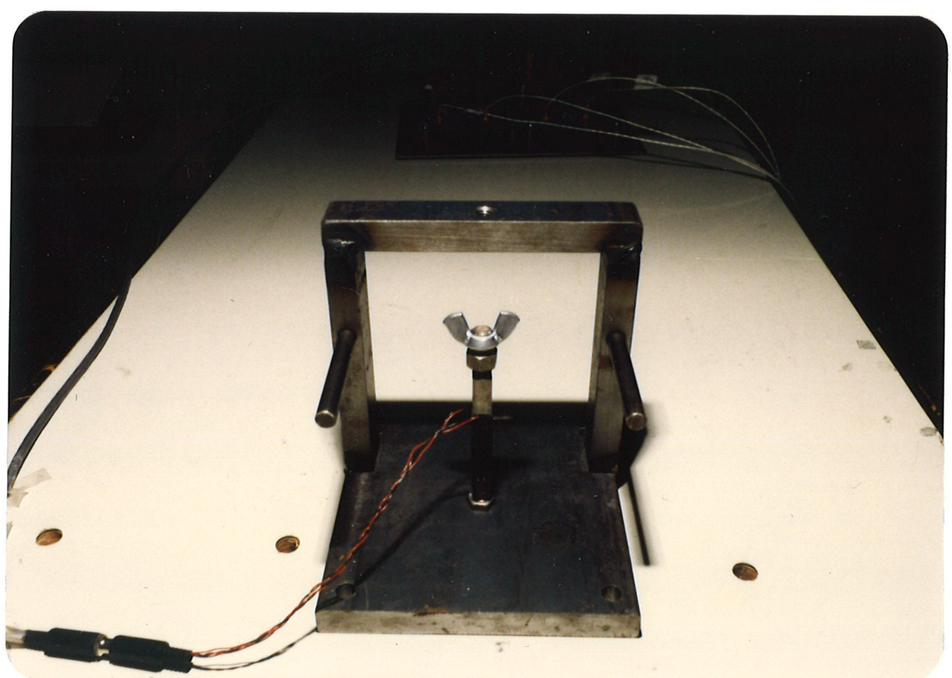


Figure 3.9: The Motion Isolation Jig

3.2 SIGNAL AMPLIFICATION AND RECORDING

3.2.1 Strain Gage Signal Amplification and Filtering

The amplification and filtering of the strain gage bridge signal was done by an Analog Devices model 2B31K strain gage amplifier. The amplifier was used with a low pass filter whose cutoff frequency was set to fifty hertz.

The amplification was needed only to make the signal easier to display on the oscilloscope. The filtering was used to smooth out the signal. The high frequency components were not of interest.

3.2.2 EMG Signal Amplification, Filtering and Recording

The EMG signals were amplified and filtered before sampling by an analog to digital convertor. The filtering was performed by a bandpass filter with cutoff frequencies of five hertz and one kilohertz.

The block and circuit diagrams for the signal amplification and filtering are shown in Appendix A [23] [24] [25].

A PDP-11/40 and an analog to digital converter were used to sample and store the EMG signals. Each of the EMG channels was sampled in rotating sequence at a frequency of one kilohertz. The signals were sampled for a period of three continuous seconds. This recording time was chosen since it was short enough in durations to minimize the effects of muscle fatigue but yet give a significant amount of data.

3.3 DATA SORTING, CALIBRATION AND CALCULATION OF FEATURE VALUES

Once the signal recording was completed, the data were uploaded from the PDP-11 to the Amdahl 5850 mainframe computer. On the mainframe computer, a program was used to: read each of the files, calculate the signal values in terms of millivolts, determine when the motion had begun and calculate the required features from that starting point onward. This program is contained in Appendix B.1.

It was necessary to determine the starting point in the data for which the desired force was being applied. When the signals were to be recorded, the person performing the motion activated the A/D and then performed the motion. Each of the motions were executed with a force which caused a change of 0.2 volts in the strain gage bridge voltage. Thus, the fifth channel provided sufficient information to determine a starting point for the motion.

Since the zero force base line voltage varied from sample file to sample file, the average of the first four data values of the fifth channel was used as the base line reference. When the strain gage data was more than 0.1 volts from the reference, the motion was assumed to have begun. It was assumed that by allowing half a second more of data to be bypassed, the steady state conditions of the motion were reached. Data from that point on were used. The exception to this rule was in the rest case. All the data following the first fifty millisecond interval were used.

The remaining portions of the program calculated the variance, third moments and the number of zero crossings. All three were estimated over a time interval of fifty milliseconds.

All of the EMG data files for each of the subjects were used with this program. Half of the features were used in generating the classifier equations and the other half were used in evaluating the success of the classifier developed. As the feature estimates were calculated for a EMG recording, the features were placed into the two sets in an alternating sequence. On average, each subject had 3100 sets of features for each of the two stages.

3.4 CLASSIFIER GENERATION AND EVALUATION

Appendix B.2 contains the program used to generate the equations for the classifier. When desired, the features were transformed prior to any state classification attempt. For the natural logarithm of the features, any zero values were set to a very small value prior to applying the transformation, otherwise, the transformation was applied directly.

The program which took all the features and used them in a pattern recognition technique was a BMDP statistical package called Stepwise Discriminant Analysis [26]. In the BMDP program it was possible to restrict the use of features which did not meet certain discriminating criteria. These criteria were discussed in the BMDP manual and also in articles on the step-wise discriminant technique [27] [28] [29]. The basic rule employed was to use each of the features if the classifier developed worked better than it did without the feature. The output of this package included the coefficients associated with the features for each of the state equations.

The classifier was generated from the state equation coefficients obtained in the BMDP program. Appendix B.3 contains the program which operated as both the classifier and the classifier evaluator. The EMG features used with the classifier/evaluator had to be transformed in exactly the same manner as used for the BMDP program. Thus the same feature space was used for implementing the classifier as was used for generating the classifier state equations.

When the classifier was to make a state choice, the feature values for the current point in the feature space were substituted into each of the state equations. The chosen state was the one with the maximum state equation value. The "rest" state was chosen if any of the eight individual rest states were chosen. This completed the classifier portion of the program.

The last task of the program was to determine the success of the classifier. By comparing the classifier chosen state to the motion state actually desired, the classifier success rate was calculated. When the two were the same, a correct choice had been made. Conversely, when they were not the same, an incorrect choice had been made.

The above programs generated the classifier and also analyzed the success of the resulting classifier. The success rates are discussed in the following chapter.

Chapter IV

DISCUSSION OF RESULTS

4.1 EMG SIGNAL GENERATION AND RECORDING CONSIDERATIONS

An assortment of difficulties were encountered in the laboratory. Attempts were made to compensate for or eliminate these difficulties.

One of the major difficulties encountered was the proper application of the EMG electrodes. The nine electrodes were geled and held in contact with the skin by means of an adhesive tape. Improper application resulted in poor EMG signal pickup and/or increased sixty hertz pickup. Several adhesive tapes were used. The tape chosen provided good contact of electrode and skin for several hours. The tape was suitably stretchy so that is could move and adjust to the contours of the body.

Other attempts to reduce sixty hertz were the grounding of the motion isolation jig and the shielding of the electrode leads. Part of the leads were not shielded. This was due to the nature of the commercially purchased electrodes. Shielding the entire length of the leads is one recommendation for future work. Naturally, the leads were twisted for their length as well.

The EMG signals were fed directly into instrumentation amplifiers. Amplifying the signals at the start of the hardware system is important since this decreases the effect of the noise generated by the system. The instrumentation amplifiers built offered a high input impedance resulting in a low loading effect on the EMG signals. A high CMRR was also obtained, even with a source impedance imbalance. The differential operational amplifier configuration helped to reduce common mode signals such as sixty hertz. The DC component produced by the electrodes themselves and the amplifiers were removed by a high pass filter.

During the winter months, high levels of static electricity were found in the laboratory. Chips in the front end of the hardware system were repeatedly burned out. Grounded diodes at the instrumentation amplifier inputs provided overvoltage protection, particularly against static discharge. Since EMG signals have magnitudes in the order of tens to hundreds of microvolts, these signals were unaffected by the diodes. When static electricity was discharged into the leads, the charge was passed by the diodes to ground.

In the initial stages of EMG sampling, it was found that when the test subject produced the desired motion, he would use compensating motions as well as the desired motion. This distributed the required force over more muscles than would otherwise be the case. The use of the motion isolation jig, which has been previously described, proved to be easily used and was quite successful in reducing this affect.

4.2 CLASSIFIER GENERATION

Having completed the EMG data collection, the next step was to calculate the linear classifier state equations. The first attempt used eight motion states and one general rest state. The step-wise discriminant procedure was used to generate equations which would separate out the nine states. Upon examining the success of the separation process, it was found that many errors were made in classifying the rest state. In particular the rest state and the motion it was associated with were getting combined. This indicated that the location and the orientation of the limb had a significant effect on the EMG signals. Based on this finding, the rest state was separated into eight separate rest states; one rest state associated with each of the eight motions. This created a total of sixteen states.

Classification of the sixteen states was then attempted. Improved results were obtained. Some of the separate rest states were alike and thus misclassified in other rest states. This was remedied by using the sixteen state classification and then having the choice of any of the eight rest states produce the general "rest" state choice. In effect, this resulted in a piece-wise linear discriminant analysis.

This latter approach proved to be the most successful of those tested. Thus, this was the approach chosen for the classifier.

4.3 CLASSIFIER EVALUATION RESULTS

Tables 4.1 through to 4.3 show the results of the classifier evaluation for each of the three EMG electrode configurations. The results for the classifiers using the unaltered features of the average variance, third moment and the number of zero crossings are shown. The results for the classifier using the natural logarithm of the features are also shown. Using the logarithm converted the linear feature space into a "warped" space. Thus, the classifier state equations generated were in effect non-linear.

In general terms, the two channel, biceps and triceps muscles, electrode configuration yielded success rates in the 50 - 60% range. The logarithm of the feature space consistently produced an increase in the average success by four to twelve percent. Also of importance was the success increase in the individual motion state with the lowest success rate.

The second electrode configuration consisted of four channels arranged around the upper arm. The classifier based on the unaltered feature space produced rates of 66.2%, 73.7% and 73.1%. The increase is 8.0% to 18.9% greater than the first configuration. The logarithm of the

Table 4.1: Classifier Success Rates

Subject 1: Unaltered Feature Space

State Number	Motion State	1	2	3	4
1	ELBOW FLEXION	81.8	51.8	90.2	85.3
2	ELBOW EXTENSION	76.3	69.9	67.0	42.6
3	WRIST PRONATION	83.2	82.8	90.8	81.1
4	WRIST SUPINATION	65.8	54.3	83.6	47.5
5	HUMERAL ROTATION INWARD	44.1	37.8	52.5	36.1
6	HUMERAL ROTATION OUTWARD	61.6	52.4	90.3	40.8
7	ARM EXTENSION	78.6	68.3	77.6	59.0
8	ARM RETRACTION	15.3	21.8	54.3	32.8
9-16	REST	89.2	84.3	90.9	83.1
	AVERAGE	66.2	58.2	77.5	56.5

Logarithm of Feature Space

State Number	Motion State	1	2	3	4
1	ELBOW FLEXION	86.4	72.3	96.9	94.6
2	ELBOW EXTENSION	79.5	67.6	76.6	67.5
3	WRIST PRONATION	88.7	87.4	96.4	89.6
4	WRIST SUPINATION	74.4	55.6	92.6	58.2
5	HUMERAL ROTATION INWARD	50.0	37.0	66.2	46.1
6	HUMERAL ROTATION OUTWARD	74.7	64.6	98.5	50.0
7	ARM EXTENSION	79.0	65.6	92.7	60.5
8	ARM RETRACTION	25.3	24.0	65.6	39.8
9-16	REST	90.4	84.1	95.1	88.7
	AVERAGE	72.0	62.0	86.7	66.1

Col: 1 - 4 Channel Configuration: equally spaced channels around the upper arm
2 - 2 Channel Configuration: biceps/triceps channels taken from 1
3 - 4 Channel Configuration: biceps/triceps channels and anterior/posterior deltoid channels
4 - 2 Channel Configuration: biceps/triceps channels taken from 3

Table 4.2: Classifier Success Rates

Subject 2: Unaltered Feature Space

State Number	Motion State	1	2	3	4
1	ELBOW FLEXION	73.4	70.4	67.5	47.4
2	ELBOW EXTENSION	72.3	73.2	72.0	47.7
3	WRIST PRONATION	83.2	65.0	79.6	71.7
4	WRIST SUPINATION	78.5	76.7	42.0	19.7
5	HUMERAL ROTATION INWARD	65.3	44.0	72.3	63.0
6	HUMERAL ROTATION OUTWARD	46.0	12.8	97.4	46.4
7	ARM EXTENSION	81.3	74.6	79.4	46.9
8	ARM RETRACTION	71.2	50.0	48.8	23.0
9-16	REST	92.1	76.5	90.4	88.1
	AVERAGE	73.7	60.4	72.2	50.4

Logarithm of Feature Space

State Number	Motion State	1	2	3	4
1	ELBOW FLEXION	87.1	67.8	60.3	56.4
2	ELBOW EXTENSION	81.3	76.3	83.9	67.4
3	WRIST PRONATION	95.5	76.8	80.0	69.6
4	WRIST SUPINATION	87.4	87.0	54.2	26.5
5	HUMERAL ROTATION INWARD	90.7	66.7	74.5	63.4
6	HUMERAL ROTATION OUTWARD	68.5	26.4	99.6	53.2
7	ARM EXTENSION	91.1	80.8	93.9	52.6
8	ARM RETRACTION	80.2	58.6	47.1	20.5
9-16	REST	94.2	78.7	92.0	88.4
	AVERAGE	86.2	68.8	76.2	55.3

Col: 1 - 4 Channel Configuration: equally spaced channels around the upper arm
2 - 2 Channel Configuration: biceps/triceps channels taken from 1
3 - 4 Channel Configuration: biceps/triceps channels and anterior/posterior deltoid channels
4 - 2 Channel Configuration: biceps/triceps channels taken from 3

Table 4.3: Classifier Success Rates

Subject 3: Unaltered Feature Space

State Number	Motion State	1	2	3	4
1	ELBOW FLEXION	80.4	47.2	96.9	58.4
2	ELBOW EXTENSION	81.3	77.2	66.7	51.1
3	WRIST PRONATION	80.7	43.3	88.1	74.6
4	WRIST SUPINATION	61.5	46.2	78.1	33.9
5	HUMERAL ROTATION INWARD	68.4	61.9	68.3	50.4
6	HUMERAL ROTATION OUTWARD	45.7	20.4	87.9	29.6
7	ARM EXTENSION	87.4	73.9	97.9	62.4
8	ARM RETRACTION	70.2	37.0	93.9	91.4
9-16	REST	82.9	80.4	81.1	68.8
	AVERAGE	73.1	54.2	84.3	57.8

Logarithm of Feature Space

State Number	Motion State	1	2	3	4
1	ELBOW FLEXION	91.1	62.6	100.0	62.8
2	ELBOW EXTENSION	88.4	83.0	90.7	77.2
3	WRIST PRONATION	93.7	51.7	94.9	83.1
4	WRIST SUPINATION	73.9	66.7	91.3	42.6
5	HUMERAL ROTATION INWARD	77.9	72.5	77.6	62.6
6	HUMERAL ROTATION OUTWARD	72.7	43.3	97.5	44.6
7	ARM EXTENSION	86.6	69.7	100.0	67.5
8	ARM RETRACTION	70.6	46.6	98.8	82.4
9-16	REST	83.4	82.0	76.9	77.3
	AVERAGE	82.0	64.2	92.0	66.7

Col: 1 - 4 Channel Configuration: equally spaced channels around the upper arm
2 - 2 Channel Configuration: biceps/triceps channels taken from 1
3 - 4 Channel Configuration: biceps/triceps channels and anterior/posterior deltoid channels
4 - 2 Channel Configuration: biceps/triceps channels taken from 3

feature space produced a classifier whose average success rate was consistently superior to the unaltered space by 5.8%, 12.5% and 6.9%. The average success rates were 72.0%,86.2% and 82.0%.

When based on individual motion states, the classifiers using the logarithm of the feature space consistently showed better performance for the second electrode configuration compared to the first. The classifiers based on an unaltered feature space produced a marginally less consistent comparison.

The final electrode configuration of the deltoid, biceps and triceps muscles produced average classifier success rates which exceeded the corresponding two channel classifier by approximately twenty percent for both the unaltered and the logarithm of the feature space. In absolute terms, the unaltered feature space classifier and the transformed feature space classifier produced rates of 77.5%, 72.2%, 84.3% and 86.7%, 76.2%, 92.0% respectively. The transformed feature space produced the more successful classifier.

Comparing the two four channel classifiers, neither clearly out performed the other. Both produced good results. The best classifier for each individual subject produced success rates of 86.7% and 92.0% by the deltoid, biceps and triceps channels and 86.2% by the four upper arm channels. All three used the transformed feature space.

The classifier decision equations were generated based on the overall classifier success rate. Due to the use of the step-wise discriminant analysis technique, it was not possible to determine if individual motions were chosen more accurately by one electrode configuration in comparison to another. If trouble was had in determining the pattern for particular motions, optimization occurred at the expense of other motions. It was the interaction of all of the motions with each other which required that the classifiers be judged as a whole.

One major consideration which does depend on individual motion success is the motion with the minimum success rate. The overall classifier performance may have been excellent, but one or more motions may have had an unacceptable individual success rate. In this case, a classifier with a poorer overall performance, but with an acceptable minimum individual motion success rate, would be chosen. This case was not found for the classifiers produced by the subjects tested.

The order in which the features were used in the step-wise discriminant analysis indicates the motion pattern discrimination ability. The features first chosen had greater discrimination ability than the ones chosen later. Table 4.4 shows the ranking of the features by this criterion. The ranking is shown for the best classifier for each of the subjects. The variance parameter proved to be the most significant followed by the number of zero crossings and the third moment. Testing of other features might be undertaken to see if they provide greater discriminating ability than do the third moments and/or the number of zero crossings. Examples of possible test features are: the absolute value of the EMG signals themselves, the coefficients obtained from autoregressive modelling, moving average modelling and autoregressive moving average modelling.

Since both of the four channel electrode configurations produced good performances, the versatility of chosing either, depending on the device user's muscle capability after limb amputation, is beneficial. The choice also may be dependent on the way the individual uses his/her muscles for each of the motions since each person may make use of their muscles in a slightly different manner.

In general terms, this research shows that it is indeed quite possible to produce a nine state prosthetic arm classifier. The pattern recognition approach used generated linear equations of statistical features for multichannel EMG signals. By this method, both of the four channel electrode configurations produced excellent classifiers.

TABLE 4.4

Discriminating Ability of the Features Used

Subject 1		Subject 2		Subject 3	
biceps:	var	biceps:	var	delt. post.:	var
delt. post.:	var	triceps:	var	triceps:	var
delt. ant.:	var	lateral:	var	delt. ant:	var
triceps:	var	medial:	3rd	biceps:	var
triceps:	zeros	biceps:	zeros	triceps:	zeros
triceps:	3rd	lateral:	3rd	biceps:	zeros
biceps:	zeros	triceps:	zeros	delt. ant.	3rd
biceps:	3rd	medial:	zeros	delt.post.:	zeros
delt. post.:	zeros	lateral:	zeros	biceps:	3rd
delt. ant.:	3rd	triceps:	3rd	triceps:	3rd
delt. post:	3rd	medial:	var	delt. post.:	3rd
delt. ant.:	zeros*	biceps:	3rd	delt. ant.:	zeros

var - variance
3rd - third moment
zeros - number of zero crossings

*Feature not used.

delt. ant. - deltoid muscle anterior
delt.post. - deltoid muscle posterior

Order of Features is from most significant to least significant.

Chapter V

CONCLUSIONS AND FUTURE CONSIDERATIONS

5.1 A SUMMARY OF THE CONCLUSIONS

This research set out to investigate a nine state EMG pattern recognition classifier. In the process, three different EMG electrode configurations were tested. As pointed out in the section for the discussion of the results, several general conclusions were obtained.

The first conclusion was that both of the four channel classifiers produced higher success rates than did the two channel classifiers. Consistently, throughout all the testing, the average success rates of the classifiers supported this conclusion. This indicated that extra motion discriminating information was being obtained from the two extra EMG channels.

The second conclusion concerned the feature space. During the testing, it was found that higher average success rates could be achieved by transforming the classifier feature space with the natural logarithm function. In every case tested, this feature space transformation did increase the average rate of success.

Also of significance was the result that comparable success rates were obtained for both of the four EMG channel classifiers. For the best classifier for each of the three subjects tested, the biceps, triceps and deltoid muscles electrode configuration was used in two of the classifiers and the remaining case used the four equally spaced electrodes around the upper arm. This indicated that a comparable amount of motion discriminating information was being obtained from the deltoid muscle and the two electrodes positioned between the biceps and triceps muscles.

These are the conclusions obtained from this research. Suggestions for what may be done for future research are contained in the following section.

5.2 FUTURE RESEARCH AND CONSIDERATIONS

From the success of the two four channel classifiers, the question arises of whether combining these into a six channel classifier would increase the success rate sufficiently to offset the added cost and complexity. High success rates were obtained for the classifiers developed under the limitations imposed. Adding more EMG channels may allow for further device capability by reducing some of those limitations.

One of the limitations imposed on the classifiers developed was the use of a consistent and constant force during each of the motions. One of the next steps in this research would be to relax this limitation. If allowing a continuous variation of user muscle force proves to be beyond present capabilities, breaking down the force into discrete force ranges may prove to be a solution. It may also be possible to produce variable device speed and/or device force for each of the motions.

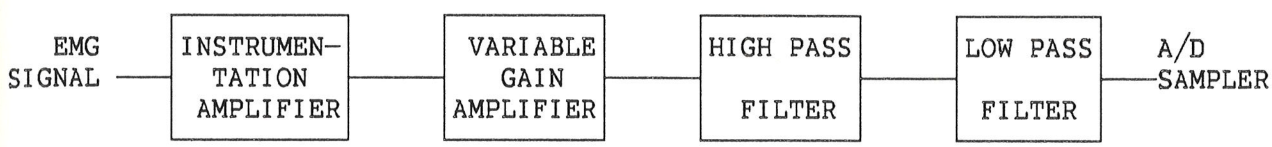
Another step in the evolution of the classifier would be to allow multiple motions simultaneously. This would allow prosthetic device users the ability to perform more complex device movements. An aid to this versatility may be the use of pre-programmed motion coordination and sequences. Statistical analysis of which motions, how often they are performed and in what manner they are executed would be required. The device controller would be programmed to implement motion sequences once a sequence was identified.

As previously discussed, the choice of EMG signal features used for the pattern recognition is of importance. Research in this area may involve producing various models of the EMG signal or simply using an ad hoc approach. Testing of the features in a classifier would ultimately indicate the better choices.

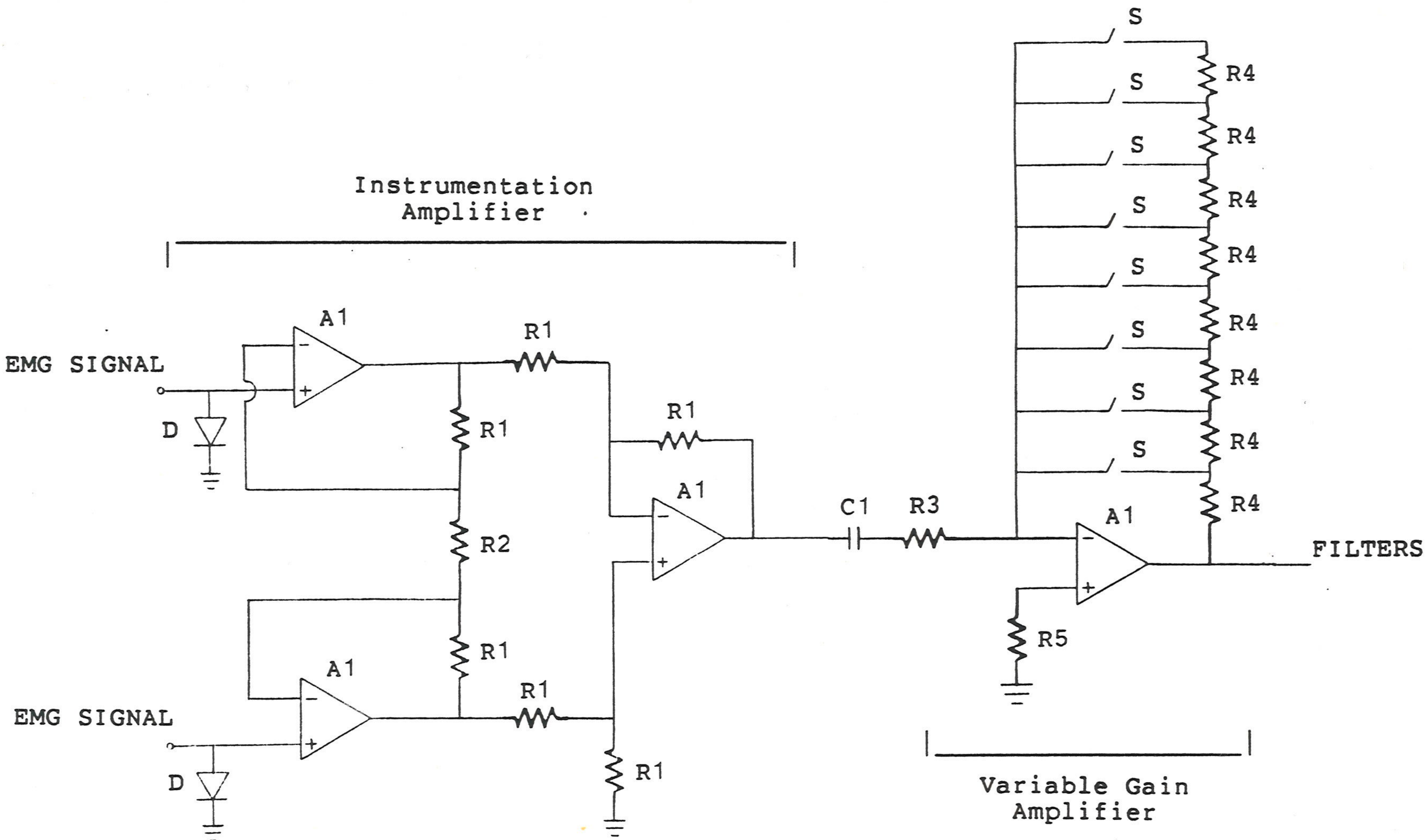
The suggestions presented here are those which are somehow directly related to the research presented in this thesis. These are only some of the many research areas which could and possibly should be considered for future investigation.

Appendix A

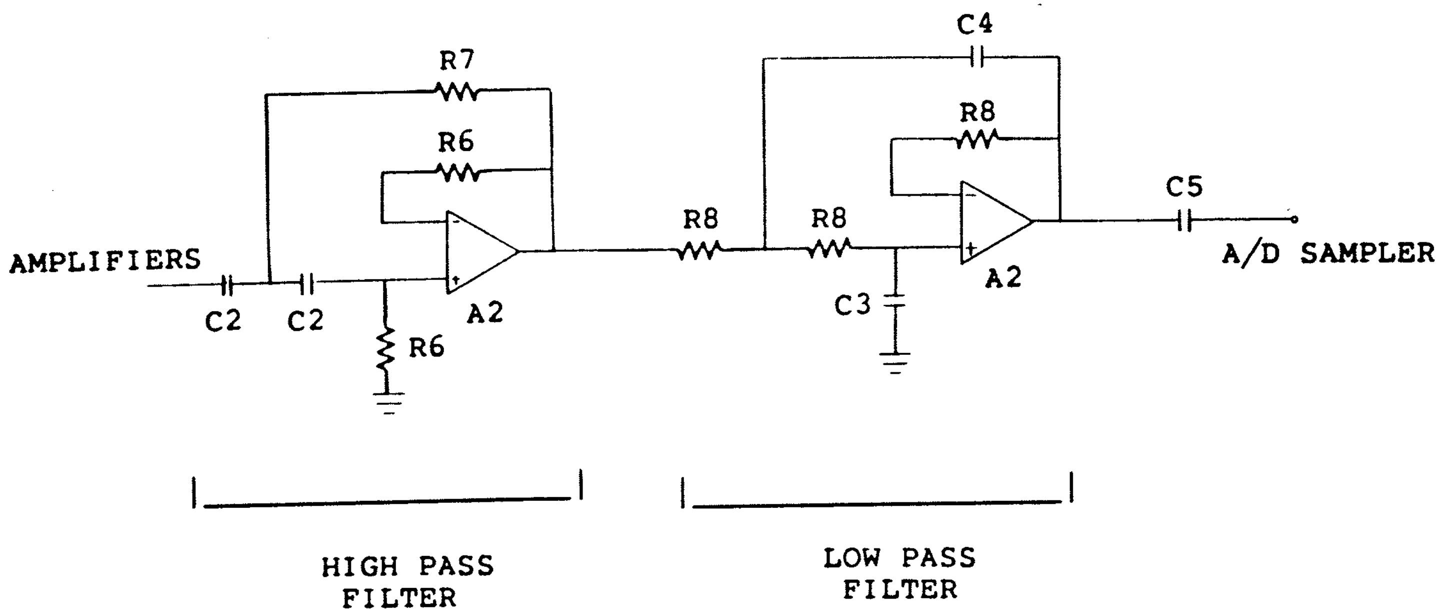
AMPLIFIER AND FILTER BLOCK AND CIRCUIT DIAGRAMS



Appendix A.1: Amplifier and Filter Block Diagram.



Appendix A.2: Amplifier and Filter Circuit Diagram



Appendix A.2: Amplifier and Filter Circuit Diagram (continued)

Circuit Component Legend

A1 - LM351 precision operational amplifiers

A2 - LM348 quad operational amplifier

C1 - 0.1 microfarad capacitor

C2 - 0.2 microfarad capacitor

C3 - 0.125 microfarad capacitor

C4 - 0.225 microfarad capacitor

C5 - 0.1 microfarad capacitor

D - 1N4148 diode

R1 - 100 kilo ohm resistor

R2 - 2 kilo ohm resistor

R3 - 10 kilo ohm resistor

R4 - 50 kilo ohm resistor

R5 - 10 kilo ohm resistor

R6 - 218 kilo ohm resistor

R7 - 109 kilo ohm resistor

R8 - 1 kilo ohm resistor

S - single pole single throw switch

Appendix B

DATA MANIPULATION, CLASSIFIER AND CLASSIFIER EVALUATION PROGRAMS

B.1 DATA MANIPULATION PROGRAM

Appendix B

DATA MANIPULATION, CONTROLLER AND EVALUATION PROGRAMS

B.1 DATA MANIPULATION PROGRAM

```
 LEVEL 2.3.0 (JUNE 78)                        OS/360  FORTRAN H EXTENDED                DATE 85.121/13.05.37         PAGE    1
REQUESTED OPTIONS: ,EB,,,,OBJ,,MAP,,GOSTMT,,,SIZE(256K),S,NAME(MAIN),OPT(0),LC(654),AD(NONE),FLAG(I),
OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)

   ISN 0002             REAL CH0(3001),CH1(3001),CH2(3001),CH3(3001),CH4(3001),X(15),REF
   ISN 0003             REAL VAR0(60),VAR1(60),VAR2(60),VAR3(60)
   ISN 0004             REAL MOM0(60),MOM1(60),MOM2(60),MOM3(60)
   ISN 0005             REAL ZERO0(60),ZERO1(60),ZERO2(60),ZERO3(60)
   ISN 0006             REAL CAL0,CAL1,CAL2,CAL3,TEMP0,TEMP1,TEMP2,TEMP3
   ISN 0007             INTEGER GAIN0,GAIN1,GAIN2,GAIN3,CASE,I,J,K,TEMP,START
   ISN 0008             INTEGER COUNT0,COUNT1,COUNT2,COUNT3
   ISN 0009             INTEGER VARCNT,Z
                  C
                  C PRINT OUT WHICH EMG FILE IS BEING WORKED ON.
                  C
   ISN 0010             WRITE(6,4)
   ISN 0011        4    FORMAT(' RICK LEHNER: APRIL 4/85.')
   ISN 0012             WRITE(6,3)
   ISN 0013        3    FORMAT(' DELTOID CONFIGURATION: FILE FLEX1')
                  C
                  C READ IN THE AMPLIFIER GAIN SWITCH VALUES.
                  C    THE VARIABLE NAMES ARE "GAIN0" TO "GAIN3".
                  C    (FOR CHANNELS 0 TO 3)
                  C
   ISN 0014             READ(5,1) GAIN0,GAIN1,GAIN2,GAIN3,CASE
   ISN 0015           1 FORMAT(5I2)
                  C
                  C CALCULATE THE CALIBRATION FACTOR TO OBTAIN THE EMG VOLTAGES
                  C      WITH UNITS OF MILLIVOLTS.
                  C      (VARIABLES ARE "CAL0" TO "CAL3")
                  C
   ISN 0016             CAL0=1.E+3/(GAIN0*280.)
   ISN 0017             CAL1=1.E+3/(GAIN1*280.)
   ISN 0018             CAL2=1.E+3/(GAIN2*280.)
   ISN 0019             CAL3=1.E+3/(GAIN3*280.)
                  C
                  C PRINT OUT THE CALIBRATION VALUES.
                  C
   ISN 0020             WRITE(6,2) CAL0,CAL1,CAL2,CAL3,CASE
   ISN 0021           2 FORMAT(' CAL0= ',E15.4,' CAL1= ',E15.4,' CAL2= ',E15.4,' CAL3= ',E
                       +15.4,' CASE= ',I2)
                  C
   ISN 0022             DO 1100 J=1,1000
                  C
                  C READ IN A LINE OF DATA.
                  C    THE DATA IS IN 15I4 FORMAT.
                  C    THE DATA IS IN THE FORM OF:
                  C      4 ( CH0 CH1 CH2 CH3 CH4)
                  C      WHERE "CH0" TO "CH4" ARE THE DATA VALUES OF CHANNELS 0 TO 4.
                  C
   ISN 0023             READ (5,1000) (X(I),I=1,15)
   ISN 0024        1000 FORMAT(15F4.0)
                  C
                  C THE A/D IN THE LAB, TRANSFORMED VOLTAGE VALUES OF -1 VOLT TO +1 VOLT
                  C    INTO THE RANGE OF INTEGER VALUES OF 0 TO 4095.
                  C    TRANSFORM THE DATA BACK TO THE -1 VOLT TO +1 VOLT RANGE
                  C    AND MULTIPLY BY THE CHANNEL CALIBRATION VALUE.
                  C    AFTER THIS MANIPULATION, "CH0" TO "CH4" CONTAIN THE VALUES OF
                  C    THE ORIGINAL, PREAMPLIFIED ELECTRODE VOLTAGES.
                  C
   ISN 0025             CH0(3*J-2)=(X(1)*(2./4095.)-1.)*CAL0
   ISN 0026             CH1(3*J-2)=(X(2)*(2./4095.)-1.)*CAL1
   ISN 0027             CH2(3*J-2)=(X(3)*(2./4095.)-1.)*CAL2
   ISN 0028             CH3(3*J-2)=(X(4)*(2./4095.)-1.)*CAL3
   ISN 0029             CH4(3*J-2)=(X(5)*(2./4095.)-1.)
   ISN 0030             CH0((3*J-2)+1)=(X(6)*(2./4095.)-1.)*CAL0
   ISN 0031             CH1((3*J-2)+1)=(X(7)*(2./4095.)-1.)*CAL1
   ISN 0032             CH2((3*J-2)+1)=(X(8)*(2./4095.)-1.)*CAL2
   ISN 0033             CH3((3*J-2)+1)=(X(9)*(2./4095.)-1.)*CAL3
   ISN 0034             CH4((3*J-2)+1)=(X(10)*(2./4095.)-1.)
   ISN 0035             CH0((3*J-2)+2)=(X(11)*(2./4095.)-1.)*CAL0
   ISN 0036             CH1((3*J-2)+2)=(X(12)*(2./4095.)-1.)*CAL1
   ISN 0037             CH2((3*J-2)+2)=(X(13)*(2./4095.)-1.)*CAL2
   ISN 0038             CH3((3*J-2)+2)=(X(14)*(2./4095.)-1.)*CAL3
   ISN 0039             CH4((3*J-2)+2)=(X(15)*(2./4095.)-1.)
   ISN 0040        1100  CONTINUE
                  C
                  C THIS FILE USES CH4 (THE STRAIN GAUGE VALUE) TO DETERMINE THE
                  C     STARTING POINT OF THE DESIRED EMG SIGNALS.  ALL PREVIOUS
                  C     VALUES ARE DISCARDED.
                  C METHOD: ONCE A VALUE OF 0.1 VOLTS ABOVE THE REFERENCE HAS BEEN
                  C         HAS BEEN OBTAINED IN CH4,
                  C            AN EXTRA HALF SECOND IS SPANNED BEFORE THE STARTING
                  C            POINT IS POSITIONED.
                  C
                  C      NOTE: FOR THE RESTING CASES (IE. CASE=9 TO 16), THE WHOLE FILE
                  C      (PLUS 50 MILLISECONDS FOR A STARTING DELAY), IS TO BE USED.
                  C            THEREFORE, START IS SET TO 51 IN THAT CASE.
                  C
                  C
                  C CALCULATE AN INITIAL REFERENCE POINT FOR THE STRAIN GAGE CHANNEL.
                  C USE THE AVERAGE OF THE FIRST FOUR SAMPLES TO SET THE
                  C   REFERENCE POINT.  CALL THE REFERENCE POINT 'REF'.
                  C
   ISN 0041             IF ((CASE .EQ. 9) .OR. (CASE .EQ. 10) .OR. (CASE .EQ. 11) .OR.
                       +    (CASE .EQ. 12) .OR. (CASE .EQ. 13) .OR. (CASE .EQ. 14) .OR.
                       +    (CASE .EQ. 15) .OR. (CASE .EQ. 16)) GO TO 1425
   ISN 0043             REF=(CH4(1)+CH4(2)+CH4(3)+CH4(4))/4.
                  C
   ISN 0044             I=1
   ISN 0045        1300 IF (ABS(CH4(I) - REF) .GE. 0.1) GO TO 1400
   ISN 0047             I=I+1
                  C
                  C CHECK TO ENSURE THE STARTING POSITION IS NOT AT THE END OF THE DATA.
                  C
   ISN 0048             IF (I .GT. 3000) GO TO 1325
```

```
ISN 0050          GO TO 1300
            C
            C IF THE STARTING POSITION GOES TO THE END OF THE DATA, INDICATE
            C     THIS CONDITION IN THE PRINT OUT.
            C
ISN 0051     1325 WRITE(6,1326)
ISN 0052     1326 FORMAT(' NO FORCE DETECTED BY STRAIN GAGES.')
ISN 0053          GO TO 2700
ISN 0054     1400 CONTINUE
            C
            C ADD THE 0.5 SECOND DELAY TO THE STARTING POSITION AND ROUND OFF
            C     TO THE NEAREST 50 MILLISECOND SEGMENT OF DATA.
            C
            C THE VARIABLE NAME FOR THE STARTING POSITION IS "START".
            C
ISN 0055          I=I+500
ISN 0056          TEMP=MOD(I,50)
ISN 0057          TEMP=50-TEMP
ISN 0058          START=I+TEMP+1
ISN 0059          GO TO 1430
ISN 0060     1425  START=51
ISN 0061     1430  CONTINUE
            C
            C PRINT OUT THE STARTING POSITION.
            C
ISN 0062          WRITE(6,1450) START
ISN 0063     1450 FORMAT(' USEFUL EMG SIGNAL STARTS AT INDEX ',I4)
            C
            C
            CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
            C                                                                       C
            C ROUTINE TO CALCULATE THE VARIANCE OF 4 CHANNELS OF EMG MEASUREMENTS.C
            C                                                                       C
            C VARIABLE "START" IS THE STARTING INDEX POINTER  OF "ACCEPTABLE" EMG C
            C     DATA.                                                             C
            C                                                                       C
            C THE VARIANCES ARE CALCULATED (ASSUMING A ZERO MEAN) AND AVERAGED      C
            C      OVER 50 MILLISECONDS (IE. 50 SAMPLES AT A SAMPLING FREQUENCY     C
            C      OF 1 KILOHERTZ).  THE VALUES ARE STORED IN ARRAYS VAR0 TO VAR3. C
            C      THE VARIABLE "VARCNT" IS THE COUNT OF THE NUMBER OF VARIANCE     C
            C      VALUES STORED IN EACH VARIANCE ARRAY.                            C
            C                                                                       C
            CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
            C
            C INITIALIZE THE NUMBER OF VARIANCE STATISTICS CALCULATED TO ZERO.
            C
ISN 0064          VARCNT=0
ISN 0065          DO 1500 J=START,3000,50
            C
            C SUM THE VALUE OF THE VARIANCE FOR EACH CHANNEL SEPARATELY OVER
            C     FIFTY MILLISECONDS OF DATA.
            C
ISN 0066             Z=((J-1)/50)
ISN 0067             VAR0(Z)=0.0
ISN 0068             VAR1(Z)=0.0
ISN 0069             VAR2(Z)=0.0
ISN 0070             VAR3(Z)=0.0
ISN 0071             DO 1600 I=1,50
ISN 0072                K=J+I-1
ISN 0073                VAR0(Z)=CH0(K)*CH0(K)+VAR0(Z)
ISN 0074                VAR1(Z)=CH1(K)*CH1(K)+VAR1(Z)
ISN 0075                VAR2(Z)=CH2(K)*CH2(K)+VAR2(Z)
ISN 0076                VAR3(Z)=CH3(K)*CH3(K)+VAR3(Z)
ISN 0077     1600    CONTINUE
            C
            C OBTAIN THE AVERAGE VARIANCE BY DIVIDING THE SUM OF VARIANCES
            C     BY 50 (THE NUMBER OF VALUES SUMMED).
            C
ISN 0078             VAR0(Z)=(1./50.)*VAR0(Z)
ISN 0079             VAR1(Z)=(1./50.)*VAR1(Z)
ISN 0080             VAR2(Z)=(1./50.)*VAR2(Z)
ISN 0081             VAR3(Z)=(1./50.)*VAR3(Z)
ISN 0082             VARCNT=VARCNT+1
ISN 0083     1500 CONTINUE
            C
            C PRINT OUT THE NUMBER OF SETS OF STATISTICS TO BE CALCULATED PER
            C     CHANNEL.
            C
ISN 0084          WRITE(6,1550) VARCNT
ISN 0085     1550 FORMAT(' THE NUMBER OF VARIANCE,THIRD MOMENT AND ZERO CROSSINGS CA
                 +LCALATED IS: ',I3)
            C
            C PRINT OUT THE FORMAT OF THE RECORDED STATISTICS TO FOLLOW.
            C
ISN 0086          WRITE(6,1551)
ISN 0087     1551 FORMAT('-THE CALCULATED STATISTICS ARE:')
ISN 0088          WRITE(6,1552)
ISN 0089     1552 FORMAT(' CASE         VARIANCE (CH0      CH1      CH2      CH3)')
ISN 0090          WRITE(6,1553)
ISN 0091     1553 FORMAT('          THIRD MOMENT(CH0      CH1      CH2      CH3)')
ISN 0092          WRITE(6,1554)
ISN 0093     1554 FORMAT('        ZERO CROSSINGS(CH0      CH1      CH2      CH3)')
            C
            C
            CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
            C                                                                       C
            C ROUTINE TO CALCULATE THE THIRD MOMENT OF 4 CHANNELS OF EMG            C
            C      MEASUREMENTS.                                                    C
            C                                                                       C
            C VARIABLE "START" IS THE STARTING INDEX POINTER  OF "ACCEPTABLE" EMG C
            C     DATA.                                                             C
            C                                                                       C
            C THE MOMENTS ARE CALCULATED (ASSUMING A ZERO MEAN) AND AVERAGED        C
            C      OVER 50 MILLISECONDS (IE. 50 SAMPLES AT A SAMPLING FREQUENCY     C
            C      OF 1 KILOHERTZ).  THE VALUES ARE STORED IN ARRAYS MOM0 TO MOM3. C
            C      THE VARIABLE "VARCNT" IS THE COUNT OF THE NUMBER OF THIRD        C
            C      MOMENT VALUES STORED IN EACH VARIANCE ARRAY.                     C
            C                                                                       C
            CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
            C
ISN 0094          DO 1700 J=START,3000,50
            C
            C SUM THE VALUE OF THE THIRD MOMENTS FOR EACH CHANNEL SEPARATELY
            C     OVER FIFTY MILLISECONDS OF DATA.
            C
ISN 0095             Z=((J-1)/50)
ISN 0096             MOM0(Z)=0.0
ISN 0097             MOM1(Z)=0.0
ISN 0098             MOM2(Z)=0.0
ISN 0099             MOM3(Z)=0.0
```

```
ISN 0100              DO 1800 I=1,50
ISN 0101                 K=J+I-1
ISN 0102                 MOMO(Z)=ABS(CH0(K)*CH0(K)*CH0(K))+MOM0(Z)
ISN 0103                 MOM1(Z)=ABS(CH1(K)*CH1(K)*CH1(K))+MOM1(Z)
ISN 0104                 MOM2(Z)=ABS(CH2(K)*CH2(K)*CH2(K))+MOM2(Z)
ISN 0105                 MOM3(Z)=ABS(CH3(K)*CH3(K)*CH3(K))+MOM3(Z)
ISN 0106      1800    CONTINUE
             C
             C OBTAIN THE AVERAGE THIRD MOMENT VALUE BY DIVIDING THE SUM OF THE
             C     THIRD MOMENTS BY 50 (THE NUMBER OF VALUES SUMMED).
             C
ISN 0107              MOMO(Z)=(1./50.)*MOMO(Z)
ISN 0108              MOM1(Z)=(1./50.)*MOM1(Z)
ISN 0109              MOM2(Z)=(1./50.)*MOM2(Z)
ISN 0110              MOM3(Z)=(1./50.)*MOM3(Z)
ISN 0111      1700 CONTINUE
             C
             CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
             C                                                                     C
             C ROUTINE TO CALC. THE NUMBER OF ZERO CROSSINGS OF 4 CHANNELS OF EMG  C
             C      MEASUREMENTS.                                                  C
             C                                                                     C
             C VARIABLE "START" IS THE STARTING INDEX POINTER  OF "ACCEPTABLE" EMG C
             C     DATA.                                                           C
             C                                                                     C
             C THE NUMBER OF ZERO CROSSINGS ARE CALCULATED AND AVERAGED            C
             C      OVER 50 MILLISECONDS (IE. 50 SAMPLES AT A SAMPLING FREQUENCY   C
             C      OF 1 KILOHERTZ). THE VALUES ARE STORED IN ARRAYS ZEROO TO ZERO3.C
             C      THE VARIABLE "VARCNT" IS THE COUNT OF THE NUMBER OF ZERO       C
             C      CROSSING STORED IN EACH VARIANCE ARRAY.                        C
             C                                                                     C
             CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
             C
             C
             C PAD DATA ARRAYS WITH ONE ZERO AT THE END FOR ZERO CROSSING COUNTING.
             C
ISN 0112              CH0(3001)=0.0
ISN 0113              CH1(3001)=0.0
ISN 0114              CH2(3001)=0.0
ISN 0115              CH3(3001)=0.0
             C
ISN 0116              DO 1900 J=START,3000,50
             C
             C INITIALIZE THE COUNT OF THE NUMBER OF EMG SIGNAL ZERO CROSSINGS
             C     PER FIFTY MILLISECONDS TO ZERO.
             C
ISN 0117                 COUNT0=0
ISN 0118                 COUNT1=0
ISN 0119                 COUNT2=0
ISN 0120                 COUNT3=0
ISN 0121                 Z=((J-1)/50)
ISN 0122                 DO 2000 I=1,50
ISN 0123                    K=J+I-1
             C
             C MULTIPLY TWO CONSECUTIVE SIGNAL SAMPLES TOGETHER.  IF THE VALUE
             C     IS NEGATIVE, THE VALUE OF THE SIGNAL HAS CROSSED THROUGH THE
             C     ZERO VALUE.
             C
ISN 0124                    TEMP0=CH0(K)*CH0(K+1)
ISN 0125                    TEMP1=CH1(K)*CH1(K+1)
ISN 0126                    TEMP2=CH2(K)*CH2(K+1)
ISN 0127                    TEMP3=CH3(K)*CH3(K+1)
ISN 0128                    IF (TEMP0 .LT. 0.0) COUNT0=COUNT0+1
ISN 0130                    IF (TEMP1 .LT. 0.0) COUNT1=COUNT1+1
ISN 0132                    IF (TEMP2 .LT. 0.0) COUNT2=COUNT2+1
ISN 0134                    IF (TEMP3 .LT. 0.0) COUNT3=COUNT3+1
ISN 0136      2000       CONTINUE
             C
             C COPY THE TOTAL FIFTY MILLISECOND ZERO CROSSING COUNTS INTO THE
             C     ARRAYS "ZEROO" TO "ZERO3".
             C
ISN 0137                 ZEROO(Z)=COUNT0
ISN 0138                 ZERO1(Z)=COUNT1
ISN 0139                 ZERO2(Z)=COUNT2
ISN 0140                 ZERO3(Z)=COUNT3
ISN 0141      1900 CONTINUE
             C
             C WRITE OUT THE CALCULATED STATISTICS TO TWO DIFFERENT DATASETS
             C     (ALTERNATING BETWEEN THE TWO).
             C
ISN 0142              DO 2200 J=START,3000,50
ISN 0143                 Z=((J-1)/50)
ISN 0144                 IF ( MOD(Z,2) .EQ. 0 ) GO TO 2500
ISN 0146                 WRITE(11,2100) CASE,VAR0(Z),VAR1(Z),VAR2(Z),VAR3(Z)
ISN 0147      2100       FORMAT(14,4E17.8)
ISN 0148                 WRITE(11,2300) MOMO(Z),MOM1(Z),MOM2(Z),MOM3(Z)
ISN 0149      2300       FORMAT(4X,4E17.8)
ISN 0150                 WRITE(11,2400) ZEROO(Z),ZERO1(Z),ZERO2(Z),ZERO3(Z)
ISN 0151      2400       FORMAT(4X,4E17.8)
ISN 0152                 WRITE(6,2100) CASE,VAR0(Z),VAR1(Z),VAR2(Z),VAR3(Z)
ISN 0153                 WRITE(6,2300) MOMO(Z),MOM1(Z),MOM2(Z),MOM3(Z)
ISN 0154                 WRITE(6,2400) ZEROO(Z),ZERO1(Z),ZERO2(Z),ZERO3(Z)
ISN 0155                 GO TO 2600
ISN 0156      2500       CONTINUE
ISN 0157                 WRITE(12,2100) CASE,VAR0(Z),VAR1(Z),VAR2(Z),VAR3(Z)
ISN 0158                 WRITE(12,2300) MOMO(Z),MOM1(Z),MOM2(Z),MOM3(Z)
ISN 0159                 WRITE(12,2400) ZEROO(Z),ZERO1(Z),ZERO2(Z),ZERO3(Z)
ISN 0160                 WRITE(6,2100) CASE,VAR0(Z),VAR1(Z),VAR2(Z),VAR3(Z)
ISN 0161                 WRITE(6,2300) MOMO(Z),MOM1(Z),MOM2(Z),MOM3(Z)
ISN 0162                 WRITE(6,2400) ZEROO(Z),ZERO1(Z),ZERO2(Z),ZERO3(Z)
ISN 0163      2600       CONTINUE
ISN 0164      2200 CONTINUE
ISN 0165      2700 CONTINUE
ISN 0166              STOP
ISN 0167              END
```

```
RICK LEHNER: APRIL 4/85.
DELTOID CONFIGURATION: FILE FLEX1
CAL0=      0.4464E+00 CAL1=       0.4464E+00 CAL2=       0.4464E+00 CAL3=       0.4464E+00 CASE=   1
USEFUL EMG SIGNAL STARTS AT INDEX  951
THE NUMBER OF VARIANCE,THIRD MOMENT AND ZERO CROSSINGS CALCALATED IS:  41
THE CALCULATED STATISTICS ARE:
CASE             VARIANCE (CH0        CH1           CH2         CH3)
             THIRD MOMENT (CH0        CH1           CH2         CH3)
           ZERO CROSSINGS (CH0        CH1           CH2         CH3)
   1   0.57712048E-02   0.11497305E-02   0.28061285E-03   0.18671497E-03
       0.68710302E-03   0.47439782E-04   0.64486776E-05   0.38291337E-05
       0.50000000E+01   0.80000000E+01   0.70000000E+01   0.11000000E+02
   1   0.13576176E-01   0.17572592E-02   0.23851394E-03   0.19393041E-03
       0.34456323E-02   0.11188492E-03   0.59512768E-05   0.44927474E-05
```

	0.11000000E+02	0.60000000E+01	0.13000000E+02	0.17000000E+02
1	0.27404139E-02	0.15176032E-02	0.21582103E-03	0.38515753E-03
	0.25474001E-03	0.78139812E-04	0.53143449E-05	0.13673659E-04
	0.14000000E+02	0.50000000E+01	0.80000000E+01	0.15000000E+02
1	0.52863322E-02	0.16050600E-02	0.23613124E-03	0.26265997E-03
	0.65437006E-03	0.81641585E-04	0.49387709E-05	0.64979577E-05
	0.70000000E+01	0.70000000E+01	0.60000000E+01	0.12000000E+02
1	0.17765205E-01	0.15433382E-02	0.32174448E-03	0.27865078E-03
	0.52628927E-02	0.75476346E-04	0.93370718E-05	0.76055703E-05
	0.12000000E+02	0.60000000E+01	0.12000000E+02	0.13000000E+02
1	0.55899806E-02	0.13078151E-02	0.16204586E-03	0.21040863E-03
	0.72808168E-03	0.63110478E-04	0.32730586E-05	0.41715903E-05
	0.70000000E+01	0.60000000E+01	0.15000000E+02	0.70000000E+01
1	0.79124533E-02	0.18915986E-02	0.18697417E-03	0.33745938E-03
	0.14528071E-02	0.10996377E-03	0.39998222E-05	0.96692002E-05
	0.10000000E+02	0.70000000E+01	0.16000000E+02	0.16000000E+02
1	0.36084577E-02	0.18061625E-02	0.18264970E-03	0.32897014E-03
	0.33181673E-03	0.10022364E-03	0.34288278E-05	0.89480864E-05
	0.80000000E+01	0.70000000E+01	0.13000000E+02	0.11000000E+02
1	0.73496327E-02	0.15322028E-02	0.21954789E-03	0.20433581E-03
	0.10063390E-02	0.75370030E-04	0.50278377E-05	0.48779739E-05
	0.11000000E+02	0.60000000E+01	0.16000000E+02	0.90000000E+01
1	0.73706359E-02	0.13800643E-02	0.29770378E-03	0.24427474E-03
	0.11842276E-02	0.62159248E-04	0.99498629E-05	0.58434343E-05
	0.13000000E+02	0.80000000E+01	0.15000000E+02	0.14000000E+02
1	0.71526058E-02	0.18409824E-02	0.28961594E-03	0.27916627E-03
	0.11334405E-02	0.11242076E-03	0.72103776E-05	0.65325430E-05
	0.14000000E+02	0.60000000E+01	0.70000000E+01	0.10000000E+02
1	0.61831698E-02	0.19354222E-02	0.27696369E-03	0.32328023E-03
	0.74681663E-03	0.10294816E-03	0.68300769E-05	0.91319707E-05
	0.10000000E+02	0.60000000E+01	0.15000000E+02	0.13000000E+02
1	0.49106069E-02	0.15721330E-02	0.18759235E-03	0.15599377E-03
	0.55058277E-03	0.83213585E-04	0.41782905E-05	0.32352082E-05
	0.80000000E+01	0.60000000E+01	0.19000000E+02	0.17000000E+02
1	0.26062976E-02	0.24668227E-02	0.20527735E-03	0.30100206E-03
	0.20596622E-03	0.17082601E-03	0.51032375E-05	0.85612473E-05
	0.14000000E+02	0.60000000E+01	0.11000000E+02	0.18000000E+02
1	0.22364734E-02	0.20178782E-02	0.13109668E-03	0.21216219E-03
	0.18065608E-03	0.11373071E-03	0.19955814E-05	0.64127416E-05
	0.10000000E+02	0.60000000E+01	0.11000000E+02	0.21000000E+02
1	0.63004456E-02	0.16512356E-02	0.23973300E-03	0.28786180E-03
	0.83049037E-03	0.84235740E-04	0.52268142E-05	0.78720641E-05
	0.80000000E+01	0.80000000E+01	0.14000000E+02	0.16000000E+02
1	0.65440387E-02	0.14515661E-02	0.33039367E-03	0.25161402E-03
	0.10775006E-02	0.77567674E-04	0.99366853E-05	0.57571424E-05
	0.12000000E+02	0.80000000E+01	0.13000000E+02	0.12000000E+02
1	0.43386966E-02	0.17476319E-02	0.27651316E-03	0.38967887E-03
	0.44672238E-03	0.10286635E-03	0.68206054E-05	0.15873404E-04
	0.10000000E+02	0.60000000E+01	0.90000000E+01	0.14000000E+02
1	0.43826401E-02	0.13368891E-02	0.15947706E-03	0.23749880E-03
	0.45736064E-03	0.61225786E-04	0.33230826E-05	0.51187017E-05
	0.13000000E+02	0.60000000E+01	0.12000000E+02	0.10000000E+02
1	0.75000748E-02	0.15887818E-02	0.27381303E-03	0.26617432E-03
	0.97163371E-03	0.72918774E-04	0.72452649E-05	0.61946685E-05
	0.11000000E+02	0.60000000E+01	0.16000000E+02	0.20000000E+02
1	0.22926687E-02	0.12976192E-02	0.19995405E-03	0.18857687E-03
	0.16387252E-03	0.59658822E-04	0.44741719E-05	0.38329590E-05
	0.90000000E+01	0.60000000E+01	0.11000000E+02	0.17000000E+02
1	0.74938722E-02	0.20981298E-02	0.14387122E-03	0.21897203E-03
	0.12127717E-02	0.12261054E-03	0.26095859E-05	0.53262011E-05
	0.12000000E+02	0.60000000E+01	0.90000000E+01	0.15000000E+02
1	0.97221658E-02	0.14010298E-02	0.27003838E-03	0.46324078E-03
	0.13977145E-02	0.64882930E-04	0.65410459E-05	0.17244922E-04
	0.80000000E+01	0.60000000E+01	0.13000000E+02	0.14000000E+02
1	0.42381324E-02	0.14899503E-02	0.29711914E-03	0.28739194E-03
	0.41547441E-03	0.75422984E-04	0.81054577E-05	0.71254462E-05
	0.11000000E+02	0.80000000E+01	0.17000000E+02	0.13000000E+02
1	0.10540102E-01	0.18948459E-02	0.16088298E-03	0.31239982E-03
	0.19025181E-02	0.10347484E-03	0.30938927E-05	0.91128841E-05
	0.80000000E+01	0.60000000E+01	0.16000000E+02	0.10000000E+02
1	0.25207065E-02	0.18629406E-02	0.22636703E-03	0.24399905E-03
	0.23058934E-03	0.10435587E-03	0.55448290E-05	0.65736422E-05
	0.19000000E+02	0.60000000E+01	0.18000000E+02	0.13000000E+02
1	0.12454320E-01	0.14564812E-02	0.25653699E-03	0.30221348E-03
	0.23257826E-02	0.67506524E-04	0.67492892E-05	0.75538310E-05
	0.70000000E+01	0.60000000E+01	0.18000000E+02	0.16000000E+02
1	0.13629247E-01	0.14371250E-02	0.29462529E-03	0.28786599E-03
	0.25988792E-02	0.68505818E-04	0.72922176E-05	0.84157982E-05
	0.70000000E+01	0.60000000E+01	0.10000000E+02	0.17000000E+02
1	0.55922903E-02	0.14884530E-02	0.34000655E-03	0.25214418E-03
	0.59779384E-03	0.75475429E-04	0.12365472E-04	0.55145747E-05
	0.11000000E+02	0.60000000E+01	0.15000000E+02	0.17000000E+02
1	0.79508945E-02	0.16637968E-02	0.26715570E-03	0.31919894E-03
	0.98591927E-03	0.87690947E-04	0.66115235E-05	0.94766347E-05
	0.90000000E+01	0.60000000E+01	0.80000000E+01	0.80000000E+01
1	0.62562898E-02	0.16522966E-02	0.30965987E-03	0.45948941E-03
	0.79157436E-03	0.86120053E-04	0.84529529E-05	0.19258616E-04
	0.10000000E+02	0.60000000E+01	0.18000000E+02	0.10000000E+02
1	0.84078163E-02	0.13006292E-02	0.40673604E-03	0.31847018E-03
	0.16771792E-02	0.57182144E-04	0.13269088E-04	0.94049747E-05
	0.10000000E+02	0.60000000E+01	0.10000000E+02	0.13000000E+02
1	0.12080029E-01	0.19251846E-02	0.21439417E-03	0.45043952E-03
	0.23134279E-02	0.11289708E-03	0.55103928E-05	0.14065085E-04
	0.13000000E+02	0.60000000E+01	0.17000000E+02	0.15000000E+02
1	0.88895373E-02	0.17940949E-02	0.25499170E-03	0.28683036E-03
	0.13275289E-02	0.97684999E-04	0.70520573E-05	0.67334940E-05
	0.10000000E+02	0.60000000E+01	0.15000000E+02	0.15000000E+02
1	0.47317408E-02	0.17904674E-02	0.20249857E-03	0.22175408E-03
	0.54282509E-03	0.99970537E-04	0.51688585E-05	0.48527008E-05
	0.10000000E+02	0.60000000E+01	0.15000000E+02	0.17000000E+02
1	0.70026964E-02	0.25241433E-02	0.27777767E-03	0.35525789E-03
	0.92101959E-03	0.17276547E-03	0.75763037E-05	0.10938239E-04
	0.12000000E+02	0.60000000E+01	0.11000000E+02	0.10000000E+02
1	0.86997487E-02	0.14567494E-02	0.46922406E-03	0.39642002E-03
	0.14144753E-02	0.70976632E-04	0.15234090E-04	0.12617194E-04
	0.13000000E+02	0.60000000E+01	0.13000000E+02	0.13000000E+02
1	0.86617991E-02	0.18939672E-02	0.34989091E-03	0.34585525E-03
	0.12599956E-02	0.10861820E-03	0.99235112E-05	0.10279267E-04
	0.12000000E+02	0.80000000E+01	0.14000000E+02	0.11000000E+02
1	0.87362789E-02	0.17745111E-02	0.46620565E-03	0.40401635E-03
	0.14581392E-02	0.97346900E-04	0.15343088E-04	0.12421090E-04
	0.90000000E+01	0.60000000E+01	0.15000000E+02	0.10000000E+02
1	0.13326757E-01	0.12796484E-02	0.38747699E-03	0.39223325E-03
	0.30348799E-02	0.61763116E-04	0.10544685E-04	0.11112469E-04
	0.11000000E+02	0.60000000E+01	0.13000000E+02	0.19000000E+02
1	0.94087273E-02	0.17109273E-02	0.24792575E-03	0.37723407E-03
	0.13931417E-02	0.91811118E-04	0.79641159E-05	0.11878539E-04
	0.11000000E+02	0.60000000E+01	0.17000000E+02	0.12000000E+02

B.2 CLASSIFIER STATE EQUATION COEFFICIENT GENERATION

B.2 CLASSIFIER STATE EQUATION COEFFICIENT GENERATION

```
LEVEL 2.3.0 (JUNE 78)                    OS/360  FORTRAN H EXTENDED          DATE 85.136/09.38.42          PAGE    1
REQUESTED OPTIONS: ,EB,,,,OBJ,,MAP,,GOSTMT,,,SIZE(256K),S,NAME(MAIN),OPT(0),LC(654),AD(NONE),FLAG(I),
OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)

   ISN 0002           REAL VAR0,VAR1,VAR2,VAR3
   ISN 0003           REAL VAR0,VAR1,VAR2,VAR3
   ISN 0004           REAL MOM0,MOM1,MOM2,MOM3
   ISN 0005           REAL ZERO0,ZERO1,ZERO2,ZERO3
   ISN 0006           INTEGER Z,NUM
                C
                C THIS PROGRAM RESCALES THE VALUES OF THE STATISTICS.
                C
                C THE FILE EMBEDDED SPECIFIES THE SPECIFIC MODIFICATION TO BE
                C    PERFORMED.
                C    THE FILES AVAILABLE ARE AS FOLLOWS:
                C               MOM3_100   ...... USED TO MULTIPLY THE 3RD
                C                                 MOMENTS BY 100.
                C               LOG        ...... TO TAKE THE NATURAL LOGARITHM
                C                                 OF EACH OF THE STATISTICS.
                C
                C THE STATISTICS ARE READ IN, THE REQUIRED RESCALING IS PERFORMED
                C     AND THE FINAL STATISTICS ARE WRITTEN OUT TO A NEW DATASET.
                C
                C THE VARIABLES REPRESENTING THE STATISTICS ARE AS FOLLOWS:
                C         VAR0  ... VAR3  = THE VARIANCE OF EMG CHANNELS 0 TO 3
                C         MOM0  ... MOM3  = THE THIRD MOMENTS OF EMG CHANNELS 0 TO 3
                C         ZERO0 ... ZERO3 = THE NUMBER OF ZERO CROSSINGS OF
                C                           CHANNELS 0 TO 3
                C
                C THE VARIABLE NUM IS THE TOTAL NUMBER OF STATISTIC CASES TO BE
                C     MODIFIED.
                C
   ISN 0007           NUM=3220
   ISN 0008           DO 100 Z=1,NUM
   ISN 0009              READ(10,200) CASE,VAR0,VAR1,VAR2,VAR3
   ISN 0010              READ(10,300) MOM0,MOM1,MOM2,MOM3
   ISN 0011              READ(10,400) ZERO0,ZERO1,ZERO2,ZERO3
                C
                C TAKE THE NATURAL LOGARITHMS OF THE STATISTICS.
                C
                C THE FIRST STEP IS TO RESET THE STATISTICS WHICH HAVE VALUES
                C     WHICH ARE LESS THAN OR EQUAL TO ZERO TO A SMALL POSITIVE
                C     NUMBER.   THIS ENSURES THAT THE VALUE OF THE LOGARITHM
                C     ARGUEMENT IS VALID.
                C
   ISN 0012              IF (VAR0 .LE. 0.0) VAR0 = 0.1 E-30
   ISN 0014              IF (VAR1 .LE. 0.0) VAR1 = 0.1 E-30
   ISN 0016              IF (VAR2 .LE. 0.0) VAR2 = 0.1 E-30
   ISN 0018              IF (VAR3 .LE. 0.0) VAR3 = 0.1 E-30
   ISN 0020              IF (MOM0 .LE. 0.0) MOM0 = 0.1 E-30
   ISN 0022              IF (MOM1 .LE. 0.0) MOM1 = 0.1 E-30
   ISN 0024              IF (MOM2 .LE. 0.0) MOM2 = 0.1 E-30
   ISN 0026              IF (MOM3 .LE. 0.0) MOM3 = 0.1 E-30
   ISN 0028              IF (ZERO0 .LE. 0.0) ZERO0 = 0.1 E-30
   ISN 0030              IF (ZERO1 .LE. 0.0) ZERO1 = 0.1 E-30
   ISN 0032              IF (ZERO2 .LE. 0.0) ZERO2 = 0.1 E-30
   ISN 0034              IF (ZERO3 .LE. 0.0) ZERO3 = 0.1 E-30
                C
                C PERFORM THE LOGARITHM TRANSFORMATION ON THE STATISTICS.
                C
   ISN 0036              VAR0 = LOG(VAR0)
   ISN 0037              VAR1 = LOG(VAR1)
   ISN 0038              VAR2 = LOG(VAR2)
   ISN 0039              VAR3 = LOG(VAR3)
   ISN 0040              MOM0 = LOG(MOM0)
   ISN 0041              MOM1 = LOG(MOM1)
   ISN 0042              MOM2 = LOG(MOM2)
   ISN 0043              MOM3 = LOG(MOM3)
   ISN 0044              ZERO0 = LOG(ZERO0)
   ISN 0045              ZERO1 = LOG(ZERO1)
   ISN 0046              ZERO2 = LOG(ZERO2)
   ISN 0047              ZERO3 = LOG(ZERO3)
                C
   ISN 0048              WRITE(11,200) CASE,VAR0,VAR1,VAR2,VAR3
   ISN 0049              WRITE(11,300) MOM0,MOM1,MOM2,MOM3
   ISN 0050              WRITE(11,400) ZERO0,ZERO1,ZERO2,ZERO3
   ISN 0051         100  CONTINUE
   ISN 0052         200     FORMAT(I4,4E17.8)
   ISN 0053         300     FORMAT(4X,4E17.8)
   ISN 0054         400     FORMAT(4X,4E17.8)
   ISN 0055              STOP
   ISN 0056              END

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)
*STATISTICS*    SOURCE STATEMENTS =       55, PROGRAM SIZE =      1372, SUBPROGRAM NAME =   MAIN
*STATISTICS*  NO  DIAGNOSTICS GENERATED
****** END OF COMPILATION ******                                       136K BYTES OF CORE NOT USED
```

```
PAGE    1
BMDP7M  -  STEPWISE DISCRIMINANT ANALYSIS.
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL     1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

      MAY 16, 1985  AT  9:39:37

PROGRAM CONTROL INFORMATION

/ PROBLEM TITLE IS '16 MOTION EMG CLASS. (RL-DELTOID): 3 SEC SAMPLES
                   LOG FEATURES:VAR,3RD MOM,ZEROS TOLERANCE=0.01'.
/ INPUT UNIT IS 9.
        VARIABLES ARE 13.
        FORMAT IS '(I4,4E17.8/4X,4E17.8/4X,4E17.8)'.
/ VARIABLE NAMES ARE CASE,CH0VAR,CH1VAR,CH2VAR,CH3VAR,
                     CH03RD,CH13RD,CH23RD,CH33RD,CH0Z,CH1Z,CH2Z,CH3Z.
           GROUPING IS CASE.
/ GROUP CODES(1)  ARE 1 TO 16.
        NAMES(1) ARE FLEX,EXT,PRON,SUP,HUMIN,HUMOUT,ARMEXT,ARMRET,
                     FLEX_REST,EXT_REST,PRON_REST,SUP_REST,
                     HIN_REST,HOT_REST,ART_REST,AEX_REST.
/ DISC TOL=0.01.
/ END

PROBLEM TITLE IS
16 MOTION EMG CLASS. (RL-DELTOID): 3 SEC SAMPLES  LOG FEATURES:VAR,3RD MOM,ZEROS
 TOLERANCE=0.01
NUMBER OF VARIABLES TO READ IN. . . . . . . . .        13
NUMBER OF VARIABLES ADDED BY TRANSFORMATIONS. .         0
TOTAL NUMBER OF VARIABLES . . . . . . . . . . .        13
NUMBER OF CASES TO READ IN. . . . . . . . . . . TO END
CASE LABELING VARIABLES . . . . . . . . . . . .
MISSING VALUES CHECKED BEFORE OR AFTER TRANS. . NEITHER
BLANKS ARE. . . . . . . . . . . . . . . . . . . MISSING
INPUT UNIT NUMBER . . . . . . . . . . . . . . .         9
REWIND INPUT UNIT PRIOR TO READING. . DATA. . .       YES
NUMBER OF WORDS OF DYNAMIC STORAGE. . . . . . .    176126
NUMBER OF CASES DESCRIBED BY INPUT FORMAT . . .         1

VARIABLES TO BE USED
     1 CASE         2 CH0VAR       3 CH1VAR       4 CH2VAR       5 CH3VAR
     6 CH03RD       7 CH13RD       8 CH23RD       9 CH33RD      10 CH0Z
    11 CH1Z        12 CH2Z        13 CH3Z
INPUT FORMAT IS
(I4,4E17.8/4X,4E17.8/4X,4E17.8)
MAXIMUM LENGTH DATA RECORD IS    72 CHARACTERS.
I N P U T    V A R I A B L E S . . . . .
  VARIABLE     RECORD   COLUMNS     FIELD  TYPE               VARIABLE     RECORD   COLUMNS     FIELD  TYPE
 INDEX   NAME     NO.   BEGIN  END   WIDTH                   INDEX   NAME     NO.   BEGIN  END   WIDTH
 ----- --------  ----   -----  -----  -----  ----              ----- --------  ----   -----  -----  -----  ----
     1 CASE         1       1     4     4    F                    8 CH23RD       2      39    55   17.8   F
     2 CH0VAR       1       5    21   17.8   F                    9 CH33RD       2      56    72   17.8   F
     3 CH1VAR       1      22    38   17.8   F                   10 CH0Z         3       5    21   17.8   F
     4 CH2VAR       1      39    55   17.8   F                   11 CH1Z         3      22    38   17.8   F
     5 CH3VAR       1      56    72   17.8   F                   12 CH2Z         3      39    55   17.8   F
     6 CH03RD       2       5    21   17.8   F                   13 CH3Z         3      56    72   17.8   F
     7 CH13RD       2      22    38   17.8   F

TOLERANCE. . . . . . . . .      0.010
F-TO-ENTER . . . . . . . .      4.000       4.000
F-TO-REMOVE. . . . . . . .      3.996       3.996
METHOD . . . . . . . . . .          1
MAXIMUM FORCED LEVEL . . .          0
MAXIMUM NUMBER OF STEPS. .         26
GROUPING VARIABLE. . . . .          1
NUMBER OF GROUPS . . . . .         16
PRIOR PROBABILITIES. . . .    0.06250    0.06250    0.06250    0.06250    0.06250    0.06250    0.06250    0.06250    0.06250    0.06250
                              0.06250    0.06250    0.06250    0.06250    0.06250    0.06250
BASED ON INPUT FORMAT SUPPLIED     3 RECORDS READ PER CASE.

                                                                  INTERVAL RANGE
  VARIABLE       MINIMUM  MAXIMUM  MISSING CATEGORY CATEGORY  GREATER LESS THAN
  NO. NAME        LIMIT    LIMIT    CODE     CODE     NAME      THAN    OR = TO

    1 CASE
                                           1.00000 FLEX
                                           2.00000 EXT
                                           3.00000 PRON
                                           4.00000 SUP
                                           5.00000 HUMIN
                                           6.00000 HUMOUT
                                           7.00000 ARMEXT
                                           8.00000 ARMRET
                                           9.00000 FLEX_RES
                                           10.0000 EXT_REST
                                           11.0000 PRON_RES
                                           12.0000 SUP_REST
                                           13.0000 HIN_REST
                                           14.0000 HOT_REST
                                           15.0000 ART_REST
                                           16.0000 AEX_REST

NUMBER OF CASES READ. . . . . . . . . . . . . .      3220
```

PAGE 2 BMDP7M 16 MOTION EMG CLASS. (RL-DELTOID): 3 SEC SAMPLES LOG FEATURES:VAR,3RD MOM,ZEROS TOLERANCE=0.01

MEANS

GROUP = VARIABLE	FLEX	EXT	PRON	SUP	HUMIN	HUMOUT	ARMEXT	ARMRET	FLEX_RES
2 CH0VAR	-4.53243	-7.12455	-8.29278	-4.69276	-5.98727	-4.56905	-4.45123	-4.34282	-6.98904
3 CH1VAR	-6.54533	-7.95632	-6.44531	-6.58251	-8.18727	-6.50650	-8.08299	-7.75507	-6.75511
4 CH2VAR	-8.22060	-8.49580	-7.48827	-7.65684	-8.23732	-6.64412	-7.29406	-8.60356	-9.39087
5 CH3VAR	-7.73825	-8.01691	-8.25087	-8.05224	-8.85991	-5.69716	-8.30700	-8.30667	-8.42822
6 CH03RD	-6.28273	-10.13265	-11.93231	-6.58397	-8.47899	-6.39852	-6.22719	-6.04638	-10.02767
7 CH13RD	-9.53475	-11.46292	-9.08458	-9.39926	-11.85266	-9.26913	-11.66889	-11.19035	-9.91311
8 CH23RD	-11.90461	-12.22891	-10.74542	-11.01625	-11.87089	-9.46712	-10.48025	-12.47595	-13.72265
9 CH33RD	-11.10497	-11.51939	-11.86979	-11.59757	-12.83847	-7.99097	-12.00454	-11.96699	-12.14303
10 CH0Z	2.30503	2.56394	2.67279	2.32896	2.25780	2.18821	2.16492	2.23875	2.14474
11 CH1Z	1.85522	2.50902	2.67086	2.61440	2.34734	2.53391	2.45596	2.32900	1.79496
12 CH2Z	2.51588	2.70982	2.65113	2.74007	2.59901	2.49359	2.63228	2.57975	1.69960
13 CH3Z	2.47078	2.57872	2.68201	2.71096	2.58525	2.46391	2.67517	2.73417	2.40405

STEP NUMBER 11
VARIABLE ENTERED 9 CH33RD

VARIABLE	F TO REMOVE	FORCE LEVEL	TOLERANCE	*	VARIABLE	F TO ENTER	FORCE LEVEL	TOLERANCE
DF=	15 3194			*	DF=	15 3193		
2 CH0VAR	35.523	1	0.011721	*	12 CH2Z	2.370	1	0.993370
3 CH1VAR	63.124	1	0.018993	*				
4 CH2VAR	24.989	1	0.017278	*				
5 CH3VAR	15.184	1	0.026619	*				
6 CH03RD	20.120	1	0.012052	*				
7 CH13RD	46.203	1	0.019140	*				
8 CH23RD	18.281	1	0.017513	*				
9 CH33RD	6.341	1	0.027185	*				
10 CH0Z	31.996	1	0.834863	*				
11 CH1Z	77.096	1	0.904544	*				
13 CH3Z	17.206	1	0.930603	*				

U-STATISTIC OR WILKS' LAMBDA 0.0006090 DEGREES OF FREEDOM 11 15 3204
APPROXIMATE F-STATISTIC 223.317 DEGREES OF FREEDOM 165.00 28558.34

F - MATRIX DEGREES OF FREEDOM = 11 3194

	FLEX	EXT	PRON	SUP	HUMIN	HUMOUT	ARMEXT	ARMRET	FLEX_RES	EXT_REST	PRON_RES	SUP_REST	HIN_REST
EXT	338.32												
PRON	696.11	389.74											
SUP	181.31	306.96	405.89										
HUMIN	308.55	103.13	547.88	271.77									
HUMOUT	496.83	576.16	707.48	429.63	840.90								
ARMEXT	262.77	211.43	595.14	147.74	92.34	561.73							
ARMRET	183.86	207.94	806.40	209.82	119.11	670.83	98.45						
FLEX_RES	183.13	265.08	570.88	407.58	261.40	815.36	436.16	314.96					
EXT_REST	401.33	98.15	676.61	549.13	135.02	911.73	333.15	239.13	199.11				
PRON_RES	854.88	297.54	240.76	715.31	374.83	1150.50	608.40	770.64	487.27	362.87			
SUP_REST	742.52	219.66	209.76	611.87	303.73	1030.12	519.99	648.29	420.96	292.52	9.03		
HIN_REST	413.15	127.82	595.79	402.08	21.72	979.53	164.84	175.99	279.18	97.35	309.33	254.98	
HOT_REST	438.87	195.95	378.35	329.46	122.00	676.56	124.83	325.26	442.01	293.15	267.95	232.04	141.30
ART_REST	416.28	235.64	1009.60	522.62	122.04	1076.11	239.21	98.99	329.98	120.11	679.94	576.90	93.89
AEX_REST	324.47	284.85	951.97	341.10	111.81	898.86	98.97	44.69	431.80	265.99	774.52	669.05	132.57

	HOT_REST	ART_REST
ART_REST	359.45	
AEX_REST	279.30	70.33

PAGE 19 BMDP7M 16 MOTION EMG CLASS. (RL-DELTOID): 3 SEC SAMPLES LOG FEATURES:VAR,3RD MOM,ZEROS TOLERANCE=0.01

CLASSIFICATION FUNCTIONS

GROUP = VARIABLE	FLEX	EXT	PRON	SUP	HUMIN	HUMOUT	ARMEXT	ARMRET	FLEX_RES
2 CH0VAR	-2.03498	-17.39735	-25.21513	1.75497	-6.98155	-6.58783	3.97777	7.90172	-10.23085
3 CH1VAR	-76.21024	-112.10809	-101.97128	-91.95091	-109.34354	-103.89841	-113.19562	-110.71252	-65.37184
4 CH2VAR	-188.94879	-206.21506	-177.75122	-187.12181	-198.65536	-181.95581	-184.89874	-199.27016	-190.35573
5 CH3VAR	-119.93744	-117.94588	-128.53973	-121.51674	-126.82166	-98.64326	-121.88005	-120.13445	-126.27003
6 CH03RD	7.98012	14.74476	16.71112	4.97699	9.47879	9.05151	3.92287	2.65997	10.01461
7 CH13RD	21.44942	40.05547	41.44778	32.90550	38.00632	40.16631	41.23454	39.14694	13.51963
8 CH23RD	93.66634	104.67595	93.41444	95.31046	100.46114	93.46805	93.47971	97.87715	92.68385
9 CH33RD	56.13783	55.69861	59.28171	55.25334	56.88985	50.92828	55.10838	55.16310	58.56625
10 CH0Z	34.26988	32.18433	30.02817	33.81175	30.21637	30.50066	32.12589	34.43571	26.52313
11 CH1Z	20.93422	29.19496	33.99014	33.99777	26.95135	31.90842	29.25356	26.37157	19.82785
13 CH3Z	36.00658	37.38445	38.21135	39.89088	35.81857	38.43614	38.16074	40.42921	33.86853
CONSTANT	-604.32056	-720.45703	-626.82397	-628.38452	-736.44312	-501.40894	-680.28394	-727.90845	-663.44629

GROUP = VARIABLE	EXT_REST	PRON_RES	SUP_REST	HIN_REST	HOT_REST	ART_REST	AEX_REST
2 CH0VAR	-18.53235	-33.14113	-29.69966	-8.91727	-18.42804	2.93311	11.41638
3 CH1VAR	-111.59721	-105.81723	-111.39975	-112.73651	-112.73776	-119.39746	-116.97835
4 CH2VAR	-190.76260	-184.86017	-187.89960	-199.15721	-178.79684	-199.97472	-199.16731
5 CH3VAR	-124.48099	-131.44891	-131.67152	-128.18449	-135.12714	-128.69815	-129.35846
6 CH03RD	15.64356	20.27672	18.68268	10.20791	15.45588	4.78399	0.80612
7 CH13RD	37.25018	38.06224	41.61768	38.57224	40.38237	41.07089	40.88963
8 CH23RD	91.84641	96.18370	97.17804	100.10609	92.78116	96.27715	98.57259
9 CH33RD	58.78130	58.73576	59.78914	56.84973	62.57262	59.40950	58.86172
10 CH0Z	31.26355	28.02344	28.77460	29.79813	28.62814	31.03616	34.78694
11 CH1Z	21.58781	28.78018	28.12048	25.61290	26.10260	22.60910	24.77679
13 CH3Z	34.06599	35.49644	37.48961	35.53537	37.08507	38.43895	39.05705
CONSTANT	-765.66431	-745.60791	-745.14185	-780.24097	-686.56567	-812.85791	-771.71045

CLASSIFICATION MATRIX

NUMBER OF CASES CLASSIFIED INTO GROUP -

GROUP	PERCENT CORRECT	FLEX	EXT	PRON	SUP	HUMIN	HUMOUT	ARMEXT	ARMRET	FLEX_RES	EXT_REST	PRON_RES	SUP_REST
FLEX	94.8	219	1	0	1	0	0	0	1	9	0	0	0
EXT	75.6	0	155	1	1	7	0	0	1	2	30	0	0
PRON	96.0	0	1	242	2	0	0	0	0	0	0	0	5
SUP	95.6	1	0	0	238	0	0	9	1	0	0	0	0
HUMIN	70.7	0	6	0	0	159	0	7	0	1	3	0	0
HUMOUT	99.5	1	0	0	0	0	211	0	0	0	0	0	0
ARMEXT	92.0	0	0	0	0	1	0	196	3	0	0	0	0
ARMRET	72.5	6	1	0	4	0	0	1	140	0	0	0	0
FLEX_RES	90.0	17	0	0	0	1	0	0	0	162	0	0	0
EXT_REST	87.2	0	7	0	1	1	0	0	0	2	157	0	0
PRON_RES	69.4	0	0	3	0	0	0	0	0	0	0	125	46
SUP_REST	45.0	0	1	4	0	1	0	0	0	0	0	59	81
HIN_REST	76.7	0	0	0	0	29	0	1	0	0	4	0	0
HOT_REST	92.8	0	0	0	0	8	0	4	0	0	0	1	0
ART_REST	95.0	0	0	0	0	0	0	0	0	0	3	0	0
AEX_REST	94.4	0	0	0	0	3	0	4	0	0	0	0	0
TOTAL	84.8	244	172	250	247	210	211	222	146	176	197	185	132

PAGE 20 BMDP7M 16 MOTION EMG CLASS. (RL-DELTOID): 3 SEC SAMPLES LOG FEATURES:VAR,3RD MOM,ZEROS TOLERANCE=0.01

		HIN_REST	HOT_REST	ART_REST	AEX_REST
FLEX	94.8	0	0	0	0
EXT	75.6	8	0	0	0
PRON	96.0	0	2	0	0
SUP	95.6	0	0	0	0
HUMIN	70.7	41	1	3	4
HUMOUT	99.5	0	0	0	0
ARMEXT	92.0	0	5	0	8
ARMRET	72.5	0	0	18	23
FLEX_RES	90.0	0	0	0	0
EXT_REST	87.2	8	0	4	0
PRON_RES	69.4	2	4	0	0
SUP_REST	45.0	0	34	0	0
HIN_REST	76.7	138	0	8	0
HOT_REST	92.8	0	167	0	0
ART_REST	95.0	3	0	171	3
AEX_REST	94.4	0	0	3	170
TOTAL	84.8	200	213	207	208

JACKKNIFED CLASSIFICATION

GROUP	PERCENT CORRECT	FLEX	EXT	PRON	SUP	HUMIN	HUMOUT	ARMEXT	ARMRET	FLEX_RES	EXT_REST	PRON_RES	SUP_REST
		NUMBER OF CASES CLASSIFIED INTO GROUP -											
FLEX	94.4	218	1	0	1	0	0	0	1	10	0	0	0
EXT	75.1	0	154	1	1	8	0	0	1	2	30	0	0
PRON	96.0	0	1	242	2	0	0	0	0	0	0	0	5
SUP	95.2	2	0	0	237	0	0	9	1	0	0	0	0
HUMIN	69.3	0	6	0	0	156	0	7	1	1	3	0	0
HUMOUT	99.5	1	0	0	0	0	211	0	0	0	0	0	0
ARMEXT	91.1	1	0	0	0	1	0	194	4	0	0	0	0
ARMRET	72.5	6	1	0	4	0	0	1	140	0	0	0	0
FLEX_RES	88.9	19	0	0	0	1	0	0	0	160	0	0	0
EXT_REST	87.2	0	7	0	1	1	0	0	0	2	157	0	0
PRON_RES	68.9	0	0	3	0	0	0	0	0	0	0	124	47
SUP_REST	42.8	0	1	4	0	1	0	0	0	0	0	63	77
HIN_REST	76.1	0	0	0	0	29	0	1	0	0	4	0	0
HOT_REST	92.2	0	0	0	0	8	0	4	0	0	0	2	0
ART_REST	93.9	0	0	0	0	0	0	0	0	0	4	0	0
AEX_REST	94.4	0	0	0	0	3	0	4	0	0	0	0	0
TOTAL	84.2	247	171	250	246	208	211	220	148	175	198	189	129

PAGE 21 BMDP7M 16 MOTION EMG CLASS. (RL-DELTOID): 3 SEC SAMPLES LOG FEATURES:VAR,3RD MOM,ZEROS TOLERANCE=0.01

		HIN_REST	HOT_REST	ART_REST	AEX_REST
FLEX	94.4	0	0	0	0
EXT	75.1	8	0	0	0
PRON	96.0	0	2	0	0
SUP	95.2	0	0	0	0
HUMIN	69.3	43	1	3	4
HUMOUT	99.5	0	0	0	0
ARMEXT	91.1	0	5	0	8
ARMRET	72.5	0	0	18	23
FLEX_RES	88.9	0	0	0	0
EXT_REST	87.2	8	0	4	0
PRON_RES	68.9	2	4	0	0
SUP_REST	42.8	0	34	0	0
HIN_REST	76.1	137	0	9	0
HOT_REST	92.2	0	166	0	0
ART_REST	93.9	4	0	169	3
AEX_REST	94.4	0	0	3	170
TOTAL	84.2	202	212	206	208

PAGE 22 BMDP7M 16 MOTION EMG CLASS. (RL-DELTOID): 3 SEC SAMPLES LOG FEATURES:VAR,3RD MOM,ZEROS TOLERANCE=0.01

SUMMARY TABLE

STEP NUMBER	VARIABLE ENTERED	VARIABLE REMOVED	F VALUE TO ENTER OR REMOVE	NUMBER OF VARIABLES INCLUDED	U-STATISTIC	APPROXIMATE F-STATISTIC	DEGREES OF FREEDOM	
1	2 CH0VAR		1382.4395	1	0.1338	1382.439	15.00	3204.00
2	5 CH3VAR		821.4221	2	0.0276	1071.501	30.00	6406.00
3	4 CH2VAR		551.9856	3	0.0077	876.382	45.00	9513.11
4	3 CH1VAR		590.6018	4	0.0020	809.542	60.00	12497.32
5	11 CH1Z		166.0343	5	0.0011	635.486	75.00	15331.80
6	7 CH13RD		49.0278	6	0.0009	491.300	90.00	17996.54
7	10 CH0Z		32.4947	7	0.0008	397.931	105.00	20479.07
8	6 CH03RD		20.3022	8	0.0007	332.562	120.00	22773.88
9	13 CH3Z		18.6841	9	0.0007	286.231	135.00	24881.40
10	8 CH23RD		18.2033	10	0.0006	251.940	150.00	26806.73
11	9 CH33RD		6.3410	11	0.0006	223.317	165.00	28558.34

B.3 CLASSIFIER AND CLASSIFIER EVALUATION PROGRAM

B.3 CLASSIFIER AND CLASSIFIER EVALUATION PROGRAM

```
 LEVEL 2.3.0 (JUNE 78)                         OS/360  FORTRAN H EXTENDED                  DATE 85.141/15.36.49         PAGE    1
REQUESTED OPTIONS: ,EB,,,,OBJ,,MAP,,GOSTMT,,,SIZE(256K),S,NAME(MAIN),OPT(0),LC(654),AD(NONE),FLAG(I),
OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)

   ISN 0002            REAL VAR0,VAR1,VAR2,VAR3
   ISN 0003            REAL VAR0,VAR1,VAR2,VAR3
   ISN 0004            REAL MOM0,MOM1,MOM2,MOM3
   ISN 0005            REAL ZERO0,ZERO1,ZERO2,ZERO3
   ISN 0006            INTEGER Z,NUM
                 C
                 C THIS PROGRAM RESCALES THE VALUES OF THE STATISTICS.
                 C
                 C THE FILE EMBEDDED SPECIFIES THE SPECIFIC MODIFICATION TO BE
                 C    PERFORMED.
                 C    THE FILES AVAILABLE ARE AS FOLLOWS:
                 C              MOM3_100    ...... USED TO MULTIPLY THE 3RD
                 C                                 MOMENTS BY 100.
                 C              LOG         ...... TO TAKE THE NATURAL LOGARITHM
                 C                                 OF EACH OF THE STATISTICS.
                 C
                 C THE STATISTICS ARE READ IN, THE REQUIRED RESCALING IS PERFORMED
                 C     AND THE FINAL STATISTICS ARE WRITTEN OUT TO A NEW DATASET.
                 C
                 C THE VARIABLES REPRESENTING THE STATISTICS ARE AS FOLLOWS:
                 C         VAR0  ... VAR3  = THE VARIANCE OF EMG CHANNELS 0 TO 3
                 C         MOM0  ... MOM3  = THE THIRD MOMENTS OF EMG CHANNELS 0 TO 3
                 C         ZERO0 ... ZERO3 = THE NUMBER OF ZERO CROSSINGS OF
                 C                           CHANNELS 0 TO 3
                 C
                 C THE VARIABLE NUM IS THE TOTAL NUMBER OF STATISTIC CASES TO BE
                 C     MODIFIED.
                 C
   ISN 0007            NUM=3122
   ISN 0008            DO 100 Z=1,NUM
   ISN 0009               READ(12,200) CASE,VAR0,VAR1,VAR2,VAR3
   ISN 0010               READ(12,300) MOM0,MOM1,MOM2,MOM3
   ISN 0011               READ(12,400) ZERO0,ZERO1,ZERO2,ZERO3
                 C
                 C TAKE THE NATURAL LOGARITHMS OF THE STATISTICS.
                 C
                 C THE FIRST STEP IS TO RESET THE STATISTICS WHICH HAVE VALUES
                 C     WHICH ARE LESS THAN OR EQUAL TO ZERO TO A SMALL POSITIVE
                 C     NUMBER.   THIS ENSURES THAT THE VALUE OF THE LOGARITHM
                 C     ARGUEMENT IS VALID.
                 C
   ISN 0012               IF (VAR0 .LE. 0.0) VAR0 = 0.1 E-30
   ISN 0014               IF (VAR1 .LE. 0.0) VAR1 = 0.1 E-30
   ISN 0016               IF (VAR2 .LE. 0.0) VAR2 = 0.1 E-30
   ISN 0018               IF (VAR3 .LE. 0.0) VAR3 = 0.1 E-30
   ISN 0020               IF (MOM0 .LE. 0.0) MOM0 = 0.1 E-30
   ISN 0022               IF (MOM1 .LE. 0.0) MOM1 = 0.1 E-30
   ISN 0024               IF (MOM2 .LE. 0.0) MOM2 = 0.1 E-30
   ISN 0026               IF (MOM3 .LE. 0.0) MOM3 = 0.1 E-30
   ISN 0028               IF (ZERO0 .LE. 0.0) ZERO0 = 0.1 E-30
   ISN 0030               IF (ZERO1 .LE. 0.0) ZERO1 = 0.1 E-30
   ISN 0032               IF (ZERO2 .LE. 0.0) ZERO2 = 0.1 E-30
   ISN 0034               IF (ZERO3 .LE. 0.0) ZERO3 = 0.1 E-30
                 C
                 C PERFORM THE LOGARITHM TRANSFORMATION ON THE STATISTICS.
                 C
   ISN 0036               VAR0 = LOG(VAR0)
   ISN 0037               VAR1 = LOG(VAR1)
   ISN 0038               VAR2 = LOG(VAR2)
   ISN 0039               VAR3 = LOG(VAR3)
   ISN 0040               MOM0 = LOG(MOM0)
   ISN 0041               MOM1 = LOG(MOM1)
   ISN 0042               MOM2 = LOG(MOM2)
   ISN 0043               MOM3 = LOG(MOM3)
   ISN 0044               ZERO0 = LOG(ZERO0)
   ISN 0045               ZERO1 = LOG(ZERO1)
   ISN 0046               ZERO2 = LOG(ZERO2)
   ISN 0047               ZERO3 = LOG(ZERO3)
                 C
   ISN 0048               WRITE(13,200) CASE,VAR0,VAR1,VAR2,VAR3
   ISN 0049               WRITE(13,300) MOM0,MOM1,MOM2,MOM3
   ISN 0050               WRITE(13,400) ZERO0,ZERO1,ZERO2,ZERO3
   ISN 0051        100 CONTINUE
   ISN 0052        200    FORMAT(I4,4E17.8)
   ISN 0053        300    FORMAT(4X,4E17.8)
   ISN 0054        400    FORMAT(4X,4E17.8)
   ISN 0055            STOP
   ISN 0056            END

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)
*STATISTICS*     SOURCE STATEMENTS =        55, PROGRAM SIZE =      1372, SUBPROGRAM NAME =   MAIN
*STATISTICS*  NO  DIAGNOSTICS GENERATED
****** END OF COMPILATION ******                                        136K BYTES OF CORE NOT USED
```

```
 LEVEL 2.3.0 (JUNE 78)                         OS/360  FORTRAN H EXTENDED              DATE 85.141/15.37.40        PAGE   1
REQUESTED OPTIONS: ,EB,,,,OBJ,,MAP,,GOSTMT,,,SIZE(256K),S,NAME(MAIN),OPT(0),LC(654),AD(NONE),FLAG(I),
OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)

   ISN 0002                 INTEGER I,N,STATE,CHOSEN,RIGHT,WRONG,LEAD,FPRINT,NCASES
   ISN 0003                 INTEGER R(16),W(16),WPART(16,16),REST,RTREST
   ISN 0004                 REAL CV0(16),CV1(16),CV2(16),CV3(16)
   ISN 0005                 REAL C30(16),C31(16),C32(16),C33(16)
   ISN 0006                 REAL CZ0(16),CZ1(16),CZ2(16),CZ3(16),CCN(16)
   ISN 0007                 REAL PERRT,PERWRG,PERWR(16,16),PERRST
   ISN 0008                 REAL FV0,FV1,FV2,FV3,F30,F31,F32,F33,FZ0,FZ1,FZ2,FZ3
   ISN 0009                 REAL S(16)
                      C
   ISN 0010                 WRITE(6,10)
   ISN 0011             10  FORMAT('0SUBJECT: RICK LEHNER')
                      C
                      C
                      C NCASES IS THE NUMBER OF CASES TO BE USED IN THE CONTROLLER.
                      C
   ISN 0012                 NCASES=16
                      C SET THE VARIABLE "FPRINT" TO 1 FOR A FULL PRINTOUT OF STATE
                      C    EQUATION VALUES FOR EACH OBSERVATION.
                      C SET "FPRINT" TO 0 TO GET ONLY THE OVERALL STATISTICS.
                      C
   ISN 0013                 FPRINT=1
                      C
                      C
                      C READ IN WHICH SET OF EMG LEADS HAVE BEEN USED.
                      C IF THE VARIABLE "LEAD" IS EQUAL TO 0, THEN THE FOLLOWING
                      C    CONFIGURATION WAS USED: LEAD 0: BICEPS
                      C                                 1: TRICEPS
                      C                                 2: MEDIAL
                      C                                 3: LATERAL
                      C                                 4: STRAIN GAUGE
                      C
                      C IF THE VARIABLE "LEAD" IS EQUAL TO 1, THEN THE FOLLOWING
                      C    CONFIGURATION WAS USED: LEAD 0: BICEPS
                      C                                 1: TRICEPS
                      C                                 2: DELTOID ANTERIOR
                      C                                 3: DELTOID POSTERIOR
                      C                                 4: STRAIN GAUGE
                      C
                      C
                      C READ IN THE NUMBER OF OBSERVATIONS TO BE TESTED.
                      C
   ISN 0014                 READ(9,*) LEAD,N
                      C
                      C PRINT OUT THE LEAD CONFIGURATION AND THE NUMBER OF OBSERVATIONS
                      C   TO BE TESTED.
                      C
   ISN 0015                 IF (LEAD .EQ. 0) GO TO 100
   ISN 0017                 WRITE(6,200)
   ISN 0018                 WRITE(6,300)
   ISN 0019                 WRITE(6,400)
   ISN 0020                 WRITE(6,500)
   ISN 0021                 WRITE(6,600)
   ISN 0022                 WRITE(6,700)
   ISN 0023            200  FORMAT('0THE LEAD CONFIGURATION IS AS FOLLOWS.')
   ISN 0024            300  FORMAT(' LEAD 0: BICEPS')
   ISN 0025            400  FORMAT('       1: TRICEPS')
   ISN 0026            500  FORMAT('       2: DELTOID ANTERIOR')
   ISN 0027            600  FORMAT('       3: DELTOID POSTERIOR')
   ISN 0028            700  FORMAT('       4: STRAIN GAUGE')
   ISN 0029                 GO TO 800
   ISN 0030            100  CONTINUE
   ISN 0031                 WRITE(6,900)
   ISN 0032                 WRITE(6,1000)
   ISN 0033                 WRITE(6,1100)
   ISN 0034                 WRITE(6,1200)
   ISN 0035                 WRITE(6,1300)
   ISN 0036                 WRITE(6,1400)
   ISN 0037            900  FORMAT('-THE LEAD CONFIGURATION IS AS FOLLOWS.')
   ISN 0038           1000 FORMAT(' LEAD 0: BICEPS')
   ISN 0039           1100 FORMAT('       1: TRICEPS')
   ISN 0040           1200 FORMAT('       2: MEDIAL')
   ISN 0041           1300 FORMAT('       3: LATERAL')
   ISN 0042           1400 FORMAT('       4: STRAIN GAUGE')
   ISN 0043            800  CONTINUE
                      C
                      C PRINT OUT THE NUMBER OF OBSERVATIONS TO BE TESTED
                      C    AND GIVE SOME OF THE PARTICULARS OF THE CONTROLLER
                      C    BEING TESTED.
                      C
   ISN 0044                 WRITE(6,1500) N
   ISN 0045           1500 FORMAT('0THE NUMBER OF OBSERVATIONS TO BE TESTED IS: ',I4)
                      C
   ISN 0046                 WRITE(6,1600)
   ISN 0047           1600  FORMAT('0SIXTEEN MOTIONS: TOL=0.01, BI/TRI LOG OF FEATURES')
                      C INITIALIZE THE NUMBER OF RIGHT AND WRONG CHOICES MADE TO ZERO.
                      C
                      C THE FIRST DIGIT OF THE VARIABLES IS AS FOLLOWS:
                      C             - "R" INDICATES THE RIGHT CHOICES
                      C             - "W" INDICATES THE WRONG CHOICES
                      C THE INDEX INDICATES THE STATE NUMBER.
                      C FOR THE WRONG CHOICES, THE SECOND INDEX INDICATES THE CHOSEN STATE.
                      C
                      C INITIALIZE THE ARRAYS TO THE ZERO VALUE.
                      C
   ISN 0048                 DO 1700 I=1,NCASES
   ISN 0049                    R(I)=0
   ISN 0050                    W(I)=0
   ISN 0051                    DO 1800 J=1,NCASES
   ISN 0052                    WPART(I,J)=0
   ISN 0053           1800        CONTINUE
   ISN 0054           1700  CONTINUE
                      C
                      C INITIALIZE A VARIABLE "REST".
                      C REST IS A VARIABLE WHICH COUNTS THE NUMBER OF OBSERVATIONS
                      C    ARE REST CASES (IE. "CASE" = 9 TO 12) BUT HAS BEEN MISCLASSIFIED
                      C    BY THE CONTROLLER INTO THE WRONG REST CASE (IE. "CHOSEN"
                      C    IS ASSIGNED THE VALUE FROM 9 TO 12).
                      C INITIALIZE "PERREST".
                      C PERREST IS THE PERCENTAGE NUMBER OF MISCLASSIFIED REST OBSERVATIONS.
                      C
   ISN 0055                 REST=0
   ISN 0056                 REST=0
   ISN 0057                 PERRST=0
                      C
                      C
```

```
C
C READ IN THE COEFFICIENTS OF THE LINEAR STATE EQUATION.
C THE COEFFICIENTS ARE PREFACED WITH A "C".
C THE FEATURE VARIABLE IS PREFACED WITH AN "F".
C
C THE SECOND DIGIT IS: -A "3" FOR THE THIRD MOMENT FEATURE
C                      -A "Z" FOR THE NUMBER OF ZERO CROSSINGS FEATURE
C                      -A "V" FOR THE VARIANCE FEATURE
C
C THE THIRD DIGIT IS THE EMG CHANNEL NUMBER (0 TO 3).
C
C THE INDEX VALUE IS THE STATE EQUATION NUMBER.
C
C THE CONSTANT FOR THE EQUATION IS INDICATED IN THE VARIABLE NAME
C    WITH A "CN" FOR THE SECOND AND THIRD DIGITS.
C
C
      READ(9,*) (CV0(I),I=1,4)
      READ(9,*) (CV1(I),I=1,4)
      READ(9,*) (CV2(I),I=1,4)
      READ(9,*) (CV3(I),I=1,4)
      READ(9,*) (C30(I),I=1,4)
      READ(9,*) (C31(I),I=1,4)
      READ(9,*) (C32(I),I=1,4)
      READ(9,*) (C33(I),I=1,4)
      READ(9,*) (CZ0(I),I=1,4)
      READ(9,*) (CZ1(I),I=1,4)
      READ(9,*) (CZ2(I),I=1,4)
      READ(9,*) (CZ3(I),I=1,4)
      READ(9,*) (CCN(I),I=1,4)
C
      READ(9,*) (CV0(I),I=5,8)
      READ(9,*) (CV1(I),I=5,8)
      READ(9,*) (CV2(I),I=5,8)
      READ(9,*) (CV3(I),I=5,8)
      READ(9,*) (C30(I),I=5,8)
      READ(9,*) (C31(I),I=5,8)
      READ(9,*) (C32(I),I=5,8)
      READ(9,*) (C33(I),I=5,8)
      READ(9,*) (CZ0(I),I=5,8)
      READ(9,*) (CZ1(I),I=5,8)
      READ(9,*) (CZ2(I),I=5,8)
      READ(9,*) (CZ3(I),I=5,8)
      READ(9,*) (CCN(I),I=5,8)
C
      READ(9,*) CV0(9)
      READ(9,*) CV1(9)
      READ(9,*) CV2(9)
      READ(9,*) CV3(9)
      READ(9,*) C30(9)
      READ(9,*) C31(9)
      READ(9,*) C32(9)
      READ(9,*) C33(9)
      READ(9,*) CZ0(9)
      READ(9,*) CZ1(9)
      READ(9,*) CZ2(9)
      READ(9,*) CZ3(9)
      READ(9,*) CCN(9)
C
      READ(9,*) (CV0(I),I=10,13)
      READ(9,*) (CV1(I),I=10,13)
      READ(9,*) (CV2(I),I=10,13)
      READ(9,*) (CV3(I),I=10,13)
      READ(9,*) (C30(I),I=10,13)
      READ(9,*) (C31(I),I=10,13)
      READ(9,*) (C32(I),I=10,13)
      READ(9,*) (C33(I),I=10,13)
      READ(9,*) (CZ0(I),I=10,13)
      READ(9,*) (CZ1(I),I=10,13)
      READ(9,*) (CZ2(I),I=10,13)
      READ(9,*) (CZ3(I),I=10,13)
      READ(9,*) (CCN(I),I=10,13)
C
      READ(9,*) (CV0(I),I=14,16)
      READ(9,*) (CV1(I),I=14,16)
      READ(9,*) (CV2(I),I=14,16)
      READ(9,*) (CV3(I),I=14,16)
      READ(9,*) (C30(I),I=14,16)
      READ(9,*) (C31(I),I=14,16)
      READ(9,*) (C32(I),I=14,16)
      READ(9,*) (C33(I),I=14,16)
      READ(9,*) (CZ0(I),I=14,16)
      READ(9,*) (CZ1(I),I=14,16)
      READ(9,*) (CZ2(I),I=14,16)
      READ(9,*) (CZ3(I),I=14,16)
      READ(9,*) (CCN(I),I=14,16)
C
C PRINT OUT THE MOTIONS REPRESENTED BY EACH STATE NUMBER.
C
      WRITE(6,1900)
      WRITE(6,2000)
      WRITE(6,2100)
      WRITE(6,2200)
      WRITE(6,2300)
      WRITE(6,2400)
      WRITE(6,2500)
      WRITE(6,2600)
      WRITE(6,2700)
      WRITE(6,2800)
      WRITE(6,2900)
      WRITE(6,3000)
      WRITE(6,3100)
      WRITE(6,3200)
      WRITE(6,3300)
      WRITE(6,3400)
C
 1900 FORMAT(' STATE 1:  ELBOW FLEXION')
 2000 FORMAT(' STATE 2:  ELBOW EXTENSION')
 2100 FORMAT(' STATE 3:  WRIST PRONATION')
 2200 FORMAT(' STATE 4:  WRIST SUPINATION')
 2300 FORMAT(' STATE 5:  HUMERAL ROTATION INWARD')
 2400 FORMAT(' STATE 6:  HUMERAL ROTATION OUTWARD')
 2500 FORMAT(' STATE 7:  ARM EXTENSION')
 2600 FORMAT(' STATE 8:  ARM RETRACTION')
 2700 FORMAT(' STATE 9:  REST: ELBOW FLEXION')
 2800 FORMAT(' STATE 10: REST: ELBOW EXTENSION')
 2900 FORMAT(' STATE 11: REST: WRIST PRONATION')
 3000 FORMAT(' STATE 12: REST: WRIST SUPINATION')
 3100 FORMAT(' STATE 13: REST: HUMERAL ROTATION INWARD')
 3200 FORMAT(' STATE 14: REST: HUMERAL ROTATION OUTWARD')
```

```
ISN 0153      3300 FORMAT(' STATE 15: REST: ARM EXTENSION')
ISN 0154      3400 FORMAT(' STATE 16: REST: ARM RETRACTION')
              C
              C PRINT OUT THE STATE EQUATION COEFFICENTS.
              C
ISN 0155            WRITE(6,3500)
ISN 0156      3500 FORMAT('0THE COEFFICIENTS OF THE LINEAR STATE EQUATIONS ARE: ')
              C
ISN 0157            DO 3600 J=1,NCASES
ISN 0158               WRITE(6,3700) J
ISN 0159      3700     FORMAT('0THE COEFFICIENTS OF STATE EQUATION',I3,' ARE:')
ISN 0160               WRITE(6,3800) CV0(J),CV1(J),CV2(J),CV3(J)
ISN 0161               WRITE(6,3900) C30(J),C31(J),C32(J),C33(J)
ISN 0162               WRITE(6,4000) CZ0(J),CZ1(J),CZ2(J),CZ3(J)
ISN 0163               WRITE(6,4100) CCN(J)
ISN 0164      3600 CONTINUE
ISN 0165      3800 FORMAT(' THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3: ',4F15.5)
ISN 0166      3900 FORMAT(' THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3: ',4F15.5)
ISN 0167      4000 FORMAT(' THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3: ',4F15.5)
ISN 0168      4100 FORMAT(' THE CONSTANT ADDED TO THE EQUATION:        ',F15.5)
              C
              C IF "FPRINT" = 1 PRINT OUT TITLES FOR THE EXTRA PRINT OUT MATERIAL.
              C
ISN 0169            IF(FPRINT .EQ. 0) GO TO 4200
ISN 0171            WRITE(6,4250)
ISN 0172      4250 FORMAT('1THE STATE EQUATION VALUES FOR EACH OBSERVATION ARE:')
ISN 0173            WRITE(6,4275)
ISN 0174      4275 FORMAT('0 ')
ISN 0175      4200 CONTINUE
              C
              C CALCULATE THE VALUES OF THE LINEAR STATE EQUATIONS FOR
              C     EACH OBSERVATION.
              C THE LINEAR STATE EQUATION WITH THE LARGEST VALUE IS THE CHOSEN STATE.
              C
ISN 0176            DO 4300 I=1,N
              C
              C READ IN THE ACTUAL EXPERIMENTAL STATE AND THE FEATURE VALUES FOR
              C     EACH OF THE OBSERVATIONS.
              C
ISN 0177               READ(10,*) STATE,FV0,FV1,FV2,FV3
ISN 0178               READ(10,*) F30,F31,F32,F33
ISN 0179               READ(10,*) FZ0,FZ1,FZ2,FZ3
              C
              C THE FIRST DIGIT OF THE VARIABLE NAME FOR THE CANONICAL EQUATIONS IS
              C    AN "S".
              C THE INDEX INDICATES THE CANONICAL EQUATION NUMBER (1 TO NCASES.)
              C
              C FOR THE CASE WHERE FEWER THAN NCASES CASES ARE POSSIBLE, SIMPLY SET
              C    THE COEFFICIENTS FOR THE EXTRA EQUATIONS TO ZERO.
              C
ISN 0180               DO 4400 J=1,NCASES
ISN 0181               S(J)=CV0(J)*FV0+CV1(J)*FV1+CV2(J)*FV2+CV3(J)*FV3+C30(J)*F30
                   +         C31(J)*F31+C32(J)*F32+C33(J)*F33+CZ0(J)*FZ0+CZ1(J)*FZ1
                   +         CZ2(J)*FZ2+CZ3(J)*FZ3+CCN(J)
ISN 0182      4400     CONTINUE
              C
              C PRINT OUT THE OBSERVATION NUMBER AND THE VALUES OF THE STATE EQUATIONS
              C
ISN 0183            IF(FPRINT .EQ. 0) GO TO 4500
ISN 0185            WRITE(6,4600) I,S(1),S(2),S(3),S(4)
ISN 0186      4600 FORMAT('0OBS = ',I4,' S1 = ',F15.5,' S2 = ',F15.5,' S3 = ',F15.5,
                  +' S4 = ',F15.5)
ISN 0187            WRITE(6,4700) S(5),S(6),S(7),S(8),S(9)
ISN 0188      4700 FORMAT('    S5 = ',F15.5,' S6 = ',F15.5,' S7 = ',F15.5,' S8 = ',
                  +F15.5,' S9 = ',F15.5)
ISN 0189            WRITE(6,4800) S(10),S(11),S(12),S(13),S(14)
ISN 0190      4800 FORMAT('    S10 = ',F15.5,' S11 = ',F15.5,' S12 = ',F15.5,' S13 = ',
                  +F15.5,' S14 = ',F15.5)
ISN 0191            WRITE(6,4900) S(15),S(16)
ISN 0192      4900 FORMAT('    S15 = ',F15.5,' S16 = ',F15.5)
ISN 0193      4500 CONTINUE
              C
              C DETERMINE WHICH OF THE STATE EQUATIONS HAS THE MAXIMUM VALUE.
              C THAT STATE IS THE CHOSEN STATE.
              C THE VARIABLE "CHOSEN" IS ASSIGNED THAT CHOSEN VALUE.
              C
ISN 0194               IF ((S(1) .GT. S(2)) .AND. (S(1) .GT. S(3)) .AND. (S(1) .GT.
                   +      S(4)) .AND. (S(1) .GT. S(5)) .AND. (S(1) .GT. S(6)) .AND.
                   +      (S(1) .GT. S(7)) .AND. (S(1) .GT. S(8)) .AND. (S(1) .GT.
                   +      S(9)) .AND. (S(1) .GT. S(10)) .AND. (S(1) .GT. S(11)) .AND.
                   +      (S(1) .GT. S(12)) .AND. (S(1) .GT. S(13)) .AND. (S(1) .GT.
                   +      S(14)) .AND. (S(1) .GT. (15)) .AND. (S(1) .GT. S(16)))
                   +      CHOSEN = 1
              C
ISN 0196               IF ((S(2) .GT. S(1)) .AND. (S(2) .GT. S(3)) .AND. (S(2) .GT.
                   +      S(4)) .AND. (S(2) .GT. S(5)) .AND. (S(2) .GT. S(6)) .AND.
                   +      (S(2) .GT. S(7)) .AND. (S(2) .GT. S(8)) .AND. (S(2) .GT.
                   +      S(9)) .AND. (S(2) .GT. S(10)) .AND. (S(2) .GT. S(11)) .AND.
                   +      (S(2) .GT. S(12)) .AND. (S(2) .GT. S(13)) .AND. (S(2) .GT.
                   +      S(14)) .AND. (S(2) .GT. S(15)) .AND. (S(2) .GT. S(16)))
                   +      CHOSEN = 2
              C
ISN 0198               IF ((S(3) .GT. S(1)) .AND. (S(3) .GT. S(2)) .AND. (S(3) .GT.
                   +      S(4)) .AND. (S(3) .GT. S(5)) .AND. (S(3) .GT. S(6)) .AND.
                   +      (S(3) .GT. S(7)) .AND. (S(3) .GT. S(8)) .AND. (S(3) .GT.
                   +      S(9)) .AND. (S(3) .GT. S(10)) .AND. (S(3) .GT. S(11)) .AND.
                   +      (S(3) .GT. S(12)) .AND. (S(3) .GT. S(13)) .AND. (S(3) .GT.
                   +      S(14)) .AND. (S(3) .GT. S(15)) .AND. (S(3) .GT. S(16)))
                   +      CHOSEN = 3
              C
ISN 0200               IF ((S(4) .GT. S(1)) .AND. (S(4) .GT. S(2)) .AND. (S(4) .GT.
                   +      S(3)) .AND. (S(4) .GT. S(5)) .AND. (S(4) .GT. S(6)) .AND.
                   +      (S(4) .GT. S(7)) .AND. (S(4) .GT. S(8)) .AND. (S(4) .GT.
                   +      S(9)) .AND. (S(4) .GT. S(10)) .AND. (S(4) .GT. S(11)) .AND.
                   +      (S(4) .GT. S(12)) .AND. (S(4) .GT. S(13)) .AND. (S(4) .GT.
                   +      S(14)) .AND. (S(4) .GT. S(15)) .AND. (S(4) .GT. S(16)))
                   +      CHOSEN = 4
              C
ISN 0202               IF ((S(5) .GT. S(1)) .AND. (S(5) .GT. S(2)) .AND. (S(5) .GT.
                   +      S(3)) .AND. (S(5) .GT. S(4)) .AND. (S(5) .GT. S(6)) .AND.
                   +      (S(5) .GT. S(7)) .AND. (S(5) .GT. S(8)) .AND. (S(5) .GT.
                   +      S(9)) .AND. (S(5) .GT. S(10)) .AND. (S(5) .GT. S(11)) .AND.
                   +      (S(5) .GT. S(12)) .AND. (S(5) .GT. S(13)) .AND. (S(5) .GT.
                   +      S(14)) .AND. (S(5) .GT. S(15)) .AND. (S(5) .GT. S(16)))
                   +      CHOSEN = 5
              C
ISN 0204               IF ((S(6) .GT. S(1)) .AND. (S(6) .GT. S(2)) .AND. (S(6) .GT.
                   +      S(3)) .AND. (S(6) .GT. S(4)) .AND. (S(6) .GT. S(5)) .AND.
                   +      (S(6) .GT. S(7)) .AND. (S(6) .GT. S(8)) .AND. (S(6) .GT.
                   +      S(9)) .AND. (S(6) .GT. S(10)) .AND. (S(6) .GT. S(11)) .AND.
```

```
               +      (S(6) .GT. S(12)) .AND. (S(6) .GT. S(13)) .AND. (S(6) .GT.
               +      S(14)) .AND. (S(6) .GT. S(15)) .AND. (S(6) .GT. S(16)))
               +      CHOSEN = 6
           C
ISN 0206             IF ((S(7) .GT. S(1)) .AND. (S(7) .GT. S(2)) .AND. (S(7) .GT.
               +      S(3)) .AND. (S(7) .GT. S(4)) .AND. (S(7) .GT. S(5)) .AND.
               +      (S(7) .GT. S(6)) .AND. (S(7) .GT. S(8)) .AND. (S(7) .GT.
               +      S(9)) .AND. (S(7) .GT. S(10)) .AND. (S(7) .GT. S(11)) .AND.
               +      (S(7) .GT. S(12)) .AND. (S(7) .GT. S(13)) .AND. (S(7) .GT.
               +      S(14)) .AND. (S(7) .GT. S(15)) .AND. (S(7) .GT. S(16)))
               +      CHOSEN = 7
           C
ISN 0208             IF ((S(8) .GT. S(1)) .AND. (S(8) .GT. S(2)) .AND. (S(8) .GT.
               +      S(3)) .AND. (S(8) .GT. S(4)) .AND. (S(8) .GT. S(5)) .AND.
               +      (S(8) .GT. S(6)) .AND. (S(8) .GT. S(7)) .AND. (S(8) .GT.
               +      S(9)) .AND. (S(8) .GT. S(10)) .AND. (S(8) .GT. S(11)) .AND.
               +      (S(8) .GT. S(12)) .AND. (S(8) .GT. S(13)) .AND. (S(8) .GT.
               +      S(14)) .AND. (S(8) .GT. S(15)) .AND. (S(8) .GT. S(16)))
               +      CHOSEN = 8
           C
ISN 0210             IF ((S(9) .GT. S(1)) .AND. (S(9) .GT. S(2)) .AND. (S(9) .GT.
               +      S(3)) .AND. (S(9) .GT. S(4)) .AND.( S(9) .GT. S(5)) .AND.
               +      (S(9) .GT. S(6)) .AND. (S(9) .GT. S(7)) .AND. (S(9) .GT.
               +      S(8)) .AND. (S(9) .GT. S(10)) .AND. (S(9) .GT. S(11)) .AND.
               +      (S(9) .GT. S(12)) .AND. (S(9) .GT. S(13)) .AND. (S(9) .GT.
               +      S(14)) .AND. (S(9) .GT. S(15)) .AND. (S(9) .GT. S(16)))
               +      CHOSEN = 9
           C
ISN 0212             IF ((S(10) .GT. S(1)) .AND. (S(10) .GT. S(2)) .AND. (S(10) .GT.
               +      S(3)) .AND. (S(10) .GT. S(4)) .AND. (S(10) .GT. S(5)) .AND.
               +      (S(10) .GT. S(6)) .AND. (S(10) .GT. S(7)) .AND. (S(10) .GT.
               +      S(8)) .AND. (S(10) .GT. S(9)) .AND. (S(10) .GT. S(11)) .AND.
               +      (S(10) .GT. S(12)) .AND. (S(10) .GT. S(13)) .AND. (S(10)
               +      .GT. S(14)) .AND. (S(10) .GT. S(15)) .AND. (S(10) .GT.
               +     S(16))) CHOSEN = 10
           C
ISN 0214             IF ((S(11) .GT. S(1)) .AND. (S(11) .GT. S(2)) .AND. (S(11) .GT.
               +      S(3)) .AND. (S(11) .GT. S(4)) .AND. (S(11) .GT. S(5)) .AND.
               +      (S(11) .GT. S(6)) .AND. (S(11) .GT. S(7)) .AND. (S(11) .GT.
               +      S(8)) .AND. (S(11) .GT. S(9)) .AND. (S(11) .GT. S(10)) .AND.
               +      (S(11) .GT. S(12)) .AND. (S(11) .GT. S(13)) .AND. (S(11)
               +      .GT. S(14)) .AND. (S(11) .GT. S(15)) .AND. (S(11) .GT.
               +      S(16))) CHOSEN = 11
           C
ISN 0216             IF ((S(12) .GT. S(1)) .AND. (S(12) .GT. S(2)) .AND. (S(12) .GT.
               +      S(3)) .AND. (S(12) .GT. S(4)) .AND. (S(12) .GT. S(5)) .AND.
               +      (S(12) .GT. S(6)) .AND. (S(12) .GT. S(7)) .AND. (S(12) .GT.
               +      S(8)) .AND. (S(12) .GT. S(9)) .AND. (S(12) .GT. S(10)) .AND.
               +      (S(12) .GT. S(11)) .AND. (S(12) .GT. S(13)) .AND. (S(12)
               +      .GT. S(14)) .AND. (S(12) .GT. S(15)) .AND. (S(12) .GT.
               +      S(16))) CHOSEN = 12
           C
ISN 0218             IF ((S(13) .GT. S(1)) .AND. (S(13) .GT. S(2)) .AND. (S(13) .GT.
               +      S(3)) .AND. (S(13) .GT. S(4)) .AND. (S(13) .GT. S(5)) .AND.
               +      (S(13) .GT. S(6)) .AND. (S(13) .GT. S(7)) .AND. (S(13) .GT.
               +      S(8)) .AND. (S(13) .GT. S(9)) .AND. (S(13) .GT. S(10)) .AND.
               +      (S(13) .GT. S(11)) .AND. (S(13) .GT. S(12)) .AND. (S(13)
               +      .GT. S(14)) .AND. (S(13) .GT. S(15)) .AND. (S(13) .GT.
               +      S(16))) CHOSEN = 13
           C
ISN 0220             IF ((S(14) .GT. S(1)) .AND. (S(14) .GT. S(2)) .AND. (S(14) .GT.
               +      S(3)) .AND. (S(14) .GT. S(4)) .AND. (S(14) .GT. S(5)) .AND.
               +      (S(14) .GT. S(6)) .AND. (S(14) .GT. S(7)) .AND. (S(14) .GT.
               +      S(8)) .AND. (S(14) .GT. S(9)) .AND. (S(14) .GT. S(10)) .AND.
               +      (S(14) .GT. S(11)) .AND. (S(14) .GT. S(12)) .AND. (S(14)
               +      .GT. S(13)) .AND. (S(14) .GT. S(15)) .AND. (S(14) .GT.
               +      S(16))) CHOSEN = 14
           C
ISN 0222             IF ((S(15) .GT. S(1)) .AND. (S(15) .GT. S(2)) .AND. (S(15) .GT.
               +      S(3)) .AND. (S(15) .GT. S(4)) .AND. (S(15) .GT. S(5)) .AND.
               +      (S(15) .GT. S(6)) .AND. (S(15) .GT. S(7)) .AND. (S(15) .GT.
               +      S(8)) .AND. (S(15) .GT. S(9)) .AND. (S(15) .GT. S(10)) .AND.
               +      (S(15) .GT. S(11)) .AND. (S(15) .GT. S(12)) .AND. (S(15)
               +      .GT. S(13)) .AND. (S(15) .GT. S(14)) .AND. (S(15) .GT.
               +      S(16))) CHOSEN = 15
           C
ISN 0224             IF ((S(16) .GE. S(1)) .AND. (S(16) .GE. S(2)) .AND. (S(16) .GE.
               +      S(3)) .AND. (S(16) .GE. S(4)) .AND. (S(16) .GE. S(5)) .AND.
               +      (S(16) .GE. S(6)) .AND. (S(16).GE. S(7)) .AND. (S(16).GE.
               +      S(8)) .AND. (S(16) .GE. S(9)) .AND. (S(16) .GE. S(10)) .AND.
               +      (S(16) .GE. S(11)) .AND. (S(16) .GE. S(12)) .AND. (S(16)
               +      .GE. S(13)) .AND. (S(16) .GE. S(14)) .AND. (S(16) .GE.
               +      S(15))) CHOSEN = 16
           C
           C
           C
           C COMPARE THE CHOSEN STATE TO THE ACTUAL EXPERIMENTAL STATE.
           C
ISN 0226             IF (CHOSEN .EQ. STATE) GO TO 5000
           C
ISN 0228                IF (STATE .EQ. 1) GO TO 5100
ISN 0230                IF (STATE .EQ. 2) GO TO 5200
ISN 0232                IF (STATE .EQ. 3) GO TO 5300
ISN 0234                IF (STATE .EQ. 4) GO TO 5400
ISN 0236                IF (STATE .EQ. 5) GO TO 5500
ISN 0238                IF (STATE .EQ. 6) GO TO 5600
ISN 0240                IF (STATE .EQ. 7) GO TO 5700
ISN 0242                IF (STATE .EQ. 8) GO TO 5800
ISN 0244                IF (STATE .EQ. 9) GO TO 5900
ISN 0246                IF (STATE .EQ. 10) GO TO 6000
ISN 0248                IF (STATE .EQ. 11) GO TO 6100
ISN 0250                IF (STATE .EQ. 12) GO TO 6200
ISN 0252                IF (STATE .EQ. 13) GO TO 6300
ISN 0254                IF (STATE .EQ. 14) GO TO 6400
ISN 0256                IF (STATE .EQ. 15) GO TO 6500
ISN 0258                IF (STATE .EQ. 16) GO TO 6600
           C
           C IF AN INCORRECT CHOICE WAS MADE, INCREMENT THE VARIABLE "WPART".
           C THE FIRST INDEX IS THE ACTUAL STATE.
           C THE SECOND INDEX IS THE INCORRECT STATE CHOSEN.
           C
ISN 0260    5100 CONTINUE
ISN 0261         WPART(1,CHOSEN) = WPART(1,CHOSEN) + 1
ISN 0262         GO TO 6700
           C
ISN 0263    5200 CONTINUE
ISN 0264         WPART(2,CHOSEN) = WPART(2,CHOSEN) + 1
ISN 0265         GO TO 6700
           C
ISN 0266    5300 CONTINUE
```

```
ISN 0267          WPART(3,CHOSEN) = WPART(3,CHOSEN) + 1
ISN 0268          GO TO 6700
            C
ISN 0269     5400 CONTINUE
ISN 0270          WPART(4,CHOSEN) = WPART(4,CHOSEN) + 1
ISN 0271          GO TO 6700
            C
ISN 0272     5500 CONTINUE
ISN 0273          WPART(5,CHOSEN) = WPART(5,CHOSEN) + 1
ISN 0274          GO TO 6700
            C
ISN 0275     5600 CONTINUE
ISN 0276          WPART(6,CHOSEN) = WPART(6,CHOSEN) + 1
ISN 0277          GO TO 6700
            C
ISN 0278     5700 CONTINUE
ISN 0279          WPART(7,CHOSEN) = WPART(7,CHOSEN) + 1
ISN 0280          GO TO 6700
            C
ISN 0281     5800 CONTINUE
ISN 0282          WPART(8,CHOSEN) = WPART(8,CHOSEN) + 1
ISN 0283          GO TO 6700
            C
            C IF THE ACTUAL STATE IS THE REST STATE CASE, BUT THE INCORRECT
            C    CHOICE IS STILL A REST STATE CASE, INCREMENT THE VARIABLE "REST".
            C
ISN 0284     5900 CONTINUE
ISN 0285          WPART(9,CHOSEN) = WPART(9,CHOSEN) + 1
ISN 0286          IF ((CHOSEN .GE. 9) .AND. (CHOSEN .LE. 16)) REST=REST+1
ISN 0288          GO TO 6700
            C
ISN 0289     6000 CONTINUE
ISN 0290          WPART(10,CHOSEN) = WPART(10,CHOSEN) + 1
ISN 0291          IF ((CHOSEN .GE. 9) .AND. (CHOSEN .LE. 16)) REST=REST+1
ISN 0293          GO TO 6700
            C
ISN 0294     6100 CONTINUE
ISN 0295          WPART(11,CHOSEN) = WPART(11,CHOSEN) + 1
ISN 0296          IF ((CHOSEN .GE. 9) .AND. (CHOSEN .LE. 16)) REST=REST+1
ISN 0298          GO TO 6700
            C
ISN 0299     6200 CONTINUE
ISN 0300          WPART(12,CHOSEN) = WPART(12,CHOSEN) + 1
ISN 0301          IF ((CHOSEN .GE. 9) .AND. (CHOSEN .LE. 16)) REST=REST+1
ISN 0303          GO TO 6700
            C
ISN 0304     6300 CONTINUE
ISN 0305          WPART(13,CHOSEN) = WPART(13,CHOSEN) + 1
ISN 0306          IF ((CHOSEN .GE. 9) .AND. (CHOSEN .LE. 16)) REST=REST+1
ISN 0308          GO TO 6700
            C
ISN 0309     6400 CONTINUE
ISN 0310          WPART(14,CHOSEN) = WPART(14,CHOSEN) + 1
ISN 0311          IF ((CHOSEN .GE. 9) .AND. (CHOSEN .LE. 16)) REST=REST+1
ISN 0313          GO TO 6700
            C
ISN 0314     6500 CONTINUE
ISN 0315          WPART(15,CHOSEN) = WPART(15,CHOSEN) + 1
ISN 0316          IF ((CHOSEN .GE. 9) .AND. (CHOSEN .LE. 16)) REST=REST+1
ISN 0318          GO TO 6700
            C
ISN 0319     6600 CONTINUE
ISN 0320          WPART(16,CHOSEN) = WPART(16,CHOSEN) + 1
ISN 0321          IF ((CHOSEN .GE. 9) .AND. (CHOSEN .LE. 16)) REST=REST+1
            C
ISN 0323     6700 CONTINUE
            C
            C PRINT OUT THAT AN INCORRECT STATE WAS CHOSEN.
            C
ISN 0324          IF (FPRINT .EQ. 0) GO TO 6800
ISN 0326                WRITE(6,6900) STATE,CHOSEN
ISN 0327     6900       FORMAT(' ERROR:  ACTUAL EXPERIMENTAL STATE IS: ',I3,' CHOSE
                 +N STATE IS: ',I3,'                ********************************')
            C
ISN 0328             GO TO 6800
            C
ISN 0329     5000    CONTINUE
ISN 0330             R(STATE) = R(STATE) + 1
            C
            C PRINT OUT THAT A CORRECT STATE WAS CHOSEN.
            C
ISN 0331             IF (FPRINT .EQ. 0) GO TO 6800
ISN 0333             WRITE(6,6950) STATE
ISN 0334     6950    FORMAT(' CORRECTLY CHOSE STATE: ',I3)
ISN 0335     6800    CONTINUE
ISN 0336     4300 CONTINUE
            C
            C PRINT OUT THE OVERALL STATISTICS.
            C
ISN 0337          WRITE(6,7000)
ISN 0338     7000 FORMAT('1THE OVERALL TEST RESULTS ARE SHOWN BELOW.')
ISN 0339          WRITE(6,7100) N
ISN 0340     7100 FORMAT('0TOTAL NUMBER OF TEST OBSERVATIONS IS: ',I6)
            C
            C CALCULATE THE TOTAL NUMBER OF RIGHT AND WRONG CHOICES (RIGHT,WRONG
            C    RESPECTIVELY), AND THE PERCENTAGES OF RIGHT AND WRONG CHOICES
            C    (PERRT,PERWRG RESPECTIVELY).
            C
            C THE TOTAL NUMBER OF CORRECT CHOICES, "RIGHT", IS THE SUM OF THE
            C    NUMBER OF CORRECT CHOICES OF EACH STATE ( R(1) TO R(16) ).
            C
            C THE TOTAL NUMBER OF INCORRECT CHOICES, "WRONG", IS THE SUM OF
            C    ALL THE WRONG CHOICES FOR EACH OF THE INDIVIDUAL
            C    STATES ( W(1) TO W(16) ).
            C
ISN 0341          RIGHT=R(1)+R(2)+R(3)+R(4)+R(5)+R(6)+R(7)+R(8)+R(9)+R(10)+R(11)
                +       R(12)+R(13)+R(14)+R(15)+R(16)
            C
ISN 0342          DO 7200 J=1,NCASES
ISN 0343             DO 7300 K=1,NCASES
ISN 0344                IF (K .EQ. J) GO TO 7300
ISN 0346                W(J) = W(J) + WPART(J,K)
ISN 0347     7300    CONTINUE
ISN 0348     7200 CONTINUE
            C
ISN 0349          WRONG=W(1)+W(2)+W(3)+W(4)+W(5)+W(6)+W(7)+W(8)+W(9)+W(10)+W(11)
                +       W(12)+W(13)+W(14)+W(15)+W(16)
            C
            C PRINT OUT THE RAW NUMBERS OF RIGHT AND WRONG CHOICES.
            C
```

```
ISN 0350          DO 7400 J=1,NCASES
ISN 0351                   WRITE(6,7500) J
ISN 0352    7500           FORMAT('-STATISTICS FOR STATE',I3)
           C
ISN 0353                   WRITE(6,7600) J,R(J)
ISN 0354    7600           FORMAT(' TOTAL NUMBER OF CORRECT CHOICES OF STATE ',I3,
                +          ' IS: ',I4)
ISN 0355                   WRITE(6,7700) J,W(J)
ISN 0356    7700           FORMAT(' TOTAL NUMBER OF WRONG CHOICES OF STATE ',I3,
                +          ' IS: ',I4)
           C
ISN 0357              DO 7800 K=1,NCASES
ISN 0358                   IF (J .EQ. K) GO TO 7800
ISN 0360                   WRITE(6,7900) K,WPART(J,K)
ISN 0361    7900           FORMAT(' NUMBER OF TIMES INCORRECTLY CHOSE STATE ',I3,
                +          ' IS: ',I4)
ISN 0362    7800 CONTINUE
ISN 0363    7400 CONTINUE
           C
           C
           C PRINT OUT THE PERCENTAGE STATISTICS.
           C
ISN 0364          WRITE(6,8000)
ISN 0365    8000 FORMAT('1TEST RESULTS GIVEN IN PERCENTAGES')
           C
ISN 0366          DO 8100 J=1,NCASES
ISN 0367                   WRITE(6,8200) J
ISN 0368    8200           FORMAT('-STATISTICS FOR STATE',I3)
           C
           C THE TOTAL NUMBER OF OBSERVATIONS FOR THE STATE I IS THE NUMBER OF
           C    RIGHT AND THE NUMBER OF WRONG CHOICES (IE. R(I) + W(I) )
           C
           C "PERRT" IS THE PERCENTAGE NUMBER OF RIGHT CHOICES.
           C
           C "PERWR" IS THE PERCENTAGE NUMBER OF WRONG CHOICES.
           C
ISN 0369                   IF ((R(J)+W(J)) .EQ. 0) GO TO 8300
ISN 0371                   PERRT=FLOAT(R(J))/FLOAT(R(J)+W(J))*100.
ISN 0372                   PERWRG=FLOAT(W(J))/FLOAT(R(J)+W(J))*100.
ISN 0373                   WRITE(6,8400) J,PERRT
ISN 0374    8400           FORMAT('0TOTAL % NUMBER OF CORRECT CHOICES OF STATE ',I3,
                +          ' IS: ',F5.1)
ISN 0375                   WRITE(6,8500) J,PERWRG
ISN 0376    8500           FORMAT(' TOTAL % NUMBER OF WRONG CHOICES OF STATE ',I3,
                +          ' IS: ',F5.1)
           C
ISN 0377              DO 8600 K=1,NCASES
ISN 0378                   IF (J .EQ. K) GO TO 8600
ISN 0380                   PERWR(J,K)=FLOAT(WPART(J,K))/FLOAT(R(J)+W(J))*100.
ISN 0381                   WRITE(6,8700) K,PERWR(J,K)
ISN 0382    8700           FORMAT(' % NUMBER OF TIMES INCORRECTLY CHOSE STATE ',I3,
                +          ' IS: ',F5.1)
LEVEL 2.3.0 (JUNE 78)             MAIN            OS/360  FORTRAN H EXTENDED              DATE 85.141/15.37.40          PAGE   2
ISN 0383    8600 CONTINUE
ISN 0384                   GO TO 8100
ISN 0385    8300           WRITE(6,8800)
ISN 0386    8800           FORMAT(' NO OCCURANCES OF THIS STATE.')
ISN 0387    8100 CONTINUE
           C
           C
           C PRINT A SUMMARY OF RESULTS.
           C
ISN 0388          WRITE(6,8900)
ISN 0389    8900 FORMAT('1SUMMARY OF RESULTS.')
           C
ISN 0390          PERRT=FLOAT(RIGHT)/FLOAT(N)*100.
ISN 0391          WRITE(6,9000 ) PERRT
ISN 0392    9000 FORMAT('0OVERALL PERCENTAGE NUMBER OF CORRECT CHOICES: ',F5.1)
ISN 0393          PERWRG=FLOAT(WRONG)/FLOAT(N)*100.
ISN 0394          WRITE(6,9100) PERWRG
ISN 0395    9100 FORMAT(' OVERALL PERCENTAGE NUMBER OF WRONG CHOICES:   ',F5.1)
ISN 0396          DO 9200 I=1,NCASES
ISN 0397          WRITE(6,9300) I
ISN 0398    9300 FORMAT('0STATE: ',I3)
           C
           C IF NO OBSERVATIONS OF A PARTICULAR STATE OCCURS, SKIP THE
           C    CALCULATIONS AND SO INDICATE ON THE PRINT OUT.
           C
ISN 0399          IF ((R(I)+W(I)) .EQ. 0) GO TO 9400
ISN 0401          PERRT=FLOAT(R(I))/FLOAT(R(I)+W(I))*100.
ISN 0402          WRITE(6,9500) I,PERRT
ISN 0403    9500 FORMAT(' PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE ',I3,' IS:'
               +,F5.1)
ISN 0404          PERWRG=FLOAT(W(I))/FLOAT(R(I)+W(I))*100.
ISN 0405          WRITE(6,9600) I,PERWRG
ISN 0406    9600 FORMAT(' PERCENTAGE NUMBER OF WRONG CHOICES IN STATE ',I3,' IS:',
               +F5.1)
ISN 0407          GO TO 9200
ISN 0408    9400 CONTINUE
ISN 0409          WRITE(6,9700) I
ISN 0410    9700 FORMAT(' NO OCCURANCES OF STATE ',I3)
ISN 0411    9200 CONTINUE
           C
           C CALCULATE THE TOTAL PERCENTAGES FOR THE REST STATES (STATES 9 TO 16).
           C
           C CALCULATE THE TOTAL NUMBER OF REST OBSERVATIONS WHICH WERE
           C    CORRECTLY CLASSIFIED INTO THE INDIVIDUAL STATES
           C    (IE. "CASE" = 9 TO 16).
           C THIS VARIABLE IS "RTREST".
           C
ISN 0412          RTREST=R(9)+R(10)+R(11)+R(12)+R(13)+R(14)+R(15)+R(16)
ISN 0413          PERRT=FLOAT(RTREST)/FLOAT(RTREST+W(9)+W(10)+W(11)+W(12)+W(13)
               +        W(14)+W(15)+W(16))*100.
ISN 0414          PERWRG=100.-PERRT
ISN 0415          WRITE(6,9800) PERRT
ISN 0416    9800 FORMAT('0PERCENTAGE NUMBER OF CORRECT CHOICES OF THE INDIVIDUAL RE
               +ST STATES: ',F5.1)
ISN 0417          WRITE(6,9900) PERWRG
ISN 0418    9900 FORMAT(' PERCENTAGE NUMBER OF WRONG CHOICES OF THE INDIVIDUAL REST
               + STATES:   ',F5.1)
           C
           C RECALCULATE THE CONTROLLER SUCCESS BASED ON REST STATES 9 TO 16
           C    BEING COMBINED INTO ONE STATE.
           C
ISN 0419          WRITE(6,10000)
ISN 0420   10000 FORMAT('-COMBINING ALL REST STATES, 9 TO 16, INTO ONE STATE.')
           C
ISN 0421          WRITE(6,10100) REST
ISN 0422   10100 FORMAT('0THE NUMBER OF REST STATES MISCLASSIFIED IN ANOTHER REST
               +STATE WERE: ',I4)
```

```
              C
              C CALCULATE THE OVERALL GROUPED TOTAL PERCENTAGES OF THE REST STATE.
              C THIS ALLOWS THE REST STATE CHOICES WHICH WERE MISCLASSIFIED AS ANOTHER
              C     REST STATE TO BE RECLASSIFIED AS A CORRECT CHOICE.
              C
   ISN 0423         RTREST=RTREST+REST
   ISN 0424         PERRT=FLOAT(RTREST)/FLOAT(RTREST-REST+W(9)+W(10)+W(11)+W(12)
                   +      W(13)+W(14)+W(15)+W(16))*100.
   ISN 0425         PERWRG=100.-PERRT
   ISN 0426         WRITE(6,10200) PERRT
   ISN 0427   10200 FORMAT('0MODIFIED PERCENTAGE NUMBER OF CORRECT CHOICES OF THE REST
                   + STATE: ',F5.1)
   ISN 0428         WRITE(6,10300) PERWRG
   ISN 0429   10300 FORMAT(' MODIFIED PERCENTAGE NUMBER OF WRONG CHOICES OF THE REST S
                   +TATE:   ',F5.1)
   ISN 0430         RIGHT=RIGHT+REST
   ISN 0431         PERRT=FLOAT(RIGHT)/FLOAT(N)*100.
   ISN 0432         WRITE(6,10400) PERRT
   ISN 0433   10400 FORMAT('-MODIFIED OVERALL PERCENTAGE NUMBER OF CORRECT CHOICES:  '
                   +,F5.1)
   ISN 0434         PERWRG=100.-PERRT
   ISN 0435         WRITE(6,10500) PERWRG
   ISN 0436   10500 FORMAT(' MODIFIED OVERALL PERCENTAGE NUMBER OF WRONG CHOICES:    '
                   +,F5.1)
   ISN 0437         STOP
   ISN 0438         END

*OPTIONS IN EFFECT*NAME(MAIN) NOOPTIMIZE LINECOUNT(54) SIZE(0256K) AUTODBL(NONE)
*OPTIONS IN EFFECT*SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT NOXREF NOALC NOANSF NOTERM IBM FLAG(I)
*STATISTICS*     SOURCE STATEMENTS =      437, PROGRAM SIZE =     28610, SUBPROGRAM NAME =  MAIN
*STATISTICS*  NO  DIAGNOSTICS GENERATED
****** END OF COMPILATION ******
```

```
SUBJECT: RICK LEHNER
THE LEAD CONFIGURATION IS AS FOLLOWS.
LEAD 0: BICEPS
     1: TRICEPS
     2: DELTOID ANTERIOR
     3: DELTOID POSTERIOR
     4: STRAIN GAUGE
THE NUMBER OF OBSERVATIONS TO BE TESTED IS: 3122
SIXTEEN MOTIONS: TOL=0.01, BI/TRI LOG OF FEATURES
STATE 1:  ELBOW FLEXION
STATE 2:  ELBOW EXTENSION
STATE 3:  WRIST PRONATION
STATE 4:  WRIST SUPINATION
STATE 5:  HUMERAL ROTATION INWARD
STATE 6:  HUMERAL ROTATION OUTWARD
STATE 7:  ARM EXTENSION
STATE 8:  ARM RETRACTION
STATE 9:  REST: ELBOW FLEXION
STATE 10: REST: ELBOW EXTENSION
STATE 11: REST: WRIST PRONATION
STATE 12: REST: WRIST SUPINATION
STATE 13: REST: HUMERAL ROTATION INWARD
STATE 14: REST: HUMERAL ROTATION OUTWARD
STATE 15: REST: ARM EXTENSION
STATE 16: REST: ARM RETRACTION
THE COEFFICIENTS OF THE LINEAR STATE EQUATIONS ARE:
THE COEFFICIENTS OF STATE EQUATION  1 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:        -2.03498     -76.21024    -188.94879    -119.93744
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:         7.98012      21.44942      93.66634      56.13783
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        34.26988      20.93422       0.0          36.00658
THE CONSTANT ADDED TO THE EQUATION:            -604.32056
THE COEFFICIENTS OF STATE EQUATION  2 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:       -17.39735    -112.10809    -206.21506    -117.94588
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:        14.74476      40.05547     104.67595      55.69861
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        32.18433      29.19496       0.0          37.38445
THE CONSTANT ADDED TO THE EQUATION:            -720.45703
THE COEFFICIENTS OF STATE EQUATION  3 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:       -25.21513    -101.97128    -177.75122    -128.53973
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:        16.71112      41.44778      93.41444      59.28171
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        30.02817      33.99014       0.0          38.21135
THE CONSTANT ADDED TO THE EQUATION:            -626.82397
THE COEFFICIENTS OF STATE EQUATION  4 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:         1.75497     -91.95091    -187.12181    -121.51674
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:         4.97699      32.90550      95.31046      55.25334
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        33.81175      33.99777       0.0          39.89088
THE CONSTANT ADDED TO THE EQUATION:            -628.38452
THE COEFFICIENTS OF STATE EQUATION  5 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:        -6.98155    -109.34354    -198.65536    -126.82166
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:         9.47879      38.00632     100.46114      56.88985
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        30.21637      26.95135       0.0          35.81657
THE CONSTANT ADDED TO THE EQUATION:            -736.44312
THE COEFFICIENTS OF STATE EQUATION  6 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:        -6.58783    -103.89841    -181.95581     -98.64326
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:         9.05151      40.16631      93.46805      50.92828
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        30.50066      31.90842       0.0          38.43614
THE CONSTANT ADDED TO THE EQUATION:            -501.40894
THE COEFFICIENTS OF STATE EQUATION  7 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:         3.97777    -113.19562    -184.89874    -121.88005
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:         3.92287      41.23454      93.47971      55.10838
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        32.12589      29.25356       0.0          38.16074
THE CONSTANT ADDED TO THE EQUATION:            -680.28394
THE COEFFICIENTS OF STATE EQUATION  8 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:         7.90172    -110.71252    -199.27016    -120.13445
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:         2.65997      39.14694      97.87715      55.16310
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        34.43571      26.37157       0.0          40.42921
THE CONSTANT ADDED TO THE EQUATION:            -727.90845
THE COEFFICIENTS OF STATE EQUATION  9 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:       -10.23085     -65.37184    -190.35573    -126.27003
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:        10.01461      13.51963      92.68385      58.56625
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        26.52313      19.82785       0.0          33.86853
THE CONSTANT ADDED TO THE EQUATION:            -663.44629
THE COEFFICIENTS OF STATE EQUATION 10 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:       -18.53235    -111.59721    -190.76260    -124.48099
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:        15.64356      37.25018      91.84641      58.78130
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        31.26355      21.58781       0.0          34.06599
THE CONSTANT ADDED TO THE EQUATION:            -765.66431
THE COEFFICIENTS OF STATE EQUATION 11 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:       -33.14113    -105.81723    -184.86017    -131.44891
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:        20.27672      38.06224      96.18370      58.73576
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        28.02344      28.78018       0.0          35.49644
THE CONSTANT ADDED TO THE EQUATION:            -745.60791
THE COEFFICIENTS OF STATE EQUATION 12 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:       -29.69966    -111.39975    -187.89960    -131.67152
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:        18.68268      41.61768      97.17804      59.78914
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        28.77460      28.12048       0.0          37.48961
THE CONSTANT ADDED TO THE EQUATION:            -745.14185
THE COEFFICIENTS OF STATE EQUATION 13 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:        -8.91727    -112.73651    -199.15721    -128.18449
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:        10.20791      38.57224     100.10609      56.84973
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        29.79813      25.61290       0.0          35.53537
THE CONSTANT ADDED TO THE EQUATION:            -780.24097
THE COEFFICIENTS OF STATE EQUATION 14 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:       -18.42804    -112.73776    -178.79684    -135.12714
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:        15.45588      40.38237      92.78116      62.57262
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        28.62814      26.10260       0.0          37.08507
THE CONSTANT ADDED TO THE EQUATION:            -686.56567
THE COEFFICIENTS OF STATE EQUATION 15 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:         2.93311    -119.39746    -199.97472    -128.69815
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:         4.78399      41.07089      96.27715      59.40950
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        31.03616      22.60910       0.0          38.43895
THE CONSTANT ADDED TO THE EQUATION:            -812.85791
THE COEFFICIENTS OF STATE EQUATION 16 ARE:
THE VARIANCE COEFFICENTS, CHANNEL 0 TO 3:        11.41638    -116.97835    -199.16731    -129.35846
THE THIRD MOMENT COEFF. , CHANNEL 0 TO 3:         0.80612      40.88963      98.57259      58.86172
THE # OF ZERO CROSSINGS,  CHANNEL 0 TO 3:        34.78694      24.77679       0.0          39.05705
THE CONSTANT ADDED TO THE EQUATION:            -771.71045
```

```
THE STATE EQUATION VALUES FOR EACH OBSERVATION ARE:

OBS =    1 S1 =       682.25098 S2 =       690.62573 S3 =       675.58716 S4 =       696.28149
 S5 =       693.85620 S6 =       676.46704 S7 =       701.68823 S8 =       697.22803 S9 =       665.34692
 S10 =       679.81201 S11 =       662.66675 S12 =       669.69775 S13 =       688.00659 S14 =       690.03174
 S15 =       686.66528 S16 =       695.55786
CORRECTLY CHOSE STATE:   7
OBS =    2 S1 =       715.08105 S2 =       731.44678 S3 =       713.52393 S4 =       725.58789
 S5 =       733.34351 S6 =       702.00195 S7 =       733.88623 S8 =       727.04980 S9 =       705.55493
 S10 =       721.31665 S11 =       713.51123 S12 =       717.37476 S13 =       730.55396 S14 =       732.11377
 S15 =       721.33472 S16 =       727.62939
CORRECTLY CHOSE STATE:   7
OBS =    3 S1 =       701.27954 S2 =       701.81812 S3 =       674.66919 S4 =       699.01709
 S5 =       708.04932 S6 =       673.37354 S7 =       707.41748 S8 =       707.91479 S9 =       693.04639
 S10 =       697.67773 S11 =       674.94092 S12 =       680.29858 S13 =       704.89282 S14 =       699.26074
 S15 =       703.12378 S16 =       708.45996
ERROR:  ACTUAL EXPERIMENTAL STATE IS:   7 CHOSEN STATE IS:  16          ********************************
OBS =    4 S1 =       611.21753 S2 =       603.70532 S3 =       580.31128 S4 =       605.20874
 S5 =       610.88184 S6 =       588.81177 S7 =       613.06445 S8 =       611.60034 S9 =       600.82593
 S10 =       600.50293 S11 =       575.36475 S12 =       580.59692 S13 =       605.92773 S14 =       603.92236
 S15 =       604.15796 S16 =       609.89209
CORRECTLY CHOSE STATE:   7
OBS =    5 S1 =       719.11328 S2 =       725.22461 S3 =       706.51855 S4 =       726.51465
 S5 =       730.53931 S6 =       696.79028 S7 =       732.98193 S8 =       730.43530 S9 =       709.00513
 S10 =       719.79346 S11 =       703.53613 S12 =       708.71289 S13 =       727.33911 S14 =       725.10376
 S15 =       724.27563 S16 =       730.79028
CORRECTLY CHOSE STATE:   7
OBS =    6 S1 =       679.52979 S2 =       687.52832 S3 =       671.36987 S4 =       691.38428
 S5 =       693.78491 S6 =       669.78174 S7 =       699.84888 S8 =       692.48145 S9 =       667.34839
 S10 =       677.75659 S11 =       664.50659 S12 =       669.89062 S13 =       689.09253 S14 =       693.12012
 S15 =       684.89014 S16 =       693.42651
CORRECTLY CHOSE STATE:   7
OBS =    7 S1 =       641.62671 S2 =       647.06396 S3 =       634.66309 S4 =       656.30176
 S5 =       650.58203 S6 =       640.80176 S7 =       658.49194 S8 =       651.40674 S9 =       625.43604
 S10 =       629.46411 S11 =       618.87231 S12 =       624.90894 S13 =       642.92505 S14 =       648.18164
 S15 =       637.10571 S16 =       648.00610
CORRECTLY CHOSE STATE:   7
OBS =    8 S1 =       637.60864 S2 =       629.23364 S3 =       607.82837 S4 =       635.48657
 S5 =       638.77222 S6 =       611.46582 S7 =       641.97388 S8 =       641.81030 S9 =       629.96045
 S10 =       628.05078 S11 =       602.37573 S12 =       607.98437 S13 =       634.30859 S14 =       630.80493
 S15 =       635.33569 S16 =       639.84668
CORRECTLY CHOSE STATE:   7
OBS =    9 S1 =       639.13770 S2 =       633.56104 S3 =       616.26880 S4 =       642.71826
 S5 =       641.39526 S6 =       622.71265 S7 =       647.44189 S8 =       644.48047 S9 =       625.01367
 S10 =       625.78784 S11 =       604.24634 S12 =       610.63843 S13 =       634.85669 S14 =       637.22900
 S15 =       634.08496 S16 =       642.59961
CORRECTLY CHOSE STATE:   7
OBS =   10 S1 =       656.59692 S2 =       652.88379 S3 =       631.90527 S4 =       660.46069
 S5 =       661.61304 S6 =       638.92554 S7 =       668.92676 S8 =       665.57520 S9 =       639.93652
 S10 =       646.94727 S11 =       622.69409 S12 =       629.14185 S13 =       656.05835 S14 =       657.93140
 S15 =       656.33740 S16 =       665.72729
CORRECTLY CHOSE STATE:   7
OBS =   11 S1 =       641.81226 S2 =       634.07422 S3 =       617.47852 S4 =       647.18286
 S5 =       642.24438 S6 =       622.45532 S7 =       650.17334 S8 =       646.95825 S9 =       625.13647
 S10 =       625.58447 S11 =       605.23779 S12 =       610.80225 S13 =       635.75391 S14 =       635.66235
 S15 =       633.82690 S16 =       645.08960
CORRECTLY CHOSE STATE:   7
OBS =   12 S1 =       672.64062 S2 =       678.90137 S3 =       660.09839 S4 =       681.65845
 S5 =       685.72632 S6 =       659.90552 S7 =       690.72192 S8 =       684.28198 S9 =       662.39404
 S10 =       670.32275 S11 =       655.67700 S12 =       660.65796 S13 =       681.54199 S14 =       683.77344
 S15 =       677.41333 S16 =       684.87524
CORRECTLY CHOSE STATE:   7
OBS =   13 S1 =       665.79761 S2 =       665.72754 S3 =       645.57910 S4 =       669.69556
 S5 =       671.26416 S6 =       648.66382 S7 =       674.90771 S8 =       673.47705 S9 =       652.13452
 S10 =       657.12231 S11 =       636.50830 S12 =       642.88965 S13 =       665.70386 S14 =       664.74561
 S15 =       663.88647 S16 =       671.29956
CORRECTLY CHOSE STATE:   7
OBS =   14 S1 =       725.07227 S2 =       731.94458 S3 =       698.21655 S4 =       728.24829
 S5 =       741.48901 S6 =       698.94653 S7 =       741.86572 S8 =       740.88623 S9 =       717.48096
 S10 =       729.66260 S11 =       702.08789 S12 =       706.82788 S13 =       739.51758 S14 =       730.40771
 S15 =       739.24731 S16 =       743.93262
ERROR:  ACTUAL EXPERIMENTAL STATE IS:   7 CHOSEN STATE IS:  16          ********************************
OBS =   15 S1 =       680.58765 S2 =       685.58008 S3 =       662.62939 S4 =       686.56958
 S5 =       692.56030 S6 =       664.05396 S7 =       695.65991 S8 =       691.59863 S9 =       669.65381
 S10 =       679.23389 S11 =       658.36401 S12 =       663.46387 S13 =       688.29077 S14 =       687.59790
 S15 =       685.59668 S16 =       691.93799
CORRECTLY CHOSE STATE:   7
OBS =   16 S1 =       650.45361 S2 =       648.77417 S3 =       637.59912 S4 =       662.79370
 S5 =       658.65771 S6 =       636.76270 S7 =       668.28174 S8 =       659.72144 S9 =       631.95679
 S10 =       637.84888 S11 =       625.12695 S12 =       630.22388 S13 =       652.29150 S14 =       658.37183
 S15 =       647.06909 S16 =       660.26440
CORRECTLY CHOSE STATE:   7
OBS =   17 S1 =       636.61230 S2 =       640.47583 S3 =       625.93164 S4 =       638.69238
 S5 =       640.37598 S6 =       625.59058 S7 =       642.60937 S8 =       637.36890 S9 =       627.75317
 S10 =       631.64526 S11 =       620.01929 S12 =       624.51123 S13 =       635.43701 S14 =       639.77344
 S15 =       628.60962 S16 =       634.35034
CORRECTLY CHOSE STATE:   7
OBS =   18 S1 =       628.65723 S2 =       625.65552 S3 =       615.59692 S4 =       634.50269
 S5 =       630.41235 S6 =       615.77856 S7 =       637.74097 S8 =       632.53271 S9 =       614.08325
 S10 =       617.44507 S11 =       603.23389 S12 =       609.13721 S13 =       624.27393 S14 =       629.91724
 S15 =       620.89136 S16 =       629.85376
CORRECTLY CHOSE STATE:   7
OBS =   19 S1 =       628.41235 S2 =       632.41162 S3 =       617.56885 S4 =       637.31714
 S5 =       640.71094 S6 =       618.21484 S7 =       646.57764 S8 =       637.23267 S9 =       616.99829
 S5 =       742.12891 S6 =       703.37134 S7 =       743.80664 S8 =       746.74292 S9 =       720.41089
 S10 =       732.21826 S11 =       700.79419 S12 =       707.24268 S13 =       739.41504 S14 =       728.37061
 S15 =       742.93994 S16 =       747.19092
CORRECTLY CHOSE STATE:  16
OBS = 3120 S1 =       735.94092 S2 =       730.35083 S3 =       695.67261 S4 =       732.36572
 S5 =       743.59033 S6 =       697.83594 S7 =       746.52954 S8 =       750.65894 S9 =       721.88843
 S10 =       731.83521 S11 =       696.85083 S12 =       704.35132 S13 =       741.36816 S14 =       732.51782
 S15 =       747.32520 S16 =       754.05518
CORRECTLY CHOSE STATE:  16
OBS = 3121 S1 =       738.87085 S2 =       741.77954 S3 =       709.97949 S4 =       737.94507
 S5 =       751.80713 S6 =       704.24951 S7 =       750.39062 S8 =       752.91016 S9 =       731.92017
 S10 =       742.96143 S11 =       714.10278 S12 =       719.86353 S13 =       750.43311 S14 =       739.87305
 S15 =       752.18652 S16 =       755.31763
CORRECTLY CHOSE STATE:  16
OBS = 3122 S1 =       777.86084 S2 =       780.10986 S3 =       745.77734 S4 =       778.82764
 S5 =       790.46606 S6 =       742.44482 S7 =       790.56592 S8 =       793.76978 S9 =       769.06006
 S10 =       780.06885 S11 =       748.37646 S12 =       754.76611 S13 =       788.48389 S14 =       778.41650
 S15 =       792.61670 S16 =       797.96069
CORRECTLY CHOSE STATE:  16
```

```
THE OVERALL TEST RESULTS ARE SHOWN BELOW.
TOTAL NUMBER OF TEST OBSERVATIONS IS:   3122
STATISTICS FOR STATE  1
TOTAL NUMBER OF CORRECT CHOICES OF STATE   1 IS:  217
TOTAL NUMBER OF WRONG CHOICES OF STATE   1 IS:    7
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:    2
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:    5
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:    0
STATISTICS FOR STATE  2
TOTAL NUMBER OF CORRECT CHOICES OF STATE   2 IS:  151
TOTAL NUMBER OF WRONG CHOICES OF STATE   2 IS:   46
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:    2
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:    3
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:    1
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:    1
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:    1
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   28
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   10
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:    0
STATISTICS FOR STATE  3
TOTAL NUMBER OF CORRECT CHOICES OF STATE   3 IS:  240
TOTAL NUMBER OF WRONG CHOICES OF STATE   3 IS:    9
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:    3
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:    4
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:    2
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:    0
STATISTICS FOR STATE  4
TOTAL NUMBER OF CORRECT CHOICES OF STATE   4 IS:  226
TOTAL NUMBER OF WRONG CHOICES OF STATE   4 IS:   18
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:    7
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:    2
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:    7
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:    2
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:    0
STATISTICS FOR STATE  5
TOTAL NUMBER OF CORRECT CHOICES OF STATE   5 IS:  145
TOTAL NUMBER OF WRONG CHOICES OF STATE   5 IS:   74
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:    5
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:    1
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:    3
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:    2
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   52
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:    1
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:    4
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:    6
STATISTICS FOR STATE  6
TOTAL NUMBER OF CORRECT CHOICES OF STATE   6 IS:  203
TOTAL NUMBER OF WRONG CHOICES OF STATE   6 IS:    3
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:    1
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:    2
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:    0
STATISTICS FOR STATE  7
TOTAL NUMBER OF CORRECT CHOICES OF STATE   7 IS:  190
TOTAL NUMBER OF WRONG CHOICES OF STATE   7 IS:   15
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:    1
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:    6
```

```
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:     1
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:     7
STATISTICS FOR STATE  8
TOTAL NUMBER OF CORRECT CHOICES OF STATE   8 IS:   122
TOTAL NUMBER OF WRONG CHOICES OF STATE   8 IS:   64
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:    11
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:     6
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:     3
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:     1
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:    21
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:    22
STATISTICS FOR STATE  9
TOTAL NUMBER OF CORRECT CHOICES OF STATE   9 IS:   163
TOTAL NUMBER OF WRONG CHOICES OF STATE   9 IS:    11
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:    11
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:     0
STATISTICS FOR STATE 10
TOTAL NUMBER OF CORRECT CHOICES OF STATE  10 IS:   154
TOTAL NUMBER OF WRONG CHOICES OF STATE  10 IS:    20
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:    10
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:     1
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:     1
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:     5
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:     3
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:     0
STATISTICS FOR STATE 11
TOTAL NUMBER OF CORRECT CHOICES OF STATE  11 IS:   112
TOTAL NUMBER OF WRONG CHOICES OF STATE  11 IS:    62
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:     4
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:    49
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:     9
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:     0
STATISTICS FOR STATE 12
TOTAL NUMBER OF CORRECT CHOICES OF STATE  12 IS:    68
TOTAL NUMBER OF WRONG CHOICES OF STATE  12 IS:   106
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:     1
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:    65
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:     2
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:    38
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:     0
STATISTICS FOR STATE 13
TOTAL NUMBER OF CORRECT CHOICES OF STATE  13 IS:   133
TOTAL NUMBER OF WRONG CHOICES OF STATE  13 IS:    41
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:     3
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:    26
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:     0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:     4
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:     7
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:     1
STATISTICS FOR STATE 14
TOTAL NUMBER OF CORRECT CHOICES OF STATE  14 IS:   163
TOTAL NUMBER OF WRONG CHOICES OF STATE  14 IS:    11
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:     0
```

```
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:    1
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:    3
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:    4
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:    3
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:    0
STATISTICS FOR STATE 15
TOTAL NUMBER OF CORRECT CHOICES OF STATE  15 IS:  165
TOTAL NUMBER OF WRONG CHOICES OF STATE  15 IS:    9
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:    4
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:    2
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:    3
STATISTICS FOR STATE 16
TOTAL NUMBER OF CORRECT CHOICES OF STATE  16 IS:  167
TOTAL NUMBER OF WRONG CHOICES OF STATE  16 IS:    7
NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:    1
NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:    4
NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:    0
NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:    2
```

```
TEST RESULTS GIVEN IN PERCENTAGES
STATISTICS FOR STATE  1
TOTAL % NUMBER OF CORRECT CHOICES OF STATE   1 IS:  96.9
TOTAL % NUMBER OF WRONG CHOICES OF STATE   1 IS:   3.1
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   0.9
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   2.2
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   0.0
STATISTICS FOR STATE  2
TOTAL % NUMBER OF CORRECT CHOICES OF STATE   2 IS:  76.6
TOTAL % NUMBER OF WRONG CHOICES OF STATE   2 IS:  23.4
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   1.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   1.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   0.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:  14.2
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   5.1
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   0.0
STATISTICS FOR STATE  3
TOTAL % NUMBER OF CORRECT CHOICES OF STATE   3 IS:  96.4
TOTAL % NUMBER OF WRONG CHOICES OF STATE   3 IS:   3.6
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   1.2
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   1.6
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   0.8
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   0.0
STATISTICS FOR STATE  4
TOTAL % NUMBER OF CORRECT CHOICES OF STATE   4 IS:  92.6
TOTAL % NUMBER OF WRONG CHOICES OF STATE   4 IS:   7.4
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   2.9
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   0.8
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   2.9
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.8
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   0.0
STATISTICS FOR STATE  5
TOTAL % NUMBER OF CORRECT CHOICES OF STATE   5 IS:  66.2
TOTAL % NUMBER OF WRONG CHOICES OF STATE   5 IS:  33.8
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   2.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   0.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   1.4
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.9
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:  23.7
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   0.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   1.8
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   2.7
STATISTICS FOR STATE  6
TOTAL % NUMBER OF CORRECT CHOICES OF STATE   6 IS:  98.5
TOTAL % NUMBER OF WRONG CHOICES OF STATE   6 IS:   1.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   0.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   1.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   0.0
STATISTICS FOR STATE  7
TOTAL % NUMBER OF CORRECT CHOICES OF STATE   7 IS:  92.7
TOTAL % NUMBER OF WRONG CHOICES OF STATE   7 IS:   7.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   0.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   2.9
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.0
```

```
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   0.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   3.4
STATISTICS FOR STATE  8
TOTAL % NUMBER OF CORRECT CHOICES OF STATE   8 IS:  65.6
TOTAL % NUMBER OF WRONG CHOICES OF STATE   8 IS:  34.4
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   5.9
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   3.2
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   1.6
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   0.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:  11.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:  11.8
STATISTICS FOR STATE  9
TOTAL % NUMBER OF CORRECT CHOICES OF STATE   9 IS:  93.7
TOTAL % NUMBER OF WRONG CHOICES OF STATE   9 IS:   6.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   6.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   0.0
STATISTICS FOR STATE 10
TOTAL % NUMBER OF CORRECT CHOICES OF STATE  10 IS:  88.5
TOTAL % NUMBER OF WRONG CHOICES OF STATE  10 IS:  11.5
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   5.7
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.6
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   0.6
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   2.9
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   1.7
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   0.0
STATISTICS FOR STATE 11
TOTAL % NUMBER OF CORRECT CHOICES OF STATE  11 IS:  64.4
TOTAL % NUMBER OF WRONG CHOICES OF STATE  11 IS:  35.6
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   2.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:  28.2
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   5.2
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   0.0
STATISTICS FOR STATE 12
TOTAL % NUMBER OF CORRECT CHOICES OF STATE  12 IS:  39.1
TOTAL % NUMBER OF WRONG CHOICES OF STATE  12 IS:  60.9
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.6
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:  37.4
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  13 IS:   1.1
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:  21.8
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   0.0
STATISTICS FOR STATE 13
TOTAL % NUMBER OF CORRECT CHOICES OF STATE  13 IS:  76.4
TOTAL % NUMBER OF WRONG CHOICES OF STATE  13 IS:  23.6
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   1.7
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   3 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   4 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   5 IS:  14.9
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   6 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   7 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   8 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   9 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  10 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  11 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  12 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  14 IS:   2.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  15 IS:   4.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE  16 IS:   0.6
STATISTICS FOR STATE 14
TOTAL % NUMBER OF CORRECT CHOICES OF STATE  14 IS:  93.7
TOTAL % NUMBER OF WRONG CHOICES OF STATE  14 IS:   6.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   1 IS:   0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   2 IS:   0.6
```

```
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    3 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    4 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    5 IS:    1.7
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    6 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    7 IS:    2.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    8 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    9 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   10 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   11 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   12 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   13 IS:    1.7
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   15 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   16 IS:    0.0
STATISTICS FOR STATE 15
TOTAL % NUMBER OF CORRECT CHOICES OF STATE  15 IS:  94.8
TOTAL % NUMBER OF WRONG CHOICES OF STATE  15 IS:  5.2
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    1 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    2 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    3 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    4 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    5 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    6 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    7 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    8 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    9 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   10 IS:    2.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   11 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   12 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   13 IS:    1.1
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   14 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   16 IS:    1.7
STATISTICS FOR STATE 16
TOTAL % NUMBER OF CORRECT CHOICES OF STATE  16 IS:  96.0
TOTAL % NUMBER OF WRONG CHOICES OF STATE  16 IS:  4.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    1 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    2 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    3 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    4 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    5 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    6 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    7 IS:    0.6
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    8 IS:    2.3
% NUMBER OF TIMES INCORRECTLY CHOSE STATE    9 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   10 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   11 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   12 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   13 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   14 IS:    0.0
% NUMBER OF TIMES INCORRECTLY CHOSE STATE   15 IS:    1.1
```

```
SUMMARY OF RESULTS.
OVERALL PERCENTAGE NUMBER OF CORRECT CHOICES:  83.9
OVERALL PERCENTAGE NUMBER OF WRONG CHOICES:     16.1
STATE:    1
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE    1 IS: 96.9
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE    1 IS:  3.1
STATE:    2
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE    2 IS: 76.6
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE    2 IS: 23.4
STATE:    3
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE    3 IS: 96.4
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE    3 IS:  3.6
STATE:    4
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE    4 IS: 92.6
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE    4 IS:  7.4
STATE:    5
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE    5 IS: 66.2
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE    5 IS: 33.8
STATE:    6
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE    6 IS: 98.5
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE    6 IS:  1.5
STATE:    7
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE    7 IS: 92.7
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE    7 IS:  7.3
STATE:    8
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE    8 IS: 65.6
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE    8 IS: 34.4
STATE:    9
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE    9 IS: 93.7
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE    9 IS:  6.3
STATE:   10
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE   10 IS: 88.5
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE   10 IS: 11.5
STATE:   11
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE   11 IS: 64.4
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE   11 IS: 35.6
STATE:   12
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE   12 IS: 39.1
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE   12 IS: 60.9
STATE:   13
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE   13 IS: 76.4
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE   13 IS: 23.6
STATE:   14
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE   14 IS: 93.7
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE   14 IS:  6.3
STATE:   15
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE   15 IS: 94.8
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE   15 IS:  5.2
STATE:   16
PERCENTAGE NUMBER OF CORRECT CHOICES IN STATE   16 IS: 96.0
PERCENTAGE NUMBER OF WRONG CHOICES IN STATE   16 IS:  4.0
PERCENTAGE NUMBER OF CORRECT CHOICES OF THE INDIVIDUAL REST STATES:  80.8
PERCENTAGE NUMBER OF WRONG CHOICES OF THE INDIVIDUAL REST STATES:    19.2


COMBINING ALL REST STATES, 9 TO 16, INTO ONE STATE.
THE NUMBER OF REST STATES MISCLASSIFIED IN ANOTHER REST  STATE WERE:  199
MODIFIED PERCENTAGE NUMBER OF CORRECT CHOICES OF THE REST STATE:  95.1
MODIFIED PERCENTAGE NUMBER OF WRONG CHOICES OF THE REST STATE:     4.9
MODIFIED OVERALL PERCENTAGE NUMBER OF CORRECT CHOICES:   90.3
MODIFIED OVERALL PERCENTAGE NUMBER OF WRONG CHOICES:      9.7
```

REFERENCES

[1] C.L. Taylor, "The Biomechanics of Control in Upper-Extremity Prostheses", Orthotics and Prosthetics, Vol. 35, No. 1, pp. 7-28, March 1981.

[2] E.A. Lewis, C.R. Sheredos, T.T. Sowell, "Clinical Application Study Of Externally Powered Upper-Limb Prosthetics Systems: The VA Elbow, the VA Hand, and the VA/NU Myoelectric Hand Systems", Bulletin of Prosthetics Research, BPR 10-24, pp.51-136, Fall 1975.

[3] J.E. Paciga, D.A. Gibson, R. Gillespie, "Clinical Evaluation of UNB 3-State Myoelectric Control for Arm Prostheses", Bulletin of Prosthetics Research, BPR 10-34, Vol. 17, No. 2, pp. 21-33, Fall 1980.

[4] L. Philipson, D.S. Childress, J. Strysik, "Digital Approaches to Myoelectric State Control of Prostheses", Bulletin of Prosthetics Research, BPR 10-36, Vol. 18, No. 2, pp. 3-11, Fall 1981.

[5] S.C. Jacobsen, D.F. Knutti, R.T. Johnson, H.H. Sears, "Development of the Utah Artificial Arm", IEEE Transactions On Biomedical Engineering, Vol. BME-29, No. 4, pp.249-269, April 1982.

[6] P.D. Richard, "5 - State Myoelectric Control System", Progress Report No. 18, pp. 19-22, Biomedical Engineering, University of New Brunswick.

[7] P.D. Richard, R.E. Gander, P.A. Parker, "Operator Error and Multistate Myoelectric Control", Progress Report No. 18, pp. 23-28, Biomedical Engineering, University of New Brunswick.

[8] R.N. Scott, J.E. Paciga, P.A. Parker, "Operator Error In Multistate Myoelectric Control Systems", Medical and Biological Engineering and Computing, Vol. 16, pp. 296-301, 1978.

[9] M. McKenzie, Evaluation of Three Digital EMG Processors, M.Sc. Thesis, University of Manitoba, 1985.

[10] J.V. Basmajian, Primary Anatomy, Eighth Edition, Williams & Wilkins, Baltimore, Md., 1982.

[11] P.C. Doerschuk, D.E. Gustafson, A.S. Willsky, "Upper Extremity Limb Function Discrimination Using EMG Signal Analysis", IEEE Transactions On Biomedical Engineering, Vol. BME-30, No. 1, pp. 18-28, Jan. 1983.

[12] D.C. Dening, F.G. Gray, R.M. Haralick, "Prosthesis Control Using a Nearest Neighbor Electromyographic Pattern Classifier", IEEE Transactions On Biomedical Engineering, Vol. BME-30, No. 6, pp. 356-360, June 1983.

[13] C.R. Jensen, G.W. Schultz, Applied Kinesiology, Second Edition, McGraw-Hill, New York, 1977.

[14] R.W. Wirta, D.R. Taylor, F.R. Finley, "Pattern-Recognition Arm Prosthesis: A Historical Perspective - A Final Report", Bulletin of Prosthetics Research, pp. 8-35, Fall 1978.

[15] G.N. Saridis, T.P. Gootee, "Emg Pattern Analysis and Classification for a Prosthetic Arm", IEEE Transactions on Biomedical Engineering, Vol. BME-29, No. 6, pp. 403-412, June 1982.

[16] P. Herberts, C. Almstrom, R. Kadefors, P.D. Lawrence, "Hand Prosthesis Control Via Myoelectric Patterns", Acta Orthop. Scand., Vol. 44, pp. 389-409, 1973.

[17] P. Herberts, C. Almstrom, K. Caine, "Clinical Application Study of Multifunctional Prosthetic Hands", The Journal of Bone and Joint Surgery, Vol. 60-B, No. 4, pp. 552-560, Nov. 1978.

[18] J.T. Tou, R.C. Gonzalez, Pattern Recognition Principles, Addison-Wesley Publishing Company, London, 1974.

[19] H.C. Andrews, Introduction to Mathematical Techniques In Pattern Recognition, Wiley-Interscience, New-York, 1983.

[20] M.M. Tatsuoka, Selected Topics In Advanced Statistics: An Elementary Approach, Number 6, Discriminant Analysis: The Study of Group Differences, Institute for the Personality and Ability Testing, Champaign, Illinois, 1970.

[21] A. Papoulis, Probability, Random Variables, and Stochastic Processes, Second Edition, McGraw-Hill, New York, 1984.

[22] L.R. Rabiner, R.W.Schafer, Digital Processing of Speech Signals, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1978.

[23] M.R. Newman, Medical Instrumentation Application and Design, Houghton Mifflin Company, Boston, 1978.

[24] R.F. Coughlin, F.F. Driscoll, Operational Amplifiers and Linear Integrated Circuits, Prentice Hall, Inc., Englewood Cliffs, N.J., 1977.

[25] G.B. Rutkowski, Integrated-Circuit Operational Amplifiers, Second Edition, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1984.

[26] R. Jennrich, P. Sampson, BMDP Statistical Software, 1981 Edition, University of California Press, Berkeley, 1981.

[27] P.A. Lachenbruch, Discriminant Analysis, Hafner Press, New York, 1975.

[28] R. Sitgreaves, Discriminant Analysis and Applications, Chapter: Some Operating Characteristics of Linear Discriminant Functions, Academic Press, New York, 1973.

[29] M.C. Costanza, A.A. Afifi, "Comparison of Stopping Rules in Forward Stepwise Discriminant Analysis", Journal of the American Statistical Association, Vol. 74, No. 368, pp.777-785, Dec. 1979.