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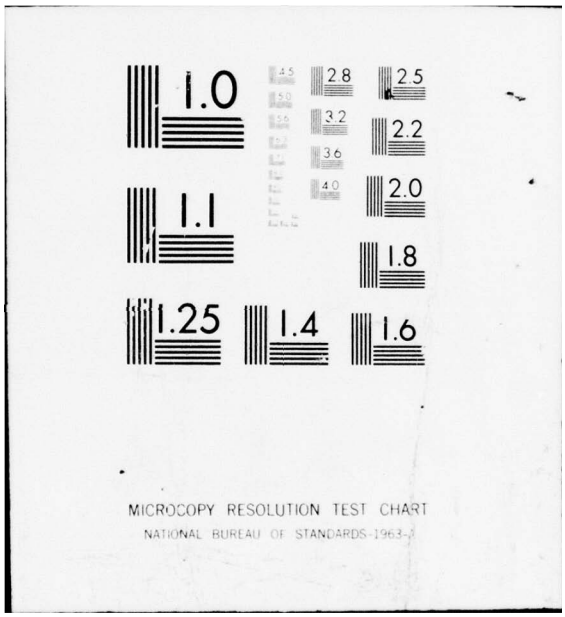
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RADC-TR-77-349
Final Technical Report
November 1977

APPLICATIONS PROGRAMS FOR THE WAVEFORM PROCESSING SYSTEM

Pattern Analysis & Recognition Corporation

Approved for public release; distribution unlimited.

ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, New York 13441

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This report describes the additions and changes to the Waveform Processing System (WPS) developed by Pattern Analysis and Recognition Corporation for the Rome Air Development Center under contract F30602-76-C-0373.

Many new options were added to the system, along with enhancements which resulted in a more flexible and reliable pattern recognition tool.

This is an addendum to the WPS final report which is in four volumes. over

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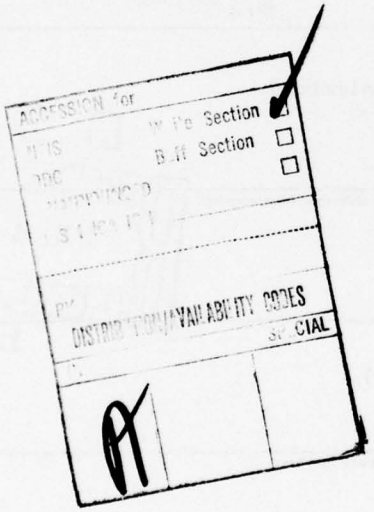
Volume I is the technical report, Volume II is the user's manual, Volume III is the technical report and user's manual for PARLAN, the language developed for WPS, and Volume IV is the software documentation.



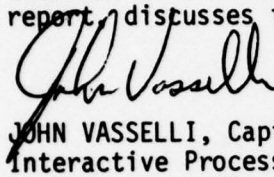
PREFACE

This volume serves as an addendum to the four volume technical report (RADC-TR-76-224) which describes the Waveform Processing System. This system was developed by the Pattern Analysis and Recognition Corporation (PAR) under contract F30602-72-C-0193. The additional work described in this report was performed by PAR under contract F30602-76-C-0373.

TABLE OF CONTENTS

EVALUATION

This report describes additions and modifications made to the Waveform Processing System (WPS). Based upon use of the WPS system for actual problem solving, new options which would enhance the systems capabilities, reduce times necessary for data manipulation, and improve efficiency, were designed. This report, serving as an addendum to the four volume Waveform Processing System technical report, discusses the implementation of those options.



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SECTION 1

INTRODUCTION

During the latter stages of the initial WPS contract, as more and more time was being spent actually solving pattern recognition problems, it was noted that many things could be done to improve the overall system performance. New options were identified which would reduce the time necessary for data manipulation, and changes were noted which would improve the efficiency of the operating system. It was due to these new thoughts, gained through experience, that led to the creation of this follow-on effort.

SECTION 2

SYSTEM CHANGES

2.1. TRAP HANDLING

When the WPS system was first actually utilized as a pattern recognition tool, it was discovered that hardware-generated error traps were not being handled properly. When a trap generation sequence occurred, the system could not recover since WPS is a stand alone system, and as such, does not communicate with the trap handler in DOS. This correction received high priority since the location and identification of a trap, plus the ability to automatically recover, are essential to the overall system efficiency.

The *"WAVEFORM PROCESSING SYSTEM" now handles all traps that are generated* by the 11/45 hardware. At run time, the "DOS" interrupt vectors are replaced by vectors which point to the "WPS" trap handler, located in the executive monitor routine.

When a trap occurs, control is restored to the waveform processing system, and the error message is displayed on the Tektronix and "VG". At this point, the executive also closes all open files, to insure a high level of filing system integrity.

The following list enumerates the "WPS" trap messages.

1. Trap 4

   a) Odd Address.

   b) Parity Error.

   c) Stack Violation.

2. Trap 10

   a) Illegal Instruction.

3. Trap 250

   a) Memory Management Error.

2.2. TREE TABLE REDUCTION

When storing large amounts of data on the WPS system disk, we discovered that the filing system tables seemed to overflow prematurely. It was decided that the storage capabilities of the system could be enhanced by analyzing the sector allocation mix pertaining to the various filing system tables.

The resulting changes are invisible to the user, but they greatly enhance the system capabilities. As data accumulates, one of the first tables to overflow is the "SECTOR TABLE". It tells how each file is segmented on the RPØ2. By taking the "TREE TABLE" allocation of four sectors, and cutting it to two sectors, we can then assign another sector to the "SECTOR TABLE", thus doubling its size. The other sector was assigned to the "USAGE ELEVEN" table, doubling its size also. This table is used to keep track of the free space on the disk. Since the "TREE TABLE" is tree specific, and both the "SECTOR"

& "USAGE ELEVEN" tables are system specific, this change increases the amount of data which can be stored under WPS by at least 50%. We will pay for the loss of two "TREE TABLE" sectors, however, in that the number of nodes that can be located under a senior node is reduced from 199 to 99. This restriction seems to be of little consequence, however, since in the normal collection and digitization of data it is very rare to have greater than 99 subclasses under a given class.

If data should accumulate to the point where a filing system table does overflow, the user is warned via a message appearing on the vector general.

SECTION 3

NEW OPTIONS

3.1. PARLAN PREDICATES

The addition of a high level language to a system represents a quantum jump in the ease by which users can implement their own software. No longer is it necessary to learn assembly language or the ins and outs of a complex I/O structure. To even further aid in program development the "PARLAN Predicates" were designed. They represent the most extensive group of new options implemented under the effort.

The following routines were written with the hope that they would represent some of the most frequently needed algorithms for waveform processing work. They represent only the start of what the user can create with the "PARLAN LANGUAGE".

The following predicates are available with the WPS system:

1. "SMODIF"
   a. averages over a window of two (3 points) with rectangular weighting.
   b. computes the first forward difference.

2. "AMFRA" - extracts nine features from an amplitude modulated waveform.

   a. pulsewidth

   b. rise time

   c. fall time

   d. peak to 90% time

   e. first peak to first valley

   f. percent ripple

   g. first valley to second peak time

   h. percent first valley to second peak

   i. slope of line from first to second peak such that if y' = 0 heights are equal.

3. "POWER" - computes the power spectrums over a sliding window.

4. "LOG10" - computes the log base ten of a number.

5. "INFLEX" - computes the inflection points in a waveform.

6. "CONVPT" - converts a time to an ordinal point count relative to the beginning of a waveform.

7. "FIX" - output is integer part of input $X_o = [X_i]$

8. "SQRT" - output is square root of input $X_o = \sqrt{X_i}$

9. "POWER (F1;F2;F3) - Fe = $F1^{F2}$

10. "LOG10 (F1;F2) - F2 = $\log_{10}$ F1

11. "IBITR" - performs a bit reversal of the type required to unscramble the results of an FFT.

12. "SAMP" - samples of waveform.

13. "WAVSUM" - calculates the summation, integral, average, and energy of a waveform.

14. "DIF" - computes the first or second forward difference of a waveform.

15. "SHIFT" - shifts the waveform by an integral number of samples.

16. "RECWAV" - performs a full or half wave rectification on the waveform.

17. "ADDSUB" - adds any fraction of one waveform to another waveform.

18. "HSTGRM" - computes the histogram of a waveform.

19. "ZRCRSL" - computes the zero crossing locations of a waveform.

20. "FRDMOD" - not yet debugged -- frequency demodulation.

21. "COSSIN" - COS or SIN $X_0 = \text{COS } X_i$ or $X_0 = \text{SIN } X_i$

22. "TAN" - TAN $X_0 = \text{TAN } X_i$

23. "EXP" - exponential $X_0 = e\ X_i$

24. "LN" - logarithm $X_0 = \ln X_i$

25. "ARCTAN" - TAN^{-1} $X_0 = \text{TAN}^{-1}\ X_i$

26. "HYP" - COSH or SINH $X_0 = \text{COSH } X_1$ or $X_0 = \text{SINH } X_i$

27. "ARSINH" - $SINH^{-1}$ $X_0 = \text{SINH}^{-1}\ X_i$

28. "SMOOTH" - Does all or any of the following:

    - o Truncates the waveform.
    - o Resamples the waveform.
    - o Smooths the waveform by applying a sliding window.

      Possible window choices are:

      - oo Rectangular
      - oo Triangular
      - oo Hanning
      - oo Hamming

29. "REDUCE" - Does any or all of the following:

- o Truncates the waveform.
- o Resamples the waveform.
- o Reduces the dynamic range of the waveform.

30. o Walsh Transform.

31. o Shift Waveform an Integral Number of Samples.

32. o Find Extrema (ordered by location).

33. o FFT

3.2. DISPLAY A PRIORI MARKERS

This new option allows the user to display a waveform in the same manner as under the Single Display Frame, but with one exception. Superimposed on the display are up-arrows indicating the beginning and end of the a priori segmentation markers, located in the waveform header. This is very useful as it allows the user to visually confirm the location of the markers before actually performing the editing in the Segmentation frame. The markers may be erased and/or inserted under the Editing frame.

3.3. DELETE VECTOR

This routine will delete one vector or a range of data vectors from a given data set. The user must specify the "ID" or range of "ID's" to be deleted.

3.4. DELETE VECTOR NODE

As the name implies, this "VG" light button option will allow the user to delete a node from a given vector data tree.

3.5. APPEND FEATURE VECTORS

This option allows the user to combine the vectors in two given trees, with the same structure. See Figure 7-7 in Vol. I - RADC-TR-76-224.

3.6. SORT WAVEFORMS

The routine allows the user to sort waveforms from a given tree into a new tree, each node of which represents one of the new classes. The user may sort using temporary symbols, ID's or fields within the ID. See Figure 7-8, RADC-TR-76-224, Vol. I - WPS Final Report.

SECTION 4

OPTION IMPROVEMENTS

oo DELETE TREE

This routine was awkward to use for OLPARS data in that it did not delete the mean covariance files associated with the tree. The user, therefore, was left to delete each file, one by one, using DELETE FILE. DELETE TREE was modified under this contract so that when the user invokes this option on OLPARS data the mean covariance files are automatically deleted.

oo DELETE SUBSTRUCTURE

This option which concatenates all of the substructured data under a senior or lower node into one user specified lowest node did not function due to the filing system changes which were invoked under the initial effort. Modifications were made to reactivate this useful file utility.

oo LODWAV

This overlay allows the user to read waveform data into the system from magnetic tape. It was originally written such that the data could only be stored in a one tree per tape format -- very inefficient! The routine was modified so that any number of waveform trees can be read in from one tape.

oo OLPARS LIGHT PEN OPTIONS

Long range plans see the WPS system being implemented on other systems which are similar, but not exactly equivalent to the original at RADC. For this region every effort was made to design routines which are as flexible as possible. The Vector General display has two different subroutine calling options, each requiring different software. For this reason all of the OLPARS options which utilize these options were modified so that they would "know" which VG they were running on, thus enabling them to utilize the proper code.

oo PARCOV

This routine calculates the covariance matrix of a given class in an OLPARS data set. When operating on large data sets it was found to lack sufficient accuracy. It was modified to utilize double precision floating point instead of single. Also, the calculations are being performed in blocks to guard against overflows. This new version was implemented throughout the system.

oo SEGMENTATION MODULE

This module allows the user to automatically segment a given waveform or node with respect to some criteria i.e., threshold, zero crossings, etc. The original dialogue between the user and the system was found to be clumsy and time consuming. For this reason the user-system dialogue was redesigned.

oo TEXT

The routines which retrieve and store text information were never modified to conform with the current data set philosophy now employed under WPS. Under this effort the necessary changes were implemented.

SECTION 5

NOTES ON OPERATIONAL PROCEDURES

During the course of getting to know a system certain procedures arise as being the best way to accomplish a certain task. These operational procedures are rarely ever set down in writing, but instead go into making an experienced operator. This is an effort to enumerate some good operating procedures for using the Waveform Processing System.

- Incredible as it sounds, many novice users find that the system fails to materialize after the "RUN WPS" command has been given, due to failure of the "VG" to be turned on!

- One of the most efficient ways of locating a system problem is to dump all of the tables on the line printer. If the system is up, the user can use the "OUTPUT" frame, if the system does not respond, use "PRNTBL". This is a stand-alone routine which runs under "DOS".

- The hard-copy option is now an overlay and not a subroutine. As such the user can no longer invoke this function when sitting in the middle of an overlay at a question and answer point.

- When using the edit module it is imperative that the node containing the waveform to be altered be opened as opposed to the whole tree.

- Control - x is a handy way to escape from an option that was wrongly selected and is now asking for user input. Even though many precautions are taken it is still dangerous to use this function to kill a routine that is executing.

- If the execution of a "PARLAN" program comes to an abnormal conclusion, it is invisible to the user that one or more files may have been left open. To make sure that every filing system table is initialized, do a "CONTROL T" and rerun WPS.

- Operations on vector trees seem to reach maximum efficiency when vector trees are kept short -- around 10 or 12 nodes maximum. In creating trees therefore, the practice should be to create many short trees as opposed to one very large structure.

- The "CURRENT DATA SET" does not exist, only at that point where the entire system has just been built and data set has yet been chosen. Once "SELECT DATA SET" has been run there will always exist some current waveform data set with its associated vertical and horizontal scaling parameters. In essence, it can never be assumed that the default scaling parameters are being utilized on a given display; always check the scaling.

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