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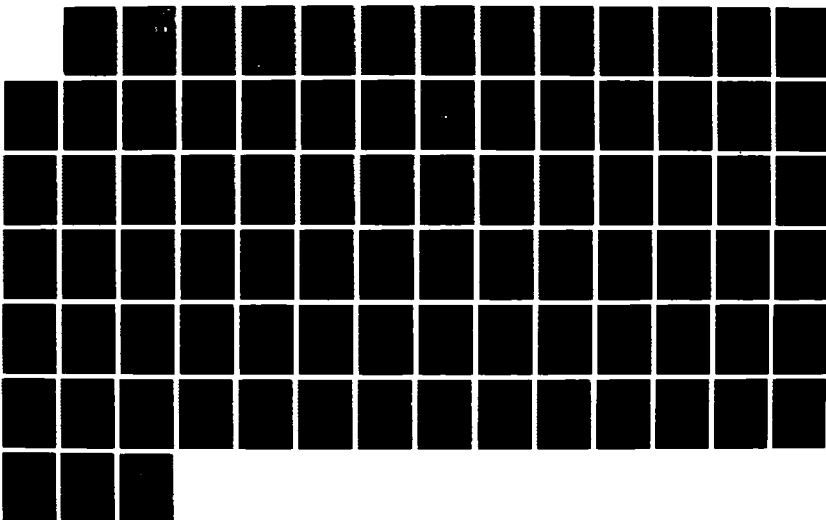
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FORD AEROSPACE AND COMMUNICATIONS CORP NEWPORT BEACH CA  
R M BIENTAK ET AL. 13 NOV 87 DAAL02-85-C-8183

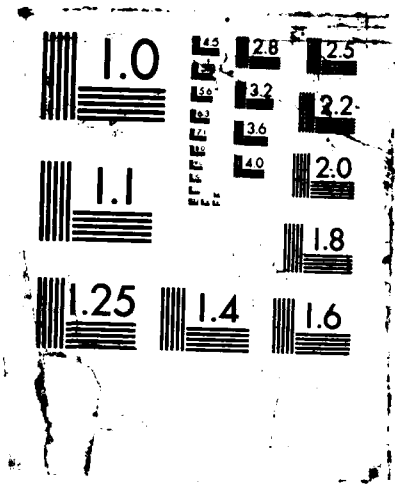
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FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

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R. M. Bieniak  
T. G. Gaa  
B. K. Harris  
T. L. Rodriguez

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FORD AEROSPACE & COMMUNICATIONS CORPORATION  
AERONUTRONIC DIVISION  
NEWPORT BEACH, CALIFORNIA 92658

November 1987

Final Scientific and Technical Report  
for Period 15 July 1985 Through 13 November 1987

Prepared for

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U. S. ARMY ELECTRONIC RESEARCH AND DEVELOPMENT COMMAND  
CENTER FOR NIGHT VISION AND ELECTRO-OPTICS  
FORT BELVOIR, VIRGINIA 22060-5677

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FORT BELVOIR, VIRGINIA 22060-5677



**Ford Aerospace &  
Communications Corporation**  
Aeronutronic Division  
Newport Beach, California 92658

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
FINAL REPORT

CONTENTS

1	INTRODUCTION . . . . .	1
2	FEATURE ANALYSIS . . . . .	2
2.1	Activation Of Feature Analysis . . . . .	2
2.2	Feature Analysis Process Overview Flowchart . . . . .	4
2.3	Automatic Processing . . . . .	5
2.4	Image Selection . . . . .	5
2.5	Algorithm Processing List Creation . . . . .	7
2.5.1	Processing List Retrieval . . . . .	7
2.5.2	Interactive Processing List Build . . . . .	8
2.5.3	Modify Current Processing List . . . . .	10
2.6	Processing List Execution . . . . .	12
2.7	Process Images . . . . .	12
2.8	Repeat Feature Analysis Process . . . . .	13
2.9	Joystick Inputs . . . . .	15
2.10	Input / Output Data File Descriptions . . . . .	15
3	IMAGE CHARACTERISTICS (IC) - FULL FRAME . . . . .	18
3.1	Activation Of Image Characteristics . . . . .	18
3.2	Image Characteristics Overview Flowchart . . . . .	20
3.3	Automatic Processing . . . . .	21
3.4	Image Selection . . . . .	21
3.5	Algorithm Processing List Creation . . . . .	23
3.5.1	Processing List Retrieval . . . . .	24
3.5.2	Interactive Processing List Build . . . . .	24
3.5.3	Modify Current Processing List . . . . .	25
3.6	Processing List Execution . . . . .	28
3.7	Process Images . . . . .	28
3.8	Repeat Image Characteristics Process . . . . .	29
3.9	Joystick Inputs . . . . .	30
3.10	Input / Output Data File Descriptions . . . . .	31
3.11	Non-Symmetric Sub-Image Selection . . . . .	35
3.11.1	Sub-Image Selection . . . . .	35
4	AUTOMATIC GROUND TRUTHING . . . . .	38
4.1	Activation Of Ground Truthing . . . . .	38
4.2	Ground Truthing Process Overview Flowchart . . . . .	40
4.3	Image Selection . . . . .	41
4.4	Algorithm Processing List Creation . . . . .	41
4.4.1	Processing List Retrieval . . . . .	42
4.4.2	Interactive Processing List Build . . . . .	42
4.4.3	Modify Current Processing List . . . . .	43
4.5	Process Image . . . . .	45
4.6	Repeat Ground Truthing Process . . . . .	47
4.7	Input / Output Data File Descriptions . . . . .	48
5	SUPPORT FUNCTIONS . . . . .	52
5.1	Automatic Data Processing . . . . .	53
5.1.1	Automatic Processing Overview Flowchart . . . . .	54
5.1.2	Activation Of Automatic Data Processing . . . . .	55
5.1.3	VAX Instruction File Format . . . . .	56
5.1.4	Joystick Inputs . . . . .	56
5.1.5	Processing Status . . . . .	57
5.1.6	Repeat Processing . . . . .	57
5.1.7	Error Recovery . . . . .	57
5.1.8	Error Messages . . . . .	57
5.1.9	Building An Automatic Data Processing File . . . . .	58

5.1.10	Sample Automatic Data Processing Input Files . .	59
5.2	Video Configuration Selection . . . . .	60
5.2.1	FPAD System Configuration . . . . .	60
5.3	Frame Number Referencing . . . . .	62
5.3.1	Frame Numbering And Selection Process . . . . .	62
5.4	Nato Tape Read . . . . .	64
5.4.1	Begin Program Execution . . . . .	64
5.4.2	Return To VMS . . . . .	64
5.4.3	Read New Tape . . . . .	64
5.4.4	Read Same Tape . . . . .	64
5.4.5	Tape Read Process . . . . .	65
5.4.6	Notes . . . . .	66
5.5	VAX/FPAD Interface . . . . .	67
5.5.1	Pascal Callable Routines . . . . .	68
6	FPAD POWER UP / SHUT DOWN . . . . .	72
6.1	Power Up . . . . .	72
6.2	Shut Down . . . . .	73
7	ALGORITHM SUMMARY . . . . .	75
8	DOCUMENTATION . . . . .	77
9	ABBREVIATIONS IN THIS WORK . . . . .	78
10	CONTRACT CROSS REFERENCE . . . . .	79

# FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

## 1 INTRODUCTION

This is the Final Scientific and Technical Report for the integration of the Field Programmable Algorithm Demonstrator (FPAD) into the Fast Algorithm Simulation and Test (FAST) Facility at the Center for Night Vision and Electro-Optics (CNVEO) under contract number DAAL02-85-C-0103. This report covers the activity period from July 1985 to November 1987.

The primary function of this document is to serve as a comprehensive users guide for all the FPAD FAST application and support software packages. These packages include :

- o Feature Analysis ;
- o Image Characteristics ;
- o Ground Truthing ;
- o Automatic Data Processing ;
- o Video Configuration Selection ;
- o Frame Number Referencing ;
- o NATO Tape Read ; *and*
- o VAX / FPAD Interface .

The final five sections of this document describe how to boot the FPAD system, summarizes the algorithms used in the project, identifies the documentation produced, defines the abbreviations used in the document, and provides a cross reference to FAST contract tasks.

There are two terms used throughout this document, they are USER'S CRT and USER'S MONITOR. The user's CRT refers to the VAX terminal that the user is entering commands and responses to control the FPAD system. The user's monitor refers to to analog output monitor that displays the imagery that is being processed by FPAD.



# FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

## Feature Analysis User's Guide

### 2 FEATURE ANALYSIS

The purpose of the Feature Analysis function is to gather feature vectors from target imagery and examine feature stability. The eventual result is a library of features that can be used for comparison to other feature libraries generated by various sensor types, including FLIR and millimeterwave devices. This could facilitate the investigation of multi-sensor target recognition schemes.

This section describes to the Feature Analysis User how to accomplish the following tasks :

	Page
o ACTIVATION OF FEATURE ANALYSIS	2
o IMAGE SELECTION	5
o ALGORITHM PROCESSING LIST CREATION	7
- PROCESSING LIST RETRIEVAL	7
- INTERACTIVE PROCESSING LIST BUILD	8
- MODIFY CURRENT PROCESSING LIST	10
o PROCESS IMAGES	12
o REPEAT FEATURE ANALYSIS PROCESS	13
o INTERPRET INPUT / OUTPUT FILES	15

#### 2.1 Activation Of Feature Analysis

To invoke the Feature Analysis function, do the following:

1. Log on to the VAX.
2. Verify the FPAD system power is on.
3. Type "FPAD" at the VAX command level.

Transparent to the user, the command level procedure allocates the FPAD logical device to lock out other system users. If FPAD has been previously allocated, the user is automatically notified that FPAD is in use and the process exits and returns to the VAX command level. The following message is displayed on the user's CRT.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

FPAD ALLOCATED BY ANOTHER USER

USER'S CRT

Once the FPAD device has been successfully allocated, the following menu is displayed on the user's CRT. (For a high level overview of processing, see the flowchart on the following page.)

APPLICATIONS MENU

- 1) FEATURE ANALYSIS
- 2) IMAGE CHARACTERISTICS
- 3) GROUND TRUTHING
- 4) EXIT

USER'S CRT

ENTER SELECTION (1-4) :

Select the Feature Analysis function. At this point the Feature Analysis software is loaded into FPAD if necessary. If the software is already resident in FPAD, no loading will occur. The Feature Analysis function is then activated. The following message is displayed during the loading process.

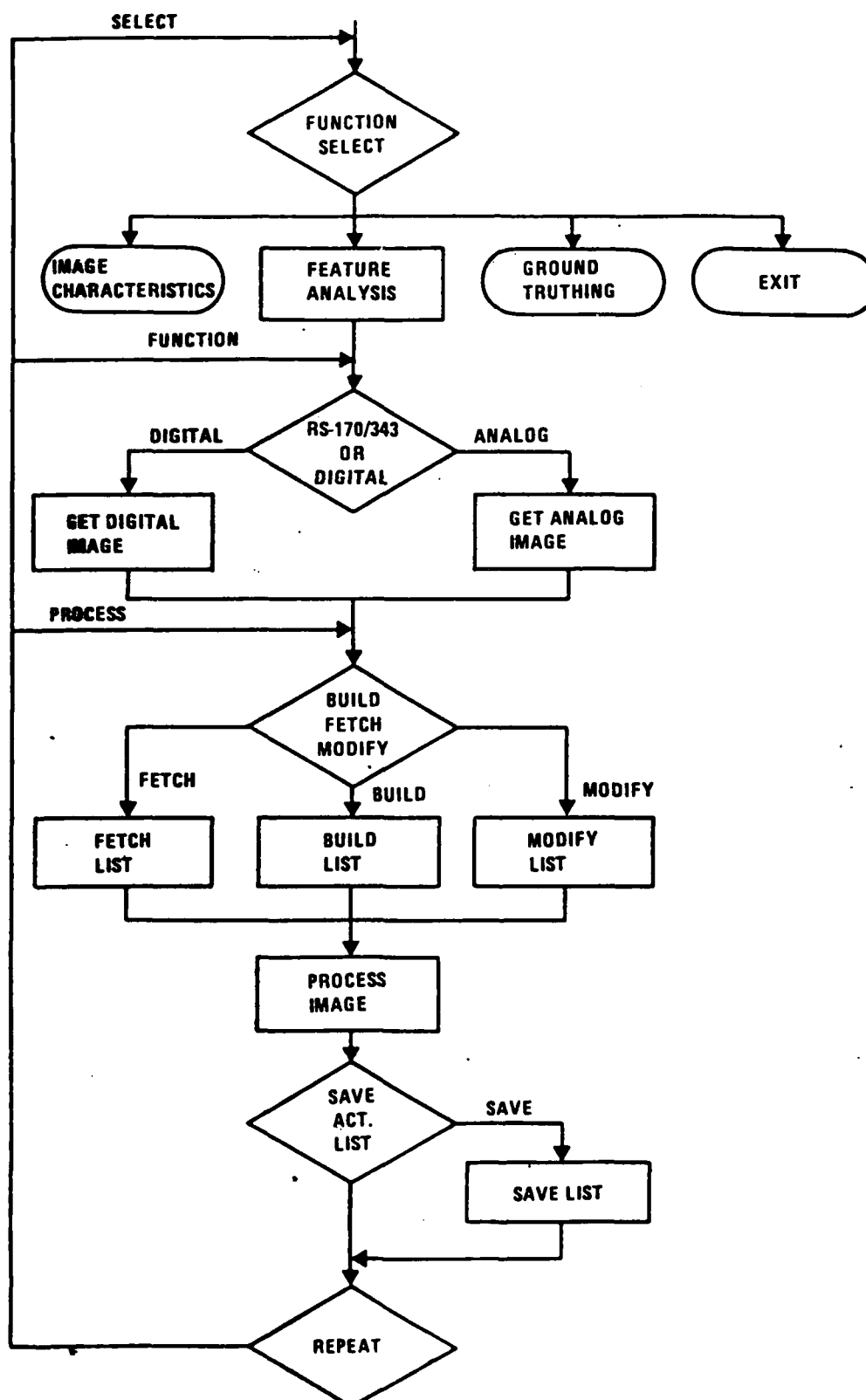
LOADING SYSTEM

USER'S CRT

This message is displayed to inform user of current system status.

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Feature Analysis User's Guide

2.2 Feature Analysis Process Overview Flowchart



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

Once the proper load file is stored in FPAD, the following message is displayed:

FEATURE ANALYSIS

USER'S CRT

### 2.3 Automatic Processing

After the appropriate software is loaded, the system prompts the user for Automatic Data Processing.

AUTOMATIC PROCESSING (Y/N) :

USER'S CRT

If the user selects "Y", then autoproccessing is activated. Refer to Automatic Data Processing User's Guide for more detailed information (page 53).

### 2.4 Image Selection

From the following menu, select the type of input imagery to process with Feature Analysis.

SELECT IMAGERY TYPE FOR PROCESSING

- 1) RS-170 CHANNEL 1 (NON-INTERLACE)
- 2) RS-343 CHANNEL 1 (NON-INTERLACE) USER'S CRT
- 3) DIGITAL VAX TO VFM
- 4) DIGITAL VFM TO VAX

ENTER CHOICE (1-4) :

If VAX to VFM digital video load is selected, the system prompts the user for the file to load into the Video Frame Memory.

ENTER FILENAME FOR VFM LOADING (.DAT ASSUMED) : USER'S CRT

If digital video data from VFM to VAX data file is selected, the system prompts for the VFM number (0 - 3) and the VAX filename to store the data.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

ENTER VFM NUMBER FOR READ (0-3) :

USER'S CRT

ENTER FILENAME FOR VFM DATA STORAGE (.DAT ASSUMED) :

After a digital video read from VFM has been completed, the system redisplay the configuration menu and prompts the user for another configuration.

If the user selected TV type imagery for processing, the user must select a mechanism for retrieving a RS-170/343 frame from either a VTR or a TV Camera. The system prompts the user for the selection process with the following menu :

FRAME SELECTION PROCESS

- 1) SELECT FRAME WITH JOYSTICK
- 2) SELECT FRAME USING ID NUMBER

USER'S CRT

ENTER CHOICE (1-2) :

If the user decides to search for a specific frame ID number, the system prompts the user for the search frame ID number.

INPUT FRAME ID NUMBER FOR PROCESSING :

USER'S CRT

If the user selected the digital load option, the digital video data would be resident in a FPAD video frame memory. For the RS-170/343 TV format data, the frame for processing is ready to be selected. Start the video stream (analog) into the FPAD. For the TV camera, apply power to device, and for a VTR, start the video stream by depressing the play button on the recorder/player. Live video is displayed on the video monitor.

USER'S MONITOR

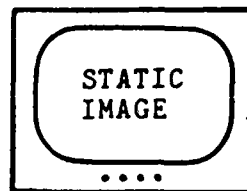


For frame ID searches, when a frame ID match occurs the frame is automatically stored in a FPAD video frame memory. If selecting an image from the joystick, upon viewing the desired

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY Feature Analysis User's Guide

image, depress switch A on the joystick to select and store the frame. See joystick switch definition in section titled, Joystick Inputs (page 15). If the user is searching for a specific frame ID number and no match occurs, the user has two options: load another tape and continue to search for the ID number, or select a frame for processing via the FPAD joystick frame selection process. Upon frame selection, via FPAD joystick or ID number match, or after completing a digital load, the following is displayed on the video monitor.

USER'S MONITOR



The image to be processed with the Feature Analysis function has been selected and stored in a video frame memory of FPAD.

### 2.5 Algorithm Processing List Creation

The user now must select the type of algorithmic processing to be done on the image. The algorithmic processing list can be built through an interactive menu, via a canned algorithmic processing list saved in a VAX file, or through a modification of an existing processing list.

#### ALGORITHMIC PROCESSING LIST CREATION

- 1) PROCESSING LIST RETRIEVAL
- 2) INTERACTIVE PROCESSING LIST BUILD      USER'S CRT
- 3) MODIFY CURRENT PROCESSING LIST
- 4) EXECUTE CURRENT PROCESSING LIST
- 5) EXIT

ENTER CHOICE (1-5) :

#### 2.5.1 Processing List Retrieval -

If a canned format is to be retrieved from a VAX file, the user is asked for the filename containing the algorithmic processing list with its associated parameters.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

INPUT CANNED ACTIVATION LIST FILENAME (.SPC ASSUMED) :

Once the input file has been selected, the activation list and its associated parameters are displayed on the user's CRT as in the following example. If the user does not know the Canned Activation List filename or accidentally enters option 1, an exit mechanism is provided. The system prompts the user up to three times for a valid filename, if after three attempts a valid filename is not entered, the Algorithmic Processing List Creation Menu is redisplayed for user selection.

ALGORITHMIC PROCESSING LIST

USER'S CRT

- 1) INTENSITY BASED HISTOGRAM HOT TARGET
- 2) USER CONTROLLER JOYSTICK CONNECTION = BLACK

2.5.2 Interactive Processing List Build -

If the user selects to build an algorithmic processing list through a menu script, the user is prompted for all the possible options that can be performed to accomplish feature analysis processing.

The following prompts are displayed awaiting a user response:

MEDIAN FILTER INPUT IMAGERY (Y/N) :

USER'S CRT

If the user responds to this prompt with a "N", the system proceeds to the next item selection question, otherwise it prompts the user for the median filter size.

MEDIAN FILTER SIZE (3,5,7,...,31) :

USER'S CRT

If the value given is not 3,5,7,...,31, the system reprompts the user until a proper value is selected.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

SEGMENTATION PROCESS

USER'S CRT

- 1) INTENSITY BASED SEGMENTATION HOT TARGET
- 2) INTENSITY BASED SEGMENTATION COLD TARGET
- 3) 2-CLASS SEGMENTATION
- 4) MULTI-CLASS SEGMENTATION (HOT)
- 5) MULTI-CLASS SEGMENTATION (COLD)

ENTER CHOICE (1-4) :

The user must select a segmentation process for extracting candidate blobs from the background image for use with the feature vector creation process.

SEGMENT CONNECTION PROCESS

USER'S CRT

- 1) USER CONTROLLER JOYSTICK CONNECTION
- 2) AUTOMATED SEGMENT ASSOCIATOR

ENTER CHOICE (1-2) :

Upon completion of the segmentation process, the user must have a process selected for identifying which segmented blobs should be used for secondary calculations. These calculations include segment association and feature vector creation. The user controlled joystick segment association process interfaces to the user in exactly the same manner as the non-symmetric image selection (see non-symmetric user's guide for more detail - page 35).

The last item the user must input is the definition of the process control mechanism. This refers to the fact that the process in FPAD can be interrupted after each processing step for visual verification on the output monitor. Upon verification, the user may continue processing from the user's CRT.

DISPLAY INTERMEDIATE PROCESSING RESULTS (Y/N): USER'S CRT

If the user responds "N" the process executes as fast as possible with no user intervention. If "Y", then system stops, displays results and waits for user response on the CRT.



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

2.5.3 Modify Current Processing List -

The user can choose one of three ways to modify the current algorithm processing list. The user may insert new algorithms, delete algorithms from the list, or modify parameters. The following menu of modification choices are displayed on the user's CRT.

MODIFICATION MENU

- |                               |            |
|-------------------------------|------------|
| 1) INSERT NEW ALGORITHM       |            |
| 2) DELETE ALGORITHM           | USER'S CRT |
| 3) MODIFY ALGORITHM PARAMETER |            |
| 4) EXIT                       |            |

ENTER CHOICE (1-4) :

The insert new algorithm modification menu displays only the algorithms that can be inserted into the current processing scenario. The user is then prompted to select from the algorithms as in the following example.

ADDITIONAL ALGORITHMS FOR INSERTION

- |                                |            |
|--------------------------------|------------|
| 1) MEDIAN FILTER INPUT IMAGERY |            |
| 2) EXIT                        | USER'S CRT |

ENTER CHOICE (1-2) :

This example is based on the algorithm processing list on the previous page. If the user decides to select median filter input imagery, it is inserted into the appropriate place in the algorithmic processing list. This alleviates user knowledge of processing dependencies. If the user selects EXIT, no inserts are done.

The delete algorithm option allows the user to remove algorithms from the current processing list. To accomplish this, the algorithm processing list is displayed on the user's CRT.

ALGORITHMIC PROCESSING LIST	USER'S CRT
-----------------------------	------------

- |  |            |
|--|------------|
| 1) MEDIAN FILTER INPUT IMAGERY = 5X5           |            |
| 2) INTENSITY BASED HISTOGRAM                   | HOT TARGET |
| 3) USER CONTROLLER JOYSTICK CONNECTION = BLACK |            |
| 4) EXIT  |            |

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

At this point, the user is allowed to delete the algorithm number corresponding to the item to be deleted from the algorithm processing list. If the user decides not to delete an algorithm, the user can enter the number corresponding to exit.

ENTER ALGORITHM NUMBER TO DELETE : USER'S CRT

The last modification the user can make is parameter modification for a specific algorithm. The system displays the current processing list, and prompts the user for an algorithm number and new processing parameters for that algorithm.

ALGORITHMIC PROCESSING LIST USER'S CRT

- 1) MEDIAN FILTER INPUT IMAGERY = 5X5
- 2) INTENSITY BASED HISTOGRAM HOT TARGET
- 3) USER CONTROLLER JOYSTICK CONNECTION = BLACK
- 4) EXIT

The user identifies which algorithm needs a parameter change and then specifies the new parameter.

ENTER ALGORITHM NUMBER FOR PARAMETER CHANGE : USER'S CRT

If the user modifies an algorithm that contains no parameters, the system responds with a message indicating that no parameter change is available for that algorithm.

NO PARAMETER CHANGE AVAILABLE USER'S CRT

If a parameter change is valid for the selected algorithm, the system prompts the user for a new parameter value.

ENTER NEW PARAMETER VALUE : USER'S CRT

The system continues to prompt the user for algorithm processing list modifications until the user exits the modification menu script.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

2.6 Processing List Execution

After a processing list retrieval, build, or modification, the current processing list is displayed along with the processing list creation menu. If the user selects the execute current processing list option, the current algorithmic processing list displayed is executed.

The user has one final option, save the results of the processing in a VAX data file or just view the results of the processing. The system prompts the user for the save / no save choice :

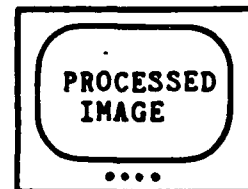
SAVE OUTPUT DATA IN A FILE (Y/N) :           USER'S CRT

If "N" is selected, the data from the processing is not saved. However, if the "Y" option is selected, the user is prompted for the filename to store results after processing is complete.

2.7 Process Images

At this point, all the information necessary to perform the Feature Analysis functions has been input and is ready for processing. The algorithmic processing list has been built and processing in the FPAD system begins. After each algorithm which changes or transforms the video data has completed, the resultant image is displayed on the user output monitor.

USER'S MONITOR



If the user had previously selected to view and display intermediate results, the system responds with a prompt at each intermediate step and waits for a signal to continue.

CONTINUE (<cr>) :                           USER'S CRT

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

Additionally, at each intermediate phase of the process, the system displays the current algorithmic phase being processed in feature analysis.

ALGORITHM MEDIAN FILTER PROCESSING

USER'S CRT

If the user had selected not to view intermediate imagery, the process continues uninterrupted until processing by feature analysis is complete. Upon process completion, the user is prompted for the name of the file to store results. The file may be a new file or an existing open file. If there is no file currently opened to store results, the user is prompted for the filename to store the results.

INPUT FILENAME TO STORE RESULTS (.DAT ASSUMED) : USER'S CRT

If a data file is currently opened, the user is prompted to store results in the currently opened file.

STORE RESULTS IN CURRENT DATA FILE (Y/N) : USER'S CRT

If the user selects "Y", the VAX stores all the results from feature analysis at the end of the currently opened output file. If the user responds with a "N", a new file is requested, and the following prompt is displayed.

INPUT FILENAME TO STORE RESULTS (.DAT ASSUMED) : USER'S CRT

Currently, all data produced has been stored and the next processing cycle is ready to execute.

## 2.8 Repeat Feature Analysis Process

If the user plans to use the current algorithmic processing list at a later date, the user can save the list in a VAX file for later recall.

SAVE ACTIVATION AND PARAMETER LIST (Y/N) : USER'S CRT

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

If the user decides to save the activation and parameter list for future use, the system prompts the user for a VAX output file in which to save the results.

INPUT ACTIVATION LIST STORAGE FILENAME (.SPC ASSUMED) :

For the next processing cycle of feature analysis the user has several different choices for processing. Using the same image, the user may alter the algorithm processing list via the modification mechanism, or the user may select a different image, or select a different configuration and new image. The user is prompted for the selection of these choices.

CONTINUE PROCESSING WITH CURRENT IMAGE (Y/N) : USER'S CRT

If the user responds "Y", the system automatically continues processing the current image allowing the user to modify the algorithm processing list in the following manner.

First the current processing list and parameters are displayed on the user's CRT, for example :

ALGORITHMIC PROCESSING LIST

USER'S CRT

- 1) MEDIAN FILTER INPUT IMAGERY = 5X5
- 2) INTENSITY BASED HISTOGRAM HOT TARGET
- 3) USER CONTROLLER JOYSTICK CONNECTION = BLACK

The user can choose one of three ways to modify the current algorithm processing list. The user may insert new algorithms, delete algorithms from the list, or modify parameters.

If the user selects "N", the system then prompts the user to see if processing should continue with a different image or system configuration.

SELECT NEW IMAGE TO PROCESS (Y/N) :

USER'S CRT

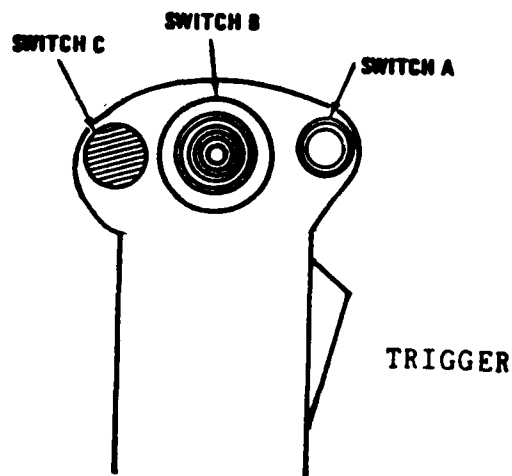
If "Y", the system returns to the Image Configuration and Selection menus and asks user to select a new image for processing. If "N", then the system exits the Feature Analysis application and returns the user to the main applications menu.

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### Feature Analysis User's Guide

#### 2.9 Joystick Inputs

As discussed previously, joystick inputs are required to sometimes select an image to process, or connect segmented image blobs. The joystick is also required to select an Area of Interest when performing segmentation (Intensity based, 2-class, or Multi-class) algorithms. When the segmentation algorithm is performed, a graphics gate appears on the monitor. The user can adjust the size and position of the gate using the joystick in order to encompass the area of the image over which processing is to be done. The thumb tracker (switch B) is used to adjust the position of the gate, and the thumb tracker used simultaneously with the trigger switch at the first detent is used to adjust the size of the gate. When the desired portion of the image has been encompassed by the gate, the user must depress switch A of the grip to allow processing of the sub-image to start.



Palm Grip (joystick) Switch Definition

#### 2.10 Input / Output Data File Descriptions

##### Output Results File

This file contains the results of performing image filtering, segmentation, and feature vector creation from user selected

# FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

## Feature Analysis User's Guide

imagery. The results are in three parts: (1) The raw data in histogram form used to generate statistical data, (2) the moments data calculated from the segmented image which includes, mean, standard deviation, skewness, and kurtosis, and (3) the target shape information which includes number of perimeter points, interior point, height, and width. They reside in a file in the following format:

```

Example:  xxxx   Gray Level 0 Occurrences   Low Word
          xxxx   High Word
          xxxx   Gray Level 1 Occurrences   Low Word
          xxxx   High Word
          .
          .
          .
          xxxx   Gray Level 255 Occurrences   Low Word
          xxxx   High Word
          xxxx   Mean
          xxxx   Standard Deviation
          xxxx   Skewness
          xxxx   Kurtosis
          xxxx   Number of Perimeter Points
          xxxx   Number of Interior Points
          xxxx   Height
          xxxx   Width
  
```

These data files may also be concatenated during multiple processing runs. The filenames take the format:

userselectedname.DAT

To examine file contents, use DEC utility DUMP.

DUMP/WORD/HEX userselectedname.DAT

Each run produces three blocks of information stored on the VAX. Blocks one and two contain the image histogram, while block three contains the feature vector information. The remaining space in block three is set to the value zero. The file is written using a fixed 2-byte record format.

### Canned Algorithm File

This file contains the algorithms and parameters necessary to process Feature Analysis application software. During the execution of Feature Analysis, the user interactively builds an algorithmic processing list and associated parameters that

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Feature Analysis User's Guide

specifies what processes are performed on the image. At the completion of the processing the user may save the algorithmic list in a file for later retrieval. This canned algorithmic file is created by the system and can be used at a later date to perform the same algorithmic suite. The user inputs the filename to store algorithms, the .SPC extension is appended automatically.

userselectedfile.SPC

Autoprocess Specification File

This file contains the processing specifications and user inputs in a command file for executing Feature Analysis with no user keystrokes. These command level files contain all the inputs the user would make during interactive processing. This file is created using a standard VAX editor.

Example:

3	-- CONFIGURATION SELECTION
TESTIM	-- IMAGE TO LOAD
1	-- CANNED ACTIVATION LIST
ACTLIST7	-- CANNED ACTIVATION LIST FILENAME
Y	-- SAVE OUTPUT RESULTS IN A FILE
OUTDAT	-- OUTPUT FILE FOR RESULTS
N	-- NO NEW CONFIGURATION
N	-- NO NEW IMAGE



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

### 3 IMAGE CHARACTERISTICS (IC) - FULL FRAME

The purpose of the Image Characteristics function is to gather statistical data about various input imagery. The collected statistical data will be used to relate scene data to Automatic Target Recognizer (ATR) output parameters and to calculate a "transfer function" for the ATR'S performance. The statistical data includes : intensity histogram, gradient histogram, and moment data. The statistical gathering is performed on the entire image, demagnified image, convolved image, or user selected subset of the image.

This section describes to the Image Characteristics User how to accomplish the following tasks :

	Page
o ACTIVATION OF IMAGE CHARACTERISTICS	18
o IMAGE SELECTION	21
o ALGORITHM PROCESSING LIST CREATION	23
- PROCESSING LIST RETRIEVAL	24
- INTERACTIVE PROCESSING LIST BUILD	24
- MODIFY CURRENT PROCESSING LIST	25
o PROCESS IMAGES	28
o REPEAT IMAGE CHARACTERISTICS PROCESS	29
o INTERPRET INPUT / OUTPUT FILES	31
o NON-SYMMETRIC IMAGE SELECTION	35

#### 3.1 Activation Of Image Characteristics

To invoke the Image Characteristics function, do the following:

1. Log on to the VAX.
2. Verify the FPAD system power is on.
3. Type "FPAD" at the VAX command level.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

Transparent to the user, the command level procedure allocates the FPAD logical device to lock out other system users. If FPAD has been previously allocated, the user is automatically notified that the system is in use and the process exits and returns to the VAX command level. The following message is displayed on the user's CRT.

FPAD ALLOCATED BY ANOTHER USER

USER'S CRT

After the FPAD device has been allocated by the user, the following menu is displayed on the user's CRT. (For a high level overview of processing, see the flowchart on the following page.)

APPLICATIONS MENU

- 1) FEATURE ANALYSIS
- 2) IMAGE CHARACTERISTICS
- 3) GROUND TRUTHING
- 4) EXIT

USER'S CRT

ENTER SELECTION (1-4) :

Select the Image Characteristics function to perform statistical calculations. At this point the Image Characteristics software is loaded into FPAD if necessary, if the software is already resident in FPAD, no loading will occur. The Image Characteristics function is then activated. The following is displayed during the loading process.

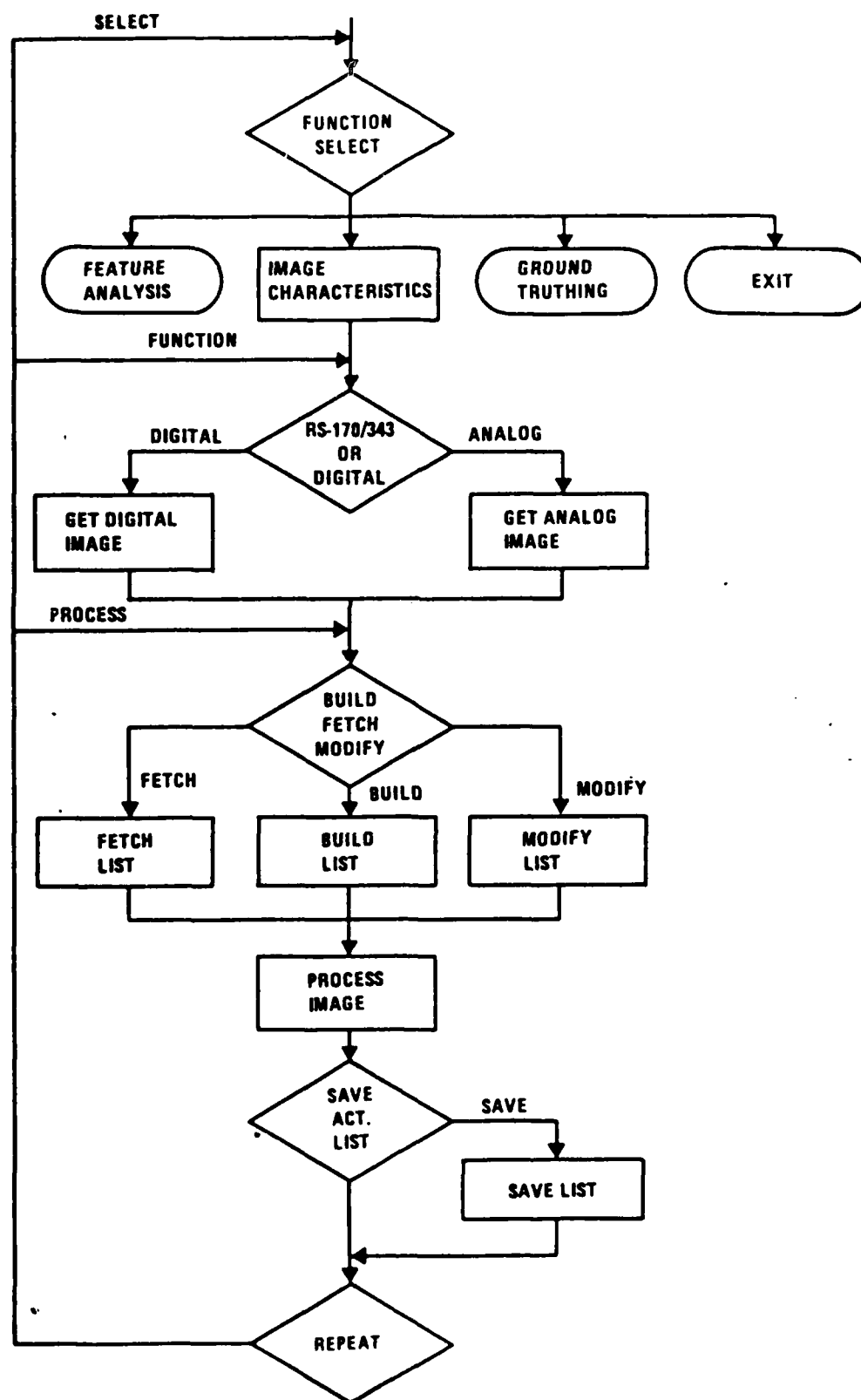
LOADING SYSTEM

USER'S CRT

This message is displayed to inform user of current system status.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

3.2 Image Characteristics Overview Flowchart



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

Once the proper load file is stored in FPAD, the following message is displayed:

IMAGE CHARACTERISTICS

USER'S CRT

### 3.3 Automatic Processing

After the appropriate software is loaded, the system prompts the user for Automatic Data Processing.

AUTOMATIC PROCESSING (Y/N) :

USER'S CRT

If the user selects "Y", then autoproccessing is activated. Refer to Automatic Data Processing User's Guide for more detailed information (page 53).

### 3.4 Image Selection

From the following menu, select the type of input imagery to process with Image Characteristics.

SELECT IMAGERY TYPE FOR PROCESSING

- 1) RS-170 CHANNEL 1 (NON-INTERLACE)
- 2) RS-343 CHANNEL 1 (NON-INTERLACE) USER'S CRT
- 3) DIGITAL VAX TO VFM
- 4) DIGITAL VFM TO VAX

ENTER CHOICE (1-4) :

If VAX to VFM digital video load is selected, the system prompts the user for the file to load the Video Frame Memory.

ENTER FILENAME FOR VFM LOADING (.DAT ASSUMED) : USER'S CRT

If digital video data from VFM to VAX data file is selected, the system prompts the user for the VFM number (0 - 3) and the VAX filename to store the data.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

ENTER VFM NUMBER FOR READ (0-3) :

USER'S CRT

ENTER FILENAME FOR VFM DATA STORAGE (.DAT ASSUMED) :

After a digital video read from VFM has been completed, the system redisplay the configuration menu and prompts the user for another configuration.

If the user selected TV type imagery for processing, the user must select a mechanism for retrieving a RS-170/343 frame from either a VTR or a TV Camera. The system prompts the user for the selection process with the following menu :

FRAME SELECTION PROCESS

- 1) SELECT FRAME WITH JOYSTICK
  - 2) SELECT FRAME USING ID NUMBER
- USER'S CRT

ENTER CHOICE (1-2) :

If the user decides to search for a specific frame ID number, the system prompts the user for the search frame ID number.

INPUT FRAME ID NUMBER FOR PROCESSING :      USER'S CRT

If the user selected the digital load option, the digital video data would be resident in a FPAD video frame memory. For the RS-170/343 TV format data, the image for processing is ready to be selected. Start the video stream (analog) into the FPAD. For the TV camera, apply power to device, and for a VTR, start the video stream by depressing the play button on the recorder/player. Live video is displayed on the video monitor.

USER'S MONITOR

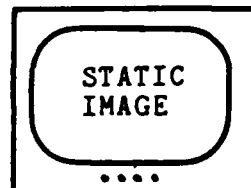


## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### Image Characteristics User's Guide

For frame ID searches, when a frame ID match occurs the frame is automatically stored in a FPAD video frame memory. If selecting an image from the joystick, upon viewing the desired image, depress switch A on the joystick to select the frame. See joystick switch definition in section titled, Joystick Inputs. If the user is searching for a specific frame ID number and no match occurs, the user has two options: load another tape and continue to search for the ID number, or select a frame for processing via the FPAD joystick frame selection process. Upon frame selection, via FPAD joystick or ID number match, or after completing a digital load, the following is displayed on the video monitor.

USER'S MONITOR



The image to be processed with the Image Characteristics function has been selected and stored in a video frame memory of FPAD.

### 3.5 Algorithm Processing List Creation

The user now must select the type of algorithmic processing to be done on the image. The algorithmic processing list can be built through an interactive menu, via a canned algorithmic processing list saved in a VAX file, or through a modification of an existing processing list.

#### ALGORITHMIC PROCESSING LIST CREATION

- |                                      |            |
|--------------------------------------|------------|
| 1) PROCESSING LIST RETRIEVAL         |            |
| 2) INTERACTIVE PROCESSING LIST BUILD | USER'S CRT |
| 3) MODIFY CURRENT PROCESSING LIST    |            |
| 4) EXECUTE CURRENT PROCESSING LIST   |            |
| 5) EXIT                              |            |

ENTER CHOICE (1-5) :

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

3.5.1 Processing List Retrieval -

If a canned format is to be retrieved from a VAX file, the user is asked for the filename containing the algorithmic processing list with its associated parameters. If the user does not know the Canned Activation List filename or accidentally enters option 1, an exit mechanism is provided. The system prompts the user up to three times for a valid filename, if after three attempts a valid filename is not entered, the Algorithmic Processing List Creation Menu is redisplayed for user selection.

INPUT CANNED ACTIVATION LIST FILENAME (.SPC ASSUMED) :

Once the input file has been selected, the activation list and its associated parameters are displayed on the user's CRT as in the following example .

ALGORITHMIC PROCESSING LIST

1) MAGNIFY / DEMAGNIFY = 4	USER'S CRT
2) CONVOLUTION = MASK5X5.DAT	
3) DISPLAY INTERMEDIATE RESULTS	

3.5.2 Interactive Processing List Build -

If the user selects to build an algorithmic processing list through a menu script, the user is prompted for all possible options that can be performed to accomplish image characteristics processing.

The following prompts are displayed awaiting a user response:

MAGNIFY / DEMAGNIFY IMAGE (Y/N) :                      USER'S CRT

If the user responds to this prompt with a "N", the system proceeds to the next item selection question, otherwise it prompts the user for magnify / demagnify value.

INPUT MAGNIFY(+) OR DEMAGNIFY(-) VALUE (2-11,16,32,OR 64) :

If the value given is not in the legal range of values, the system reprompts the user until a proper value is selected.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

The sign of the magnify / demagnify choice specifies the direction of image growth. Positive sign specifies image magnification, while negative sign specifies demagnification.

NON-SYMMETRIC IMAGE SELECTION REQUIRED (Y/N) : USER'S CRT

If the user responds with a "Y" response, the system allows the user to select a portion of the image for image characteristic processing. For details on sub-image selection, see Non-symmetric Image Selection Users Guide (page 35).

INTENSITY/GRADIENT PROCESS REQUIRED (I/G) : USER'S CRT

If the user selects the intensity process, the system proceeds to the next question concerning algorithm selection. If the user selects the gradient process, the system prompts the user for the filename containing the convolution mask to apply to the image data.

INPUT CONVOLUTION FILENAME (.DAT ASSUMED) : USER'S CRT

For more details on the format of the file, see section titled, Input / Output Data File Descriptions (page 31).

The last item the user needs to input is the definition of process control mechanism. This refers to the fact that the process in FPAD can be interrupted after each processing step for visual verification on the output monitor. Upon verification, the user may continue processing from the user's CRT.

DISPLAY INTERMEDIATE PROCESSING RESULTS (Y/N) : USER'S CRT

If the user responds "N" the process executes as fast as possible with no user intervention. If "Y", then the system stops, displays results and waits for user response on the CRT.

### 3.5.3 Modify Current Processing List -

The user can choose one of three ways to modify the current



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

algorithm processing list. The user may insert new algorithms, delete algorithms from the list, or modify parameters. The following menu of modification choices is displayed on the user's CRT.

MODIFICATION MENU

- |                               |            |
|-------------------------------|------------|
| 1) INSERT NEW ALGORITHM       |            |
| 2) DELETE ALGORITHM           | USER'S CRT |
| 3) MODIFY ALGORITHM PARAMETER |            |
| 4) EXIT                       |            |

ENTER CHOICE (1-4) :

The insert new algorithm modification choice displays only the algorithms that can be inserted into the current processing scenario. The user is then prompted to select from the algorithms as in the following example.

ADDITIONAL ALGORITHMS FOR INSERTION

- |                                  |            |
|----------------------------------|------------|
| 1) NON-SYMMETRIC IMAGE SELECTION |            |
| 2) EXIT                          | USER'S CRT |

ENTER CHOICE :

This example relates to the algorithm processing list on the previous page. If the user decides to select non-symmetric image selection, it is inserted into the appropriate place in the algorithmic processing list. This alleviates user knowledge of processing dependencies. If the user selects EXIT, no inserts are done.

The delete algorithm option allows the user to remove algorithms from the current processing list. To accomplish this, the algorithm processing list is displayed on the user's CRT.

ALGORITHM PROCESSING LIST

- |                                 |            |
|---------------------------------|------------|
| 1) MAGNIFY / DEMAGNIFY = 4      | USER'S CRT |
| 2) CONVOLUTION = MASK5X5.DAT    |            |
| 3) DISPLAY INTERMEDIATE RESULTS |            |
| 4) EXIT                         |            |

At this point, the user is allowed to delete the algorithm

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

number corresponding to the item to be deleted from the algorithm processing list. If the user decides not to delete an algorithm, the user can enter the number corresponding to exit.

ENTER ALGORITHM NUMBER TO DELETE : USER'S CRT

The last modification the user can make is parameter modification for a specific algorithm. The system displays the current processing list, and prompts the user for an algorithm number and the new processing parameters for that algorithm.

ALGORITHM PROCESSING LIST

- 1) MAGNIFY / DEMAGNIFY = 4
- 2) CONVOLUTION = MASK5X5.DAT USER'S CRT
- 3) DISPLAY INTERMEDIATE RESULTS
- 4) EXIT

The user identifies which algorithm needs a parameter change and then specifies the new parameter.

ENTER ALGORITHM NUMBER FOR PARAMETER CHANGE : USER'S CRT

If the user modifies an algorithm that contains no parameters, the system responds with a message indicating that no parameter change available for that algorithm.

NO PARAMETER CHANGE AVAILABLE USER'S CRT

If a parameter change is valid for the selected algorithm, the system prompts the user for a new parameter value.

ENTER NEW PARAMETER VALUE : USER'S CRT

The system continues to prompt the user for algorithm processing list modifications until the user exits the modification menu script.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

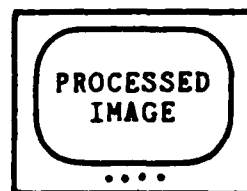
### 3.6 Processing List Execution

After a processing list retrieval, build, or modification, the current processing list is displayed along with the processing list creation menu. If the user selects the execute current processing list option, the current algorithmic processing list displayed is executed.

### 3.7 Process Images

At this point, all the information necessary to perform image characteristics functions has been input and is ready for processing. The algorithmic processing list has been built and processing in the FPAD system begins. After each algorithm which changes or transforms the video data has completed, the resultant image is displayed on the user output monitor.

USER'S MONITOR



If the user had previously selected to view and display intermediate results, the system responds with a prompt at each intermediate step and waits for a signal to continue.

CONTINUE (<cr>) :

USER'S CRT

Additionally, at each intermediate phase of the process, the system displays the current algorithmic phase being processed in image characteristics.

ALGORITHM MAGNIFY / DEMAGNIFY PROCESSING      USER'S CRT

If the user had selected not to view intermediate imagery, the process continues uninterrupted until processing by image characteristics is complete. Upon process completion, the user is prompted for the name of the file to store results. The file may be a new file or an existing open file. If there is no file currently opened to store results, the user is prompted

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

for the filename to store the results.

INPUT FILENAME TO STORE RESULTS (.DAT ASSUMED) : USER'S CRT

If a data file is currently opened, the user is prompted to store results in the currently opened file.

STORE RESULTS IN CURRENT DATA FILE (Y/N) : USER'S CRT

If the user selects "Y", the VAX stores all the results from image characteristics at the end of the currently opened output file. If the user responds with a "N", the user is prompted for the new filename to store results.

INPUT FILENAME TO STORE RESULTS (.DAT ASSUMED) : USER'S CRT

Currently, all data produced has been stored and next processing cycle is ready to be done. All data files are opened when they are first used and are closed either when a new file is opened or when processing is terminated.

### 3.8 Repeat Image Characteristics Process

If the user plans to use the current algorithmic processing list at a later date, the user can save the list in a VAX file for later recall.

SAVE ACTIVATION AND PARAMETER LIST (Y/N) : USER'S CRT

If the user decides to save the activation and parameter list for future use, the system prompts the user for a VAX output file in which to save the results.

INPUT ACTIVATION LIST STORAGE FILENAME (.SPC ASSUMED) :

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY Image Characteristics User's Guide

For the next processing cycle of image characteristics the user has several different choices for processing. Using the same image, the user may vary algorithm processing list via the modification mechanism, or the user may select a different image, or select a different configuration and new image. The user is prompted for the selection of these choices.

CONTINUE PROCESSING WITH CURRENT IMAGE (Y/N) : USER'S CRT

If the user responds "Y", the system automatically continues processing the current image allowing the user to modify the algorithm processing list in the following manner.

First the current processing list and parameters is displayed on user's CRT, for example :

### ALGORITHM PROCESSING LIST

USER'S CRT

- 1) MAGNIFY / DEMAGNIFY = 4
- 2) CONVOLUTION = MASK5X5.DAT
- 3) DISPLAY INTERMEDIATE RESULTS

The user can choose one of three ways to modify the current algorithm processing list. The user may insert new algorithms, delete algorithms from the list, or modify parameters.

If the user selects "N", the system then prompts the user to see if processing should continue with a different image or system configuration.

SELECT NEW IMAGE TO PROCESS (Y/N) :

USER'S CRT

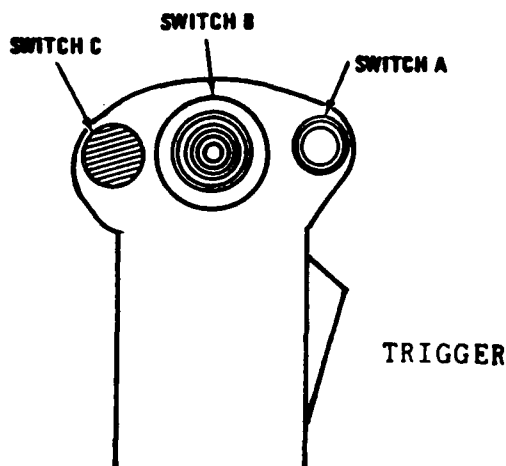
If "Y", the system returns to the Image Configuration and Selection menus and ask the user to select a new image for processing. If "N", then the system exits the Image Characteristics application and returns the user to the main applications menu.

### 3.9 Joystick Inputs

As discussed previously, joystick inputs are required to sometimes select an image to process, or select a non-symmetric image. The joystick is also required to select an Area of Interest when generating a histogram or performing an image

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY Image Characteristics User's Guide

magnification. When the histogram generation or magnification is performed, a graphics gate appears on the monitor. The user can adjust the size and position of the gate using the joystick in order to encompass the area of the image over which processing is to be done. The thumb tracker (switch B) is used to adjust the position of the gate, and the thumb tracker used simultaneously with the trigger switch at the first detent is used to adjust the size of the gate. When the desired portion of the image has been encompassed by the gate, the user must depress switch A of the grip to allow processing of the sub-image to start. Also, on the histogram process, the user can toggle between viewing the histogram of the image or the image itself by pulling the trigger on the palm grip to the second detent. To exit histogram process, depress switch A on the grip.



Palm Grip (Joystick) Switch Definition

### 3.10 Input / Output Data File Descriptions

#### Output Results File

This file contains the results of performing statistical analysis on an image, convolved image, demagnified image, or nonsymmetric image. The results are in two parts: (1) The raw data in histogram form used to generate the statistical data. (2) The moments data calculated from the histogram: mean, standard deviation, skewness, and kurtosis. They reside in a file in the following format:

# FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY Image Characteristics User's Guide

```

Example:  xxxx  Gray Level 0 Occurrences  Low Word
          xxxx  High Word
          xxxx  Gray Level 1 Occurrences  Low Word
          xxxx  High Word
          .
          .
          .
          xxxx  Gray Level 255 Occurrences  Low Word
          xxxx  High Word
          xxxx  Mean
          xxxx  Standard Deviation
          xxxx  Skewness
          xxxx  Kurtosis

```

These data files may also be concatenated during multiple processing runs. The filenames take the format:

UserSelectedName.DAT

To examine file contents, use DEC Utility DUMP.

DUMP/WORD/HEX UserSelectedName.DAT

Each run produces three blocks of information stored on the VAX. Blocks one and two contain the image histogram, while block three contains the image statistical information. The remaining space in block three is set to the value zero. The file is written using a fixed 2-byte record format.

## Convolution Mask File

This file contains the convolution mask size and the actual mask data that is applied to the video data. The mask file contains one data item per line of the data file which goes into the actual mask in row major order. The following example gives the format for a NxN convolution mask where N = 3.

# FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY Image Characteristics User's Guide

Example: 3 x 3 North Mask

NORTH\_MASK.DAT

1	1	1	File Contents -	3	Size of Mask
-1	2	-1		1	
-1	-1	-1		1	
				-1	
				2	Mask Data
				-1	
				-1	
				-1	
				-1	

## Canned Algorithm File

This file contains the algorithms and parameters necessary to process Image Characteristics Application software. During the execution of Image Characteristics, the user interactively builds an algorithmic processing list and associated parameters which specifies what processes are performed on image. At the completion of the processing the user may save the algorithmic list in a file for later retrieval. This canned algorithmic file is created by the system and can be used at a later date to perform the same algorithmic suite. The user inputs the filename to store algorithms, the SPC extension is appended automatically.

UserSelectedFile.SPC

## Autoprocess Specification File

This file contains the processing specifications and user inputs in a command file for executing Image Characteristics with no user keystrokes. These command level files contain all the inputs the user would make during interactive processing. This file is created using a standard VAX editor.



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

Example:

1	-- CONFIGURATION SELECTION
2	-- REFERENCE FRAME SELECTION
12345	-- FRAME ID NUMBER
1	-- CANNED ACTIVATION LIST
ACTLIST8	-- CANNED ACTIVATION LIST FILENAME
Y	-- SAVE PROCESSING RESULTS
OUTDAT	-- OUTPUT FILE FOR RESULTS
N	-- NO NEW CONFIGURATION
N	-- NO NEW IMAGE

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

3.11 Non-Symmetric Sub-Image Selection

The purpose of the Non-Symmetric Image Selection function is to allow the user of the Image Characteristics data reduction software the capability to select sub-images within the current working image and perform statistical analysis on the sub-image. The Non-Symmetric Image Selection function is a subordinate subroutine to the Image Characteristics function. The following user guide describes how the Image Characteristics user interfaces with the Non-Symmetric Image Selection process.

3.11.1 Sub-Image Selection -

During the Image Characteristics process identification the user is asked if a non-symmetric sub-image will be processed by the Image Characteristics function.

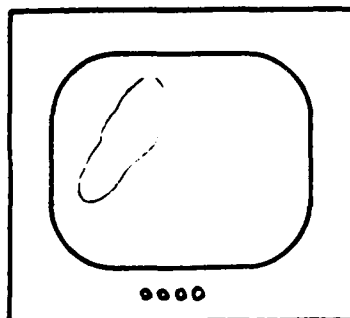
NON-SYMMETRIC IMAGE SELECTION REQUIRED (Y/N) : USER'S CRT

The user is allowed to select a portion of the image for Image Characteristic processing. The system also prompts the user for the sub-image highlighting color (black/white). If no sub-images are required for processing, the system continues with Image Characteristics function.

HIGHLIGHTING COLOR FOR TRACE (BLACK/WHITE) : USER'S CRT

Upon completion of the algorithm selection that is internal to Image Characteristics driver, the image is displayed on the user monitor.

USER'S MONITOR



STATIC  
IMAGE

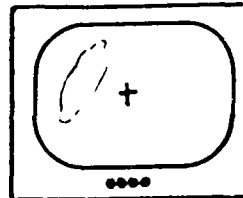
# FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY Image Characteristics User's Guide

When the system is ready, the system sends a message to the user's CRT and displays a crosshair on the user's monitor. This allows the user to select a sub-image for processing.

ALGORITHM NON-SYMMETRIC PROCESSING

USER'S CRT

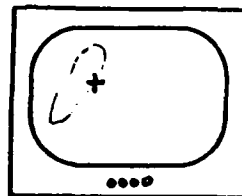
USER'S MONITOR



STATIC  
IMAGE

Using the FPAD joystick thumb controller (switch B), position crosshair to the edge of the image for tracing.

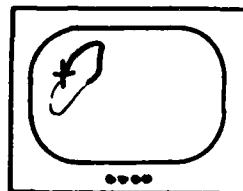
USER'S MONITOR



STATIC  
IMAGE

When the user has satisfactorily placed the crosshair on the edge of the sub-image, the trace is initialized from the FPAD joystick by depressing switch A on the joystick. As the crosshair is moved around the sub-image, the edge of the image is highlighted with the previously selected highlight color. Using the FPAD thumb controller on the joystick, move the crosshair around the sub-image until the sub-image is encompassed by the trace.

USER'S MONITOR

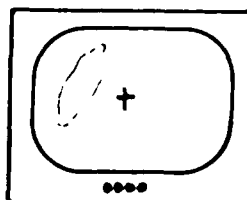


STATIC  
IMAGE

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Image Characteristics User's Guide

If at any time during the trace, the user wishes to restart the tracing process, the user should depress switch A on the FPAD joystick and the system restores the processing to the initial trace mode.

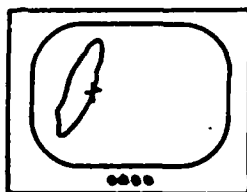
USER'S MONITOR



STATIC  
IMAGE

When the user has satisfactorily completed sub-image tracing, terminate the trace mode by pushing switch C up on the FPAD joystick.

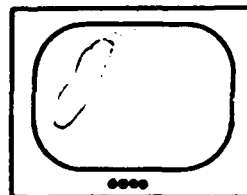
USER'S MONITOR



STATIC  
IMAGE

Upon successful termination of trace mode, the system displays the user selected sub-image on the user's monitor.

USER'S MONITOR



STATIC  
IMAGE

For detailed joystick switch definition, see section titled Joystick Inputs (page 30).

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

4 AUTOMATIC GROUND TRUTHING

The purpose of the Ground Truthing function is to provide users the capability to measure tracker or ATR performance against a known ground truth file. The software resident in the FPAD allows the user to select targets from the FPAD joystick, then automatically create the ground truth file. The information in the ground truth file might include target position, pixel extent, and various other target statistics.

This section describes to the Ground Truthing User how to accomplish the following tasks :

	Page
o ACTIVATION OF GROUND TRUTHING	38
o IMAGE SELECTION	41
o ALGORITHM PROCESSING LIST CREATION	41
- PROCESSING LIST RETRIEVAL	42
- INTERACTIVE PROCESSING LIST BUILD	42
- MODIFY CURRENT PROCESSING LIST	43
o PROCESS IMAGES	45
o REPEAT GROUND TRUTHING PROCESS	47
o INTERPRET INPUT / OUTPUT FILES	48

4.1 Activation Of Ground Truthing

To invoke the Ground Truthing function, do the following:

1. Logon to the VAX.
2. Verify the FPAD system power is on.
3. Type "FPAD" at the VAX command level.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

Transparent to the user, the command level procedure allocates the FPAD logical device to lock out other system users. If FPAD has been previously allocated, the user is automatically notified that the system is in use and the process exits and returns to the VAX command level. The following message is displayed on the user's CRT.

FPAD ALLOCATED BY ANOTHER USER

USER'S CRT

After the FPAD device has been allocated by the user, the following menu is displayed on the user's CRT. (For a high level overview of processing, see the figure on the following page.)

APPLICATIONS MENU

- 1) FEATURE ANALYSIS
- 2) IMAGE CHARACTERISTICS
- 3) GROUND TRUTHING
- 4) EXIT

USER'S CRT

ENTER SELECTION (1-4) :

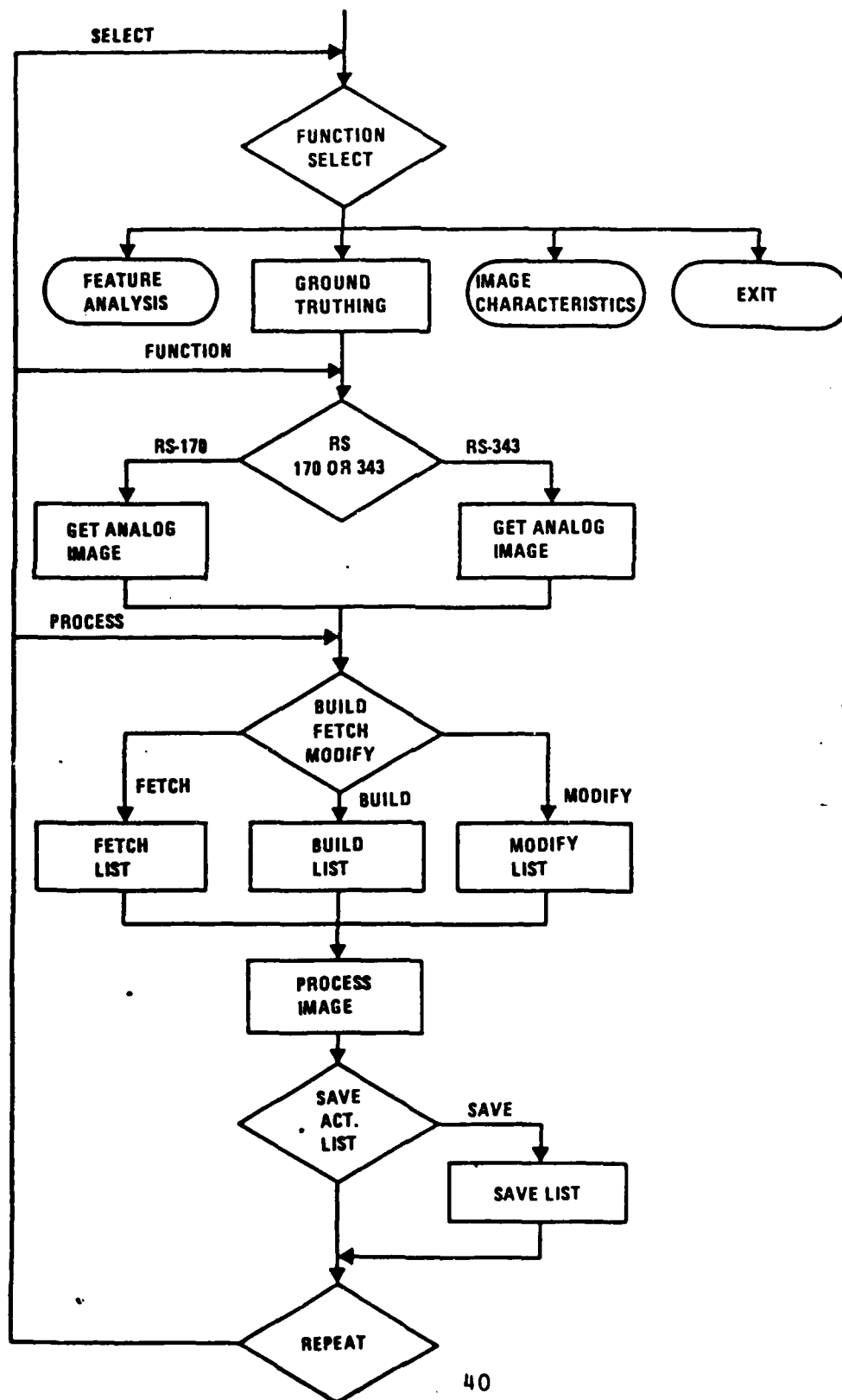
Select the Ground Truthing function. At this point the Ground Truthing software is loaded into FPAD if necessary. If the software is already resident in FPAD, no loading occurs. The Ground Truthing function is then activated. The following is displayed during the loading process. This message is displayed to inform the user of the current system status.

LOADING SYSTEM

USER'S CRT

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

4.2 Ground Truthing Process Overview Flowchart



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

Once the proper load file is stored in FPAD, the following message is displayed:

GROUND TRUTHING

USER'S CRT

#### 4.3 Image Selection

From the following menu, select the type of input imagery to process with Ground Truthing.

SELECT IMAGERY TYPE FOR PROCESSING

- 1) RS-170 CHANNEL 2 (NON-INTERLACE)
- 2) RS-343 CHANNEL 2 (NON-INTERLACE) USER'S CRT
- 3) DIGITAL VAX TO VFM
- 4) DIGITAL VFM TO VAX

ENTER CHOICE (1-4) :

The user must select a TV video format for processing with the Ground Truthing function. If the user selects digital video data from a VAX file to be used for processing, the system reprompts for a valid TV format. The Ground Truthing application software requires a contiguous stream of analog RS-170/343 frames from either a VTR or a TV Camera to facilitate processing.

USER'S MONITOR



#### 4.4 Algorithm Processing List Creation

The user now needs to select the type of algorithmic processing to be done on the imagery. The algorithmic processing list can be built through an interactive menu, or via a canned algorithmic processing list saved in a VAX file, or through a modification of an existing processing list.



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

The final two options allow the user to execute the currently displayed processing list with no changes, or exit the Ground Truthing process.

ALGORITHMIC PROCESSING LIST CREATION

- 1) PROCESSING LIST RETRIEVAL
- 2) INTERACTIVE PROCESSING LIST BUILD USER'S CRT
- 3) MODIFY CURRENT PROCESSING LIST
- 4) EXECUTE CURRENT PROCESSING LIST
- 5) EXIT

ENTER CHOICE (1-5) :

4.4.1 Processing List Retrieval -

If a canned format is to be retrieved from a VAX file, the user is asked for the filename containing the algorithmic processing list. All files containing algorithm specifications must have a .SPC extension. The system assumes a .SPC extension for all files to be stored or retrieved. DO NOT include .SPC in the filename.

INPUT CANNED ACTIVATION LIST FILENAME (.SPC ASSUMED) :

Once the input file has been selected, the activation list and its associated parameters are displayed on the user's CRT, as in the following example. If the user does not know the Canned Activation List filename or accidentally enters option 1, an exit mechanism is provided. The system prompts the user up to three times for a valid filename, if after three attempts a valid filename is not entered, the Algorithmic Processing List Creation Menu is redisplayed for user selection.

ALGORITHMIC PROCESSING LIST

- 1) INTENSITY CENTROID USER'S CRT
- 2) RECORD TRACK DATA = 0,1,2,3,20,21

4.4.2 Interactive Processing List Build -

If the user selects to build an algorithmic processing list through a menu script, the user is prompted for all the

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

possible options which can be performed to accomplish the Ground Truthing processing.

The following prompts are displayed awaiting a user response:

GROUND TRUTHING ALGORITHM

- 1) INTENSITY CENTROID
- 2) GEOMETRIC CENTROID
- 3) SSDA CORRELATION

USER'S CRT

ENTER CHOICE (1-3) :

The user may select an Intensity Centroid, Geometric Centroid, or SSDA Correlation process to be used to create Ground Truth data. The user must now select the number of track database entries to save per processing time and identify the exact database entries to save.

INPUT NUMBER OF ENTRIES TO RECORD (1-8) : USER'S CRT

If the user inputs a number which falls outside the 1 to 8 range, the system reprompts the user for another input. Upon valid selection of the number of entries to record, the system prompts the user for the track file offsets of the data to be recorded.

TRACK FILE OFFSET FOR RECORDING : USER'S CRT

This prompt is repeated until all the entries for recording have been input. If an illegal track file offset is specified, the system continues to reprompt until a valid input is received. See Table 1 for the legal Track File Offsets the user may select.

#### 4.4.3 Modify Current Processing List -

The user can choose one of three ways to modify the current Ground Truthing processing list. The user may change the algorithm used to generate the Ground Truth data, the offsets in the track file which are recorded every processing time, or the user can modify the algorithm and offsets to be recorded. The current processing list and the modification menu is displayed on the user's CRT. The following is a

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

sample display.

ALGORITHM PROCESSING LIST

- 1) INTENSITY CENTROID
- 2) RECORD TRACK DATA = 0,1,2,3

USER'S CRT

MODIFICATION MENU

- 1) ALGORITHM
- 2) OFFSET RECORDING
- 3) BOTH ALGORITHM AND OFFSET
- 4) EXIT

ENTER CHOICE (1-4) :

The algorithm modification menu displays the list of algorithms which can be used to generate the Ground Truth Data. The user is then prompted to select from the list of available algorithms.

GROUND TRUTHING ALGORITHMS

- 1) INTENSITY CENTROID
- 2) GEOMETRIC CENTROID
- 3) SSDA CORRELATION

USER'S CRT

ENTER CHOICE (1-3) :

The offset recording modification choice allows the user to change which track database offsets get recorded each processing time. The user selects the number of track database entries to record and identifies the offset of each database entry.

INPUT NUMBER OF ENTRIES TO RECORD (1-8) : USER'S CRT

If the user inputs a number which falls outside the 1 to 8 range, the system reprompts the user for another input. Upon valid selection of the number of entries to record, the system prompts the user for the track file offsets of the data to be recorded. See Table 1 for specification of the track file offsets.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

TRACK FILE OFFSET FOR RECORDING : USER'S CRT

This prompt is repeated until all the entries for recording have been input. If an illegal track file offset is specified, the system continues to reprompt until a valid input is received.

The last modification choice prompts the user for both algorithm for ground truth generation, and offsets to record each processing time. The exit option allows the user an escape mechanism from the modification menu.

#### 4.5 Process Image

At this point, all the information necessary to perform Ground Truthing functions has been input and is ready for processing. The algorithmic processing list has been built and processing in the FPAD system begins.

Before acquiring targets, the user selects a file to store results. The file may be a new file or an existing open file. If the user wishes to perform the tracking function without saving the results, acquire targets and enter track mode before selecting a file to store results. Targets may be deacquired, and new targets acquired and tracked. Then, if the user wishes to store processing results, input the filename for data storage. All data files are opened when they are first used, and are closed either when a new file is opened or when processing terminates.

STORE DATA IN OPEN OUTPUT FILE (Y/N) : USER'S CRT

If the user selects "Y", the VAX stores all the results from Ground Truthing at the end of the currently open output file. If the user responds with a "Y" and no file is open, or if a new file is requested, the following prompt is displayed.

INPUT FILENAME TO STORE RESULTS (.DAT ASSUMED) : USER'S CRT

All Ground Truthing result files must have a .DAT extension. The system assumes a .DAT extension for all files to be stored. DO NOT include .DAT in the filename. Currently, all data produced has been stored and next processing cycle is ready to execute.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

In the system, the acquisition and deacquisition scheme is controlled through the FPAD joystick. See Figure A for switch and control identification.

To acquire a target, do the following :

- a. Initialize the target acquisition process by momentarily depressing switch A on the joystick. The message "ACQ MODE" is displayed on the monitor and gate appears in the center of the display.
- b. Using switch B, position the gate on the desired target. Pull the trigger switch in to the first detent position and manipulate switch B to size the gate.
- c. When the gate is positioned and sized correctly around the target, momentarily depress switch A to initialize the tracking scenario.

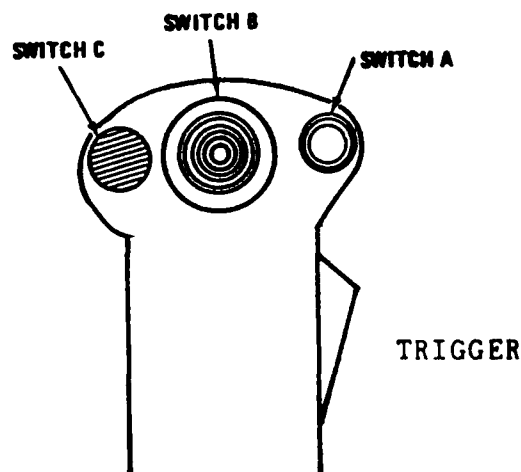


Figure A - Joystick Description

In the system, the deacquisition scheme is controlled through the FPAD joystick. A target can be manually deacquired from the joystick by pulling the trigger switch in to the second detent position and pushing up on switch C of the joystick.

To terminate the tracking sequence and return control to the VAX driver, the user must execute an "Exit Sequence" from the FPAD joystick. This is performed by pulling switch C down until the next prompt is displayed on the user's CRT.

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### Automatic Ground Truthing User's Guide

Once all the parameters have been set up by the user, the typical Ground Truthing scenario proceeds as follows :

- o Enter filename to store results.
- o Acquire target manually.
- o Deacquire target manually.
- o Enter new or existing filename.
- o Acquire target manually.
- o Deacquire target manually.
- o Enter new or existing filename.
- o Execute termination sequence.

#### 4.6 Repeat Ground Truthing Process

If the user plans to use this configuration of algorithms at a later date, the user can save the algorithm processing list in a VAX file for later recall.

SAVE ACTIVATION AND PARAMETER LIST (Y/N) :                      USER'S CRT

If the user decides to save the activation and parameter list for future use, the system prompts the user for a VAX output file in which to save the processing list. All files containing algorithm specifications have a .SPC extension. The system assumes a .SPC extension for all files stored or retrieved. DO NOT include .SPC in the filename.

INPUT ACTIVATION LIST STORAGE FILENAME (.SPC ASSUMED) :

For the next processing cycle of Ground Truthing the user has several different choices for processing. The user may alter the algorithm processing list via the modification mechanism or select a different configuration. The user is prompted for the selection of these choices.

CONTINUE PROCESSING WITH CONFIGURATION (Y/N) :                      USER'S CRT

# FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

## Automatic Ground Truthing User's Guide

If the user responds "Y", the system automatically continues processing the current system configuration allowing the user to modify the algorithm processing list in the following manner. First the current processing list and parameters is displayed on user's CRT, for example :

### ALGORITHMIC PROCESSING LIST

```
1) INTENSITY CENTROID          USER'S CRT
2) RECORD TRACK DATA = 0,1,2,3,20,21
```

The user can choose one of three ways to modify the current algorithm processing list. The user may insert new algorithms, delete algorithms from the list, or modify parameters.

If the user wishes to exit Ground Truthing, continue processing with current configuration, this returns the user to main processing list menu. At the main processing list menu, select the exit option.

## 4.7 Input / Output Data File Descriptions

### Output Results File

This file contains the results of performing tracking function on the user selected analog image sequence. The data residing in the file are the user selected trackfile information recorded every processing time. The data resides in the following format:

```
Example      xxxx      Time 0      x Position
              xxxx      y Position
              xxxx      x Size
              xxxx      y Size
              xxxx      Time 1      x Position
              xxxx      y Position
              xxxx      x Size
              xxxx      y Size
              .
              .
              .
              xxxx      Time n      x Position
              xxxx      y Position
              xxxx      x Size
              xxxx      y Size
```

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### Automatic Ground Truthing User's Guide

In this example, the user selected to record four items, x and y position and size. These data files may also be concatenated during multiple processing runs. The filenames take one format:

userselectedname.DAT

To examine file contents, use DEC utility DUMP.

DUMP/WORD/HEX userselectedname.DAT

The VAX file consists of fixed 1024-byte records. The large record size was used to reduce the file writes to the VAX disk, this allows the VAX to read and store all the the FPAD produced information without any data lose. If runs are concatenated, each run is separated by a set of zeros. At the end of each logical VAX block there is anywhere from zero to seven trailing zeros depending on the number of words stored per processing time.

#### Canned Algorithm File

This file contains the algorithms and parameters necessary to process Ground Truthing application software. During the execution of Ground Truthing, the user interactively builds an algorithmic processing list and associated parameters which specifies what processes are performed on the image. At the completion of the processing the user may save the algorithmic list in a file for later retrieval. This canned algorithmic file is created by the system and can be used at a later date to perform the same algorithmic suite. The user inputs the filename to store data, the .SPC extension is appended automatically.

userselectedfile.SPC



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

TABLE 1 - TRACK FILE OFFSET TABLE

The offsets in the track table provides the Ground Truthing User with the capability to reference data stored in the FPAD and record data information for later analysis in the VAX.

OFFSET	CONTENTS
0	TARGET X POSITION - UPPER LEFT CORNER
1	TARGET Y POSITION - UPPER LEFT CORNER
2	TARGET X SIZE
3	TARGET Y SIZE
4	TARGET X CENTER
5	TARGET Y CENTER
6	TARGET X ENDING POSITION - LOWER RIGHT CORNER
7	TARGET Y ENDING POSITION - LOWER RIGHT CORNER
8	SKIP SAMPLE RATE
9	NUMBER OF PIXELS IN X DIRECTION
10	NUMBER OF LINES IN Y DIRECTION
11	PREDICTED X POSITION - SCALED BY 16
12	PREDICTED Y POSITION - SCALED BY 16
13	PREDICTED X RATE - SCALED BY 16
14	PREDICTED Y RATE - SCALED BY 16
15	CURRENT TRACKER MODE 0 - CENTROID 1 - CORRELATION
16	CURRENT VFM NUMBER FOR POST PROCESSING - 0,1,2,3
17	TARGET DEACQUISITION STATUS 0 - OK 1 - LOST LOCK
18	TARGET EXIT FIELD OF VIEW STATUS 0 - OK 1 - EXIT FIELD OF VIEW
19	REFERENCE WINDOW SCRATCH PAD ADDRESS

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Automatic Ground Truthing User's Guide

OFFSET	CONTENTS
20	CORRELATION STATUS WORD 0 - REFERENCE WINDOW UPDATE NEEDED SET WHEN FIRST ENTERING CORRELATION TRACKING OR WHEN REFERENCE UPDATE CRITERIA EXCEEDED 1 - NEED TO SET MINIMUM AND MAXIMUM CORR VALUES 2 - NORMAL CORRELATION
21	MINIMUM CORRELATION VALUE FROM THE FIRST FRAME
22	MAXIMUM CORRELATION VALUE FROM THE FIRST FRAME
23	CURRENT MINIMUM CORRELATION VALUE
24	AVERAGE TARGET INTENSITY
25	AVERAGE BORDER INTENSITY
26	HOT/COLD TARGET FLAG 0 - HOT 1 - COLD 2 - GREY
27	UPPER THRESHOLD
28	LOWER THRESHOLD
29	NEW X GATE SIZE
30	NEW Y GATE SIZE
31	NUMBER OF PIXELS BEFORE SKIP SAMPLING REQUIRED
32	PREVIOUS X SIZE
33	PREVIOUS Y SIZE
34	GATE OR THRESHOLD ACTIVATION
35	PREVIOUS X POSITION - UPPER LEFT CORNER
36	PREVIOUS Y POSITION - UPPER LEFT CORNER
37	INSTANTANEOUS X RATE
38	INSTANTANEOUS Y RATE
39	COAST COUNT
40	COAST MODE FLAG 0 - NORMAL TRACKING 1 - COAST MODE
41	CONTRAST RATIO
42	CLUTTER INDICATION FLAG
43	TARGET EXTREME POINT
44	SIGNAL TO NOISE RATIO
45	ALGORITHM SELECTED BY TSL
46	FRAME NUMBER LOWER WORD
47	FRAME NUMBER UPPER WORD

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

5 SUPPORT FUNCTIONS

The following functions are available to the FPAD FAST user to support image processing activities on FPAD. The support functions include :

	Page
o Automatic Data Processing	53
o Configuration Selection	60
o Frame Number Referencing	62
o Nato Tape Read	64
o VAX / FPAD Interface	67

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

## 5.1 Automatic Data Processing

The purpose of the Automatic Data Processing function is to provide an operational mode that requires minimal user interaction. Image Characteristics and Feature Analysis are the only modes that automatic processing is available for, i.e., no automatic processing is available for Ground Truthing.

In the automatic mode, the FPAD system processes image data as specified by the VAX instruction file. The instruction file includes all user inputs, i.e., the user prepares an instruction file that contains every input that the user would normally input on a VAX terminal. The user then logs on the VAX, activates the FAST software, selects Image Characteristics or Feature Analysis, and selects Automatic Data Processing. The only other required input is the VAX filename of the instruction set. The data is then be processed automatically.

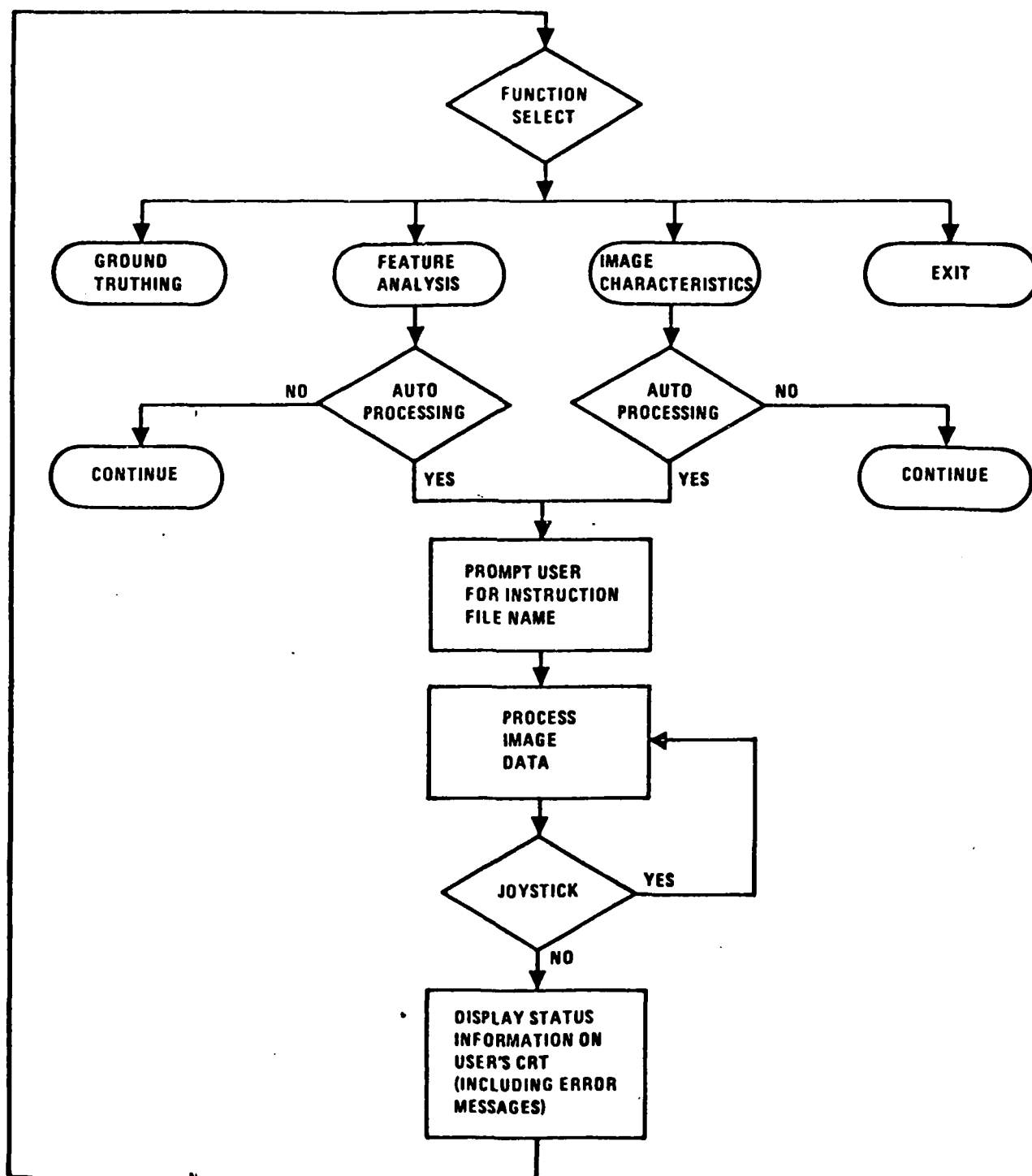
This section describes to the Image Characteristics and Feature Analysis User how to accomplish the following tasks :

	Page
o ACTIVATION OF AUTOMATIC DATA PROCESSING	55
o HOW TO PREPARE VAX INPUT INSTRUCTION FILES FOR:	58
- VIDEO CONFIGURATION	
- VIDEO FRAME NUMBERS	
- ALGORITHM SELECTION (Restricted to Processing List Retrieval only)	
o JOYSTICK INPUTS	56
o REPEAT AUTOMATIC PROCESSING	57
o ERROR RECOVERY AND MESSAGES	57

An Automatic Data Processing overview flowchart is shown on the following page. Automatic Processing code is nested within the Feature Analysis and Image Characteristics code so Automatic Processing is transparent to the user during normal operations.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

5.1.1 Automatic Processing Overview Flowchart -



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

5.1.2 Activation Of Automatic Data Processing -

The code for Automatic Processing resides within the Feature Analysis and Image Characteristics VAX software. The user is prompted for Automatic Processing when Feature Analysis or Image Characteristics is selected, and functions that are not available in the Automatic Processing mode are branched over when the Automatic Processing mode is selected. All inputs for Automatic Processing are specified in a VAX instruction file, and options that are not available must not be included in the input file.

To invoke the Automatic Data Processing function, do the following:

1. Log on to the VAX.
2. Verify the FPAD system power is on.
3. Type "FPAD" at the VAX command level.

Transparent to the user, the command level procedure allocates FPAD logical device to lock out other system users. If FPAD has been previously allocated, the user is automatically notified that the system is in use, and the process exits and returns to the VAX command level. The following message is displayed on the user's CRT.

FPAD ALLOCATED BY ANOTHER USER

USER'S CRT

After the FPAD device has been allocated by the system, the following menu is displayed on the user's CRT.

APPLICATIONS MENU

- 1) FEATURE ANALYSIS
- 2) IMAGE CHARACTERISTICS
- 3) GROUND TRUTHING
- 4) EXIT

USER'S CRT

ENTER SELECTION (1-4) :

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY Support Functions User's Guide

If Feature Analysis or Image Characteristics is selected, the appropriate software is loaded into FPAD unless it is already loaded. If the software must be loaded, the system loads it and displays the following message on the user's CRT.

LOADING SYSTEM

USER'S CRT

After the appropriate software is loaded, the system prompts the user for Automatic Data Processing.

AUTOMATIC PROCESSING (Y/N) :

USER'S CRT

If the user selects "N", interactive processing continues. If "Y" is selected, the system prompts the user for the VAX instruction filename as follows.

AUTO PROCESSING FILENAME :

USER'S CRT

Image data is processed according to the VAX instruction file. If the user does not know the Autoprocessing filename or accidentally enters "Y", an exit mechanism is provided. The system prompts the user up to three times for a valid filename, if after three attempts a valid filename is not entered, Autoprocessing is terminated and interactive processing is activated.

### 5.1.3 VAX Instruction File Format -

The Automatic Data Processing input file format is one input per line, and the order must be the same as if the user were inputting instructions on a CRT. Comments to the right of the inputs are optional. A sample input file is provided at the end of this section.

### 5.1.4 Joystick Inputs -

If the instruction file contains options that require joystick inputs, the image processing halts and allows the joystick inputs. Automatic processing resumes upon joystick input termination. Joystick inputs are required for Non-Symmetric Image Selection, Feature Analysis segment connection, Histogram area selection, providing detection

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### Support Functions User's Guide

area specifications for the segmenters, and to select desired frame for processing.

The user must monitor the user's CRT to determine when to input joystick commands. Joystick inputs when the system is not expecting them are ignored.

#### 5.1.5 Processing Status -

At each intermediate phase of the process the system displays the current algorithmic phase being processed in Feature Analysis or Image Characteristics.

ALGORITHM MEDIAN PROCESSING

USER'S CRT

#### 5.1.6 Repeat Processing -

The instruction file may contain as many image processing cases as desired, but each case must be input in the file, i.e., there is no looping within the input file.

#### 5.1.7 Error Recovery -

Errors that occur in the Automatic Processing file force termination of automatic processing and returns the user to the interactive mode. Previously stored results are saved. The user needs to delete successfully processed data's inputs before rerunning after the error has been corrected, i.e., prior to rerunning, the user should correct the error in the input file, delete all inputs for runs that were successfully completed, and restart the process.

#### 5.1.8 Error Messages -

The following error messages are outputted "as required" for post processing error analysis.

1. File 'filename' not found
2. Option 'option ' not available



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

3. Unexpected input 'echo input'

Processing goes into interactive mode upon error detection, and the error message is displayed on the user's CRT.

5.1.9 Building An Automatic Data Processing File -

The Automatic Data Processing input file is a text file that contains one input per line. Notes to the right of the inputs are optional.

1. INPUT Imagery type (1 - 4):

- o 1,2 - INPUT Frame selection process (1 or 2)  
- INPUT Frame ID number for option 2
- o 3 - INPUT Vax 'filename'
- o 4 - INPUT VFM number (0 - 3)  
- INPUT Vax 'filename'

2. INPUT Algorithm processing list manipulation (1 or 4)

- o 1 - INPUT 'filename' Canned activation list
- o 4 - { Execute current activation list. }  
{ DO NOT enter this option for the first pass. }

3a. INPUT 'filename' to store results {used for first pass only}

OR

3b. INPUT Store results in currently opened file (Y or N)

- o N - INPUT 'filename' to store results

4. INPUT Continue processing with current image (Y or N)

- o Y { Goto step number 2. }
- o N - INPUT New image to process (Y or N)  
Y { Goto step number 1. }  
N { Terminate Automatic Processing }

# FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY Support Functions User's Guide

## 5.1.10 Sample Automatic Data Processing Input Files -

### Image Characteristics Example

Instruction File Inputs	Process Selection Explanation
3	Digital image VAX to VFM .
IMAGE1	Digital image filename.
1	Algorithm processing list retrieval.
ACTLIST1	Canned activation list filename.
Y	Store output data
OUTDAT	Output filename to store results.
N	Continue processing with current image?
Y	New image to process?
4	Digital Image read VFM to VAX.
1	VFM Number for read.
SAVEIMAGE	VAX file to store results.
3	Digital image VAX to VFM.
IMAGE2	Digital image filename.
1	Algorithm processing list retrieval.
ACTLIST2	Canned activation list filename.
Y	Store output data
Y	Store data in open output file?
N	Continue processing with current image?
N	New image to process?

### Notes :

- 1) The last entry terminates the Automatic Processing mode.
- 2) The following options are not available in the Automatic Processing mode.
  - o Build Processing List.
  - o Modify Processing List.
  - o Save Activation List.
  - o View Intermediate Results
- 3) Canned activation lists are created in the user interactive processing list build mode. After definition the user elects to save the processing list, therefore it is not possible for the user to create the canned processing input files manually.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

5.2 Video Configuration Selection

The purpose of the Configuration Selection Support function is to allow the user to define the type of imagery to be processed by the application / data reduction software. This support function is called from all the application / data reduction software packages for system configuration.

5.2.1 FPAD System Configuration -

From the following menu, select the type of input imagery to process with the application software. The available input imagery includes : RS-170/343 TV compatible video data, and digital video data residing in VAX disk files. The Configuration Selection function provides one additional capability to the FPAD user, the capability to read data stored in a FPAD video frame memory and move the data to a VAX disk file for analysis or future use.

SELECT IMAGERY TYPE FOR PROCESSING

- 1) RS-170 CHANNEL 1 (NON-INTERLACE)
- 2) RS-343 CHANNEL 1 (NON-INTERLACE) USER'S CRT
- 3) DIGITAL VAX TO VFM
- 4) DIGITAL VFM TO VAX

ENTER CHOICE (1-4) :

If the user selects digital video data from a VAX file, the system prompts the user for the file to load the Video Frame Memory.

INPUT FILENAME FOR VFM LOADING (.DAT ASSUMED) : USER'S CRT

If digital video data from VFM to VAX data file is selected, the system prompts for the VFM number (0 - 3) and the VAX filename to store the data.

ENTER VFM NUMBER FOR READ (0-3) :

USER'S CRT

ENTER FILENAME FOR VFM DATA STORAGE (.DAT ASSUMED) :

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### Support Functions User's Guide

The capability to move digital data from a VFM to the VAX allows the user to store processed or unprocessed data from the FPAD in a VAX disk file. Upon completing the digital data read, the Configuration Selection function prompts the user for another FPAD system configuration. During digital input and output, the FPAD must either be connected to an RS-343 input device on input channel 2, or have no input video on input channel 2.

This support function is a general purpose module for FPAD configuration. The driver code which activates the module determines if the selected configuration is suitable for the application. If the selected configuration is invalid for the application, the configuration menu is redisplayed and the user selects a new configuration. The only unexecutable configuration is if the user selects digital video data for use with the ground truthing application, the application software would not get the stream of analog data at a 60Hz rate it needs to accomplish the processing task.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

5.3 Frame Number Referencing

The purpose of the Frame Number Referencing Support function is to provide personnel using the FAST Facility the capability to correlate image statistical data with the specific image from which it was derived, and to provide a means for selecting images from RS-170/343 input sources. This support function is called from all the application / data reduction software packages for frame number referencing.

5.3.1 Frame Numbering And Selection Process -

If the user selects TV type imagery for processing, the user must select a mechanism for retrieving a RS-170/343 frame from either a VTR or a TV Camera. The system prompts the user for the selection process with the following menu:

FRAME SELECTION PROCESS

- 1) SELECT FRAME WITH JOYSTICK
- 2) SELECT FRAME USING ID NUMBER                      USER'S CRT

ENTER CHOICE (1-2) :

If the user decides to search for a specific ID number, the system prompts the user for the search ID number.

INPUT FRAME ID NUMBER FOR PROCESSING :              USER'S CRT

At this point, the digital video data is already loaded into a video frame memory. For the RS-170/343 TV format data, the frame for processing is ready to be selected. Start the video stream (analog) into the FPAD, verify the Datum is attached and power is applied to the device. For the TV camera apply power to the device and for a VTR start video stream by depressing play button on the recorder/ player. Video is displayed on the video monitor.

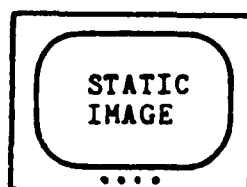
FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

USER'S MONITOR



For frame ID searches, when a frame ID match occurs the frame is automatically stored in a FPAD video frame memory. If selecting an image with the joystick, upon viewing the desired image, depress switch A on the joystick to select the frame. If the user is searching for a specific frame ID number and no match occurs, the user has two options: load another tape and continue to search for the ID number, or select a frame for processing via the FPAD joystick frame selection process. Upon frame selection, via FPAD joystick or ID number match, or after completing a digital load, the following is displayed on the video monitor.

USER'S MONITOR



At this point, the image to be processed with application software has been selected, and stored in a video frame memory of FPAD. Also, the frame number read by the Datum Reader has been stored for application use. If digital data was loaded into the FPAD, the system displays on the user monitor the digitally loaded data.

If the system is searching for a specific frame ID number, and the user wishes to terminate search, a frame may be selected by the FPAD joystick. This joystick selection of a frame overrides the search mechanism and provides a means to recover from a no match situation.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

5.4 Nato Tape Read

The purpose of this program is to read a NATO format tape containing image data, and then store that data in a user specified file on VAX disk. The NATO format that is read by this program is that specified by the FPAD/FAST contract. Other formats may fail to be read during program execution. In the current implementation of the taperead program, all images read from tape are stored in a 512 by 512 format. This means that any images that are larger than 512 by 512 are skip sampled in order to fit the 512 by 512 format.

5.4.1 Begin Program Execution -

To start the NATO tape read program enter the command

@TAPERREAD

A menu appears on the terminal with the options

- 1) RETURN TO VMS
- 2) READ NEW TAPE
- 3) READ SAME TAPE

5.4.2 Return To VMS -

Selection of this function from the main menu dismounts the tape, and deallocate the tape drive if required. The user is returned to the VMS operating system.

5.4.3 Read New Tape -

Selection of this function causes the dismount of the previous tape, or the allocation of a tape drive as necessary. Next, the user is asked to mount a new tape and then the tape read process begins as outlined below. Note: The user must take note of which tape drive is allocated.

5.4.4 Read Same Tape -

Selection of this function invokes the rewind of the current tape on the drive. The tape read process begins as outlined below.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

5.4.5 Tape Read Process -

When options 'READ NEW TAPE,' or 'READ SAME TAPE' are selected, the tape read process is started. The user receives the prompt

```
INPUT TAPE DRIVE USING
  1) MTA0
  2) MTA1
ENTER NUMBER:
```

When the user has correctly specified a tape drive, the next prompt appears.

```
SELECT TYPE OF TAPE READ
  1) READ FILES N TO LAST FILE
  2) READ FILE N ONLY
ENTER CHOICE:
```

Mode 1 causes all the files starting with file N up to and including the last file on the tape to be read. Mode 2 causes file N to be read only. When a read mode has properly been selected, the following prompt appears.

```
INPUT TAPE FILE TO READ (0-N)=
```

The response to this question must be zero or a positive integer value. The number corresponds to the sequential position of the file on the tape. For example, 0 corresponds to file 1, 1 to file 2, and so on. After the file number has been specified, a search for the file is performed, and the file is read. Information from header block 1 for the file is displayed on the user monitor. When the file has been read, the user is asked for the name of the file to store the image data on VAX disk.

```
FILENAME FOR IMAGE DATA (.DAT WILL BE APPENDED)=
```

The user must input a legal filename without an extension. The .DAT extension is appended to the name. For example, if IMAGE1 is given as the filename, the results are stored in file IMAGE1.DAT. Once the data has been written to disk, the program returns to the main menu if file N only was read. Otherwise, the files N+1 through the last file is read. For each file read, the header 1 block information is displayed, and the user is asked for a filename to store results. When all files have been read, the program returns to the main menu.



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

5.4.6 Notes -

The tape drive mount and dismount are performed automatically through a VAX command file. If no drives are available for use, the command file exits without running the tape read program. If the program should fail during execution, or if the user aborts the program during execution, it is highly probable that the tape drive is still allocated to the user. The user should release the drive with the following commands.

```
>DISMOUNT <drive name>  
>DEALLOCATE <drive name>
```

Some error checking for the user response to the program prompts has been written into the program. However, it is still possible to crash the program by entering wrong response values to the message prompts. If this occurs, it is necessary to dismount the tape and deallocate the drive before restarting the program.

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### Support Functions User's Guide

#### 5.5 VAX/FPAD Interface

The purpose of the VAX/FPAD link is to allow a user at a VAX terminal to use the FPAD image processor as if the user were directly connected to its LSI-11/23 System Controller. Tasks that previously ran in the LSI-11/23 can be moved to the VAX, re-linked with a VAX-specific run-time library and run in the same manner as on the LSI-11/23.

The physical communications link is a coaxial cable using the Ethernet protocol at a data rate of 10 Megabits per second. In practice, however, the effective data rate is about 1.05 Megabits per second for typical applications. This implementation is designed to allow for considerable future expansion.

The link is implemented with the following major software and hardware components.

##### 1. On the VAX:

- o A set of subroutines to link with an FPAD application task that transforms user I/O requests into inter-processor request packets.
- o A buffer protocol module that accepts the above packets and encapsulate them in an FPAD-specific protocol before passing them to the Ethernet I/O driver.
- o An I/O driver (DEC supplied) that handles the Ethernet protocol over the coaxial cable.

##### 2. Between the VAX and LSI-11/23:

- o A DEC DEUNA Ethernet controller interface for the VAX Unibus.
- o A DEC H-4000 Ethernet transceiver to connect the DEUNA to the coaxial cable.
- o A Coaxial cable between the VAX transceiver and the LSI-11/23 transceiver.
- o A DEC H-4000 Ethernet transceiver to connect the coaxial cable to the controller in the LSI-11/23.
- o A DEC DEQNA Ethernet controller interface for the LSI-11/23 Q-bus.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

3. On the LSI-11/23:

- o An RSX-11 I/O driver to handle the Ethernet protocol over the coaxial cable.
- o An RSX-11 task to read packets from the I/O driver and determine which of the FPAD I/O drivers should receive them, then pass them to the appropriate driver.
- o An RSX-11 I/O driver to control the FPAD DMA interface to the Control Processor.
- o An RSX-11 I/O driver to control the FPAD STA/STD diagnostic I/O bus.

5.5.1 Pascal Callable Routines -

The FPAD/VAX Interface is transparent to the user. There is no user's guide for this function; however, a brief explanation of the Pascal Callable routines are included in the following paragraphs.

The following are descriptions of the Pascal Callable Routines. The format is:

- o Name - Brief Description.

Function Name ( Input : Type )

Sample Pascal call

- o CLRCPF - Clear CP Event Flag.

Function ClrCPF ( EFNumber : Integer ) : Integer; External;

EVENT\_FLAG\_STATUS := ClrCPF(2);

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

- o RDCPF - Read CP Event Flag.

```
Function RdCPF ( EFNumber : Integer ) : Integer; External;  
EVENT_FLAG_DATA := RdCPF(1);
```

- o READCP - Read a Block of CP memory.

```
Function ReadCP ( Length      : Integer;  
                  CPAddress   : Integer;  
                  VAR Buffer   : Array[1..n] of Integer  
                  ) : Integer; External;  
  
READ_STATUS := ReadCP ( 512, READ_ADDRESS, DATA_BLOCK );
```

- o RMAIL - Read FPAD CP Mailbox.

```
Function Rmail ( Mailbox : Integer;  
                VAR Message : Integer ) : Integer; External;  
  
READ_MAIL_STATUS := Rmail ( 15, NEW_MAIL );
```

- o SENDMP - Send Sequenced Message to FPAD CP.

```
Function SendMP ( Length : Integer;  
                 VAR Message : Array[1..128] of Integer  
                 ) : Integer; External;  
  
MESSAGE_STATUS := SendMP ( 128, MESSAGE_BUF);
```

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

- o SETCPF - Set CP Event Flag.

```
Function SetCPF ( EFNumber : Integer ) : Integer; External;  
EVENT_FLAG_STATUS := SetCPF ( EVENT_FLAG_1 );
```

- o SMAIL - SEND Mail to CP Mailbox.

```
Function SMail ( Mailbox : Integer;  
                VAR Message : Integer ) : Integer; External;  
SEND_MAIL_STATUS := SMail ( BOX_01, NEW_MAIL );
```

- o STNIS - Read a Word from FPAD System Test Bus.

```
Function STNIS ( VAR STAddr, STData : Unsigned;  
                VAR                Status : Integer ); NonPascal;  
STNIS ( STA_ADDRESS, STD_DATA, ERROR_STATUS );
```

- o STNOS - Write a Word to FPAD System Test Bus.

```
Function STNOS ( VAR STAddr, STData : Unsigned;  
                VAR                Status : Integer ); NonPascal;  
STNOS ( STA_ADDRESS, STD_DATA, ERROR_STATUS );
```

- o STRBLK - STA / STD Block Read.

```
FUNCTION STRBlk ( Length      : Integer ;  
                 STAddress    : Unsigned ;  
                 VAR Buffer    : Array [1..n] of Unsigned ;  
                 NoIncrement  : Integer  
                 ) : Integer; External;  
BLOCK_STATUS := STRBlk (256, READ_ADDR, VFM_BUFFER, NOINC);
```

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Support Functions User's Guide

- o STREAD - Read a Buffer full of Address / Data Pairs.

```
Function STRead ( Length      : Integer ;  
                  VAR Buffer   : Array [1..n] of Unsigned  
                  ) : Integer; External;
```

```
READ_STATUS := STRead (128,READ_BUFFER);
```

- o STWBLK - STA / STD Block Write.

```
Function STWBlk ( Length      : Integer ;  
                  STAddress   : Unsigned ;  
                  VAR Buffer   : Array [1..n] of Unsigned;  
                  NoIncrement : Integer  
                  ) : Integer; External;
```

```
BLOCK_STATUS := STWBlk (256, WRITE_ADDR, VFM_BUFFER, NOINC);
```

- o STWRIT - Write a Buffer full of Address / Data Pairs.

```
Function STWrit ( Length      : Integer ;  
                 VAR Buffer   : Array [1..n] OF Unsigned  
                 ) : Integer; External;
```

```
WRITE_STATUS := STWrit (128,SETUP_BUFFER);
```

- o WRITCP - Write a block to CP memory.

```
Function WritCP ( Length      : Integer;  
                  CPAddress   : Integer;  
                  VAR Buffer   : Array[1..n] of Integer  
                  ) : Integer; External;
```

```
WRITE_STATUS := WritCP ( LENGTH,WRITE_ADDRESS,BUFFER );
```

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Booting FPAD

6 FPAD POWER UP / SHUT DOWN

6.1 Power Up

The following list defines the procedures for powering up the FPAD system for application use. These procedures should be executed in the order prescribed to minimize the chance of damage to the primary power supply and the FPAD system. The power up steps include :

- o Turn on the primary power supply supplemental cooling fans. The fans are located on each side of the primary power.
- o Turn on the VAX 11/780 and the LSI 11/23 terminals. The VAX terminal allows the user to interface to the VAX computer, and the LSI terminal allows the user to verify the RSX system in the LSI is executing properly.
- o Turn on the video input device and the video output monitor. The video input device supplies FPAD with video for processing, and the output monitor allows the results of the processing to be viewed by the user.
- o Turn on the primary power supply for the FPAD system. This power supply converts 110 volt power into the 28 volts @ 60 watts required by FPAD.
- o Turn on the FPAD system power. The two switches on the front of the system control the power, they both must be in the up position.
- o Initialize and configure the Ethernet to specify the FPAD node name and characteristics, also set up pointer to the bootable RSX image required by the LSI processor. If the system manager installs the following procedures in the VAX system startup, the FPAD system user may not need to perform the following functions.
  - Logon to the VAX under the FMVIPS account, the password is FMVIPS.
  - Type the word DECNET, this moves the user to the proper subdirectory where the network command files reside.
  - Execute network initialization command file, @ZERONET.
  - Execute network configuration command file, @NVSETNET.
- o On the VAX, type REPLY/ENABLE. This activates operator console messages for display on the user terminal. These messages provide feedback to the user on the status of the

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### Booting FPAD

LSI boot over Ethernet.

- o Initiate the boot over Ethernet. This process moves the RSX11S operating system from a VAX disk file over Ethernet to the LSI 11/23 memory. To activate boot, center the halt switch and depress the reset switch on the FPAD SC chassis. The chassis is on the back side of FPAD. Messages should start being displayed on the VAX terminal. The two important messages displayed are : (1) TERQNA Load Successful and (2) RSX11S Load Successful. This takes approximately one minute. If messages displayed indicate an error condition, restart the boot by depressing reset switch. Finally, the terminal connected to the LSI should display the message : RSX11S VERSION 4.2 .

At the completion of the boot procedure, the FPAD system is ready to execute the application software packages. If problems arise during the boot procedure, try the following to correct the situation :

- o Attempt to reboot the system by depressing the reset switch on the FPAD SC chassis. If this fails, try halting the LSI by moving the halt switch out of the center position then recentering the switch. Try to boot system by depressing reset switch.
- o If system still fails to boot, examine the status lights on the DEQNA board, if any of the lights are on, one of a number of problems could have occurred. The problems range from cabling, transceiver failure, bad network configuration, to DEQNA board failure. See system manager for network assistance.

## 6.2 Shut Down

The following list defines the procedures for shutting down the FPAD system for application use. These procedures should be executed in the order prescribed to minimize the chance of damage to the primary power supply and the FPAD system. The shut down steps include :

- o Log off the VAX before leaving FPAD room.
- o Turn off the power on the FPAD chassis. This is accomplished by pushing either switch to the down position.



FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Booting FPAD

- c Turn off primary power supply.
- o Turn off FPAD support equipment, this includes : power supply fans, video input and output devices, and the VAX and LSI terminals.

Note : If the ambient room temperature exceeds 75 F, shut down the FPAD system before any damage is done to the primary power supply or the FPAD system.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Algorithm Summary

7 ALGORITHM SUMMARY

The following lists the current algorithm capability of the FPAD FAST Facility. The algorithm descriptions are grouped under the major application area in which they reside and execute. Their functional capabilities are briefly described.

The following describes the algorithms which reside under the Image Characteristics Application Package.

- o Convolution (NxN). This algorithm allows a user selected nxn convolution mask to be applied to the input image. The mask sizes range from 3x3 to 31x31. This task is performed in a software module within the HSDM.
- o Magnify (1 to N) / Demagnify (N to 1). The algorithm allows the user to magnify or demagnify the input image by a user selected value for data analysis. This task is either performed by a hardware preprocessor or a software process executing in the HSDM depending on the magnify / demagnify value.
- o Moments Calculation (1th to 4th). The raw data is collected by FPAD with the final calculation being done on the VAX. The raw data is a histogram of the user selected image which is sent to the VAX for analysis. The histogram function is performed within the HSDM.
- o The user can perform the statistical analysis on both symmetric and nonsymmetric imagery. Nonsymmetric images may be selected by the user through the FPAD joystick and then handed off to the analysis software for moment data calculation.

The following describes the algorithms which reside under the Ground Truthing Application Package.

- o Centroid (Geometric and Intensity). These centroid trackers are composed of a suite of algorithms which allow the trackers to perform their function. These algorithms include an adaptive threshold and sizing function, threshold and gate sizing filters, acquisition and deacquisition processing. The adaptive threshold and sizing algorithms process every field time to allow proper threshold and gate size selection to allow optimal centroid performance. The threshold and gate sizing filters minimize the effect of erroneous data on the centroid calculations. The acquisition and deacquisition schemes allow the user to manually acquire and deacquire targets for ground truth data creation.

FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY  
Algorithm Summary

- o Correlation (SSDA). The correlation tracker is composed of a suite of algorithms which allow the tracker to perform its function. The algorithm suite is composed of basically the same components as the centroid trackers with the exception of the algorithm used to generate the track error signal, centroid vs. correlation.

The following describes the algorithms which reside under the Feature Analysis Application Package.

- o Median Filter (NxN). The capability allows the user to pass a nxn median filter over the input imagery to perform noise removal. The filter size ranges from 3x3 to 31x31. This process is performed by software in the HSDM.
- o Segmentation (2-Class and Multi-Class). This process performs target extraction from the background using an intensity based segmentation process. The 2-Class segmentation process is limited because it breaks all images into target and background. In many cases, the target candidate is composed of multiple intensity levels. The major advantage of the multi-class segmentation process is that it can extract multi-intensity level targets successfully from the background data. The segmentation is performed in software by the HSDM.
- o Region Association (Manual and Automatic). This process allows selected segmented blobs be further analyzed with the feature vector process. The selection can be done manually by the user or automatically by the machine.
- o Feature Vector Builder. This process takes raw data about the segmented blob and creates a feature vector of the blob for analysis on the VAX.

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### 8 DOCUMENTATION

This section briefly describes the various documentation packages created in association with the FPAD FAST contract.

- o Contract Number DAAL02-85-C-0103.
- o FACC Quarterly Scientific and Technical Reports for FAST, Volumes 1-6, Oct. 1985 to Jan 1987.
- o FACC Acceptance Test Plan for the FPAD FAST Facility, September 1986.
- o Engineering Drawings. The hardware design documents specify the hardware implementations for FPAD and it's asociated interfaces.
- o Operation and Maintenance Manual. FPAD hardware manual that describes the functional capabilities of the system and maintenance procedures.
- o Program Maintenance Manual. FPAD software manual that describes where files reisde, how to build code, and use the FPAD related software tools.
- o FPAD FAST Training Class Material.
- o FPAD FAST Software Design Reference Volumes
  - TASK 1 - Engineering Support
  - TASK 4 - VAX / FPAD Interface
  - TASK 5 - Configuration Selection
  - TASK 6 - Reference Frame Numbering
  - TASK 7 - Feature Analysis
  - TASK 8 - Image Characteristics
  - TASK 9 - Non-Symmetric Image Selection
  - TASK 10 - Ground Truthing

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### 9 ABBREVIATIONS IN THIS WORK

#### ABBREVIATION DEFINITION

ATR	Automatic Target Recognizer
COTR	Contracting Officer's Technical Representative
CP	Control Processor
<cr>	Carriage Return
CRT	Cathode Ray Tube
DEC	Digital Equipment Corporation
DMA	Direct Memory Address
FACC	Ford Aerospace and Communications Corporation
FAST	Fast Algorithm Simulation and Test
FLIR	Forward Looking Infrared
FPAD	Field Programmable Algorithm Demonstrator
HEX	Hexadecimal
HI-RES	High Resolution (RS-343 Video)
HLDR	High Level Design Review
Hz	Hertz (cycles per second)
IC	Image Characteristics
ID	Identification
I/O	Input/Output
IPL	Image Processing Laboratory
LO-RES	Low Resolution (RS-170 Video)
LSI	System Controller Processor
LSPC	Low Speed Port Controller
QIO	Q-Bus Input / Output Command
User CRT	Digital VT100 Terminal connected to a VAX 11/780
User Monitor	Video display device connected to FPAD Analog Output
RSX	Operating System for LSI
SC	System Controller
SSDA	Sequential Similarity Differencing Algorithm
STA	System Test Address Bus
STD	System Test Data Bus
TBD	To Be Determined
TV	Television
VAR	Variable
VAX	Digital Equipment Corporation VAX 11/780
VFM	Video Frame Memory
VMS	Operating System for DEC VAX 11/780
VTR	Video Tape Recorder
Y/N	User input Y(es) or N(o)

## FAST ALGORITHM SIMULATION AND TEST (FAST) FACILITY

### 10 CONTRACT CROSS REFERENCE

	Page
o Task 4 - VAX / FPAD Interface	67
o Task 5 - Video Configuration Selection	60
o Task 6 - Frame Numeber Referencing	62
o Task 7 - Feature Analysis	2
o Task 8 - Image Characteristics - Full Frame	18
o Task 9 - Non-Symmetric Subimage Selection	35
o Task 10 - Automatic Ground Truthing	38
o Task 1 - Engineering Support. The related information produced on the support phase was nested within the appropriate function.	
o Task 2 - Installation. Installation of FPAD at CNVEO.	
o Task 3 - Formal Training. Training class at CNVEO.	

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