Reprinted from

Seventh International Symposium

Machine Processing of

Remotely Sensed Data

with special emphasis on

Range, Forest and Wetlands Assessment

June 23 - 26, 1981

Proceedings

Purdue University
The Laboratory for Applications of Remote Sensing
West Lafayette, Indiana 47907 USA

A DEVELOPMENT OF INTERACTIVE IMAGE PROCESSING SOFTWARE SYSTEM TIPE

KIYONARI FUKUE, HARUHISA SHIMODA,
TOSHIBUMI SAKATA

Tokai University
Kanagawa, Japan

I. ABSTRACT

Conventional monitors of image processing systems have not sufficient flexibility, expandability and easy-handing capability.

TIPE has been developed to overcome these problems. The monitor of TIPE consists of following three subsystems ;

(1) A scheduling system including a scheduler and menu files.
(2) A control parameter management system including a control parameter management module and control parameter files.
(3) A catalog system including a catalog management module, catalog files and a header management module.

Scheduling system is based upon menu files which are hierarchicaly organized. In the control parameter management system, control parameters are stored in a disc file called a control parameter file. When a series of program is repeatedly scheduled, TIPE user need not to input most of these parameters and can select a proper control parameter file.

TIPE maintains digital image informations in a form called TSF(TRIC Standard Format). The catalog system and the TSF establish an image data base that allows the system to maintain the image files automatically.

With the configuration of TIPE described above, the great deel of flexibility and expandability were achieved. Furthermore, easy-handling capability was achieved by providing an image data base concept and the control parameter system.

II. INTRODUCTION

In the last decade, degital image processings of remote sencing data have grown from a research stage to a quasi-operational stage. According to this growth, number of application softwares and image data have so much increased that a development of an image processing system which can effectively manage these programs and data is inevitable. Most of users of these systems have also changed from resarchers to administrators who knows almost nothing about computers.

TIPE(TIAS Image Processing Executive) has been developed to meet these requirements. The characteristics of TIPE are shown below.

(1) It can accept and process various types of image data.
(2) It requires no special knowledge or complex operations, i,e, any remote sensing user can operate the system.
(3) Selections of programs or image data files are easy, hence operators can devote himself to the image analysis.
(4) It has high expandability and flexibility.

III. HARDWARE SYSTEMS

TIPE runs on the hardware system named TIAS(Tokai Image Analysis System) 2000. It is a distributed network system composed of three minicomputers and three microcomputers. Fig.1 shows the block diagram of TIAS 2000. Besides conventional computer peripherals such as magnetic tape drives or line printers, it has six image I/O subsystems. They are

(1) two color graphic subsystem,
(2) TV digitizing subsystem,
(3) rotating drum digitizer/film recorder subsystm,
(4) two tablet digitizing subsystem,
(5) color ink jet plotting subsystem, and
(6) black and white laser beam plotter subsystem.

Three kinds of subsystems, i,e, drum digitizer/recorder, tablet digitizer and color ink jet plotter are controlled by microcomputers, hence they can work stand alone. Three minicomputers, Hewlett Packard 2113E, 2111F and 2117F are connected with DS 1000, which is a manufacturer supported distributed network system.

TIAS 2000 can fulfill all of the requirements in the field of remote sencing image processings by its various kinds of image I/O's and has a great survivability from its distributed configuration.

IV. SOFTWARE SYSTEM DESIGN

TIAS 2000 was developed to work under both the research and semi-operational environment. The former task requires a large flexibility to the software system, while the latter requires a minimal operator interaction.

Remote sensing users may know almost nothing about image processing programs. In order to help these operators, the system should send detailed messages about the program. However, researchers will know most of the programs. Detailed massages will become just noises to these operators.

In order to construct an effective image processing system, three other points should be considerd. With the progress of remote sensing activities, the quantity of image data files increases day by day. The number of MT volumes are now far beyond the human handling capability. The image processing system should have a kind of image data base to handle these image data.

The second point is that both the users and researchers do not like to input definite parameters, such as line or pixel numbers of an image file to the computer. Therefore, these values should be included

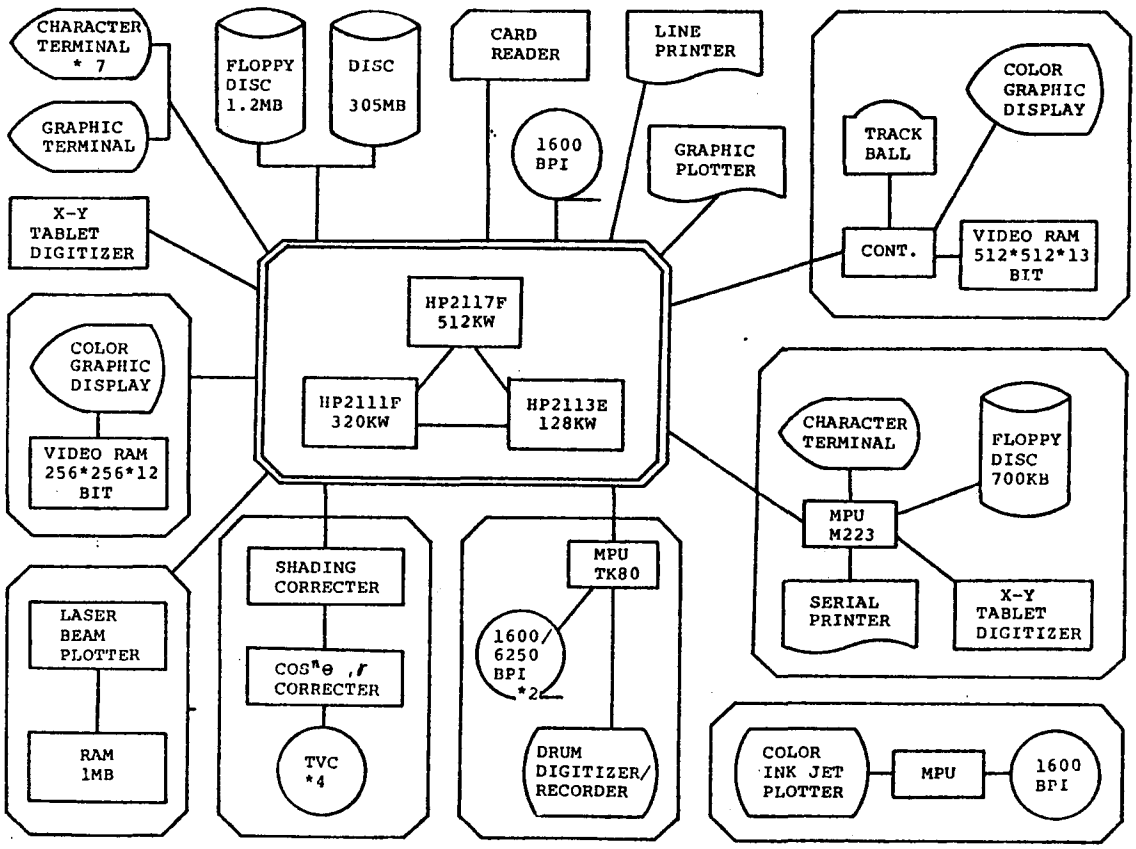

Fig.1 A block diagram of TIAS 2000.

in the image file itself. This point suggests the introduction of a standard image data format, which also reduces the efforts in new program developments.

The last but not the least point is that the pattern recognition ability of human kind far overcom the computer ability. In order to fully utilize this human ability, most of the image processings will be done interactively.

The software system should support these man-machine interactions as much as possible. TIPE-2, the software system of TIAS 2000 can meet all the requirements described above.

V. TIPE-2

Fig.2 shows a block diagram of TIPE-2. It is composed of a scheduler, four kinds of files and several kinds of standard file formats. It runs on RTE-IVB operating system supplied by Hewlett-Packerd. Most of the modules are written by Fortran, wich makes this system easy to transplant to the other image processing system.

A. SCHEDULER, MENU AND PACKAGE

In general, many kinds of algolithms are presented and used for a specific purpose of image processing. Thus a lot of programs are included in an image processing system and an operator consumes much of his effort for the selection of proper programs for his purpose. The scheduler and the menu file can solve this problem.

The scheduler guides the operator from an abstract processing contents to the definite program in a top-down mode with the aid of menu. The menu have a tree structure architecture(Fig.3) and the lowest level menu decides a specific program. As the menu is described function oriented, i,e, not program oriented, operators can easily find the most appropriate program. In order to achieve this function, the same program can appear in several menu items.

The functions and the program names are stored in the menu file, and additions or deletions of programs to or from TIPE-2 are easily achieved by modifying the menu file, which gives a large flexibility to TIPE-2. As TIPE-2 permits multiple menu files, application oriented operators can select a more proper subset menu for his purpose. On the contrary, research oriented operators can directly select a program without the aid of menu. Table 1 shows the level-0 items of the mother menu.

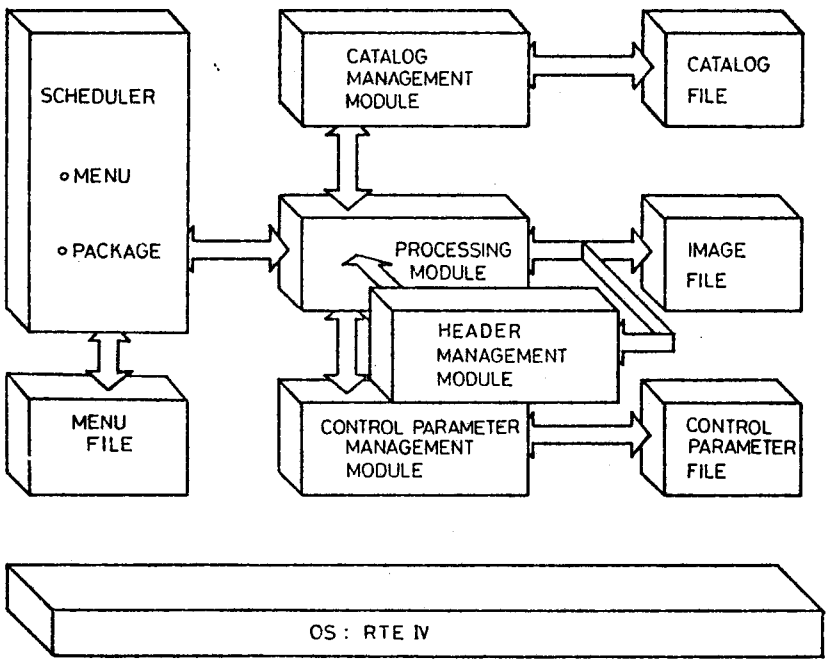

Fig.2 A block diagram of TIPE-2.

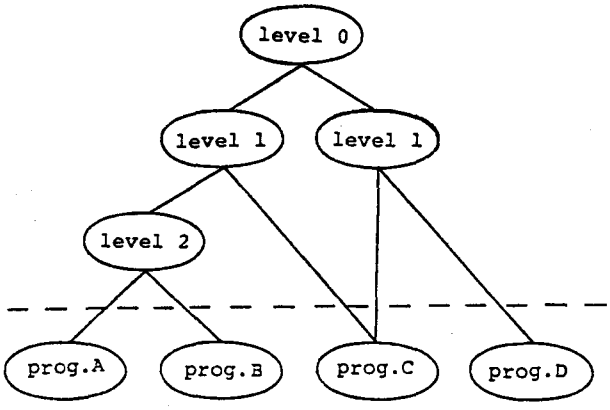

Fig.3 The architecture of menu.

Table 1 The level-0 items of the mother menu.

SM. SYSTEM MAINTENANCE
SS. SYSTEM FILE SERVICE
IO. IMAGE I/O
FC. FORMAT CONVERSION
DP. DISPLAY-
RD. RADIOMETRIC CORRECTION
GC. GEOMETRIC CORRECTION
EH. ENHANCE
SC. STATISTICAL CALCULATION
FE. FEATURE EXTRACTION
GT. TRAINING AREA SELECTION
CL. CLASSIFICATION
CD. CHANGE DETECTION
PS. POST PROCESSING
MS. MISCELLANEOUS

Table 2 The retrieval keys of TIPE 2.

1.	Image name
2.	Creater's name of the image file
3.	Creation data of the image file
4.	Institution name who took the image
5.	Observation date of the image
6.	Kind of sensor
7.	Kind of platform
8.	Location of object
9.	Image size on the ground
10.	Pixel size on the ground
11.	Processing level
12.	Relation of owner-member

The scheduler can select a package other than menu. In a package mode, a series of pre-defind programs are automatically scheduled for a specific applications. Thus, a routine work operator can avoid troublesome interactions with the system.

B. CATALOG MANAGEMENT MODULE AND CATALOG FILES

Recently, many researches have been done about image data bases, and several types of image data beses are presented. However, existing on-line image data bases have not sufficient capacity for remote sensing images. In our center, there are about 800 MT volumes and this number will increase to several thousands in few years.

TIPE-2 adopts, therefore, off-line image data base. The images can be retrieved through two kinds of retrieval method. They are alpha-numeric retrieval and human retrieval. The image files inputted to TIPE-2 are registered with their alph-numeric attributes which describe the contents of the image in catalog file.

Image processing modules access the desired image file through the catalog management module. If there are two or more images which correspond to the specified retrieval key, the catalog managiment module displays compressed images of these images and the operator decide the most appropriate image for his purpose. With the aid of this human intervention, the selection of retrieval keys and/or data base schema can be made very simple. Table 2 shows the existing retrieval keys of TIPE-2.

The catalog management module has another function. It is a maintenance of image files. Operation histories of each image files are also included in the catalog file, and the maintenance informations are also supplied by this module.

C. PARAMETER MANAGEMENT MODULE AND PARAMETER FILE

The dynamic executing states of frequently used programs can be devided into two types. In one type of jobs, the same programs is repeatedly executed and in the other type of jobs, a sequence of programs are repeatedly executed. Each programs usually require several parameters. In the case of repeated execution, most of these parameters do not change. Therefore, the operator's load for parameter input can be greatly decreased by recoding the parameters which were used in

the previous execution.

In TIPE-2, inputed parameters are stored in the parameter file and the parameter management module accesses the file. These parameter files are defined according to each job.

The parameter file has another effect. Operation logs of each image processing jobs can be completely recorded by this parameter file. It is very easy to reproduce the same result as the previous processing from the original image with the aid of this parameter file. It is also used for debugging miss operations.

D. HEADER MANAGEMENT MODULE AND STANDARD IMAGE FORMAT

Image data inputted to TIPE-2 are first converted to a standard image format called TSF(TRIC Standard Format). Fig.4 shows the TRIC standard MT format. The volume label describes the contents of the MT volume. It is also used to indicate the relations to other MT volumes if the contained file is a part of a multi volume file.

The first record in the file is a fixed length header called FCB(File Control Block). The variable length records between FCB and image data are optional and any kinds of informations can be written here. As the structure of image data are described in the FCB, this format is highly flexible. Most of the image data structures, such as pixel interleaved , line interleaved, channel interleaved or subframes are permitted in this format.

Table 3 shows the items included in the FCB. Each processing modules accept the informations about image data structure from FCB through header management les. As most of the informations the image files can be obtained th the header management module, oper need not to input these parameters

E. PROCESSING MODULES

Processing modules were selecte the experience of several hundreds remote sensing image processings i They are highly sophisticated espe in the man-machine interaction. easy to use and support most of th rator's input errors. Some of th requires much processing times are rated with specially developed alg Table 4 shows some examples of pro times of such jobs. Table 5 show 1 and 2 menu which almost correspo each processing modules.

Table 4 Examples of Processing Times for LANDSAT MSS Image(full scene).

Processing	Time (minutes)
Scan Line Noise Elimination	40
Geometric Correction (resampling with 100m*100m pixel size by nearest neighbor method)	40
Maximum Liklihood Classification (20 classes)	35

VI. SUMMARY

The characteristics of TIPE-2 c summarized as below.

(1) Adoptations of retrieval syste image data and application pro
(2) A recursive use of input param data.
(3) An adoptation of highly flexib format.
(4) The separation of each modules their data files.
(5) Descriptions by high level lan
(6) A positive introduction of hum intervention.

These characteristics introduce below advantages.

(1) Operator's loads are largely decreased.
(2) System maintenance are very ea
(3) The system is highly flexible very effective.
(4) A transplants of the software to the other hardware system i easy.

Table 3 The items included in the FCB.

1. Format Revision Number	21. Effective Frame Region
2. Kind of Data File	22. Number of Sub-Frames
3. File Name	23. X,Y Length of Each Sub-Frame
4. Creater's Name of The File	24. Effective Region of Each Sub-Frame
5. Creation Date of The File	25. Merged Region of Each Sub-Frame
6. Generater's Name of Data	26. Number of pixels per Each Line
7. Generation Date of Data	27. Data Length per One Pixel
8. Kind of Sensor	28. Number of Channels per One Pixel
9. Kind of Platform	29. Number of Effective Channels
10. Location of Object	30. Effective Channel Number
11. Image Size on The Ground	31. Number of Ancillary Records
12. Pixel Size on The Ground	32. Record Length of Each Ancillary Record
13. Processing Level	33. Record Position of The Mean Record
14. Configuration of Sub-frame	34. Record Position of The Covariance Record
15. Configuration of Data	35. Record Position of The Histgram Record
16. Data Type	36. Comment
17. Negative/Positive Code	
18. Number of Data Bits	
19. Number of Effective Data Bits	
20. X,Y Length of The Frame	

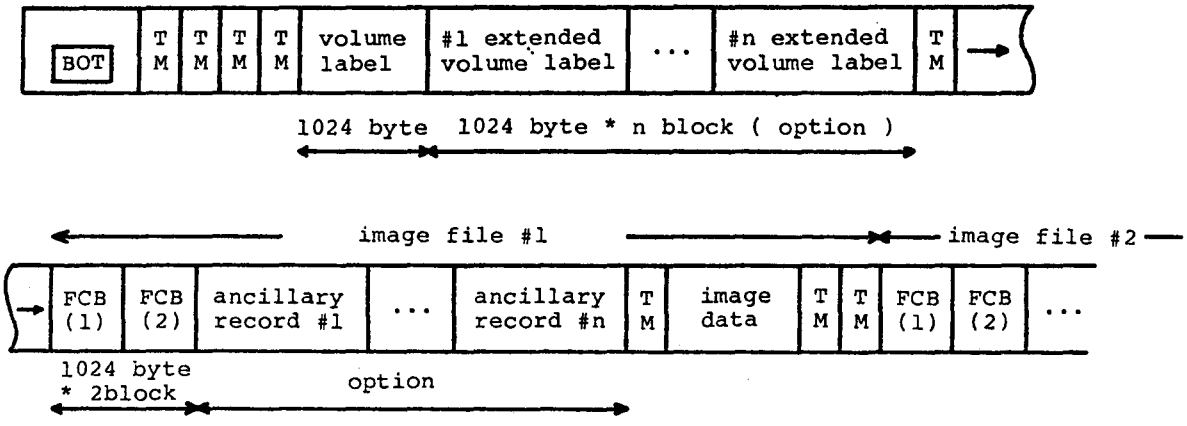

Fig.4 TRIC standard MT format.

Table 5 The level 1 and 2 items of the mother menu.

```
******* LEVEL 1 : I/O ***********************************************
  IMAGE DATA COPY                    COPY
   *IO01. LANDSAT MSS                 *IO08. RAM TO DISC
   *IO02. LANDSAT RBV                 *IO09. TRACK BALL AREA TO
   *IO03. SEASAT SAR                         IMAGE AREA
   *IO04. NIMBUS CZCS
  IMAGE I/O
    IO05. DATA I/O
    IO06. DDR I/O
   *IO07. TV DIGITIZER

******* LEVEL 1 : FORMAT CONVERSION ******************************
  LANDSAT MSS --> TSF                MOSAICK
   *FC01. BIP  --> TSF                *FC09. MEAN & ST.DV EQUALIZATION
   *FC02. BIP2 --> TSF                *FC10. MOSAICK
   *FC03. BIL  --> TSF
   *FC04. NIMBUS CZCS --> TSF         *FC11. INTERPOLATION
   *FC05. TSF --> LANDSAT FORMAT
    FC06. DATA TYPE CONVERSION
    FC07. MERGE / SPLIT
   *FC08. EXPANSION / REDUCTION

******* LEVEL 1 : DISPLAY ***************************************
    DP01. MAINTENANCE                *DP11. DITHER
    DP02. DISPLAY                    *DP12. 3-DIMENSINAL DISPLAY
    DP03. CARSOL                     *DP13. COLOR PLOTTER
   *DP04. DATA READ
   *DP05. DATA WRITE
    DP06. HISTGRAM
   *DP07. CHARACTER DISPLAY
    DP08. GRAPH
  LINE DRAWING
   *DP09. IMAGE AREA
   *DP10. TRACK BALL AREA --> IMAGE AREA

******* LEVEL 1 : RADIOMETRIC CORRECTION ************************
   *RC01. LANDSAT SCAN LINE NOISE     RC08. IMAGE TO IMAGE OPERATION
          ELIMINATION
  CONTRAST ENHANCE                   STATISTICAL CONVERSION
   *RC02. TRANSFORM FUNCTION          *RC09. BASIC STATISTICS
   *RC03. MIN-MAX, GAIN-OFFSET        *RC10. LINEAR CONVERSION
          FORMULA                     *RC11. PRINCIPAL COMPONENT
   *RC04. HISTGRAM SCALING                   CONVERSION
                                      *RC12. REGRESSION CONVERSION
  HISTGRAM CONVERSION
   *RC05. HISTGRAM GENERATION         *RC13. CONVOLUTION
   *RC06. CONVERSION TABLE            RC14. SHADING CORRECTION
          GENERATION                  RC15. ATMOSPHERIC CORRECTION
   *RC07. HISTGRAM CONVERSION

******* LEVEL 1 : GEOMETRIC CORRECTION ***************************
  GCP SELECTION                      SCENE CORRECTION
   *GC01. IMAGE GCP SELECTION         *GC07. COEFFICIENT CALCULATION
   *GC02. GCP FILE GENERATION         *GC08. RESAMPLING
  LANDSAT SYSTEM CORRECTION
   *GC03. LANDSAT SIAT DATA READ
   *GC04. COEFFICENT CALCULATION
   *GC05. SCAN & PIXEL FUNCTION CALCULATION
   *GC06. RESAMPLING

******* LEVEL 1 : ENHANCE ***************************************
  CONTRAST ENHANCE                   SMOOTHING
   *EH01. TRANSFORM FUNCTION          *EH09. CONVOLUTION
   *EH02. MIN-MAX, GAIN-OFFSET        *EH10. CONDITIONAL SMOOTHING
          FORMULA                     *EH11. SMOOTHING ( large mask )
   *EH03. HISTGRAM SCALING
   *EH04. EDGE ENHANCE               RELAXATION LABELLING
    EH05. IMAGE TO IMAGE OPERATION   *EH12. INITIAL DATA CALCULATION
   *EH06. HISTGRAM EQULAIZATION TO   *EH13. PROCESSING
          NORMAL DISTRIBUTION
                                     *EH14. DYNAMIC THRESHOLD
  LEVEL SLICE                        *EH15. LINE THINNING
   *EH07. COLOR CODE FILE GENERATION
   *EH08. LEVEL SLICE
```

Table 5 The level 1 and 2 items of the mother menu. (continue)

```
####### LEVEL 1 : STATISTICAL CALCULATION ############################
  STATISTICAL CONVERSION                PRINCIPAL COMPONENT ANALYSIS
   *SC01. BASIC STATISTICAL              *SC07. PRINCIPAL COMPONENT
          CALCULATION                           VECTOR CALCULATION
   *SC02. LINEAR CONVERSION             *SC08. ANALYSIS
   *SC03. PRINCIPAL COMPONENT           FACTOR ANALYSIS
   *SC04. REGRESSION CONVERSION          *SC09. COEFFICENT CALCULATION
                                         *SC10. ANALYSIS
  REGRESSION ANALYSIS
   *SC05. COEFFICENT CALCULATION         SC11. HISTGRAM
   *SC06. ANALYSIS

####### LEVEL 1 : FEATURE EXTRACTION #################################
   *FE01. ORTHOGONAL                    SMOOTHING
          TRANSFORMATION                 *FE08. CONVOLUTION
                                         *FE09. CONDITIONAL SMOOTHING
  TEXTURE ANALYSIS                       *FE10. SMOOTHING ( large mask )
   *FE02. STATISTICAL
   *FE03. SPATIAL FREQUENCY             REGRESSION ANALYSIS
                                         *FE11. COEFFICENT CALCULATION
    FE04. IMAGE TO IMAGE OPERATION       *FE12. ANALYSIS
  LEVEL SLICE                           PRINCIPAL COMPONENT ANALYSIS
   *FE05. COLOR CODE FILE                *FE13. PRINCIPAL COMPONENTS
          GENERATION                             VECTOR CALCULATIONT
   *FE06. LEVEL SLIC                     *FE14. ANALYSIS
   *FE07. CONVOLUTION

####### LEVEL 1 : TRAINING AREA SELECTION ############################
  GROUND TRUTH MAP GENERATION            GT08. TRAINING DATA STATISTICS
   *GT01. TARGET AREA DISPLAY            *GT09. GT ADDRESS OVERLAY
   *GT02. ZOOM                           *GT10. TRAINING DATA CLAS-
   *GT03. MESH                                  SIFICATION
   *GT04. TRAINING DATA SELECTION
   *GT05. DATA MODIFICATION
   *GT06. TRAINING DATA NAMR FILE GENERATION
   *GT07. DATA CONVERSION

####### LEVEL 1 : CLASSIFICATION #####################################
  MULTI DIMENSIONAL LEVEL SLICE         TABLE LOOK UP CLASSIFICATION
   *CL01. COLOR CHART FILE               *CL08. WORD TYPE 4-CH. SINGLE
          GENERATION                            DISC FILE
   *CL02. COLOR CODE FILE                *CL09. VIS
          GENERATION
   *CL03. LEVEL SLICE                   NON-PARAMETRIC CLASSIFICATION
                                         *CL10. GT DATA FILE SMOOTHING
   *CL04. CLUSTERING                     *CL11. CLASSIFICATION
  MAXIMUM LIKLIHOOD CLASSIFICATION
   *CL05. WORD TYPE 4-CH. SINGLE FILE
   *CL06. WORD TYPE MULTI FILE & VIS
   *CL07. BYTE TYPE

####### LEVEL 1 : POST PROCESSING ####################################
   *PS01. COLOR CODING                   *PS08. DATA WRITE
                                         *PS09. DATA CHANGE
  SMOOTHING                              *PS10. COLOR CHART DISPLAY
   *PS02. CONVOLUTION                    *PS11. EXCLUSIVE OPERATION
   *PS03. CONDITINAL SMOOTHING           *PS12. LOGICAL OR OPERATION
   *PS04. SMOOTHING ( large mask )
   *PS05. CHARACTER DISPLAY
   *PS06. AREA CALCULATION
   *PS07. CONTOUR EXTRACTION

####### LEVEL 1 : MISCELLANIONS ######################################
  DATA READ                             FILE COPY, SAVE, RESTORE
   *MS01. RECTANGLE                      *MS09. RAM TO DISC
   *MS02. DISC or MT FILE                *MS10. DISC <--> MT ( copy )
   *MS03. POINT                          *MS11. DISC <--> MT
   *MS04. TERGET POINT REAL ADRRESS             ( save, restor )
          DATA
   *MS05. CENTER POINT & 8-NEIGHBOU
          POINT DATA
   *MS06. REAL ADRESS CALCULATION
  IMAGE REVERS
   *MS07. UP-DOWN, LEFT-RIGHT
   *MS08. NEGATIVE - POSITIVE
```

Table 5 The level 1 and 2 items of the mother menu. (continue)

```
******* LEVEL 2 : DATA I/O ***********************************************
  LANDSAT                          NIMBUS CZCS
   *I0051. ANCILLARY DATA OUTPUT    *I0054. DATA OUTPUT
                                    *I0055. ILT-A RECORD OUTPUT
  SEASAT SAR                        *I0056. ANCOR POINT DATA OUTPUT
   *I0052. ANCILLARY DATA OUTPUT    *I0057. DOCUMENTATION RECORD OUTPUT
   *I0053. DISC TO MT               *I0058. HEADER OUTPUT
                                    *I0059. DATA RECORD OUTPUT

******* LEVEL 2 : DDR I/O ************************************************
   *I0061. CONTROL
   *I0062. RESEAU MARK GENERATION
   *I0063. COLOR CHART GENERATION
   *I0064. LATTITUDE & LONGITUDE GENERATION
   *I0065. RELATIVE RADIOMETRIC TRANSFORMATION
   *I0066. IMAGE I/O

******* LEVEL 2 : DATA TYPE CONVERSION **********
   *FC061. BYTE  PACK / UNPACK
   *FC062. BYTE      --) WORD
   *FC063. WORD      --) BYTE
   *FC064. FLOATING --) INTEGER
   *FC065. INTEGER  --) FLOATING

******* LEVEL 2 : MERGE / SPLIT **********
  IMAGE 4-CH
   *FC071. MERGE
   *FC072. SPLIT ( word type )
   *FC073. SPLIT ( byte type )
  IMAGE FILE
   *FC074. MERGE
   *FC075. SPLIT
   *FC076. EXTRACTION

******* LEVEL 2 : MAINTENANCE ********************
   *DP011. LINEAR TEST PATTERN DISPLAY
   *DP012. B/W CHART DISPLAY
   *DP013. COLOR CHART DISPLAY
   *DP014. SIN & RECTANGLE WAVE PATTERN DISPLAY
   *DP015. DIAGNOSTICS
   *DP016. CONTROL

******* LEVEL 2 : DISPLAY **********
   *DP021. B/W
   *DP022. COLOR
   *DP023. PSEUDO COLOR
   *DP024. STANDARD

******* LEVEL 2 : CARSOL ***************
   *DP031. CROSS WIRE
   *DP032. ZOOM
   *DP033. TRACK BALL TRACE
  MESH
   *DP034. STANDARD
   *DP035. LATITUDE & LONGITUDE GENERATION

******* LEVEL 2 : HISTGRAM ***************
  RAM or LP DISPLAY
   *DP061. BYTE TYPE
   *DP062. WORD TYPE
  GRAPHIC DISPLAY
   *DP063. HISTGRAM FILE GENERATION
   *DP064. DISPLAY
   *DP065. SCALE WRITE

******* LEVEL 2 : COLOR PLOTTER ***************
   *DP131. DOT PATTERN GENERATION
   *DP132. B/W CHART OUTPUT
   *DP133. TARGET DEVICE ( RAM )
   *DP134. TARGET DEVICE ( DISC )
   *DP135. CHECK
```

Table 5 The level 1 and 2 items of the mother menu. (continue)

```
******* LEVEL 2 : IMAGE TO IMAGE OPERATION **********
  CH. OPERATION
   *RC081. NOMALIZATION
   *RC082. ARITHMETIC OPERATION
   *RC083. RATIOING
  IMAGE OPERATION
   *RC084. NOMALIZATION
   *RC085. ARITHMETIC OPERATION
   *RC086. RATIOING

******* LEVEL 2 : SHADING CORRECTION **********
  COSINE CORRECTION
   *RC141. CURVED SURFACE DISPLAY
   *RC142. CORRECTION
  POLYNOMIAL CORRECTION
   *RC143. CURVED SURFACE DISPLAY
   *RC144. CORRECTION
  FFT CORRECTION
   *RC145. IMAGE GENERATION
   *RC146. CORRECTION

******* LEVEL 2 : IMAGE TO IMAGE OPERATION **********
  CH. OPERATION
   *EH051. NORMALIZATION
   *EH052. ARITHMETIC OPERATION
   *EH053. RATIOING
  IMAGE OPERATION
   *EH054. NORMALIZATION
   *EH055. ARITHMETIC OPERATION
   *EH056. RATIOING

******* LEVEL 2 : HISTGRAM ********************
  RAM or LP DISPLAY
   *SC111. BYTE TYPE
   *SC112. WORD TYPE
  GRAPHIC DISPLAY
   *SC113. HISTGRAM FILE GENERATION
   *SC114. DISPLAY
   *SC115. HISTGRAM SCALE WRITE

******* LEVEL 2 : IMAGE TO IMAGE OPERATION **********
  CH. OPERATION
   *FE041. NORMALIZATION
   *FE042. ARITHMETIC
   *FE043. RATIOING
  IMAGE OPERATION
   *FE044. NORMALIZATION
   *FE045. ARITHMETIC
   *FE046. RATIOING

******* LEVEL 2 : TRAINING DATA STATISTICS **********
   *GT081. STATISTICS OUTPUT
   *GT082. INTERCLASS DISTANCE
  HISTGRAM
   RAM
   *GT083. 3-DIMENTIONAL DISPLAY
   GRAPHIC
   *GT084. GT HIST FILE HISTGRAM CONVERSION
   *GT085. GT DATA FILE HISTGRAM CONVERSION
   *GT086. DISPLAY
  DATA DISTRIBUTION DISPLAY
   *GT087. 2-DIMENSIONAL ELIPSOID DISPLAY
   *GT088. 2-DIMENSIONAL POINT DISPLAY
```

Mr. Kiyonari Fukue recieved the B.S. and M.S. degrees from the Tokai University of Kanagawa, Japan, in 1976 and 1978, respectively. From April 1978 to March 1981 he was a graduate student of doctor cource in the Department of Electro Photo-Optics Enginering, Tokai University. Currently, he is an assistant at the Institute of Research and Development, Tokai University. His research interests include digital image processing and system, especially in remote sensing.

Dr. Haruhisa Shimoda recieved the Ph.D. degree in solid state physics of Organic semiconductor from the University of Tokyo, Tokyo, Japan, in 1972. Since 1972, he has been an Assistant Professor of the Department of Electro Photo-Optics Enginering at the Tokai University, Kanagawa, japan. He is currently engaged in field of digital image processing, a development of image processing system, and application of digital image processing to remote sensing.

Dr. Toshibumi Sakata recieved B.S. degree of Chemical Enginering from Chiba University. He took doctor in Enginering of Chemical Physics at the University of Tokyo and then joined to the Institute of Industrial Sciene there, as a research associate. He was a research scientist of Munich University during 1964 to 1966. In 1966 he moved to the Tokai University and he had a chair of professor in 1971. Presently he is the director of Tokai Research and Information Center, the Tokai University.