ASEAN - AN IMAGE ANALYSIS SYSTEM FOR REMOTE SENSING TRAINING AND EDUCATION

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ABSTRACT

The image analysis system ASEAN (Advanced System for Environmental ANalysis with Remote Sensing Data) was designed and programmed by a software development group ImaSOFT, Department of Remote Sensing Technology and GIS, Institute for Geography, National Center for Natural Science and Technology of Vietnam under technical cooperation with Remote Sensing Technology Center of Japan and financial support from National Space Development Agency of Japan. ASEAN is continuously developed since 1989 with different version ranging from the simplest for MS-DOS with standard VGA 320x200x256 colors, through versions supporting SpeedStar 1.0 and SpeedStar PRO 2.0 true color graphics cards up to the latest version designed for Windows 3.1 operating system. The most remarkable feature of the ASEAN is the use of algorithms that speed up image analysis process even on PC platforms. Today ASEAN is continuously improved in cooperation with NASDA (National Space Development Agency of Japan), RESTEC (Remote Sensing Technology Center of Japan) and released through Regional Remote Sensing Seminar on Tropical Eco-system which is organized by NASDA, UNCRD and ESCAP as public domain software for training, research and education. In the paper, the authors describe functionality of the ASEAN, some of relevant analysis algorithms and discussion on computer assisted remote sensing teaching and training aspect of the system.

1. INTRODUCTION

We are living at the age when computers became popular than at any time before. This fact is due to the fast advancement of microelectronics technology. This progress impacts almost every field of human activities including research, study, learning and entertainment. The learning and teaching process became realized in favorable conditions with an assistance of personal computer and the help of simple, easy-to-understand and user friendly software. In the field of remote sensing, especially digital image processing, there are many software that are being used in research and education. Professional software is expensive, requires usually special hardware configuration and is very often locked so its usage is limited to office and not every body can have easy access to it. This truth is doubled for developing countries if the economic condition is taken into account. Two problems arise during usage of a professional digital image processing system. They are real understanding the nature of the analysis process and proper operation with the system. In order to resolve this problem the user usually needs long time of intensive training and experience. Now a days there is a direction to develop low cost and small software package with basic processing functions that can run on various PC computer configuration. Such a kind of software is designed for training or self-training and not for commercial purpose and is developed under sponsorship from national or international space and remote sensing organization.

In this paper, the authors describe about a software that is result of international cooperation among ImaSOFT Lab., Institute of Geography, NCST of Vietnam, Remote Sensing Technology Center of Japan (RESTEC) and National Space Development Agency of Japan (NASDA). This is the software developed for hands-on-training in the frame work of annual Regional Remote Sensing Seminar on Tropical Eco-System Management which is organized and sponsored by NASDA, UNCRD and ESCAP (1993 Kuching, Sarawak, Malaysia. 1994 Bali, Indonesia. 1995 Subic, Philippines. 1996 Fiji).

2. OVERVIEW ON ASEAN

ASEAN was continuously developed since 1989 with different versions ranging from the simplest for MS-DOS with standard VGA 320 x 200 x 256 colors (MIPS), through version supporting true color graphics cards SpeedStar 1.0, SpeedStar PRO 2.0 (ASEAN 1.0, ASEAN 2.0) up to the latest version designed for Windows 3.1 (WinASEAN 2.0, WinASEAN 2.1). ASEAN is an abbreviation that stands for *Advanced System for Environmental ANalysis with remote sensing data.* The most remarkable feature of the ASEAN is application of data format and analysis algorithm developed by the author that speed up image analysis process even on PC platform. ASEAN left the traditionally used pixel - by - pixel algorithm and utilizes look - up - table approach when it manipulates with each pixel value combination instead of working with different pixel so problem of calculation with the same input data is avoided and overall performance of the system is significantly improved. ASEAN is programmed by dynamic memory allocation techniques so it is not line - but array - oriented software. Number of spectral bands which can be processed by ASEAN is up to 10. There are two ASEAN packages one for MS-DOS and the other for MS-Windows operating system. This paper will deal with Windows version of ASEAN.

The main processing functions of ASEAN are as following:

Preprocessing..

* Data Conversion
* CD-ROM Utilities
* Windows Cutting out
* Histogram Calculation
* Image Enhancement
* Image Encoding
* Vegetation Index Calculation
* Arithmetic Operation
* Principal Component Analysis
* Optical Image Filtering
  - General Filters
  - Special Filters
* SAR Image Filtering

Image display

* Image Display
* Pseudo Color Image Display
* Classified Image Display
* Image Display and Print

Classification...

* Training Area Selection
* Training Area Redisplay
* Training Data Statistics Calculation
* Training Address Modification
* Maximum Likelihood Classification

Post Classification...

* Classified Image Filtering
* Area Measurement
* Class Code Change and Merge

Geometric Correction...

* Ground Control Point Selection
* Image Control Point Selection
* Coefficient Computation and Resampling

Change Analysis...

* Plural Image Display
* Generation Of Change Matrix
* Visualization Of the Change matrix

Bird's Eye View Generation

* DEM Data Conversion
* Bird's Eye View Generation
* Bird's Eye View Image Display

Image Overlay

Help

Tutorial

The file system of ASEAN is organized as following:

.GIH Standard ASEAN image data format.
.CLS Standard ASEAN classified image format
.CPT System format for vegetation index calculation, training data statistics calculation, modification, classification...
.ADR Training address file
.TRN Training data statistics
.HST Histogram file
.LEV Level data file for pseudo color image display
.ENH Look up table for enhanced image display
.GCP GCP/ICP coordinate file for geometric correction
.DXY system file for geometric correction
.CHA Change matrix between two classified images
.WSP Work space mark file
.DEM Digital elevation model data file

Hardware requirement for running ASEAN is quite standard and almost all of recent types of PC can be used for the application. The requirement for hardware is listed as below:

- CPU 386 , 486 or above
- Math coprocessor
- Base memory 640 Kb
- Extended memory 3 Mb (at least)
- Floppy disk drive 5.25 and 3.5 inch
- Hard disk drive 80 Mb
- Super VGA color Monitor
- 24 bits graphics accelerator properly setup for Windows environment
- Color printer
- CD-ROM drive
- Mouse
- Operating system MS DOS 3.3 or above
- Microsoft Windows 3.1 or latter for Windows version

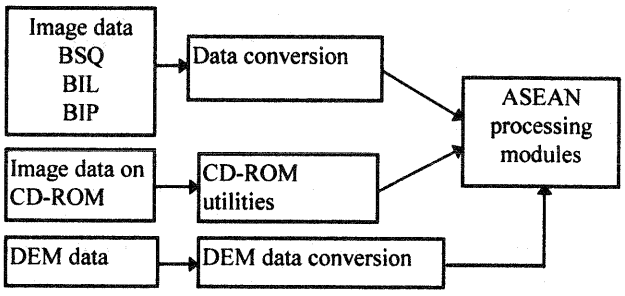
3. DESCRIPTION OF SOME RELEVANT FUNCTIONS AND ALGORITHMS

3.1 Data Conversion

In order to process image data by WinASEAN the first step to be carried out is to convert data from different formats to WinASEAN standard image format. WinASEAN can process any standard image format as BSQ single file, BSQ multiple file, BIL and BIP. The data structure of the standard WinASEAN image format is as follows:

Header 1024 bytes
Data part: Image data in common BSQ, BIL, BIP formats

In the header part there are important information about the actual image data such as number of lines, number of pixels per lines, actual image format of the image data part, location of the data and whether the data is attached to the header or not. Because WinASEAN can now process image of arbitrary size (depends only on the free memory available and memory management capability of the Windows environment) so for huge volume of data it is better to separate header from data part. By this way problem of copying of huge volume of data is now abandoned. The file extension of WinASEAN data format is .GIH. It is **G**eneral **I**nformation **H**eader. The size of the GIH file depends on the selection in the conversion program. For small image window it is better to include data with header but for big image (say full scene of image stored on CD-ROM) is better to separate header apart from data.



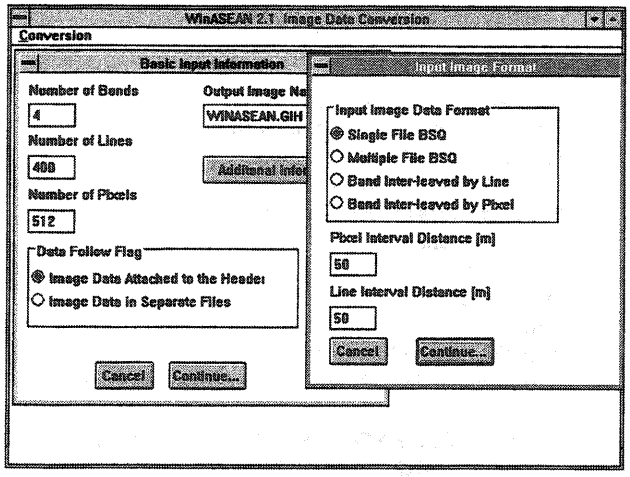


Figure 1. Data conversion menu

3.2 Image Display

There are two image file types that can be displayed: WinASEAN GIH and classified image WinASEAN CLS. WinASEAN GIH file is displayed by using Image display and classified image by Classified image display menu. Programs automatically detects whether input file is of suitable format for display or not. Another function for image display is Pseudo Color Image Display that is actually level slicing. The original GIH image is displayed in true color mode so number of slices can be up to 255. User selects certain gray value range and assigns it to arbitrary color.

Under the Image display menu is there another function Image Display and Print. By this function user can display two image types: full color image with extension .GIH and classified image with extension .CLS and send them to system printer at selected scale. This is not hard copy as often used in many Windows application by PrintScreen or Alt+PrintScreen function. In order to print a image at exact scale program requires following input data:

- Ground resolution of image (usually in meters)
- Scale factor
- Technical parameters of the system printer (supported by Windows)

After program was informed about the above data, actual ground coverage of the image will be computed and transformed into printer resolution unit (dots per inch). The size of the selected area to be printed is input not in image but in printer resolution dimension.

3.3 Image Encoding

Image encoding is a special technique used by WinASEAN to improve calculation speed of classification, image transform etc. After encoding, data in the WinASEAN GIH format is converted to WinASEAN CPT format with structure as follow :

- Image header 1024 bytes
- Encoded image data Number of lines * number of columns * code size in bytes
- LUT1 Look - up - table containing all Unique Pixel vectors (UPV)
- LUT2 UPV frequency

The code size used for encoded image data is of 2 or 3 bytes. UPV frequency is hold in table with type of 1, 2 or 3 bytes. During processing program works with look-up-table LUT1 and LUT2 insteed with whole of image and then by index replacing technique, result image, for example, classified or principal component will be created.

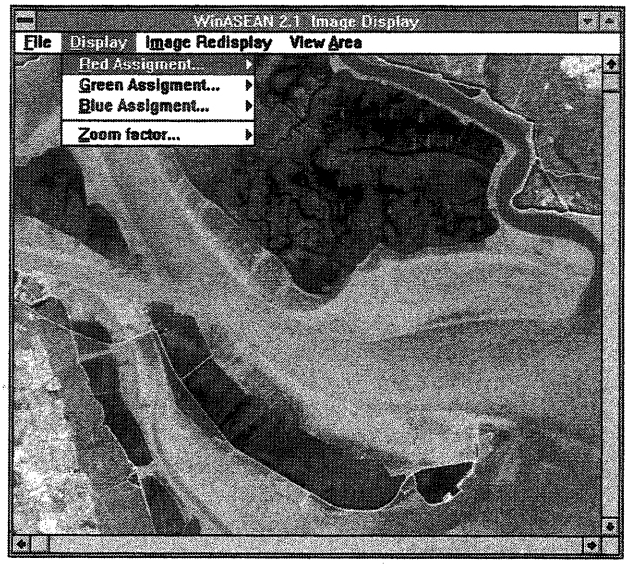


Figure 2. Image display menu

3.3 Arithmetic Operation

Inter-channel or inter-image operation are very useful for image enhancement, feature extraction and multitemporal image analysis. Addition, subtraction, multiplication, division and their combination can be applied for many purposes, including noise elimination. In order to carry out the most different arithmetic operation either among bands of one image or among different bands of different images, the algorithm is divided into 3 steps. In the first step program prompts for input data, then a temporal image in .GIH format is created. In the second step program asks user to give actual formula which defines the arithmetic operation to be considered. In fact the formula is not limited on basic arithmetic operation only, but any mathematics expression of length up to 60 characters long and consisted of FORTRAN intrinsic functions can be supplied. The construction of the formula must follow strictly FORTRAN syntax. Program checks syntax of the input formula and if there is no error it proceeds to next step when actual computation will be realized. In order to prevent division by zero, all digital counts having values 0 is assigned 1 before calculation.

3.4 Multispectral Classification

Multispectral classification is based on the Maximum likelihood classification method and consists of the following operation:

- Training area selection
- Training data statistics calculation
- Training data redisplay for checking
- Training data modification (if necessary)

After checking training data and statistics computation the maximum likelihood classification can be carried out. Input files are image file in CPT format and training data (statistics) file. Output will be classified image in CLS format. WinASEAN 2.0

can classify up to 255 classes, class 0 is always reserved for unknown (unclassified) class.

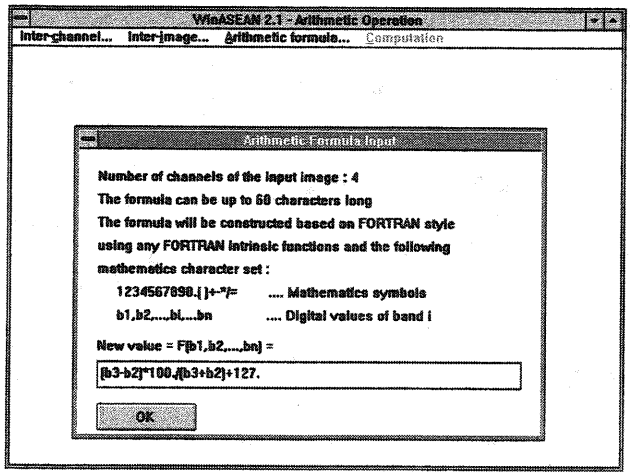


Figure 3. Formula definition for Arithmetic operation

Program first classifies the look up table LUT1 and then the image data in CPT format will be labeled according to the code of pixel value vector that has been classified in LUT1. During classification program prompts for two parameters : sigma range and correction factor. The sigma range is actually multiplicity of standard deviation of the class. Default value of it is set to 3.0. The correction factor is primary conversion coefficient. Decrease of it has the effect to falsely increase the likelihood for the class. Its default value is set to 1.0. When classification result seems to be incorrect by unknown reason, it is possible to use this coefficient to correct the result. The classification process is interactive that is after classification user can observe at once the result on the screen and if the result does not meet the requirement then by changing sigma range and correction factors classification can be repeated until satisfied result is achieved.

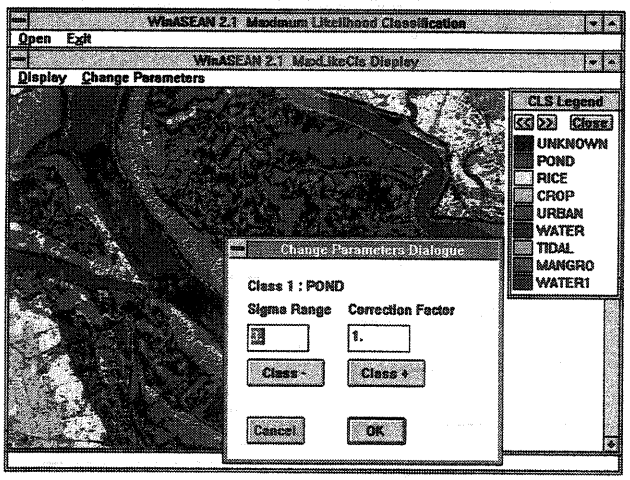


Figure 4. Maximum likelihood classification

3.5 Change Analysis

This is a group of three separate functions used to display multidate image after registration, extraction of the change between two classified images and display of the change matrix.

By Plural image display menu two or three multidate images can be mixed and displayed. The nature of the mixed display is to assign certain band of input images to one of three image planes red, green or blue. The result image is an overlay of different bands from different images. WinASEAN can mix image data in different format as BSQ, BIL, BIP.

In order to generate view of changes based on two classified images taken from different time ASEAN create at first change matrix and stores it in file .CHA. Program ignores all combination between the same classes and assigns them black color for display. The .CHA file has structure as following

Image header	1024 bytes
Encoded image data	Number of lines * number of columns * code size
Color table	
LUT2	Frequency of each change pattern
Name of the first image	
Legend of the first image	
Name of the second image	
Legend of the second image	
LUT1	Look - up - table containing all changes

Because the change matrix is actually not image so in order to display it program assigns to each code three artificial gray values and then use it to generate visual presentation. The color is selected so that the color difference between codes is maximal. During display individual color presentation for each change combination can be changed. By this way some change combinations can be switched off by assigning to black color or enhanced some combination by changing their color to vivid one.

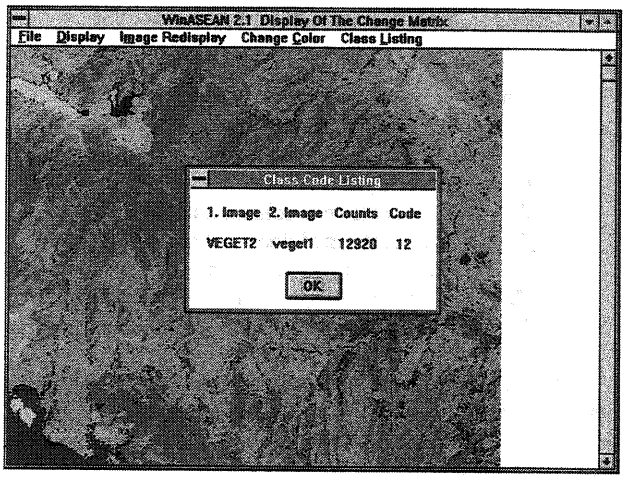


Figure 5. Change matrix display

3.6 Bird's Eye View Image Generation

The goal of bird's eye view image generation is to create a projected image according to the selected azimuth, depression angles and DEM of the selected area. DEM (Digital Elevation Model) contains ground height or elevation of each pixel and it is represented as grid with ground resolution as same as resolution of remote sensing data to be overlaid on the DEM. Each cell of the DEM contain information about elevation which is usually coded by 1, 2 or 4 bytes.

Each pixel is now represented by a vector $P(x,y,z,I)$ where x is column, y line number, z is elevation and I is digital count of the pixel. The bird's eye view generation is divided into two steps. The first one is to find out a projected vector $P'(x',y',z')$ given by azimuth angle α, depression angle ζ, distance d between eye position and view plane. The second one is to assigned digital count to the newly computed pixel.

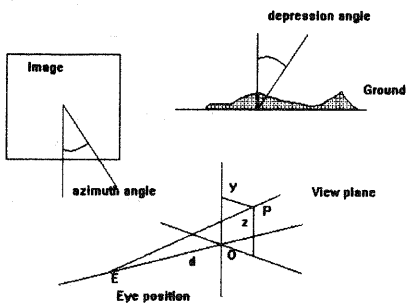


Figure 6. Bird's eye view image generation scheme

The projection is then done by the following formulas:

$$x' = x\cos\alpha - y\sin\alpha$$
$$y' = (x\sin\alpha + y\cos\alpha)\cos\phi + z\sin\phi$$
$$z' = (x\sin\alpha + y\cos\alpha)\sin\phi + z\cos\phi$$
$$x'' = x'\frac{d}{d+z'}$$
$$y'' = y'\frac{d}{d+z'}$$

Where

x	... original column number
y	... original line number
z	... original elevation
x'	... transformed column number
y'	... transformed line number
z'	... transformed elevation
x", y"	... projected coordinates in view plane
d	... distance between eye position and view plane

After the position of the pixel in view plane has been computed, we must assign to it digital count and to decide whether it belongs to hidden surface or not. This will be done by simple resampling algorithm applying for the farthest up to the nearest line from eye position.

4. REMOTE SENSING TRAINING ASPECT OF ASEAN

The primary goal of the ASEAN is training and education. All of the functions were designed in a sequence that is intuitive and easy to understand. Many Windows control styles as graying or disabling menu items were used to prevent possible errors, for example, execution of a certain function is blocked when the input data is incomplete, or the print menu is always grayed when the computing process is not yet finished.

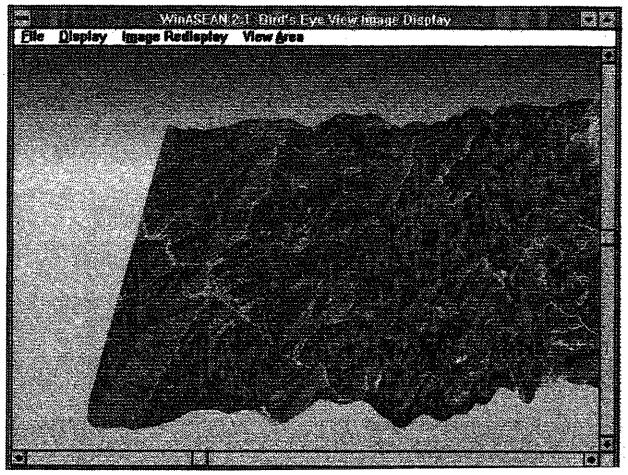


Figure 7. Bird's eye view image display

The computation algorithms of ASEAN were carefully selected and developed to achieve maximal processing speed on PC computers and so ASEAN became a real interactive system. The Arithmetic Operation menu with capability to input arbitrary formula create very interesting module when the user can try various formula for image transform. This is very flexible approach not only for training but research as well. The manual of ASEAN is comprehensive. The help system follows Windows style and provides quick searching of guide for relevant functions. The most interesting feature of ASEAN that is very suitable for training is that most of major functions were recorded by Windows Recorder and sample data. Whenever the user click Tutorial and select a function, ASEAN will perform playback demonstrating visually how to use that function. By such an organization the training or self-training become more attractive. At the present time, the ASEAN is used for remote sensing training in many countries in the SE region and it is released through the annual Regional Remote Sensing Seminar on Tropical Eco-System Management organized by NASDA, UNCRD and ESCAP and other JICA training workshop as public domain software.

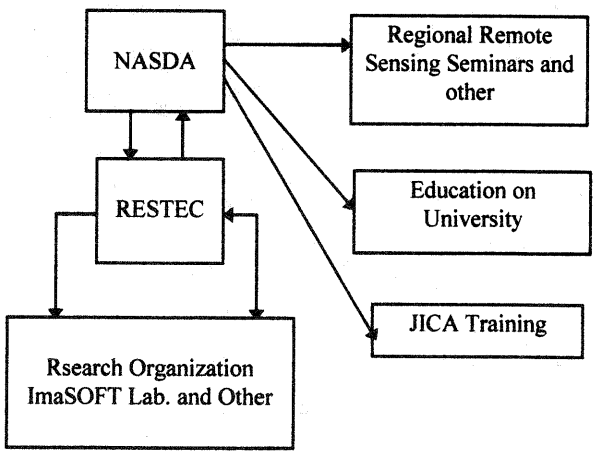


Figure 8. Development and distribution scheme of ASEAN

5. CONCLUSION

The development and application of ASEAN for remote sensing training and education is meaningful from many points of view. Such a kind of software can be considered as a bridge between end-user and commercial professional one. This is low cost, high performance software driven by user friendly interface installable on almost all of recent PC computers with modest hardware requirement.

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References

Nguyen Dinh Duong *et al.*, MIPS: A Digital Image Processing System For Personalcomputers With VGA Graphics Adapters. Asian-Pacific Remote Sensing Journal, Vol. 4, No. 1, July 1991.

Nguyen Dinh Duong, A New Data Format For Digital Image Processing. Asian-Pacific Remote Sensing Journal, Vol. 5, No. 1, July 1992.

Shoji Takeuchi *et al.*, Development of CD-ROM Image Data Set and It's Handling Software by Personal Computer. Proceedings of the ISPRS Commission VI Symposium: Facing the Chance and Challenge. October 10-13, 1994. Beijing, China.

Image Analysis And GIS With A Personal Computer. Textbook for Hands-on Training of the 4th Regional Remote Sensing Seminar on Tropical Ecosystem Management. Subic, Philippines, September 4-9, 1995. National Space Development Agency of Japan, Remote Sensing Technology Center of Japan.