

# CARST 1.0 AND REMOTE SENSING TRAINING AT GEOINFO LTD. IN VIETNAM

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## Commission VI

**KEY WORDS:** Remote Sensing, Training, Digital Image Analysis, WinASEAN, Interactive Tutorial.

### ABSTRACT:

Computer Assisted Remote Sensing Training software - CARST 1.0 was developed by the GeoInfo Ltd. for hands-on training in remote sensing and GIS. The CARST 1.0 is composed of the WinASEAN 5.0 Edu, Remote Sensing Notes published by the Japan Association of Remote Sensing and GIS Work Books of Prof. Shunji Murai. The WinASEAN 5.0 Edu provides basic digital image analysis functions that can handle both one-byte and two-byte image data. Each function is explained in on-line help, which is available in English and Vietnamese version. The help file is linked to the digital books providing users deeper understanding of remote sensing and GIS background. The system is further accompanied with interactive tutorials developed by InstantDemo software that allows beginners to self-train step-by-step basic digital image analysis functions. The CARST 1.0 is being used for hands-on training in remote sensing courses organized by the company GeoInfo Ltd. in Vietnam. The training is organized in three courses: Introductory, Basic and Advanced. In the Introductory course the trainees are introduced to basic terms of remote sensing and principles of visual interpretation. Some explanations of digital image analysis are also given in this course. In the Basic course the trainees will learn basic digital image analysis functions through hands-on training using the WinASEAN software. In the Advanced course programming is focus point, which is essential for development of more complex analysis including GIS modelling. One copy of CARST 1.0 and dataset is given free of charge to each trainee to allow self-training in his own time. This paper will provide readers information of the CARST 1.0 and experience in remote sensing training by GeoInfo Ltd. in Vietnam.

## 1. INTRODUCTION

Capacity building is key means of successful implementation of remote sensing application. It is realized in many forms and on different levels such as university programs on remote sensing, training courses offered by space organizations or research organizations. University education provides systematic knowledge on remote sensing but does not target much on skill building. It is also usually limited to graduate or master course students. The courses organized by space agencies and research organizations are often irregular and short in duration (some days only). They target mostly on demonstration of remote sensing technology or data and some application case studies. In these courses, promotion of remote sensing is more important than practical training on data usage. In a situation when remote sensing data has become more accessible with low cost, analysis software is popular in either open source or trial ware and any modest PC can provide good environment for image analysis including high quality display of image, the number of people who really understand remote sensing and capable to process skilfully satellite image to generate practical results bringing certain benefits to the society is still limited. The application of remote sensing is still beyond a point of expectance in developing countries. There could be many reasons hidden behind but maybe one of them is a lack of sophisticated hands-on training on data analysis.

The aim of this paper is to provide information of development of the Computer Assisted Remote Sensing Training 1.0-CARST 1.0. This is a software package consisted of three components: Windows based Advanced System for Environment data ANalysis with remote sensing - WinASEAN 5.0, interactive tutorial and electronic books on remote sensing

and GIS: Remote Sensing Note published by the Japanese Association of Remote Sensing (JARS), 1999 and GIS Work Book Volume 1 (Fundamental Course) and Volume 2 (Technical Course), Copyright Prof. Shunji Murai, 1999. The CARST 1.0 is being used for remote sensing training in the GeoInfo Ltd. which is a private company established as joint venture with the Department of Environmental Information Study and Analysis, Institute of Geography, Vietnam. Currently there was a quite positive response from the remote sensing user community to training program of the GeoInfo. Applicants are mainly university graduate, master course students, researchers and technical staff of space agency, mapping and remote sensing application agencies. Lectures and training are conducted mainly in after-office hours or during weekend.

## 2. COMPUTER ASSISTED REMOTE SENSING TRAINING PACKAGE CARST 1.0

The Computer Assisted Remote Sensing Training package has been developed by integration of three components: WinASEAN 5.0, interactive tutorial and electronic textbooks: Remote sensing note and GIS Work books. The purpose of the development is to provide trainees a user-friendly, integrated working environment, which fulfils the needs of hands-on training as well as beforehand search for explanation of advanced topics in remote sensing and GIS theory. Visual interactive tutorial is also an excellent tool for helping trainees in mastering the software by self-learning and training.

## 2.1 Overview on WinASEAN 5.0

WinASEAN 5.0 is the latest development version of the software package WinASEAN – Windows based Advanced System for Environmental data ANalysis with remote sensing that has been long time used for hands-on training in the framework of the Earth Observation for Tropical Ecosystem Management Seminars which had been annually organized from 1992 to 2000 by NASDA and UN ESCAP (Nguyen Dinh Duong and S. Takeuchi, 1997). The WinASEAN 5.0 is released in two versions: educational WinASEAN Edu and professional WinASEAN Pro. The only difference between two packages is that educational version can process image with size less than 2000 pixels per line and 2000 lines per image. All analysis functions are identical for both versions except that image display modules of educational version has the capability to show an image with dimension the same as of the professional one. WinASEAN 5.0 can process one byte and two byte image data.

WinASEAN 5.0 is developed based on the WinASEAN 4.0 (Nguyen Dinh Duong, 2003) and is composed of main menu and processing modules as listed below:

### a) Preprocessing

- Data Conversion: *to import image to WinASEAN. The basic formats as BSQ, BIL and BIP are supported. The DIMAP format of SPOT5 is also accepted.*
- CD-ROM Utilities: *for reading image data stored on CD media.*
- Image Window Cutting: *for cutting a window from an image.*
- Histogram Calculation
- Image Enhancement: *Establishment of enhancement look-up table based on methods: linear stretch, histogram equalization, Gaussian stretch, logarithm and square root enhancement.*
- Image Encoding: *To encode multispectral image to a form consisted of unique pixel vectors.*
- Vegetation Index Calculation: *Computation of Normalized Differential Vegetation Index.*
- Arithmetic Operation: *To carry out arithmetic operation among spectral channels of an image. The formula is input in Fortran 77 convention.*
- Modeller: *To allow inclusion of a simple Fortran 77 code for advanced analysis. This operation can be carried out among images of the same dimension.*
- Principal Component Analysis
- Optical Image Filtering: *Optical image filtering by special filters or general filter with arbitrary size.*
- SAR Image Filtering
- Hyperspectral Transformation for Colour composite : *To create colour composite of images with number of spectral channels higher then 3.*

### b) Image Display

- False Colour Image Display: *Display of an image by different colour combination.*
- Pseudo Colour Image Display: *Display of single image channel by level slicing.*
- Classified Image Display
- Image Display and Print: *To print an image in required scale.*

### c) Multispectral Classification

- Training Area Selection: *To define training sample for classification.*

- Training Area Redisplay: *Redisplay of selected training samples for checking purpose.*
- Training Data Statistics Calculation
- Training Address Modification: *To modify a training address file by deletion of a class or to merge two training address files together.*
- Maximum Likelihood Classification: *Multispectral classification by maximum likelihood method.*

### d) Post Classification

- Classified Image Filtering: *To remove isolated pixels by majority filter.*
- Area Measurement: *To compute an area occupied by each class using spatial resolution information.*
- Class Code Change and Merge: *To merge classes together or to change name of a class.*

### e) Geometric Correction

- Ground Control Point Selection: *To define ground control points by using maps or GPS measurement.*
- Image Control Point Selection: *To define image control points on master image.*
- Coefficient Computation and Resampling: *To compute geometric correction coefficients according to the selected GCP or ICP.*
- Image Mosaicking: *To create mosaic of georeferenced images.*
- Image Ortho-rectification by Regression: *Ortho rectification of image by using DEM and regression method.*

### f) Change Analysis

- Plural Image Display: *Display of multi-temporal images in colour composite.*
- Generation of Change Matrix: *To establish change matrix of two classified images.*
- Visualization of the Change Matrix: *Visualization of the change matrix.*
- Masking by Two CLS Images: *To suppress some classes in one classified image by mask in the other one.*

### g) Bird's Eye View

- DEM Data Conversion: *To import DEM to WinASEAN format.*
- Bird's Eye View Generation: *To develop BEV image by using DEM and ortho-rectified image.*
- Bird's Eye View Image Display
- BEV Image Sequence Generation: *To create a series of BEV in different azimuth and depression angles.*
- BEV Image Sequence Display

### h) Image Overlay

*To overlay two images for change analysis study.*

### i) Utilities

- File Information: *To retrieve basic information of an image.*
- Conversion of MIF to CLS: *To carry out vector to raster conversion. Supported vector format is MapInfo MIF. Raster format is WinASEAN classified image.*
- Geometric Correction of MIF and DXF files: *To carry out geometric correction of vector data in MIF and DXF formats.*
- Shading Optical Image: *To develop a shaded image of DEM according to time and Julian day of satellite observation to assist geometric correction of an image in case of unavailability of topographical maps or difficulty in GCP selection.*
- Shading SAR Image: *To simulate SAR image by using DEM and satellite orbit parameters for geometric correction of SAR image.*

- j) Help:  
*On-line help integrated with interactive tutorial and electronics books on remote sensing and GIS.*

Detail description of WinASEAN including information on algorithm can be found in WinASEAN help. WinASEAN user interface and processing flows were designed and developed primarily for training and education purposes. However, the system can be used for practical use due to well-developed algorithm, which allows high performance of data analysis.

## 2.2 Some Unique Functions of WinASEAN

WinASEAN covers basic digital image analysis functions. However, there are some unique functions that are not available even in commercial packages. In this paper, the author would like to highlight two functions: Hyperspectral transformation for colour composite: colour composite module for image with number of spectral channels larger than 3 and Modeller: real time modelling tool by programming in Fortran 77 language.

### 2.2.1 Hyperspectral Transformation for Colour Composite

The conventional methodology for colour composite generation of multispectral images is to assign three spectral channels to three principal colour red, green or blue respectively. In case the number of spectral channels of an image is greater than 3, only three-channel subset of the image can be visualized at one time. In order to display more information in the visualised image, principle component analysis technique could be applied to bring most image information into the first three components and using these components to generate colour composite. Disadvantages of this technique are that colour tone of the objects is not stable and there is still some image information in the higher components not showed in the final image. A special technique called as Hyperspectral Transformation for Colour Composite – HTCC has been developed by the author. This technique is based on transformation of multispectral image data from n spectral channels to three-component space using conic vector space (Nguyen Dinh Duong, 2000). The transformation is done by the following equation:

$$\begin{bmatrix} a_1 & \dots & a_n \\ b_1 & \dots & b_n \\ c_1 & \dots & c_n \end{bmatrix} \times \begin{pmatrix} p_1 \\ \cdot \\ \cdot \\ p_n \end{pmatrix} = \begin{pmatrix} p'_1 & p'_2 & p'_3 \end{pmatrix}$$

Where  $p_i$  is original image digital count and  $p'_i$  is transformed value. The coefficients  $a_1, a_n, b_1, b_n, c_1, c_n$  can be computed using different transformation model. For the case of 4 channel image data, the transformation is done by the following equation:

$$\begin{bmatrix} -0.866025 & +0.000000 & +0.866025 & +0.000000 \\ +0.000000 & +0.866025 & +0.000000 & -0.866025 \\ +0.500000 & +0.500000 & +0.500000 & +0.500000 \end{bmatrix} \times \begin{pmatrix} p_1 \\ p_2 \\ p_3 \\ p_4 \end{pmatrix} = \begin{pmatrix} p'_1 \\ p'_2 \\ p'_3 \end{pmatrix}$$

Because the transformed components are in achromatic space so it is necessary to convert them to IHS and RGB space for colour visualization. The conversion can be done by any of common IHS-RGB algorithms. The new colour composite provides more information than any of the conventional ones. The visualized image is an excellent tool for vegetation study

and water and infrastructure mapping. Conversion of transformed components  $p'_i$  into I, H, S system is done by formulas:

$$I = \sqrt{p'^2_1 + p'^2_2 + p'^2_3} \quad S = \text{Arc tan} \left( \frac{\sqrt{p'^2_1 + p'^2_2}}{p'_3} \right)$$

$$H = \text{Arc tan} \left| \frac{p'_2}{p'_1} \right|$$

Example of colour composite for the TM image data with 6 visible spectral channels is given on the figure 1. HTCC image is given on the figure 1b (right), while 1a (left) shows the standard false colour composite.

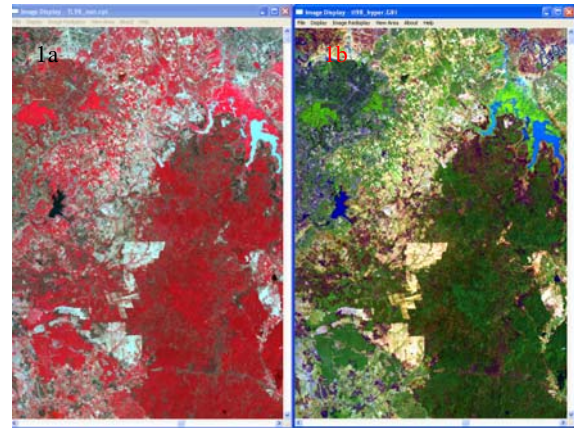


Figure 1. Standard false colour composite of Landsat TM data (left) and HTCC image (right)

Thanks to presence of short wave infrared information the hyperspectral transformation colour composite become clearer with higher contrast, better separation between bare land and turbid water body.

### 2.2.2 Modeller and on-line Programming

Modeller was developed in integration of Open Watcom Fortran 77 compiler 1.4 with WinASEAN. The Modeller module is composed of two parts: executable file developed by the Microsoft Visual C++ 6.0 and Fortran PoweStation 4.0 and Dynamic link library DLL file created during execution time. The DLL part is compiled and linked by the Open Watcom Fortran 1.4. This mechanism allows user to integrate a Fortran program input by the user to create a new special function for image analysis.

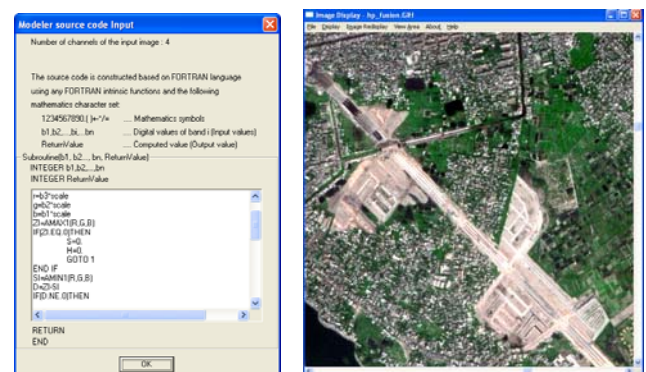


Figure 2. Input window of the Modeller and SPOT5 pan-sharpened image by the Modeller

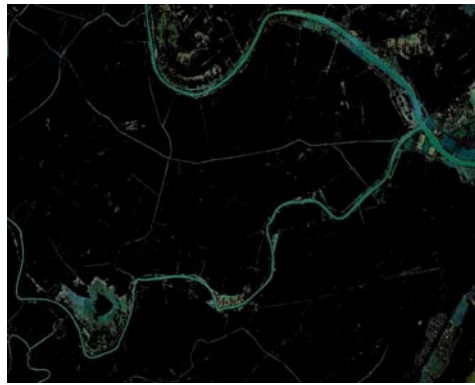


Figure 3. Extraction of hydrographical features by Modeller

Modeller can be used as key module for GIS modelling and analysis. Many advanced analysis as data fusion, reclassification using DEM and GIS data could be realized with Modeller. On the Figure 2 is an example of Modeller Fortran code input window and SPOT5 pan-sharpened image by Modeller. The Figure 3 shows extraction of hydrographical features by spectral pattern analysis algorithm programmed in Modeller.

### 1.1 Help and Interactive Tutorial

Training under guideline of instructors is common in practice. However, self-training is quite important for better understanding and building sophisticated skill in data analysis. The self-training now is better organized with help system of WinASEAN 5.0. The WinASEAN 5.0 Help system is composed of three parts: the Help and user manual in html format, interactive tutorial developed by using the InstantDemo software with video file in the ShockWave format and the electronic books Remote Sensing Note and GIS Work Books.

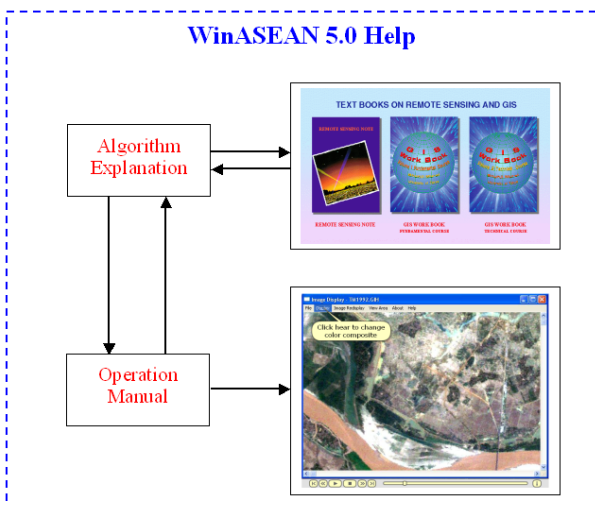


Figure 4. Structure of WinASEAN 5.0 Help system

Help for each function in WinASEAN is organized in two parts: algorithm explanation and operation manual. The concept of the help system is explained on the Figure 4. Algorithm explanation window is linked to textbooks on remote sensing and GIS for deeper algorithm description. For better navigation in help system, remote sensing and GIS textbooks are opened in separate windows. The operation manual is integrated with interactive tutorial that is available in ShockWave video format

for each menu. The Windows system will automatically notify user for updating Flash tool if it is not yet installed.



Figure 5. Interactive tutorial in ShockWave format

In the WinASEAN 4.0, steps of each operation were recorded by SnagIt software to create video demonstration file, which can be playback by Windows Media player to show how to operate each function. Disadvantages of this method is the video files are too large in size and also there was no possibility for interaction between trainee and the software. The InstantDemo software of the NetPlay has been used in WinASEAN 5.0 to overcome these obstacles. The InstantDemo provide high quality video file in ShockWave format, which is quite small in size. There is plenty of video editing function including making annotation in form of Bubble talk, duplicating frames and inserting pause points (hot spots).

## 2. REMOTE SENSING TRAINING AT GEOINFO LTD. IN VIETNAM

GeoInfo Ltd. is a private company operating in the field of geoinformatics. GeoInfo has been established as join venture in that the Department of Environmental Information Study and Analysis, Institute of Geography is the main partner in remote sensing and GIS. Training in remote sensing and GIS is one of common activities of the company. Remote sensing training is organized in three courses: Introductory, Basic and Advanced courses. Participants are mainly graduate students, master and doctoral course students, researchers and staff of space agency and remote sensing application institutions in Vietnam. Lectures are organized mostly outside working hours in evening time or during weekends. The contents of the courses focus on data analysis skill development. However, some explanations on remote sensing theory are still available in the courses but kept on minimal level. WinASEAN Edu version and dataset is provided to each trainee to offer self-training in their own time. To ensure high quality for the training, number of participants is limited to 12 and one computer is shared by two trainees.

### 2.1 The Introductory Course

The Introductory course is organized in four lectures. Each lecture is 150 minutes long. In this course the trainees are explained about fundamentals of remote sensing, the principle of visual interpretation and how to read false colour composite image. Contents of the course is given below:

- Lecture 1      Fundamentals of remote sensing
- Lecture 2      Introduction into digital image analysis



- Lecture 3 Introduction into WinASEAN, colour composite of multispectral image, spectral characteristics of land cover.
- Lecture 4 Steps in visual image interpretation, training in visual image interpretation.

## 2.2 The Basic Course

In this course trainees have the opportunities to practise with basic digital image analysis operation starting from image data import to multispectral classification. The course is broken down into the following 10 lectures.

- Lecture 1 Common remote sensing data format, image display, histogram computation, optical image enhancement and filtering.
- Lecture 2 Geometric correction: principles.
- Lecture 3 Geometric correction: image to maps registration.
- Lecture 4 Multispectral image classification by maximum likelihood method.
- Lecture 5, 6 Multispectral classification: practice.
- Lecture 7 Arithmetic operation, vegetation index, level slicing. Post classification operations.
- Lecture 8 Principle component analysis. Hyperspectral transformation for colour composite.
- Lecture 9 Change analysis: visual detection and overlay operation. Change detection map.
- Lecture 10 Change analysis: continue. Introduction to content in the Advanced course.

## 2.3 The Advanced Course

The advanced course aims to provide trainees advanced analysis and integrated practical application. Applicants for this course are selected among professional staff of remote sensing application agencies, researchers and doctoral course students. Requirement for admission is that applicant should have participated the Basic course and have some experiences in remote sensing application. The course is organized in 20 lectures as follow:

- Lecture 1 Introduction to DEM and 3D image display.
- Lecture 2 Introduction to Fortran programming.
- Lecture 3 Modeller – Advanced analysis module.
- Lecture 4 Combination of GIS information to support multispectral classification, vector to raster conversion.
- Lecture 5 Advanced multispectral classification.
- Lecture 6 Classification using colour matching.
- Lecture 7 Data fusion.
- Lecture 8 Microwave remote sensing.
- Lecture 9 Advanced geometric correction. Image to image registration, multi-sensor image overlay.
- Lecture 10 Combination of optical and microwave data for land cover study.
- Lecture 11,12 Land cover mapping using optical and microwave data
- Lecture 13 Spectral pattern analysis: vegetation cover extraction.
- Lecture 14 Spectral pattern analysis: water body and hydrographic features extraction.
- Lecture 15 Spectral pattern analysis: barren land extraction.
- Lecture 16 Image mosaicking, virtual reality visualization.
- Lecture 17 Introduction to other image analysis software as: MultiSpec, PCI, ENVI and ERDAS Imagine.

- Lecture 18 Practice with PCI software.
- Lecture 19 Practice with ENVI software.
- Lecture 20 Practice with ERDAS Imagine software.
- Participants from the following organizations have attended training:

- Ministry of Natural Resource and Environment, MONRE.
- Institute for Land administration research, MONRE.
- Ministry of Agriculture and Rural Development.
- Mapping agency, Ministry of Defence.
- Colleague of Military Technology.
- Hanoi University of Mining and Geology.
- University of Forestry.
- University of Agriculture.
- Institute of Mechanics, VAST.
- Vietnam-Russian Tropical Technology Center.



Figure 6. Remote sensing training at the GeoInfo Ltd.

## 3. FUTURE DEVELOPMENT

There is a plan to develop CARST 2.0, which will have the same concept as of the CARST 1.0 except that WinASEAN will be of version 6.0. The upgrading of WinASEAN bases on adding the following new functions:

- Time series remote sensing data analysis functions including: ground truth database management, classification of land cover by time series satellite data by spectral pattern analysis method.
- Export of WinASEAN image data to generic binary format.

## 4. CONCLUSIONS

The CARST 1.0 is an initiative of the author to develop a comprehensive environment and practical tools for remote sensing training and education. The concept of integration of WinASEAN 5.0, interactive tutorial and textbooks on remote sensing and GIS seems very useful for both beginners and advanced users. The curriculum of training presented in this paper is just the first trial and it will be improved gradually to satisfy the needs from user community. While CARST 1.0 with WinASEAN Edu is free, the version with WinASEAN Pro is provided with low charge in an effort to cover expenditure on software development, maintenance and Web service. After one year of conducting training at GeoInfo Ltd. some lessons could be drawn as follow:

- Capacity building is key issue for developing countries including Vietnam.
- Academic education on remote sensing in Vietnam lacks sophisticated hands-on training and practice.
- Remote sensing training curriculum in GeoInfo targets to fill gaps between theory and practice.
- The training at GeoInfo are useful complement to various university remote sensing program including distance e-learning courses.

#### **ACKNOWLEDGEMENT**

The author would like to thank Prof. Shunji Murai for valuable comments and suggestions during development of the package and financial support for the author to participate this Conference. The author also would like to thank Prof. Shoji Takeuchi and Dr. Yoshinari Oguro, Hiroshima Institute of Technology for contribution of functions Shading optical image, Shading SAR image and Image ortho-rectification by regression to the WinASEAN 5.0. The author thanks Prof. Shoji Takeuchi for hard working in testing the software and many useful comments.

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