Education Based on Computer operation for Remote Sensing and GIS Beginners' Training

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Abstract

This paper describes on a development of personal computer assisted educational system for fundamentals of remote sensing and GIS. This system consists of NEC PC9801 series personal computer and its peripheral equipments. Main functions of it are classified to GIS data collection, compilation, image data processing and investigation of regional characteristics using processed remote sensing and GIS data. All kinds of functions should be done by an interactive computer operation. The authors' research group had been used this system as a teaching material of some beginners' training course in several seminars.

Through this kind of training, beginners can learn what remote sensing is, what raster GIS is. The change detection and combined analysis with remote sensing and GIS data can be carried out as its typical applications.

Key Words: Education, Fundamentals, Remote Sensing, GIS,NVI, Change Detection

1. Introduction

In recent years the progress of computer technology is remarkable. According its progress, particularly personal computer system has become common in our daily life. This popularization of personal computer is mainly caused by reduction of system purchase cost and its easy operation. Actually many modern children have some computer games as we call them fami-com (family computer such as Nintendo) in their house and usually enjoyed them.

From the mentioned background, the authors' research group has developed educational system for remote sensing and GIS using personal computer system and its peripheral equipments.The basic concepts of system design are understandable and easy operation because it's educational tool for beginners' training.

The training by this system is classified to two main parts. One is fundamentals and other is applications. The fundamentals are the introduction to remote sensing and GIS. Also the applications are mainly analysis by themselves,

2. System Configuration

2.1 Hardware Configuration

NEC PC9801 series of 16 bit personal computer system was used as a main frame, digitizer and frame memory were also used as its peripheral equipments. Hardware configuration is shown in Fig.1.

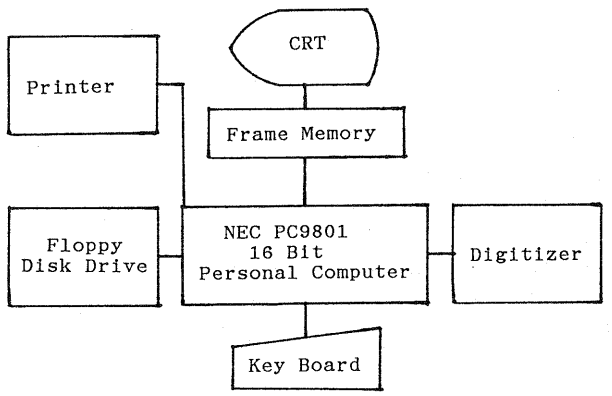

Fig.1 Hardware Configuration

2.2 Software Configuration

In this educational system, several kinds of functions are prepared for understanding remote sensing and GIS. Every function is made by some programs. Software configuration is shown in Fig.2. Right part of this figure corresponds to one program unit. Every program is made by BASIC and machine language. All programs as well as the function are controlled by menu-program. Therefore trainee can select optionally the function program from menu-program in response to the necessity.

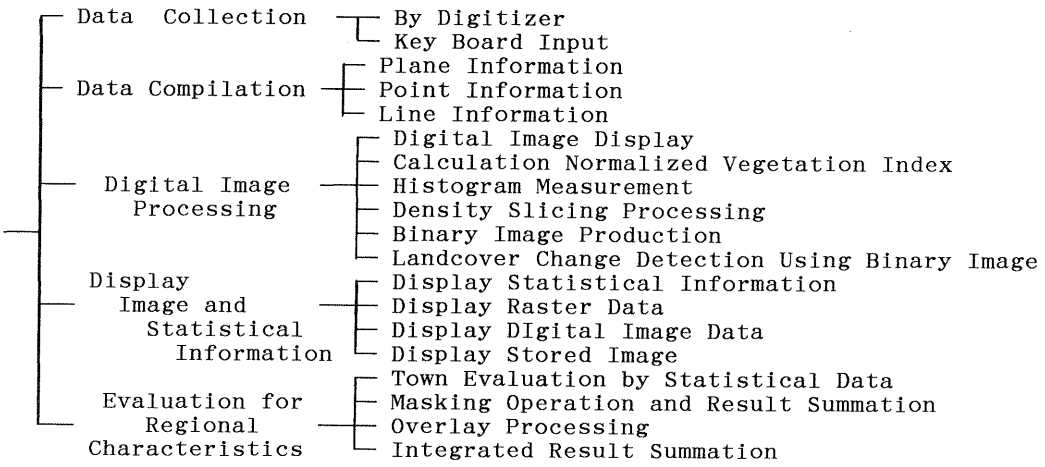

Fig.2 Software Configuration

3. Fundamental Training

3.1 Basic Principles of remote sensing

The meaning of "Remote Sensing" is to observe and measure various kinds of earth surface informations. Every substance on the earth has its own characteristics of reflection and absorption in different wavelength of radio wave. Applying this principle, detailed surface conditions can be assumed by measuring reflected and radiated intensity from each substance in some wavelength. These techniques are basic principles of remote sensing.

Through the training of digital image processing, trainees can understand digital image data structure, what meaning multispectral data is, basic technique of digital image processing and what kinds of informations are obtained from remote sensing data.

(a) Digital Image Data

Typical remote sensing data such as Landsat MSS, TM, SPOT is stored in some secondary memory device.

RESTEC has been distributing these kinds of remote sensing digital image data by computer compatible tape (CCT) and floppy disk. BIL and BSQ format are adopted for data storing. Therefore the data format in floppy disk has also decided.The disk format and data constitution for floppy disk are shown in Table 1 and 2 respectively.

Table 1 Format of IBM Type Floppy Disk

Items	Contents
Recording Form	Two-sided, Double density
Memory Capacity	1 M Byte
Cylinder No.	77 Cyliners
Track No.	154 tracks (2 tracks/cylinder)
Sector No.	26 sectors/track
Sector Length	256 byte/sector

Table 2 Data Format of Satellite Data Floppy Disk

Logical Format	File Constitution	
BIL (1 file)	Header	Data
	512byte	512p X 4001 X 4B
BSQ (4 files)	Header	Data
	512byte	512p X 4001 X 1B

(b) Multi-Spectral Data

Remote sensing can observe the various earth surface informations in the different wavelength (i.e. spectral band) such as visible and near infrared region. Most of remote sensing sensors have several observation instruments. For instance Landsat TM has a scanning optical-mechanical sensor system that observes visible, reflective-infrared, middle-infrared, and thermal-infrared regions of spectral wavelength. Collecting digital image data that consists of several kinds of spectral informations is so called multi-spectral data.

(c) Initial Statistics Extraction

Single band data of remote sensing is expressed by brightness value with the location, composed of rows and columns. Generally the brightness value will range from 0 to 255 ($=2^8$). It is called 8 bit image.

The histogram measurement function is necessary for an analyst to understand the actual digital image data distribution. In this training, trainees can recognize what meaning of 8 bit image data is by displaying the result of single band histogram measurement.

(d) Band ratio

Typical characteristics of spectral reflectance for healthy, dead vegetation and dry soil are shown in Fig.3. Healthy vegetation generally reflects from 40 to 50% of incident near-infrared energy, with chlorophyll in it absorbs about 80 to 90% of incident of visible region. Dead vegetation has higher reflectance than healthy vegetation in visible spectrum and has lower reflectance in reflected-infrared region.

From mentioned basic principle, the difference and ratio of brightness values between visible and near infrared band suppose to be effective for the vegetation monitoring. The red/infrared ratio data

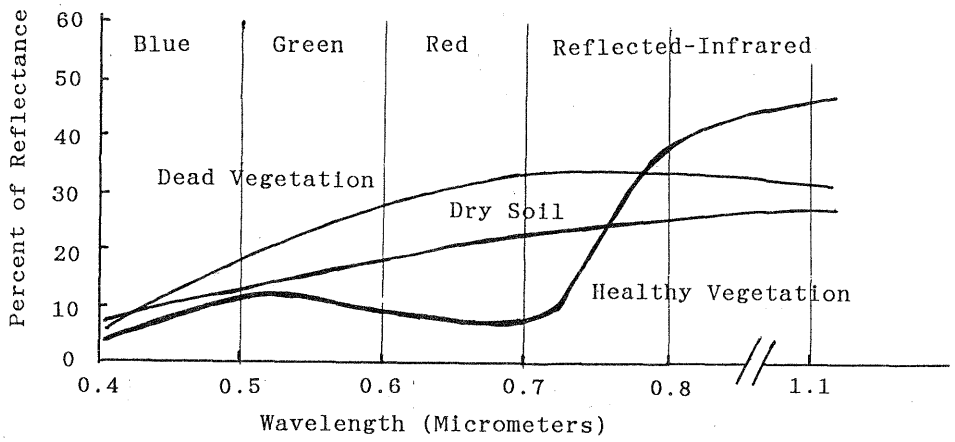

Fig.3 Typical Characteristics of Spectral Reflectance

of TM band 3, 4 brightness values are used for this training. Calculated index is called Normarized Difference (Vegetation) Index (i.e. NVI or NDI).

(e) Density Slicing

The density slicing is one of the basic techniques for an image enhancement. Density slicing is the conversion of the continuous tone of digital image data to some classes. Every interval of each class corresponds to the specific brightness value range. Used personal computer system has basically only 8 colors for displaying on CRT monitor. By mentioned density slicing and histogram measurement for NVI data, basic concept of NVI and contrast stretch can be understood.

3.2 Basic Principles of Geographic Information System

Geographic information system (GIS) is a term that is to store the geographically distributed informations in XY coordinate system, retrieval and analysis of these informations using computer system. It also contains database, the hardware and software, retrieving, analyzing, and displaying.

(a) Data Structure

The geographic location data that are acquired by a digitizer is classified to following three kinds of data feature types; (1)Point, (2)Line, (3)Polygon.

Every location data also has an attribute information for its explanation such as one's name. The point type data is a single point location data and expressed by xy coordinate. The line type data is the link of points data and its data consists of same structure as point type data. The polygon type data is almost same as the line type data. But this kind of data constitutes one closed loop. Data structure is the same as line type data. Fig.4 shows the point, line and polygon type data structures. It is important to manage the point feature because point data is the basic for all kinds of data types.

(b) Vector and Raster Data Type

Generally, the data type of GIS data is classified to two kinds of data model. One is the vector data model and other is the raster data model.

Typical raster data is a digital image data such as remote sensing data. In the raster data model, one homogeneous unit is expressed by cells (pixels) that consists of grid-cells on the ground. Actual grid-cell creates a matrix that is superimposed on the earth surface. And within this systematic array of grid-cell, the attribute data is collected in order to produce raster type data.

The vector data model provides a more compact data structure than the raster model. But data structure is more complex than the raster type. Both manipulation and enhancement of digital images can not be effective for the vector domain.

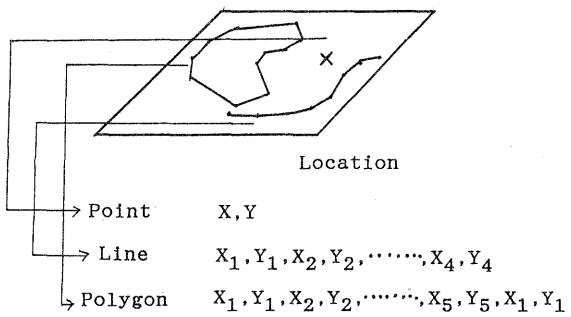

Fig.4 GIS Data Structure

(c) Geometric Manipulation

The original satellite image coordinate can not be overlapped on XY coordinate system of the map. However remote sensing data can be projected on some map coordinate using the relationship between image data coordinate and map coordinate.

GIS data has a capability to change scale, change map projection, remove, distortion and execute coordinate rotation and translation depend on its necessity. Fig.5 shows the processes are called fundamentals of geometric manipulation.

4. Application Training

In this training, each practice is basic techniques for remote sensing and geographic information system. However all practices could be constructed one training course.

The analysis area of this application training is Hachioji. In this area, re-

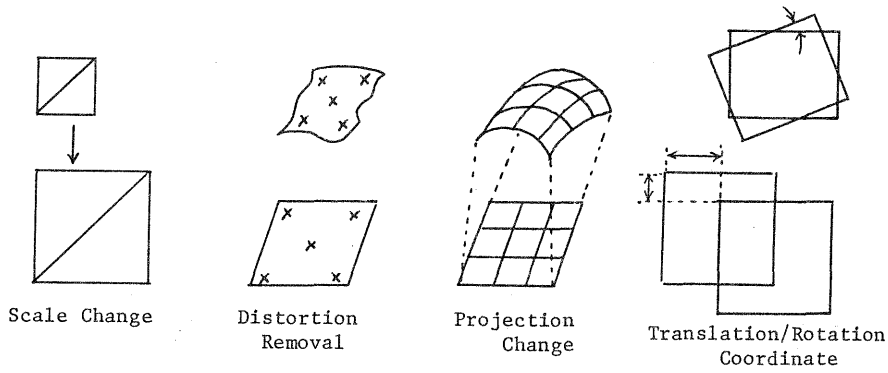

Fig.5 Fundamentals of Geometric Manipulation

cently the transfer on university from center of Tokyo have brought the new land development and resulted the environmental change for aiming new city planning. Here can reach in one hour drive by car forward western direction from center of Tokyo.

4.1 Change Detection

Two temporal Landsat TM data were prepared for the change detection analysis. One was observed on Dec.4, 1984 and other was Dec.5, 1990. As the preprocessing, geometric correction was carried out for both of TM data in order to overlap on the map coordinate. Each corrected imagery consists of 512 pixels and 400 lines data with 4 bands of band 1,2,3,4 and is stored in one floppy disk.

In this area, typical environmental change pattern is supposed that forest has been changed to bare soil by land development.

Therefore using two temporal NVI data, which concerns the status of vegetation cover, land cover change detection that is from vegetation to non-vegetation (i.e. land development) is carried out. NVI is calculated by following formula;

$$NVI = \frac{(\text{Band 4} - \text{Band 3})}{(\text{Band 4} + \text{Band 3})} * \text{Gain} + \text{Offset}$$

$$\text{Gain} = 100, \quad \text{Offset} = 50$$

Here, this change detection means where and how many area of land cover change has been occurred in six years from '84 to '90.

Actual detection procedure is as follows; (1) Calculation of Normalized Vegetation Index (2) Histogram Measurement for NVI data (3) Define threshold value for separating land cover type into vegetation and non-vegetation classes. (4) Classification to two classes by Density slicing. These processes from (1) to (4) must to be executed for each data. Finally change detection is carried out for two results of (4) by logical operation.

4.2 Regional Characteristics Investigation

In this practice, every trainee can understand how GIS will be used with remote sensing data.

At the first practice, town condition evaluation by population density is executed as an analysis using polygon and its attribute GIS data. This analysis procedure is as follows; (1) Calculation of population density using town population data as the attributes for each town (2) Grade for each town by the above calculated data (3) Coloring for each grade using town boundary raster typed data (polygon type) (4) Computation the statistics for the result of grading.

At the second practice, the relationship between population density land cover change is examined by combining the result of grading of population density and result of change detection. This process is the one of the summations of results, obtained by remote sensing.

5. Conclusion

In this developed system mentioned in this paper, there are two main training categories such as fundamentals and applications.

In the fundamental training, the image data structure, format and its own characteristics as some of basic image processing techniques could be understood through histogram measurement and density slicing practices. As fundamentals for GIS, GIS data structure and geometric manipulation could be learnt through GIS data generation by digitizer and vector-raster data type conversion.

In the application training, through the analysis of land cover change detection as an application of remote sensing, what kind of informations extract from remote sensing data could be learnt. And how combine with the result of an analysis of remote sensing data and GIS data such as town boundary polygon data, town population as its attribute data, could be understood through regional characteristics investigation.

This system has been developed in a continuing form as a series of educational tool for remote sensing and GIS. There are still some revising points in order to teach and learn easily. The authors hope to have your suggestions on this matter.