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A Study on SPOT and DEM Data as Input to Geographic Information System Applying to an Inaccessible Region

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Abstract

The two key elements of the Geographic Information System(GIS) are (1) Data base management of land resources information as computer files, and (2) Software ability to analyze and map this information. More geometrically corrected SPOT derived land cover information and digital topographic information from digitial elevation model (DEM) were integrated as input data of GIS in order to create landscape modelling. The ultimate goal of this GIS is to establish the use of physiographic data as an integral part of the comprehensive planning process in order to avoid significant environmental and economic problems.

1. Introduction

The purpose of geographic information systems (GIS) are to efficiently store, retrieve, manipulate, analyze and display the data about the land according to user-defined specifications. The importance of integration of remotely sensed data into GIS was pointed out by several authors (Gauison et al., 1965, Marble, 1981).

However, the data derived from remote sensing systems have not played a primary role as input data to GIS. These are mainly due to the fact the traditional satellite based remote sensing output is below the map accuracy standard of GIS which forms the starting point for subsequent works(American Society of Photogrammetry, 1983).

Since the launching of French SPOT satellite, satellite remote sensing can provide more geometrically corrected data because of its multilinear array(MLA) technology compared with the multi-spectral sensing(MSS) technology.

In addition, the utility of these data are increased in the inaccessible region. Thus, the purpose of this study is to utilize SPOT and DEM data as database of GIS in an inaccessible region.

2. Database of GIS in this study

Digital handling of spatial data in GIS developed in this study is based on the rasterbased satellite land use maps and digital topographic data derived from digital elevation model(DEM). Land use(cover) classification maps were geometrically corrected using ground control points (GCP) by referring the large scale topographic map.

Slope-both gradient and aspect information, and relief shade information were derived from DEM whose grid interval was 10m x 10m.

These data were all registered into Universal Transverse Mercator(UTM) coordinate system as a common base.

The GIS being developed in this study is rather designed for regional application, not detailed site analysis. Figure 1 shows the computerized information processing of data base of GIS in this study.

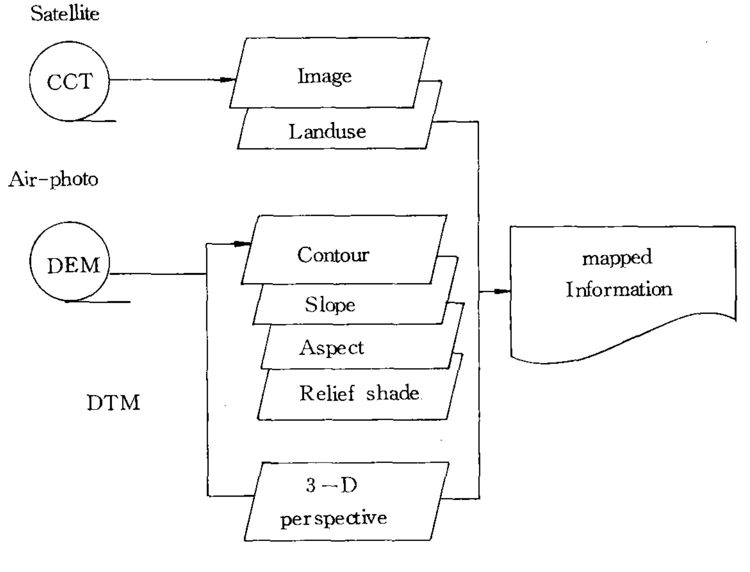

Fig. 1. Conceptual Framework of GIS Database in this study

3. DEM

DEM could be defined a mathematical simulation of which variables are overlaid upon common grid plane(Craig Tom et al., 1978).

It provides a depository for interrelating diverse land information in a common format.

A model variable or data plane such as slope gradient is one overlay of spatially registered data in a common cellular network upon all other planes or variables in the landscape model.

3–1 Contour map

DEM was constructed to be 10m x 10m grid interval of UTM coordinates which was converted and resampled from raw elevation data of 12.5m x 12.5m UTM interval(DMA, 1977).

Photo 1 is a contour map of 200m interval of the region displayed out as graphic CRT image.

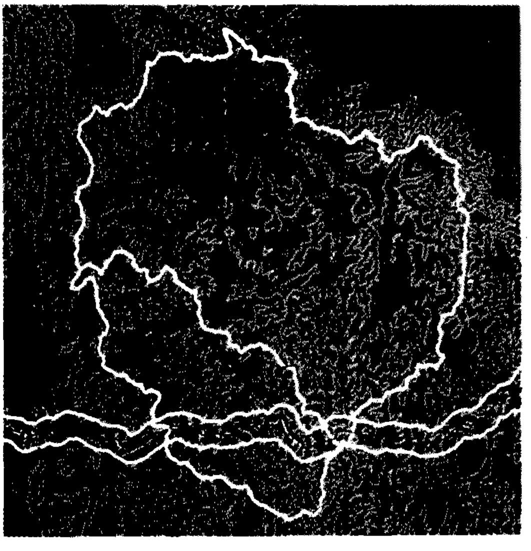

Photo 1. *Contour Map* 0m $\leqslant$Z $\leqslant$1638m.

3–2 Slope map

The essence of mapping slope gradient of each cell is calculating algorithm of the degree α (Ryutaro Tateishi, 1982).

$$\alpha = \mathrm{Tan}^{-1} \quad ((Ze\text{-}Zw)/2d)^2 - ((Zn\text{-}Zs)/2d)^2$$

where d ; grid interval

Ze, Zw, Zn, Zs; elevation of 4 points around calculating point

Photo 2 is the result of slope gradient map graded by 10° each.

Photo 2. *Slope map* $0^\circ \leqslant \alpha \leqslant 90^\circ$

3–3 Aspect map

Azimuth of slope aspect, θ, providing that θ means the clockwise degree from north, and

if $X = (Ze - Zw) / 2d$

$Y = (Zn - Zs) / 2d$

$\theta = 90^\circ - \mathrm{Tan}^{-1} (Y/X)$	when $X < 0$
$\theta = 0^\circ$	when $X=0$ and $Y < 0$
Horizontal	when $X=0$ and $Y=0$
$\theta = 180^\circ$	when $X=0$ and $Y > 0$
$\theta = 270^\circ - \mathrm{Tan}^{-1} (Y/X)$	when $X > 0$

Photo 3 is the result of aspect map using this algorithm and graded by 45° each.

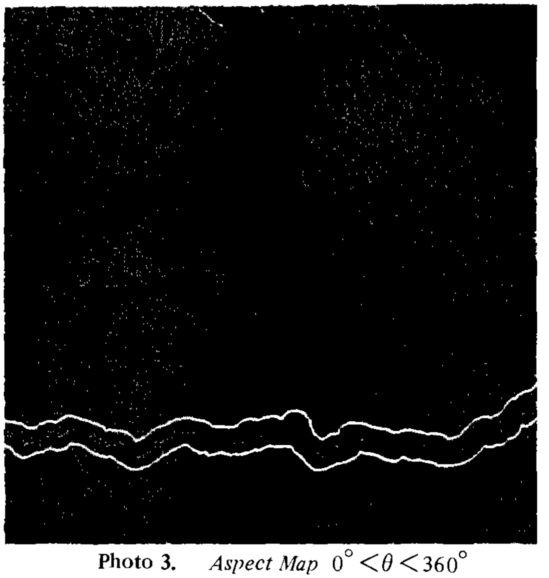

Photo 3. *Aspect Map* $0^\circ < \theta < 360^\circ$
400° = Horizontal

3–4 Relief shade map

Shading degree of relief, S, could be calculated by following equation.

S = 100 * Cos A * Cos B

Where A ; the angle between the sun ray and the normal vector of a plane
B ; the angle between the view direction and the normal vector of a plane

Photo 4 is the result of relief shade map using this algorithm and graded by 10 degree each.

4. Satellite Data Processing

In this study only the image processing of SPOT among various satellite is discussed.

4–1 SPOT Panchromatic

A panchromatic(black and white) image(scanned on Feb. 16, '87) corresponding to observa-

Photo 4. *Relief Shade Map* $\theta \leqslant S \leqslant 100$
dark light

tion over a broad spectral band 0.51–0.73 μm with 10m x 10m ground resolution was geometrically corrected by using GCP's and displayed as photo 5. 0–255 reflectance level of the band was represented by each 256 graded lightness of mono graphic CRT screen.

Photo 5. *SPOT Black and White Image*

4–2 SPOT Multispectral

A multispectral(color) image(scanned on Feb. 27, '87) corresponding to observation in 3 narrower spectral bands, with 20m x 20m ground resolution was geometrically corrected by using GCP's and displayed as photo 6, false color composite. The photo was composed with band 1 as blue, band 2 as green, and band 3 as red. 0–255 reflectance level of each band was represented by graded lightness of each color component.

Photo 6. *SPOT Color Composite.*

4–3 Land use(cover)

A particular land use can be considered as a class in a classification system, and, further, each class is defined by its similarity to other class members and some level of differentiation from nonclass members. In this study supervised classification method was used for land-use mapping. After stepwise discriminant analysis, the most optimal discriminant function is applied to all pixels in the study region.

With F level of 0.01 for including a variable and F level of 0.005 for deleting a variable where F values for each variable.

If variable j has been entered

Fj = (ajj-bjj/bjj) (n-r-g+1/g-1)

with degrees of freedom g-1 and n-r-g+1

If variable j has not been entered

$Fj = (bjj-ajj/ajj)\ (n-r-g/g-1)$

with degrees of freedom g-1 and n-g-r

Under the usual normality assumptions these are the likelihhod ratio tests of the equality over all g classes of conditional distribution of variable j given the (remaining) entered variables.

Wilks' λ to test equality of class means

$U = Det(W11)/Det(T11)$

with degrees of freedom(r, g-1, n-g)

In the later classification procedure, coefficients and constant terms of the classification of functions

$$C_{ki} = (n-g) \sum_{j=1}^{r} X_{ki}A_{ij}$$

$$C_{ko} = -1/2 \sum_{i=1}^{r} C_{ki}X_{ki}$$

Where,

$i = 1, 2, ..., r$

$k = 1, 2, ..., g$

When the number of variables entered is determined,

for $1 = 1, 2, ..., r$

$m = 1, 2, ..., g$

$k = 1, 2, ..., nl$

Value of the m classification function evaluated at case k of class 1

$$S_{lmk} = Cmo + \sum_{j=1}^{r} C_{mi}X_{lkj}$$

Posterior probability of case k in class 1 having come from class m

$$P_{lmk} = (P_m \exp(S_{lmk}) / \sum_{j=1}^{r} Pi \exp(Slik))$$

Where pm is the prior probability of class m. Photo 7 is the result of land-use classification.

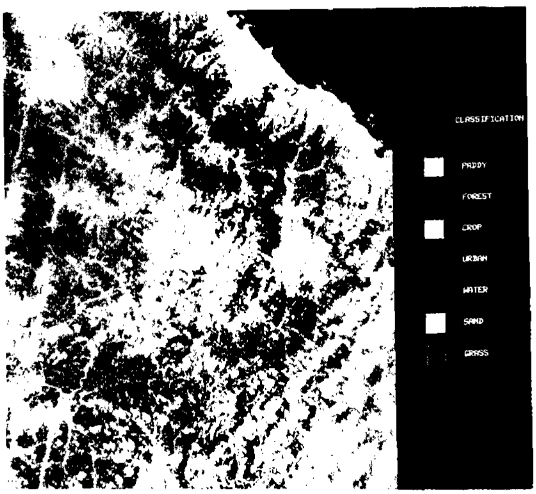

Photo 7. *Land use map*

5. Multi-file processing

Multi-date multi-file processing which provides various mapped information for decision supporting system about land resources management was implemented in this study.

Photo-8 is the image of multi-file processing of the SPOT black and white result overlain upon 3-dimensional representation of digital terrain by central projection method(Shunji Murai, 1980).

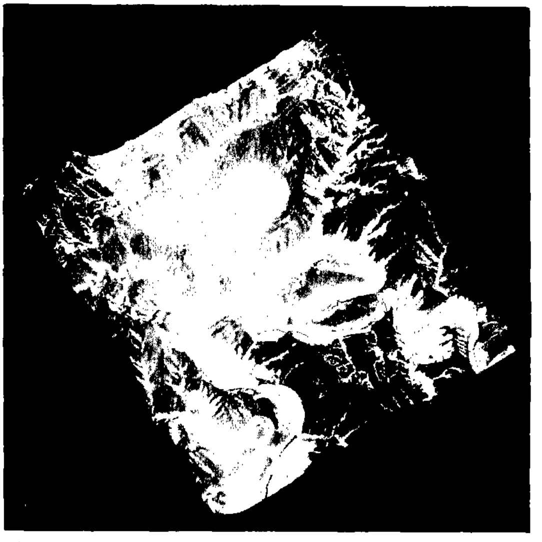

Photo 8. *SPOT Black and White 3-D Perspective View.*
Direction angle 155°
Horizontal Distance 100Km
Height 100Km

6. Conclusion

More geometrically corrected SPOT data were used for deriving land use(cover) information for an inaccessible area. Furthemore, several topographic information – gradient, aspect, and relief shade map – were integrated into data base together with SPOT derived land use information. Landscape modelling was also constructed by providing three-dimensional perspective view. As a result, it was possible to establish the use of physiographic data as an integral part of the comprehensive planning process in order to avoid significant environmental and economic problems.

7. References

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