

Digital Analysis of Forest Land Using Landsat TM and SPOT
HRV Data by Personal Image Processing System

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Abstracts

This paper refers to the feasibility of Landsat TM and SPOT HRV data for surveying and inventorying of forest land ... forest type classification, detection of tree damage and diagnosis of tree vitality. Basically, the quantitative approach to environmental assessment by remote sensing is performed based upon a characteristics of spectral pattern and geographical data base derived from a digital terrain model.

The system component of digital data processing in this analysis are made up with 16-bit micro processors and some surrounding units. The study area, Mt.Hieizan, lies wholly within Kyoto and Shiga prefectures in central Japan.

Landsat TM and SPOT HRV integration with a geographic information system could be very usefull to get an effective analysis for the forest-land management. This paper describes on the personal image processing system with Landsat TM and SPOT HRV data used in this analysis , and the comparison of several integration problems in forest inventory.

1. _ Introduction

Recent development in remote sensing and information processing technologies have presented an opportunity to improve data collection and investigation for the forest-land management. The data of airborne remote sensing has been used for detecting, monitoring, and analyzing on the earth's surface by reason of fine resolution. Although the airborne scanner suffers from greater scanner-induced image distortions than satellite remote-sensing because of the former's wider total instantaneous field of view. Moreover, its application in rugged mountain areas encounters many problems derived from the imagery may contain radiometric and geographic distortion, due to the angle effects and the illumination condition of scanning. It may be necessary, therefore, to correct the distortion for a reliable result. So we conducted a merging system with satellite remote-sensing data and geographical data for making a accuracy assessment. In this study, a digital terrain model (DTM) was used to make corrections of terrain-effect. The DTM was constructed by using the height data of 20-meter mesh setting on the 1:5,000 topographical map. In preparation for a fine resolution of imagery, furthermore, Landsat TM and SPOT HRV data were applied. By combining remote sensing analysis and geographic information

system, higher resolution can be done to update accuracy assessment, and distribution of information.

2. Materials and Methods

1) The study area

The study area, Mt.Hieizan, is located in the boundaries of Kyoto city, Kyoto Pref. and Ohtsu city, Shiga Pref. in central Japan (35°03'N,135°52'E). Fig. shows the location of the study area. Mt. Hieizan is the greatest mountain which we can see it from anyplace in Kyoto city. There is Enryakuji temple which has been many believers since the transfer of the capital of Japan to Kyoto, 1194 years ago, on the top of the mountain. It was constructed by Saicyou of a buddihist, at 785 A.D.. The forest covers about 3,000 ha extending in the range of east-west and north-south. Elevations range 150 to 848 meters. It lies in the warm-temperate forest zone. The geological features of the study area is almost consist of the Paleozoic. Within the study area are five vegetative types: namely, Japanese cedar(*Cryptomeria japonica* D.Don), Japanese cypress (*Chamaecyparis obtusa* S. and Z.), Japanese red pine(*Pinus densiflora* S. and Z.), Evergreen hardwoods, and Deciduous hardwoods. Cedar and cypress are planted on good sites on lower and mid-slopes, respectively. On the other hand, the greater part of ridges are covered with scattered pines and deciduous hardwoods. The area in which the construction of geographical data extends 6 km in north-south, 5.4 km in the direction of east-west.

2) Data and Processing

Data on June 5,1985; Landsat TM, Oct. 21, 1986; SPOT HRV were selected for the research because of the absence of cloud cover, channel data quality and time period most favorable to resource classification. The other kinds of data are topographical maps(scale of 1:10,000 and 1:5,000) , a county soil map, and vegetation information.

The system components of digital data processing in this analysis are made up with 16-bit micro processors(NEC PC9801 VM21 with frame memory and a digital data processor), hard disks(20 MB), a drum scanner, a magnetic tape unit, a coordinate digitizer, a image display and a color ink-jet printer.

Operational forest-land inventory method developed by a personal processing system for the digital classification of satellite data, a plot-sampling procedure for identifying tree types and making a geographical information.

Plot sampling sites were chosen so as to represent all distinct types present on the image, to sample different areas of large, homogenous tree types, and to provide a good spatial distribution of samples.

Fig.-2 shows the flow diagram of the procedures taken in this study. First, regulatory processing of data was made with radiometric and geometric corrections. The radiometric correction and CCT level conversion of satellite scanning data were performed based upon statistical information generated by the grant method of search. Band selection of Landsat TM data for the classification were carried out based upon the factor analysis concerning the feature extraction of parameters. Digital terrain model(DTM)

as shown in Fig. 3 was also made to carry out the correction of geometrical distortion with the 1:5,000 topographical map. The DTM was constructed by using the height data which were acquired from 20-meter mesh setting on the coordinate system of the topographical map. The TM and HRV data were geometrically corrected by the affine transformation. The coefficients were decided by the least square method. To carry out the above procedure, 15 to 20 ground control points(GCP) were selected on the 1:5,000 topographical map and also on the TM and HRV imageries. For the resampling of the geometrically corrected data, the nearest neighbor method was applied. The residual geometric errors of the TM and HRV imageries became under 30 and 20 meters in every case.

The incident regulatory model was considered in order to carry out the correction of topographical effect, because solar-incident energy upon the sensor is affected by the terrain angle between the solar azimuth and the inclined plane. For the above correction, the following regulatory model was used to reduce the distortions of terrain(1):

$$S=1/F(S'-L\rho) \dots\dots\dots(1)$$

where *S*:CCT data after adjusting, *S'*: CCT data before adjusting, *F*:Relative solar-incident factor, *L*: An estimate of atmospheric path radiance.

$$F=\sin\beta = (\cos\varepsilon \sin\phi - \sin\varepsilon \cos\alpha \cos\phi) \sin\delta + (\cos\varepsilon \cos\phi + \sin\varepsilon \cos\alpha \sin\phi) \cos\tau \cos\delta + \sin\varepsilon \sin\alpha \sin\tau \cos\delta \dots\dots\dots(2)$$

where ε : Slope angle, ϕ : Latitude at the point, α : Slope aspect, δ : Solar declination at the time of scanning, τ : Solar zenith angle.

The relative solar-incident factor at a point on the ground is defined by the above equation using values from its terrain slope-angle and slope aspect for the sun position at each grid intersection.

Classification of land-cover features was made by the supervised most-likelihood method based on the statistical data of 4 kinds of spectral bands from among TM, and HRV data respectively. In the case of SPOT HRV data,

the ratioing process between adjacent spectral band was joined in 3 bands.

Forest types in the classified Landsat TM data and SPOT HRV data were five:

namely, (1) Japanese cedar, (2) Japanese cypress, (3) Japanese red pine, (4) Evergreen hardwood, (5) Deciduous hardwood.

After classification, data categorized by individual pixel in every scene were allotted to each grid cell of geographical data. The procedure needs the accurate conversion, because one scene of satellite data is to be overlaid into the coordinate system of another scene. The computer data base consists of 5 parameters; i.e., (1) altitudes at 4 corners of each grid, (2)inclination of grid face, (3)azimuth of inclination, (4)land cover types, (5)geological features. A coordinate digitizer was also used to obtain the coordinates of each geology divide, store the coordinates on

floppy, and display the position of damaged forest stand in various graphic modes. Topographical data and other kinds of data can be supervised on the land cover type map through use of a coordinate digitizer. Moreover, the forest situation in rugged-terrain area can be assessed rapidly by integration of the information system.

3. Results and Discussion

From factor analysis, forest quality parameter by Landsat TM and SPOT HRV data were summarized in two aspects. The first one is a matter of vital function as interpreted by near-infrared band, and second one is coloration of bringing out by visible band. Results of factor analysis in Landsat TM and SPOT HRV data are shown in Table 1 and 2. As it was satisfied the condition of classification, this results was adopted 4 parameters for classification. The classified map with regards to the forest type situation divided by vegetational condition. After the ground verification of the classified results, the maps were about 82 percent accurate, based on ground truth comparison of random sample plots. Next, a digital comparison of classifications between Landsat TM and SPOT HRV revealed the differences of 5% in the total average of accurate discrimination, and 2 to 18% in the every difference between the same categorized area. Comparison of discriminant performance from TM and HRV classifications of forest-land shows in Table 3 and 4. These tables present classifying stages of every category. By the confusion matrix of classified result in both tables, supposition about the mutual relation of every spectral band in effective classification will be established. The SPOT imagery was found to prove the more desirable classification in Cypress, Red pine, Evergreen hardwood and Deciduous hardwood. Comprehensively, the SPOT classification provided a more generalized representation of the forest-land in the digital comparison between TM and HRV with their performances.

4. Conclusion

A purpose of this study is find out the potential of Landsat TM and SPOT HRV data to classify the forest types and the degree of growth of planted trees. The study area is covered with five kinds of trees and its topography is rugged. Above condition deteriorates the classification performance of forest-land situation. To improve the the classification accuracy, Landsat TM and SPOT HRV data integrated with a geographic information system for the forest-land. Results of this study are as follows:

1. Color visible band and middle-infrared band in both satellite data are effective to distinguish vegetation situation from a result of the principal component analysis.
2. Three dimensional data base consisting of Landsat TM, and SPOT HRV data corresponding topographical data makes a 3-D geo-botanical information system.
3. Classification maps obtained in this study are recognized as practical purposes in the ground survey. These maps may give us a fairly concrete information on the boundaries of forest, location, its area, and growth stages.

Literature cited

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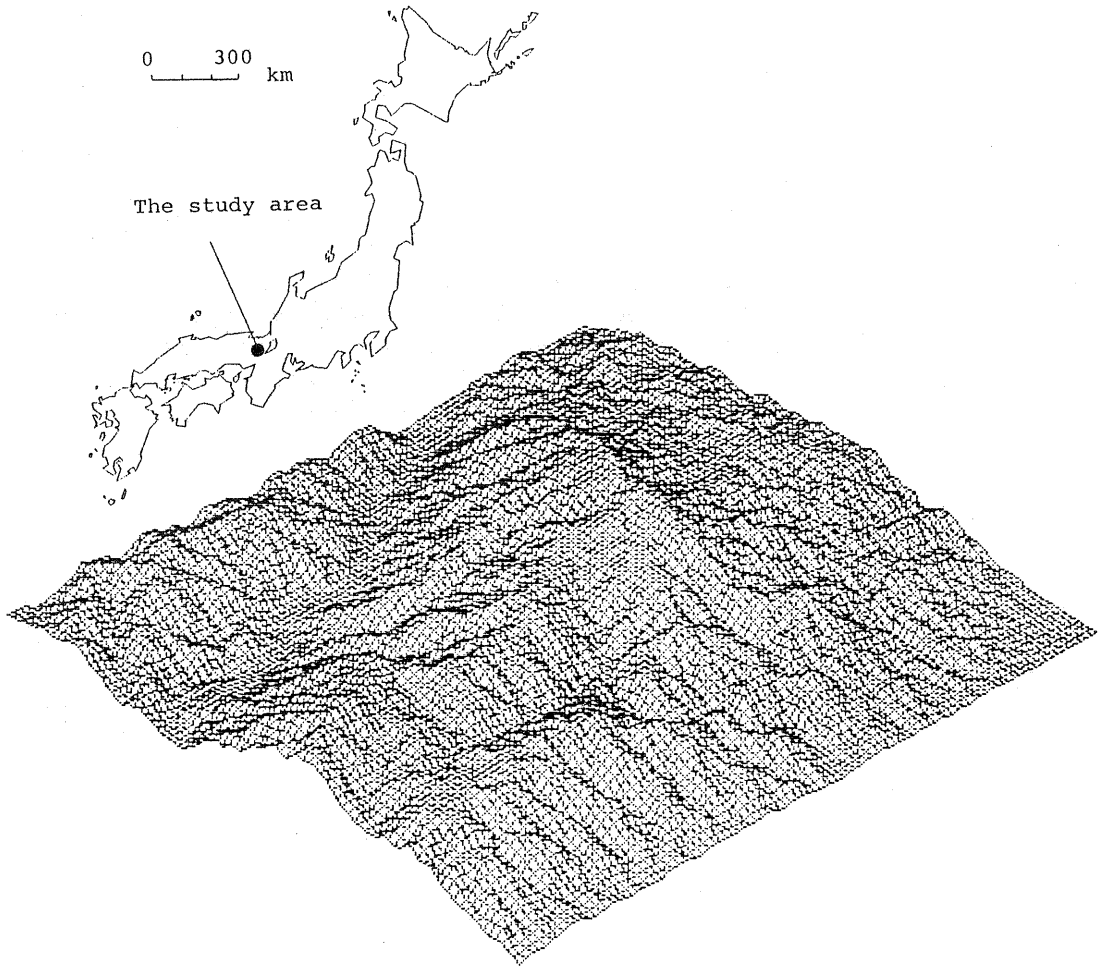


Fig.1. Location map for the Mt.Hieiizan study area.
This is a perspective view from the north-west.

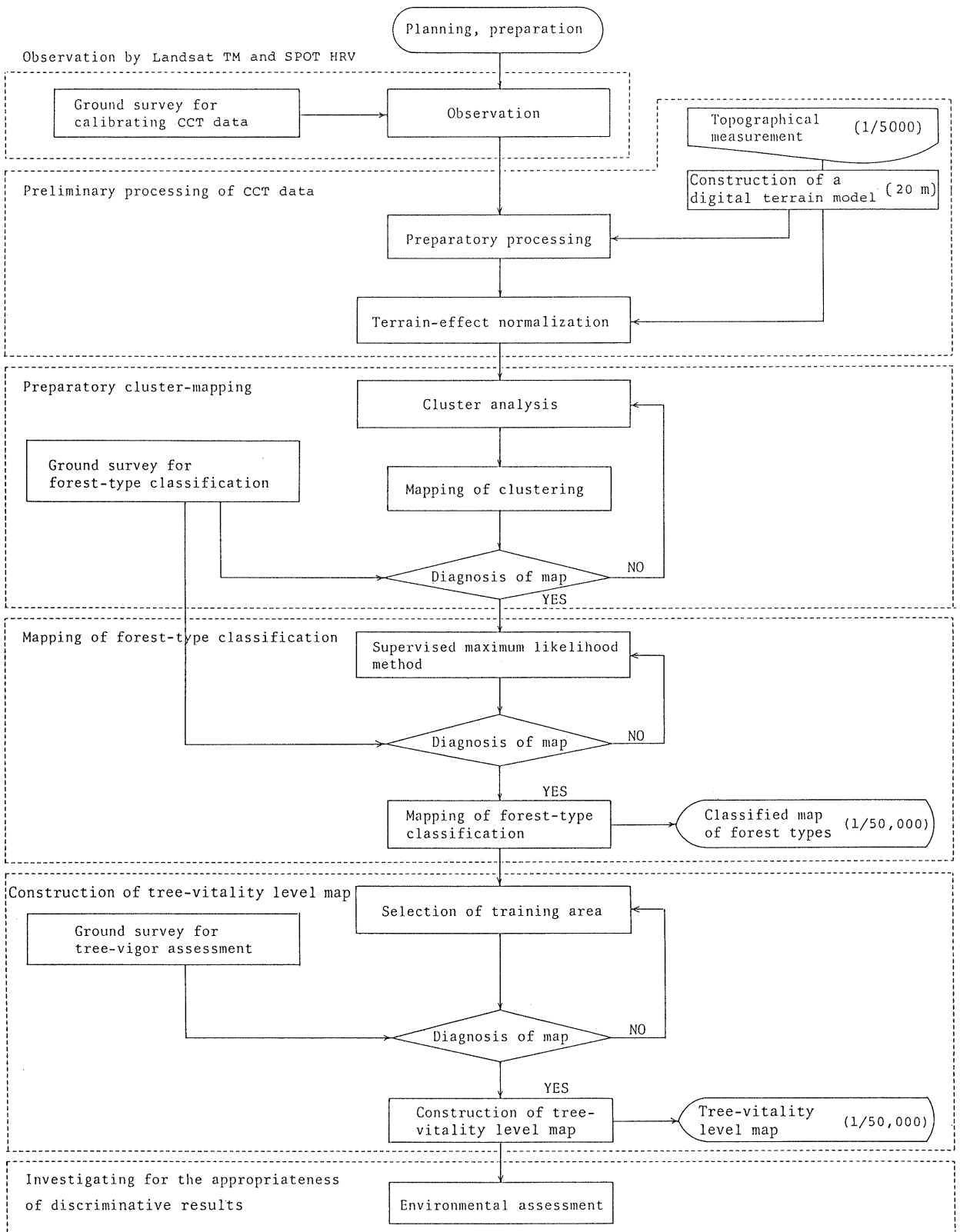


FIGURE 2. Flow diagram of data processing.

Table 1.
Eigenvalues and their contributions with TM data

Items \ Factors	1	2
Eigenvalue	3.23014	0.742438
Contribution	0.8075	0.1856
Cumulative Contribution	0.8075	0.9931

The figures 1-2 are meanig of the dimensional number in the principal compornent analysis.

Factor loadings

Factors	F 1	F 2
Band 1	0.90138	0.42178
Band 2	0.70632	-0.70633
Band 3	0.99094	-0.10789
Band 4	0.96787	0.23235

Table 2.
Eigenvalues and their contributions with SPOT data

Items \ Factors	1	2
Eigenvalue	3.49366	0.417606
Contribution	0.8734	0.1004
Cumulative Contribution	0.8734	0.9778

The figures 1-2 are meanig of the dimensional number in the principal compornent analysis.

Factor loadings

Factors	F 1	F 2
Band 1	0.97897	0.17404
Band 2	0.97745	0.15997
Band 3	0.81322	-0.58194
Band 4	-0.95839	-0.15187

Table 3. Confusion Matrix of Classified result with Landsat TM data

Class :		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[!]
[1]	J. Cedar	: 69	25	2	0	0	0	0	3	0	0	1
[2]	J. Cypress	: 15	73	10	1	0	0	0	0	0	0	1
[3]	J. Red pine	: 0	9	75	7	2	0	0	7	0	0	0
[4]	E. Hardwood	: 0	0	22	60	7	0	0	11	0	0	0
[5]	D. Hardwood	: 0	0	6	2	84	0	0	0	0	0	8
[6]	Grassland	: 0	0	10	5	0	80	0	0	0	0	5
[7]	Farmland	: 0	0	0	0	0	0	89	0	3	7	1
[8]	Bareland	: 0	0	0	0	5	0	0	95	0	0	0
[9]	Town	: 0	0	0	0	0	1	0	1	93	0	5
[10]	Watershed	: 0	2	0	0	0	0	2	0	0	88	8

* [!]:Unclassified

Table 4. Confusion Matrix of Classified result with SPOT HRV data

Class :		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[!]
[1]	J. Cedar	: 67	23	3	0	0	0	0	0	0	0	7
[2]	J. Cypress	: 4	86	1	0	6	0	0	0	0	0	3
[3]	J. Red pine	: 0	5	84	7	0	0	0	0	0	0	4
[4]	E. Hardwood	: 0	7	5	78	0	0	0	0	0	0	10
[5]	D. Hardwood	: 0	10	0	0	87	0	0	0	0	0	3
[6]	Grassland	: 0	0	5	5	0	85	0	0	0	0	5
[7]	Farmland	: 0	0	0	0	0	0	87	8	0	0	5
[8]	Bareland	: 0	0	0	0	0	0	1	87	4	0	8
[9]	Town	: 0	0	0	0	0	0	0	4	95	0	1
[10]	Watershed	: 0	0	0	0	0	0	0	0	0	96	4

* [!]:Unclassified