Korean Journal of Remote Sensing, Vol.18, No.3, 2002, pp.163~169

Comparison of Visual Interpretation and Image Classification of Satellite Data

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Abstract : The land uses of Korean peninsula are very complicated and high-density. Therefore, the image classification using coarse resolution satellite images may not provide good results for the land cover classification. The purpose of this paper is to compare the classification accuracy of visual interpretation with that of digital image classification of satellite remote sensing data such as 20m SPOT and 30m TM. In this study, hybrid classification was used. Classification accuracy was assessed by comparing each classification result with reference data obtained from KOMPSAT-1 EOC imagery, air photos, and field surveys.

Key Words : Classification Accuracy Comparison, Satellite Remotely Sensed Data, Visual Interpretation, Image Classification.

1. Introduction

Remote sensing is the science and art of obtaining information from data using a remotely located sensing device (*e. g.*, aircraft, satellite). Development in aerospace and computer technologies accelerates the techniques of information extraction in remote sensing (McCloy, 1995). The information can be extracted by visual interpretation of human or digital processing of computer. Table 1 provides a comparison between the human and the computer information extraction. As seen in the table, the methods of human interpretation and computer processing supplement each other (JARS, 1993).

High-density land use activities is done in the Korean peninsula. It may deteriorate the classification accuracy of coarse resolution satellite images such as Thematic Mapper (TM, 30m resolution) or enhanced SPOT color image (20m resolution). Therefore, the purpose of this study is to compare the classification accuracy between visual interpretation and digital classification result of SPOT color images with 20m resolution and TM data with 30 m resolution.

Received 5 November 2001; Accepted 15 December 2001.

Table 1. Comparison between human and computer information extraction.

Method	Merit	Demerit
Human (Visual interpretation)	• Interpreter's knowledge are available • Excellent in spatial information extraction	• Time consuming • Individual difference
Computer (Digital processing)	• Short processing time • Reproductivity • Extraction of physical quantities or indices is possible	• Human knowledge is unavailable • Spatial information extraction is poor

2. Materials and Methods

The study used the satellite images observed from Mokhyun Stream watershed and Tahndong Stream watershed. The former site is located at Kwangju-eup, Kyunggi-do and the covering area is 20.9km^2 (Fig. 1). The latter is located at Daedeok Science Town, Daejeon and the area is 21.0km^2 (Fig. 2).

A 20m resolution SPOT XS image obtained on July 1, 1996, and 30m resolution TM image on May 8, 2000, were used to extract land cover information in the study area. Korea Multi-Purpose Satellite-1 (KOMPSAT-1) Electro-Optical Camera (EOC) panchromatic image with 6.6m resolution and aerial photographs with 1:20,000 scale were used as the reference data. For the vector data, digital topographic maps with 1:5,000 scale were used as the sources of Ground Control Points

Fig. 2. Tahndong Stream watershed.

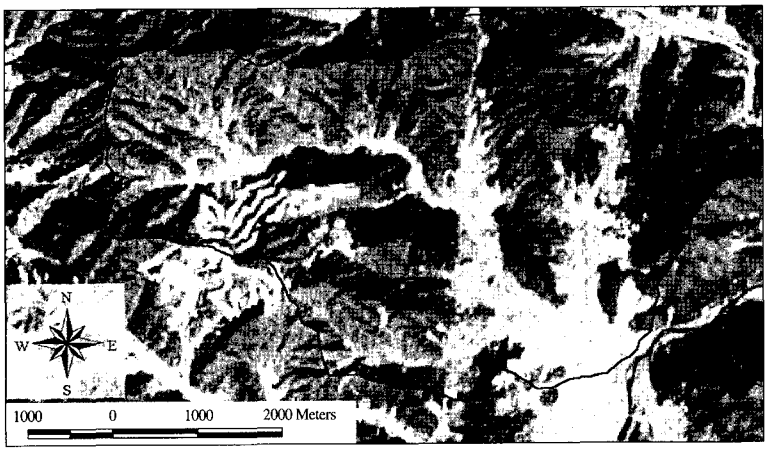


Fig. 1. Mokhyun Stream watershed.

Table 2. Data used in this study.

Data type	Data Source	Path/Row	Resolution	Date
Raster	SPOT HRV	-	20m	1996, 07, 01
	KOMPSAT1- EOC	(R)	6.6m	2000, 03, 01
	Aerial Photograph	(R)	1:20,000	-
	TM	115-35	30m	2000, 05, 08
Vector	Data Source	Data Type	Scale	Date
	Topographic Map	digital	1:5,000	1998

(R) : Reference(Collateral) data

(GCPs) and the reference data. Table 2 shows the data used in this study.

The study was processed with four steps: (1) geometric correction, (2) image enhancement, (3) image classification and interpretation, (4) accuracy assessment.

In step 1,unchangeable and clearly discriminated GCPs (*e. g.* bridge, cross-roads etc.) were selected in both satellite images after image enhancement. Cartesian coordinates for GCPs were obtained by referring to 1:5,000 digital topographic maps, and mathematical models for transformation were then considered. In this study, second-order polynomial was used to correct SPOT image geometrically with fifteen GCPs, and root mean square error (RMSE) was less than a half pixel. In the final stage of geometric correction, a geo-coded image was produced by resampling. The nearest neighbor resampling was used in this study, because it keeps the spectral radiance values of original data. In addition, KOMPSAT-1 EOC image and two aerial photographs were geometrically corrected.

In step 2, image enhancement using square-root contrast stretch was performed after RGB color composition for the visual interpretation. It stretches the dynamic range of the low end of the image while compressing its high end. It tends to lend an overall brightening to the resultant image (PCI, 1998).

In step 3, land cover classification was performed by two methods: visual interpretation and digital image classification. Enhanced SPOT XS images were used for visual interpretation. Color composition and image enhancement by square-root contrast stretches were performed before image display. Additionally, geometrically corrected KOMPSAT-1 EOC image of 6m resolution and air photo images of 1m resolution were mapped by visual interpretation. Digital classification was carried out using the hybrid classification (HC). The four classes are formed in each site. Urban, crop field, grass, and forest are formed in Mokhyun Stream watershed, and Urban, crop field, bare soil, and forest at Tahndong Stream watershed. The training sites for these four classes were selected from the colour-composite EOC and air photo images based on the field experience.

In step 4, The reference data was registered using digital topographic maps. For the classification accuracy assessment, the confusion matrix on a class-by-class basis which shows the relationship between the reference data and the corresponding results of an interpretation or classification, were derived (Lillesand and Kiefer, 2000). Because the reference data are covering the whole area, not just random sample, the confusion matrix shows the classification accuracy results of the whole site pixel by pixel. In this step, the interpretation of the air photo and KOMPSAT-1 EOC image assumed to be 100 percent correct.

3. Results and Discussion

Accuracy assessment was performed by pixel by pixel comparing visual interpretation of the acquired satellite images, the results of HC and visual interpretation of air photo. The results of image classification and accuracy assessment are presented in the following.

1) Land cover classification

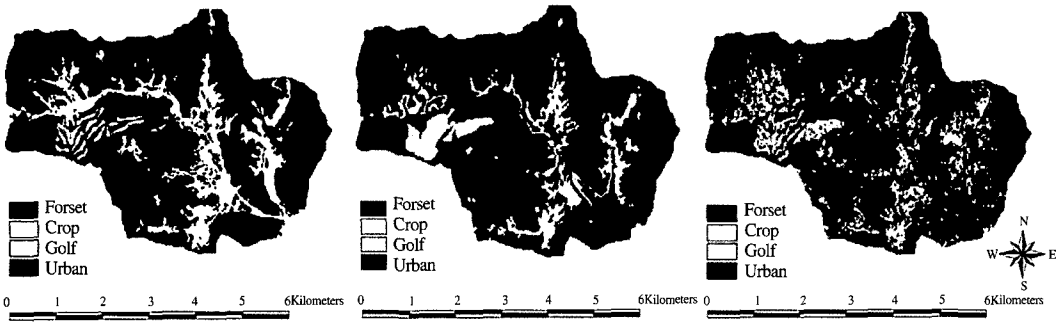
Fig. 3 shows each classification results of Mokhyun stream watershed. SPOT visual interpretation shows higher classification results than SPOT HC result based on the air photo visual interpretation. In the result of SPOT HC, crop field were misclassified as urban in air photo visual interpretation.

Fig. 4 shows the classification results of Tahndong stream watershed. TM visual interpretation shows higher classification quality than TM HC based on KOMPSAT1-EOC visual interpretation.

2) Classification accuracy assessment

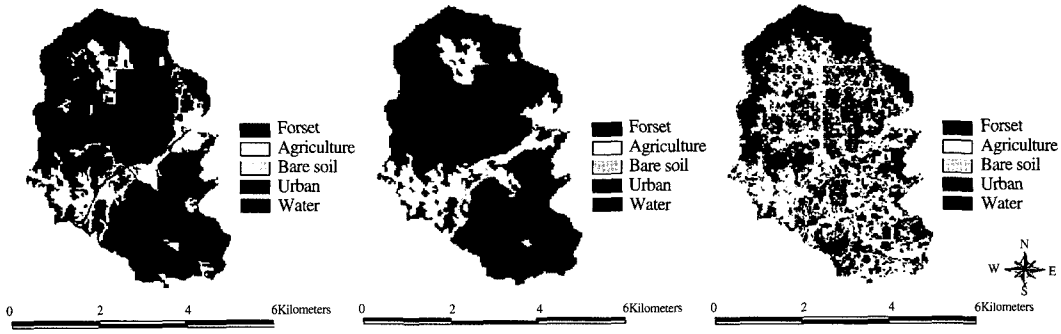
In order to assess the accuracy of Mokhyun stream watershed site, the results of SPOT visual interpretation and SPOT HC were pixel by pixel compared with air photo interpretation. Tables 3 and 4 show the confusion matrices which assess the accuracy of SPOT visual interpretation and SPOT HC respectively.

In Table 3, 84.4% of study area was classified as the same class while in Table 4, 78.3% of study area was



(a) air photo (b) SPOT visual (c) SPOT HC

Fig. 3. Land cover classification results of Mokhyun Stream watershed.



(a) KOMPSAT-1 EOC (b) TM visual (c) TM HC

Fig. 4. Land cover classification results of Tahndong Stream watershed.

Table 3. Confusion matrix between SPOT visual interpretation and air photo visual interpretation.

(unit : ha)

		SPOT visual interpretation				
		Forest	Crop field	Grass(golf)	Urban	Total
airphoto interpretation	Forest	1430.7	25.8	35.1	25.2	1516.8
	Crop field	106.1	168.2	0.7	97.3	372.3
	Grass(golf)	3.0	0.0	33.2	0.0	36.2
	Urban	11.1	21.8	0.1	131.9	164.9
	Total	1550.9	215.8	69.1	254.4	2090.2
	Error(%)	120.2(7.8)	47.6(22.1)	35.9(52.0)	122.5(48.2)	326.2(15.6)

Overall accuracy : 84.4%

Table 4. Confusion matrix between SPOT HC and air photo visual interpretation.

(unit : ha)

		SPOT HC				
		Forest	Crop field	Grass(golf)	Urban	Total
airphoto interpretation	Forest	1337.8	94.4	10.0	74.6	1516.8
	Crop field	46.4	130.9	26.6	168.2	372.1
	Grass(golf)	2.1	3.5	26.6	4.0	36.2
	Urban	11.4	9.4	3.8	140.4	165.0
	Total	1397.7	238.2	67.0	387.2	* 2090.2
	Error(%)	59.9(4.3)	107.3(45.0)	40.4(60.3)	246.8(63.8)	454.4(21.7)

Overall accuracy : 78.3%

* : rounding error

Table 5. Confusion matrix between TM visual interpretation and KOMPSAT-1 visual interpretation.

(unit : ha)

		TM visual interpretation					
		Forest	Crop field	Bare soil	Urban	Water	Total
KOMPSAT-1 EOC interpretation	Forest	803.0	72.0	5.2	115.4	0.0	995.6
	Crop field	29.3	209.6	8.5	73.5	0.9	321.8
	Bare soil	0.0	0.4	3.6	0.0	0.0	4.0
	Urban	38.9	42.4	3.2	670.8	13.1	768.4
	Water	0.0	1.5	0.3	0.5	7.7	10.0
	Total	871.2	325.9	20.8	860.2	21.7	2099.8
	Error(%)	68.2(7.7)	116.3(35.7)	17.2(82.7)	189.4(22.0)	14.0(64.5)	405.1(19.3)

Overall accuracy : 80.7%

classified as the same class. Overall accuracy of the visual interpretation was 6.1 % higher than that of the digital image classification. Forest is most clearly discriminated in both comparison results. For the crop field, grass, and urban area, visual interpretation was more accurate than SPOT HC.

For Tahndong stream watershed site, the classification accuracy was also assessed using TM and KOMPSAT-1 EOC images. Tables 5 and 6 show the confusion matrices which assess the accuracy of TM visual interpretation and TM HC respectively.

In Table 5, 80.7% of study area was classified as the

Table 6. Confusion matrix between TM HC and KOMPSAT-1 visual interpretation.

(unit : ha)

		TM HC					
		Forest	Crop field	Bare soil	Urban	Water	Total
KOMPSAT-1 EOC interpretation	Forest	702.8	274.1	0.5	17.6	0.5	995.5
	Crop field	25.6	237.4	1.0	57.7	0.1	321.8
	Bare soil	0.0	0.3	0.9	2.8	0.0	4.0
	Urban	14.9	411.6	21.3	320.6	0.0	768.4
	Water	0.2	9.5	0.0	0.4	0.0	10.1
	Total	743.5	932.9	23.7	399.1	0.6	2099.8
	Error(%)	40.7(5.5)	695.5(74.6)	22.8(96.2)	78.5(19.7)	0.6(100)	838.1(39.9)

Overall accuracy : 60.1%

same class with ground reference data while 60.1% was classified as the same class in Table 6. Overall accuracy of the visual interpretation was 20.6 % higher than that of the digital image classification. Forest is the most clearly discriminated in both comparison results. For the crop field, bare soil, urban, and water area, visual interpretation was more accurate than TM HC.

3) Discussions

Spatial resolution of 20m and 30m limits the accuracy of visual interpretation and digital classification for densely populated and high-density land use in the Korean peninsula. In this study, the water area was hardly discriminated in TM or SPOT images because the streams are so small. The forest area was easily discriminated because it is relatively homogeneous and has high spectral reflectance in near infra band. However, the crop-field could not be discriminated in image classification due to spatially complex nature of the peninsula. Some field was spectrally similar to the forest and the other area was similar to urban area because of high reflectance in vinyl-house or open soil at non-cultivated season. Thus, for the crop-field and grass areas, the visual interpretation is better working than the automated parametric classification. For the urban area, SPOT interpretation (48.2% error) is better than the classification (63.8%) while TM classification (19.7% error) is slightly better than the visual interpretation (22.0%). In this study, the KOMPSAT image provides much clearer scene compared with TM or SPOT. Therefore, it can be used as a substitute for air photos. The areas of the site analysed in this study covers 20.9km^2 and 21.0km^2. As the site's area increases, it requires more time and efforts for visual interpretation.

4. Conclusions

In this study, classification accuracy was pixel by pixel compared between the results of visual interpretation and digital classification using SPOT and Landsat TM images, and the following conclusions were then derived:

First, the overall accuracy for the SPOT visual interpretation was 6.1% higher than SPOT HC at Mokhyun stream watershed site and TM visual interpretation was 20.6% higher than TM HC at Tahndong stream watershed. Therefore, visual interpretation of enhanced color image is important in the area with high density land use like the study site in the Korean peninsula.

Second, the crop-field which are spatially complex and spectrally similar to the other classes were

discriminated in the visual interpretation better than the classification.

Overall, the visual interpretation can be effectively used for the small area in the Korean peninsula because human pattern recognition is effective for spatially complex and high density land use area.

Acknowledgements

This study was supported partially by grant 199-2-221-001-5 from the Basic Research Program of the Korea Science and Engineering Foundation

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