EXTRACTING BASE DATA FOR FLOOD ANALYSIS USING HIGH RESOLUTION SATELLITE IMAGERY

Hong-Gyoo Sohn , Jin Woo Kim, Jung Bin Lee, Yeong-Sun Song

School of Civil and Environmental Engineering, Yonsei University, Seoul, Korea
sohn1@yonsei.ac.kr, kjw@yonsei.ac.kr, ortolan@naver.com, point196@yonsei.ac.kr

Flood caused by Typhoon and severe rain during summer is the most destructive natural disasters in Korea. Almost every year flood has resulted in a big lost of national infrastructure and loss of civilian lives. It usually takes time and great efforts to estimate the flood-related damages. Government also has pursued proper standard and tool for using state-of-art technologies. High resolution satellite imagery is one of the most promising sources of ground truth information since it provides detailed and current ground information such as building, road, and bare ground. Once high resolution imagery is utilized, it can greatly reduce the amount of field work and cost for flood related damage assessment. The classification of high resolution image is pre-required step to be utilized for the damage assessment. The classified image combined with additional data such as DEM and DSM can help to estimate the flooded areas per each classified land use. This paper applied object-oriented classification scheme to interpret an image not based in a single pixel but in meaningful image objects and their mutual relations. When comparing it with other classification algorithms, object-oriented classification was very effective and accurate. In this paper, IKONOS image is used, but similar level of high resolution Korean KOMPSAT series can be investigated once they are available.

KEY WORDS: KOMPSAT-2, IKONOS, Object-oriented classification, High resolution satellite image, Flood base data

1. INTRODUCTION

Flood is one of the most destructive disasters in Korea. Typhoon and Severe rain storm in summer have resulted in a big loss of national infrastructure and civilian lives. In order to reduce the loss and minimize flood-related budget accurate assessment technique is needed. Until now, many efforts have been concentrated on using medium-resolution satellite imagery and radar imagery, such as ERS and RADARSAT. Using medium-resolution satellite imagery can help estimate the amount of damage in large-scale. However, extracting detailed information about the hazard and accurate damaged area estimation using medium-resolution is restrictive.

Radar imagery has the advantage that is less influenced by the weather condition and can penetrate thick cloud. Even though detecting watershed from SAR image is very effective, classification effort to extract flood-related information using SAR image is very inefficient and time-consuming (Sohn et al., 2005).

High resolution satellite imagery has been widely used for many applications. Especially it can be very attractive to extract base data for the analysis of flood due its large volume of information. Here base data means digital elevation model (DEM), digital surface model (DSM), and thematic map which contains watershed and flood-related classes. Among them, it is very critical to have watershed-related information in hand, since it enables us to accurately measure the damaged area caused by the flood.

To extract watershed-related information from high resolution imagery, classification is an essential step. Although several classification schemes can be used, object-oriented classification approach proved to be very effective (Shamaona, 2005).

In this research, object-oriented classification scheme to extract watershed-related information from high resolution satellite imagery is presented and its result was compared with other classification approach such as supervised and unsupervised classification method.

2. DATA AND METHOD

Our approach for extracting watershed-related information using high resolution imagery starts with choosing the level of resolution. Currently obtaining high resolution imagery is limited such as Quickbird and IKONOS. In July 2006, KOMPSAT-2 was launched and has 1m resolution in panchromatic band and 4m resolution in RGB band. It is currently in calibration stage and soon to be available to the public. Since its spatial resolution is similar to IKONOS satellite, we utilized the IKONOS imagery instead in this study. Table 1 summarizes the specification of KOMPSAT-2 and IKONOS (Lee et al., 2001).

Table 1. Characteristic of KOMPSAT-2 and IKONOS

IKONOS		
Band	Spectral Resolution	Spatial Resolution
1	0.45-0.52 μ m	4 x 4 m
2	0.52-0.60 μ m	4 x 4 m
3	0.63-0.69 μ m	4 x 4 m
4	0.76-0.90 μ m	4 x 4 m

pan	0.45-0.90 μ m	1 x 1 m
Sensor	Linear array pushbroom	
Swath	11 km	

KOMPSAT-2		
Band	Spectral Resolution	Spatial Resolution
1	0.45-0.52 μ m	4 x 4 m
2	0.52-0.60 μ m	4 x 4 m
3	0.63-0.69 μ m	4 x 4 m
4	0.76-0.90 μ m	4 x 4 m
pan	0.50-0.90 μ m	1 x 1 m
Sensor	Linear array pushbroom	
Swath	15 km	

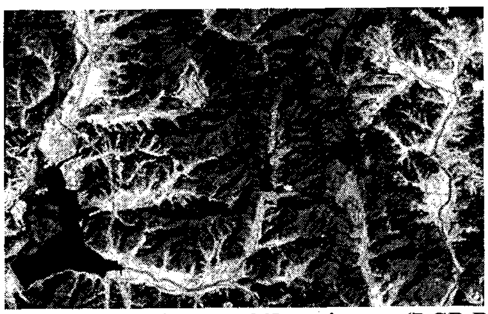

Figure 1. IKONOS image of Yong-in-gun (RGB Band)

Figure 1 shows the IKONOS image of the study area. It covers Yongin-City and only has 3 bands (blue, green, red). As shown in Figure 1, a variety of information is available such as a big lake, reservoirs, mountainous area, and some road facilities.

Several classification schemes were compared using the IKONOS imagery of the study area. For the supervised classification, box classifier, minimum-distance-to-means classifier, and maximum likelihood classifier were used. For unsupervised classification ISODATA method was used.

Conventional multi-spectral classifiers mentioned above have some limitations, such as limited sensor radiometric and spatial resolution, and vague land use classes (Jensen, 2005; Lillesand, 2005). Object-oriented classification can be useful in overcoming the restriction. Its concept is that important semantic information necessary to interpret an image is not represented in single pixels but in meaningful image objects and their mutual relations.

Object-oriented classification method was compared with supervised and unsupervised method using the IKONOS image. To check the usability of object-oriented approach the 30 m resolution LANDSAT ETM+ image is also used. The accuracy of each method was checked either by visual inspection or error matrix.

Object-oriented classification step contains three stages as shown in Figure 2. The segmentation stage is that the image is portioned into contiguous homogeneous image segments or objects. The classification stage is that image objects based on their physical properties, for example spectral values, form and texture, and their neighbourhood relationship are classified.

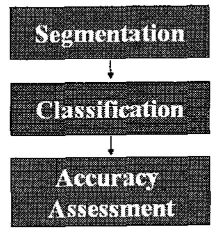

Figure 2. Object-oriented classification flow chart

Finally, the accuracy assessment stage is to examine the classification result and export generated results for further analysis with other data using advanced GIS approach.

The advantage of object-oriented classification is that it can consider several physical characteristics and spectral responses, for instance object size, colour, and shape, and it can apply different weight to different bands. Despite slow computation time over large size data, object-oriented classification is more advanced than other conventional classification algorithms.

3. RESULTS AND ANALYSIS

Supervised and unsupervised classification method, and object-oriented classification scheme were applied to the IKONOS image. Four classes which are considered to be important for the watershed information were chosen. They are water, grass, woodland, and urban classes. For each classification method the accuracy was checked either visually or analytically. For better assessment of the accuracy, same colour was assigned for each class throughout the classification processes.

Blue is assigned to water class, green to grass class, gray to urban class, and brown to woodland class.

3.1 Results of Supervised Classification

For supervised classification five training sets are chosen for each class. Figure 3 shows the result of box classification. As shown in Figure 3, a big lake located in lower left of the image is extracted well, but small reservoirs located in the centre and right was not properly classified. Among urban structures, like road, bridge, and buildings, some roads were extracted, but other urban structures were not classified well.

Figure 3. Box classification result
(Blue: Water, Gray: Urban, Black: Unclassified)

Minimum-distance-to-means (MDM) classification and maximum likelihood classification (MLC) were performed. Figure 4 represents the result of MDM and MLC classification.

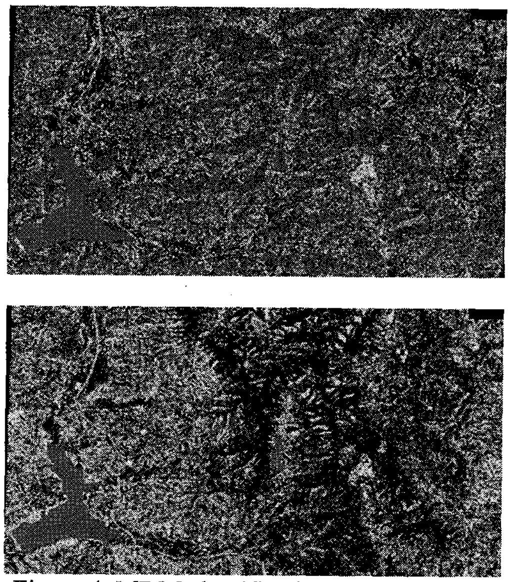

Figure 4. MDM classification (Upper) and
MLC classification (Lower)
(Blue: Water, Gray: Urban, Woodland: Brown, Grass: Green)

In Figure 4, MDM algorithm shows very inaccurate result by visual inspection. Most woodland is classified into water area. This seems to be resulted from not using near infrared band. Using RGB band of IKONOS without near infrared could not discriminate water and forest clearly. Due to shadow, many areas of woodland were classified into urban structure. MLC algorithm shows better result than MDM. Most woodland was classified accurately but due to shadows some woodland area was classified into urban areas. Water areas were extracted well.

3.2 Unsupervised Classification

ISODATA algorithm was applied to the IKONOS image. Unsupervised classification classifies image automatically according to spectral response. After classification, the user should define classified result through comparing with ground truth. Figure 5 shows the result of ISODATA classification which contains 4 classes.

Figure 5. ISODATA result

As shown in Figure 5, ISODATA classification does not provide better result than the supervised classification algorithms.

3.3 Object-oriented Classification

3.3.1 Classification Using Medium resolution image

Using Landsat ETM+ image (GLCF) having 30 m resolution, object-oriented classification was conducted and the result is shown in Figure 6.

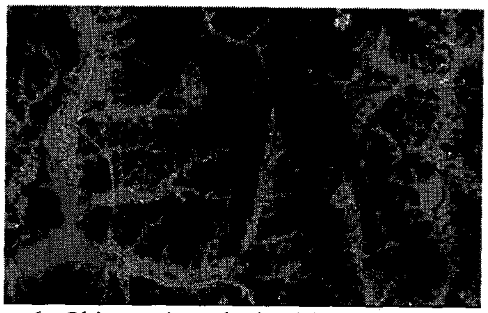

Figure 6. Object-oriented classification using ETM+ RGB band

As shown in Figure 6, better result was obtained by comparing with the previous results. Visually woodland was extracted more accurately and urban structures, such as road and building, was properly classified. However, water areas were not classified accurately, while woodland and grass were classified into water class. This result explains that low resolution of 30 m is not sufficient for making flood base data and classifying watershed-related areas.

3.3.2 Classification Using High resolution image

As explained in Figure 2, for object-oriented classification, segmentation should be performed. Segmentation technique employs bottom up region-merging starting with one-pixel objects. Smaller objects are merged into bigger ones by taking criteria of homogeneity in shape and colour into account.

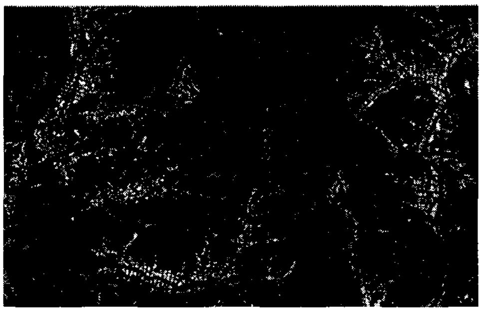

Figure 7. Segmentation result

Figure 7 shows the segmentation result applied to the IKONOS image by scale and colour parameter. After segmentation, sampling corresponding to four classes was conducted. The segmented image was classified into water, urban, woodland, and grass class.

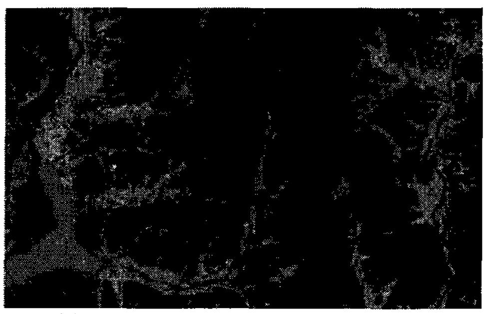

Figure 8. Object-oriented classification using IKONOS

Figure 8 represents the result by object-oriented classification. When compared with other classification algorithms, it clearly shows improved result. For quantitative analysis, accuracy assessment using error matrix is performed.

Table 2. Accuracy assessment using error matrix

	Reference Data				
Classified Data	Water	Grass	Wood land	Urban	Row Total
Water	13	0	1	0	14
Grass	0	36	1	0	37
Wood Land	0	8	184	1	193
Urban	0	3	2	7	12
Column Total	13	47	188	8	256
Producer's accuracy Water=100% Grass=76.60% Woodland=97.87% Urban=87.50%			**User's accuracy** Water=92.86% Grass=97.30% Woodland=95.34% Urban=58.33%		
Overall accuracy=93.75% KHAT=0.8496					

Table 2 shows that object-oriented classification has high overall accuracy, 93.75%. A KHAT value of 0.8496 is thought of as an indication that an observed classification is about 85% better than one resulting from chance.

4. CONCLUSION

KOMPSAT-2 was launched in July 2006, and other KOMPSAT series will be followed. Before such high resolution image is provided, the usefulness of high resolution satellite image need to be investigated in advance.

In this paper we concentrated on the application of high resolution image for the flood-related study. For this several classification approach including supervised and unsupervised method and object-oriented approach was applied to the IKONOS image. The results of supervised and unsupervised generally provide lower accuracy when checked visually. The object-oriented classification approach shows overall high accuracy of 93.75%. The classification using 4 m high resolution image is much better that that using 30 m resolution. We speculate from this that using high resolution satellite image, such as KOMPSAT-2, the compilation of flood base data are feasible and the result can be sufficiently accurate.

5. REFERENCES

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