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Application of Change Detection Techniques Using KOMPSAT-1 EOC Images

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Abstract : This research examined the capabilities of KOMPSAT-1 EOC images for the application of urban environment, including the urban changes of the study areas. This research is constructed in three stages: Firstly, for the application of change detection techniques, which utilizes multi-temporal remotely sensed data, the data normalization process is carried out. Secondly, the change detection method is applied for the systematic monitoring of land-use changes. Lastly, using the results of the previous stages, the land-use map is updated. Consequently, the patterns of land-use changes are monitored by the proposed scheme. In this research, using the multi-temporal KOMPSAT-1 EOC images and land-use maps, monitoring of urban growth was carried out with the application of land-use changes, and the potential and scope of the application of the EOC images were also examined.

Key Words : Change Detection, Data Normalization, Radiometric Control Points, Urban Growth Monitoring.

1. Introduction

After the Industrial Revolution, cities have been changed for a variety of reasons, resulting in the development of today's large cities. It is the fact that together with such rapid urban growth, the additional outbreaks of urban problems are becoming a rising hot issue for the present. That is, it is possible that the state of urban growth has an influence on the various urban problems of society. Similarly, depending on how the urban environmental changes are continually monitored together with finding solutions to solve these urban problems arising; it can allow for the improvement of mankind's quality of life.

Currently, for the urban environmental problems including the fundamental cause analysis of urban growth, spatial information techniques such as remote sensing and GIS have been applied. Following are the remote sensing techniques being applied in the field of urban environment: production of thematic map though the extraction of surface information, which utilizes multi-spectral data such as Landsat TM, ETM+ and NOAA/AVHRR (Masek *et al.*, 2000; Kressler *et al.*, 1999), surface information extraction through the composition of panchromatic image and multi-spectral image (Ha *et al.*, 2002), and monitoring urban changes through interpretation of high resolution image data with the naked eye (Darvishzadeh, 2000; Steinnocher *et al.*, 1999). These methods can vary according to the research purposes, research area, and data utilized. But

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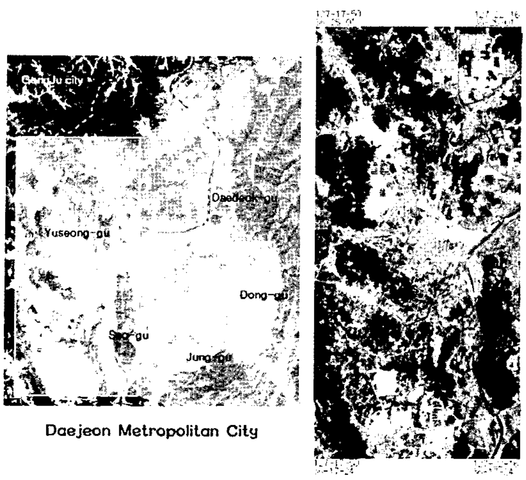

Fig. 1. Study area of Daejeon city.

in the field of urban environment, a variety of spectral information can be acquired from the remotely sensed data such as high resolution image data and multi-spectral data. Also through the composition of panchromatic image data and other image data, it has been widely applied in this field. However, unfortunately, there are not so many cases which utilized only panchromatic data on change detection in the field of urban environment.

In this research, the analysis of urban environmental change was carried out with the application of land-use changes, which utilizes the multi-temporal KOMPSAT-1 EOC image data. Also the potential and scope of the application of the EOC image data in the field of urban environment are examined closely.

2. Materials and Methods

Yuseong and its outskirts in Daejeon, which is the area of $94km^2$ with the most changeability, is selected as the study area for this research. This study used the multi-temporal remotely sensed data obtained on 9th March 2000, 12th May 2001, and 22nd April 2002 by KOMPSAT-1 EOC for the analysis of land-use changes. KOMPSAT-1 accommodates three instruments, i.e., an Electro-Optical Camera (EOC, GSD: 6.6m, Swath: 17km), an Ocean Scanning Multi-spectral Imager (OSMI, GSD: 1km, Swath: 800km), and a Space Physics Sensor (SPS), for the mission of cartography, worldwide ocean observation, and space environment monitoring respectively. Also the digital maps of 1:5,000 and the land-use maps of 1:25,000 were utilized in order to understand topographical information and land-use patterns. Other ancillary data were used such as IKONOS and aerial photo for the identification of land-use attributes.

This study utilized histogram adjustment and an empirical regression approach for minimizing atmospheric effects. Variations in solar illumination conditions, atmospheric scattering, atmospheric absorption and detector performance results in differences in radiance values unrelated to the reflectance of the land surface. Therefore, the multiple dates of remotely sensed data should be normalized so that these effects can be minimized or eliminated (Echhardt *et al.*, 1990; Hall *et al.*, 1991).

This simple method is based primarily on the fact that the infrared data ($>0.7\mu m$) are largely free of atmospheric scattering effects, whereas the visible regions ($0.4 \sim 0.7\mu m$) are strongly influenced. Normally, the EOC data are collected in the visible wavelengths ($0.51 \sim 0.73\mu m$). If the histograms are shifted to the left so that zero values appear in the data, the effects of atmospheric scattering will be somewhat minimized. This simple algorithm models the first-order effects of atmospheric scattering (Jensen, 2000).

For the application of empirical radiometric normalization, it is necessary to collect Radiometric Control Points (RCP) at multi-temporal data. Analysts sometimes utilize man-made features such as concrete, asphalt, rooftops, parking lots, and roads when normalizing multiple data (Schott *et al.*, 1988; Caselles *et al.*, 1989).

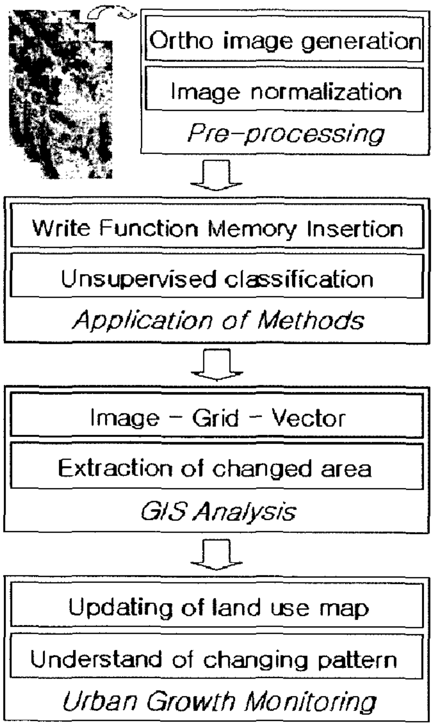

Fig. 2. Flow chart of data processing.

The process shown in Fig. 2 was carried out in this research. To minimize the topographic elevation and geometric location errors, the ortho-rectification, which utilized the digital maps of 1:5,000 and a 5m DEM (Digital Elevation Model) data was carried out, so that RMS errors between the two images are no more than 0.5 pixels. After preprocessing these steps, the patterns of land-use changes are estimated, using the change detection and image classification methods, and the GIS analysis. Then the continual monitoring of urban growth is carried out by updating the existing land-use data.

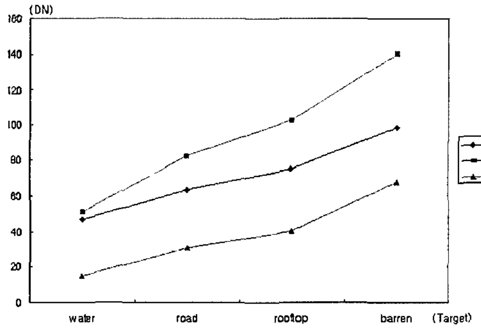

Fig. 3. Mean values of RCP.

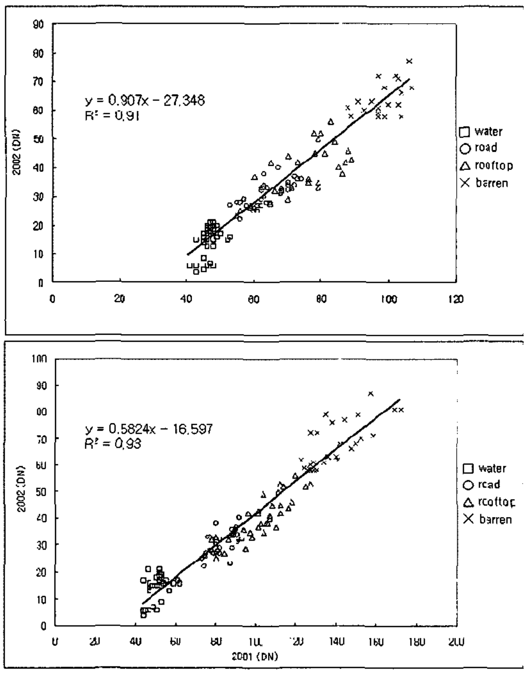

Fig. 4. Results of linear regression analysis for image normalization.

3. Experiments

1) Multiple Date Empirical Radiometric Normalization

The outcome that was analyzed the DN distribution of the EOC images for each year shows that the mean DN value of 2002 image is the lowest, and the influence of clouds and smog is barely present. Accordingly, after histogram adjustment, 2002 EOC image is selected as the reference image.

In Fig. 3, the mean DN value of the RCP (water, roads, rooftops, and barren land) sample data acquired from the image data of each period displays the spectral characteristics of the target that can be distinctively classified by each year.

A total of 50 RCPs were utilized per target for normalization of the multi-temporal images.

Image normalization was achieved by applying regression equations to the 2000 and 2001 images, which predict what a given brightness value (BV) would be if it had been acquired under the same conditions as the 2002 reference data.

2) Change Detection using Write Function Memory Insertion

One of the most important factors in the examination of urban growth is the application of change detection methods. But for the change detection techniques, radiometric and geometric influence must be minimized. In this study, the multi-temporal KOMPSAT-1 EOC images, which were minimized these influences by data normalization and ortho-rectification, were applied for urban change detection.

Change detection techniques are generally classified based on the spectral information. In this research, the WFMI method presented by Price(1992) and Jensen (2000) was applied to the multi-temporal KOMPSAT-1 EOC images.

The main concept is to insert individual bands of remotely sensed data into the specific write function memory banks (red, green, and/or blue) in the digital image processing system to visually identify changes in the images. But, WFMI must precede the accurate image normalization process as a prerequisite.

Figs. 5 and 6 show the results of the experiment for the multi-temporal data using WFMI.

In Fig. 5, the image of 2000 was placed in the green band, the image of 2001 in the red band and no image in the blue band.

The results show a dynamic change: all the areas that did not change between the different dates are depicted in the shades of yellow, whereas, the red areas display the accreted areas (including sand and barren land) and the green areas display erosion. For example, the red areas can be interpreted as urban development. A similar result can be easily identified in Fig. 6.

Fig. 7 displays the results of WFMI with a RGB composition (red: 2002, green: 2001, blue: 2000) using the KOMPSAT-1 EOC image data.

In this result, the yellow areas depict the change in land use during 2000 ~ 2001, and the red areas during 2001 ~ 2002. The yellowish-green and light yellow areas depict the gradual changes during three periods.

The main advantage of the WFMI technique is the possibility of looking at two and even three dates of remotely sensed data at one time. However, it is difficult to acquire the quantity of change in land area and 'from-

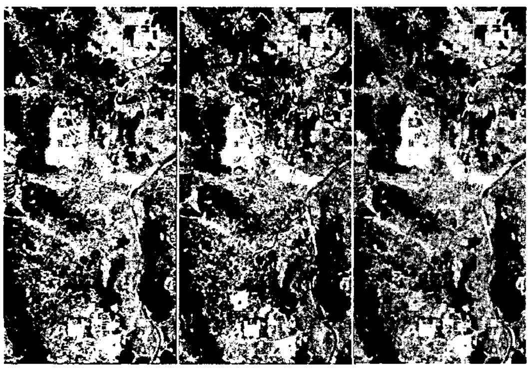

Fig. 5. Results of the experiment using WFMI (2000-2001).

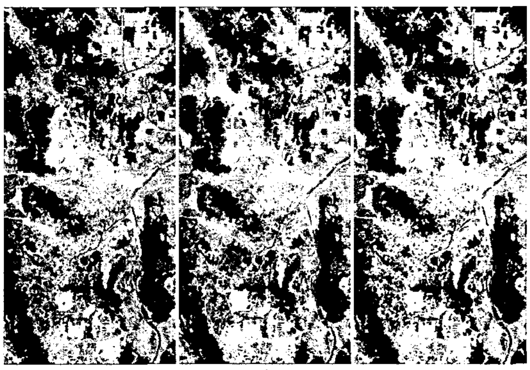

Fig. 6. Results of the experiment using WFMI (2001-2002).

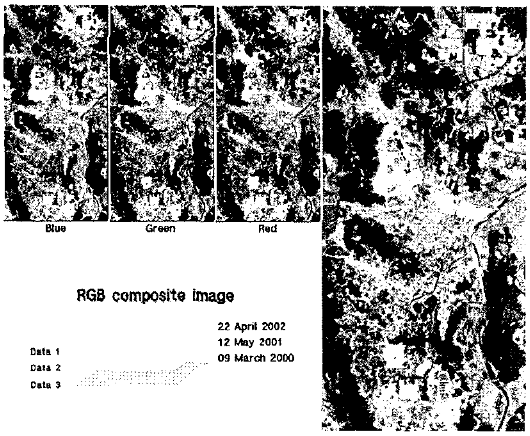

Fig. 7. Multi-temporal data visual change detection using WFMI.

to' change information of the class. But despite such a weakness, due to effective visualization, it is being greatly applied to preliminary research for rapid information extraction and more precise visual analysis.

3) Extraction of Changed Area by Classification

For the extraction of quantitative information from the results of WFMI, unsupervised classification was implemented to derive the RGB composed image as shown in Fig. 7.

Firstly, all the 100 classes were classified, and then those results were converted into a Grid data. The converted Grid data was generalized by utilizing a 5 by 5 window. This was then collected and classified into three classes. The classified Grid data is converted to vector coverage (GIS data), so that the quantitative information related to the changed area can be extracted.

- Fig. 8 depicts the results of this application. Following are the approximations of the changed quantities of land area for the each period: red (2001-2002) area: 2.6km^2, yellow (2000-2001) area: 1.1km^2, and green (2000-2001-2002) area: 1.6km^2.

4) Comparison of Existing Land-Use Maps

The land-use classes of 1:25,000 maps, which were produced in 2000, were overlapped with the KOMPSAT-1 EOC images (taken in March, 2000) and then compared. As shown in the areas ⓑ and ⓓ of Fig. 9, the results show that the land-use classes of the EOC image data agree with them of the map. But in the case of the area ⓒ, the areas in the existing land-use map are classified into paddy fields and barley fields, whereas in the actual image data it is constituted of public sites and high-rise housing. This is because the data is not up-to-date. Therefore, the land-use data must be updated systematically and periodically to provide the latest information for users.

5) Updating Geographic Information

The digital land-use data, which are presently produced and distributed by the National Geography

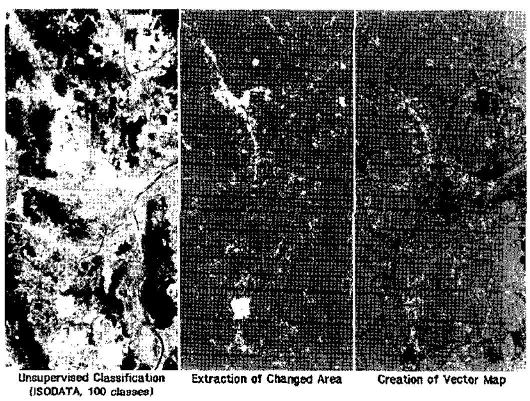

Fig. 8. Extraction of quantitative information from the results of WFMI.

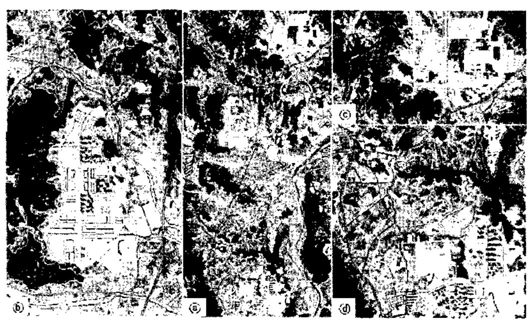

Fig. 9. Comparison of KOMPSAT-1 EOC image and land-use map (March 2000).

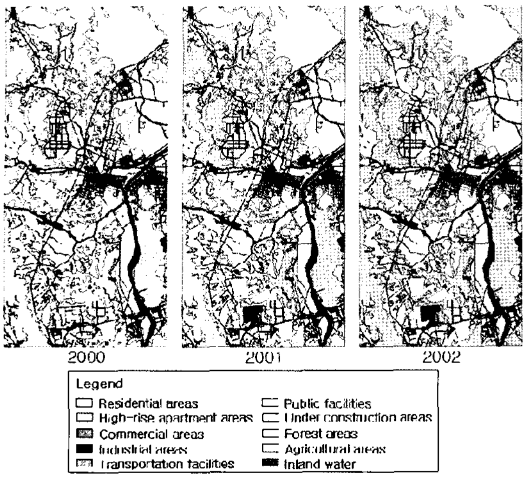

Fig. 10. Updating of land-use maps.

Institute, are obtained from the 414 paper maps produced and updated since 2000. However, it was a difficult task to systematically acquire the information related to land-use changes after 2000. The suggestion for the periodical update of land-use information by utilizing land-use maps and multi-temporal KOMPSAT-1 EOC image data is presented in this research. Using the generated vector data (Fig. 8), EOC ortho-images, other ancillary data such as high resolution IKONOS and aerial photo that utilized hand-up digitization, the land-use maps of each period can be newly updated.

Through the overlay analysis of the extracted vector data, EOC ortho-images, and land-use maps of the changed areas of each period, WFMI's weak point mentioned above (no 'from-to' change in class information) can be overcome. But there are limitations in updating the precise land-use data with the EOC image data of 6.6m spatial resolution. Especially, these limitations are more apparent in the vegetation classification of the EOC image data.

4. Conclusions

This research has presented the application of the multi-temporal KOMPSAT-1 EOC image for the analysis of land-use changes in the field of urban environment. In addition, urban growth was continually monitored, including the update of land-use information.

For this purpose, the ortho-images were generated and the image data were normalized for each period to apply precisely the techniques and obtain the correct results. The results of WFMI using the multi-temporal KOMPSAT-1 EOC images show the effective visualization related to the changed area. And the weakness of the proposed technique to extract quantitative information in land-use changes can be efficiently complemented by GIS analysis and image classification. Moreover, by applying the results to the updating of existing land-use information, a land-use map of each period can be newly produced. But due to the spatial and spectral limitations of the EOC image data, the precise information extraction related to the vegetation area is difficult. The composition of multi-spectral data and EOC image data can improve the results by using the various techniques of image classification and change detection. The further expansion of the application for KOMPSAT-1 EOC images in the field of urban environment is greatly anticipated.

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