Application of Change Detection Techniques using KOMPSAT-1 EOC Images

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ABSTRACT

This research will examine into the capabilities of KOMPSAT-1 EOC image application in the field of urban environment and at the same time, with that as its foundation, come to understand the urban changes of the study areas. This research is constructed in three stages: Firstly, for application of change detection techniques, which utilizes multi-temporal remotely sensed data, the data normalization process is carried out. Secondly, change detection method is applied for the systematic monitoring of land use changes, which utilizes multi-temporal EOC images. Lastly, by using the results of the application of land use changes, the existing land use map is updated. Consequently, the land-use change patterns are monitored, which utilize multi-temporal panchromatic EOC image data; and application potentials of ancillary data for updating existing data can be presented.

In this research, with the use of the land use change, monitoring of urban growth has been carried out, and the potential for the application of KOMPSAT-1 EOC images and the scope of application was examined. Henceforth, the future expansion of the scope of application of KOMPSAT-1 EOC image is anticipated.

Key words: Change detection, Data normalization, Radiometric control points, Urban growth monitoring

Ⅰ.INTRODUCTION

After the Industrial Revolution, cities have been changing for a variety of reasons, resulting in the development of today's large cities. It is a 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 fundamental cause analysis and problem solving of urban growth and the urban environmental problems, spatial information techniques such as remote sensing and GIS are being applied. Following are the remote sensing techniques being applied to the field of urban environment: production of thematic map though the extraction of surface information, which utilizes multi-spectral data such as Landsat TM and NOAA/AVHRR, advancement in the capabilities of surface information extraction through the composition of panchromatic image and multi-spectral image, and monitoring urban changes through interpretation of high resolution image data with the naked eye. These methods can vary according to research purposes, research area, and data utilized. But in the existing field of urban environment, the applied remotely sensed data can acquire a variety of spectral information 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 is carried out with the use of land use change, which utilizes the multi-temporal KOMPSAT-1 EOC image data. Also at the same time, EOC image data potential and scope of application in the field of urban environment is examined closely.

Ⅱ. MATERIALS AND METHODS USED

1. Data description

The most changed area is Yusung and its outskirts in Daejeon, which is area of 94㎢, is the study area for this research. This study used the multi-temporal remotely sensed data obtained on 9^{th} March 2000, 12^{th} May 2001, and 22^{nd} April 2002 for the analysis of land-over/use in this area by KOMPSAT-1 EOC. KOMPSAT-1, which is coming to its third year since launch, accommodates three instruments: an Electro-Optical Camera (EOC, GSD: 6.6m, Swath: 17㎞), an Ocean Scanning Multi-spectral Imager (OSMI, GSD: 1㎞, Swath: 800㎞), and a Space Physics Sensor (SPS) for the mission of cartography, worldwide ocean observation, and space environment monitoring respectively. Also 1:5,000 digital maps and 1:25,000 land use maps were utilized in order to understand topographical information and existing land use patterns.

2. Description of the method

This study utilized Histogram adjustment and an empirical regression approach for minimizing atmospheric effects. A problem associated with multi-temporal remotely sensed data for change detection, is that the data are usually non-anniversary dates with the sun angle, and the atmospheric and soil moisture conditions. Ideally, these data should be normalized so that these effects can be minimized or eliminated (Echhardt et al., 1990; Hal et al., 1991).

This simple method is based primarily on the fact that infrared data (>0.7㎛) are largely free of atmospheric scattering effects, whereas the visible regions (0.4-0.7㎛) are strongly influenced. Normally, EOC data are collected in visible wavelengths (0.51-0.73㎛), therefore 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, or haze (John R. Jensen, 2000).

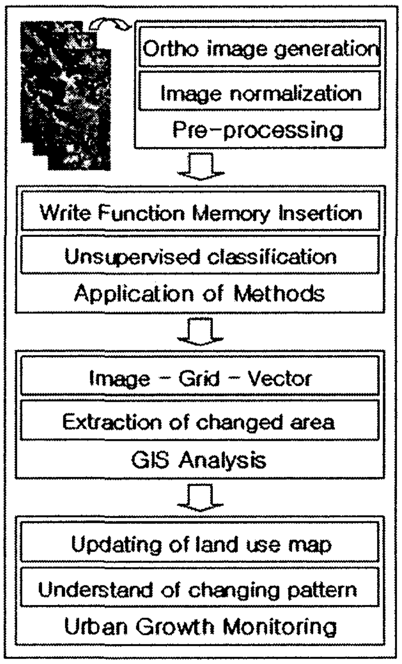

Figure 1. Flow chart of data processing

In order for the application of empirical radiometric normalization, it is necessary to collect Radiometric Control Points (RCP) at multiple 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 and Garcia, 1989).

The following process in Figure 1 was carried out in this research.

In this study, for minimizing of the topographic elevation and geometric location errors, ortho rectification was carried out, which were utilized 1:5,000 digital maps and a 5m DEM (Digital Elevation Model) data. The RMS error that occurs between the two images is no more than 0.5 pixels under. After preprocessing these steps, patterns of land use change can be understood by the application of change detection and image classification method, and GIS analysis. Then the continual monitoring of urban growth is carried out through updating existing land use data.

Ⅲ. EXPERIMENTS AND RESULTS

1. Multiple date empirical radiometric normalization

The outcome that was analyzed the DN distribution value of EOC image by each year showing, the mean value of 2002 image's DN is the lowest, and the influence of clouds and smog is barely present. So after execution of Histogram adjustment, 2002 EOC image is selected as the reference image.

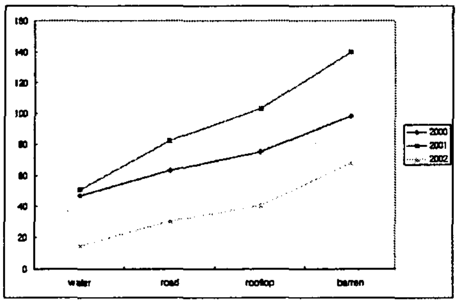

Figure 2. The mean values of RCP

In Figure 2, the mean DN value of the acquired RCP (water, roads, rooftops, barren land) sample data through image data of each period displays the spectral characteristics of the target that can be distinctively classified into each year.

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

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

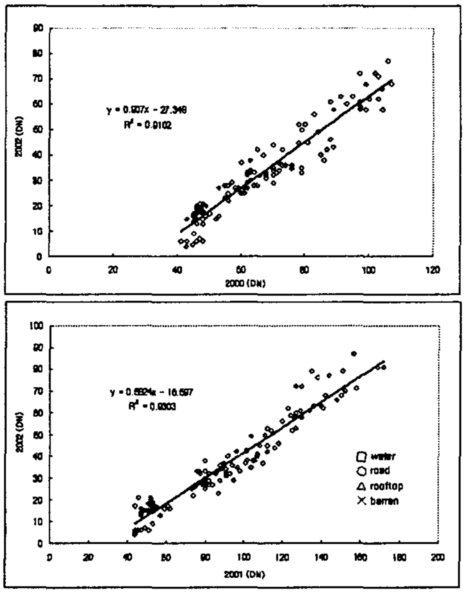

Figure 3. Results of linear regression analysis for image normalization

2. Change detection using Write Function Memory Insertion

With the foundational use of land-use change, one of the most important factors in the examination of urban growth is the application of change detection methods. But for the advancement of such applications of change detection techniques, radiometric and geometric influence must be minimized. Therefore, in this study, multi-temporal KOMPSAT-1 EOC images, which were minimized these influences through data normalization and Ortho-rectification, were applied to urban change detection.

For the most part, change detection techniques are classified generally by the image's spectral information. In this research, the WFMI methods presented by Price, K.P. (1992) and Jensen, J.R. (2000) were applied to multi-temporal KOMPSAT-1 EOC images.

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

Figure 4 and 5 shows the results of the experiment between multiple date images using WFMI.

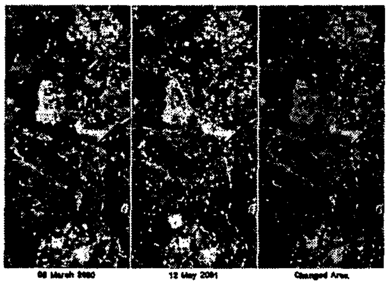

Figure 4. The result of the experiment using WFMI (2000-2001)

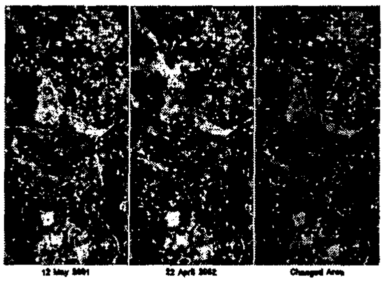

Figure 5. The result of the experiment using WFMI (2001-2002)

In Figure 4, the 2000 image was placed in the green band, the 2001 image in the red band place and no image in the blue band place. The results show a dynamic change: all the areas that did not change between each differing dates are depicted in shades of yellow. Whereas, the red areas display the accreted areas (including sand and barren land) and the green areas display erosion. This can be interpreted by the appearance of change when it occurs in the red areas, in between the two periods such as urban development. A similar result can be identified easily also in Figure 5.

Figure 6 displays the results of KOMPSAT-1 EOC image data by using WFMI –a RGB composition (red: 2002, green: 2001, blue: 2000).

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

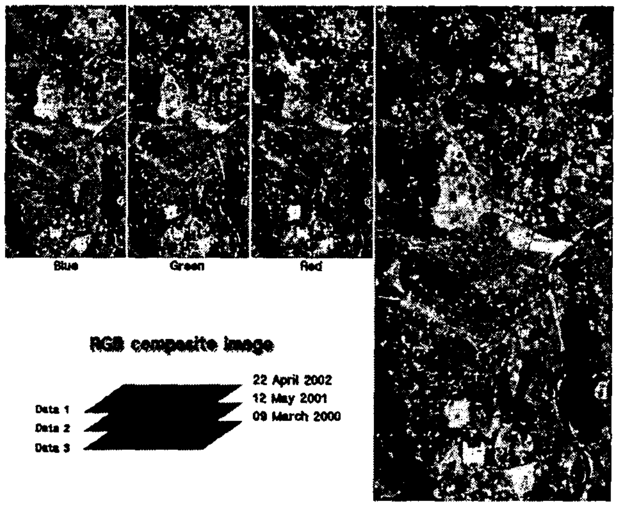

Figure 6. Multi-temporal data visual change detection using WFMI

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, in the instance of the quantity of change in land area such as quantitative information and from-to change class information, it is difficult to acquire. But despite such weaknesses, through the basic application methods and effective visualization, it is being greatly applied to preliminary research for the rapid information extraction and a more precise analysis.

3. Extraction of the changed area by classification

For the presentation of the extracted quantitative information showing WFMI's weaknesses, by using the RGB composed image derived from Figure 6, unsupervised classification was implemented. Firstly, all the 100 classes were classified by classification, and then those results were converted into Grid data. The converted Grid data utilizes a 5 by 5 window and carries out data generalization. This was then collected and classified into three classes. The classified Grid data is converted to vector coverage (GIS data), so that extraction of the quantitative information related to the changed area can be carried out –Figure 7 depicts the results of this application. Following are the approximations of the changed quantities of land area according to each period of extraction: red (2001-2002) area: 2.6㎢, yellow (2000-2001) area: 1.1㎢, and green (2000-2001-2002) area: 1.6㎢.

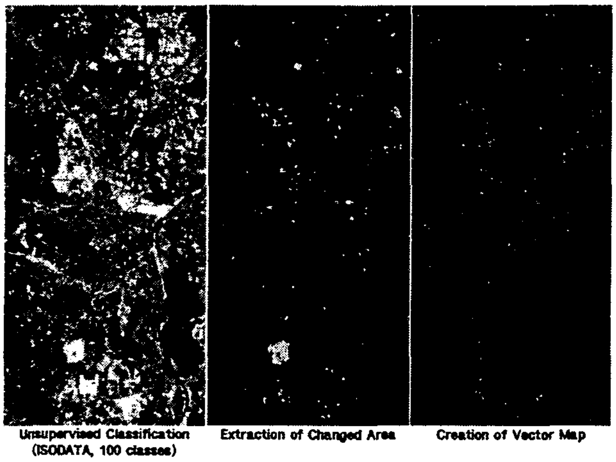

Figure 7. Extraction of the quantitative information from the results of WFMI

4. Comparison of existing land use maps

Existing 1:25,000 land use classes, which were produced in 2000, were overlapped with KOMPSAT-1 EOC images (taken in March, 2000) and then compared. These results, which can be seen in areas ⓑ and ⓓ of Figure 8, shows that sections of land use classes and EOC image data conform to one another. But in the case of 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 for the application and providing of the latest information to users.

Figure 8. Comparison of KOMPSAT-1 EOC image and existing land use map (March 2000)

5. Updating existing geographic information

The digital land use data, which are presently produced and distributed by the National Geography Institute, are the 414 updated past paper maps produced since 2000. In addition, it is an actual fact that it was a difficult task to systematically acquire information related to land use change after 2000. With this as its foundations, the suggestion for the periodical update of land use information by utilizing existing land use maps and multi-temporal KOMPSAT-1 EOC image data is presented in this research. Through the generated vector data and EOC Ortho-images that utilized hand-up digitization (in Figure 7), newly updated land use maps by each period can be produced.

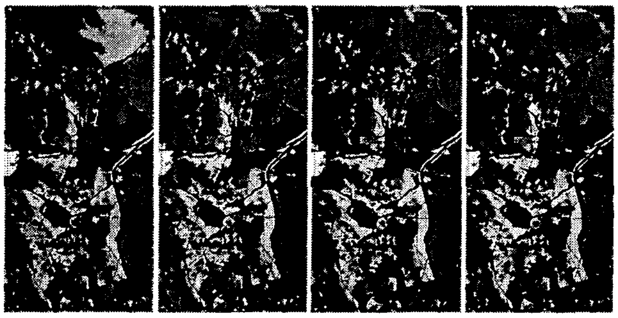

Figure 9. Update of land use map (A: existing land use map, B: 2000, C: 2001, D: 2002)

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

V. CONCLUSIONS

This research has presented the methods and scope of application of the multi-temporal KOMPSAT-1 EOC image in land use change analysis in the field of urban environment. In addition, with this as its foundations, the existing land use information was updated and at the same time, urban growth was continually monitored.

For this reason, Ortho-images were generated and image data were normalized by each period was carried out for the application of precise techniques and the derivation of results. By comparing the basic application method of WFMI (one of the change detection techniques), which applies multi-temporal KOMPSAT-1 EOC images, the effective visualization related to the changed area was presented. And through GIS analysis and image classification, it can efficiently complement this technique's weaknesses. Moreover, by applying those results to the updating of existing land use information, a land use map by each period can be newly produced. But due to EOC image data's spatial and spectral limitations, the precise information extraction related to the vegetation area is difficult. Henceforth, through the composition of multi-spectral data and EOC image data, and the technique applications of the diverse image classifications and change detection, an improvement in deriving results is concluded. And the further expansion of KOMPSAT-1 EOC image's scope of application in the field of urban environment is greatly anticipated.

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