DETECTION OF URBAN VEGETATION AND FOREST COVER IN THE CENTRAL TOKYO ENVIRONMENT USING HIGH-RESOLUTION SATELLITE REMOTE SENSING

HIDEKI HASHIBA

Dept. of Civil Engrg., Coll. of Sci. and Tech., Nihon University
E-mail: hashiba3@civil.cst.nihon-u.ac.jp

Abstract- In the central area of Tokyo, which is overcrowded with artificial structures, considering diverse points of view in order to understand the local vegetation resources is necessary. As city environments continue to develop, urban planners have increasingly recognized the importance of vegetation cover. High-resolution satellite remote sensing can be used to understand this urban environment enough. In particular, the use of the high-resolution Worldview-2 satellite for remote sensing in eight different wavelength bands has proven effective. In this study, the detailed vegetation distribution in a region of central Tokyo, Japan, was extracted using the Fuzzy K-mean clustering method upon a high-resolution image observed by the Worldview-2 remote-sensing satellite.

Index Terms- vegetation, urban environment, high resolution satellite remote sensing, clustering

I. INTRODUCTION

The vegetation and forest distribution throughout an urban area is an important indicator of the quality of the urban environment. Greater harmony between the vegetation environment and artificial structures of urban areas is required to develop an excellent urban environment in the future. For this, it is necessary to better characterize the types of vegetation and their spatial distributions in order to evaluate the vegetation environment more effectively. Some relations between the urban environment and the vegetation situation have been reported till date [1, 2]. Spatial information showing environmental elements such as the vegetation resources at high accuracy is increasingly in demand in big cities like Tokyo. Several vegetation environments have been evaluated by satellite images [3-8]; however, the understanding of detailed vegetation covering and feature analysis in Tokyo is insufficient. When the vegetation in an urban area is evaluated from the satellite image data, the spatial resolution of the observation sensor becomes an important factor. When the sensors have resolutions from 10 to about 30 m, it is difficult to understand the vegetation distribution in detail. Moreover, the use of a multi-spectrum sensor capable of observing four wavelength bands (red, green, and blue visible light and an infrared region) has been a major research topic till date. However, the use of the sensor that observes multiple wavelength bands is desirable to investigate the vegetation of urban areas in greater detail. The Worldview-2 satellite observes eight multi bands from the visible optical to infrared light regions with a spatial resolution of 2.0 m ~ 2.0 m and a radiometric resolution of 11 bits. In this study, information about urban vegetation resources was extracted from multi-spectral image data taken by the Worldview-2 satellite. Using the Fuzzy K-mean clustering method, the distributions of urban forest and vegetation areas were investigated in central Tokyo. The accuracy of this investigation was evaluation by comparison between a detailed decipherment investigation result and the image classification. In addition, the typical features of vegetation distribution in central Tokyo were evaluated from the classification result.

II. METHOD AND SATELLITE IMAGE DATA

A. Test area

The test area was encompassed by the central area of capital city, Tokyo in Japan (Fig.1). The extent of this test area was 8 km ~ 6 km. This area has been overcrowded with high skyscrapers and low-rise buildings, between which vegetation is distributed in complex patterns. Moreover, many large-scale parks are maintained.

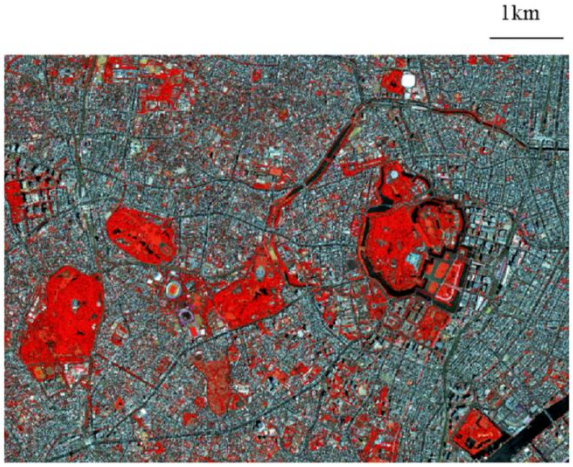


Figure 1. False color image by Worldview-2 in object area

B. Satellite image data

The multispectral data used in this study were observed by the Worldview-2 satellite on July 10, 2011, during the summer season (Tabel.1). These data contain 8-band multispectral images, each with a

spatial and radiometric resolution of from 2.0 m to 2.0 m and 11 bits, respectively. Table 1 lists the observation wavelength characteristics of each band.

Table 1: The wavelength of each band of Multi Spectral data by Worldview-2 satellite

Band No.	spectral zone	wavelength(nm)
1	coastal	400-450
2	blue	450-510
3	green	510-580
4	yellow	585-625
5	red	630-690
6	red-edge	705-745
7	near-IR1	770-895
8	near-IR2	860-1040

C. Atmospheric correction and ground surface reflectance

The multispectral image data were converted to ground surface reflectance by applying an atmospheric correction based on the satellite's observation specifications and the digital data values. For atmospheric correction, the algorithm proposed by Richter was used in this study [7, 8].

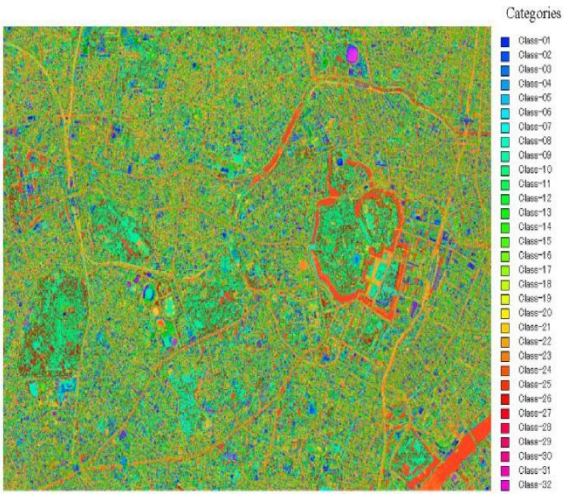


Figure 2. Displaying 32 classes classified by using Fuzzy K-mean clustering method

D. Extraction of vegetation region by clustering

The vegetation regions were extracted by clustering using the Fuzzy K-mean method [9, 10]. All the multispectral band images were used in the classification, and 32 clusters were specified. After the clustering, some areas categorized as vegetation were judged by referring to image interpretation and field investigation. Areas categorized as vegetation cover were divided into five subcategories based on their shade of green through interpretation of the image display of RGB color synthesis. The lightest green areas were judged to be lawns or grass on a plain. A map was made of the vegetation environment in the city by overlaying the extracted vegetation regions and satellite images. As a result, the features of the vegetation cover of Tokyo were considered. To verify the clustering accuracy, the vegetation areas obtained by clustering were compared with those obtained by the interpretation of the high-resolution satellite imagery with field investigation. The image was interpreted in detail using both false and natural color.

III. RESULT OF CLUSTERING FOR VEGETATION AREA

E. Vegetation mapping and characteristics of distribution

Figure 2 shows the clustering result. The land cover was classified into 32 different categories but only regions categorized as having vegetation cover are displayed. Here, five kinds of vegetation cover were selected from the image interpretation (Fig.3). The extracted vegetation was overlapped with the high-resolution satellite imagery (Fig.4).

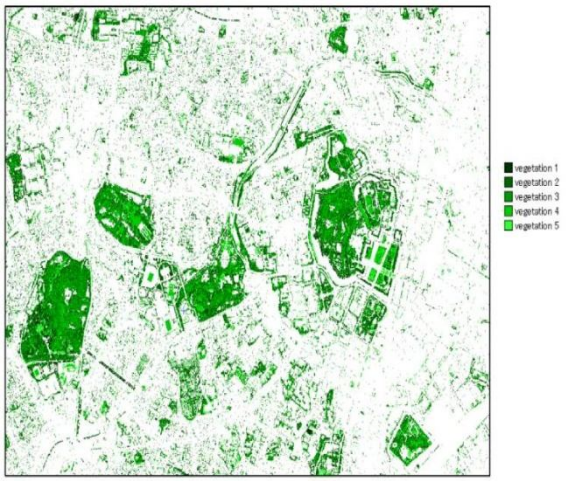


Figure 3. Distribution of vegetation extracted clustering result

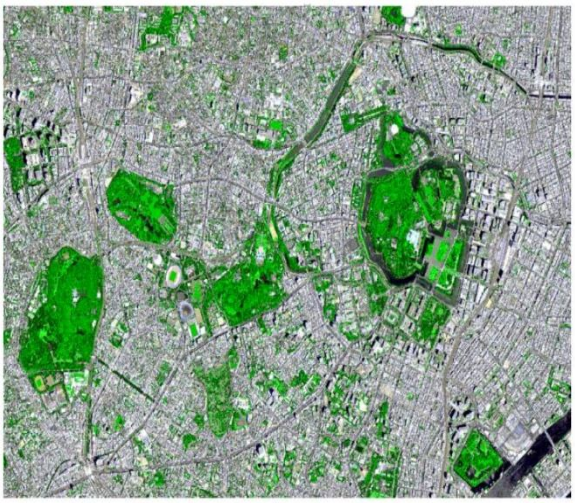


Figure 4. Mapping of the vegetation covering merged from clustering result with the high resolution true color image

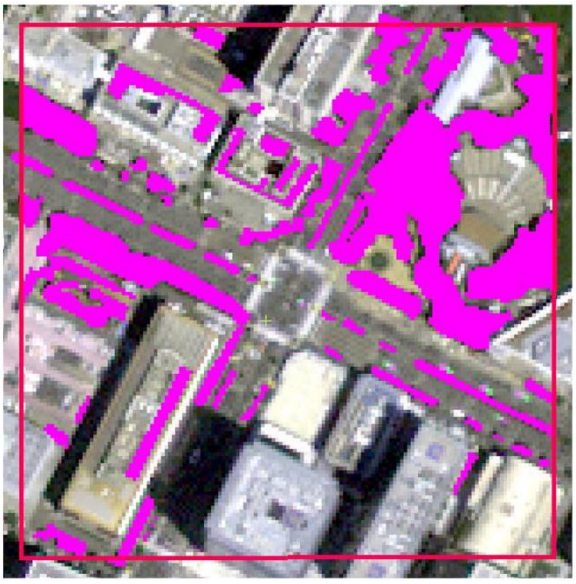
It is believed that this map overlapping the extracted, highly detailed vegetation distribution with the high-resolution satellite imagery allows for the easy understanding of the vegetation distribution in the city.

F. Evaluation of clustering accuracy

As shown in the comparison between the clustering result and the image interpretation result, overcrowded trees and detailed street trees have been sufficiently extracted (Fig. 5). The verification was performed in an area including a park, street trees, and trees scattered throughout the city. A 91% match was found between the vegetation region obtained by clustering analysis and that obtained by image interpretation and field investigation.



(a) Result of the result of classification



(b) Result of image interpretation

Figure 5. Comparison of vegetation area between Fuzzy K-mean and image interpretation

Though it is a standard making technique by the interpretation of the image of the high-resolution satellite imagery for the accuracy validation, it is thought that enough accuracy is secured by a high interpretation.

G. The typical pattern of vegetation distribution

A typical pattern of large-scale overcrowded vegetation covering in the Wildlife Park is shown in Fig. 6. On the other hand, numerous smaller green coverings were dotted in between buildings and on their roofs (Fig.7). A tendency to have many small street trees and scattered planting by the road side was also identified (Fig.8). Thus, it was concluded that the pattern of the vegetation covering in central Tokyo comprised several different types. As mentioned above, the distribution and types of vegetation could be understood in detail and had all the patterns of a typical vegetation coating. Moreover, the distribution of features of the vegetation cover of central Tokyo could be evaluated. These characteristics are a tendency that cannot be grasped to an adequate degree by satellite images of the current resolution class.



Figure 6. Case of forest garden (Hamarikyu garden)



Figure 7. Case of small green (Tokyo midtown area)



Figure 8. Case of trees on road side (Kasumigaseki district)

IV. SUMMARY

In this study, the extraction of vegetation regions in central Tokyo by high-resolution satellite remote sensing was discussed. Thirty-two kinds of land coverage were classified from the clustering processing. Five kinds of vegetation distribution regions could be extracted as a result. Moreover, the extraction accuracy of the vegetation region was 91% in a typical verification area. From these results, a variety of modes of vegetation regions, such as tree groups in city parks or street trees by the roadside were extracted from high-resolution image evaluation data. From the results, it was found that the vegetation covering made a pattern because of several factors in the central Tokyo area. By this method, information relevant to the ecology of urban vegetation should be readily acquirable over a wide area. A discussion of how to evaluate the pattern of the vegetation distribution more quantitatively will take place in the future. To settle on a more effective plan for the vegetation arrangement in an urban area, it is necessary to support it using spatial information by satellite remote sensing.

ACKNOWLEDGMENTS

The Worldview-2 images used in this study include copyrighted material of Digital Globe, Inc., All Rights Reserved.

REFERENCES

[1] Katia P., Adriano M., Effects of vegetation, urban density, building height, and atmospheric conditions on local temperatures and thermal comfort, Urban Forestry & Urban Greening, 13, pp.495-506, 2014.

[2] Young T., C.Y.Jimb, HaiqingW., Assessing the land scape and ecological quality of urban green spaces in a compact city, Landscape and Urban Planning, 121, pp.97-108, 2014.

[3] Fanhua K., Haiwei Y., Cuizhen W., Gina C., Philip J., A satellite image-based analysis of factors contributing to the green-space cool island intensity on a city scale, Urban Forestry & Urban Greening, 13, pp.846-853, 2014.

[4] Jeremy,T., Marsha, O., From space to species: ecological applications for remote sensing, TREND in Ecology and Evolution, 18(6), pp.299-305, 2003.

[5] H.Hashiba, S.Tanaka, T.Sugimura, Evaluation of city environment with vegetation covers by using several kinds of high-resolution satellite images, ASPRS (the American Society for Photogrammetry and Remote Sensing), 2006 Annual Conference Proceedings, Paper ID-104427, pp.1-9, 2006.

[6] Ruiliang, P., Shawn L., A comparative analysis of high spatial resolution IKONOS and WorldView-2 imagery for mapping urban tree species. Remote Sensing of Environment, 124, pp.516-533, 2012.

[7] R. Richter, D. Schlapfer, & A. Muller, An automatic atmospheric correction algorithm for visible / NIR imagery. International Journal of Remote Sensing, 27 (10), pp.2077-2085, 2006.

[8] R.Richter, Atmospheric, / Topographic Correction for Satellite Imagery, ATCOR2/3 User Guide, DLR - German Aerospace Center, 2010.

[9] T. Duda & M. Canty, Unsupervised classification of satellite imagery: Choosing a good algorithm, International Journal of Remote Sensing, 23(11), pp.2193-2212, 2002.

[10] P.A.Burrough, J.P.Wilson, P.F.M.van Gaans, A.J.Hansen, Fuzzy k-means classification of topo-climatic data as an aid to forest mapping in the Greater Yellowstone Area, USA, Landscape Ecology, 16(6), pp.523-546, 2001.

★★★