Comparison of pixel-based and object-based classifications of high resolution satellite data in urban fringe areas

Noritoshi Kamagata[1], Yukio Akamatsu[2], Masaru Mori[3], Yun Qing Li[4], Yoshinobu Hoshino[5] and Keitarou Hara[6]

[1, 6] Graduate School of Informatics, Tokyo University of Information Sciences
1200-2 Yatoh-cho, Wakaba-ku, Chiba, 265-8501 JAPAN
[1]h05002nk@edu.tuis.ac.jp, [6]hara@rsch.tuis.ac.jp

[2, 3] Kokusai Kogyo CO., LTD.
3-6-1 Asahigaoka, Hino City, Tokyo, 191-0065 JAPAN
[2]yakamatu@kkc.co.jp, [3]masaru_mori@kkc.co.jp

[4] Japan Space Imaging Corporation
8-1 Yaesu 2-Chome, Chuo-ku, Tokyo, 104-0028 JAPAN
yunli@spaceimaging.co.jp

[5] Tokyo University of Agriculture and Technology
3-5-8 Saiwaicho, Fuchu, Tokyo, 183-8509 JAPAN
hoshino@cc.tuat.ac.jp

Abstract: This study compares pixel-based and object-based classification of land cover using high resolution satellite data available for urban fringe regions. In the pixel-based analysis the maximum likelihood method and the ISODATA method were applied. The results showed that in both methods misclassification tended to increase due to shadows. The pixel-based classification also experienced difficulty due to factors such as the varied shapes of the forest canopy and mixing of vegetation, etc. The object-based classification, in contrast, relies on abstraction of comparatively homogenous areas, and proved capable of extracting the boundaries among all the forest types. In addition, this study employed a high number of minute patches, and proved effective even in regions where tree species were mingled together. Some misclassification problems remained, which have to be addressed by future trial and error experiments in parameter setting. Still, object-based classification of high resolution satellite data was shown to be an effective tool for analyzing vegetation cover in semi-urbanized and countryside landscapes on the outskirts of large cities, where various vegetation types, as well as buildings and other infrastructures, are mixed together in small areas.
Keywords: High resolution satellite data, Object-based classification, Pixel-based classification, Vegetation

1. Introduction

In urban fringe areas where rapid segmentation and integration of land cover occur, a precise grasp of the current vegetation pattern, as well as regular monitoring of changes, are required for efficient management of the regional landscape. Remote sensing offers the possibility of quick and inexpensive methods for identifying and classifying forest types and other landcover [1] [2]. High spatial resolution data, such as IKONOS, is especially attractive as a tool for enhanced discrimination of cover types [3]. When using high spatial resolution satellite data, however, there is a limit to the effectiveness of conventional pixel-based classification, and object-based classification has been suggested as a more effective method. This research was implemented in a region where various vegetative and structural elements are intermingled in a complicated mosaic pattern. In addition, changes in the land cover and other factors are rapid. Object-based and pixel- based classification were compared for effectiveness in this sort of heterogeneous, rapidly changing landscape. The strengths and weaknesses of each system were identified and analyzed.

This research was partially supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Japan Society for the Promotion of Science (JSPS), Grant-in-Aid for Scientific Research (B) 16380097, (C) 15510195 and supported in part by the Academic Frontier Joint Research Center, Tokyo University of Information Sciences, which is supported by MEXT, Japan.

2. Study Area

The study area, shown in Fig. 1, is located in Yokaichiba City, in the northeastern part of Chiba Prefecture, central Japan. Yokaichiba is situated a little to the east of Narita Airport, and is a primarily agricultural district that in recent decades has been increasingly impacted by urbanization and residential development. The area is characterized by narrow, highly-branched ‘yatsu’ valleys cut into the Hokuso Uplands, a level plateau about 20-25 meters above sea level. The uplands consist of fine-grained windblown sediments, while the bottom valleys contain thicker alluvial soil. The range of altitude over the study areas was slight enough that influence of altitude or geographical features could be ignored in the investigation. The forest physiognomy includes deciduous broad-leaved (C*arpinus*, *Quercus*), evergreen broad-leaved (*Quercus*, *Castanopsis*), coniferous (*Cryptomeria*, *Chamaecyparis*), and bamboo (*Phyllostachys bambusoides*, *P. heterocycla*). Deciduous broad-leaved forest is scattered, and in many areas the forest floor has been taken over by dense stands of bamboo grass (*Pleioblastus chino*). Bamboo groves, left untended are also spreading out, and often intermingle with the other forest types.

3. Methods

This study used an IKONOS (Space Imaging, Japan) multispectral image acquired on 1st April 2001with 0% cloud coverage and 4m of spatial resolution (Fig. 2). In the image, the vegetated uplands and narrow, branching Yatsu valleys, planted in rice paddy, can be clearly recognized. The research was applied only to the vegetated uplands, and not to the valley bottoms. Pixel-based and object-based classifications were applied to the data, and the results were compared. In the pixel-based analysis, both the maximum likelihood method and the ISODATA method were applied. In the object-based classification, object size, shape and other parameters can be adjusted to fit the needs of the research. In this study, the parameters were set at the level of vegetation community. The study area was divided by segmentation processing, and each segment identified was considered to be one object. Aerial photography and field studies were used to establish ground truth and set teacher data for the different vegetation types. Classification was by minimum distance method. The classification types were set as follows: evergreen broad-leaved forest; secondary mixed forest; deciduous broad-leaved forest; secondary grassland; cutover land; wetland; coniferous plantation; other plantation, bamboo grove; and orchard.

4. Results and Discussion

1) Pixel-based classification by ISODATA method

The image was clustered in 40 classes, and recoded based on aerial photography and field study data. Fig. 3 shows the results of this classification. In many cases evergreen broad-leaved forest and coniferous plantation were confused. Also, the system experienced difficulty distinguishing between bamboo groves and deciduous broad-leaved forest. This problem was especially evident because of the date of acquisition of the IKONOS image, April 1st, in spring when the new leaves on the upper branches of the deciduous trees are just beginning to emerge. At this time of year the bamboo grass on the forest floor stand out. In addition, the effect of shade and shadow caused by the canopy trees was also a source of misclassification.

2) Pixel-based classification by maximum likelihood method

The shape of the tree crowns and degree of intermingling can cause differences in classification. Two to five training sets of training data were thus utilized to minimize this problem. The results are shown in Fig. 4. This classification method experienced difficulty in distinguishing among evergreen broad-leaved forest, secondary mixed forest and coniferous forest. Secondary mixed forest was frequently misclassified as evergreen broad-leaved forest or deciduous broad-leaved forest. As was the case with the ISODATA method, bamboo forest and deciduous broad-leaved forest were often confused. The patch size of the vegetation was small, and given the high degree of intermingling, this system had difficulty identifying homogenous patches. In addition, with the high resolution data, differences in shape of crown trees and shadowing cause the system to interpret the same tree differently, making it difficult to produce homogenous patches.

3) Object-based classification by minimum distance method

Aerial photography and ground truth data were used to prevent the segmentation process from breaking up the actual boundaries between the vegetation types. Each identified segment was considered to be a single object. Aerial photography and field studies were used to establish ground truth and set teacher data for the different vegetation types. Classification was by minimum distance method. The results are shown in Fig. 5. The coniferous plantations were accurately identified, but there wee also incidents where evergreen broad-leaved forest, secondary mixed forest, deciduous broad-leaved forest were confused. Misclassifications also occurred where bamboo is invading into other vegetation types. As was the case with the ISODATA method, some problems seem to have resulted from the season of acquisition, with deciduous broad-leaved forests being misinterpreted as bamboo groves.

5. Conclusions

In the pixel-based classifications, high spatial resolution caused frequent misclassification, and the problem was compounded by intermingling and the different shapes of the canopy trees. The small size of the patches, combined with the effect of shadows, also make identification of homogenous communities difficult. With the object-based classification, classification accuracy was improved, and comparatively homogeneous plant communities were abstracted. The minimum distance method, however, still experienced some problems with misclassification, and further trial and error experiments with the scale parameters are required, especially in the kind of regions where vegetation and other parameters are mixed together in a complex pattern. In general, this research showed that the object-based classification system has a high potential for analyzing landscape patterns even in highly heterogeneous and rapidly changing urban fringe regions.

References

[1] Martin, L.R. and Howarth, P.J. 1989. Change-detection accuracy assessment using SPOT multispectral imagery of the rural-urban fringe. Remote Sens. Environ., 30, pp.55-66.

[2] Wolter, P.T. and White, M.A. 2002. Recent forest cover type transitions and landscape structure changes in northeast Minnesota, USA. Landscape Ecology, 17(2), pp. 133-155.

[3] Wang, L., Sousa, W.P. and Gong, P. 2004. Integration of object-based and pixel-based classification for mapping mangroves with IKONOS imagery. Int.J.Remote Sensing. vol.25. no24. pp 5655-5668.

[4] Benz, U.C., Hofmann, P., Willhauck, G., Lingenfelder, I. and M. Heynen. 2004. Multi-resolution, object-oriented fuzzy analysis of remote sensing data for GIS-ready information. ISPRS Journal of Photogrammetry & Remote Sensing 58. pp 239-258.

[5] Repaka, S.R. and Truax, D.D. 2004. Comparing spectral and object based approaches for classification and transportation feature extraction from high resolution multispectral imagery. ASPRS Annual Conference

[6] Hajek, F. 2005. Object-oriented classification of remote sensing data for the identification of tree species composition. Proceedings of ForestSat 2005 conference

[7] Frauman, E. and Wolff, E. 2005. Segmentation of very high spatial resolution satellite images in urban areas for segments-based classification. Proceedings of the ISPRS WG VII/1 "Human Settlements and Impact Analysis" 3rd International Symposium Remote Sensing and Data Fusion Over Urban Areas (URBAN 2005) and 5th International Symposium Remote Sensing of Urban Areas (URS 2005)

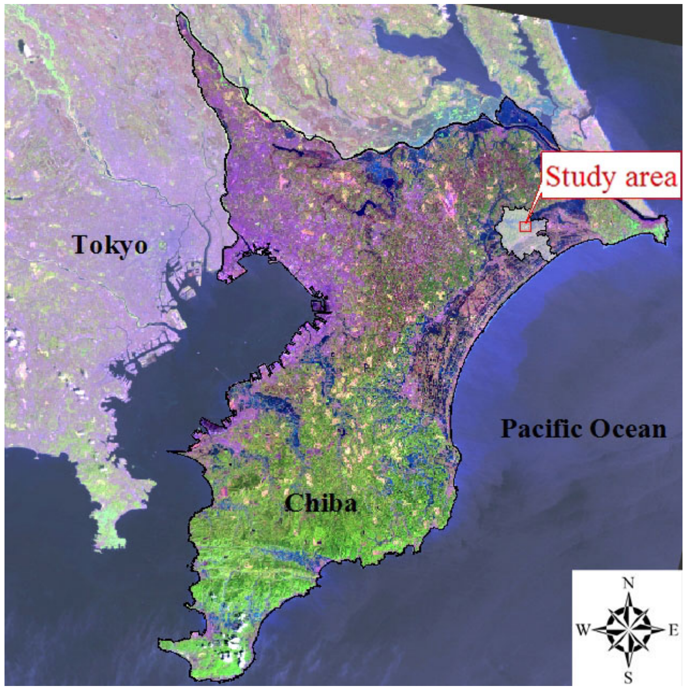

Fig. 1. Study area

Fig. 2. IKONOS image of study area

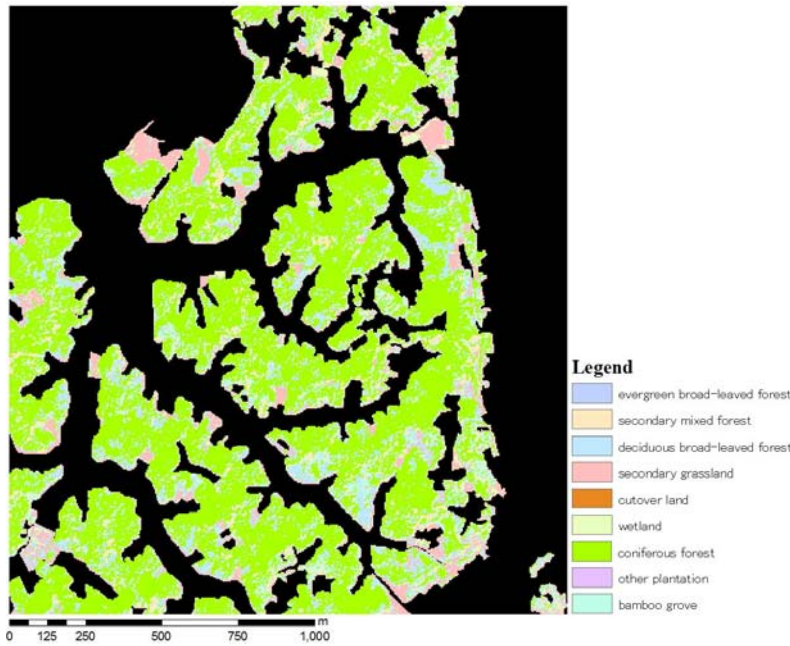

Fig. 3. Pixel-based classification by ISODATA method

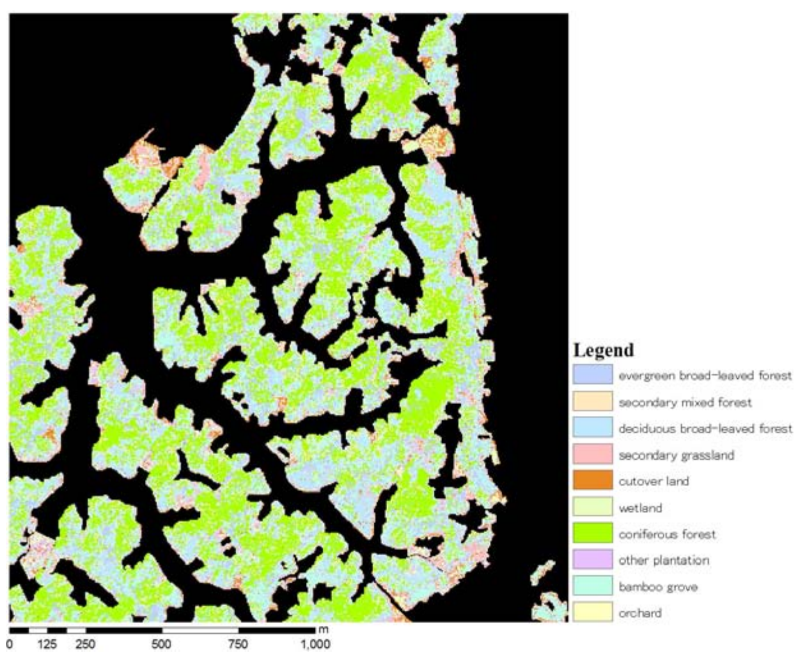

Fig. 4. Pixel-based classification by maximum likelihood method

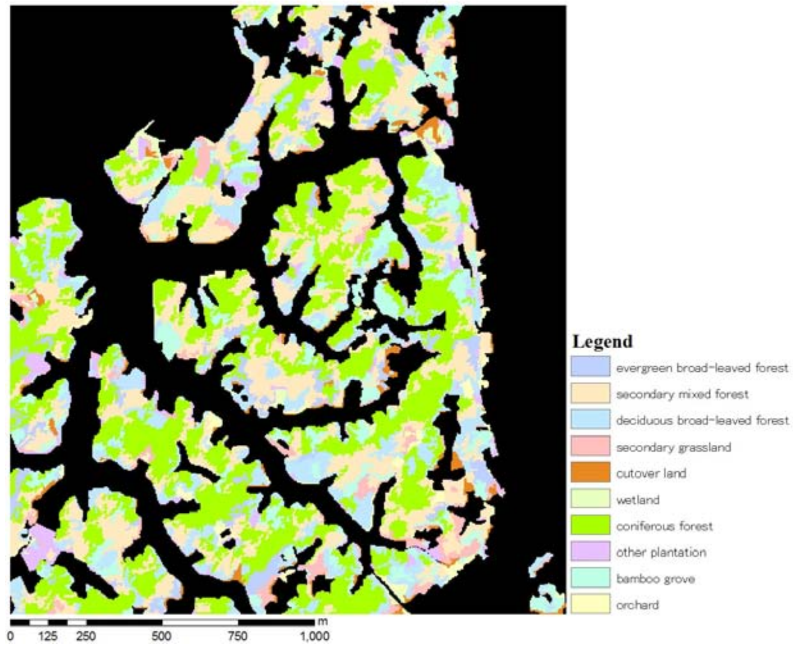

Fig. 5. Object-based classification by minimum distance method