Tree crown detection and classification using forest imagery by IKONOS

Tree Crown Detection and Classification Using Forest Imagery by IKONOS

Mamoru Kubo and Ken-ichiro Muramoto
Kanazawa University
Kakuma Kanazawa 920–1192, Japan
Email: kubo@ec.t.kanazawa-u.ac.jp

Abstract— **The purpose of this study is detection and classification of tree crowns using forest imagery taken by IKONOS. A forest image contains many tree crowns of different sizes and shape that are touching each other. By using IKONOS pan-sharpened data, discernment of tree crown and species is possible. To detect tree crowns in the image, we used Watershed segmentation. If an image is viewed as a surface, with mountains and valleys, the Watershed segmentation finds intensity valleys in an image. In this study, a gradient of intensity in an image was used in order to find valleys separating tree crowns from shadows. To classify tree species, the spatial features of each segmented region were calculated. Image features for the classification were extracted by texture analysis using gray level co-occurrence matrix. Image texture is produced by an aggregation of unit features, such as tree leaves and leaf shadows. Variations in crown texture are important in the identification of species. Supervised classification using maximum likelihood decision rules with these features was performed. Classification accuracies on the order 80% were achieved.**

I. Introduction

Satellite remote sensing technology is expected as the technique of managing the forest which is the source of absorption of carbon dioxide. It is an interesting subject to investigate each position, size, shape, and species of trees from satellite data [1].

The spatial resolution of IKONOS data used by this study is very high so that the visual interpretation of the tree crown can be carried out. Since the image of one tree crown consists of many pixels, the peculiar spatial pattern to a tree crown is formed of the difference of the brightness value between the neighboring pixels in a tree crown. Distinction of tree species is possible if this spatial pattern is used [2].

In this study, each tree crown is detected from high resolution satellite data. and the tree crowns are classified into some species class.

II. Data

The satellite data used by this study is shown in Fig. 1. The area of left image is the forest of the Arimine area in Toyama prefecture which the IKONOS satellite took on June 1, 2002.

The spatial resolution of this IKONOS data is 1 meter, and the size of right image is 128 by 128 pixels. These four images are blue, green, red, and the near-infrared band.

III. Method

Fig. 2 shows the processing procedure of this study.

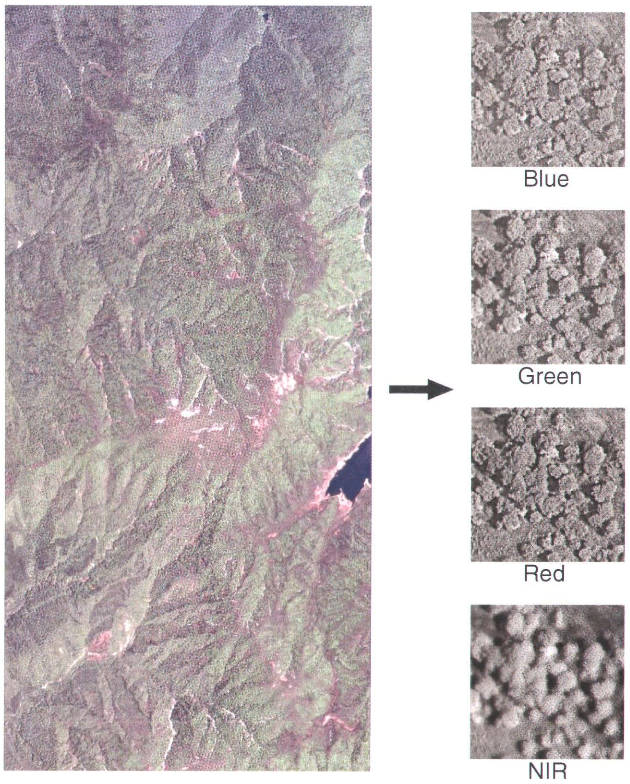

Fig. 1. IKONOS imagery

A. Segmentation

Principal component analysis(PCA) is carried out to these four images, and the first component image is created.

If segmentation of this image is carried out, many regions will be detected very much. In order to detect a tree crown, it is necessary to make the brightness value of each tree crown into an independent peak before segmentation process [3]. First, a image is smoothed using a small Gaussian filter. High spatial frequency components are removed from the image. Next, morphological reconstruction by dilation and erosion operation is performed. The brightness value of each tree crown serves as an independent peak by this processing. This processing is not made to change the shape of a tree crown unlike smooth processing. A watershed algorithm is used as segmentation for

0-7803-9051-2/05/$20.00 (C) 2005 IEEE

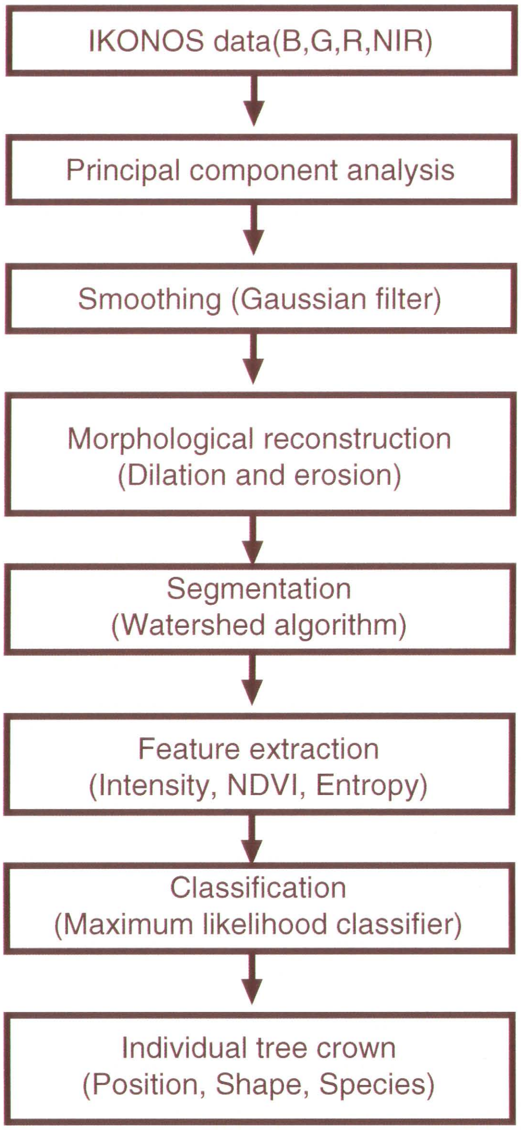

Fig. 2. Flow diagram of segmentation and classification.

Fig. 3. Training data set. Shadow is class F.

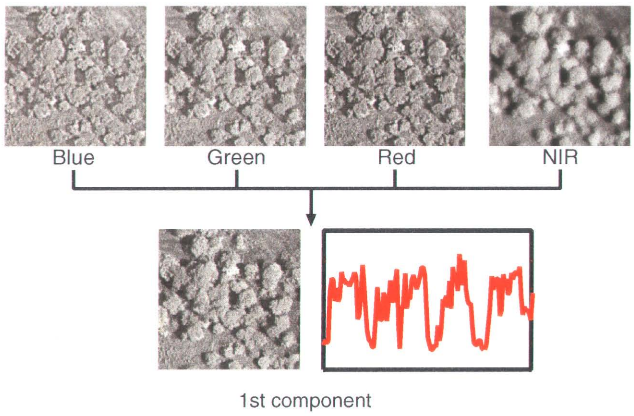

Fig. 4. Principal component analysis.

detection of tree crown [4]. This algorithm is processing which find peaks and valleys ,and extend these regions from there. The segmented region of peak or valley, and is equivalent to a tree crown or a shadow, respectively.

B. Classification

The classification processing is performed to segmented regions. The classification technique uses the maximum likelihood decision rule which needs training data. In this study, the 6 class of training data is shown in Fig. 6. Tree crowns of each class were determined manually.

The features used for a classification are intensity, NDVI(normalized difference vegetation index) and entropy. Entropy is a kind of textural feature using the gray level co-occurrence matrix(GLCM) [5], [6].

$$\mathrm{Intensity}_X = \frac{1}{N_X}\sum_{p\in X}\frac{I_{\mathrm{Red}}(p)+I_{\mathrm{Green}}(p)+I_{\mathrm{Blue}}(p)}{3}$$

$$\mathrm{NDVI}_X = \frac{1}{N_X}\sum_{p\in X}\frac{I_{\mathrm{NIR}}(p)-I_{\mathrm{Red}}(p)}{I_{\mathrm{NIR}}(p)+I_{\mathrm{Red}}(p)}$$

$$\mathrm{Entropy}(d,\theta) = -\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} p(i,j,d,\theta)log(p(i,j,d,\theta))^2$$

where $p(i,j,d,\theta)$ is the (i,j)th element of a $N \times N$ GLCM, indicating the relative frequency that gray levels i and j are found at a distance d in the relative direction θ.

The intensity of a tree crown is calculated the average of the brightness value in each tree crown from blue, green, and red data. NDVI is calculated the average value in each tree crown from red and near-infrared data.

IV. Result

The PCA result is shown in Fig. 4, and results of smoothing and morphological reconstruction is shown in Fig. 5. The segmentation results are shown in Fig. 6. The shapes of tree crown are detected correctly. The three features of training data is shown in a Fig. 7. It means that the intensity can be used for separation class B, F and F from others, NDVI can separate D and E, and entropy can separate A and C. The classification results are shown in a Fig. 8. Automatic classification accuracies were 80% compared with visual interpretation.

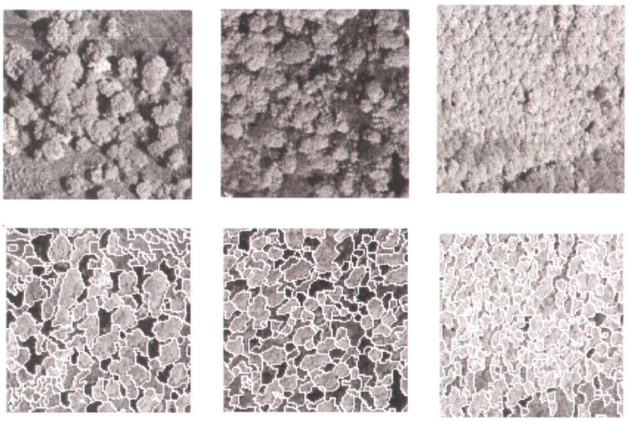

Fig. 6. Segmentation results. Upper images are first components by PCA.

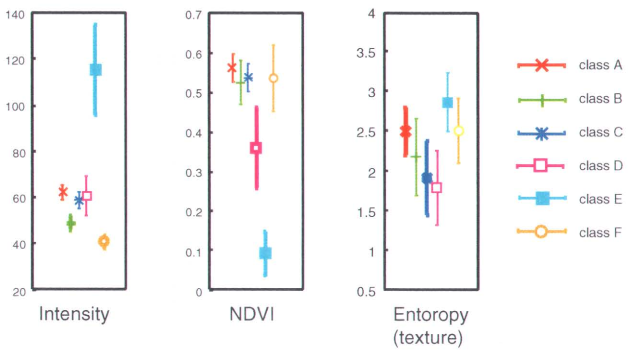

Fig. 7. Extracted features of training data.

V. Conclusion

In this study, we have detected tree crown from forest imagery by IKONOS and classified segmented regions. In detection process, watershed segmentation was used after principle component analysis, smoothing and morphological reconstruction. In classification process, two spectral features and one textural feature using gray level co-occurrence matrix were used by maximum likelihood classifier. Classification accuracies on the order 80% were achieved.

References

[1] A. Carller and E.Wolff, "Exploitation of very high resolution satellite date for tree species identification", *Photogrammetric Engineering & Remote Sensing*, vol. 70, no. 1, pp. 135-140, 2004.

[2] S. E. Franklin, R. J. Hall, L.M. Moskal, A. J. Maudie and M. B. Lavigne, "Incorporating texture into classification of forest species composition from airborne multispectral images", *Int. J. Remote Sensing*, vol. 21, no.1, pp. 61-79, 2000.

[3] L. Wang, P. Gong and G. S. Biging, "Individual tree-crown delineation and treetop detection in high-spatial-resolution aerial imagery", *Photogrammetric Engineering & Remote Sensing*, vol. 70, no. 3, pp. 351-357, 2004.

[4] L. Shafarenko, M. Petrou and J. Kittler, "Automatic watershed segmentation of randomly textured color images", *IEEE Trans. Image Processing*, vol. 6, no. 11, pp. 1530-1544, 1997.

[5] S. E. Franklin, A. J. Maudie and M. B. Lavigne, "Using spatial co-occurrence texture to increase forest structure and species composition classification accuracy", *Photogrammetric Engineering & Remote Sensing*, vol. 67, no.7, pp. 849-855, 2001.

[6] P. Maillard, "Comparing texture analysis methods through classification", *Photogrammetric Engineering & Remote Sensing*, vol. 69, no. 4, pp. 357-367, 2003.

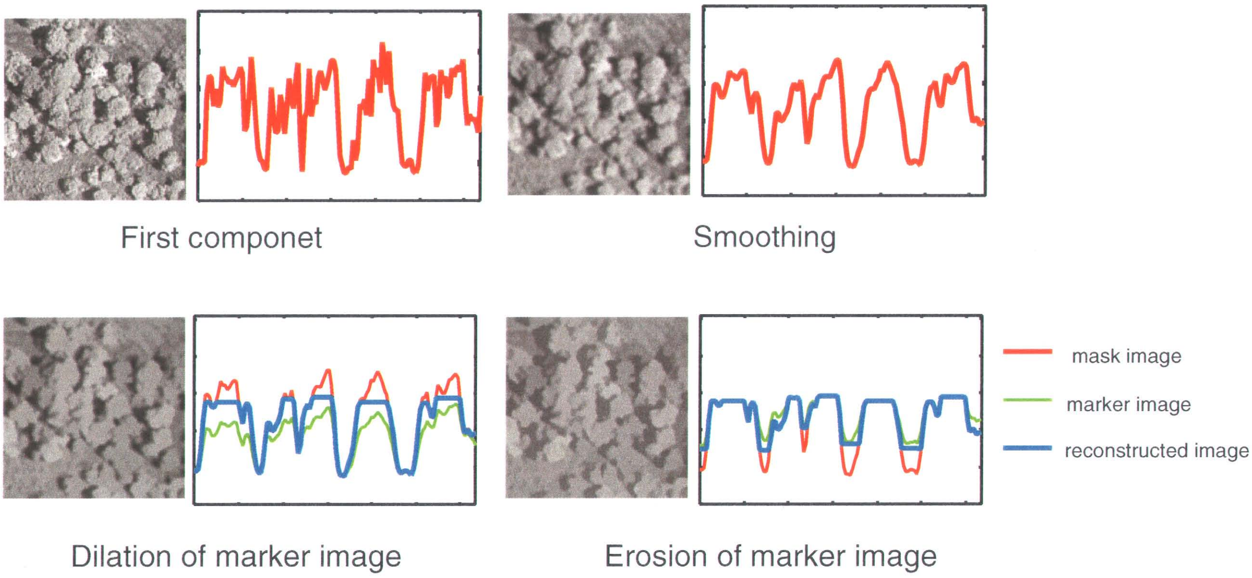

Fig. 5. Smoothing and morphological reconstruction.

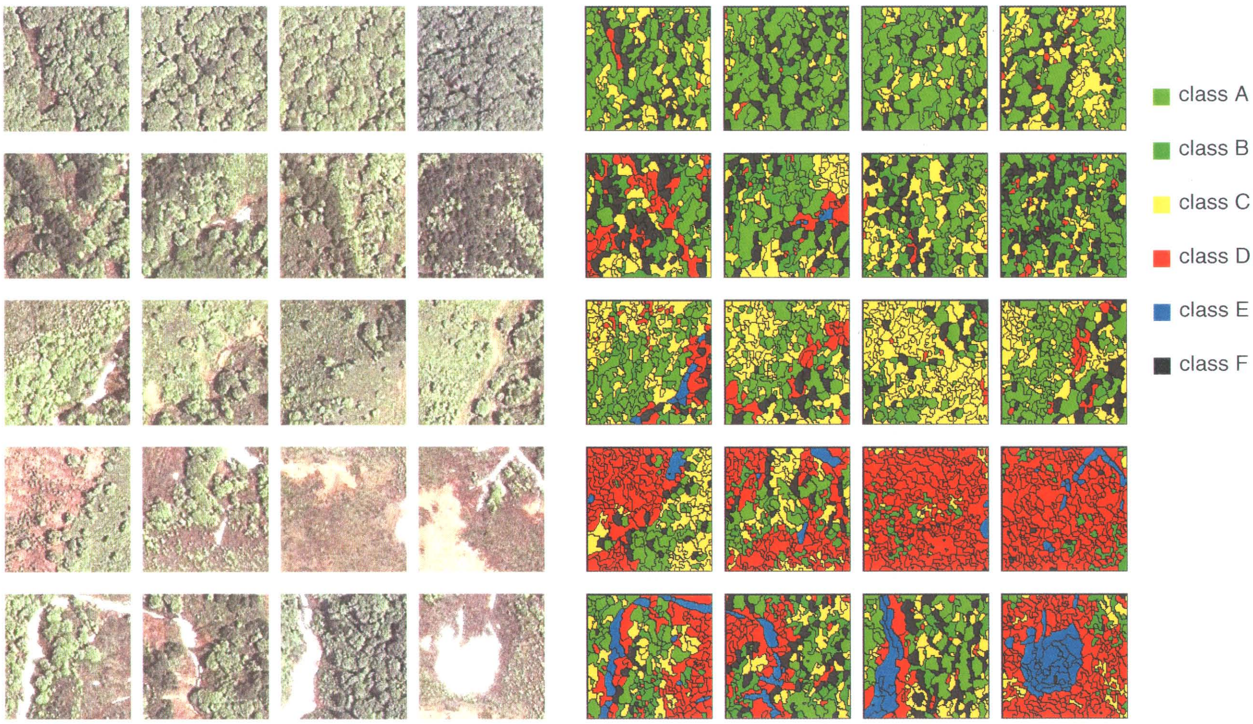

Fig. 8. Classified results.