Development of the forest type classification technique for the mixed forest with coniferous and broad-leaved species using the high resolution satellite data

Hiroshi Sasakawa
Graduate School of Agricultural and Life Sciences, The University of Tokyo
1-1- 1, Yayoi, Bunkyo-Ku, Tokyo, 113-8657, Japan
sasayan@fr.a.u-tokyo.ac.jp

Satoshi Tsuyuki
Graduate School of Agricultural and Life Sciences, The University of Tokyo
1-2- 1, Yayoi, Bunkyo-Ku, Tokyo, 113-8657, Japan
tsuyuki@fr.a.u-tokyo.ac.jp

Abstract: This research aimed to develop forest type classification technique for the mixed forest with coniferous and broad-leaved species using the high resolution satellite data. QuickBird data was used as satellite data. The method of this research was to extract satellite data for every single tree crown using image segmentation technique, then to evaluate the accuracy of classification by changing grouping criteria such as tree species, families, coniferous or broad-leaved species, and timber prices. As a result, the classification of tree species and families level was inaccurate, on the other hand, coniferous or broad-leaved species and timber price level was high accurate.

Keywords: Forest type classification, Segmentation, High resolution satellite data, QuickBird.

1.Introduction

It was thought difficult to classify the forest type in detail on the mixed forest with coniferous and broad-leaved species due to the limit of interpretation in aerial photography and the limit of resolution of satellite data. But it is expected exact classification based on identifying single tree crown will be possible by use of the high resolution satellite data. This research aimed to develop forest type classification technique for the mixed forest with coniferous and broad-leaved species using the high resolution satellite data.

2.Materials

The University forest in Hokkaido of the University of Tokyo was selected as a test site. 18 plots (one plot size was 50m by 50m) in the test site were surveyed. The test sites were located in almost flat terrain. Tree position, tree height, and crown radius (4 direction) were measured for all trees. The forest management map made by GPS survey and crown projection map made by ground measurement were used for georeferencing satellite data.

QuickBird data acquired on 7 June 2002 was used as satellite data. Off nadir angle was 13 degree. QuickBird carries panchromatic sensor and 4 color sensors such as blue, green, red, near infrared. Panchromatic resolution is 0.61m and color sensors resolution is 2.44m at nadir.

3.Methods

The method of this research was to extract satellite data for every single tree crown using image segmentation technique, then to evaluate the accuracy of classification by changing grouping criteria. Flowchart of this study was shown in Fig.1.

1) Pre-processing

Satellite data should be geographically registerd to

the forest management map and crown projection map exactly to extract single tree crown. But satellite data with original GCPs (Ground Control Points) did not have enough accuracy. So, satellite data was georeferenced again using precise GCPs. Firstly, color image data was georeferenced and resampled to panchromatic image data with pixel size of 0.64m using nearest neighbor method. Then, Panchromatic and color image data were georeferenced again using the forest management map and crown projection map and resampled. 5 resampled image data with exact GCP were made in this procedure. Maximum resumpling error of panchromatic and color image data to the forest management map and the crown projection map was 0.25m and 9m or less respectively.

2) Segmentation and classification

5 satellite data (panchromatic data and 4 color data) and crown projection map were imported to image analysis software eCognition (Definiens Imaging GmbH, Munich) as image layers for classification. eCognition does not classify single pixels, but rather image objects derived from segmentation procedure. Series of procedure of eCognition is as follows.

1.Segmentation is a bottom up region-merging technique starting with one-pixel objects. In merging step, that pair of adjacent image objects is merged. Throughout this clustering process, the underlying optimization procedure minimizes the weighted heterogeneity of resulting image objects. If the smallest growth exceeds the threshold defined by the scale parameter, the process stops

2.Classify image objects merged by segmentation using nearest neighbor method.

4.Results and Discussion

1) Accuracy of Segmentation

Weight parameters for each layer w_l, color w_c and shape w_s, and scale parameter s were used for segmentation. In this study, we analyzed proper values for each parameter by comparing results of segmentation with crown projection map. As a result, the most proper segmentation was obtained when w_l for panchromatic layer was 1 and for color layer was 0

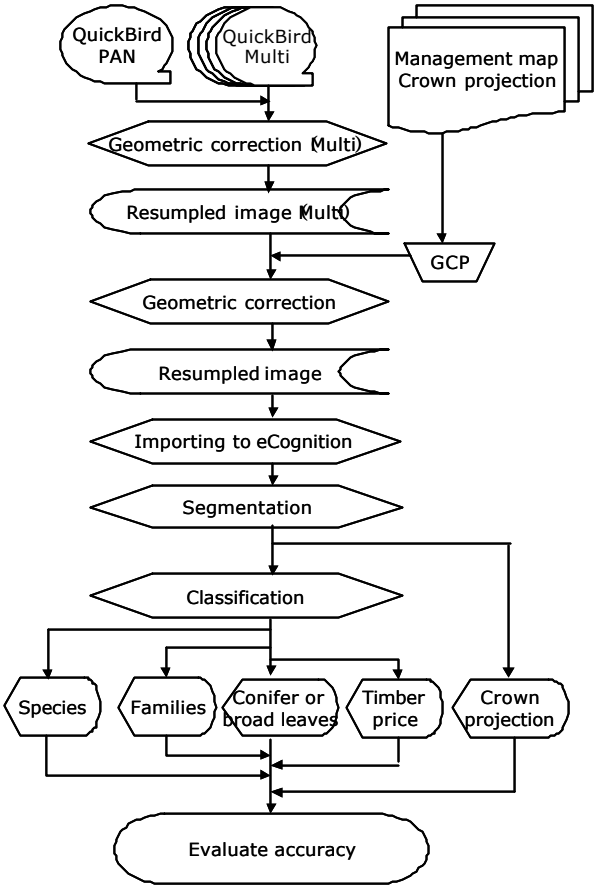

Fig. 1. Flowchart of this study

and 1, 0, 10 for w_c, w_s, s respectively. The result of segmentation could not show crown projection exactly (Fig.2, 3). The reason was due to the resolution of satellite data, changing color tone within the same crown influenced by adjacent trees' shade. But segmentation by eCognition will provide useful clues for single tree interpretation in mixed forest where manual interpretation is impossible due to very high crown cover ratio.

2) Accuracy of Classification

Firstly, evaluation map and classification map were made by supervised classification using segmentation objects created by eCognition. When region in crown projection map and the object had more than 70% overlap, it was assigned to training sample object. Evaluation map was created for each plot to be classified using all training sample objects from all plots. This map means the most correct classification result using segmentation objects. On the other hand, classification map was created for half plots using

training samples from other half plots. This map was used to access classification accuracy. ‘Classification accuracy’ means agreement ratio of crown projection map and classification map. ‘Most correct classification accuracy’ means agreement ratio of crown projection map and evaluation map. Fig. 4 to 7 show examples of classification result. Table 1 shows ‘classification accuracy’ and ‘most correct classification accuracy’. ‘Classification accuracy’ of tree species and families were 0.23 and 0.30 respectively. On the other hand, ‘classification accuracy’ of coniferous and broad-leaved species was 0.72. These results suggest that the automatic classification method used in this study can be performed to classify coniferous and broad-leaved species. However, it is difficult to classify tree species and families automatically, because single tree crown varies its brightness. Meanwhile, classification accuracy of timber price was 0.68. This result suggests that the automatic classification method is a useful tool for the estimation of the forest's value based on timber price.

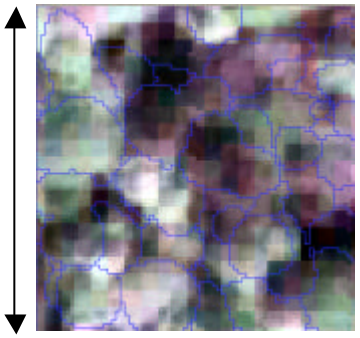

Fig. 2. Crown projection map on satellite image data

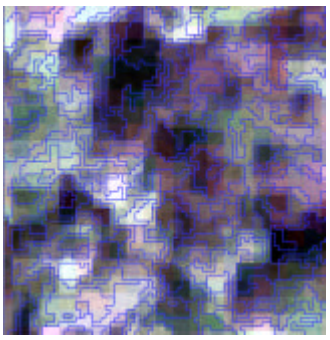

Fig. 3. Result of segmentation on satellite image data

Fig. 4. Crown projection

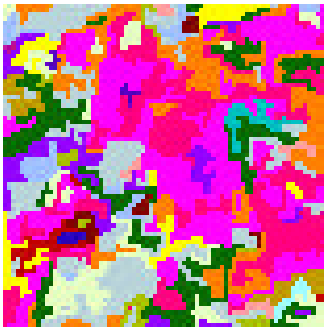

Fig. 5. Classification map classified by species

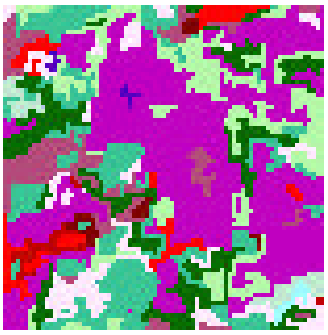

Fig. 6. Classification map classified by families

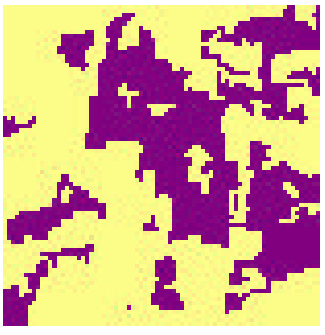

Fig. 7. Classification map classified by coniferous or broad-leaved species

Table 1. Classification accuracy and most correct classification accuracy

	Ttree species		Families		C or B species		Timber price	
	*1	*2	*1	*2	*1	*2	*1	*2
Average of all plots	0.54	0.23	0.59	0.30	0.84	0.72	0.83	0.68

*1:Most correct classification accuracy *2:Classification accuracy