Method for classification and delimitation of forest cover using IKONOS imagery

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Abstract: This study proved if the high resolution satellite imagery of IKONOS is suitable for preparing digital forest cover map. Three methods, the pixel based classification with maximum likelihood (PML), the segment based classification with majority principle(SMP), and the segment based classification with maximum likelihood(SML), were applied to classify and delimitate forest cover of IKONOS imagery taken in May 2000 in a forested area in the central Korea.
The segment-based classification was more suitable for classifying and deliminating forest cover in Korea using IKONOS imagery. The digital forest cover map in which each class is delimitated in the form of a polygon can be prepared on the basis of the segment-based classification.
Keywords: digital forest cover map, IKONOS imagery, pixel based classification, segment based classification

1. Introduction

A forest cover map, which gives the information about tree species, age class, diameter class and density for a forest type, has been widely used for forest planning and management, natural resource management, ecosystem management.

The traditional procedure for preparing the digital forest cover map involves a series of complex processes. This complex procedure is time-consuming and expensive, and still yield inaccurate results and is no longer up to date. A new classification procedure is needed for timely and accurate mapping the forest cover.

A good and promising alternative is to directly map forest cover from high resolution satellite imagery which is composed of digital grid data and cover relatively large area with regular rescanning period. This study was performed to explore the potential of high resolution satellite imagery of IKONOS and segment based classifcation for mapping the detailed forest cover map.

2. Materials and method

2.1 Study area and materials

We used the "pan-scharpened" multi-spectral IKONOS imagery taken on 8 May 2000 for the area of 11 km x 11 km in the central Korea. The study area of 400 ha was selected between left-upper coordinate (127° 40' 30'' E, 37° 31' 30'' N) and right-under coordinate (127° 45' 00'' E, 37° 28' 30'' N) and the corresponding IKONOS imagery was subset for the classification (Figure 1).

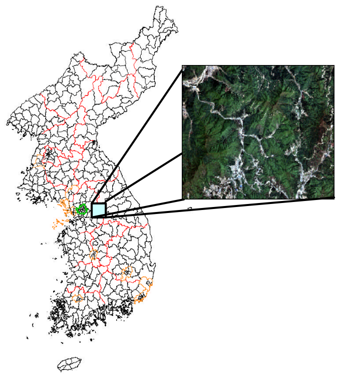

Figure 1: Study area and ortho-rectified IKONOS imagery of the study area

2.2 Method

2.2.1 Pixel based classification

The IKONOS imagery was classified first using the conventional pixel based supervised classification with maximum likelihood (PML) (Jensen, 1996; ERDAS, 1999; Lillesand and Kiefer, 2000).

2.2.2 Segment based classification

For the segment-based classification (Baatz and Shäpe, 2000; Baatz et al., 2000; Bauer and Steinnocher, 2001; Niemeyer, 2001; Van der Sande, 2003), pixels of the

IKONOS imagery were first segmented and the segments were classified on the basis of the spectral information of the pixels within the segment.

In the segment based classification with the majority principle(SMP), pixels of each class classified by the pixel based method were counted using the GRID module of ArcInfo (ESRI 1995). And a class which occupies a majority in a segment was assigned to the segment class.

In the segment based classification with maximum likelihood(SML), the new segment-specific characteristics which enable classification of each segment were first derived. The spectral mean values and theirs standard deviations were employed as the segment-specific characteristics. Mean values and standard deviations for the spectral values of the pixels in each segment were calculated using eCognition (eCognition 2002). So a new data set of 6 artificial channels could be prepared for the classification of each segment. The classification using these 6 bands were performed with Imagine (ERDAS 1999).

2.2.3 Verification and comparison of classification

The result of classification was verified with the help of the independent reference data set, and the accuracies of the above three methods were compared. Kappa values(KHAT statistics), a measure of the difference between the actual agreement between reference data and automated classifier and the chance agreement between the reference data and a random classifier (Congalton 1991, Stehman, 1996; Lillisand and Kiefer, 2000) and error matrix (Jensen 1996, Congalton 1991, , Stehman 1999, Lillesand and Kiefer 2000) including producer' s, user' s, and overall accuracy were used for verifying and comparing the classification results.

3. Results and discussions

3.1 Pixel based classification

As a whole, the forest area tends to show higher classification accuracy than the non-forest area. This is different from the result of Cho (2002) who used an IKONOS image taken before the growing season. Cho (2002) found it hard to separate forest stands with the pre-growing season imagery he analyzed. The forest areas of our IKONOS imagery taken in the early growing season had enough separation to optically identify some tree species, resulting in higher producer' s accuracy than that of by Cho (2002).

The *Quercus variabilis* shows the lowest producer' s accuracy of 0.40% in the forest area. Much of the *Quercus variabilis* were classified into *Pinus rigida*, *Larix leptolepis*, and other two oak species. Among the coniferous species, the *Larix leptolepis* shows the lowest producer' s accuracy of 0.53%. About 27% and 12% of the *Larix leptolepis* were misclassified into the *Pinus rigida* and *Pinus koraiensis*, respectively. This erroneous classification can be attributed to spectral overlap in tree species.

The *Quercus mongolica* stand was classified most accurately with the producer' s accuracy of 0.88 in the forest area. This can be attributed to the distinctive difference in spectral value of NIR band.

From the user' s point of view, the *Pinus rigida*, to which two coniferous species and *Quercus variabilis* were misclassified, shows the lowest user' s accuracy of 0.32% in forest area. It is also notable that the user' s accuracy of the grass land shows considerably lower value of 0.11. It was caused by the fact that much of the *Quercus variabilis*, *Quercus accutisima*, and agricultural land in non-forest class were misclassified into grass land which encompasses also cutting areas.

3.2 Segment based classification

3.2.1 Segment based classification with majority principle

Through the segment-based classification with majority principle, the overall accuracy was improved from 0.57 in the pixel-based classification to 0.67, and the kappa value increased from 0.50 to 0.62. However, Classification confusion still occurs among coniferous tree species, between oak species and grass land.

The misclassification of the pixel based method could be considerably reduced by using a segment-based classification with majority principle. The misclassification of the *Quercus variabilis* into coniferous tree species can be eliminated. However, some of *Quercus variabilis* was classified still into other two oak species. And about 36% of *Quercus variabilis* was misclassified into grassland, resulting in a low producer' s accuracy of 0.46. This can be explained by the fact that some of pixels of *Quercus variabilis*, which were mixed with grassland, were evaluated as minor and classified into grassland with the majority principle.

For *Larix leptolepis* stand which was falsely classified into whole classes with the pixel-based classification, misclassification can be also be much improved. However, still about 31% of *Larix leptolepis* was classified into *Pinus rigida*.

The producer' s accuracy of *Pinus rigida* was lowered from 0.61 to 0.56 through use of the segment-based classification with majority principle. While misclassification into oak species could be eliminated, misclassification into grass land and *Larix leptolepis* was increased. This means that some pixels of *Pinus rigida* were fused rather into grass land and *Larix leptolepis* than into *Pinus rigida*.

Misclassification into *Pinus rigida* and grassland still remained. Some pixels of the two coniferous tree species *Pinus koraiensis* and *Larix leptolepis* were still classified into *Pinus rigida*, resulting in a low user' s accuracy of 0.41. Misclassification into grassland still appeared in all classes except *Pinus koraiensis* and *Quercus mongolica*.

The *Quercus mongolica* and grass land obtained perfect classification accuracy. And no other segments were classified into non-forest, which results in the user's accuracy of non forest class being perfect.

3.2.2 Segment based classification with maximum likelihood method

The segment-based classification with maximum liklihood showed the best performance with an overall accuracy of 0.70 and kappa value of 0.64.
In comparison to the previous two methods, the misclassification of tree species into grassland was considerably reduced, but still much of the agricultural land in nonforest areas was classified into grassland.
For *Pinus rigida*, the misclassification into grassland seemed to be perfectly eliminated and showed considerably improved producer's accuracy of 0.82. However, misclassification from two other coniferous tree species and *Quercus variabilis* into *Pinus rigida* still remained. About 30% of the *Quercus variabilis* was misclassified into *Pinus rigida* .

The *Quercus mongolica*, *Quercus accutisima,* and grassland segments were classified totally into a single class, and no other segments were classified into *Larix leptolepis* and non-forest.
As a whole, it appears that the high variation in spectral values in pixel based classification of IKONOS imagery is greatly reduced by segment-based classification.

4. Conclusion

This study investigates the suitability of the high spatial resolution IKONOS imagery for preparing detailed digital forest cover map. Three methods, such as the pixel-based classification, segment-based classification with the majority principle, and segment-based classification with maximum likelihood, were applied to classify the IKONOS imagery.
The pixel based classification with maximum likelihood showed the poorest performance in classifying forest cover. Through the segment-based classification with majority principle, the overall accuracy was improved from 0.57 in the pixel-based classification to 0.67 and the kappa value from 0.50 to 0.62. The segment-based classification with maximum likelihood showed similar performance to the segment-based classification with majority principle, resulting in an overall accuracy of 0.70 and a kappa value of 0.64
As a whole, the segment based classification of high spatial resolution IKONOS was more feasible for preparing the detailed forest cover map and suitable as an alternative to aerial photograph for preparing and updating forest cover information. These results can serve as a tool for preparing detailed digital forest cover map in which each class is delimitated in the form of a polygon.

Acknowledgement

This study was supported by LG Yonam Foundation.

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