

VEGETATION COVER MAPPING USING HYBRID ANALYSIS OF IKONOS DATA

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ABSTRACT:

Detailed mapping of vegetation cover types is often required in various environmental study projects. Very high-resolution satellites, e.g. *IKONOS*, are expected to provide a new opportunity to make detailed vegetation cover maps efficiently for large study areas. This paper reports the methodology of the vegetation cover mapping using *IKONOS* data for a watershed management project in south-western Japan. In this study, we examined spectral, geometric, and textual properties of image objects extracted through both object-based and pixel-based image classification of *IKONOS* panchromatic, mulit-spectral, and pan-sharpen images of the study area to check whether vegetation cover types in the study area are distinguishable using *IKONOS* data. The result of the analysis shows that, in conjunction with spectral information, textural and geometric information of image objects extracted from *IKONOS* data provide useful information for detailed vegetation cover classification. Based on the analysis, we developed a multi-scale object-based image analysis method for vegetation cover mapping using *IKONOS* data. Applying the multi-scale analysis to *IKONOS* images, a vegetation cover map of the study area was obtained.

1. INTRODUCTION

In Japan, river environment information such as spatial distributions of vegetation and wild life habitats along rivers has been periodically collected by the ministry of land, infrastructure, and transportation since 1990. Along with the recent increase in concern over the restoration of the natural environment in Japan, information contents of the river information data set is now being reviewed by the ministry so that it would be able to provide more useful information for realizing environmentally appropriate watershed management. The requirements for the new data sources of the river information data, which would be an alternative for aerial photo-interpretation and field survey, include cost-effectiveness, continuity, periodicity, and objectivity. Very high-resolution satellite images are expected be a useful information source for acquiring vegetation information along major rivers in Japan, which is part of the environmental data set.

This paper reports the tentative study of the vegetation cover mapping from *IKONOS* data for a watershed management project in south-western Japan, assuming the future use of *IKONOS* data for the nationwide river information acquisition.

2. CLASSIFICATION SCHEME

Table 1 shows the classification scheme designed for the vegetation mapping in this study. The right column of the table summarizes the result of the tentative vegetation mapping from *IKONOS* data using the maximum-likelihood classifier. Based on the result, the vegetation mapping for the project seem to need both object-based and pixel-based classifier.

Table 1. Classification scheme of the vegetation map of the river information data set and the summary of the classification result of an *IKONOS* image via maximum likelihood classification
(+: Acceptable, *: Moderate, -: Unacceptable)

Class	Results of maximum likelihood classification of an <i>IKONOS</i> image
Water plant	+ Field check is necessary
Grass	+ Sometimes it is confusingly similar to deciduous trees
Deciduous tree	+ Sometimes it is confusingly similar to grasses
Coniferous tree	*Difficult to distinguish from bamboo forests
Bamboo	*Difficult to distinguish from coniferous forests
Bush	+ Field check is necessary
Bare land	+ Relatively easy to identify
Orchard	* Visual interpretation must be used in conjunction with maximum likelihood classification
Vegetable field	* Visual interpretation may be needed to ensure the classification results
Rice field	- Difficult to distinguish from agricultural fields without imagery taken at submerged period
Manmade structure	* Distinction from residential area is problematic
Residential area	* Distinction from manmade structures is problematic
Open water	+ Relatively easy to distinguish

Ground resolution of IKONOS data is smaller than the average patch sizes of the vegetation classes of this study, and pixel values alone may not provide enough information for distinguishing image objects corresponding to the instances of vegetation classes, although pixel-based classifiers such as maximum-likelihood classifiers provide useful vegetation information such as vegetation density and distribution in individual patches of vegetation classes. On the other hand, object-based classifiers can utilize contextual information as well as spectral information for image classification, and are suitable for delineating image objects corresponding to the vegetation patches on IKONOS imagery. They group contiguous pixels with similar pixel values into image objects and label them according to contextual information such as spatial relationships among image objects as well as spectral and textural properties.

3. STUDY AREA AND DATA

In this study, a trial of the hybrid vegetation mapping from actual IKONOS data was conducted. The lower part of the *Niyodo* river watershed area located in the south-western part of Japan was chosen for the study area. The land use of the study area mainly consists of natural forests and agricultural fields (rice fields, vegetable fields,

green houses, etc.).

The remote sensing data used in this study is the IKONOS pan-sharpen CIR imagery data produced from the panchromatic and multi-spectral IKONOS data taken on November 21, 2001 for the study area.

4. IMAGE SEGMENTATION

Object-based classification starts with the image segmentation process, which delineate image objects with relatively similar properties according to segmentation criteria. In this study, the segmentation algorithm developed by Baatz and Schäpe (2000), implemented in the e-cognition software, was used to conduct image segmentation of the IKONOS data with multiple scale parameters to see the correspondence between image objects and land cover instances including vegetation patches. The calculation parameters of the multi-scale segmentation used in the segmentation were “colour” (weight 0.8), “shape” (weight 0.2, further, the “shape” parameter consists of “smoothness” (weight 0.9) and “compactness” (weight 0.1)). Figure 1 shows some examples of the segmentation results at different scale parameters. These are at some intermediate steps of a region growing process from individual pixels. Figure 1 (b)

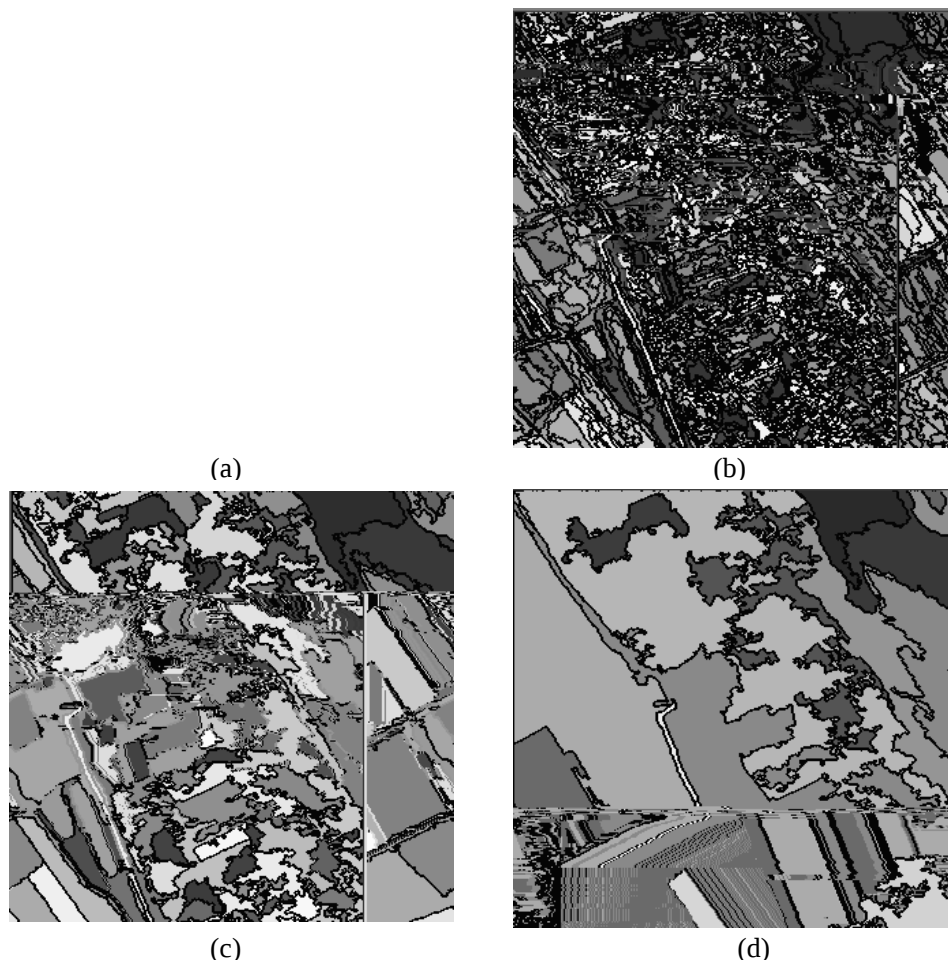


Figure 1. Segmentation results with different scale parameters
(a) IKONOS (JSI) image, (b) Scale parameter 20, (c) Scale parameter 80, (d) scale parameter 300

shows the segmentation result at scale parameter 20. Many image objects at this scale correspond to individual tree crowns, as well as other spatial objects including roofs of greenhouses, and the ground sizes of most image objects at scale parameter 20 are smaller than the typical patch sizes of the vegetation (land cover) classes shown in Table 1. On the contrary, image objects produced at scale parameter 300 appear to correspond to much coarser units of spatial features. Image objects shown in Figure 1 (c) at scale parameter 80 match polygons of the land cover classes shown in Table 1 relatively well. A research question is how to determine an optimal set of segmentation parameters for vegetation mapping in rural areas in Japan. Usuda et al. (2003) focused on the stable periods observable in a growth curve of the sizes of image objects during a region growing process as a key to decide optimal scale parameters for specific applications of image segmentation techniques. Stable periods are the period when standard deviations of pixel values of neighbouring image objects are apparently different, and the merge process of the image objects becomes relatively slow. Such stable periods of the growth of image object sizes are also observed in the image segmentation experiments in this study. Each class of vegetation classes appears to have an optimal scale parameter to be delineated properly.

5. SEGMENT-BASED CLASSIFICATION

In the object-based image classification, each segmented image object needs to be labelled with a proper class name. Some image objects in this study were relatively easy to be labelled based on the spectral properties, and others are difficult to be determined only by the spectral properties without considering other contextual information such as relative sizes, spatial relationships, texture, and so on. The IKONOS data used in this study was taken in November, and vegetation-covered and non-vegetation areas were spectrally distinctive on the imagery. Among the vegetation-classes, grasses and deciduous forests showed relatively distinctive spectral properties on the IKONOS imagery so that their labels were reliably assigned based on their spectral information such as averages and variances of pixel values belonging to specific image objects.

On the contrary, instances of some vegetation classes were difficult to distinguish from other vegetation classes. For instance, bamboo forests and other trees (both coniferous and deciduous) showed very similar reflectance properties in the visible and near-infrared spectral bands so that other properties of the image objects must be used for the labelling rules. For distinguishing bamboo forests from coniferous trees, texture information of image objects appears to be useful. Figure 2 shows the textural difference between bamboo and coniferous tree areas. Variances of pixel values in 3 x 3 moving windows are tend to be larger at pixels corresponding to bamboo forests than those of other trees.

Sizes and shapes of image objects were also useful properties for distinguishing some classes such as rice fields from others.

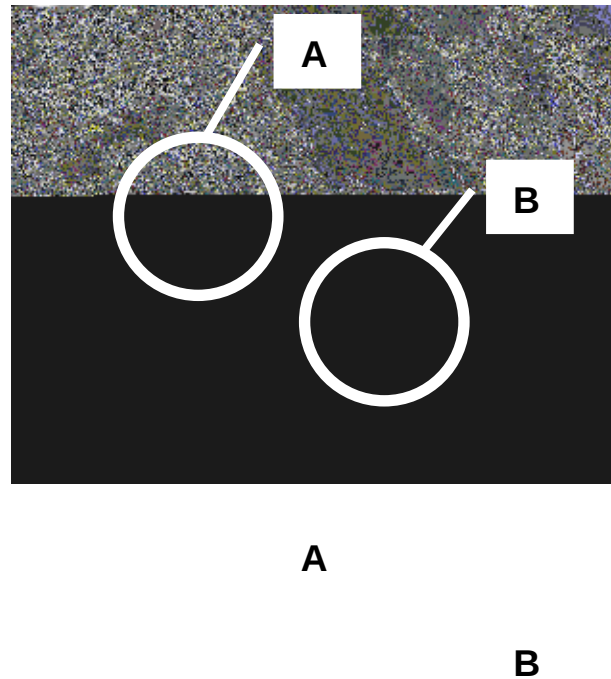


Figure 2. Texture analysis of deciduous tree- and bamboo-covered areas
Above: IKONOS (JSI) imagery
Below: Texture image
(Variance in 3 x 3 pixels)
A: Bamboo (brighter area)
B: Deciduous tree (darker area)

6. PIXEL-BASED CLASSIFICATION

Traditional pixel-based image classifiers such as the maximum likelihood classifier tend to produce salt-and-pepper-like classification results representing land covers of the study area in the aperture size of the ground resolution of the remote sensing data. These types of salt and peppers are usually seen as noises for land cover mapping in satellite remote sensing analyses. In the case of vegetation mapping using very high-resolution satellite data, salt-and-pepper-like classification results are useful in combination with object-oriented classification results, because pixel-based classification results provide additional information about the distribution and density of vegetation covers in the image objects delineated by object-based classifiers.

Figure 3 compares three vegetation maps obtained using maximum likelihood classifier, object-oriented classifier, and aerial photo-interpretation.

(a)

(b)

(c)

Figure 3. Comparison of image classification results
(a) Pixel-based classification (with maximum likelihood classifier)
(b) Object-based classification
(c) Vegetation map based on field study

7. CONCLUSIONS

This paper described the vegetation mapping using IKONOS data and the hybrid analysis method combining object-based and pixel-based image classifiers. The purpose of the development of the vegetation mapping methodology is to provide an objective and cost-effective survey method utilizing satellite remote sensing for the nationwide river environment information acquisition project. The result of the tentative analysis using the hybrid approach and IKONOS data in this study suggests that IKONOS data would be a useful additional information source for the vegetation mapping for the river environment management.

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