

Analysis to the Relationship of Classification Accuracy、 Segmentation Scale、 Image Resolution

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Abstract—Information extraction encountered a new challenge while the spatial resolution is increasing quickly. People suppose that the higher the spatial resolution is, the better the result of classification is. To prove this guess we use two approaches: pixel-based classification and object-oriented classification. The former site test shows one class has different accuracy from various resolution images. Object-oriented approach is an advanced solution for image analysis. The accuracy of object-oriented approach is much higher than those of based-pixel approach. The site result shows that each class has its optimal image segmentation scale.

Keywords—Feature, Scale; Resolution; Image analysis.

I. INTRODUCTION

With the development of remote sensing technology, very high resolution image data such QuickBird, Ikonos data make it possible for the first time to analysis surface areas with automated methods in full detail [1] The automatic classification of remotely sensing data is an essential action. People suppose that the higher the image spatial resolution is, the better the result of classification is. Unfortunately, the high spatial resolution of advanced sensors increase the spectral within-field variability and therefore may decrease the classification accuracy of traditional methods on pixel basis (like the maximum-likelihood method) [2] The reason is that classification clusters are built upon spectral homogeneities only. This general effect, which is well known in literature [3], is illustrated in figure 1 (middle).

As an alternative, object-oriented classification method has been introduced in this article. In many case, image analysis leads to meaningful objects only when the image is segmented



Figure 1. More homogeneous and realistic segmentation for urban land use classification purpose based on object-oriented method (right) compared to traditional Maximum-Likehihood method (middle)

into homogeneous areas [4]. Image segmentation is the efficient method to generate image objects for object-oriented image analysis. The generated segments act as image objects whose physical and contextual characteristics can be described by means of fuzzy logic. While investigations using data of medium and high resolution show much improvements concerning accuracy and interpretability [5][6]. eCognition is the first commercially available product for object-oriented and multi-scale image analysis. In the present article, it will be shown how eCognition can be use to detect and discriminate the interesting land use from other forms.

When classify different kinds of land use classes, how can we select image resolution and image segmentation scale? The following chapter will describe two classification results with pixel-based classification and object-oriented analysis using different resolution image and segmentation scale. Results analysis shows the relationship is among classification accuracy, segmentation scales, and image resolution in the last chapter.

II. DATA AND METHOD

A. Data

The airborne data with three bands (R, G, B) acquired on Sep 22nd 2000 used as sample data, see figure 1. The image spatial resolution is 10 centimeter, and the area is 5000*5000 pixels. Data-process includes several steps: photo scanning, color balance, ortho-correction, mosaic and subset. The classification result needs compare to a manually delineated map, field data and other information about the error produced [7].

We could identify nine classes: main road, pathway, large and small building, arbor, shrub, grassland, water and shadow. The result with manually interpretation shows in table I.



Figure 2. Image with resolution 10cm

TABLE I. RESULTS OF MANUALLY INTERPRETATION

Classes	Area (hectare)	Percentage
Main Road	17.1	17.1%
Pathway	3.3	3.3%
Large Building	13.4	13.4%
Small Building	13.8	13.8%
Arbor	3.8	3.8%
Shrub	1.2	1.2%
Grassland	26.4	26.4%
Water	5.7	5.7%
Shadow	15.4	15.4%
Total	100.0	100.0%



Figure 3. Image object levels with different segmentation: 70, 150, 500

To analysis the classification accuracy acquired from different resolution image, we prepare four kinds images with resolution 10cm, 20cm, 50cm, and 1m. The later three images were re-sampled from 10cm image using traditional up-scaling approach. To analysis the classification accuracy acquired from different segmentation scale image objects, we prepare six levels image objects with segmentation scale 75, 100, 120, 150, 200, 500 (see fig 3).

B. Method

The object-oriented image analysis is based on contiguous, homogeneous image regions [8], which are generated by the initial image segmentation. The segmentation used a bottom-up region-merging technique starting with one-pixel objects. In numerous subsequent steps smaller image objects are merged into bigger ones. Connecting all the regions, the image content is represented as a network of image objects. These image objects act as the building blocks for the subsequent image analysis. Analyzing an image in eCognition means to classify the image objects according to class descriptions organized in an appropriate knowledge base. The knowledge base itself is created by means of inheritance mechanisms, concepts and methods of fuzzy logic, and semantic modeling. The classification is based on fuzzy logic. A fuzzy rule can have one single condition or can consist of a combination of several conditions, which have to be fulfilled for an object to be assigned to a class.

III. CLASSIFICATION RESULTS AND ACCURACY ASSESSMENT

TABLE II. CLASSIFICATION ACCURACY ON DIFFERENT RESOLUTION BASED ON PER-PIXEL APPROACH

Classes	Resolution	1	2	3	4	5	6	7	8	9
Accuracy	10cm	52%	42%	39%	57%	59%	57%	47%	51%	52%
	20cm	55%	50%	40%	59%	54%	43%	50%	60%	59%
	50cm	64%	25%	48%	67%	44%	43%	61%	68%	46%
	1m	60%	17%	54%	43%	33%	29%	70%	54%	37%

1-Main road, 2- Pathway, 3-Large Building, 4- Small Building, 5-Arbor, 6- Shrub, 7- Grassland, 8- Water, 9- Shadow

TABLE III. CLASSIFICATION ACCURACY ON OPTIMAL BASED ON PER-OBJECT APPROACH

Class	1	2	3	4	5	6	7	8	9
Class accuracy	91%	83%	98%	99%	95%	86%	98%	96%	95%
Area Consistency	95%	92%	93%	92%	89%	83%	91%	92%	96%
Shape Consistency	96%	94%	91%	93%	91%	87%	89%	89%	87%

1-Main road, 2- Pathway, 3-Large Building, 4- Small Building, 5-Arbor, 6- Shrub, 7- Grassland, 8- Water, 9- Shadow

A. Results and accuracy using pixel-based approach

The classification results and accuracy show in table II. Small-area class such as arbor has high accuracy result when extracted from high-resolution image. On the contrary, Large-area class such as grassland has low accuracy result when extracted from low-resolution image. The relationship between data resolution and classification accuracy is clearly described in table II.

B. Results and accuracy using objec-oriented approach

Each class is extracted in its optimal object level (table IV). Compared to pixel-based approach, classification accuracy from object-oriented approach is much higher. Not only classed accuracy we exam, area and shape consistency are also considered in. The results and accuracy shows in table III.

IV. CONCLUSION

Two approaches were used for high-resolution image classification: pixel-based classification and object-oriented analysis. The former site test shows one class has different accuracy from various resolution images. Some classes improve their accuracy with the resolution increasing but others don't. Beyond the limitation of pixel-based approach, object-oriented approach offers a good solution with its key technology: multi-scale image segmentation. Object-oriented image analysis does not classify single pixel but rather image objects. Not only spectral information but also spatial, physical and contextual characteristics of image objects are used for classification. The site result shows that objects have their best scale image object levels to classify. The accuracy of object-oriented approach is much higher than those of based-pixel approach. It makes us believe that this process is the best selection for high-resolution image analysis. Two test results have proved that all objects couldn't be extracted well from the same resolution or scale. They need the corresponding resolution images or scale image levels. Multi-scale image analysis is the perfect method. The optimal image resolution

TABLE IV. OPTIMAL RESOLUTION AND SEGMENTATION SCALE

Classes	Optimal resolution	Optimal scale
Main Road	50cm	500
Pathway	20cm	500
Large Building	1m	200
Small Building	20cm	120
Arbor	10cm	75
Shrub	10cm	100
Grassland	1m	150
Water	50cm	200
Shadow	20cm	150

and image segmentation scale for each class are listed in table IV. Based on the analysis of image objects levels network with different segmentation scale, we select optimal segmentation scale for each class.

A. Classification accuracy and image resolution

Classes have different accuracy acquired from different resolution images. The optimal resolution image shows in table IV. Arbor with small area and distributed scattered has high accuracy in high-resolution image data. With resolution decreasing, arbor is easy to merge with the neighboring class, so the accuracy is low. On the contrary, grassland with large area has low accuracy in low-resolution image data, and high accuracy in high-resolution image data. The analysis means the opinion is unbelievably that the image resolution higher is; the classification accuracy higher is.

B. Classification accuracy and segmentation scale

Classes with different spatial feature need to extract in different image objects level. Every image object level has different segmentation scale. Classes, which have small area and complicated texture, should be extracted in small-scale image object level. Classes, which have large area and simple texture, should be extracted in large-scale image object level. The image object level with scale 75 is apt to extract arbor, but one level with scale 200 is apt to extract grassland.

C. Resolution and scale

Image data with high resolution could segment using different scale to generate many image object levels. Even the large segmentation scale image object level also has ample spectral and texture information from initial image. All the image objects didn't lost the pixel information. We could extract all kinds of classes in this object levels network. For low-resolution image, the result is not promising. During the re-sampling process, low-resolution image lost much detailed information. We couldn't extract fine classes even the segmentation scale is very small.

D. difference between two classification approach

Image pixel is the basic unit, and pixel spectral information is the only factor to work in pixel-based classification. It was found that using pixel-based method only with multi-spectral information for classification does not lead

to good results of land use, because the difference between land use classes is done not only with the help of spectral information, but also with spatial information of the image data. The same colors in a data set might show different objects (e.g. in some areas roofs and streets are built of very similar materials), the expressiveness is ambiguous. Only the combination with spatial information leads to unambiguous identification. Going far beyond the methodical limits of pixel-based approaches, multi-scale image segmentation and object-oriented approaches are used for high-resolution image analysis. In many case, image analysis leads to meaningful objects only when the image is segmented into homogeneous areas. As biophysical parameters these objects characteristics such as color, texture, shape, hierarchy, thematic attributes and class-related features will be used in classification. If the segmentation is performed at multiple scale levels, optimal spatial resolutions for the different sizes, forms and arrangements of the objects under investigation can be considered.

Using one resolution image to identify all classes with high accuracy in one region is unreasonable. Different classes need different resolution images to be extracted. Meanwhile in object-oriented image analysis, only one-scale image objects level is not ideal for all classes' abstraction. In segmentation process the approach allows the segmentation of an image into highly homogeneous image objects in any chosen resolution and the generation of a network with many scale image objects. We can select the appropriate scale object level to extract the correspond classes.

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