The Extraction of Water Information Based on SPOT5 Image Using Object-oriented Method

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Abstract—**The paper realizes water body extraction well using object-oriented classification method based on SPOT5 image. Firstly, segment image according to multi-scale image segmentation method based on edge-detection algorithm. Secondly, determine various characteristic parameters in land surface features according to object characteristics such as spectrum, shape and texture. And thirdly, use SVM (Support Vector Machine) method to achieve object classification through the establishment of the sample rules, and extract water body successfully. It takes SPOT5 image in Xiaojiaqiao section of Chaping River in Anxian County, Mianyang City, Sichuan Province, China as a case study. The results show that, compared with pixel-oriented supervised classification method, object-oriented classification method applied in water information extraction is more effective and its classification accuracy is higher.**

SPOT5 image; Water extractiong; Object-oriented classification method

I. INTRODUCTION

With the development of remote sensing technology, the spatial resolution of remote sensing images has been greatly improved. With the emergence of QUIKEBIRD, IKONOS, as well as SPOT5 image, it is possible for us to observe the changes of the land surface details on a smaller spatial scale, carry out remote sensing mapping on a large scale, and detect human activity.

SPOT5 image has been widely used to extract water information. The major method is decision tree classification Cao established decision tree model of water automatic extraction in urban areas based on SPOT5 image [1]. Deng extracted water information in plain regions using the decision tree model, which achieved very good results [2]. Du extracted water information in mountain regions using decision tree model based on SPOT4 image, and removed shadow mixed in water using shape index in addition [3]. The minor method is supervised classification for water extraction based on the multi-spectral image. But it is still rare for scholars to use object-oriented method for water extraction based on SPOT5 fused image. For example, Cao investigated water extraction in urban areas using object-oriented method based on SPOT5 fused image [4]. This paper investigates water extraction in mountain regions using object-oriented method based on the image, which can reduce the impact of terrain shadows significantly.

This paper takes Xiaojiaqiao section of Chaping River in Anxian County, Mianyang City, Sichuan Province, China for an example, and extracts water information based on SPOT5 fused image. Firstly carry out data preprocessing, concluding projection transformation, radiometric correction, geometric correction, image enhancement, image subset, image fusion and so on. Secondly extract water body information using object-oriented method and pixel-oriented supervised classification method. Thirdly proceed accuracy assessment, and compare their results. It shows that object-oriented method is more effective in the water extraction based on SPOT5 image.

II. METHODOLOGY

A. Study Area

The study area is located in Xiaojiaqiao section of Chaping River in Anxian County, Mianyang City, Sichuan Province, China, between 31°38'31 "N ~ 31°38'53" N and 104° 17'05 "E ~ 104°17'35" E, with the area about 0.54 km2, as shown in Fig. 1. SPOT5 multi-spectral image of 10-meter resolution is shown in Fig. 1(a), and SPOT5 fused image of 2.5-meter resolution is shown in Fig. 1(b). Both sides of the river banks are mountains with good vegetation cover. There is a road along the river. The dramatic differences in vegetation color come mainly from the impact of mountainous terrain, and both sides of the slopes in the images show huge differences. This river section formed the second largest quake lake only next to Tangjiashan dammed lake in Wenchuan earthquake. Through clearing and diverting, the current river morphology has been changed dramatically.

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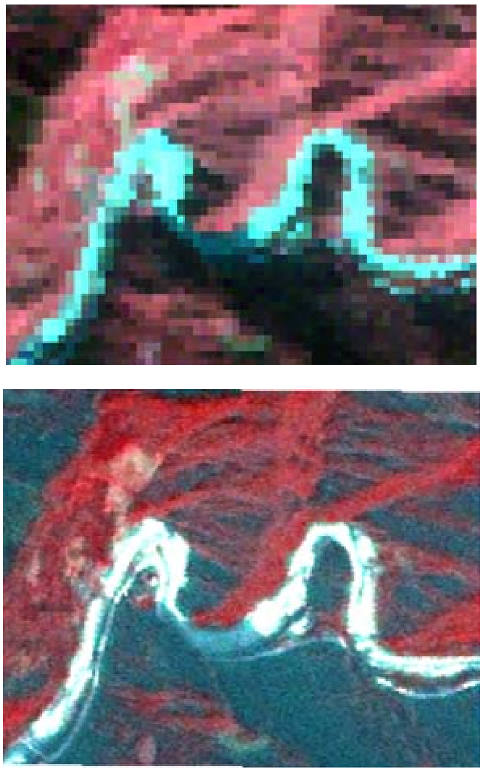


Figure 1. the scope of the study area, a) SPOT5 multi-spectral image, b) SPOT5 fused image

B. *Source Data and Technical Route*

SPOT5 satellite images of November 10, 2006(multi-spectral data of 10-meter resolution and panchromatic data of 2.5-meter resolution) are used in the research. Auxiliary data are 1-meter resolution IKONOS panchromatic image of December 26, 2008 and 30-meter resolution digital elevation model (DEM) data, which are helpful for image correction and classification.

The technical route is shown in Fig.2. Before being extracted for water body information, the source data are preprocessed to obtain better data for further classification. Image preprocessing includes project transformation， geometry correction, image fusion, image subset, resampling and so on.

Firstly, we extract water body information using supervised classification method based on SPOT5 multi-spectral image and using object-oriented method based on SPOT5 fused image separately. There are two basic steps for object-oriented method, namely segmentation using edge-based segmentation algorithm and classification using SVM method. River extraction results are expressed by vector forms, which are overlayed on SPOT5 image, and then are judged for the outcome of the pros and cons by visual interpretation. If it is not satisfactory, then adjust the segmentation parameters and classification parameters for re-segmentation, re-classification.

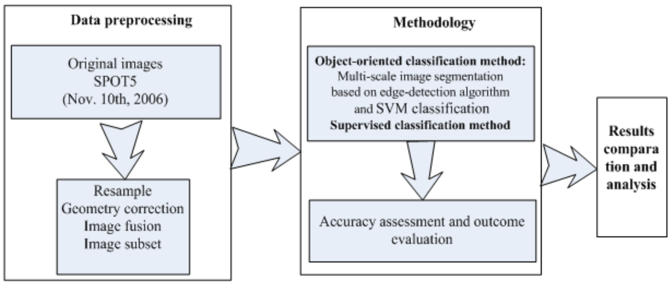


Figure 2. Technical line

C. *Data Processing*

- Basic Processing

SPOT5 source data are projected onto the same coordinate system, namely WGS_1984_UTM_Zone_48N. Multi-spectral image are re-sampled to 10 meter resolution. High-resolution image are re-sampled to 2.5 meter resolution. SPOT5 images are corrected referring to 1 meter resolution IKONOS satellite image with the geometric error controlled in less than one pixel. Because there exist image information losses such as image accuracy loss, spectral characteristics loss in image processing, it had better minimize the processing steps for the original images in order to guarantee access to the best images. In order to obtain SPOT5 fused image with high-resolution and multi-spectral characteristics, firstly correct the multi-spectral image of 10-meter resolution to the panchromatic image of 2.5-meter resolution, secondly subset the study area from the panchromatic image of 2.5-meter resolution , thirdly merge the multi-spectral image and the panchromatic subset image using PCA method for obtaining fused image with high spatial resolution and multi-spectral characteristics, at last correct the fused image referring to 1 meter resolution IKONOS satellite image. In order to obtain SPOT5 multi-spectral image of the study area, firstly correct it referring to 1 meter resolution IKONOS satellite image, and secondly subset it for the image of the study area.

- Segmentation and Classification

Traditional remote sensing classification techniques are pixel-based, meaning that spectral information in each pixel is used to classify imagery. However, there are fewer bands, which contain weaker spectral information but better spatial characteristic for the high-resolution image. It is better to consider spectral feature, geometric feature and texture information at the same time but not spectral feature alone when proceeding image classification. Object-oriented remote sensing image classification method came into being according to high-resolution image characteristics. Object-oriented classification method is based on objective, and an object is a region of interest with spatial, spectral (brightness and color), and/or texture characteristics that define the region. For high-resolution image, this object-based extraction method can be able to extract surface features with a variety of characteristic types, such as vehicles, buildings, roads, rivers, bridges, lakes, and fields.

Specifications about object-oriented classification method are as follows. Firstly segment remote sensing images for obtaining homogeneous object, secondly monitor and extract a variety of features for target features (such as spectrum, shape, texture, shadow, spatial location, the relevant layout, etc.) based on remote sensing classification and specific requirements for target features extraction, thirdly classify remote sensing images and extract target features using SVM classification method. The workflow consists of two primary steps: segmentation and classification. The segmentation task is divided into three steps: Segment, Merge, and Compute Attributes. When completing this task, it will perform the Extract Features task using SVM classification method, and then export classification results to shapefiles. The flow chart is shown in Fig.3.

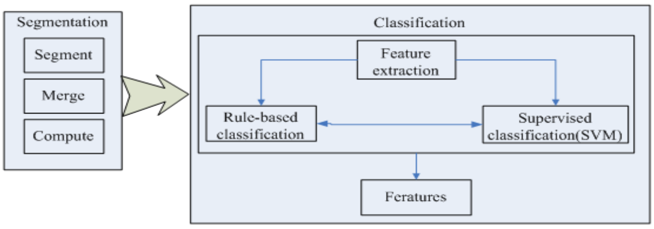


Figure 3. Image classification flow chart based on object-oriented classification method

In the Segment step, edge-based segmentation algorithm is used, which is very fast and only requires one input parameter (Scale Level). By suppressing weak edges to different levels, the algorithm can yield multi-scale segmentation results from finer to coarser segmentation. In the Merge step, it employs the Full Lambda-Schedule algorithm created by Robinson, Redding and Crisp [5].The algorithm iteratively merges adjacent segments based on a combination of spectral and spatial information. In the Compute Attributes step, we define which attributes to compute for each object. Then Support Vector Machines (SVM) classifier was applied, for it provides good classification results from complex and noisy data and can produce reliable classifications using small training samples [6]. RBF kernel was finally employed for it nonlinearly maps samples into a higher dimensional space.

At last, vector results are rasterized in order to facilitate the subsequent accuracy assessment.

D. Classification Scheme

According to research purposes, image characteristics and the distribution characteristics of land use types in the study area, multi-spectral image of 10-meter resolution `is divided into three categories, namely woodland 1 (dark red regions in the image), woodland 2(light red regions in the image), rivers, and 2.5-meter resolution fused image is divided into four categories, namely woodland 1 (dark red regions in the image), woodland 2(light red regions in the image), rivers, roads. Source images are shown in Fig. 4.

E. Accuracy Assessment

Most of the training samples were created by visual interpretation of the sample points on SPOT5 fused image and IKONOS image, together with samples from field visits and interviews to the local inhabitants. In order to obtain accuracy assessment results, we need to create sample points based on thematic map after classification and identifying the true type of the points referring to high resolution images by visual interpretation, and compare with computer automatic classification type of the points.

III. RESULTS AND DISCUSSION

A. Classification and Accuracy Assessment Result

Firstly, obtain 2.5-meter resolution SPOT5 fused image of the study area through image pre-processing operations such as projection transformation, re-sampling, geometric correction, image fusion, image subset. Secondly, segment and classify image using Object-oriented method to obtain classified vector thematic map. Thirdly, rasterize the vector map for providing basic map for accuracy assessment, as shown in Fig. 4(b). Simultaneously， classify 10-meter resolution SPOT5 multi-spectral image of the study area using supervised classification method for obtaining classified thematic map, which is shown in Fig. 4(a). Then the two results shown in Fig. 4 can be compared with each other. The dark green stands for woodland 1, the light green stands for woodland 2, the blue stands for river, and the yellow stands for road along the river. There are only three types such as woodland 1, woodland 2, river for 10-meter resolution SPOT5 multi-spectral image in Fig. 4(a). There are four types as woodland 1, woodland 2, river, road for 2.5-meter resolution SPOT5 fused image in Fig. 4(b).

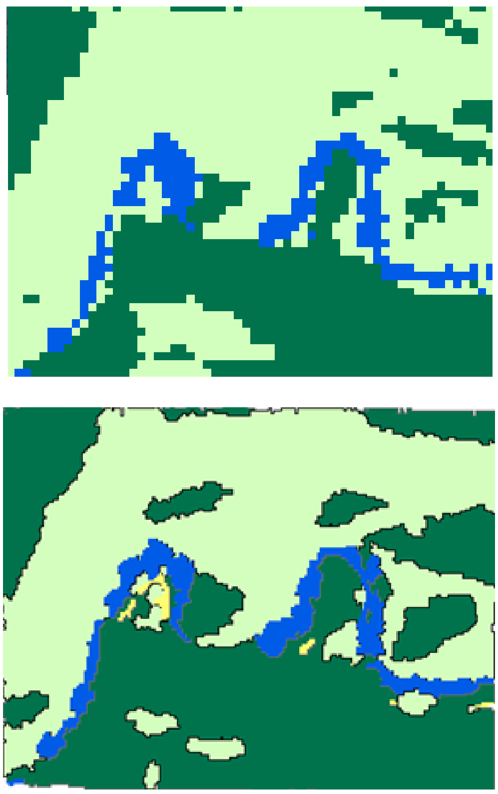


Figure 4. Classification result map of SPOT5 image, a) Classification thematic map of multi-spectral image, b)Classification thematic map of fused image

Generate 250 sample points randomly on two classified thematic maps respectively, and judge each sample point belongs to which class referring to SPOT5 fusion image and IKONOS image by visual interpretation. And then carry out accuracy assessment, as shown in TABLE Ⅰ

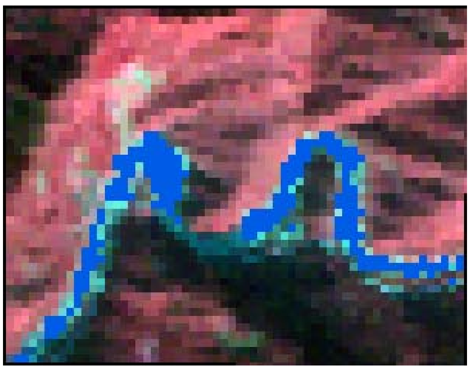
TABLE I. ACCURACY ASSESSMENT RESULTS

Classification Method	**Overall Classification Accuracy（%）**	**Overall Kappa Statistics**
Object-oriented Classification Method	95.5	0.8723
Supervised Classification Method	80.8	0.7112

B. Camparation and Discussion

It shows that in Table 1 as follows. Overall Classification Accuracy by object-oriented method is 95.5%, while Overall Classification Accuracy by supervised classification method is 80.8%, significantly lower than the result by object-oriented method. Overall Kappa Statistics by Object-oriented method is 95.5%, while Overall Kappa Statistics by supervised classification method is 80.8%, significantly lower than the result by object-oriented method. These results demonstrate the advantages of object-oriented method sufficiently.

Alternatively, the pros and cons of the results can be judged according to visual interpretation. It is shown in Fig. 5 as follows. Water extraction result by supervised classification method is superimposed on 10-meter SPOT5 multi-spectral image in Fig. 5(a). Water extraction result by object-oriented classification method is superimposed on 2.5-meter SPOT5 fused image in Fig. 5(b), and the yellow stands for road along the river. Water extraction results by two methods respectively are superimposed on 2.5-meter SPOT5 fused image in Fig. 5(c). It is clear that the edge of the extracted water body is rougher in Fig. 5(a) than in Fig. 5(b), namely the result by object-oriented method is better than by supervised classification method. It can extract road from the fused image by object-oriented method, as shown in Fig. 5(b). The road along the river was incorrectly classified to water by supervised classification method, as shown in Fig. 5(c) with arrow B.



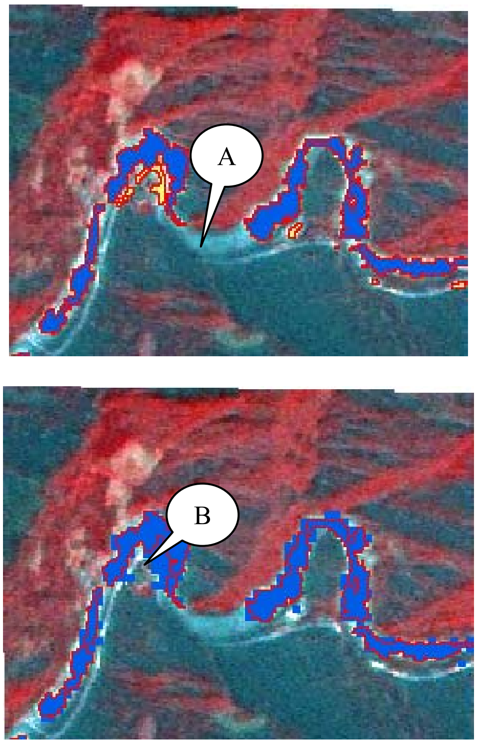


Figure 5. Water extraction result comparation, a)Water extraction result by supervised classification method, b) Water extraction result by object-oriented method, c) Overlay map of water extraction results

IV. CONCLUSION

(1) The paper extracts water information based on SPOT5 image in Xiaojiaqiao section of Chaping River in Anxian County, Mianyang City, Sichuan Province, China using object-oriented method. Overall Kappa Statistics is 95.5%, and Overall Kappa Statistics is up to 0.8723, which are much better than supervised classification result.

(2) Object-oriented method based on image segmentation and image classification can fully utilize and tap SPOT5 image characteristics such as spectrum, texture, shape, and can improve classification accuracy by combining with the relevant prior knowledge.

(3) Object-oriented method lies in the image segmentation, and the key step is how to choose a scientific and rational segmentation method. The subset object with rich information can serve for classification well.

(4) Although water extraction accuracy in this test by object-oriented method is relatively high, it can not judge the part of arrow A in Fig. 5(b) correctly which is also attached to river. There are two ways to improve this situation. One is to make changes artificially to this position. The other is to explore more advantageous segmentation algorithm to improve classification.

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