Mapping Farm Water Areas within Coastal Belts by Object-oriented Remotely Sensed Image Analysis

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Abstract: On high spatial resolution remotely sensed imagery, the similar spectral reflection of farm water areas with other waters including rivers, lakes etc. makes it difficult to distinguish them with only pixel spectral based image classification methods. In order to map farm water areas within coastal belts, an object-oriented remotely sensed image analyzing method is proposed. This method includes the following steps. 1) A multi-resolution image segmentation method combining spectral and shape features is implemented to segment an image into parcels, which is the first and important step for object based remotely sensed image analyses. 2) Multiple parcels features, including parcel spectrum, shape, and spatial topology relationship between parcels are extracted and stored for succeeding analyses. 3) The whole water areas in an image are separated from others, by a single histogram threshold segmentation method. 4) The non farm water areas, which are named the polygonal and linear water areas, are eliminated from the whole water areas by shape and spatial relationship features, and the remaining waters are for final farm water area mapping. Several experiments on SPOT-5 multi-spectrum imagery validate our methods.

Key words: remote sensing images; object-oriented image analysis; coastal belt; farm water area

1 Introduction

Traditional pixel-based object detection technology, especially image processing models based on pixel spectral statistics have many shortcomings in object detection using high spatial resolution remote sensing images. In recent years, object oriented approaches have emerged. In object-oriented approach, the analytical units are parcels, which involve more features in image analyses, and well resolved the salt-pepper noise in image classification. It has become one of hot research field in remote sensing applications.

In this study, we apply object oreented image analysis method for feature extraction within coastal belts. Coastal belts are very different from inland; they are jointly influenced by sea, land and atmosphere. Researchers have proposed many method for feature extraction within coastal regions. For example, Cheng et al. studied object segmentation near coastal belts using high spatial resolution remote sensing data [1]; Ma et al. proposed a method to extract waters from coastal region using MODIS image [2]; Feng et al., Zhu, Ma et al. and Jin et al. proposd their many methods for coastline extraction, etc [3] [4] [5] [6].

This paper introduces a feasible object-oriented farm water extraction method. Farm waters are used for cultivate aquatic argamisms. In high spatial resolution remote sensing images, the color of farm waters are similar to the common water areas. It makes traditional pixel-based classification method very difficult to separate them from common waters. In this study, we use object-oriented approach to successfully extract them.

2 Method principle and steps

The method includes three basic steps. First, a multi-resolution image segmentation method combining spectral and shape features is implemented to extract image parcels. After segmentation, a set of parcel features including spectral, shape, spatial relationships are obtained for the succeeding analyses. Then, the whole water areas including the polygonal water areas and linear water areas are extracted with multi-feature analyses. In the last step, the farm waters are extracted by eliminating polygonal water area and linear water areas. Figure 1 is the flow of our method.

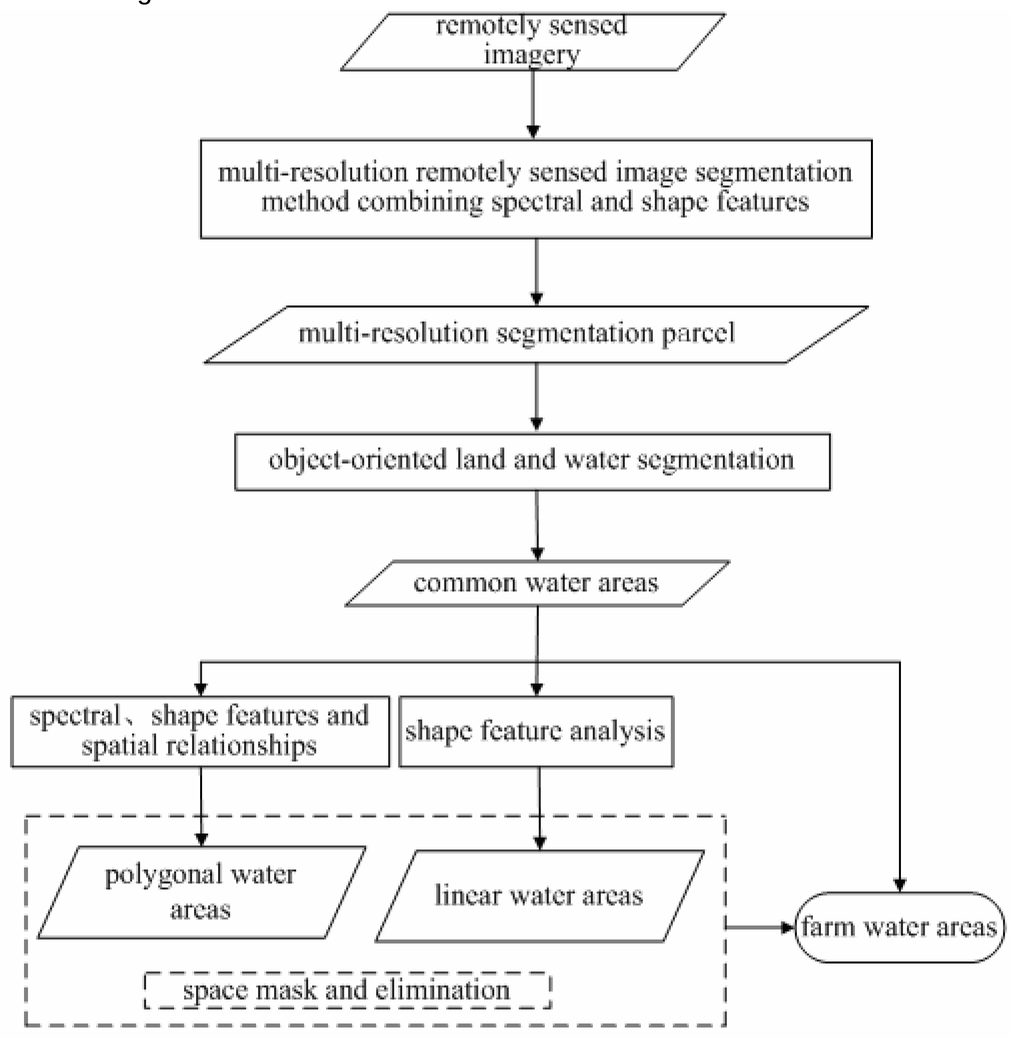


Fig.1 Farm waters extraction

2.1 Multi-resolution remotely sensed image segmentation method combining spectral and shape features

The first and most important step of object oriented image analysis is image segmentation, which segments an image into many visual homogenous parcels. Based on these parcels, which are 'objects' not 'pixels', much more features can be extracted which facilitates the succeeding image interpretation. The result of segmentation will have influence successive analysis to a large extend. In our work, we design and implement a multi-resolution image segmentation method combining spectral and shape features with reference to the basic ideas of eCognition, a famous object oriented image analyzing software package. The algorithm includes the following steps. 1) The initial segmentation parcels, called the 'sub feature units' are obtained with rainfalling watershed algorithm, for its fast speed and fair initial segmentation in visual effects. 2) A fast region merging technique is used to merge these sub feature units in a hierarchy way. In this stage, the distance between a pair of feature units is the weighted sum of the merging cost in both spectral and shape domains. A scale parameter is used to control the merging process, which will stop a merge when the minimal merging cost of parcels exceeds its power. A multi-resolution segmentation can be implemented with setting different scale parameters, for smaller scales means less cost while merging which create smaller size parcels, and vice versa. See Ref. [7] for more details.

From these parcels we can get a series of features: 1）color features including pixel values and variance; 2) shape features like parcel perimeter, area, length-width ratio; 3）spatial relationships like neighbor relationships etc. Among them, parcel pixel values, shape, and spatial topology relationship between parcels are features that we used in farm areas extraction.

2.2 Object-oriented land and water segmentation

In order to extract farm water areas, we first implement a land and water segmentation to get common water areas. In remote sensing images, waters give a dark done in near infrared band, so we use a threshold-based segmentation method to extract waters using near infrared band. Our land and water segmentation is based on object-oriented approach using spectrum mean value, so noises can be suppressed.

2.3 Eliminating of non farm waters

As our aim is to extract farm waters, so we eliminate non farm areas, including polygonal water areas and linear water areas from water areas. Figure 2 is demonstration of different water areas.

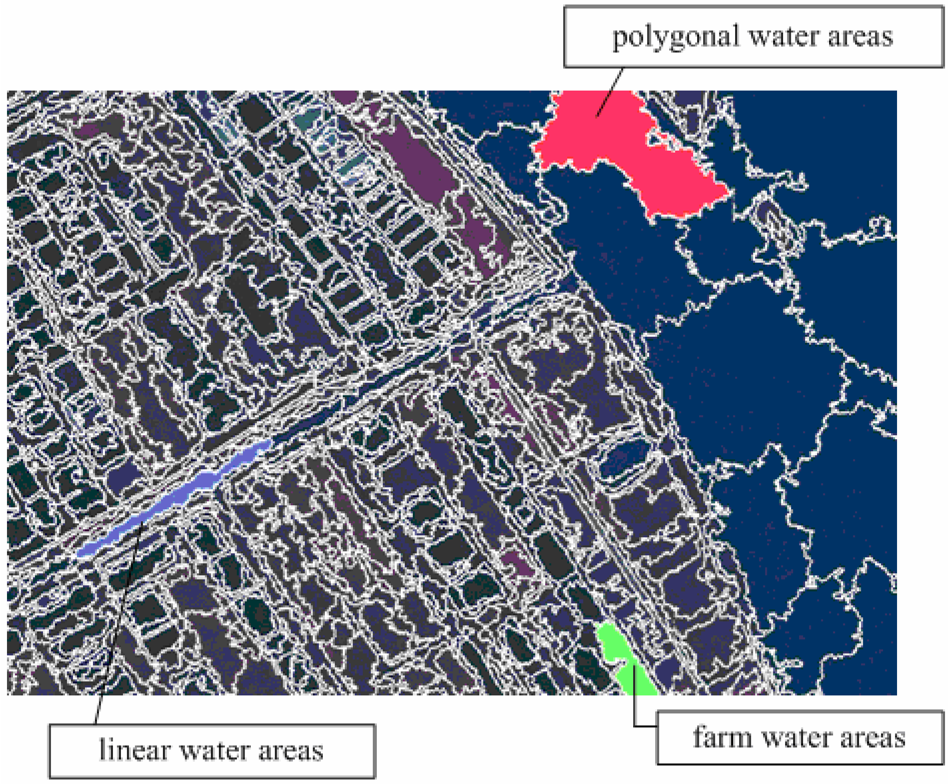


Fig.2 Different water areas

Polygonal water areas are water areas with low gray value and with large areas. We use parcel spectrum, shape, and spatial topology relationship between parcels to eliminate polygonal water areas. It includes two steps: initial polygonal water area extraction and its extension. First, if the pixel value is small and area is large of some water area, it is recognized as polygonal water areas. Then, combining neighborhood relationships, we extended polygonal water areas within the water areas to get the final polygonal water areas.

Eliminate polygonal water areas out of water areas, the remained water areas are farm water areas and linear water areas (mainly linear river, canals, etc). We can eliminate these linear waters by using length-width ratio and rectangle ratio. By eliminating polygonal water areas and linear water areas out of water areas, we will get the final farm water areas.

3 Experiments

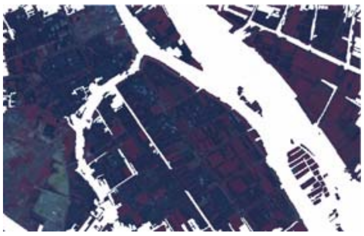
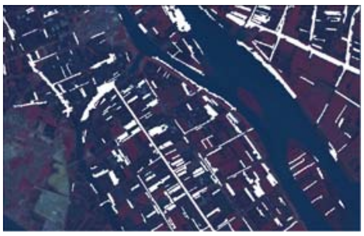
The Experiment data (see Fig. 3) are SPOT-5 multi-resolution imagery located at ZhuJiang Delta, obtained in May of 2005. The extent is from 37°30'30"N~38°9'57"N and 118°0'24"E~118°50'2"E，with spatial resolution 10 meter，and image size 24000 pixels× 24000 pixels.

Figure 4(a) is one of our sample areas. First, our multi-resolution image segmentation is implemented to get the parcels. The parameters are as follows: scale parameter is 10, color heterogeneity is 0.9, and shape heterogeneity is 0.1, smoothness 0.5 and compactness 0.5. Figure 4(b) is the segmentation result. Then we will extract water areas from it, by using threshold segmentation— pixel value of infrared band less than 23. Figure 4(c) is result of land and water segmentation. After this, we will eliminate the polygonal and linear water areas. Figure 4(d) is the original polygonal water areas. We can find it leaves out many other polygonal water areas. Figure 4(d) is the extension results. Figure 4(f) is the linear water area extraction results. Out settings are: length-width ratio more than 3 and rectangle ratio less than 0.3. By eliminate the polygonal and linear water areas from of the water areas, we will get the final farm water areas as Fig. 4(g).

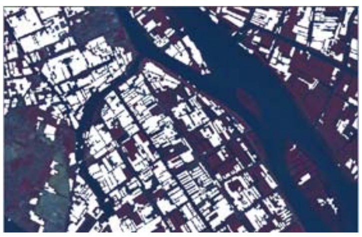
Fig.3 Experimental area



a. Area 1 **b.** Multi-resolution segmentation **c.** Land/water segmentation

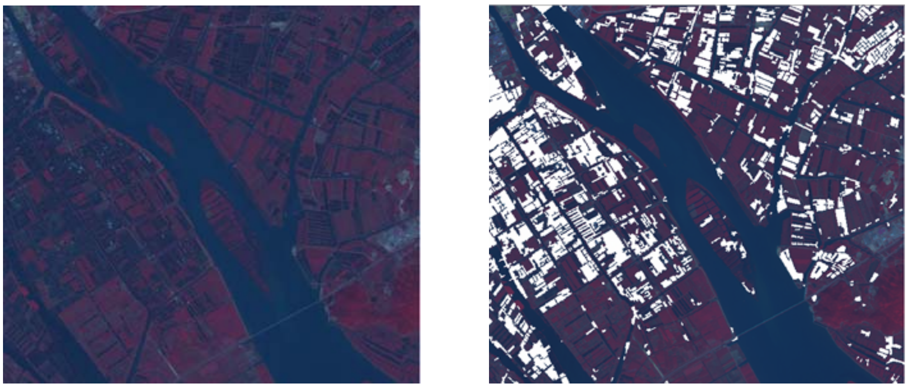
d. Original polygonal waters **e.** Extended polygonal waters **f.** Linear waters



g. Farm water areas

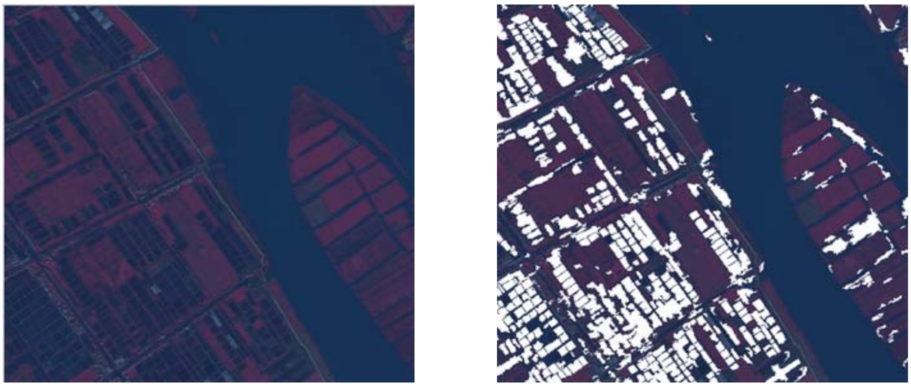
Fig.4 Experimental area 1

Figure 5(a) and figure 6(a) are two other sample areas. Parameters are similar to experimental area1.Table 1 is accuracy evaluate table. Extraction precisions are all above 80%.



a. Area 2　　　　　　　　　　　b. Farm waters

Fig.5 Experimental area 2



a. Area 3　　　　　　　　　　　b. Farm waters

Fig.6 Experimental area 3

Tab. 1 Accuracy Evaluation

Experimental areas	Number of common water area polygons	Number of farm water area polygons	Number of farm water area polygons extracted	Extraction precision（%）
area one	1522	843	749	88.84
area two	3010	1609	1505	93.53
area three	1559	578	485	83.91

4 Conclusion

In this paper a feasible object-oriented farm water extraction method is proposed. First, a multi-resolution image segmentation method combining spectral and shape features is implemented to extract image parcels. Second, a set of parcel features including spectral, shape, spatial relationships are obtained for the succeeding analyses.

Third, the whole water areas and then the polygonal water areas and linear water areas are extracted with multi-feature analyses. In the last step, the farm waters are extracted by eliminating polygonal water area and linear water areas. The core step is the elimination of non farm water areas. Our method is validated with experimental analyses.

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