INFORMATION MINING FROM REMOTE SENSING IMAGERY BASED ON MULTI-SCALE AND MULTI-FEATURE PROCESSING TECHNIQUES

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ABSTRACT:

The paper attempts to present an information extraction approach in terms of image segmentation based on an object-oriented algorithm for high-resolution remote sensing images. The hierarchy frame and multi-features of the remote sensing image understanding and processing method are put forward. Firstly we extract various internal features of relatively homogeneous primitive objects using an image segmentation algorithm based on both spectral and shape information. Secondly, those primitives are analyzed to ascertain an optimal object by adopting certain feature rules, such as the traditional feature of the spectrum, shape, texture, spatial relation etc. Results from this research indicate that the model is practical to realize and the extraction accuracy of the coastal information is significantly improved compared to traditional approaches. Therefore, this study provides a potential way to serve our highly dynamic coastal zones for monitoring, management, development and utilization.

1. INTRODUCTION

In recent years, with the development of remote sensing and data storage technique, a great number of spatial data are generated every day, much of which is remote sensing image data. However, the use efficiency of the huge quantities of remote sensing image data is still low. It is very difficult for people to process with thousands of image data and find out knowledge from them. As the researches of date mining, information retrieval, multi media database and other correlative field have rapid progress, it is become possible to manage and analyze large amounts of remote sensing images and find out useful information in different applications.

It is hard to effectively utilize the current segmentation and classification algorithms in remote sensing image processing. The fundamental problem is that the current image analysis approach is different from human vision, and it is hard for a computer to process scene segmentation and image understanding in multi-scale space or to utilize the background knowledge or prior knowledge to eliminate disturbances as human being does. For mankind, segmentation of a scene is first based on the large-scale, that is access the large target or background first, and the corresponding contour. On this basis, scene details or sub-targets are then focused gradually.

The paper attempts to present an information extraction approach in terms of image segmentation based on an object-oriented algorithm for high-resolution remote sensing images. An aim of our research is to establish the hierarchy frame and an identification system of “pixel-primitive-object”, then to carry experiments on extraction of micro-scale coastal zone features, e.g., tidal flat, water line, sea wall, and mariculture pond.

2. FLOW OF REMOTE SENSING DATA MINING

In this paper, the hierarchy frame and multi-features of the remote sensing image understanding and processing method are put forward. Remote sensing images can be divided into simple images and complex images, and the same image can be divided into simple region and complex region. In this section, we consider indicators of spectral statistical measures, geometric feature of geo-objects, and spatial scale to do the complexity description for images, and we process the wide area segmentation and scene partition with the help of the computed complexity measure (Gao, 2010; Yang, 2009). This helps to understand images from a macro perspective, and rapid segmentation can be processed in different regions based on the different complexity measures, further reduce the solution space of information retrieval (Cardaci, 2005; Mario, 2005; Song, 2005). In a scale large enough to carry out large region segmentation, the segmentation can be rough and global, aiming at providing priori knowledge for detailed segmentation. For example, based on spectrum, shape and other features, research area can be divided into water body area, artificial target area, vegetation area, mountain area, etc.(Yang, 2009).

A novel framework of image understanding and computing based on multi-scale and multi-feature is developed in this paper. As shown in Figure 1, the framework consists of five steps, which are image complexity description, big area rough division, multi-scale fine segmentation, feature primitive merging and classification, and feature primitive and target mapping.

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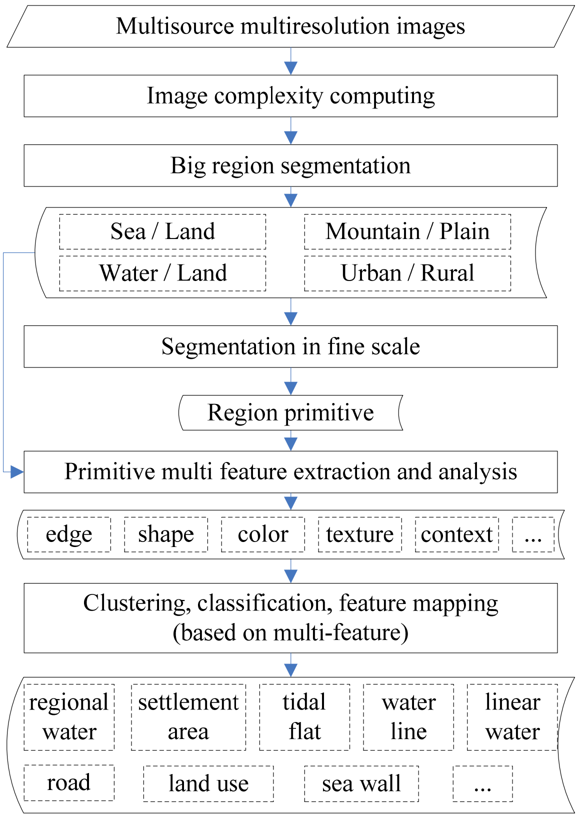

Figure 1. Framework chart of remote sensing data mining

3. IMAGE SEGMENTATION

Based on multi-scale image segmentation, we design some algorithms as follows.

3.1 Fast watershed segmentation

Using the primary image segmentation, we can obtain second plots, which is also called divisional sub-primitive. More details about Fast watershed segmentation see the Hill's paper (2003).

3.2 Fast and repeatable merger

Merging the segmentation results at the sub-primitive level, we can achieve the final divisional plots and finish the entire process of image segmentation.

Figure 2 shows the detail flow of image segmentation. In the process of merger, the difference indexes between different plots have spectral merger cost and shape merger cost, and the latter includes the weighted combination of shape compactness index and smoothness index. When the merger cost excesses the square of certain scale parameter set by the program, the terminative flag will appear and the merger algorithm will be stopped. If different scale parameters are set in the program, we will realize the process of multi-scale image segmentation. The algorithm efficiency we tested has fulfilled the needs of application.

4. FEATURE PRIMITIVE MEASUREMENT

Feature primitive measuring is a process of object expression for latent knowledge of primitives resulting from the image segmentation. In addition to the traditional feature of the spectrum, object expression rules also include shape, texture, spatial relations etc.(Yang, 2009).

4.1 Spectrum feature

(1) Spectrum statistical features

Mainly includes some statistical index such as mean, variance, histogram, and so on.

(2) Spectrum computational features

Mainly includes arithmetic operations between different bands spectrum in the same images, such as NDVI, etc.

4.2 Shape feature

Mainly includes area, perimeter, principal axle direction, and so on. Shape features focus on parameter representation, which comprising size invariance and rotation invariance, which describe sub-matrix and border-matrix or sub-function and turning-function by using Fourier function. This article only lists shape characteristics which are experimental related.

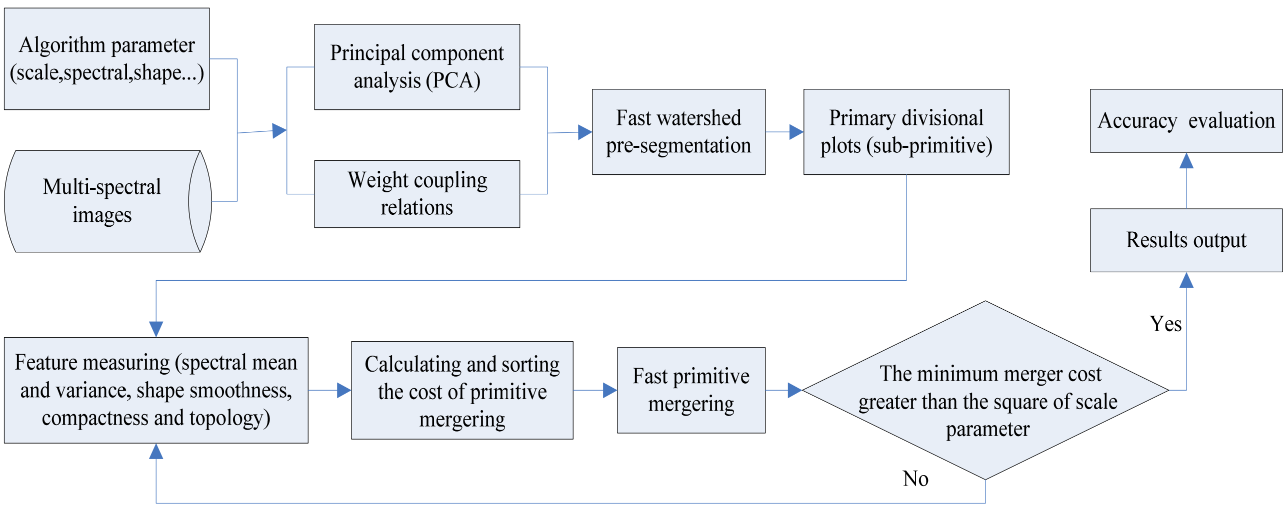

Figure 2. Flowchart of image segmentation

4.3 Texture feature

Texture can be used to describe the grey value distribution features for images. The image texture can be different kinds, like wavelet texture, GABOR filter texture, LBP texture operator, and so on (Yang, 2006). The texture extraction method by Gray Level Co-occurrence Matrix is a classical statistical analysis method, and is also recognized as an image texture analysis method presently (Li, 2006). This article describes the image gray level distribution by the Gray Level Co-occurrence Matrix.

4.4 GIS spatial relationship

Mainly construct the topological relationship between elements, as well as elements spatial orientation information and "XOR" of geographical space knowledge and so on. For example, take DEM as a constraint to distinct terrain features, and take the distance away from the water sideline as a constraint to extract features and so on.

5. EXPERIMENTS

As shown in Table 1, aiming at application of image data mining method which have been discussed above, this article extracts target information concerning typical coastal objects such as water line, sea wall, tidal flat and mariculture pond. And it executes information extraction and result verification through different choice of parameter according to different object features.

Target	Parameters
Water line	DN, area, edge feature
Sea wall	Brightness, ratio of length to width
Tidal flat	DN, area and distance to water area
mariculture zone	Hue, squareness
……	……

Table 1. Main feature parameters of coastal targets

5.1 Water Line Information

As shown in Figure 30, this research selects multispectral SPOT data with resolution of 10m,. Firstly, the image is divided into several patches, among which small apertures and shadow are filtered based on the area. Secondly, seawater and land can be identified preliminarily by means of peak-valley iteration within histogram and threshold selection. Finally, the water line is extracted according to adjacent boundary between seawater and land. The result is demonstrated in figure 4 and 5.

5.2 Tidal Flat Information

Tidal flat is the marsh immerged by sea water, formed by the iterative influence of tide under. This kind of unstable resource of water and soil is often influenced by and changes with scouring and silting.
As shown in figure 6, the experimental data represents a zone around the coastal borderline between water and continent. The types of ground objects include seawater, submarine beach, tidal flat, mariculture pond, estuary, vegetation and residential area. The color of water appears blue in the pseudocolor synthetic image and varies with water depth and sediment amount; while vegetation appears red. Generally, the tidal flat is composed of silt or mud, several tidal channels, and sometimes sparse salt-tolerant vegetation. In pseudocolor synthetic image, the tidal flat is apparently an uneven French grey silt-zone, which distributes merely alongshore and within the bays.

Figure 3. Original image (R,G,B=NR,R,G)

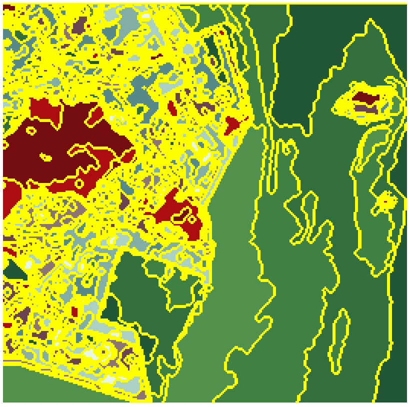

Figure 4. Segmentation result

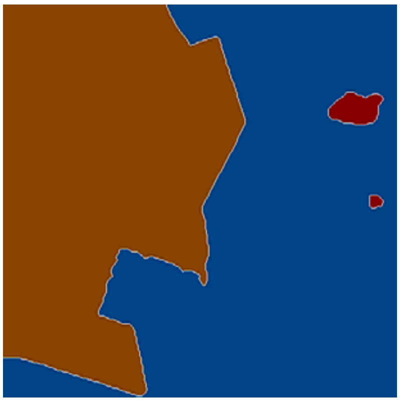

Figure 5. Water line extraction result

In this research, firstly, image segmentation is carried out and the results shown in Figure 7. Secondly, based on the mean of object and feature of area according to the 4th near-infrared band, seawater can be extracted. Thirdly, tidal flat is identified based on its hue and distribution features. Finally, we further the classification of tidal flat through analysis of the brightness, area and distance from seawater. The extraction result of tidal flat is shown as Figure 8.

Figure 6. Original image

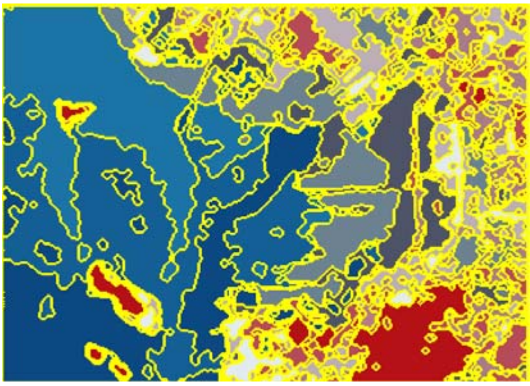

Figure 7. Object boundary display

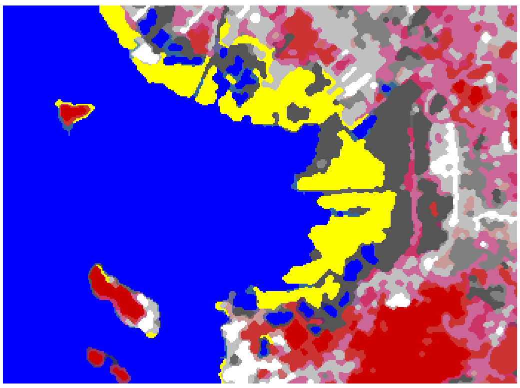

Figure 8. Extraction of tidal flat

6. CONCLUSION

Object-oriented methods of image analysis could conquer the localization of poor precision and present great superiority in the extraction of coastal moderate-and-higher resolution RS information. The tests showed that the identifying method of pixel-primitive-object can fulfill the demand of automatic interpretation of coastal information and enhance the precision of information recognition

In view of the abundance of ground objects' geometric and texture information in high-resolution coastal RS image, along with poor spectral information, the avail information of image is increasing but the noise and useless information are also increasing which complicate the relation among target ground objects. Therefore, on basis of analysis of coastal image and ground objects' internal feature, we should combine them with more geoscience knowledge and make comprehensive use of various information and expertise to increase the universality of segmentation algorithm and extraction methods in different situations.

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REFERENCES

Cardaci M，Di Gesu' V，Petrou M，Tabacchi M, 2005. On the valuation of Images Complexity: A Fuzzy Approach. *International Workshopon Fuzzy Logic and Applications*, Crema, Italy, pp.305-311.

Gao ZY, Yang XM, Gong JM, Jin H, 2010. Research on image complexity description methods. *Journal of image and graphics*, 14(12), pp.129-135.

Hill P.R., Canagarajah C.N., and Bull D.R, 2003. Image segmentation using a texture gradient based watershed transform. *IEEE Trans. on Image Processing*, 12(12), pp.1618-1633.

Li J, Liu X, Li H, 2006. Extraction of texture feature and identification method of land use information from SPOT5 image. *Journal of remote sensing*, 10(6), pp.926-931.

Mario I，Chacon M，Alma D，Corral S, 2005. Image Complexity Measure: a Human Criterion Free Approach. *2005 Annual Meeting of the North American Fuzzy Information Processing Society*, Detroit, America, pp.241-246.

Song Xuefeng, 2005. Survey and Prospect on the Science of Complexity. *Complex Systems and Complexity Science,* 2(1), pp.10-17.

Yang XM, Lan RQ, Luo JC, 2006. Quantizing and analyzing the feature information of coastal zone based on high-resolution remote sensing image. *Acta Oceanologica Sinica*, 25(6), pp.33-42.

Yang Xiaomei, Gong Jianming, Gao Zhenyu, 2009. The research on extracting method of microscale remote sensing information combination and application in coastal zone. *Acta Oceanologica Sinica*, 31(2), pp.40-48.