Features Based Parcel Unit Extraction From High Resolution Image

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Abstract—**This paper analyses the advantages of remote sensing image processing per-parcel compared to per-pixel; Based on huaman's visual mechanism and theory of scale spatial, this paper designs the technique flow of multi-scale information extraction from high resolution remote sensing images based on features: rough classification — parcel unit extraction — expression of feature — ntelligent illation — information extraction or target recognition. Especially, this paper expatiates the work flow of block and linear parcel unit extraction in detail and gives tests with IKONOS and QUICKBIRD images. The test shows that the methods of this paper is convenient to integrating visual and environmental knowledge and can improve the level of automatization and intelligentization of remote sensing data process and application.**

Keywords-high resolution remote sensing, information extraction, parcel unit, image segmentation, feature

I. INTRODUCTION

With the improvements in satellite sensor technology, data acquisition technology developed rapidly and the spatial resolution of remote sensing image increased much. In high resolution image, not only the spectral feature but also other spatial information (shape, texture, context) are more evident. With the advent of high resolution satellite imagery, the need for context-based algorithms and per-parcel image processing is increasing.

Whether to information extraction or to target recognition from high resolution remote sensing image, the extraction of parcels based on features is important prophase task. Only do this, feature expression and combination can be done and the target, even the complex target can be recognized. How the parcels are extracted? One common solution is image segmentation. In many cases, image analysis leads to meaningful objects only when the image is segmented in 'homogenous' areas [1]. The goal of this research is to attempt to find an applicable method for extracting such parcels.

This paper mainly consists of five parts: the importance and advantages of remote sensing image processing per-parcel; the work flow of multi-scale information extraction from high resolution remote sensing images based on features (section 3); the detailed steps of parcel unit extraction (section 4); experiments (section 5); conclusions (section 6).

II. PER-PARCEL IMAGE PROCESSING

In high resolution image, the spectral feature, texture, shape and spatial context information are more detailed. On the other hand, the increase of image spatial resolution makes the number of pixel on the same surface area increase accordingly. So the traditional image processing pattern per-pixel, especially based on spectral feature is low efficient, and the results got by it are limited and fragmentary or "noisy" [2].

Consequently image processing pattern per-field or per-parcel is attached more and more importance and has already been tested with many experiments. Lobo[3], Aplin[4], Mauro[5], Hellwich[6], Benz[7] and et al. tested per-field classification and they affirmed that the result got by image processing per-parcel is better than that by per-pixel, especially in high spatial resolution remote sensing images.

In this research, "parcel" or "field" refers to homogenous patches computed on certain computational rules using computers. Generally, these patches are corresponding to land use patches (agricultural fields, gardens, urban structures or roads) which already exist and are superimposed on the image [8]. For the sake of simplification and unification, this paper called the image processing pattern "per-parcel", and the elementary processing unit is called "parcel unit".

Whether to information extraction or to target recognition from high spatial remote sensing image, the parcel unit extraction is important prophase task of project. Only do this, parcel unit feature expression and combination can be implemented and the useful information or targets can be extracted, even the complex targets can be recognized. The following text gives the technique flow of multi-scale information extraction from high resolution remote sensing images based on features and the detailed steps of parcel unit extraction..

III. MULTI-SCALE INFORMATION EXTRACTION FROM HIGH RESOLUTION REMOTE SENSING IMAGES BASED ON FEATURES

Generally, procedure of information extraction from high resolution remote sensing image consists of image pre-processing, image segmentation, spatial object feature expression, learning-classification, system reasoning based on high-level knowledge. It's evidently that image segmentation is

the groundwork. However, single scale image segmentation can not give attention to macro-feature or micro-feature at the same time. What's more, when the image content is abundant, the immediate image segmentation result often contains many insignificant regions, which decreases the efficiency of target recognition to a certain extent. On the other hand, the traditional object extraction is performed in a small piece of image that already contains the object confirmed by eyes interpretation, which is lack of targets-searching ability by computers.

Hereby, this research designs the work flow of multi-scale information extraction from high resolution remote sensing images based on features (in figure 1). Firstly, through image rough classification on the large scale based on spectrum or texture, the large regions (that correspond to a certain class, such as water, woodland, building region, et al) are parted. Region partition on large-scale approach applies Support Vector Machine (SVM, [9],[10]) and Gaussian Markov Random Field (GMRF, [11]) in this research (limited by the paper length, the detailed steps are omitted here). Secondly, on the middle scale, parcel units are extracted based on not only spectrum and shape but also on spatial relation within the large region and simple targets can be recognized. At last, on the small scale, the parcel units are combined and complex targets can be recognized through reasoning.

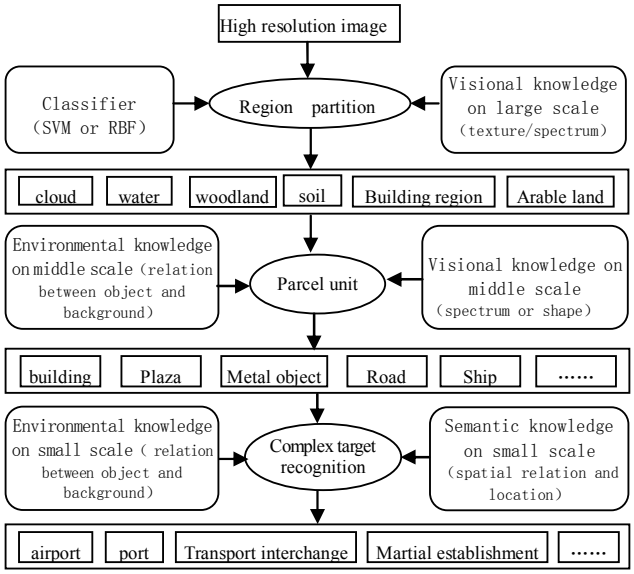


Figure 1. Work flow of multi-scale information extraction from high resolution remote sensing images based on features

IV. PARCEL UNIT EXTRACTION FROM HIGH RESOLUTION REMOTE SENSING IMAGES

After region partition on large-scale, parcel units are extracted on smaller scale. All complex targets can be decomposed into different parcels, accordingly the complex target can be regarded as the combination of many parcels.

Generally, parcel units extracting procedure consists of three steps: segmentation, vectorization and feature expression. However, different parcel unit type adopts different methods. Based on the difference of shape, parcels can be classified into block parcel unit and linear unit. The block parcel unit is expressed by the polygon feature and is always extracted by region based segmentation. The linear parcel unit (the one whose length to width ratio is much more than 1) is expressed by the linear feature and is extracted based on edge detection and morphology in this research.

A. Work Flow of Block Parcel Unit Extraction

Five main types of block parcel are identified as the reference. They are building, plaza(large area and being made of concrete)，metal object(being made of metal materials, such as plane), road and ship. figure 2 shows the procedure of the block parcel unit extraction.

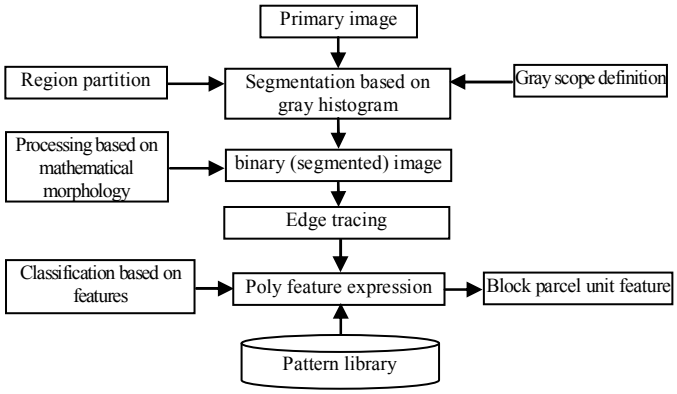


Figure 2. Work flow of block parcel unit extraction

The detailed steps are as follows:

<STEP1>: Segmentation based on gray histogram. Spectrum of block parcel unit is homogenous and it can be easily segmented only by threshold segmentation.

<STEP 2>: Post-processing of segmented image. In order to remove the isolated point in the block and make the block edge smooth, the binary (segmented) image is post-processed based on mathematical morphology.

<STEP 3>: Vectorization and feature expression. It is easy to vectorize the block by edge tracing. Thus the vector polygon is got and the shape index is computed by rectangle (as figure 4).

<STEP 4>: Block parcel unit extraction based on features. There are two approaches to identify the class of block parcel unit after the spatial features are computed. They are simple identification on rules and complex identification based on classifier. The former is suit for the block parcel whose shape is regular. Commonly, the bounding rectangle of the polygon, V1and V2, are both more than 1. Thus simple judgment on shape and area can extract the simple block parcel unit and the block parcel unit often responds to a certain simple target, such as building. However, it is possible for the complex targets to get the error result if judging only on shape and area. This research adopts the classifier based on pattern library to recognize the complex targets. Building pattern library is the first step. Secondly, the block pattern is drawn manually on the image and the system computes the pattern, then the target pattern is saved in the pattern library. Pattern library is organized by rules of shape file of arcinfo. It is composed of multi-records, the contents of every record are shown as figure

3. Thirdly, the classification model is computed after the startup of classifier, such as classifier based on BP. Fourthly, the feature vector of parcel unit is put into the classifying model and the class of parcel unit is figured out.

```
TA_PATTERN
{
ID;                          //pattern ID;
CLASS;                       // pattern class;
SUB_CLASS;                   //pattern subclass;
SPECTRAL; //spectral value of of target pattern;
AREA;                //area of target pattern;
PERIMETER;           //perimeter of target pattern;
SHAPE;               //shape index of target pattern;
TEXTURE;     //texture index of target pattern;
};
```

Figure 3. Records of pattern library

B. *Work Flow of Linear parcel unitextraction*

Linear parcel unit (such as road, bridge, etc.) extraction is based on spectrum and shape and the work flow is in figure 4. Firstly, we employ edge detection method to extract the edges of the linear objects and then use mathematical morphology methods to connect the adjoined lines and to remove the scattered points. Secondly, we employ image thinning methods to sketch the linear objects. Finally, we vectorize the image and use line segments to express the linear parcel units, so that we can compute their features, such as length, direction, the ratio of linearity, etc.

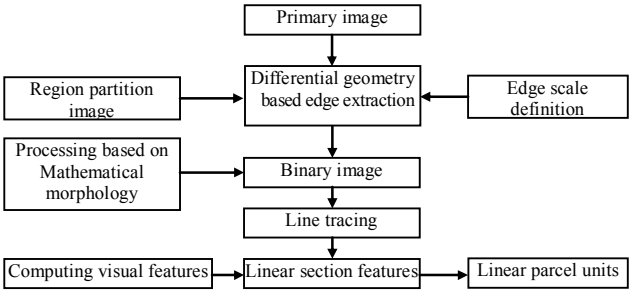


Figure 4. Work flow of linear parcel units extraction

The detailed steps are as follows:

<STEP 1>: Edge extraction. We use differential geometry based edge extraction method to sketch the edge of the image. We use Gauss kernel function based template to convolute the image and calculate the second-order Taylor expansion of fitting gray-level distribution of every pixel in the convoluted image; then we get the direction of linear structure in local areas according to the coefficients of the expansion and judge whether the current pixel is on the linear structure. This method fully considers the edge information of different directions and keeps the continuity of the edge very well. Before edge extraction, we should input the parameters of width of the edge.

<STEP 2>: Mathematical morphology based image processing and image thinning. We use mathematical morphology methods to connect the adjoined lines and to remove the short edges or scattered points. Then we use thinning algorithms to get the edge of the single pixel. At last we wipe off the short lines and dangling lines by threshold of certain length.

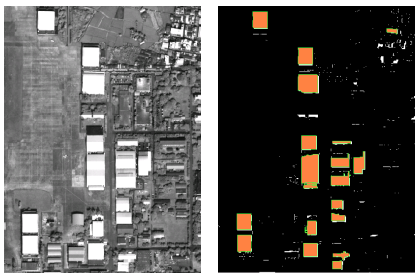
<STEP 3>: Vectorization. Based on binary image of thinning edge, we use line tracing algorithm to get the vector layer. In order to compute the feature of the line, we propose line tracing algorithm based on nodes. Firstly, we search for the node collection where multi-lines intersect each other. Then we trace the segment from the node until to find another. Therefore, the beginning and the end of all the segments are nodes.

<STEP 4>: Feature computing. After getting the vector layer, we firstly remove the redundant points of every segment and only save the node collections that determine the direction of the segment. Then we calculate the visual feature of every segment, such as length, direction angle (θ) and linearity.

V. EXPERIMENT

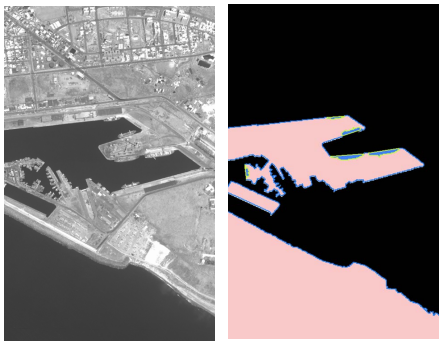
A. *Experiments of Block Parcel Unit Extraction*

According to the steps presented above, taking extraction of building and ship for examples, this research extract block parcels corresponding to buildings(figure 5, based on Spectral and shape feature), ships(figure 6, based on spectrum and shape after separating water region from non-water region) with pan band QuickBird images(0.7 meters spatial resolution).



(a) primary image **(b) extraction result**

Figure 5. Result of building parcel unit extraction



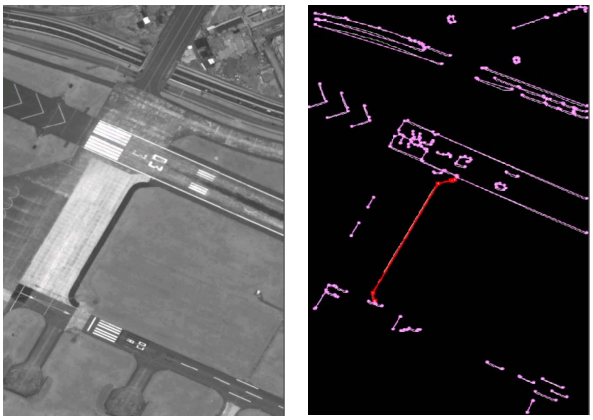
(a) primary image **(b) extraction result**

Figure 6. Result of building parcel unit extraction

B. *Experiments of Linear Parcel Unit Extraction*

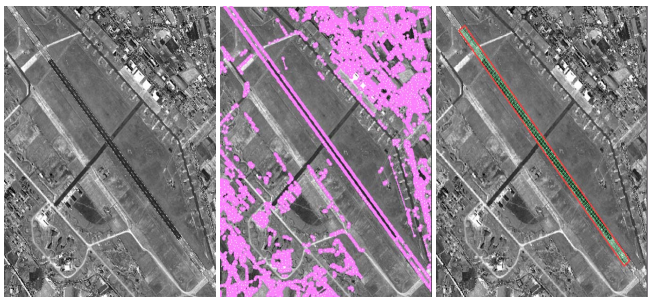
Two pieces of pan band QuickBird image with 0.7 meters spatial resolution is used in the experiment. After processing as

mentioned above, the edge extraction result and the vector layer of linear parcel unit are respectively shown in figure 7(b). Figure 8(c) is recognition result of airport-runway.



（a）primary image　　（b）vector layer of linear parcel unit

Figure 7. Experimental results of linear parcel unit extraction



（a）primary image　（b）vector layer after edge extraction　（c）recognition result of airport-runway

Figure 8. Experimental results of recognition of airport-runway

VI. CONCLUSIONS

This research designs the work flow of multi-scale information extraction from high resolution remote sensing images based on features: rough classification – parcel unit extraction (subtle segmentation) — feature expression — intelligent illation — information extraction or target recognition. This idea accords with human visional mechanism and computer scale space theory and improves the targets-searching ability of system.

In this paper, concept of parcel unit is presented and the complex target is looked upon as the combination of different parcel units. In terms of the different features embodied in the image, the parcel units are divided into two types and they are block parcel unit and linear parcel unit. Furthermore, block parcel unit are divide into four types and they are building, metal object, plaza and ship. In addition, the complex target, such as airport or port, is the combination of parcel unit mentioned previously. This idea makes it possible to recognize the complex target and to utilize knowledge conveniently.

This paper illustrates the procedure of block and linear parcel unit extraction by human and computer and gives the relative experiments. Experiment results show that the methods of this research make use of knowledge well and can extract simple target quickly and rightly. It is evident that this method improves the level of intelligentization and automatization of remote sensing image processing and analysis.

However, there are several problems to be studied and improved farther. How the transcendent knowledge are used in parcel unit extraction automatically? How to build the all-around knowledge library and pattern library by which the target pattern matching and intelligent reasoning is convenient? How to make use of the combination of parcel unit and knowledge of spatial relation to assist in complex targets recognition? Solving of all these problems are pressing and significant tasks. In order to accomplish the purpose, knowledge application and building feasible expert system are the only way, which is the chiefly research task to information extraction from high resolution remote sensing image.

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