Multi-Scale Segmentation Of The High Resolution Remote Sensing Image

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***Abstract*-The high spatial resolution remote sensing image provide more details such as color, size, shape, context and texture. The traditional pixel-based classifier cannot provide satisfying results and may reduce the classification accuracy. So the object-oriented processing for extraction of information from remote sensing data become of interest. The first step of the object-oriented processing is the segmentation. The object is derived by means of multi-scale segmentation in this paper. The hierarchical image segmentation and region-merging are implemented. The procedure of the region-merging does not stop until the average size of all object regions exceeds the scale threshold. Lastly, in order to provide an appropriate link between remote sensing image and GIS data, the region boundary will be obtained from the segmented remote sensing image and initialize the regions' boundary to a series of polygon by Douglas-Peucker (DP) algorithm.**

Keywords -multi-scale ,hierarchical ,segmentation region-merging , polygon.

Ⅰ.INTRODUCTION

Object extraction via image segmentation plays a key role in many applications and it is the first step of the image analysis. The segmentation algorithms have already been recognized as a valuable and complementary approach that similar to human operators - create regions instead of points or pixels as carriers of features which are then introduced into the classification stage.

Remote sensing has made enormous progress over the last decades and a variety of sensors now deliver medium and high resolution data on an operational basis. Remote sensing image of a large variety of space-borne and air-borne sensors provides a huge amount of data about our earth surface for global and detailed analysis, change detection and monitoring. Powerful signal processing methods are developed to explore the hided information in advanced sensor data (Curlander and kober,1992; Tsatsoulis,1993;Pierce etal.1994;Serpico and roli,1995). Nevertheless, a vast majority of applications still rely on basic image processing concepts developed in the early seventies and do not take into account other useful information[1]. With these sensors the user community faces new problems in the automatic analysis of these types of data:

1. The high resolution remote sensing image provide the more details such as color , shape, context and texture. The traditional segmentation algorithm is only based on the color information and can not provide the satisfying results and may reduce the classification accuracy in the later classification.
2. Though the high spatial resolution remote sensing image includes more details and information of the object, it is a important thing that how to fuse the characters and segment the remote sensing image effectively with all kinds of information and object character.

In this paper, we will use the color and shape information about object to segment the high spatial resolution remote sensing image.

Ⅱ. IMAGE SEGMENTATION

A. Hierarchical Image Segmentation

In order to implement the multi-scale segmentation in this paper, the stochastic pyramid is introduced. Segmentation using a hierarchical approach is normally achieved in two ways: top-down analysis and bottom-up analysis. Between these scales there is a hierarchical dependency. The hierarchical image segmentation is a set of several image segmentations at different levels of segmentation details in which the segmentation at coarser levels of detail can be produced from simple merges of regions from segmentation at finer levels of detail. Thus every level represents a different spatial scale simultaneously. So the initial image is segmented to a set of different scale images. In fact, the multi-scale segmentation is a bottom-up region-merging technique starting with one-pixel region in this paper.

In the subsequent steps, the smaller image objects are merged into other bigger ones. The region-merging technique used in the paper is region-growing. In order to accomplish the multi-scale segmentation, we will merge two adjacent regions from the minimize region. Through the region-growing and region-merging each level, the average region size increases. This indicates the scale becomes big. In this paper, we use an adjacent graph of regions to describe the partition of an image. An adjacent graph of regions is a non-direction graph in which each node corresponds to a region and two nodes are linked by an edge if and only if the corresponding two regions are spatially adjacent. A hierarchy of adjacent graphs is a stack of graphs. each of the graphs is obtained by the region-growing and region-merging from the previous level. The deepest level is the initial image base on the single pixel. The hierarchy of adjacent graphs is thus constructed by successively applying a clustering operation-region-growing and region-merging to the adjacent graph at top level of the current hierarchy [2]. The following graph Fig.1 s a hierarchy of adjacent graphs. In the figure, the circles represent the regions in the each level; the real line indicates the adjacent relationship of the two regions, only if the two regions are adjacent; the broken line explain the merging relationship from a level to another level.

The region-growing is based on the three criterions: the local quality—color and the global quality consisted of the circle-like degree and the rectangle-like degree. The procedure of the region grow will merge the two adjacent objects into one object if they satisfy the homogeneity defined by the three criterion until no object satisfy the growing criterion. Through the region-merging like this, the image of the next scale is obtained. With this method, clustering at each level can be achieved by an iterative procedure and the new image of the coarser scale is obtained continuously. During he region-growing and the region-merging, computations is expensive. In order to speed up the segmentation speed and save the time of the segmentation, when a region will merge with other adjacent regions, the merge-cost is calculated first. The two adjacent regions are merged if their merge-cost is lowest.

The procedure of the region-merging does not stop until the average size that objects of the new level are bounded exceeds the maximal given size. The focal level that we wanted is located at the top of the pyramid. The aim of the segmentation is to obtain the image as the human vision. When the suitable image size is obtained, the result of the image segmentation is best. Thus the optimal segmentation result is obtained.

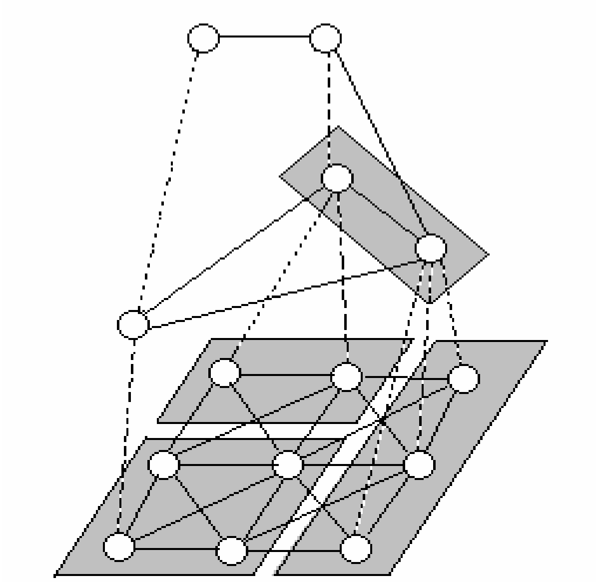

Figure 1 A hierarchy of adjacent graphs

B. The criterion define

The region-grow is based on the three criterions: the local quality—color and the global quality consisted of the circle-like degree and the rectangle-like degree. Now define as follows:

1. the color homogeneity [1][3][4][5]:

$$h_{color} = \sum_c w_c (n_{mc}\sigma_{mc} - (n_{1c}\sigma_{1c} + n_{2c}\sigma_{2c})) \quad (1)$$

The w_c indicate weight value of every channel. $\sigma_{1c}, \sigma_{2c}, \sigma_{mc}$ are the deviation of the two region and the merged region respectively. These n_{1c} , n_{2c} , n_{mc} are the numbers of the two adjacent regions and the merged region. This value indicates the similar degree of the two adjacent regions.

2. the circle-like degree homogeneity [1][3][4]:

$$h_{com} = n_m \frac{l_m}{\sqrt{n_m}} - (n_1 \frac{l_1}{\sqrt{n_1}} + n_2 \frac{l_2}{\sqrt{n_2}}) \quad (2)$$

n_1, n_2, n_m are the numbers of the two adjacent regions and the merged region respectively. l_1 , l_2 , l_m are the boundary length of the adjacent regions and the merged region respectively. The value obtained from the equation (2) represents the cluster degree of the pixels in the region. Smaller the value is, more compact the pixels in the region.

3. the rectangle-like degree homogeneity [1][3][4]:

$$h_{sth} = n_m \frac{l_m}{b_m} - (n_1 \frac{l_1}{b_1} + n_2 \frac{l_2}{b_2}) \quad (3)$$

n_1, n_2, n_m are the numbers of the two adjacent regions and the merged region respectively. l_1 , l_2 , l_m are the boundary length of the adjacent regions and the merged region respectively. b_1 , b_2 , b_m are the perimeter of the bounding box of the two adjacent regions and the merged region respectively. The value obtained by the equation (3) represents the smoothness degree of the region boundary. Similarly as the circle-like degree, Smaller the value is, Smoother the region boundary is.

According to the three criterions mentioned above, in order to fuse the three characters, a general homogeneity implemented of the merge criterion is defined as follows:

$$f = w_{color} h_{color} + (1 - w_{color})[w_{com} h_{com} + (1 - w_{com}) h_{sth}] \quad (4)$$

The w_{color} is weight value about color heterogeneity, w_{com} is weight value about the circle-like degree homogeneity. If the two adjacent regions calculate the merge criterion is satisfy the threshold, they will be merged, or they will not. When the regions in the current scale are all processed like this, the average size of all the object regions will be calculated. If the value is satisfy the size threshold, the optimized segmentation result is obtained and the iteration stop at the same time[4]. So every segmentation level is represented as a scale, thus multi-segmentation is accomplished.

C. Vector Polygon of Boundary:

Lastly, in order to provide an appropriate link between remote sensing image and GIS data, the region boundary will be obtained from the segmented remote sensing image and initialize the region boundary to a series of polygon. In this paper, because the boundary pixels of each segmented region are discrete and out-of-order, the chain-code is implemented to make the boundary pixels connect with each other in spatial relation. After this, the Douglas-Peucker (DP) algorithm is implemented to make the region boundary into polygon [7] [8] [9]. So the regions' boundaries are composed of a series of close poly-line.

III. RESULT

The following are the initial remote sensing image cut from the IKONOS image and the two segmentation image when the size threshold is 10 and 100 respectively. The red line in the image indicates the boundary lines of every region.

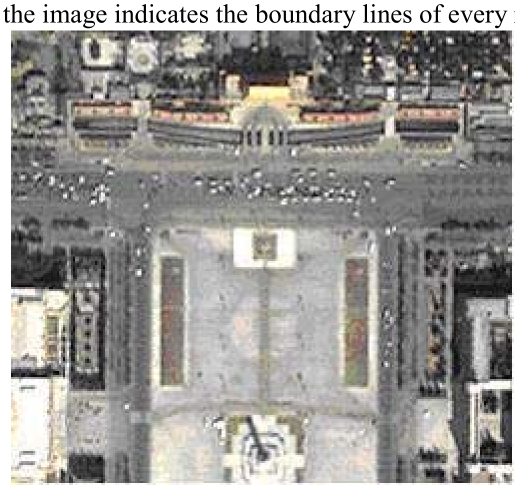

Figure 2 The initial image

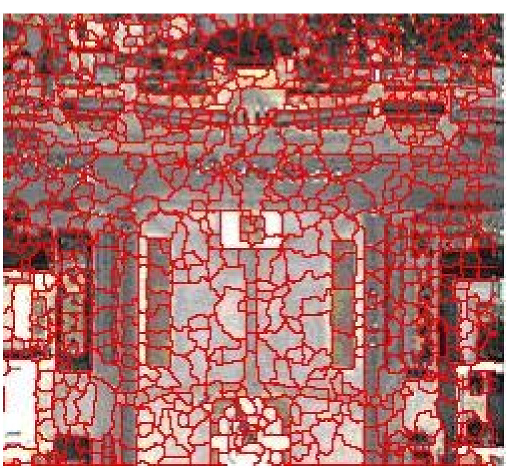

Figure 3 The size threshold=10

Figure 4 The size threshold=100

IV. CONCLUSION

Through the processing mentioned above, the segmentation can prepare for the classification of the high spatial resolution remote sensing image and make the classification is based on the a series of meaningful objects, which is help to make use of more information and increase the classification accuracy. In the last, the output of the classified image as a vector is obtained too.

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