Region segmentation of multi-spectral remote sensing images using improved JSEG algorithm

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Abstract: Image segmentation is the basic of extracting and recognizing interesting region, and it is also the key step of image analysis. Region-based JSEG algorithm is a new image segmentation algorithm considers not only color information but also spatial information, and also has a good effect in region segmentation for ordinary images and video images. In this paper, JSEG algorithm is introduced to segment remote sensing images, and is also improved to be applicable to segment multi-spectral remote sensing images and VHR remote sensing images which contain complicated texture characters. Experiments demonstrate that it can solve fuzzy region boundary problem effectively which is caused by complicated land object information.

Key words: region segmentation; multi-spectral remote sensing image; JSEG algorithm

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1 INTRODUCTION

Image segmentation is a method to segment image into different nonoverlap regions by utilizing regions' similarity and noncontinuity (Zhang, 2001). It is the basic of extracting and recognizing region of interest and also is the key step of image analysis. With the image segmentation technology developing, segmentation methods can be divided into color-based segmentation method and spatial-based segmentation method (Zhang, 2001; Sheng, 2007). The color-based segmentation method often uses K-Mean, C-Mean and other sorts of clustering methods. This category firstly separates pixels into various classes, and then merges similar classes into one region. The spatial-based segmentation method contains two representative methods: one utilizes region edge to segment images and the other utilizes region comparability to grow and merge image regions. Sobel, Laplacian, Canny operators are famous for utilizing region edge to segment images. When images contain noises, the result will include many discrete points and non-closed curves by using this kind of algorithm to segment image, even if adding some other processes it can not be improved (Ye & Cao, 2004). JSEG (Deng & Manjunath, 2001) algorithm is a typical algorithm belonging to the latter method. This algorithm was brought forward in 2001, and was firstly used to segment images and videos. After that, JSEG algorithm has been gradually used to extract interesting region of videos (Han & Ngan, 2004) and segment medical images (Celebi & Aslandogan, 2005) and both get good results.

In remote sensing image segmentation field, people have done many researches. Although it has a development, there are still many problems because of the remote sensing image's complicated spectrum characteristics and texture characteristics and some random factors coming from image screen processes (Yu et al, 2003). Remote sensing image segmentation methods can be divided into three kinds (Vision, 1982): edge detection, region segmentation, and threshold segmentation. Region segmentation method is mainly used to obtain regions of interest. This method relies on images' local spatial characteristics, so that it often over segments the images (Li et al, 2004). Region-based JSEG algorithm is a new image segmentation algorithm which considers not only color information but also spatial information, and also has a good effect in region segmentation for ordinary images and video images. Accordingly, we import JSEG algorithm to segment remote sensing images. Because remote sensing image includes multi bands and every band has relationship with others, we improve JSEG algorithm and make it applicable for remote sensing image segmentation.

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2 JSEG ALGORITHM

2.1 Algorithm theory

JSEG algorithm has two steps: color quantization and spatial segmentation.

On color quantization step, firstly, color space of raw image is converted to LUV color space; secondly, peer group filtering (PGF) (Deng et al., 1999) algorithm is used to smooth the image; lastly, General Lloyd algorithm (GLA) (Gersho & Gray, 1992) is used to quantize the image. Finally a class-map is obtained. In this class-map, pixels of original image are replaced by class labels.

On spatial segmentation step, on the basic of color quantization, region growing method and region merging method are used to segment image.

The flow of the algorithm is indicated in Fig.1.

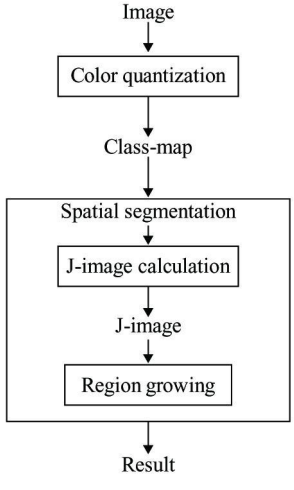


Fig.1 Flow chart of the JSEG algorithm

2.2 Color quantization

Image color quantization flow is summarized as follows:

A. Use peer group filtering algorithm to smooth the image and remove the noise. After filtering, a weight is assigned to each pixel.

B. Use General Lloyd algorithm to quantize the image. Distortion D is given by

$$D=\sum_i D_i=\sum_i\sum_n v(n)\|x(n)-c_i\|^2,\quad x(n)\in C_i \tag{1}$$

Where c_i is the center pixel of cluster C_i, $x(n)$ and $v(n)$ are the color vector and the perceptual weight for pixel n, and D_i is the total distortion for cluster C_i.

Because remote sensing images are composed by multi bands, $x(n)$ is redefined when using JSEG algorithm to segment remote sensing images: $x(n)=\{a_{n_1}, a_{n_2}, \cdots, a_{n_i}\}$, i is the band number of an image, a_{n_i} is the value of the n^{th} pixel in the i^{th} band of the image.

2.3 J-image

In the image, every pixel can be viewed as a 2-D vector $z=(x, y)$, $z=(x, y)$, $z\in Z$, Z is the set of all N data points, m is the mean,

$$m=\frac{1}{N}\sum_{z\in Z} z \tag{2}$$

Suppose Z is classified into C regions, Z_i, $i=1, \cdots, C$. Let m_i be the mean of the N_i data points of class Z_i,

$$m_i=\frac{1}{N_i}\sum_{z\in Z_i} z \tag{3}$$

Let

$$S_T=\sum_{z\in Z}\|z-m\|^2 \tag{4}$$

$$S_W=\sum_{i=1}^{C} S_i=\sum_{i=1}^{C}\sum_{z\in Z}\|z-m_i\|^2 \tag{5}$$

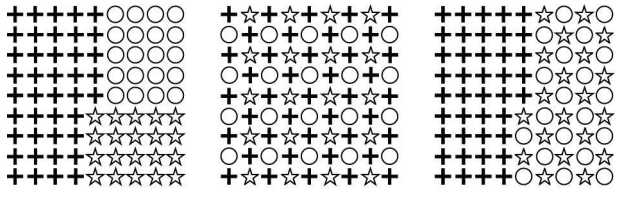
The measure J is defined as

$$J=\frac{(S_T-S_W)}{S_W} \tag{6}$$

Average J is

$$\bar{J}=\frac{1}{N}\sum_k M_k J_k \tag{7}$$

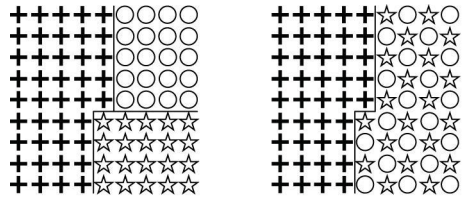
J_k is J calculated over region k, M_k is the number of points in region k, N is the total number of points in the class-map. Fig.2 is an example of different class-maps and their corresponding J values. Each symbol in the map indicates different class of data points.



Class-map 1 J=1.720 | Class-map 2 J=0 | Class-map 3 J=0.855

Fig.2 An example of different class-map and their corresponding J values

From J-image we can find: the smaller the J value is, the more possible the pixel is at the center of the region; the higher the J value is, the more possible the pixel is at the boundary of the region (Fig.3).



Segmented 1 J_+=0, J_*=0, J_o=0, $\bar{J}$=0 | Segmented 3 J_+=0, J_*=0.11, J_o=0.11, $\bar{J}$=0.05

Fig.3 Segmented class-maps and their corresponding J values

2.4 Spatial segmentation

With the result of J image, segment images are merged using region growing method (Zhang & Hao, 2005). Region growing method has three steps: seed detection, seed growing and region mergence.

2.4.1 Seed detection

At the beginning, a set of small initial areas are determined to be the basis for region growing. In general, finding the best set of seeds in a region is an important problem. JSEG algorithm uses the following method to choose seeds:

A. Calculate the average and the standard deviation of the local J value in the region, denoted as μ_J and σ_J respectively.

B. Set a threshold $T_J = \mu_J + a\sigma_J$. Pixels with local J value less than T_J are considered as candidate seeds. A seed area is defined by connecting the candidate seeds. If the candidate seed area is bigger than the size listed in table 1 at the corresponding scale, it is determined to be a seed.

Table 1 Window Size at Different Scales

Scale	Window size	Sampling	Region size	Min seed
1	9×9	1/(1×1)	64×64	32
2	17×17	1/(2×2)	128×128	128
3	33×33	1/(4×4)	256×256	512

2.4.2 Seed growing

The new region grows from the seed. Search similar and adjacent pixels and grow new region. Following approaches are used:

A. Grow from seed pixel.

B. Calculate the average of value J of unsegmenated area, and then connect the pixels whose J value is less than the average value in order to form the growing region.

C. Calculate J value and repeat the step B at smaller scale in order to get more accurate region boundary.

D. At the lowest scale, grow the unclassified pixels one by one. Unclassified pixels are stored in a buffer. Each time find out the pixel with the lowest J value and assigned it to its adjacent seed. Repeat until the buffer is empty.

2.4.3 Region mergence

Oversegmentation often exists in the result, so it's necessary to merge the regions after segmentation. Firstly, calculate each region's color and store it; then merge two regions which have the shortest color distance from each other. Secondly, update the distance. Thirdly, stop merging when the distance reaches a maximum threshold.

3 RESULT

In this paper, we use QuickBird images (Beijing) and TM images (Wuhan) for the experiments, and the image size is 400 × 400 pixels. QuickBird images' resolution is 0.64m, including three bands; TM images' resolution is 30m, including six bands. TM image is a typical multi-spectral remote sensing image.

After segmentation, we compare the results of JSEG algorithm and region growing algorithm. The results are shown in Fig. 4. The red lines in the image are edges of regions.

(1) In Fig. 4 (a), the texture is obvious for residential area and vegetation area, which results in precise edge after segmented by JSEG algorithm. However, because of the high resolution, the result of region growing algorithm is oversegmented.

(2) In fig. 4 (d), it is also a high resolution image, but it has a complicated texture of the residential area. However, JSEG algorithm can still get good edge for the residential area.

(3) In Fig. 4 (g), facing complex spectral feature and texture feature, JSEG algorithm combines them and gets a good result.

(4) In Fig. 4 (j), the difference of spectral feature between residential area and water is huge, so JSEG algorithm gets a precise edge, but the edge extracted by region growing algorithm is ambiguous.

So we can find that for not only very high resolution image but also multi-spectral image, JSEG can both segment well and rarely oversegment. By contrast, region growing algorithm can not get the right edge, and also often oversegment, especially for the very high resolution image.

4 CONCLUSION

Often, one image segmentation algorithm is only useful for one special kind of images. It is very difficult to segment all kinds of images. However, the remote sensing image has special characteristic. It includes multi bands, and each band includes complex information, which make the edge between two regions fuzzy. So, we import JSEG algorithm to segment the remote sensing image.

From the experiments we prove that JSEG algorithm can be well applicable for segmenting remote sensing images and it can solve fuzzy region boundary problem effectively which is caused by complicated land object information.

However, algorithm efficiency is very low. In the face of massive remote sensing images, the future research work should focus on how to improve algorithm efficiency.

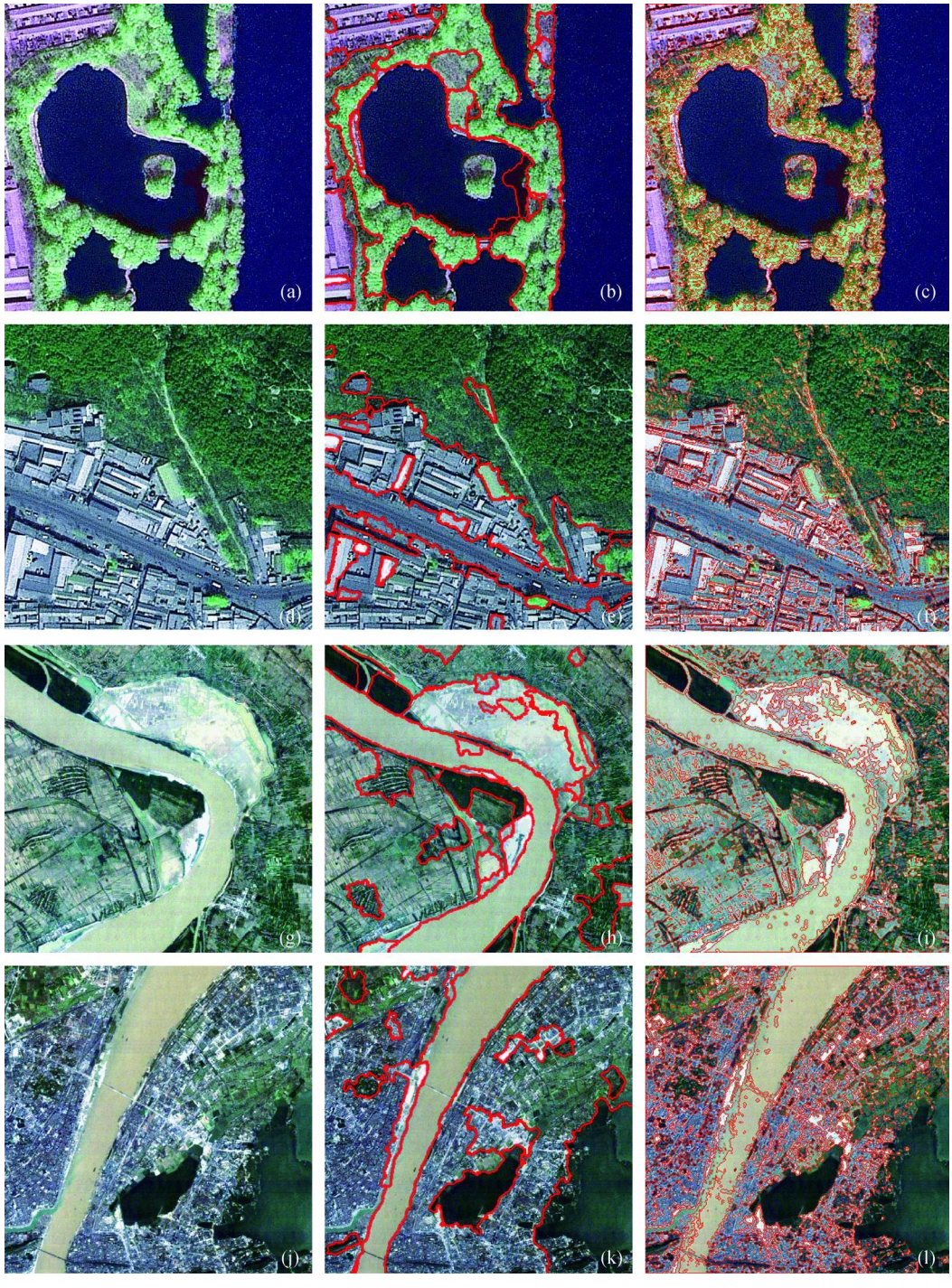


Fig. 4 Original images and segmentation results

(a) Beijing QuickBird original image; (b) JSEG segmentation result; (c) Region growing result; (d) Beijing QuickBird original image; (e) JSEG segmentation result; (f) Region growing result; (g) Wuhan TM original image; (h) JSEG segmentation result; (i) Region growing result; (j) Wuhan TM original image; (k) JSEG segmentation result; (l) Region growing result

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JSEG改进算法在多光谱遥感影像区域分割上的应用

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摘 要: 图像分割是对图像进行感兴趣区域提取与识别的基础, 是图像分析的关键步骤。基于区域分割的 JSEG算法是一种既融合了颜色信息又融合了空间信息的图像分割方法, 在普通图像和视频图像中都能得到良好的分割结果。将这一算法引入到遥感影像的分割中, 并对其做出改进, 使之适用于多光谱遥感影像和纹理特征复杂的遥感影像的区域分割。实验结果表明, 该算法很好的解决了由于影像中复杂的地物信息而产生的不同区域边界模糊的问题。

关键词: 区域分割, 多波段遥感影像, JSEG算法