A GEOSTATISTIC BASED SEGMENTATION APPROACH FOR REMOTELY SENSED IMAGES

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Abstract: As to many conventional segmentation approaches, spatial autocorrelation, perhaps being the first law of geography, is always overlooked. Thus, the corresponding segmentation results are always not so satisfying, which will further affect the subsequent image processing or analyses. In order to improve segmentation results, a geostatistic based segmentation approach with the consideration of spatial autocorrelation hidden in remote-sensing images is proposed in this article. First, by calculating the mean variance between each pair of pixels at given different lag distances, information like the size of typical targets in the scene can be obtained, and segmentation thresholds are calculated accordingly. Second, an initial region growing segmentation approach is implemented. Finally, based on the segmentation thresholds obtained at the first step and the initial segmentation results, the final segmentation results are obtained using the same region growing approach by taking the local mutual best fitting strategy. From the experiment results, we found the approach is rather promising. However, there still exists some problems to be settled, and further researches should be conducted in the future.

Keywords: Geostatistic, segmentation, Remotely sensed images.

1. Introduction

From the perspective of image engineering, conventional and widely used per-pixel approach for remotely sensed imagery is just at its low level -- image processing level. To extend and expand the application field of remote sensing, the shift in this field from per-pixel image processing to object-based image analysis taking segmentation as its initial procedure is recommended [4].

Segmentation is by no means a new research field. On the contrary, it has been a widely concerned research topic for scientists and specialists in several domains like computer vision, artificial intelligence, signal processing, etc., and also many application fields for years. However, to segment images successfully still remains a difficult task to be settled. As to the remote sensing field, corresponding researches are rather insufficient compared with that of other domains, which will prevent many potential application fields of remote sensing considerably.

So far, there are over one thousand kinds of segmentation approaches developed. However, these segmentation approaches may not be applicable in the remote sensing field due to several unique reasons [3]. As to many segmentation approaches applied into remote sensing field like the split and merge method, the wavelet approach, the pyramid approach, multiresolution segmentation approach [2], and so on, spatial autocorrelation, perhaps being the first law of geography, is always overlooked. If such autocorrelation hidden in remotely sensed imagery is not included in the segmentation routine, the segmentation results will be probably not so convincing.

As known to us, the geostatistic approach is the suitable one to uncover the spatial autocorrelation rule in some domains like geography, landscape, etc. There are many remote sensing applications based on geostatistic [5,6,8,9]. However, researches on segmentation approaches for remotely sensed images utilizing geostatistic are seldom conducted so far. In this paper, a geostatistic based segmentation approach is proposed. First, an initial segmentation region growing approach is implemented. Second, by calculating the mean variance between each pair of pixels at given different lag distances, information like the size of typical targets in the scene can be obtained. Second, segmentation thresholds are calculated accordingly. Finally, based on these segmentation thresholds and the initial segmentation results, segmentation results are obtained using a region growing approach by taking the local mutual best fitting strategy.

2. Methods

1) Target Size and Threshold Computing

According to Woodcock and Strahler, when the local invariance reaches its maximum, the relevant .spatial resolution equals the size of targets in the ground scene, and class seprateness also reaches its maximum [10]. Although the above research involves a serial of images with different spatial resolution, we can still extent its result into a situation with a single image. That is to say, when mean variance of grey value of pixel pairs at a certain lag distance reaches maximum, this distance will probably be equal to the size of target in the scene. Vice versa, mean variance of the grey value of pixel pairs will reach maximum when the distance between the pairs amounts to the size of typical targets in the scene.

In this study, the mean variance of pixel pairs at a lag distance (from 1 pixel to 256 pixels) in horizontal and vertical direction is at first calculated, the relevant curve diagram is made, the relationship between lag distance and mean variance can be learned, and the target size in horizontal and vertical direction can be obtained according to the relevant curve diagram.

Then, the normalized variance in a non-overlapped moving window with a similar size like the typical target in the scene is calculated and averaged. The averaged variance will be used as segmentation threshold in the coarse segmentation.

2) Initial segmentation

The second performed routine is an initial segmentation operation, and a region growing approach is used by taking a small threshold which ensures a fine segmentation and the reduction of computation cost. The threshold is calculated as follows,

$$H = \sum_{h \subset R} \left(\frac{P_{i,h} - \overline{F_i}}{\overline{F_i}} \right)^2, \qquad (1)$$

Where $\overline{F_i}$ is the ith feature value of segment's feature center, $P_{i,\ h}$ is the ith feature value of the hth in the segment, R stands for the segment. During the growing process, a best mutual fit strategy is taken to select the seed so as to ensure every growing from a relatively suitable location. After this segmentation, the initial result can be obtained.

3) Coarse segmentation

Coarse segmentation is actually a merging process based on the initial segments. Also by taking the local best mutual fit strategy [2], merge cost during every merge is minimized so as to ensure the maximal homogeneity of segments after mergence. When growing threshold exceeds the segmentation threshold calculated in the above routine, the growing of current segment is stopped, and the new growing begins till the whole image is processed.

3. Experimental Data

To evaluate the performance of the proposed segmentation approach, a *SPOT-HRV* data with three spectral bands (*CH1*: Green Band, 0.50-0.59mm; *CH2*: Red Band 0.61-0.68mm; *CH3*: Near Infrared Band, 0.79-0.89mm) is used. This remotely sensed image was acquired on *Feb* 3, 1999 covering the Hong Kong island. The size of the sub-image cut down from the whole image is 600 rows by 600 columns with a spatial resolution of 20m by 20m (Fig. 1).

4. Results and Discussion

As the increase of mean variance both in horizontal direction and vertical direction is not apparent when the lag distance exceeds 45, the horizontal and vertical size of typical target in the scene will probably be 45 and 45 pixels respectively (Fig. 4, 5). By calculating and averaging the normalized variance in a 45×45 non-overlapped moving window, the mean variance is acquired. In this study, the mean variance is 577.

In this study, an initial segmentation stage by using a small growing threshold in order to prevent improper merging and improve the processing speed. In this stage, it can be seen that those geo-objects in the image with predominately grey feature can be segmented quite well (Fig. 2).

From the Fig. 3, it can be seen that crop lands (always with a regular shape), mangrove areas, beach (in the upper-left corner) and water is segmented successfully. As to the residential areas, the approach proposed here shows some advantages because both patches with obvious texture feature and those with predominately grey feature can be segmented.

Nevertheless, this method has demonstrated some weaknesses such as the oversegmentation effect that is a little bit obvious in the hilly woodland areas where the highly mixture of house and the vegetations does exist due to the shortage of construction land in Hong Kong. On the other hand, the shape of residential areas is also not so satisfying. As well known to us, to segment successfully the remotely sensed imagery is really a challenge. To us, this study is only an initial test, many problems still remain unsettled. For example, how to incorporate texture information and how to select a suitable threshold in the initial segmentation, how to introduce spatial relations like distance and direction, and so on, all these problems deserve our attentions in the future researches.

4. Conclusions

As one of main information sources, remotely sensed imagery are playing an increasingly important role in many fields [7]. From the perspective of image engineering, image analyses and image understanding are all based on segmentation results, so it is very important to conduct the relevant researches on segmentation approaches for remotely sensed imagery in order to extend the application fields of remote

Fig. 1. The original Sample image

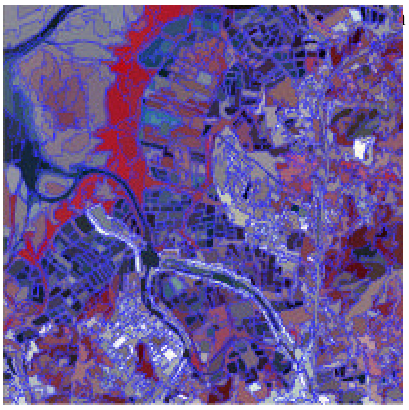

Fig. 2. Fine segmentation results

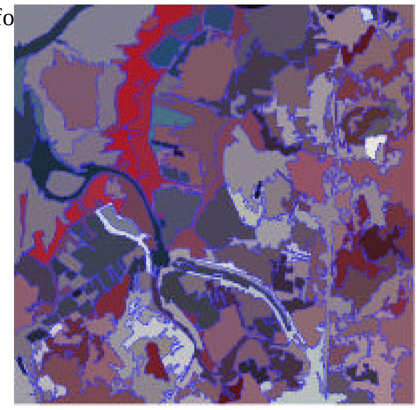

Fig. 3 Final segmentation results

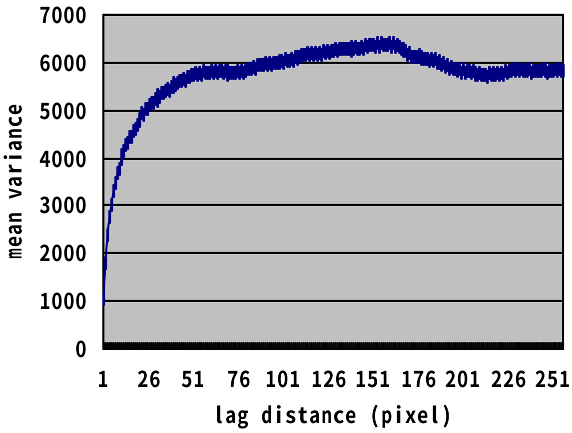

Fig. 4. The curve diagram in horizontal direction

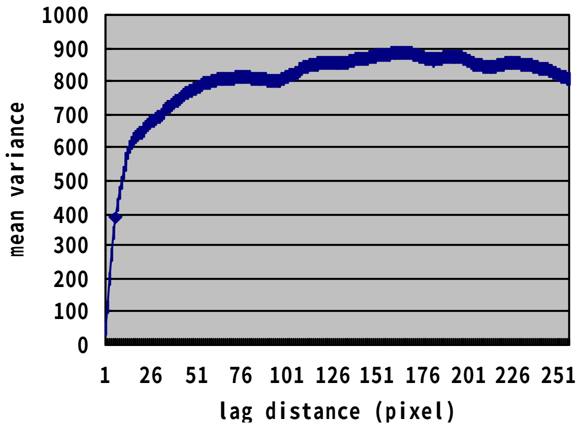

Fig. 5. The curve diagram in vertical direction

sensing. From the above research, it can be seen that the geostatistic based segmentation approach is rather promising, and deserves the further attention since it incorporate the fundamental law of geography.

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References

[1] Atkinson P.M. and P. J. Curran 1997 Choosing an appropriate spatial resolution for remote sensing investigations. Photogrammetric Engineering and Remote Sensing, Vol.63, No.12, pp.1345-1351.

[2] Baatz, M. and A. Schäpe, 2000. Multiresolution Segmentation – an optimization approach for high quality multi-scale image segmentation. Iin Angewandte Geographische Informationsverarbeitung, vol. xii, Strobl, Blaschke, and Griesebner, Eds. Heidelberg: Wichmann-Verlag, pp. 12-23.

[3] Blaschke,T., S. Lang, E. Lorup, et al., 2000. Object - oriented image processing in an integrated GIS/remote sensing environment and perspectives for environmental applications. *In* Environmental Information for Planning, Politics and the Public, A. Cremers, and K. Greve, Marburg: Metropolis -Verlag, pp.555-570.

[4] Chen Qiu -Xiao, Jian-Cheng Luo, Cheng-hu Zhou, et al, 2003. A hybrid multiscale segmentation approach for remotely sensed imagery. *Proc. of IGARSS03*, Toulouse, July 21-25.

[5] Ferro, C.J.S. and T.A.Warmer, 2002. Scale and texture in digital image classification, *Photogrammetric Engineering and Remote Sensing*, 68 (1): 51-63.

[6] Hyppanen, H. 1996. Spatia l autocorrelation and optimal spatial resolution of optical remote sensing data in boreal forest environment. International Journal of Remote Sensing. Vol.17, No. 17, pp. 3441-3452.

[7] Marceau, D. J. and G. J. Hay, 1999. Remote Sensing Contributions to the Scale Isuue, *Canadian Journal of Remote sensing*, 25 (4): 357-366.

[8] Narayanan, R.M. and M.K. Desetty, 2002. Effect spatial resolution on information content characterization in remote sensing imagery based on classification accuracy, *International Journal of Remote Sensing*, 23 (3): 537-553.

[9] Wang G., G.Gertner, X. Xiao et al., 2001. Appropriate plot size and spatial resolution for mapping multiple vegetation types. Photogrammetric Engineering and Remote Sensing, Vol.67, No.5, pp.575-584

[10] Woodcock C.E. and A.H. Strahler, 1987. The factor of scale in remote sensing, *Remote Sensing of environment,* 21: 311-332.