Journal of China University of Geosciences, Vol. 19, No. 4, p.421–428, August 2008 *ISSN 1002-0705*
Printed in China

Solution of Multiple-Point Statistics to Extracting Information from Remotely Sensed Imagery

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ABSTRACT: Two phenomena of similar objects with different spectra and different objects with similar spectrum often result in the difficulty of separation and identification of all types of geographical objects only using spectral information. Therefore, there is a need to incorporate spatial structural and spatial association properties of the surfaces of objects into image processing to improve the accuracy of classification of remotely sensed imagery. In the current article, a new method is proposed on the basis of the principle of multiple-point statistics for combining spectral information and spatial information for image classification. The method was validated by applying to a case study on road extraction based on Landsat TM taken over the Chinese Yellow River delta on August 8, 1999. The classification results have shown that this new method provides overall better results than the traditional methods such as maximum likelihood classifier (MLC).

KEY WORDS: information extraction, spectral information, spatial information, multiple-point statistics.

INTRODUCTION

Since the concept of geostatistics introduced by Matheron in the 1960s, various types of kriging techniques have been widely applied for estimation and mapping purposes in several fields of geosciences including geology, geography science, ecology science, environment science, and soil science etc.. Kriging methods are generally based on the semi-variogram, which has been constructed traditionally on the basis of two-point (pair of points) statistics. This two-point based structural function has been found with limitation on characterizing the complex structures of geographical objects. As an alternative approach, multi-point statistics was introduced by Guardiano and Srivastava (1993). This

This study was supported by the National Natural Science Foundation of China (No. 40671136), the National High Technology Research and Development Program of China (Nos. 2006AA06Z115, 2006AA120106).
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Manuscript received March 28, 2008.
Manuscript accepted May 14, 2008.

concept has been studied consequently by various authors such as Journel and Zhang (2005), Zhang et al. (2005), Strebelle (2000), and Journel (1993). Its main idea is to utilize a training image instead of a variogram to characterize the structural and spatial association properties of geographical objects.

The other challenge in information extraction from remotely sensed imagery is owing to the situation that similar objects may show different spectra and different objects sometimes correspond to the similar spectrum. The substantial efforts in past decades and some excellent methods have been developed by researchers to combine spectral and spatial information to improve the quality of image classification, for example, the contextual classification, the classification using textural and structural information, and the classification utilizing geostatistics (Franklin et al., 2000; Denis, 1998; Gong, 1992). These methods have been commonly used with reasonable classification accuracy. However, each method has its own advantages and disadvantages for processing different images for different purposes. For instance, the contextual classification method introduces the structural information through statistical significance of spatial interdependent characteristics on basis of a hypothesis that the neighborhood pixels tend to be similar types (Gong, 1992). However, the large-scale spatial relationships in images have not been given significant consideration in this method. Texture classification requires abundant occurrences of the surface objects to obtain structural information (Franklin et al., 2000). However, not all remotely sensed imageries have sufficient occurrences of surface objects with texture features. Traditional geostatistics classification on the basis of two-point statistics can utilize both spatial structural information and spatial correlation (Denis, 1998), but cannot represent the complex structure of geographical objects.

Faced with this issue of improving the accuracy of extracting information from remotely sensed imagery, multi-point statistics may provide a solution. In this article, a method based on multi-point statistics is proposed to combine spectral information and spatial information to improve the accuracy of extracting information from remotely sensed imagery. To analyze the performance of this method, it was used to extract road information from Landsat TM image that was taken over the Chinese Yellow River delta on August 8, 1999. Compared to the traditional MLC methods, this new method shows superior performance for the classification of remotely sensed imagery.

In this article, we provide a detailed description of this new method and a case study. Also we compare the results obtained from MLC and this method. Some conclusion remarks and future work are given.

METHODOLOGY

The method proposed in this article is an integrated approach that combines conventional spectrum-based supervised classification algorithms such as MLC with the multiple-point geostatistics method. First, it uses supervised MLC to classify remotely sensed imagery. Then, based on the classification results obtained by the supervised classification method, we extract spatial structural information by means of multi-point simulation (MPS) algorithms. Further, we use fusion methods to integrate the classification results obtained by these two classification methods. For convenience without loss of generality, we choose MLC as the first classifier and the single normal equation simulation (SNESIM) proposed by Strebelle (2000) as the second classifier. The latter is a commonly used MPS algorithm. The theory of evidence (Guan and Bell, 1991; Shafer, 1976; Dempster, 1967) is used to fuse these two classification results. The whole process comprises the following steps: (1) MLC supervised classification; (2) MPS classification; (3) data fusion based on the theory of evidence; and (4) determination of each pixel class.

MLC

The maximum likelihood classifier is one of the most popular classification methods in remotely sensed imagery processing and it has been discussed in various literatures. In MLC, the posterior probability of a pixel is calculated and used to classify pixels into groups with maximum probability component. The results obtained by MLC can be represented as probability vectors, in which each value