Extraction of Golf Course Based on Texture Feature of SPOT5 Image

Cishun Chen, Jianfei Chen , Xiaolin Zhang*
School of Geographical Sciences, Guangzhou University,
Guangzhou, China
Chencishun123@163.com

Abstract—Based on SPOT5 remote sensing image in 2008, we selected two golf courses---one in urban area of Shenzhen and the other in the forest area of Shenzhen, as the two study areas. First, we made principal components analysis of the two areas for data compression and enhancing geometric information. Second, we processed the image and filtered the noise by the wavelet transformation, and the textures of the SPOT5 images were analyzed using Gray Level Co-occurrence Matrices. Based on these analyses, we selected four statistic indexes (contrast Contrast, homogeneity, correlation and entropy.) Finally, with the selection by man-machine interpretation, we chose the optimal threshold for image segmentation and information extraction of the golf course. The results showed that the method of texture feature extraction is better in classifying the land types during information extraction of the golf course and providing more precise results compared to the traditional method.

Keywords-Remote Sensing Image Processing; Golf Course; SPOT5 Image; Gray Level Co-occurrence Matrices; Texture Features

I. INTRODUCTION

As issued by the State Council General Office "The notice of suspended on new golf course" on January 10, 2005, all the golf course projects that have the approval procedures of planning, land using and starting but have not yet been started should be stopped. Golf course project is explicitly prohibited in "the prohibition project directory of land use" in 2006.And according to "the notice of taking survey on construction of golf courses" which was issued by the National Development and Reform Commission, the Ministry of Land and Resources and the Ministry of Housing and Urban-Rural Department etc 7 departments in November 2009 and October 2010, requires survey on the golf courses that have more than 9 holes. But the government restrictions on building golf courses didn't achieve the desired result; the number of golf courses had jumped from 170 to more than 1,000. The information from the Ministry of Land and Resources shows that the land law enforcement will focus on finding out the number of golf courses nationwide, and rectifying the illegal occupation of arable land. How to use remote sensing image quickly and accurately identify the golf course and other special surface features extraction, is needed to explore and improve the technology methods in monitoring land use.

Texture is a complex visual entity, or a combination of sub-models, which has brightness, color, gradient, size and other characteristics. Texture can reflect the natural landscape and the internal structure of target objects, and is the important basis for object recognition and information extraction [1]. The texture analysis and feature extraction image texture could promote the automation of image interpretation, and texture analysis can help suppress the phenomenon of foreign body with the same spectrum and the same species with different spectrum [2]. For the remote sensing images with complexity space and mixed spectrum, if space is also incorporated into the classification of property, then the classification accuracy can be improved [3]. Texture information can be observed the details of the surface changes in a smaller space, and reflect the different spatial structure and internal differences of the target objects, it is important basis for high-resolution satellite image interpretation and information extraction [4.5]. Combination with conventional classification methods, texture analysis methods could improve the final classification accuracy, and develop a better understanding of remote sensing image, even to extract a variety of useful thematic information. Construction of the golf course must have excellent geographical landscape conditions [6]. In general, the greens and fairways are the most important region of the golf courses [7], and need to be planted special grasses and the special design, which will bound to be reflected in the image texture features. The thesis focuses on extracting the golf course by texture extraction with Gray Level Co-occurrence Matrices method, and verifying its accuracy according to the different textures about greens and fairways with other green features , woodland in particular etc.

II. Data and Methods

A. Study Data

The basic data used in this study is remote sensing data, SPOT5 images taken on 2008.10.26, and WRS=286/304, which has 2.5m of panchromatic spatial resolution , and its multi-spectral band is 10m. Because the basic data of SPOT 5 images has the characteristics of high spatial resolution and the texture information is very rich, so that it could reflect the surface detail, and can be more accurately to extract surface features [8]. This study selected two golf courses--- one in urban area and the other in the forest area of Shenzhen as the two study areas.

B. Analysis Method

* Corresponding author.
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Gray level co-occurrence matrix (GLCM) is a method that calculates the image space of each pixel to meet the frequency by booking conditions in different distances and directions, and provides a lot of texture analysis of statistical indicators to assist spectral classification [9 ~ 11]. GLCM method is better than the Gray Run Length Method and Spectroscopy Method [12], and is widely used in texture statistics analysis and measurement. GLCM calculation starts from the image (x,y) as gray i, then statistics the probability P (i, j, δ, θ) by the distance δ,the pixel gray is j (x + △ x, y + △ y).

The mathematical formula is:

P(i, j, δ, θ)={[(x, y), (x+△x, y+△y)],f(x, y)=i, f(x+△x, y+△y)=j; x=0, 1, 2, …, Nx-1;y=0, 1, 2, … , Ny-1}

Where, i, j = 0, 1, 2... L-1; x, y as a pixel in the image of coordinates; L as the image of the gray series; Nx, Ny are the numbers of images in the ranks.

Haralick and others extracted 14 kinds of values with GLCM texture features [13], and commonly features statistics used in the texture extraction of remote sensing images are: the contrast, entropy, the inverse difference moment, the correlation, energy, angular second moment, covariance, and so on. But Barald thought that the calculation of GLCM was much large [14], for simplicity, we use the following four most commonly used characteristics of extract image texture feature:

- Contrast (Con): Contrast is the inertia moment of main diagonal in GLCM; and measures the distribution of matrix value and the number of local changes in images. It reflects the definition of images and the groove depth of texture.

$$Con = \sum_{i=0}^{N}\sum_{j=0}^{N}(i-j)^2\frac{P_{ij}(d,\theta)}{\sum_{i=0}^{N}\sum_{j=0}^{N}P_{ij}(d,\theta)}$$

- Correlation (Cor): Correlation is a measure of the similarity between Spatial Gray Level Co-occurrence Matrix Elements on the line or column direction, and the values reflect the gray correlation of local image. If the matrix element values are in a equal level, then the correlation will be large. Conversely, the correlation will be small. If there are textures in horizontal direction, the correlation in horizontal direction will be larger than others.

$$Cor=\sum_{i=0}^{N}\sum_{j=0}^{N}p(i,j)\frac{P_{ij}(d,\theta)}{\sum_{i=0}^{N}\sum_{j=0}^{N}P_{ij}(d,\theta)}$$

- Homogeneity (Homo): Homogeneity reflects the homogeneity of texture and measures the local changes of texture. The larger value illustrates that the image texture is lack of change between local regions.

$$Hamo = \sum_{i=0}^{N}\sum_{j=0}^{N}\frac{1}{1+(i-j)^2}\frac{P_{ij}(d,\theta)}{\sum_{i=0}^{N}\sum_{j=0}^{N}P_{ij}(d,\theta)}$$

- Entropy (Ent): The entropy is a measure of information on images, it is a random value, and so does the texture. If the elements of symbiotic matrix has the greatest randomness, the values of co-occurrence matrix almost equal, and all the elements are dispersed, the entropy will be the largest. It represents the non-uniformity and complexity of texture.

$$Ent = -\sum_{i=0}^{N}\sum_{j=0}^{N}C_{ij}\log\frac{P_{ij}(d,\theta)}{\sum_{i=0}^{N}\sum_{j=0}^{N}P_{ij}(d,\theta)}$$

When we got the results by GLCM, we should take appropriate actions to eliminate the impact of directions. The common method is to eliminate of that by the superposition of four directions. That means making gray level co-occurrence matrix by parameters offset in four different directions (0°, 45°, 90° and 135°), and then calculate their characteristics index including mean and variance. The purpose of this treatment is to inhibit the direction component, so that the results have nothing to do with the direction.

C. *Extraction of Golf Course*

According to the characteristics of land use shown in the images, and the requirements of golf courses extraction in this study, the images can be divided into 5 classes—construction land, golf course turf, other green spaces, water body and others. Firstly, we made principal component analysis for the two areas, in which the urban test area variance contribution of the first principal component was 85.9385, and the forest test area in the first principal component of variance was 89.3127. As the first principal component represents the basic information of 4-bands images, and it reflects the features of edge texture information and basic color characteristics, so that we can use the first principal component to replace other bands involved in information extraction. Secondly, we got high frequency texture information image which contained all directions through the wavelet decomposition and single wavelet reconstruction from the first principal component by biorthogonal wavelet function in Matlab. Thirdly, basing on the principal component analysis and wavelet transform, we obtained the statistical index of corresponding texture features by GLCM, including contrast, correlation, homogeneity, and entropy. Then we used the man-machine interaction method to select the threshold of statistical index of corresponding texture features, and the optimal threshold is used for image segmentation and information extraction of golf courses. Finally, we assessed the accuracy of the classification results, and compared with the results of traditional maximum likelihood classification. Specific processes shown in Figure 1:

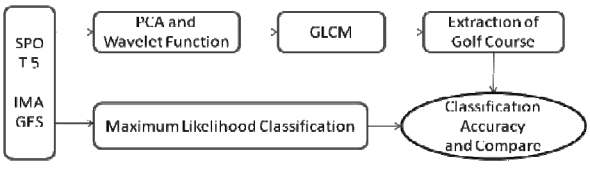


Figure 1. Flow chart of golf course extraction

III. RESULTS AND EVALUATION

A. Texture Feature Extraction

Choose the statistics index of texture as the basis of golf courses extraction. Figure 2 shows the texture index of the two pilot urban and forest areas by GLCM(contrast(a), homogeneity (b), entropy(c) and correlation (d).As we know that contrast and homogeneity represent the degree of uniformity, and the contrast edges and effect, and the neighborhood average, and the spatial variation of variance, and other geometric structures. For the contrast indicator (Figure 2 (a)), there are very good characterization for the construction land and others, but for the homogeneity and correlation index (Figure 2 (b), Figure 2 (d)), there are much confusion characterization showing for the features, so we could select the contrast indicator to extract the construction land, water body and others. Entropy is a characterization of the complexity of the relationship between image spaces, when the image of the surface feature more complex and texture more rough, the value will be much smaller, but the number will be larger when we make logarithmic and choose the opposite number, that means the more complex the spatial objects are, the larger the entropy is, it can be used for further separation and extraction of surface features [15].

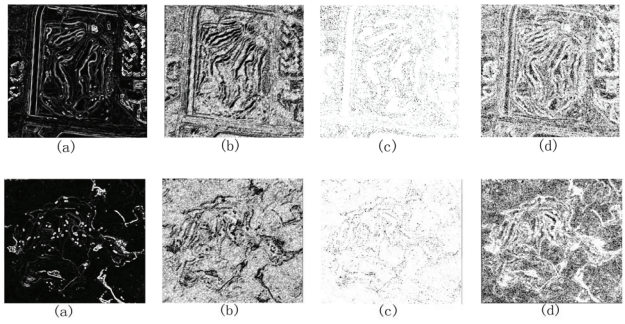
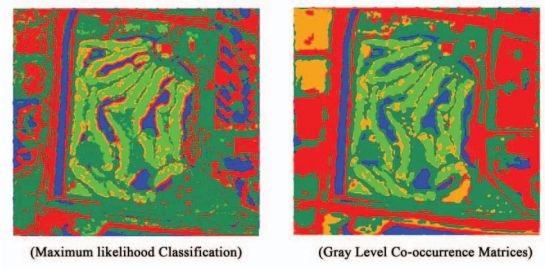


Figure 2. The result of texture analysis
(a)Contrast; (b) Homogeneity; (c) Correlation; (d)Entropy

B. Results and Classification Accuracy Assessment

Compared with the results of texture feature extraction and the traditional pixel-based classification method—maximum likelihood classification (Figure 3), we could find that: For the maximum likelihood extraction method, there are obvious phenomenon of "salt and pepper phenomenon ", on the contrary, the result extracted by GLCM is much better. Especially in test area of forest, there even is lots of misclassification on golf courses extraction.



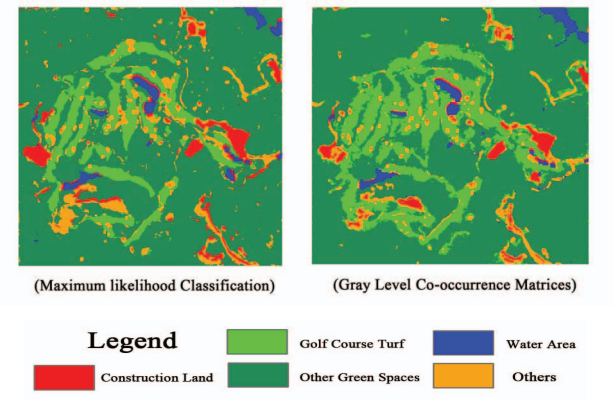


Figure 3. The comparison chart of extraction results

Calculate the overall accuracy and kappa coefficient as table 1. For the extraction of golf course turf in urban test area, the accuracy is only at 76.23% by maximum likelihood method, but it increased to 85.67% by the texture features added. So did the extraction of golf course turf in forest test area, the accuracy is at 64.12%,and for an accuracy at 80.02% by the texture features added. The reason could be that the traditional maximum likelihood classification is pixel-based; so the golf course turf is easily misclassification with other green spaces. After the texture features being joined, golf course turf is more obvious than other green spaces; it is helpful in the classification.

The overall accuracy of pixel-based maximum likelihood extraction is only 75.3952% and 74.2756%, and the Kappa coefficient is 0.6573 and 0.6058 respectively. Whereas the overall accuracy of GLCM-based method extraction is 80.3964% and 82.4919%, Kappa coefficient is 0.7372 and 0.7401. While the overall accuracy increased by 5.0012% and 8.2163%, and the Kappa coefficient increased by 0.0799 and 0.1343 respectively. Whether urban area or forest area of golf courses, the results of extraction are considerable improved by the GLCM-based method, even more effective in the forest area.

TABLE I. THE COMPARISON TABLE OF CLASSIFICATION ACCURACY

		Maximum Likeli-hood Method	GrayLevel Co-occurrence Matrices
Golf courses in urban area	**Golf courses turf**	76.23	85.67
	Overall accuracy（%）	75.3952	80.3964
	Kappa coefficient	0.6573	0.7372
Golf courses in forest area	**Golf courses turf**	64.12	80.02
	Overall accuracy（%）	74.2756	82.4919
	Kappa coefficient	0.6058	0.7401

IV. CONCLUSIONS

This study combines the feature characteristics of golf courses with the rich texture information of SPOT 5 high resolution image. After the principal component analysis of two pilot areas, we choose wavelet analysis method to prominent the texture information of golf courses fairway and turf, then calculate the statistics index of texture features by GLCM, obtain the four index——contrast, correlation, homogeneity and entropy, which could reflect the internal structure of different types of land better. The contrast test indicated that: the extraction of golf courses information based on SPOT 5 images, compared with the traditional pixel-based maximum likelihood method, can improve the overall accuracy and Kappa coefficients significantly. Further improvement of the method will help the remote monitoring and information extraction of the golf courses and other special places.

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