Shadow Extraction of Remote Sensing Images Based on Fractal and Texture Analysis

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Abstract

Based on the characteristic of remote sensing images, the shadow scope was detected with the method of texture analysis, and then the information in the shadow region was resumed by image enhancement. Then based on the random midpoint replacement method of fractal interruption, the shadow region was filled, and then the ground features in the shadow were retrieved truly. The processing result proved the method validity in project.

Introduction

City remote sensing image is the foundation of city's planning, exploitation and construction. Since so many buildings exist in the city, the shadow phenomenon is quite serious for both satellitic and aviatic image.

The ground features within the shadow region of remote sensing image are always difficult to read due to too less information. In the project, the shadow disturbs the result of image processing greatly. So how to remove the shadow from image has been paid much attention to for many years.

General Methods of Shadow Detection

In recent years, several methods of shadow detection from remote sensing image have been put forward, such as Histogram[1], Homostasis[2], normalized processing[3], texture analysis[4], and DSM data[5], etc.

1 Histogram shadow method is to detect the shadow region with the mehtod of double-peaks, then enhances image by extending its Histogram, finally detects the information within shadow. Although this method is simple, the image processing effectivity is always not so good because of much errors.

2 Homostasis shadow detection method is based on the image's reflectivity and radialization in space region and frequency region simultaneously. Although this method is robust, the problem of Histogram method cannot be avoid.

3 Normalized processing shadow method is to magnify the gray levels in the shadow region, but to reduce the gray levels outside according to some certain scale. Therefore, how to define the scale accurately must be solved firstly in project.

4 Texture analysis method is based on use of both the spectrum information and texture one of remote sensing image. This method is an effective one to detect and remove shadow region, and is widely used at present.

Other methods, such as shadow detection based on DSM data, is also effective. However, DSM data can only work with high-resolution remote sensing (such as IKONOS image), so its application scope is limited.

Texture Analysis Method

As the important image information, texture reflects the coarseness, contrast, fine degree, and regulation, etc.of the image. Based on the statistics, co-occurrence matrix describes the relationship among one pixel and its neighbors. By co-occurrence matrix and its texture exponents, the shadow region of city remote sensing image was processed in this paper.

Different from common statistical methods, the co-occurrence matrix one doesn't calculate with original gray level of image, but to do with the 2-order combined conditional probability between gray levels of image. Where $P(i, j/d, \theta)$ represents the probability of gray level (i, j) with the gray level i under different distance d and direction θ.

Since co-occurrence matrix includes great deal of information of image, 14 different kinds of correlated texture exponents were defined by Haralick[6~8]. They reflect image texture character. The general texture exponents are mainly:

1) Energy One

$$E = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1}\left[P(i, j/d)\right]^2 \quad (1)$$

2) Contrast One

$$C = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1}(i-j)^2 P(i, j/d) \quad (2)$$

3) Entropy One

$$En = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1}P(i, j/d)\log P(i, j/d) \quad (3)$$

4) Local Consistency One

$$H = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1}\frac{P(i, j/d)}{1+(i-j)^2} \quad (4)$$

Through simulated experiments with different images and regions, it can be proved that the shadow detection with energy exponent is better than others.

In the calculating process of co-occurrence matrix and correlated texture exponents, the result is sensitive to the calculated direction and window size. The study demonstrates[4] that for high-resolution remote sensing images, the result is not sensitive to the direction when detect shadow with co-occurrence matrix and correlated texture exponent. Besides that, the simulation results demonstrate that the effect is best with the 3×3 window.

In order to obtain better image quality, the shadow region must be processed further with the co-occurrence matrix and correlated texture exponent. For simple, it is possible to divide the image into several parts, and optimize the image with 3×3 model. The cyclostyle coding is shown as Fig.1, where each pixel is calculated with its surrounding ones.

2	4	8
256		16
128	64	32

Fig.1 the cyclostyle coding

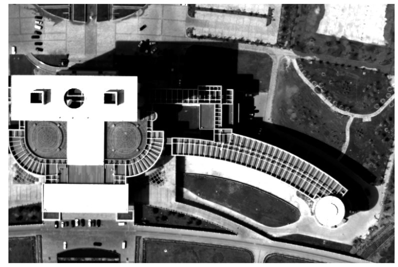

Fig.2 The aviatic remote sensing image of governmental building

Random Midpoint Replacement Method

In order to retrieve the ground features within the shadow region, the interruption method is needed. Although the original interruption method such as linear one, double-precision one, is easy to be realized, the image fractal character is always be destroyed in some degree, and then the interruption result is not accurate enough. Due to the fractal character of most natural scenery's surface in remote sensing image, random midpoint replacement (RMR) methods, one of fractal interruption ones, is selected to retrieve the ground features within shadow region.

Based on the exponential relationship of average, variance and time interval in the FBM function, the RMR method gets the interruption point level by adding an Gauss random item, which reflects the exponential relationship of FBM's variance, on the average of nearby points.

Study demonstrates that RMR method is suitable to the self-similar curve (or surface), such as mountain, sea ridge, etc. effectively. Its formula is

$$x(i) = \frac{1}{2}\left[x(i-1) + x(i+1)\right] + \sqrt{1-2^{2H-2}} \cdot \left|\Delta t\right|^{H} \cdot \sigma \cdot Gauss(\cdot) \qquad (5)$$

Where $Gauss(\cdot)$ function is a random serial with zeros mean and step variance. σ , Δt , and H are variance, distance of interruption points, and *Hurst* exponent respectively. H and fractal dimension D have the relationship

$$D = D_T + 1 - H \qquad (6)$$

Where D_T is topu dimension. Based on formula 5, the sample curve (or surface) with any resolution can be gotten. In RMR function, the wave and roughness are determined by parameter H , σ and Δt simultaneously. The larger σ is, the greater curve waves. Similarly, the larger H is, the more smooth curve is. When $H = 1$, the RMR method turns to normal linear interruption one.

The study demonstrates that the RMR method can simulate the complex curve (or surface) accurately, and reflect the fractal character of natural scenery in remote sensing image.

Simulation Result

In order to prove the method effectiveness, the shadow region of city remote sensing image is detected and removed in this paper, and then the ground features within the shadow region were retrieved with the RMR method. The selected aviatic image is the governmental building in Shihezi city of Xinjiang province, shown as Fig.2

It can be seen from Fig.2 that shadow region is too heavy to identify anything in it.

Firstly, the shadow region was detected with the texture analysis method. After processing with cyclostyle, opening and closing method, the isolated points were removed and little region was filled. The detected shadow region is shown as Fig.3.

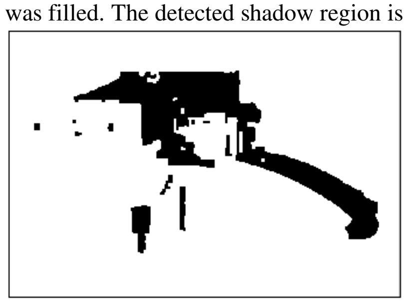

Fig.3 The detected shadow region

Secondly, the shadow region is processed with the image enhancement method, and then the information in it was extracted. The extracted shadow region is shown as Fig.4.

Fig.4 The extracted shadow region

It can be seen from Fig.4 that although the ground features within the shadow region can be detected, the image quality is still not well and difficult to be identified. Finally, in order to retrieve the ground features, the RMR method is used to simulate the scenery in shadow region.

Where σ and *Hurst* were selected according to that of outside scenery near the shadow region, and *Hurst* Exponent was gotten with formula 6. For different region, $\sigma_1 = 0.1953$, $H_1 = 0.21$, and $\sigma_2 = 0.0674$, $H_2 = 0.73$ respectively. The final result of shadow detection is shown as Fig.5

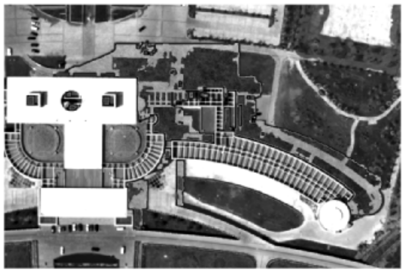

Fig.5 The resumed shadow region of governmental building

Comparing with Fig.2 and 4, it can be seen that the ground features within shadow region is resumed truly in Fig.5. The image quality is well.

Result and Expectation

In the processing of city remote sensing image, building shadow needs to be solved imminently. Based on the co-occurrence matrix and its correlated texture exponent, the shadow region was detected in this paper. Besides that, based on the image enhancement method and RMR, the shadow region was detected and simulated, and then the ground features within the shadow region were retrieved truly. The simulation results proved the method effective in this paper.

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Author Biography

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His research realms include fractal signal processing, road detection, target detection, image restoration, etc. He has published more than 10 papers in the famous publication and conference in China or abroad.

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