MULTI-SPECTRAL REMOTE SENSING IMAGE RETRIEVAL BASED ON K-L TRANSFORMATION

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ABSTRACT:

Along with the rapid development of remote sensing technology, remote sensing images have been used in more and more fields. How to retrieval the images rapidly and effectively from the gigantic database consequentially becomes an important and challenging task. Considering the characteristic of multi-spectral or hyper-spectral remote sensing images, K-L transformation based image retrieval method is proposed in this paper. Instead of original multi-spectral image, an image retrieval can be carried out using the histogram of the first three principal component images,. If we use an annular histogram in the image retrieval process, the spatial information of the image is introduced at the same time, which makes the retrieval more effective.

1. INTRODUCTION

Remote sensing image is actually a spatial information data. The diversity, complexity and magnitude of the remote sensing data asks for higher accuracy and efficiency in the organization, feature description and similarity matching of the remote sensing image , which contribute to the significance and difficulty of the research on remote sensing image retrieval.

The main visual feature of multi-spectral or hyperspectral remote sensing images includes spectral feature, texture feature, as well as the shape feature, while the spectral feature is the most fundamental characteristics. In addition, compared to other visual features, spectral characteristics has less dependence on the size ,the rotation and perspective of the image, thus has a higher robustness. However, the multi-spectral characteristic and magnitude of multi-spectral or hyperspectral remote sensing image data bring a serious challenge to the efficiency of image retrieval. Due to the high correlation between different bands of remote sensing images, in image retrieval, we should consider the redundant of the image data. The main purpose of K-L transform is to compress the useful information in original multi-band images to the fewest new principal component images which are uncorrelated.

The spectral feature based image retrieval is similar to the methods based on colour feature. At present, the common used colour-based image retrieval methods are colour histogram, cumulative histogram, colour moment, colour convergence vector and the colour correlogram [Zhou Mingquan,2007] and so on. However, these methods above did not take the spatial information of the image into account. Therefore, to these images with rich spatial information, the methods with only colour histogram it is not applicable. The solution is to use image division methods. However, neither the fixed mode, semi-dynamic or dynamic approach has the disadvantage of rotational invariance. Considering this, Aibing Rao (1999) put forward a method of annular histogram.

2. K-L TRANSFORMATION AND ANNULAR HISTOGRAM

2.1 The Process of K-L Transformation

According to the definition of K-L transformation, the process of K-L transformation for multi-spectral images is as follows:

(1) X is the data matrix of multi-spectral images (each line stands for a band of the image), We can calculate its covariance matrix C;.

(2) Calculate the eigenvalues λ and eigenvectors U of covariance matrix C, and then compose transformation matrix T;

(3) With K-L transformation we can get the new matrix Y , each row of the matrix is a principal component.

2.2 Annular Histogram

Aibing Rao put forward a new kind of histogram called annular histogram (Aibing Rao, 1999); it can be used to describe the distribution of the spectrum. Let $(P_{ij})_{C*R}$ be an image of size $C*R$, where P_{ij} is the colour of pixel (i, j) . Let $U=\{(x,y),1\le x\le C,1\le y\le R\}$, and suppose B_1, B_2 , ..., B_M are the blocks in the colour space after quantization with M colour bins.

Let $S_q=\{(x,y)\,|\,(x,y)\in U, P_{xy}\in B_q, 1\le q\le M\}$, then $U=\bigcup_{q=1}^{M} S_q$ is a partition of U. Here each S_q , called

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histogram subset of bin B_q , is the set of pixels whose colour is in the q^{th} bin.

Next consider the histogram subset S_q as a geodetic set on the 2-D plane for each color bin B_q. Let $C^q = (x^q, y^q)$ be the centroid of S_q, where x^q and y^q are defined as

$$x^q = \frac{1}{|S_q|}\sum_{(x,y)\in S_q} x; \quad y^q = \frac{1}{|S_q|}\sum_{(x,y)\in S_q} y \qquad (1)$$

Let r^q be the radius of S_q which is defined as

$$r^q = \max_{(x,y)\in S_q}\sqrt{(x-x^q)^2+(y-y^q)^2} \qquad (2)$$

Given a number N, uniformly divide the radius into N buckets, then draw N concentric circles with C^q as the centre and with kr^q / N as the radius for each $1 \le k \le N$ from N annular regions. The intersections of S_q with each of the regions from the innermost to the out-most one, R_{q1}, R_{q2},…, R_{qN} give a partition of S_q. Vector ($|R_{q1}|, |R_{q2}|, ..., |R_{qN}|$) is called the annular distribution density of the set S_q. N is called the spatial granularity of the density.

Set $A_{ij} = |R_{ij}|$ for $i = 1,2,...,M$ and $j = 1,2,...,N$, then a $M*N$ matrix $A = (A_{ij})_{M*N}$ is a modification of the traditional histogram. This matrix is called annular histogram of the image (Aibing Rao, 1999).

Comparing to the strategy image block, annular histogram not only introduces spatial information in image retrieval, but also has the character of rotational invariance.

3. REMOTE SENSING IMAGE RETRIEVAL BASED ON K-L TRANSFORMATION

Multispectral remote sensing image has pertinence between different spectral bands, with K-L transformation we can concentrate the useful information of the multispectral images into a minimal number of principal component images, it is known that the first principal component image contains over 80% of the information of the original variable and the first three principal component images contains over 90%. Choose the first three principal component images to take the place of the original images, and then extract the histogram as the content of image retrieval and calculate the similarity of the images.

3.1 Feature Extraction

Choose the first three principal component images with K-L transform, and use them to take the place of the original images, and then extract the traditional histogram and annular histogram respectively.

Let r the gray lever of the pixels in an image, the probability density function P(r) describes the gray level distribution as

$$P(r_k) = n_k / N \qquad (3)$$

where N is the total number of pixels in an image;
r_k is the k^{th} gray lever;
n_k is the number of the pixels with gray lever r_k ;

Thus $P(r_k)$ describes the probability of the gray level distribution(Jia Yonghong,2003). Traditional histogram describes the overall description of the gray levers of the image, while the annular histogram introduces the spatial information.

3.2 Similarity Measurement

Different methods are selectable if we extract different feature to measure the similarity of the images. In the experiment the common method, namely histogram overlap algorithm (Zhou Mingquan, 2007) in measuring the similarity of histogram is chosen, the function is as follows:

$$D_{hi}(q,t) = 1 - \frac{\sum_{m=0}^{M-1}\min(h_q(m), h_t(m))}{|h_q|} \qquad (4)$$

Where q is the query image, t is the target image, h_q is the histogram of the query image, and h_r is the histogram of the target image, with $|h_q| = \sum_{m=0}^{M-1} h[m]$.

With the principal component images, the similarity can be calculated, it is the weighted sum of the histogram of the principal component images, the function is as follows:

$$D = \sqrt{\alpha D_R^2 + \beta D_G^2 + \gamma D_B^2} \qquad (5)$$

Where D_R, D_G, D_B are the histogram overlap algorithm of the three principal component images between the query and target images;
α, β, γ are the weights respectively.

3.3 Evaluation Methodology

The standard average ranking method is used to evaluate the method proposed in this paper. The function is shown as follows:

$$K = \frac{1}{NN_A}\left(\sum_{r=1}^{N_A}\rho_r - \frac{N(N+1)}{2}\right) \quad (6)$$

Where N is the number of images retrieved

N_R is the number of the related images concluded in N

ρ_r is the serial number of the related images

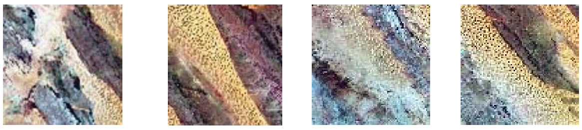
N_A is the the number of all related images

In an ideal case, K is 0, which means the related images are in the front of all images retrieved.

4. EXPERIMENTAL RESULTS AND ANALYSIS

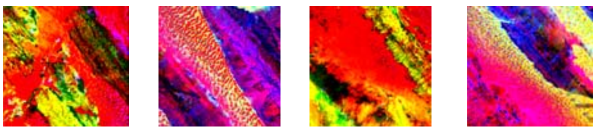
4.1 Experimental Data

In the experiment, a set of TM images from three temporal download from earth science data interface is used, we divide the image into four segments, each with a size 500*500. Figure 1 is the subset images, and Figure 2 is the K-L transform images (the first principal component image is displayed with red, the second green and the third blue) .



(a) (b) (c) (d)

Figure 1. The subset images



(a) (b) (c) (d)

Figure 2. Images after K-L transformation

4.2 Experimental Results and Analysis

The method proposed is evaluated by the standard average ranking index, the results is shown in table 1, and one of retrieval results is shown in figure 3:

	a	b	c	d	averag
M1	0.19	0.11	0.06	0.11	0.12
M2	0.11	0.03	0.08	0.08	0.08
M3	0	0	0.17	0.03	0.05

Table 1. Result of standard average ranking method

In the table, M1 denotes the method using global histogram, M2 denotes the method with global histogram based on K-L transform, and M3 denotes the method with annular histogram based on K-L transform. a, b, c, d are the query images.

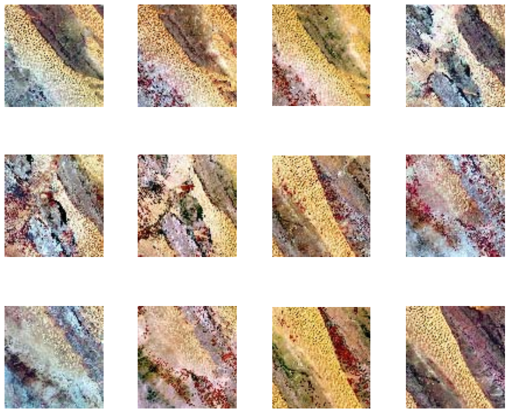


Figure 3. M3’s retrieval results (r=60)

The results show that the method using K-L transform based global histogram is more powerful than the traditional one whether in accuracy or efficiency, and when using annular histogram in the retrieval, the spatial information of the image is introduced, which further improves the accuracy.

5. CONCULSION

Considering the multi-spectral characteristics of remote sensing images, an image retrieval method based on K-L transform is proposed, and the experimental results show that the proposed method improved both the precision and recall ratio of image retrieval.

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