The texture image retrieval algorithm that combines wavelet transform with uniform pattern LBP

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Abstract

The texture feature extraction is a hot research topic in the field of image retrieval.The paper proposes a fusion method of wavelet transform and the uniform pattern LBP to extract the texture of image, so as to realize the image retrieval.Firstly It conducts wavelet transform of image and extracts each subband mean and variance of wavelet coefficient.Then in each subband coefficient matrix, It extracts the LBP features. Finally the LBP features combine with the mean and variance of wavelet coefficient to constitute texture feature vector for image retrieval, The method overcomes the defects of single feature retrieval and proves that it is a more effective way of feature fusion.Then retrieve in the brodatz texture image database. Compared with other methods, a better retrieval results have been achieved.

Keywords

texture;LBP;wavelet transform;characteristic vector;retrieval.

1. Introduction

Thanks to the development of multimedia technology, more and more people spread and share images and videos on the Internet, it also makes the image database get bigger. Therefore, producing an efficient image retrieval system is more and more necessary. Image retrieval system is divided into Text-based image retrieval (TBIR) and Content-based image retrieval (CBIR)[1].TBIR technology use keywords to describe images, namely creating a link between image keywords and image storage paths. This system has a strong subjective consciousness and spends a lot of human resources to annotation images stored in a database. CBIR queries images by extracting color, texture, shape, spatial location relationship characteristics and the combination of these characteristics of the object or area in an image, effectively overcomes the defects of TBIR. Image texture feature extraction has been a hot research topic in CBIR technology research. Wavelet transform to image singularity detection is very effective, especially suitable for image texture feature extraction, so widely used in image retrieval. The author uses wavelet transform for image feature extraction and image retrieval in [2]. LBP (Local Binary Pattern) is developed on the basis of image texture spectrum. It has also made very good effect on texture feature extraction. The author uses LBP operator to proceed texture feature extraction of image in [3].This paper proposes a method which combines wavelet transform with uniform pattern LBP to conduct texture image feature extraction for image retrieval, realizes that image texture combines transform domain characteristic and statistical characteristic effectively. The method has obtained the good recall and precision.

2. Related work

Texture is an irregularity in the image locally, but on the whole exhibits some regular features. Unlike color features, texture feature is no longer characteristics based on the pixel, it need to include more

than one pixel area to do statistical calculation. It mainly describes the relationship between the local area adjacent pixels. It is more emphasis on the local, with great advantages in pattern matching, so it is not because of local bias and cannot match the success. It has the rotational invariance and the regional, and strong resistance to noise, so becomes a hot spot in the field of image retrieval. There are three kinds of texture analysis methods used commonly: statistical method, structural method and spectral method.

Wavelet Transform

Spectrum analysis method realizes feature extraction in transform domain. Wavelet transform [4-5] is a typical method to extract texture features in transform domain .It is developed by Fourier transform, so It has the characteristics of Fourier transform, and compensates for the deficiency. The wavelet transform makes basic wavelet conduct displacement τ ,then do the inner production with signals $x(t)$ to be analyzed under different scales α , as shown in formula(1):

$$\mathrm{WT}_x(\alpha,\tau)=\frac{1}{\sqrt{\alpha}}\int_{+\infty}^{-\infty}x(t)\varphi^*(\frac{t-\tau}{\alpha})dt \tag{1}$$

In formula (1), α is the scale factor, its effect is scaling to the basic wavelet, τ represents displacement. Wavelet transform is conducted to the basic wavelet scale expansion and displacement. It obtains time information through translating basic wavelet. It obtains frequency information through the basic wavelet scale expansion. It operates basic wavelet's scale expansion and translation in order to calculate the coefficient of the wavelet, the coefficients are on behalf of the relationship between wavelet and local signal. After a wavelet transform image signal is divided into four frequency bands, namely the high frequency part of horizontal, vertical and diagonal direction and the low frequency part. The energy of image mainly concentrates in the low frequency part and high frequency part of the energy is less.Figure1 is wavelet decomposition diagram, L represents the low frequency part, H represents high frequency part,1、2 represent the decomposition series.

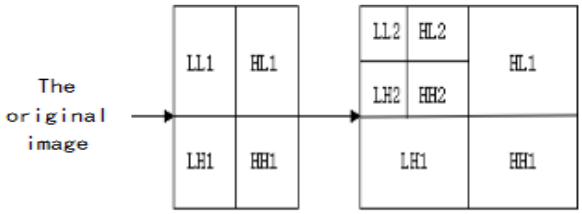
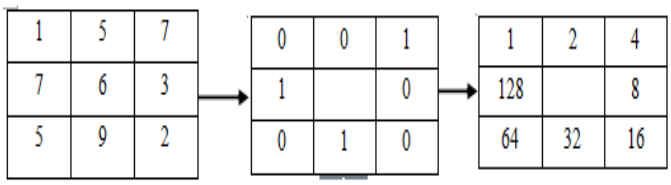


Figure1.Wavelet decomposition schematic diagram

Local Binary Pattern

LBP[6] belongs to texture statistical feature of image. It is a kind of effective method to extract the texture primitive, It counts image texture primitive to represent the texture characteristics. It was proposed by Ojala[7] on the basis of texture spectrum method, and achieved good effect on the image texture feature extraction .Basic LBP is calculated by comparing a 3×3 window center pixel and its neighborhood. If the element is below the center pixel, It is set to 0.If greater than the center pixel, It is set to 1.Finally multiply weighting template by the image elements after threshold processing to get the LBP of image center pixel values, the concrete implementation method is shown in figure 2.



LBP=128×1+32×1+4×1=164

Figure2.A specific example of basic LBP implementation

In order to describe the texture structure under different scales, ojala [8] put forward the circular field instead of rectangular areas. Assuming that the field radius of central point is R, P pixel points, It writes LBP values of the central pixel for $LBP_{P,R}$ .Specific implementation is shown in formula (2), (3). g_p represents each pixel values of the circular field, g_c represents the center pixel values.

$$LBP_{P,R} = \sum_{i=1}^{P} 2^{(i-1)} \times f(g_p - g_c) \tag{2}$$

$$f(x) = \begin{cases} 1, x \geq 0 \\ 0, else \end{cases} \tag{3}$$

Ojala[8] then put forward a uniform pattern LBP, the pattern of LBP contains image local texture information, most of image texture features can efficiently be described and significantly reduce the number of features. Unified pattern LBP refers that when It is calculated in a cycle for the circular neighborhood, It can appear 2 times jump of 1 to 0 or 0 to 1 at most. For example, there are two times jump in 00011000,It is a unified pattern;00101100 has four times jump, It is not unified model. The realization of a uniform pattern of LBP can be seen in formula (4),(5).

$$LBP_{P,R} = \begin{cases} \sum_{P=1}^{P} f(g_p - g_c), \text{ if } U(LBP_{P,R}) \leq 2 \\ P+1, otherwise \end{cases} \tag{4}$$

$$\begin{aligned} U(LBP_{P,R}) = & \left| f(g_p - g_c) - f(g_1 - g_c) \right| + \\ & \sum_{P=2}^{P} \left| f(g_p - g_c) - f(g_{p-1} - g_c) \right| \end{aligned} \tag{5}$$

3. Algorithm implementation process

It is very effective for wavelet transform to detect a single pixel in the image, but It is short of description of image local characteristics. LBP operator can implement the description of image local primitive structure. This paper presents a image retrieval algorithm which fuses the two kinds of characteristics together. The concrete implementation steps are as follows：

Step1: Conduct two layers wavelet transform to all the images in the image library, one low frequency subband and six high frequency subbands are achieved after the transformation. Then calculate the mean and standard deviation of each subband coefficient matrix;

Step2: Extract the unified pattern LBP feature of each subband after the transformation;

Step3:Means and variances of wavelet subbands, LBP eigenvalues constitute the texture feature vector of image, save all the image texture feature vector in the image characteristics library;

Step4:Extract the texture feature to the query image according to the above method, conduct similarity measure between the characteristics and the features in the library, this article adopts the

method of Euclidean distance to match the feature ,its concrete implementation see formulas (6),q、p are two feature vectors, D is the Euclidean distance of two vectors;

$$D(q,p)=\left(\sum_{i=1}^{n}\left|q_i-p_i\right|^2\right)^{1/2} \tag{6}$$

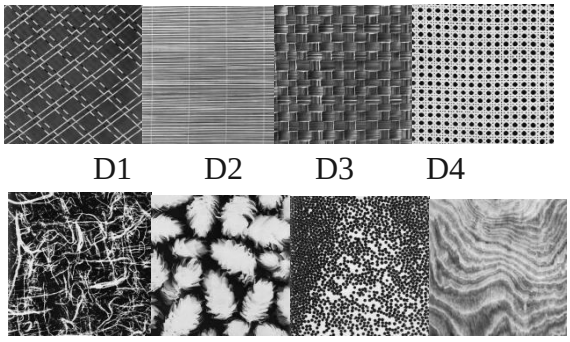
Step5:According to the result of similarity measure, screen in the image library, and return matching results according to the similarity of size from small to large, so as to get the image precision(Formula (7)) and recall(Formula (8)).

$$\mathrm{P}=\frac{S}{M} \tag{7}$$

$$R=\frac{\mathrm{S}}{N} \tag{8}$$

In the above two formulas, P represents precision, R represents recall, M is the set of all images retrieved, N is image collection which is relevant to query image in the image library, S is the number of images which are relevant to query image in a search process.

4. Experiment results analysis



Experiments use Brodatz texture image library.The texture image library has 112 images. Each image's size is 640×640,30 uniform images and 30 randomly heterogeneous images are randomly selected.Uniform images are the images whose texture is clear and texture is in the same direction, such as D1~D4.Non-uniform images are inconsistent in the texture direction and pockety images, such as D5~D8.It divides each of the 60 images into 25 images to get a total of 1500 images.As shown in figure 3, D8 is divided into 25 images.Experiment uses three methods to extract characteristics of uniform and non-uniform images respectively.Every image retrieval returns 25 related images in the 1500 images library .Here M and N are the same in the formula (2) and (3) , so the precision is also recall, the results shown in table 1.

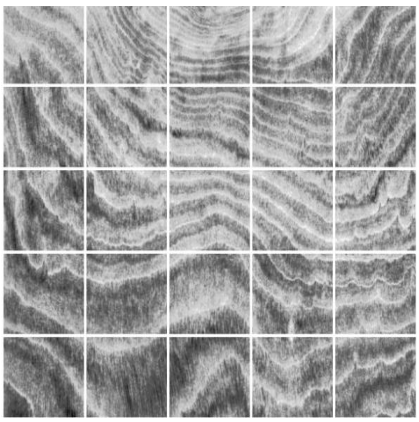


Figure3.D8 segmentation image

Algorithm1(Wavelet):Conduct wavelet trans-form of 2 layers to images using db2、sym4 and haar as wavelet base respectively, after the transformation means and variances of each subband coefficients matrix are as the feature vector for image retrieval;

Algorithm2 (LBP):Extract the unified pattern LBP characteristics of image, generate LBP histogram as the feature vector for image retrieval;

Algorithm3 (This paper): The algorithm which this paper proposed in the third quarter.

That can be seen from table 1 that haar shows better retrieval effect than db2 and sym4 in the image library according to the choice problem of wavelet base. In the retrieval process, the average precision based on the algorithm in this paper after using haar increased by 1.2% compared with the db2, increased by 4.8% which was relative to the sym4.

At the same time you can see, both for the uniform or non-uniform images, this algorithm's average precision is higher than that of wavelet transform method and the LBP feature extraction method in the image library. For example, comparing the three algorithms whose wavelet basis is haar, the average precision rate of the algorithm in this paper is about 13.0% higher than that of LBP features, about 26.1% higher than that of wavelet transform. Obviously, combination wavelet transform which is sensitive to image singularity characteristics with LBP which can effectively extract image primitive structure characteristics, they can form a complementary to realize a better retrieval effect to image.

Table1: The average precision cooperation of three different feature extraction methods

	Uniform images	Non-uniform images	All the images
Wavelet（sym4）	64.4%	41.2%	52.8%
Wavelet（db2）	71.1%	42.1%	55.8%
Wavelet（haar）	76.7%	42.5%	59.6%
LBP	87.1%	58.3%	72.7%
This paper（sym4）	91.7%	69.9%	80.9%
This paper（db2）	92.9%	76.0%	84.5%
This paper（haar）	94.9%	76.4%	85.7%

5. Summary

This paper presents a method which combines uniform pattern LBP with wavelet transform to extract image texture feature. Adopting the unified LBP feature is in order to reduce the complexity of the calculation under the premise of ensuring that the useful image information is not lost. Making it fusion with the wavelet transform to retrieval is in order to achieve the combination of image texture statistical characteristic and spectrum characteristic. The method extracts the texture image characteristics more effectively. The approach retrieves in the brodatz texture image library, achieves higher precision and recall rate than just using wavelet transform to search and the adoption of uniform LBP feature to retrieval, improves the performance of the system, realizes its validity and progressive. In future research, It is possible to fuse with texture model and look for the most effective fusion style of three kinds in order to achieve higher retrieval accuracy.

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