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Image Retrieval Using Rotated Complex Wavelet Filters for Textile Pattern

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Abstract: Unique pattern characteristics of textile pattern are proposed as a factor to consider in the image retrieval algorithm. Dual-tree complex wavelet and Rotated Complex Wavelet (RCW) transform are used to build feature value which is based on the corresponding wavelet coefficients. Then image retrieval method is established on the correlation sequence which is including the characteristics direction of textile pattern instead of the traditional means and variances. The results can be provides basic theoretical support for content-based image retrieval.

Key words: Complex wavelet transform, image retrieval, fabric pattern

INTRODUCTION

In recent years, large-scale image database retrieval becomes an important topic of pattern recognition. As the main factor of fashion and fabric design patterns in art and design has been widely used within the fashion industry, however, it is difficult for designers and customers to find the pattern they want from the mass data.

As an important low-level visual feature, texture has been widespread concerned and texture feature extraction has become a major content-based image retrieval methods.

Wavelet-based textur e feature extraction method has better frequency localization than the traditional color distribution feature extraction method ,and so become a hot research (Celik and Tjahjadi, 2010; Zhu and Shao, 2011; Xavier and Mary *et al*., 2011; Quellec *et al*., 2010). Early Manjunath and Ma (1996) and Loupias *et al*. (2000) proposed texture analysis method based Gabor transform which meaningful visual perception attributes of images can be extracted from. Balmelli and Mojsilovic (1999) tried to use wavelet image features to retrieval the content-based image; Jafari-Khouzani and Soltanian-Zadeh (2005) proposed rotation and scale invariant texture features based on wavelet multi-resolution analysis such as wavelet packet theory, but its texture is lost to some direction information; Han and Ma (2007) got an rotation and scale invariant texture features based on improved Garbor filter, but it had high computational complexity; Pun[14] proposed representation method for image texture of based on Log-polar, which have rotation and scale invariance, but it translate the scale variable into shift variables, which destroyed the frequency characteristics of the signal. For the two-dimensional image, Gluckman (2005) pointed out that using the first-order statistical feature of the sub-bands of the wavelet transform (i.e., the mean and energy) as a texture descriptor is not sufficient. To avoid the disadvantages of wavelet transform, Zhang *et al*. (2009), proposed the first generation Curvelet transform theory. Different with the wavelet transform, in addition to the two parameters of scale and displacement, it added a directional parameter which had better ability to identify the direction. Kokare *et al*. (2005) and Miller and Kingsbury (2008) applied complex wavelet transform method in image retrieval. Because of the complex wavelet rotation invariant and strong direction selectivity, it had better texture retrieval results, but the method used the mean and variance to describe image features and so its ability to identify between the similar images is weak (Huang *et al*., 2011). Clausi and Deng (2005) designed texture feature extraction methods which is combine with other statistical methods in order to improve texture recognition and get higher spatial separation characteristics.

Meanwhile, researchers of Nanjing University (Jiang *et al*., 2010), Sichuan University (Wang *et al*., 2007). Xi'an University of Technology (Meng and Guo, 2011; An *et al*., 2008), Nanjing University of Technology (Huang and Jin, 2011), Jilin University (Song and Wang, 2009) Liaoning Normal University (Cai *et al*., 2008) did a lot of fruitful work on the feature extraction methods using wavelet transform, complex wavelet transform and other integration of multi-method in medicine, remote sensing, trademarks and other areas.

However, there is a significant difference between the retrieval method for fashion industry and for other fields (for example medicine). Usually, finding similar style is the goal instead of precise image. In addition, fabric patterns have some unique pattern design features. In fact, the image with different characteristics should be extracted in different texture features to achieve better results. Almost no research work is found on image retrieval method based on the characteristics of the textile pattern. Rules between textile pattern between and image retrieval method is not clear.

In this study, we combine the classification feature of textile such as horizontal, vertical, cross-stripes, flowers pattern in the retrieval method.

Feature table formed by Dauchechies complex wavelet transform is the basic data for textile Image Classification

ROTATED COMPLES WAVELET TRANSFORM

The two-dimensional (2-D) discrete wavelet transform decomposes an image signal f(x, y):

Frequency-domain partition in discrete wavelet transform resulting from one-level decomposition is shown in Fig. 2.

After the discrete wavelet transform, H_{hh} captures some image information in the diagonal direction, but it is difficult to confirm which direction the information come from(angle 45° or 135°) . So, we design a new wavelet transform which has orientation identification. The filter of 2D discrete wavelet transform is rotated 45°. Then there are changes of the decomposition orientation shown in Fig. 3.

So, the High-pass and low-pass coefficient:

$$H_{LL} = h^T h$$
$$H_{LH} = h^T g$$
$$H_{HL} = g^T h$$
$$H_{HH} = g^T g$$

h the Daubechies High-pass coefficient and g is low-pass coefficient. Computational complexity between the rotated wavelet transform and the conventional wavelet transform is the same.

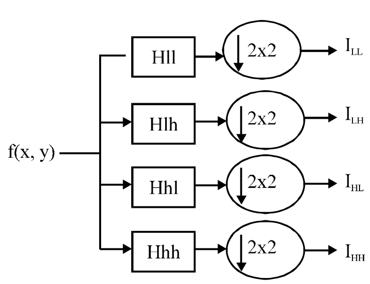

Fig. 1: 2-D Discrete wavelet transform

The dual-tree complex wavelet transform (DT-CWT) decomposes an image signal.

The upper tree is the real parts of DT-CWT and the below one is the imaginary parts. 2 means separate point sampling. It is found that the coefficient after the complex wavelet transform has shift invariance and good directional selectivity. In this study, the dual-tree complex wavelet is implemented using two separable transforms and by combining sub-band signals appropriately. The decomposed coefficients come from the separable transform is used as the output. The six wavelet sub-bands captures pattern information in six directions $\{+15,+45,+75,-15,-45,-75\}$.

CORRELATION SEQUENCE C(d)

There are many kinds of textile pattern. We study the basic pattern of horizontal, vertical, cross-stripes and flowers pattern. First, the DT-CWT decomposes the image (256×256 pixel). Then the means μ_{ij} ($i = 1, \ldots, 4$, $j = 1, \ldots, 6$) and standard variance σ_{ij} of the wavelet coefficients in six directions are calculated at each sub-band image. We design the correlation sequence C(d):

$$C(d) = \frac{1}{N_0(d)} \sum_{k=0}^{N_0(d)} Cor(kd, (k+1)d)$$

$$Cor(i, j) = \frac{\sum_{m=1}^{N} \{c_i(m) - \mu_{ci}\}\{c_j(m) - \mu_{cj}\}}{\sigma\{c_i(m)\}\sigma\{c_j(m)\}}$$

$$N_0(d) = \frac{N-1}{d},\ d = 1, 2, \ldots, N-1$$

$$D_x(orD_y) = \frac{1}{N-1} \sum_{d=1}^{N-1} C(d),\ d = 1, 2, \ldots N-1$$

The means of the correlation sequence is including the characteristics direction of textile pattern. Instead of the traditional means and variances, the data after normalization is used as texture feature to form feature retrieval method.

EXPERIMNETAL RESULTS

500 images (256×256) are collected from the Fashion Company fabric database. There are some of them shown in Fig. 5.

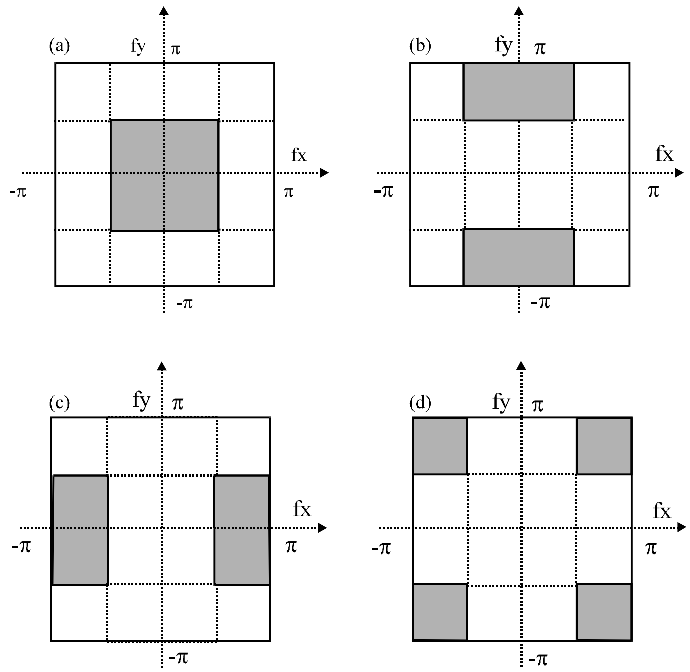

Fig. 2: Frequency-domain partition in discrete wavelet transform resulting (a) H_{ll} (b) H_{lh} (c) H_{hl} and (d) H_{hh}

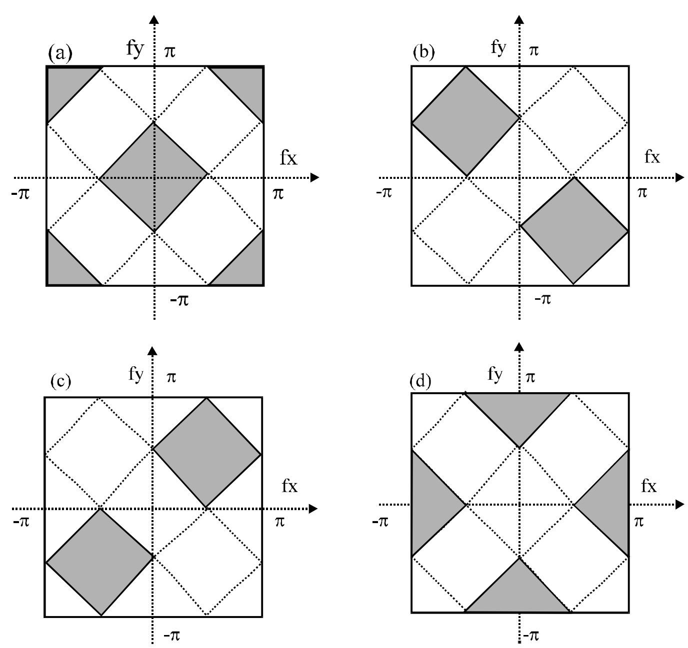

Fig. 3: Frequency-domain partition in rotated wavelet transform resulting (a) H^R_{ll} (b) H^R_{lh} (c) H^R_{hl} and (d) H^R_{hh}

We get the D_x, D_y of each pattern after calculation. Parts of results are shown in Table 1. It shows that the horizontal patterns, D_x is higher in the horizontal sub-bands and the vertical patterns, D_y is, meanwhile the cross-stripes patterns have ghave lower directivity values.

Table 1: Parts of results of directionality values

Image No.	D_x	D_y	Image No.	D_x	D_y
(1)	0.934	0.091	(5)	0.791	0.635
(2)	0.912	0.125	(6)	0.921	0.789
(3)	0.053	0.956	(7)	0.015	0.018
(4)	0.045	0.891	(8)	0.014	0.017

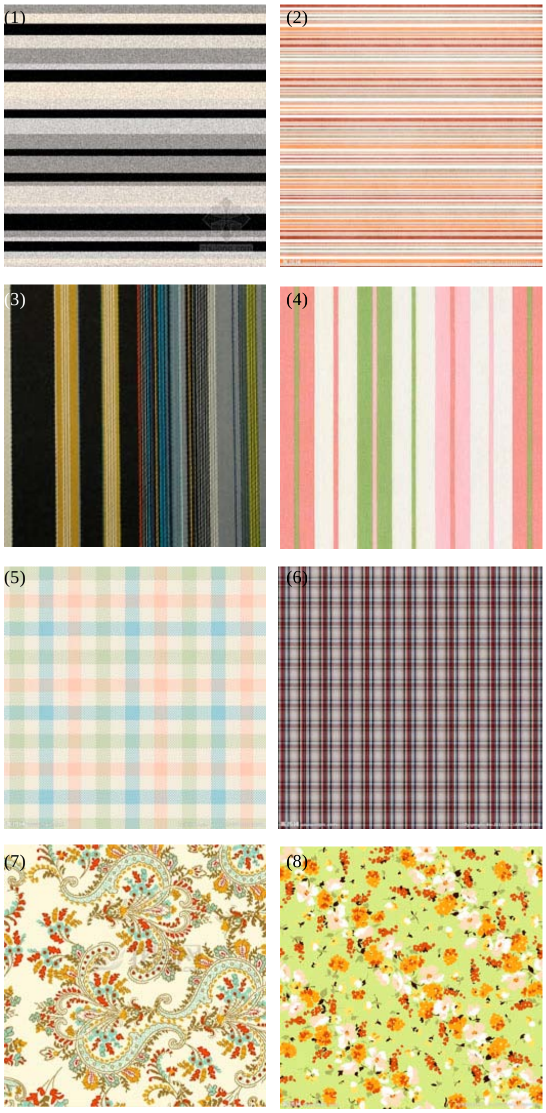

Fig. 4: The dual-tree complex wavelets transform

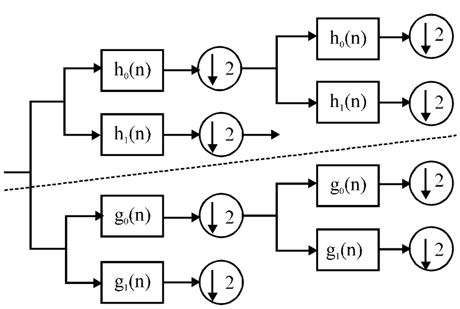

Fig. 5: Some fabric pattern images

We analysis the results of 500 images and the directionality values range of various images are shown as Table 2.

Table 2: Directionality values range of various images

Images	D_x	D_y
Horizontal	0.812-0.965	0.078-0.169
vertical	0.04900.155	0.811-0.955
cross-stripes	0.618-0.931	0.677-0.934
flowers	0.011-0.024	0.012-0.029

CONCLUSION

In this study, Dual-tree complex wavelet and Rotated Complex Wavelet (RCW) transform are used to build feature value which is based on the corresponding wavelet coefficients. Then image retrieval method is established on the correlation sequence C(d) which is including the characteristics direction of textile pattern instead of the traditional means and variances. Further studies can be extended to other types of textile pattern category.

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