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High-Resolution Automated Fingerprint Recognition System (AFRS) based on Gabor wavelet and SVM

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Abstract— motivated by the desire to construct efficient biometric systems, we propose a fingerprint identification system based on Gabor wavelet and Support vector Machine (SVM).We demonstrate that the Gabor wavelet based on features can capture textural information at different scales and orientations and it can achieve high recognition rates utilizing well-tuned SVM. Also, we introduce optimal filter in terms of accuracy and time complexity by changing the parameters of Gabor wavelet. Results obtained from the polyu HRF dataset show that the accuracy of the proposed system is comparable to that obtained using other well-known systems.

Index Terms— Gabor wavelet, SVM, Fingerprint Recognition, Biometric.

1 Introduction

As one of the most popular biometric attributes, the fingerprint is widely used in the verification of identity. Most fingerprint recognition techniques making use of minutiae as fingerprint feature. Using these methods has some problems, because the image must be pre-processed before extracting features. The main steps for minutiae extraction are smoothing, local ridge orientation estimation, ridge extraction, thinning, and minutiae detection [1]. So the accuracy of the system is related to the accuracy of all steps. Another method of fingerprint recognition is using texture features as a feature vector. A method for extracting textural features is using the Gabor wave-let. Gabor filter-based features have been successful and widely applied to texture segmentation [2], face recognition [3], handwriting recognition [4] and fingerprint enhancement [5]. This is because the characteristics of the Gabor filter, especially the frequency and orientation representations, are similar to those of the human visual system [6]. The receptive field space structure of the mammalian visual simple cortical cell can be described with Gabor mathematic function [7]. It has some great properties such as space position selection, direction selection, frequency selection and orthogonally. It extracts the Gabor wavelet coefficients of different direction and scale as features from data gray distribution [8].

Recently, high resolution (≥ 1000ppi) fingerprint images have been increasingly used for fingerprint recognition compared with traditional low-resolution (~500ppi) fingerprint images, they offer better features on fingerprint and thus it can help to further improve the fingerprint recognition accuracy [9]. In this paper, features directly are extracted from fingerprint images by Gabor wavelet without any pre-processing. Then, a SVM classifier is used to learn the data set. The proposed system is assessed on polyu HRF data set. The results of experiments confirm the effectiveness of the proposed system.

This paper is organized as follow: Section 2 describes in detail Gabor wavelet. Section 3 describes support vector machine algorithm. In section 4, we describe proposed system. In section 5, we describe experimental results.your paper.

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2 Gabor Wavelet

Gabor wavelet function is as follows:

$$\Psi(x_0, y_0, \omega_0, \theta) = \frac{1}{2\pi\sigma^2} e^{-(x_0^2+y_0^2)/2\sigma^2}\left[e^{j\omega_0 x_0} - e^{{\omega_0}^2\sigma^2/2}\right] \quad (1)$$

Where $x_0 = x\cos\theta + y\sin\theta$, $y_0 = -x\sin\theta + y\cos\theta$, x and y are the position of pixel. The center frequency is ω_0. The orientation of the Gabor wavelet determines by θ. The norm variance of Gauss function is σ. So in (1), ω_0 controls the Scale of Gabor filters and θ controls the orientation of Gabor filters. In this paper, five center frequencies are used as follows:

$$\omega_0^1 = \sqrt{2}\pi/2, \omega_0^2 = \sqrt{2}\pi/3, \omega_0^3 = \sqrt{2}\pi/4, \omega_0^4 = \sqrt{2}\pi/5, \omega_0^5 = \sqrt{2}\pi/6$$

The orientation parameter $\theta$is selected as follows:

$$\theta^1 = 0, \theta^2 = \pi/4, \theta^3 = \pi/2, \theta^4 = 3\pi/4 \ .$$

Also, we set $k_{max} = \pi/2$

3 Support Vector Machine

SVM is developed based on statistical learning theory [10]. SVM has a very good performance for high-dimensional and is non-linear pattern classification problem by minimizing the Vapnik-Chervonenkis dimensions and achieving a minimal structural risk [11]. Suppose that the training set be as follows:

$$D = \left\{(x_i, y_i) | x_i \in R^p, y_i \in \{-1,1\}\right\} \ ; \ i = 1, \dots, n$$

Where $y_i = 1$, $y_i = -1$which Defines the x_i class. x_i is a p di-

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mensional vector. The goal is to find hyper plane with the maximum margin that can separate the points having $y_i = 1$from those having $y_i = -1$.

Solving optimal hyper plane can be modeled as a quadratic programming problem. For given training samples, optimal weight w and offsets b for the minimizing cost function weight is found. When the training samples are separated and are nonlinear, auxiliary variable ξ_i; $i = 1, \ldots, l$ is used. So the classification problem can be considered as a hyper plane optimization problem as follows:

$$\min \varphi(x) = \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{l}\xi_i \qquad (2)$$
$$s.t \quad y_i(w.x_i + b) \geq 1 - \xi_i$$
$$\xi_i \geq 0; i = 1, \ldots, l$$

In these equations, C is the penalty parameter, which, can help to reduce the number of training errors. After solving the optimization problem, the corresponding optimal decision is as follows:

$$f(x) = sgn\left[\sum_{i=1}^{l} y_i \alpha_i^* K(x, x_i) + b^*\right]. \qquad (3)$$

4 Proposed System

In this paper, fingerprint identification method based on Gabor wavelet and support vector machine have been proposed. Initially, Gabor wavelet features of finger-print samples are extracted and a training set is created. Then the SVM is trained by this training set and optimal classification decision function is computed.

4.1 Gabor wavelet feature extraction

Initially Gabor wavelet filter mask is created according to (1). Assuming that $I(x, y)$ is finger-print image and $G_{m,n}(x, y)$ is Gabor wavelet filter mask. Next, image should be convolution with mask, namely:

$$I_{m,n}(x, y) = I(x, y) * G_{m,n}(x, y)$$

$I_{m,n}(x, y)$ is contain of extracted features. In this paper, image size and mask size are considered equal. If the mask and image size be $M \times N$, then size of $I_{m,n}(x, y)$will be $M \times N$. To create a feature vector, $I_{m,n}(x, y)$ is divided into 4 blocks and the mean and standard deviation for each block are computed. Finally, a feature vector matrix 1×160 is obtained.

$$V = [\mu_{11}, \sigma_{11}; \mu_{12}, \sigma_{12}; \mu_{13}, \sigma_{13}; \mu_{14}, \sigma_{14}; \ldots; \mu_{pq}, \sigma_{pq}]$$

Where number of filters is p and q is number of blocks. In this paper, 20 Gabor wavelet filter is applied to the fingerprint image, which the scale S = 5, and orientation O = 4 are selected.

4.2 SVM fingerprint recognition

As it can be seen in Fig. 1, from extracted features by Gabor wavelet training set and test set are created. According to various classes of training samples, the samples are labeled from 1 to N. where N is the number of people. In next step the kernel function and parameters of Support Vector Machine are deter-mined and by using training set, Support Vector Machine trained and the optimal decision function is obtained. RBF is intended as kernel function, kernel argument and regularization content are selected 27 and 9 respectively.

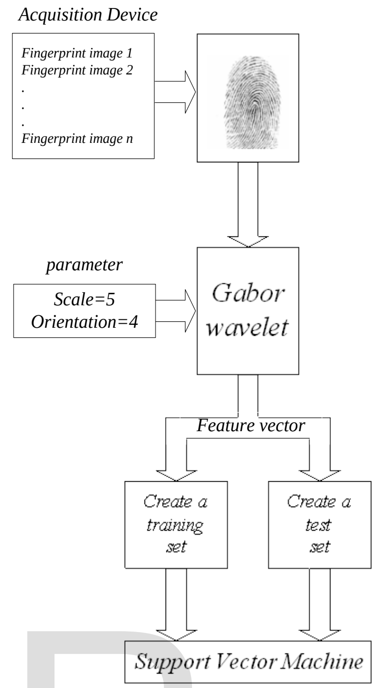

Fig. 1. block diagram proposed system

5 Experimental Results

In this paper we have used the polyu HRF database [12]. Papers [13], [14], [15] have used from this database for their experiments. Examples of this database are shown in Fig. 2.

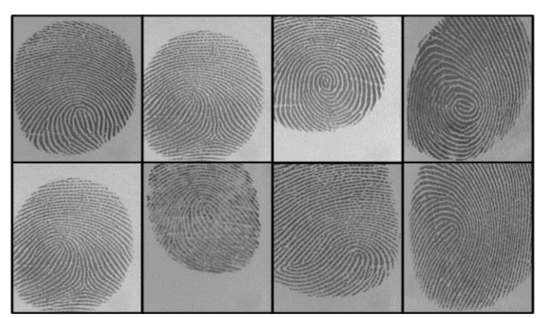

Fig. 2. Examples of database

Fig. 3 shows magnitude Gabor features of two fingerprints belonging to one person. Fig. 4 shows magnitude Gabor features of two fingerprints belonging to different two-person. Fig. 3 and Fig. 4 shows that the magnitude Gabor features of two fingerprints belonging to one person are very similar and the magnitude Gabor features of two fingerprints belonging to two different persons are different. So we can use magnitude

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Gabor features as features.

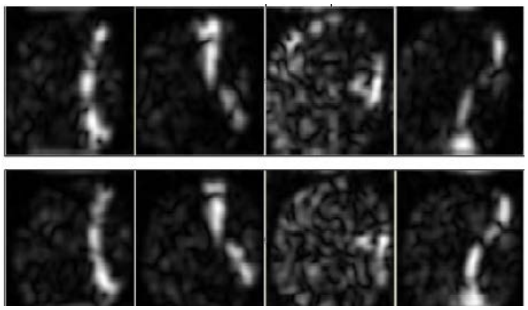

Fig. 3. magnitude Gabor features of two fingerprints belonging to one person

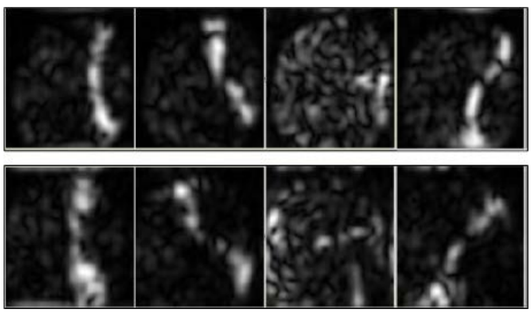

Fig. 4. magnitude Gabor features of two fingerprints belonging to different two-person

We have chosen 500 fingerprint images from 50 people (10 photos per person) for the experiment. For training set, 6 images per person and for test set others of four images have used. Experimental results show accuracy of 95.5%. About choice of scale for Gabor wavelets, experiments are performed with further scales and direction. As illustrated in Fig. 5 and Fig. 6, the results in terms of both time complexity and error rate are compared. As can be seen in Fig. 2, in best filter scale= 5 and orientation = 4.

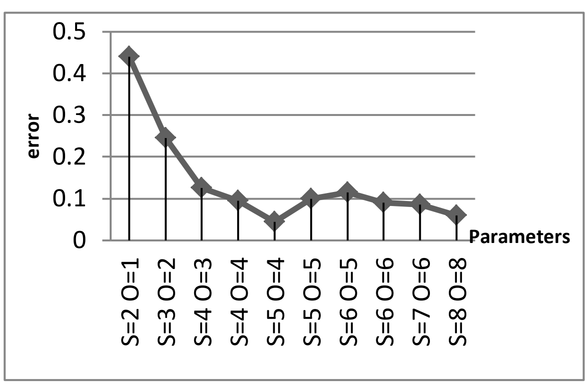

Fig. 5. Error rate of various parameters

In this paper, experiments were done using a computer with MATLAB R2009a software. Computer configuration is Intel core i3 processor and 4 GB RAM.

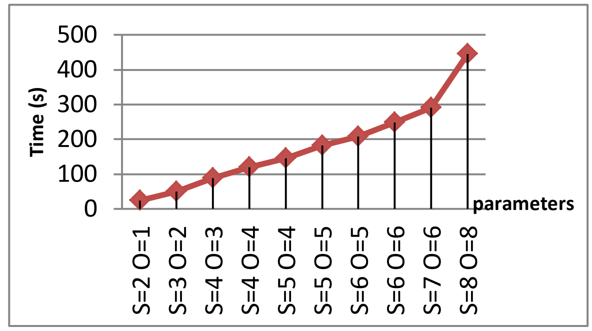

Fig. 6. time complexity of various parameters

6 Conclusion

In this paper fingerprint feature extraction by Gabor wavelet filter and their classification by Support Vector Machines are presented. Gabor wavelet filter is controlled by two parameters $\omega_0$and θ after which Comparison of various parameters we introduced appropriate Gabor wavelet filter. Then, the extracted features, training the Support Vector Machine and the rest is considered as test set. Experiments show that the method is very accurate and its value is equal to 95.5%. According to the results of Chapter 5, scale = 5 and orientation = 4 is considered for filter.

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References

[1] A. Jain, Lin Hong, R. Bolle, "On-line fingerprint verification," *IEEE Trans. Pattern Analysis and Machine Intelligence*, vol. 19, pp. 302-314, 1997.

[2] T.P. Weldon, W.E. Higgins, D.F. Dunn, "Efficient Gabor filter design for texture segmentation," *Science Direct. Pattern Recognition*, vol. 29, pp. 2005-2015, December 1996.

[3] J. Lampinen, E. Oja, "Distortion tolerant pattern recognition based on self-organizing feature extraction," *IEEE Trans. Neural Networks*, vol. 6, pp. 539-547, 1995.

[4] Y. Hamamoto, S. Uchimura, M. Watanabe, T. Yasuda, Y. Mitani, S. Tomita, "A Gabor filter-based method for recognizing handwritten numerals," *Pattern Recognition*, Vol. 31, pp. 395-400, April 1998.

[5] L. Hong, Y., Wan, A., Jam, "Fingerprint image enhancement: algorithm and performance evaluation," *IEEE Trans*, Vol. 20, pp. 777-789, 1998.

[6] J.G. Daugman, "Uncertainty relation for resolution in space, spatial frequency, and orientation optimized by two-dimensional visual cortical filters," *Optical Society of America*, Vol. 2, No. 7, pp. 1160-1169, July 1985.

[7] J.G. Daugman, "Complete discrete 2-D Gabor transforms by neural networks for image analysis and compression," *IEEE Trans. On Acoustics Speech and Signal Processing*, Vol. 16, pp. 1169-1179, July, 1988.

[8] Zhang Guo-yun, Guo Long-yuan, Wu Jian-hui, Li Hong-min, Guo Guan-qi, "Face detection using Gabor wavelet and SVM," *International Conference. Computer Application and System Modeling (ICCASM)*,

vol. 2, pp. V2-588 - V2-590, 2010.

[9] A.K. Jain, Y. Chen, and M. Demirkus, "Pores and Ridges: High-Resolution Fingerprint Matching Using Level 3 Features," *IEEE Trans. PAMI*, vol. 29(1), pp. 15-27, 2007.

[10] Qing SONG, Hui YUAN, Xisheng LIU, Chen QIU, "Support Vector Machine forthe Liquid Drop Fingerprint Recognition," *IEEE Conference Publications*, pp. 280 - 282, 2012.

[11] V. Cherkassky, "The nature of statistical learning theory," *IEEE Trans. Neural Networks*, vol. 6, pp. 1564, Nov 1997.

[12] The Hong Kong Polytechnic University (PolyU) High Resolution-Fingerprint(HRF)Database. *http://www4.comp.polyu.edu.hk/~biometrics/HRF/HRF.htm*.

[13] D. Zhang, Feng Liu, Qijun Zhao, Guangming Lu, Nan Luo, "Selecting a Reference High Resolution for Fingerprint Recognition Using Minutiae and Pores," *IEEE Trans. Instrumentation and Measurement*, VOL. 60, PP. 863-871, 2011.

[14] Qijun Zhao, D. Zhang, Lei Zhang, Nan Luo, "High resolution partial fingerprint alignment using pore–valley descriptors," *Science Direct. Pattern Recognition*, vol. 43, pp. 1050-1061, March 2010.

[15] Qijun Zhao, D. Zhang, Lei Zhang, Nan Luo, "Adaptive fingerprint pore modeling and extraction," *Science Direct. Pattern Recognition*, vol. 43, pp. 2833–2844, August 2010.