An Iris Recognition Algorithm of Multiple Features Extraction and Fusion

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Abstract. In this paper, an iris recognition algorithm of multiple features extraction and fusion was proposed, which was different from the classical iris recognition algorithm that focused on a single texture feature. Firstly, the collected iris images were preprocessed. Secondly, features of preprocessed images were extracted by using Log-Gabor filter and Haar wavelet, and values of similarity were calculated by adopting Hamming Distance and Weighted Euclidean Distance methods. Finally, the Logistic Regression Classifier was used to fuse and classify the values of similarity. The experimental results verified the effectiveness of the algorithm, and a higher correct recognition rate was gained.

1. Introduction

With the development of information and network technology, the traditional methods of identification such as authentication keys and passwords are easy to lose, forget and other shortcomings. So the traditional methods has been unable to meet the needs of this age, and we should have more effective and reliable authentication method to ensure the information security. Based on biometric identification technology, such as fingerprint recognition, face recognition, iris recognition, vein recognition and other identification methods, has become a hot research topic in recent years. Because iris recognition as an important biometric identification technology, has universality, uniqueness, stability, non-invasive and many advantages. Iris recognition can be seen a study of typical computer vision combination with pattern recognition. Before formulating a iris recognition system, there need a device to collect iris image. Then preprocessed iris image, extracted, coded, matched feature template and achieved identification result. So a complete system composes of iris image preprocessing, feature extraction and pattern matching[1].

In this paper an algorithm of multiple features extraction and fusion is proposed rather than a single feature extraction. Firstly, iris area is segmented by canny edge detection operator and least square fitting theory. 2-D Log-Gabor filter is used to extract feature and encoded one template and Haar wavelet of decomposition level 3 is used to extract feature and encoded the other template. Then, calculated the two values of similarity and achieve the result of classification by support vector machine. The iris recognition algorithm of this paper achieved an accuracy 99.13% on CASIA iris image Database. Fig.1 shown block diagram of proposed algorithm which is described in detail in the following sections.
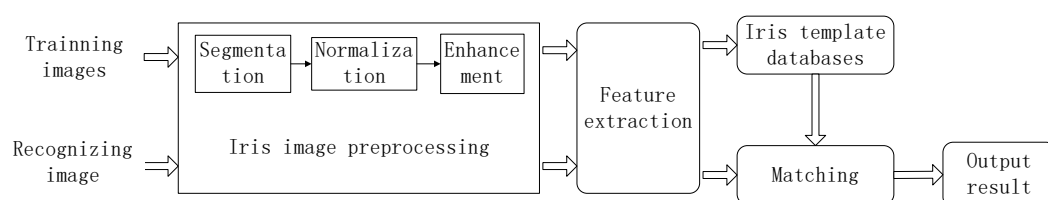

Fig. 1 The block diagram of iris recognition algorithm

2. Iris Image Preprocessing

2.1 Segmentation.

Iris image segmentation that is positioned to the inside boundary between the pupil and the iris, the outside boundary between the iris and the sclera, as shown in Fig.2. Firstly, located the inside boundary. And located the outside boundary secondly, following these steps:

(1)Established a histogram based on the gray level of acquired iris image. Because the gray level of the pupil is smaller than the iris, and the iris's gray level is larger than the sclera. Determinated a threshold value by the histogram, and the acquired binary iris image.

(2)Removal of the binary image eyelashes noise by the operation of the morphological erosion and dilation.

(3)Canny edge detection algorithm and least squares fitting algorithm were used to determine the inner circle of iris boundary.

(4)Canny edge detection algorithm and iris inside boundary were used to eliminate the false outside boundary point.

(5)Least squares fitting algorithm determined the outside boundary..

2.2 Normalization and Enhancement.

In order to allow matching, transformed the different dimensions iris area images to the fixed dimension. Fig.5 show the result of the operation by the rubber sheet mode[2]l.

The iris image contrast after normalization is low, and is not conducive to directly extract the texture features. So the enhancement of image contrast is necessary. In this work, histogram equalization is used to enhance the contrast of the iris texture.

3. Feature Extraction and Matching

3.1 Log-Gabor Filter.

Log-Gabor filter was devised by Field[3] , and it is not only good about multi-channel and multi-resolution characteristics, but also has no DC component. So Log-Gabor filter is strictly a band-pass filter, and could make up for the shortages of Gabor filters' expression of the high frequency component.

$$h_{\{Re,Im\}} = \mathrm{sgn}_{\{Re,Im\}} \, ifft(G(f) * fft(I(n))). \tag{1}$$

Feature encoding is implemented by processing the normalized iris image with the 2D Log-Gabor filter. According to Daugman iris recognition algorithm, the result of filtering is then phase classified to four kinds.

$$h_{Re} = \begin{cases} 1, \mathrm{Re}\, ifft(G(f) * fft(I(n))) \geq 0 \\ 0, \mathrm{Re}\, ifft(G(f) * fft(I(n))) < 0 \end{cases}, h_{Im} = \begin{cases} 1, \mathrm{Im}\, ifft(G(f) * fft(I(n))) \geq 0 \\ 0, \mathrm{Im}\, ifft(G(f) * fft(I(n))) < 0 \end{cases}. \tag{2}$$

3.2 Hamming Distance.

Hamming Distance could be used to evaluate the similarity of to binary templates, through calculating the percentage of corresponding bits about total number of binary templates. Assume A_i and B_i are two binary feature template of iris images.

$$HD = \frac{1}{N} \sum_{i=1}^{n} A_i \oplus B_i \tag{3}$$

In order to eliminate influences of iris images' rotation and skewing, two binary templates were comparing to calculate the Hamming Distance of about three each cyclic shift, and took the minimum value to be recognized as the iris the value of similarity.

3.3 Haar Wavelet Decomposition.

Wavelets were commonly used to image analysis[4]. Haar wavelet as a basic orthonormal wavelet and the simplest possible wavelet is easy to calculate. In this paper, Harr wavelet is used to decomposed three times by the normalized iris images, and the result was shown Fig.2. In the Fig.2, subimages were called wavelet channel: LL, HL, LH, HH. Every channel is the original image

information in different frequency and selection. According to the original image with different energy characteristics in different frequencies and directions, we used the following formula to calculate the wavelet channels the energy and variance as iris image features.

$$f = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} x(i,j), \delta = \sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}\left[x(i,j) - EC_n\right]^2 / (MN-1)}. \qquad (4)$$

Because the HH channel included more image noises, we abandoned them, and calculated LL3, HL3, LH3, HL2, LH2, HL1 and LH1 channels characteristic values to encode the template of the iris image.
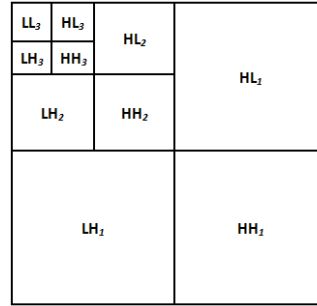

Fig.2 Wavelet transform sketch

3.4 Weighted Euclidean Distance.

Euclidean metric is also known as Euclidean Distance, is a distance definition applies to multi-dimensional vectors. In this work reciprocal variance is used as a weight to calculate the similarity. This method is called Weighted Euclidean Distance. Formula is as follows, the f_i is one unknown sample of the i-th feature, $f_i^{(k)}, \delta_i^{(k)}$ is the mean and variance of the i-th feature of the k-th sample, N is the total number of features.

$$WED(k) = \sum_{i=1}^{N} \frac{(f_i - f_i^{(k)})^2}{(\delta_i^{(k)})^2}. \qquad (5)$$

3.5 Logistic Regression Classifier.

From the section 2 and 3, we achieve two values of similarity, one is implemented by 2D Log-Gabor filter and Hamming Distance called after HD_i, and the other one is implemented by Haar wavelet and Weighted Euclidean Distance called after WED_i. HD_i and WED_i are used for training and testing of the Logistic Regression Classifier[5].

$$WED(k) = \sum_{i=1}^{N} \frac{(f_i - f_i^{(k)})^2}{(\delta_i^{(k)})^2}. \qquad (5)$$

4. Experimental Results

This paper was implemented using MATLAB R2014b in the Windows 8.1 operating system with Intel Pentium Processor, 2.41GHz and 4 GB RAM. We calculate the False Accept Rate (FAR), the False Reject Rate (FRR) and the Correct Recognition Rate (CRR) values for iris databases CASIA[6] V1.0 are described.

In this work 648 images of CASIA V1.0 were used to train and 108 images were used to test. The recognition accuracy and time were compared between the different methods. Comparison of recognition accuracy with different feature vectors such as 2D Log-Gabor filter, Haar wavelet or the method of this paper is given in Table 1. It can be see that 2D Log-Gabor filter or Haar wavelet is used as feature templates to match only then recognition accuracy is obtained 92.59% and 81.48% respectively. The CRR can increase to 99.13% when combined both 2D Log-Gabor filter and Haar wavelet are used to extract features, combined both Hamming Distance and Weighted Euclidean Distance to calculate the values of similarity, and fused the multi-feature by Logistic Regression Classifier.

Table 1 Recognition rate and time of different methods

Method	FAR/%	FRR/%	CRR/%	Time/ms
Log-Gabor	0.08	0.76	92.59	69.7
Haar	2.05	8.53	81.48	48.3
Proposed	0.07	0.65	98.73	78.6

5. Conclusion

This paper makes use of 2D Log-Gabor filter and Harr Wavelet to extract the texture features from the iris image, Hamming Distance and Weighted Euclidean Distance to calculate the values of similarity, and the Logistic Regression Classifier to fuse the multi-feature and match classification. Experimental results demonstrate the effectiveness of the proposed algorithm, the algorithm of this paper can achieve high correct recognition rate.

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