Iris Feature Extraction based on the Feature Vector between the Key Points

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Abstract

Iris texture contains a number of prominent,stable details,these details can be extracted to quantifty the stability of the iris features.This paper proposes a quantitative method to extract the iris block local details of a multi channel 2-D Gabor Filter, iris block and filter the most similar and the same size and local sub filter block center as feature points and focus feature points and calculate the selected as the key points,then calculate those feature vector between the key points,and the iris feature to recognize iris matching.A recognition examination on CASIA iris database and 550 of the image make clear that systems recognition rate is 98.77%. The experimental result show that the algorithm used quantitative iris detailed feature to quantitative analysis have higer recognition accuracy,it coforms to the demand of existing iris recognition system development.

Keywords

Iris Recognition; Feature Extraction; 2-D Gabor Filter; Key Point; Feature Vector.

1. Introduction

Iris recognition with its own characteristics (uniqueness, stability, security, non contact) has become a new generation of biological recognition technology, which is superior to the other kinds of biological recognition technology in the security and error recognition rate of. Iris recognition technology has been widely used in the field of Internet security, transportation, intelligent equipment and so on.

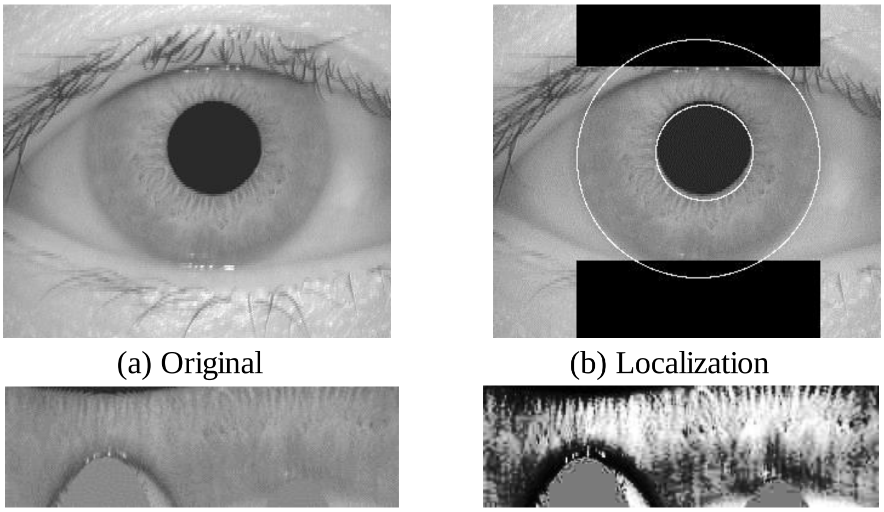
In this paper, the feature extraction method based the relative distance between the key points,put the iris detail feature is quantified as the key point,use the feature vector to characterize the relationship between the key points,we propose a feature extraction method based on feature vector between the key points.This method will divide the normalized iris image into 16 sub block image, for each sub block iris image is filtered using multi-resolution 2-D Gabor filter, a filter to extract multiple similar feature points, and then for each subgraph in similar feature points center of gravity as the key point.Finally, the feature vector between the key points is calculated as the iris feature, and the image characteristic of the database is used to calculate the Euclidean distance, and the matching result is obtained according to the rule of the judgment.Through experimental verification, the method is simple, less time consuming and less time to ensure the accuracy of the method.

2. Iris Recognition System

Iris recognition system mainly consists of four modules: image acquisition module, image preprocessing module, feature extraction module and feature matching module.

2.1 Iris Image Preprocessing

Iris image will have some invalid regional interference in iris localization such as eyelid and eyelash, in order to speed up the extraction speed of iris, reduce interference, there are method of take part on the removal the upper and lower parts of the eye image. Figure 1 shows the results of the iris preprocessing.



(a) Original (b) Localization

(c) Normalization (d) Enhancement

Fig. 1 Iris preprocessing

In the localization of the inner boundary of the iris, the image is operated by thresholding method, and the inner boundary of the iris is located quickly by the pupil's geometric characteristic. When the iris outer boundary is located, the Canny operator is used to detect the edge of the iris, and the Hough transform is used to locate the outer boundary of the iris.

In order to facilitate the calculation, the iris image is normalized. In this paper, the method of the two dimensional polar coordinate transformation proposed by Daugman is used to expand the iris image to a resolution of 256*100 pixels, which can reduce the influence of the horizontal displacement of the iris and the change of the pupil.

In order to eliminate the influence of noise on the image, this paper uses the method of histogram equalization to enhance the image.

2.2 Iris Feature Extraction

In order to describe the characteristics of the iris texture, the iris image and the filter function are convolution, and the coefficients of the output image represent the similarity between the image and the filter function.Set f is a $m \times n$ image, g is a two-dimensional filtering function, the discrete convolution is:

$$h = f * g \tag{1}$$

$$h(x,y) = \sum_m \sum_n f(m,n) g(x-m, y-n) \tag{2}$$

Where h is output image, $*$ is 2-D discrete convolution, $h(x,y)$ said in the image to (x,y) as the center of the f image, sub image blocks and two-dimensional g function has the same size of the inner product with the two-dimensional function of g. Results is described the similarity between the sub block and the two-dimensional g function,with $|h(x,y)|$ said.

The center of the image sub block has a larger relationship coefficient, the size of the system indicates that the similarity between the sub block in the space form and the function of the two dimension, the higher the value of the system, the lower the degree of similarity. In this paper, we will have a large number of sub block center (x,y) as the feature points, and select a number of feature points, calculate the center of gravity as the key point. Iris feature matching is based on the feature vectors of these key points.

2.3 Multichannel Gabor Filter

Because the 2D Gabor filter can locate the texture details in different scales and directions, the paper sets a set of multi-channel Gabor filter [4] to extract the feature of iris texture.

2D Gabor is:

$$G(x,y,T,\theta)=\frac{1}{2\pi\alpha\beta}e^{-\frac{x'^2}{2\alpha^2}-\frac{y'^2}{2\beta^2}}\cdot e^{-\frac{2\pi i}{T}x'} \tag{3}$$

θ is the direction of filter, α, β is the length and width of the Gauss function, T is the filter cycle, (x',y') is the coordinates of (x,y) the rotation with θ.the result is:

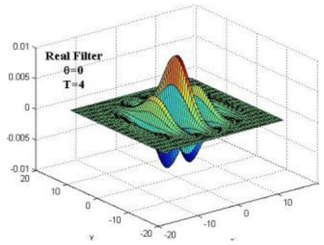
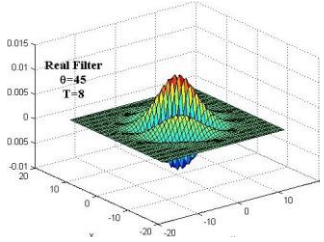
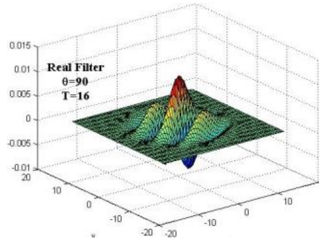
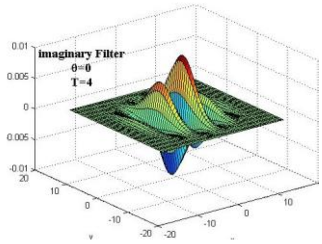
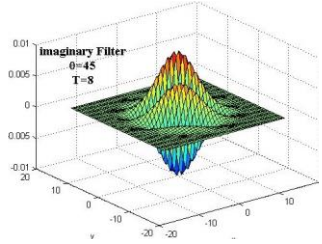
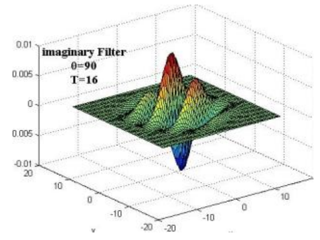
$$\begin{bmatrix} x' \\ y' \end{bmatrix}=\begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}\cdot\begin{bmatrix} x \\ y \end{bmatrix} \tag{4}$$

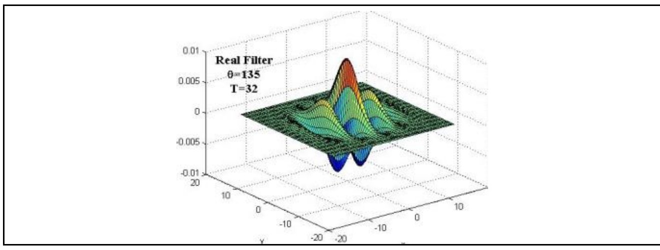
By Euler's theorem is:

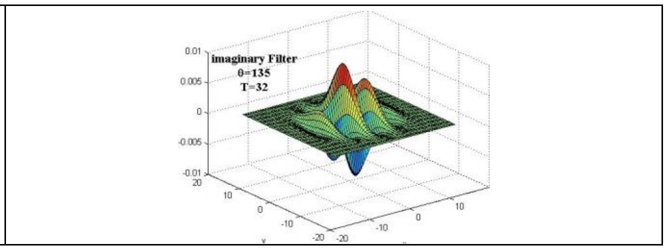
$$e^{i\omega t}=\cos\omega t+i\sin\omega t \tag{5}$$

Therefore,2-D Gabor filter can be divided into two symmetrical real parts which are modulated by cosine function, and the imaginary part which is modulated by the sine function. Multi scale and multi direction filter can extract more texture details, build multi-channel 2D Gabor filter, need to set different direction angle θ and wavelength. According to the experimental data, the parameters of this paper are: $\theta=0^\circ,45^\circ,90^\circ,135^\circ$;the wavelength is: 4, 8, 16, 32. Due to the symmetry of the filter, in fact, covering the 8 direction angle $(0^\circ,45^\circ,90^\circ,135^\circ,180^\circ,225^\circ,270^\circ,315^\circ)$, corresponding to the height and width of the Guass respectively were 4, 8, 16, 8 and 32, 16, 32, 64. This is a total of 16 functions, each function has two filter imaginary and real, a total of 32 filters, filter according to the azimuth from sequential labeling, using i(i=1,2,..., 32) said filter. The filter is shown in table 1.

Table 1. Three Scheme comparing

Real part	Imaginary part
  	  





In the spatial domain to do the image convolution operation is more time consuming, and in the frequency domain image only need to do the multiplication operation, such as the (6). In order to reduce the time complexity of the computation, this paper uses the method of multiplication in frequency domain to find the convolution of the image.

The corresponding relation between time domain and frequency domain of two dimensional function is $f(x,y) \Leftrightarrow F(u,v), g(x,y) \Leftrightarrow G(u,v)$ .Convolution theorem is known as the formula:

$$\begin{aligned} f(x,y) * g(x,y) &\Leftrightarrow F(u,v) \cdot G(u,v) \\ f(x,y) \cdot g(x,y) &\Leftrightarrow F(u,v) * G(u,v) \end{aligned} \tag{6}$$

2-D Fourier transform and inverse transform definition, such as the formula:

$$\begin{aligned} F(u,v) &= \xi(f(x,y)) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y) e^{-i2\pi(ux+vy)} dxdy \\ f(x,y) &= \xi^{-1}(F(u,v)) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} F(u,v) e^{-i2\pi(ux+vy)} dudv \end{aligned} \tag{7}$$

The convolution of two dimensional functions in the spatial domain is:

$$f(x,y) * g(x,y) = \xi^{-1}(\xi(f(x,y)) \cdot \xi(g(x,y))) \tag{8}$$

Fast 2-D Fourier transform FFT can speed up the convolution speed, inverse transform FFT^{-1} is:

$$f(x,y) * g(x,y) = FFT^{-1}(FFT(f(x,y)) \cdot FFT(g(x,y))) \tag{9}$$

3. Key Point Extraction

Analysis of texture feature of iris can be seen near the rich texture details of the pupil, iris outer edge due to interference factors such as the eyelids, eyelashes and covering methods, relatively large influence on extracting the true features,we remove the lower part of the normalized iris image (i.e. the iris outer edge), division of sub block image using only the middle and upper part of the iris image. As shown in figure, the normalized iris image (256x100 pixels) of the middle and upper part of level is divided into 8 blocks of size 32 x 32, a total of 16 blocks, and press the number from left to right from the top to the bottom of the order of k sub image (k=1,2,... 16) said.

Each image is obtained after filtering filter, the maximum absolute value of the corresponding sub image and the filter is most similar, the center point of maximum sub block image is maximum of the relation value, this points is the channel filter feature points. Due to the influence of illumination and noise and other factors, value of other points will has high similarity and the feature points, so choose a maximum corresponding coefficients as feature point is not reliable, the maximum value is selected a certain number of points, then their center of gravity the center of gravity, known as the key point of this paper is to extract the features of the.

The centre of gravity algorithm of these feature points is as follows

Set $f(x,y)$ is absolute value of the filtering sub image,

$$P = \{(x_1, y_1), (x_2, y_2), \cdots, (x_m, y_m)\} \tag{10}$$

P said a series of characteristic points in coordinates, M is number be selected as feature point. The barycentric coordinate (x_p, y_p) of feature points be selected as shown in (11):

$$x_p = \frac{\sum_{i=1}^{m} x_i F(x_i, y_i)}{\sum_{i=1}^{m} F(x_i, y_i)}$$

$$y_p = \frac{\sum_{i=1}^{m} y_i F(x_i, y_i)}{\sum_{i=1}^{m} F(x_i, y_i)} \qquad (x_i, y_i) \in P \ldots (11)$$

As was stated above,16 channel gabor filter be adopted in this paper has 32 subfilter altogether.so every iris in image can get 32×16=512 key points. Sorting key points in accoedance with separated graph order and filter order, so the coordinate definition in key points of number K sub-image as shown in (12).

$$P(k) = \{(x_{p1}, y_{p1})_k, (x_{p2}, y_{p2})_k, \cdots, (x_{p32}, y_{p32})_k\} \qquad k = 1, 2, \ldots 16 \qquad (12)$$

3.1 Vector calculation between key point

By the above statement, we kown coordinate that key point number i in sub-image number k is $(x_{pi}, y_{pi})_k$,so we get a 32d length of iris feature vector V_k , as shown in (13):

$$V_k = \{(x_{p1}, y_{p1})_k, (x_{p2}, y_{p2})_k, \cdots, (x_{p32}, y_{p32})_k\} \qquad k = 1, 2, \ldots, 16 \qquad (13)$$

Every iris image has 16 such iris feature vector ,it is iris feature that we want to extract.

3.2 Iris feature matching

When feature vector of acquisition iris image be extracted, we need to use those features with features template of database to matching one by one. According to trait of extractive iris feature, this paper adopt the method that calculate Euclidean distance of two feature vector to judge classification.

The Euclidean distance of iris feature is that to calculate space distance between sample feature vector and library sample feature vector ,the size of distance value is standard to judge that two sample whether or not be one kind, the smaller of the value the greater possibility of one kind, smaller possibility conversely.

Feature vector of iris image wait to match and su-block that library sample image corresponding is V_k, V_k' ,and Euclidean distance value of feature vector as shown in (14):

$$D_k(V_k, V_k') = \sqrt{(V_k - V_k')^2} \qquad k = 1, 2, \ldots, 16 \qquad (14)$$

So space distance average value of feature vector as shown in (15):

$$D = \frac{\sum_{k=1}^{16} \sqrt{D_k}}{16} \qquad (15)$$

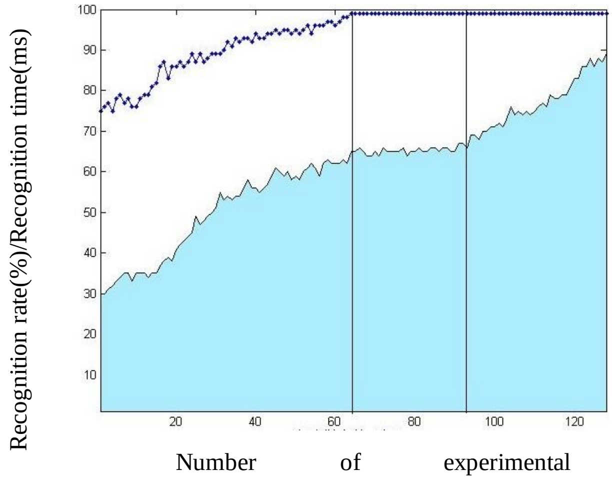
Among them,D is parameter of iris matching similarity.

4. Experiment and result analysis

4.1 Classification rule

Iris database of experiment be used in this paper is CASIA（1.0）database of The Chinese academy of sciences of institute of automation and 500 two eyes iris database that is BA.

When we calculate key points, that how to select sub-clock image feature point number m is a tremendous factor that can influence experimental result. The more feature points we select the more calculating amount, but recognition accuracy does not increase anymore. When feature point we selected is small, accuracy rate can drop obviously. Experiment database as shown in figure 5



Number of experimental samples(group)

Fig. 4 the influence of m value on recognition rate and operation time

The influence about choosing different m value for recognition rate and extracting time as shown in form 2, so rational selection to feature point can ensure the accuracy and reduce the loss of operation at the same time, in this paper m be selected is 64.

Table 2. M value range influence

m	Result
$m < 32$	Recognition rate is very low, illumination and noise have an effect on it, some feature points that have bigger coefficient value will be missed, and small feature points we selected can not reflect the real situation.
$64 \leq m \leq 96$	High recognition rate, little changed, and proper operation loss
$m < 128$	More superfluous feature points be used for calculating recognition, operation loss increased greatly.

On the threshold value of average space distance D to determine, this paper adopt method that match every element in two samples with random combination to count and analyse. Two samples each contain ten similar iris image, the number is A1~J1, A2~J2, get 100 groups of matching database in all as shown in figure 5. We can see from figure 6 about that when similar image matching (A1A2, B1B2...), it is value D of average euclidean distance in the rage of 19 to 23,when different types of iris is matching ,value D are bigger more than 40.

So threshold value of value D in this paper is selected to 23.

4.2 Result analysis

Compared with four kind of classical iris recognition algorithm on recognition rate,feature encoding, matching time,total time four aspects ,as shown in form 3.

Table 3. Algorithm comparison

Method	Recognition rate (%)	Feature extraction time	Matching time	Total time(ms)
Daugman	100	595.2	4.3	599.5
Yu[2]	98.2	305.4	8.9	314.3
This paper	98.77	278.3	7.5	254.8

We can see from data in the form about that algorithm in this paper have higher recognition rate than Boles algorithm and Wilds algorithm, below Daugman algorithm , close to Yu algorithm, and they both have higher recognition. Higher recognition be sured in this paper, algorithm used in this paper on operation rate increase 9.06% than Yu algorithm.

We can see from experiment, algorithm in this paper can improve recognition rate of system when it use quantized iris detail as iris feature, it reduce complexity of algorithm that operate on key point we extracted to calculate feature vector, it can improve the rate of system, all of result show that the algorithm in this paper is feasible and effective.

5. Conclusion

Feature extraction algorithm based on feature vector beween key points is what to deal with veins detail quantification ,compared with morphology of using iris veins and iris feature extracted to a consistent ,iris feature extracted from this method have higher stability, it drop complexity of calculating feature points distance of time and speed up the feature extraction rate. Relative location be adopted when we calculate key points, it avoid correction to iris displacement, and reduce time loss of system. The experimental results show that when we extract and matching iris in same iris database, compared with other common algorithm, algorithm in this paper have advantage of higher recognition rate and higher speed.

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