ENHANCED IRIS RECOGNITION BASED ON IMAGE MATCH AND HAMMING DISTANCE

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Abstract- Iris recognition and favor because of its high recognition rate, noninvasive and simple algorithm and other advantages, in a variety of biometric identification technology is very prominent. The iris texture feature extraction is the core of the iris recognition algorithm. Fractal geometry theory provides new ideas and methods to express nonlinear image information, the fractal dimension is an important parameter of fractal geometry, is a measure of complexity of irregular change, covering blanket dimension can better reflect the graphics changes in different resolution characteristics; missing is the fractal dimension and independent statistics, is a supplement to the fractal dimension, overcome the different texture characteristics may have the same fractal dimension of the problem. This paper presents a blanket and missing items based on the combination of texture feature extraction algorithm, can make full use of radiation in different resolution iris texture information and texture, classification ability make feature matrix has a better. Iris matching is the key of iris recognition. How to effectively carry out the matching of the iris code matrix is the decisive step in iris recognition. In this paper based on the normalized correlation classifier, the matching method of cyclic shift, eliminated from the same eyes of different iris image due to differences in rotation caused, improve matching accuracy.

Index terms*:* Iris recognition; Score fusion; Iris location; Image match; Code matrix

I. INTRODUCTION

The rapid development of global economy, science and technology makes the modern society of increasingly high demand to the security [1]. The traditional identification methods cannot meet the need of information security, so people proposed biometric identification technology by using biometric identification, such as fingerprint, iris and voice. The iris recognition technology with its non invasiveness, high reliability, rapid development, it has become a research hotspot in the field. Identity recognition method based on content and based on the traditional identity authentication items. Content authentication based on password or password recognition based on authentication based on user, goods according to key, identity card or passport and identification of user [2]. The two method is easy to counterfeit, the security is relatively low, can not meet the needs of social development.

Before and after corneal lens, iris is located, is a layer of film disc containing pigments, composed of connective tissue cells and muscle fiber, which is the pupil [3, 4]. The iris and the pupil function are closely related, iris's role is to control the size of the pupil, iris color and most visible feature expansion and contraction of pupil and iris. Iris can be subdivided: surrounding the pupil area, is the ring can make the pupil dilation of the organization. Outside is a hair like fibers, is a peripheral annular region. Iris fiber is soft, loosely woven, through the pupil according to light intensity in the retina of control of the pupil size, how to adjust to the retina light. The pupil contraction is the reflection of unconscious, not by the neural control. Iris details of feature rich, including spot, radial folds, circular fold, depression, projection [5]

An iris recognition system is mainly composed of several parts below:

(1) Acquisition of iris image is the image acquisition system of iris image acquisition. The iris is a small organ, ca. 10 mm, there is a big difference between the different races of iris color. Iris color, white light, texture significantly. Iris yellow to dark brown, texture is not obvious. At present the main is to obtain iris image by CCD, CMOS and other optical sensors.

(2) By acquiring iris image collection device to usually includes not only the iris, often have the rest of the eye, but also in the high non aggressive, because the test is not required, the size and location of the iris in the image will be changed. Therefore, prior to the iris recognition, must be normalized image. In some cases, iris image illumination is not uniform, the size of the pupil will be different with light intensity bigger or smaller, it will make the iris image deformation, affect the accuracy of iris recognition [6]. The main task of image preprocessing includes iris

image denoising, positioning, segmentation, normalization and enhancement. Preprocessing of iris is the key step in iris recognition.

(3) Contains the texture and shape feature rich iris image, to extract the spatial information, this paper uses a set of 2D Gabor filter to decompose the iris image, and get the recognition of the features needed codes [7]. Coding model used in this paper is actually a kind of coarse quantization of iris texture, can distinguish different iris, in order to accelerate the speed of operation, the use of a set of 2D Gabor filter is not orthogonal complete, just as Gabor basis functions choosing different direction intervals constitute the filter group, on the image block filter, get the iris code needs. All the code is stored in the database, to prepare for.

(4) Feature matching is that the image is to be determined in accordance with the above all the steps of feature extraction, and then the feature code and database feature codes are compared, finally obtains results, complete identification [8-9, 20-21].

Biometric identification technology with its high accuracy by the academic circles and the business community was carried more and more attention. Iris is the body's internal organs, it has complex structure and rich texture of iris, the uniqueness and stability, such as collection features make it very suitable for identification. Compared with the technology of identity recognition in contact with the palmprint recognition, fingerprint recognition, iris recognition has the type, non aggressive; compared with face recognition, speech recognition and other non-invasive technology, iris recognition has higher accuracy; and iris has the advantages of difficult to counterfeit, difficult to change. According to statistics, iris recognition error rate is the lowest among all biometric identification. It is because of these advantages, iris recognition gradually from the biometric identification technology of talent showing itself, become a hot research topic in the field of biometrics identification.

Iris recognition is a new biometric identification technology, because of its obvious advantages, has gradually become a research hotspot in the field. This paper analyses the principle of the algorithm of iris recognition system structure; from the image localization, iris image feature extraction and pattern matching multiple processing steps to carry on the research of iris recognition algorithm; and the algorithm is realized using Matlab7.0, CASIA.IrisV3.Interval iris image database finally, Chinese Academy of Sciences Institute of automation test on the performance of the algorithm. The eye image is obtained by sampling equipment, including not only the eyelids, eyelashes, iris also includes the whites of the eyes,

pupil some unnecessary content. Iris image is obtained, also often received such as the effects of light, focusing not, eye movements as well as the operator's operation error and other factors, resulting in reduced image quality. Preprocessing of iris is to minimize the influence of above factors on the recognition, the recognition more effectively.

II. RELATED THEORY AND METHOD

2.1 The main iris recognition algorithm

2.1.1 Bilinear interpolation

Bresenham proposed a fast algorithm for drawing straight lines using error correction method, Field linear interpolation Bresenham algorithm is applied to linear. Bresenham algorithm analysis in two-dimensional plane, the error change of the linear approximation using equidistant discretization, error estimation method will calculate all the points on a straight line from floating-point multiplication and division is integer addition and subtraction [10, 11, 12].

The bilinear interpolation algorithm is completed at the same time two Bresenham line drawing process, is also a kind of improvement to the nearest neighbor interpolation, according to (U_0, V_0) gray four points around the point values to estimate the (U_0, V_0) gray value of the point, the process of calculation see Figure 1:

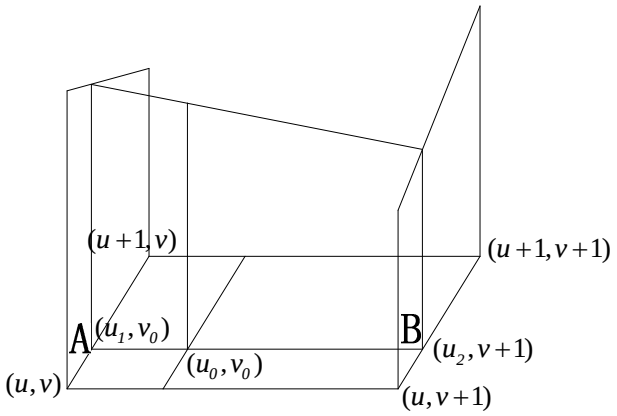

Figure 1. The process of calculation

The bottom edge of the rectangle composed of four integer points in adjacent components, each point is the point of gray values, by (U, V) and (U+1, V) linear relationship can be obtained gray A value, then the (U, V+1) and (U+1, V+1 the linear relationship between the point) can be obtained by gray B value, and finally by the gray A point and B point values can be calculated (U_0, V_0) gray value of the point.

$$f(u_1,v_0) = f(u+v) + a(f(u+1,v) - f(u+v)) \quad (1)$$

$$f(u_2, v+1) = f(u, v+1) + a(f(u+1, v+1), f(u, v+1)) \quad (2)$$

$$f(u_0, v_0) = f(u_1, v_0) + b(f(u_2, v+1) - f(u_1, v_0)) \quad (3)$$

$$a = u_1 - u_0 \quad (4)$$

$$b = v + 1 - v_0 \quad (5)$$

By acquiring iris image acquisition device to usually includes not only the iris, often have the eyes of other parts of the system, and in highly aggressive, because of the test is not required, the size and position of the iris in the image will be changed. Therefore, before the iris recognition, must be normalized image. In some cases, iris image illumination is not uniform, the size of the pupil will be with different light intensity bigger or smaller, it will make the iris image deformation, affect the accuracy of iris recognition. The main task of image preprocessing includes iris image denoising, positioning, segmentation, normalization and enhancement. Iris preprocessing is the key step in iris recognition [13-16].

2.1.2 Three bicubic convolution method

In order to get more accurate (U_0, V_0) gray value of the point, we not only need consider the (U_0, V_0) affects directly adjacent point to it, and the need to consider the gray 16 adjacent points the points around the value effect on it. By the continuous signal sampling theorem, the sampled value by interpolation C (x) interpolation, can be accurate to restore the original function, but also can accurately obtain the sampling point value between any point [17, 18]. The three interpolation using C (x) three times polynomial approximation:

$$C(x) = \frac{\sin \pi x}{\pi x} \quad (6)$$

$$C(x) = \begin{cases} 1 - 2|x|^2 + |x|^3 & 0 \le x < 1 \\ 4 - 8|x| + 5|x|^2 - |x|^3 & 1 \le x < 2 \\ 0 & 2 \le x \end{cases} \quad (7)$$

By using the above interpolation function, can be calculated (U_0, V_0) gray value of the point, specific calculation steps can compact representation by matrix:

$$f(u_0, v_0) = ABC \quad (8)$$

$$A = [c(1+u_0), c(u_0), c(1-u_0), c(2-u_0)] \quad (9)$$

The eye image obtained by the acquisition device, including not only the eyelids, eyelashes, iris also includes the whites of the eyes, pupil some unnecessary content [19]. The iris image is obtained, also often received such as the effects of light, focus, eye movements as well as the

operator's operation error and other factors, resulting in reduced image quality. Preprocessing of iris is to minimize the effects of the above factors on the recognition, the recognition is more effective.

$$B=\begin{bmatrix} f(u'-1,v'-1) & f(u'-1,v') & f(u'-1,v'+1) & f(u'-1,v'+2) \\ f(u',v'-1) & f(u',v') & f(u',v'+1) & f(u',v'+2) \\ f(u'+1,v'-1) & f(u'+1,v') & f(u'+1,v'+1) & f(u'+1,v'+2) \\ f(u'+2,v'-1) & f(u'+2,v') & f(u'+2,v'+1) & f(u'+2,v'+2) \end{bmatrix} \tag{10}$$

$$C=\begin{bmatrix} c(1+v_0) \\ c(v_0) \\ c(1-v_0) \\ c(2-v_0) \end{bmatrix} \tag{11}$$

Quality of iris images directly affects the recognition effect, therefore before recognition of image quality evaluation is very important. Evaluate the quality of image is divided into subjective evaluation and objective evaluation of two methods. The subjective evaluation refers to the person's visual effect as the judgment standard, the method for different observers and the effect is not stable, also cannot use the mathematic model for quantitative description of image quality.

2.2 The process of iris recognition

Iris recognition system consists of the following five parts, and the identification of iris image acquisition and image quality detection, iris location, iris image preprocessing, iris feature extraction, matching.

The use of image acquisition equipment shooting iris image and determines the quality of iris image, if qualified, to locate the iris, the annular iris image is converted to rectangular and normalized processing and image enhancement, then the iris texture feature extraction using a certain algorithm, to obtain feature coding, finally use the classifier for iris matching, output the classification result (whether it belongs to the same eye). Figure 2 is a flow chart of iris recognition.

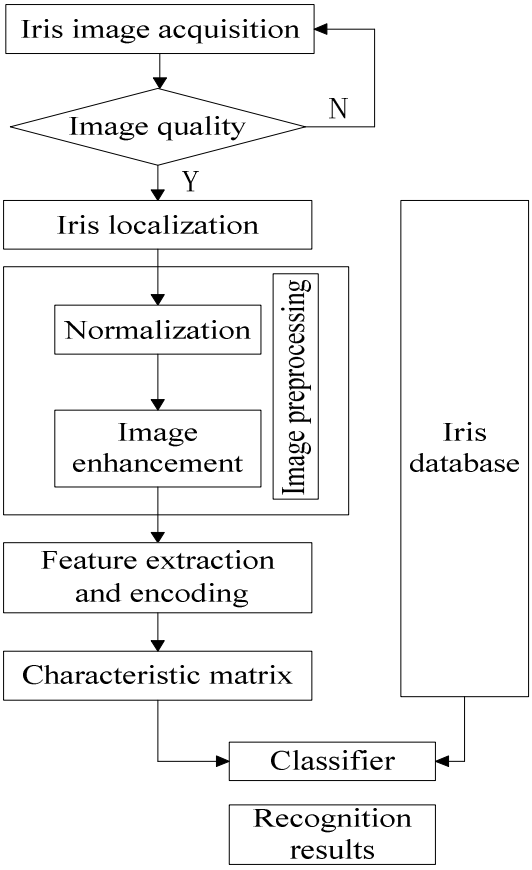

Figure 2. The flow chart of iris recognition.

Through the gray level histogram distribution of iris image analysis, the iris and pupil, eyelids and other facial skin, were concentrated in three grades of gray, gray eyes and other facial skin was higher than that of the iris, iris gray above the pupil, from gray level histogram of the two wave valley can get gray threshold between the iris and pupil gray the threshold and the iris and sclera.

Gray image clear definition refers to the image gray value distribution in the gray level range as wide as possible within the same region, and the distribution of gray balance, gray level between different regions with obvious differences. Iris image gray histogram distribution was shown in Figure 3.

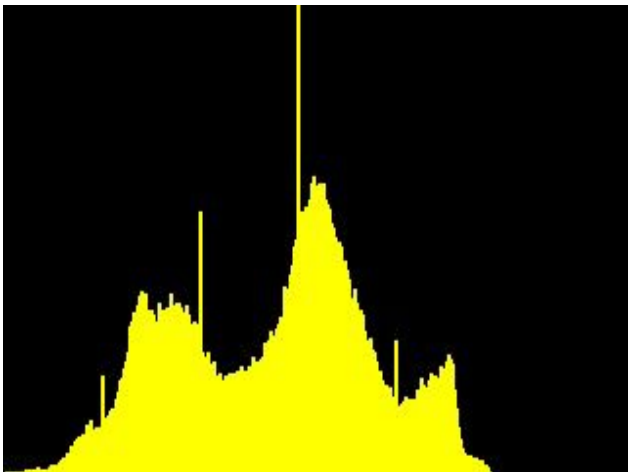

Figure 3. Iris image gray histogram distribution

2.3 The normalized and calibration of iris image

Iris is a curved surface, along the axis of projection to the plane and perpendicular to the axis of the upper approximation, can get a circle. Iris localization algorithm is to find the center and radius of the iris and the pupil of the eye image of a person, the iris from the image segmentation. Iris localization mainly includes the internal and external edge of iris. The other part of the iris section and the gray scale image section in the clear distinction between the existing positioning, segmentation algorithm based on image gray analysis mostly, and the inner and outer edge of iris setting for circular curve, from the eyes of the structure and the algorithm execution results, this assumption is reasonable. Iris location main segmentation methods are as follows:

Daugman uses the circulation integral operator to determine the iris edge:

$$max_{(r,x_c,y_c)}\left|G(r)*\frac{\partial}{\partial r}\oint_{(r,x_c,y_c)}\frac{I(x,y)}{2\pi r}ds\right| \tag{12}$$

In the formula I (x, y) gray function eye image, the circular outline the iris with center point (x_0, y_0), radius parameter model representation of R.

$$G(r)=\frac{1}{\sqrt{2\pi\sigma}}e^{-\frac{(r-r_0)^2}{2\sigma^2}} \tag{13}$$

Contour extraction, the gray value of the image projection to the X and Y directions. According to these data to remove some irrelevant point diagram, using the least square method to the rest of the point and circle.

A curve equation of the circle to:

$$R^2=(x-A)^2+(y-B)^2 \tag{14}$$

Discrete point (x, y) where i $\in$ (1, 2... N) to the center distance of:

$$d_i^{\,2}=(X_i-A)^2+(Y_i-B)^2 \tag{15}$$

The Q (a, b, c) on a, b, c derivative, the partial derivative is equal to 0, get the extremum point.

Iris is a curved surface, along the axis of projection to the plane of the vertical axis and the upper approximation, can get a circle. Iris location algorithm is to find the center and radius of the iris and the pupil of the eye in the image of a person, the iris from the image segmentation. The other part of the iris gray part and image in the clear distinction between the existing positioning, segmentation algorithm based on image gray analysis mostly, and the inner and outer edge of iris circular curve setting, from the eyes of the structure and the present algorithm execution results, this assumption is reasonable.

$$\begin{aligned}\frac{\partial Q(a,b,c)}{\partial a} &= \sum 2(X_i^2 + Y_i^2 + aX_i + bY_i + c)X_i = 0 \\ \frac{\partial Q(a,b,c)}{\partial b} &= \sum 2(X_i^2 + Y_i^2 + aX_i + bY_i + c)Y_i = 0 \\ \frac{\partial Q(a,b,c)}{\partial c} &= \sum 2(X_i^2 + Y_i^2 + aX_i + bY_i + c) = 0\end{aligned} \tag{16}$$

Within the circle I(Ix, Iy) as the origin of coordinates, I point as a horizontal line, point to the ring part by I ray, respectively to the internal and external to the A point and B point, connected with the outer circle of O (Ox, Oy) and I point, O point and B point connection, angle of IB and horizontal angle theta, alpha IO and horizontal line, by ray IB around the I rotation of 360 °, AB traveled route is the iris part, this part launches into a rectangle.

III. COMPOSITION OF IRIS RECOGNITION SYSTEM

3.1 Iris image location and segmentation

The precision iris impacted the subsequent recognition directly. This paper uses the first determine the highlight point, then the contour extraction to determine the threshold of pupil segmentation and, finally, to detect the iris inner edge by using the method of Hough transform. Hough transform algorithm is robust, but high complexity. Because we highlight point detection algorithm based on the identified a small sub images of the pupil extraction, greatly reducing the amount of calculation of Hough transform algorithm. Iris image preprocessing: (a) Original image (b) Detected inner boundary. (c) Detected outer boundary. (d) Lower half of the irisregion for matching was shown in Figure 4.

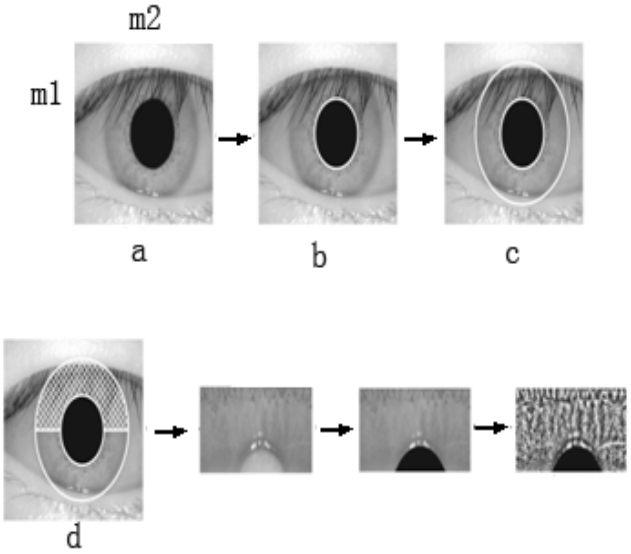

Figure 4.Iris image preprocessing: (a) Original image (b) Detected inner boundary. (c) Detected outer boundary. (d) Lower half of the irisregion for matching.

The uneven illumination image, threshold segmentation will occur after many interference, the pupil boundary angular, but around a lot of interference, it increased a lot of difficulty to determine the inner edge of iris. So the gray add eight point in the original image of every point in a gray and around it, and then divided by 9 as new corresponding points in the gray. With the signal processing theory to explain, this practice is the realization of a simple low pass filter. Continuous changes in the gray image, if there were gray and the adjacent pixel difference point, such as a dark region suddenly appeared a bright spot, the gray mutation in high frequency domain represents a high frequency, low pass filter function is to filter out high-frequency component, so as to reduce the image the purpose of noise.

3.2 Location of the iris inner edge

In locating the iris outer boundary, we still use the basic principles of the three point circle parameters of non collinear circle, but the need for the details of the algorithm is improved. Because the gray iris and sclera among mutant than iris and pupil are obvious, so the need to increase the detection template size, in order to enhance the edge contrast; smoothing the image using Gauss filter before detecting the edge, improve the ability to resist noise. In addition, outside edge of the iris by two horizontal edges easily by occlusion of eyelid and eyelash, therefore in the outer edge localization can be used in the left and right sides of the vertical edge points.

Iris coordinate transformation diagram was shown in Figure 5.

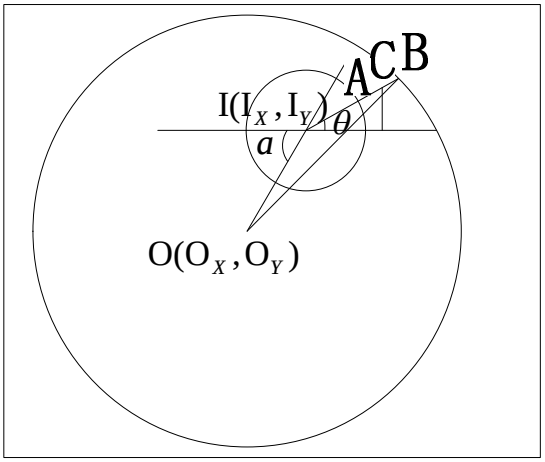

Figure 5. Iris coordinate transformation diagram

The Hough transform is proposed by Paul Hough, it implements the mapping relationship from an image space to the parameter space. The basic idea is to point line duality, namely corresponding image spatial collinear points in parameter space intersecting line; in turn, all linear in the parameter space intersect at the same point has a corresponding collinear points and in the image space. Hough transform curve or straight line detection in the specific shape of the original image, into the extremism in the parameter space problems. Usually use Hough transform to detect the two value image of the straight line or curve.

3.3 Fragile bit distance

When the iris inner and outer circular deviation is less than the threshold (5 pixels), namely that the deviation is caused by physiological factors, when the iris inner and outer circular deviation is greater than the set threshold value, namely that the deviation is due to the rotation of the eyeball caused, involved in the model of this paper is the first case based on consider second cases, treatment is more complex, and can be avoided by adjusting the acquisition device.

Figure 6 shows the result of score distributions for fragile bit distance. Figure 7 shows the genuine and impostor score distributions of Hamming distance.

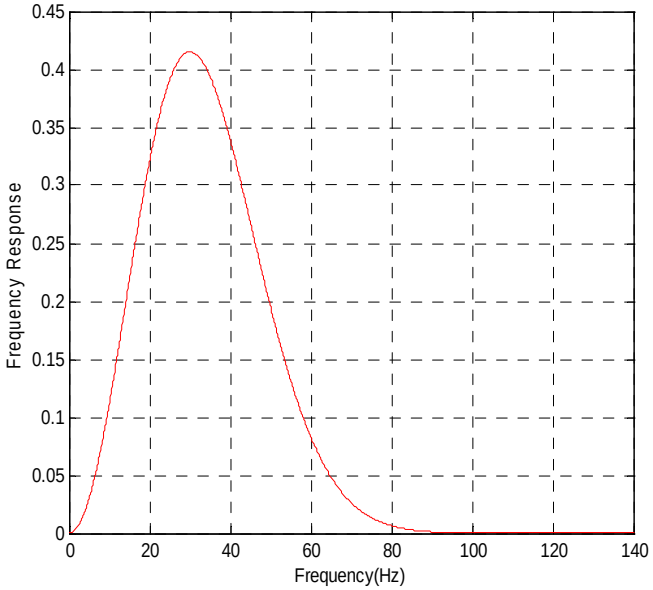

Figure 6. The result of score distributions for fragile bit distance.

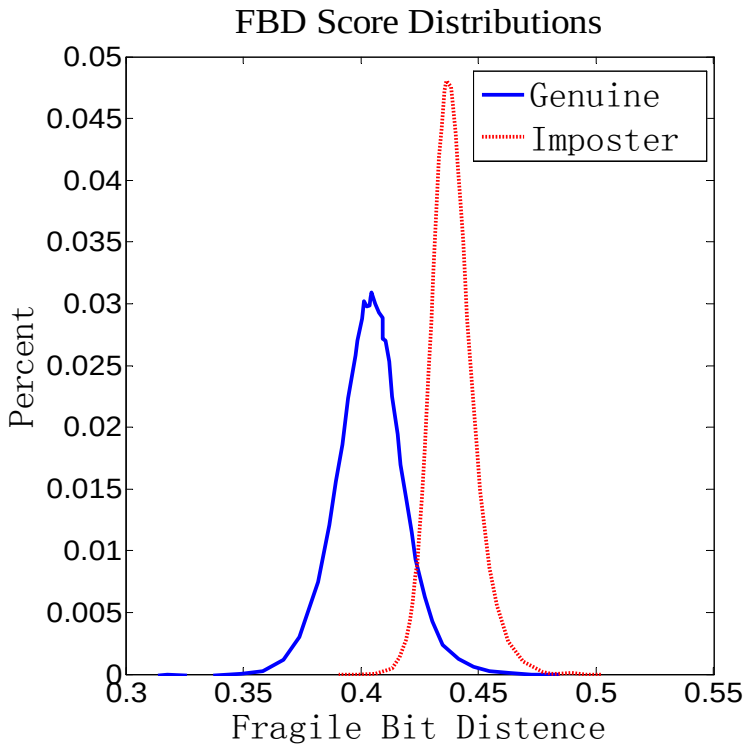

Figure 7. The genuine and impostor score distributions of Hamming distance.

Because the camera position and eye when shooting location exists axis do not coincide, translation variation of iris position image led to the shooting, and shooting distance is not fixed,

causing the size resolution changes, other effects of light on pupil size makes the iris region stretching change, these reasons result in different within the outer boundary of iris image, radius different size, location is not fixed, iris. Iris normalization is for the purpose of solving the eye rotation and telescopic images caused by the difference of the pupil.

IV. EXPERIMENTAL RESULTS

4.1 Statistical significance tests

Table 1 shows the results of fusion using multiplication.

TABLE 1. αHD+(1-α)FBD Statistically Significantly Different from 0.6HD+0.4FBD.

α	**Avg.EER**	**p-value**	**Yes/No?**
0	6.28×10^{-2}	2.81×10^{-8}	Yes
0.1	2.09×10^{-2}	1.75×10^{-6}	Yes
0.2	1.16×10^{-2}	1.79×10^{-4}	Yes
0.3	8.98×10^{-3}	1.24×10^{-2}	Yes
0.4	8.21×10^{-3}	4.29×10^{-1}	No
0.5	8.08×10^{-3}	9.62×10^{-1}	No
0.6	8.08×10^{-3}	-	-
0.7	8.19×10^{-3}	1.18×10^{-1}	No
0.8	8.37×10^{-3}	2.56×10^{-2}	Yes
0.9	8.56×10^{-3}	5.25×10^{-3}	Yes
1.0	8.68×10^{-3}	3.68×10^{-3}	Yes

The experimental results of using 5 percent fragile bit masking for all three tests are shown in Figure 8.

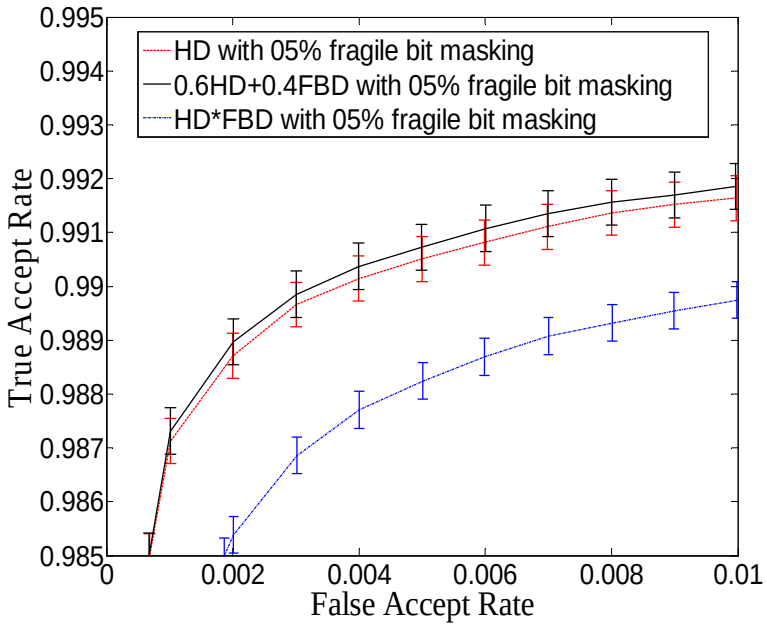

Figure 8. The experimental results of using 5 percent fragile bit masking for all three tests

4.2 Positioning results and analysis

The quality of iris image directly affects the recognition effect, therefore before recognition of image quality evaluation is very important. Image quality assessment is divided into subjective evaluation and objective evaluation of two methods. Subjective evaluation refers to the person's visual effect as the judgment standard, the method for different observers and the effect is not stable, also cannot use the mathematic model for quantitative description of image quality.

Objective evaluation of image quality is refers to the use of objective criteria certain, usually some mathematics to image content description to judge whether to reach the application requirements of image quality. Because of the objective evaluation criteria is accurate, rapid, quantitative operation and other characteristics, it is widely applied in practical engineering. Objective evaluation standard of the most commonly used are the mean square error (MSE) and peak signal to noise ratio (PSNR).

The test process is straight lines in the figure is removed, the Figure 9 is gray variation curve of the line point.

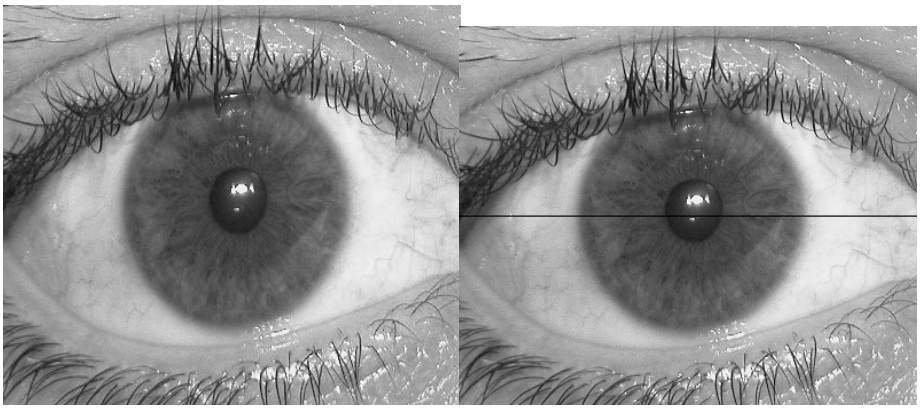

Figure 9. Evaluation method

4.3 Analysis of the recognition results

Figure 10 shows the iris blanket peacekeeping statistical distribution of normalized correlation between fractal dimension based on DFBR. As can be seen from the graph, the correlation and the within class iris asked the iris have obvious differences, so it can be normalized correlation fractal dimension as the iris classification basis.

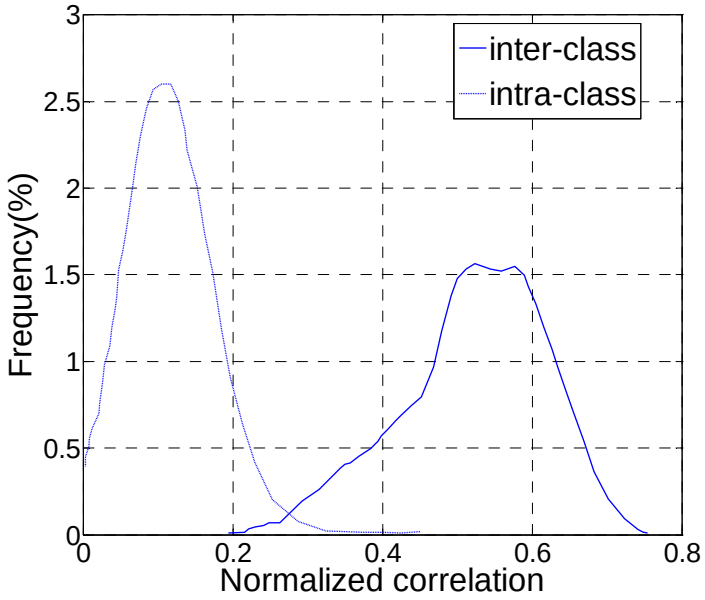

Figure 10 (a) The between class and within class iris iris based on DFBR fractal distribution of normalized correlation

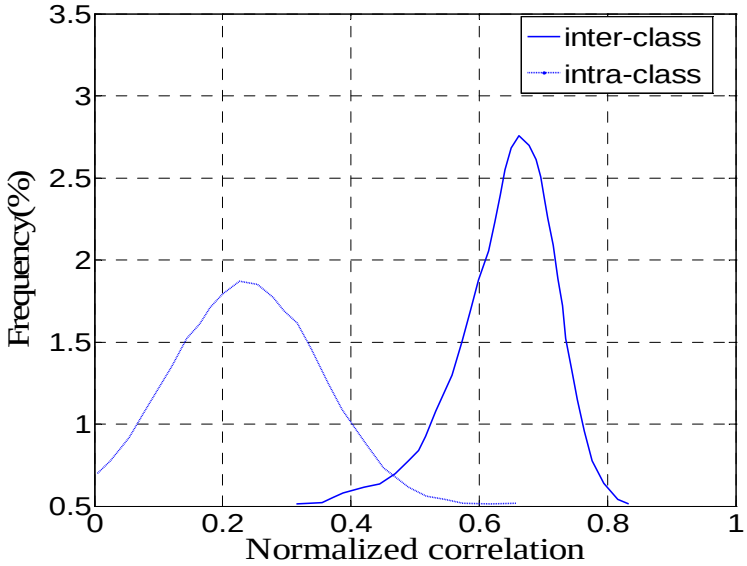

Figure 10 (b) Between the iris and the within class correlation dimension distribution of normalized iris blanket

In a variety of grid conditions, the longitudinal expansion blanket than ordinary blanket to obtain a better recognition effect. This also proves the longitudinal expansion blanket dimension in the advantage of expression of iris texture alignment of radiation. At the same time, 5x5 grid is most suitable for iris texture changes the size, self similarity can reflect the iris texture, can get the best recognition results.

V. CONCLUSIONS

This paper describes the whole process of iris recognition algorithm and implementation steps. Mainly includes the positioning of iris image, iris segmentation, normalization and enhancement, feature extraction and matching. In the classical learning algorithm of iris recognition at the same time, also made some improvement, improve the efficiency of the algorithm, experiments show the effectiveness of the proposed algorithm. Iris localization will directly affect the recognition effect. At the edge of the positioning, a positioning has bias conditions, using four point comparison mechanisms, which select the location result more reasonable. At the same time, the boundary detection template to improve, enhance the gray contrast, interference effectively random noise.

Quality assessment of iris image using the subjective method and objective method to evaluate the iris image, removed some do not meet the requirements of the image, improve the

recognition effect. The pupil center position according to the highlight point position reduces the search time complexity. Extraction of the outer edge of the pupil, and puts forward the method of the internal point threshold segmentation and empty. Locating the iris, application of transcendental pupil and iris information, reduce unnecessary computation point, reduce the time complexity. Iris normalization using the center deviation correction algorithm, compare the performance and computational cost of three interpolation algorithm.

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