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Individual Biometric Authentication based on the Iris

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Abstract. *With the development of the current networked society, personal authentication based on biometrics has received more and more attention. The interesting properties of the iris such as its texture stability make it a robust biometric trait for personal authentication. In this paper, we propose an iris authentication approach based on data base CASIA version 1.0. First, we apply the Hough transform for the iris detection. Then, the Gabor wavelet is used for coding. Finally, the Hamming distance is employed to make the authentication decision.*

Keywords. *Authentication, biometrics, iris, Hough transform, Gabor wavelets, Hamming distance.*

1. Introduction

The traditional security systems are founded on the individuals' visual recognition, possession of a key; the knowledge of a password or a personal identification number (PIN). All these methods have many drawbacks, such as the cost, the risk of loss, lapse of memory, flight and falsification. So, we need conceiving other systems. To solve these problems, we propose the multimodal biometrics systems; they authorize the recognition of the people with a high degree of accuracy. The multimodality is the combination of several biometric methods making it possible to increase the total performances and to decrease the error rates [1]. Several factors are fundamental for the biometric systems: precision, acquisition speed, acceptability by the users, and unicity of the biometric body. For this purpose, we are interested in the biometric authentication and particularly in the authentication by the iris. We notice that the iris contains interesting characteristics for more reliability and precision. Indeed, identical twins are enough characteristics in the iris so that we can distinguish them; the left eye is different from the right eye for each person, and the probability of having same iris is 10^{-72}.

The paper is organized as follows. In the next section, we discuss related work. The approach for iris authentication is described in detail in section 2. Section 3 gives the experimental results of the method using the CASIA iris database. Section 4 concludes the paper.

2. Related Work

Iris authentication has been an active research issue. The Daugman's system [2][3] is the best popular iris algorithm. The iris is modeled as two circles, which are not necessarily concentric. Each circle is defined by three parameters (x_0, y_0, r), where (x_0, y_0) locates the centre of a circle with radius r. Daugman used an integral-differential operator to estimate the three parameter values for each circular boundary. It searches the whole image with respect to an increasing radius r to maximize the equation (1) below:

$$\max_{(r, x_0, y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint \frac{I(x, y)}{2\pi r} ds \right|. \quad (1)$$

Where:

I(x, y) is the intensity value in the image at location (x, y), ds is the circular arc2πr is used to normalize the integral, Gσ (r) is a Gaussian filter used as a smoothing function, (*) is the convolution operator.

The eyelids are modeled as parabolic arcs. An integral-differential operator - as described in equation 1 is also used to locate the upper and lower eyelids. In that case, the integral is computed over a parabolic arc instead of a circular arc. The regions detected for the eyelids are excluded from the iris image. The segmented iris image is normalized and converted from Cartesian image coordinates to polar image coordinates. Then, a 2D Gabor filter is used to encode the iris image to a binary code of 256 bytes in length. In the matching part, the Hamming distance is used to indicate the similarity of two iris codes.

Wildes proposed another approach in [4]. The principle consists in using the gradient-based Hough transform to detect the two circular boundaries of an iris. It includes two steps. First, a binary edge map is generated by using a Gaussian filter. Then, votes in a circular Hough space are analyzed to estimate the three parameters of one circle (x_0, y_0, r). A Hough space is defined as:

$$H(x_c, y_c, r) = \sum_{j=1} h(x_j, y_j, x_c, y_c, r).$$
$$\text{with} \quad (2)$$
$$h(x_j, y_j, x_c, y_c, r) = \begin{cases} 1, if\,(x_j, y_j) \in C(x_c, y_c, r) \\ 0, else \end{cases}.$$

Where (x_j, y_j) is a pixel of edge

Wildes's system uses a Laplacian pyramid decomposition to encode the iris texture patterns. Then, it uses normalized correlation to determine the similarity of two iris codes. The final decision is obtained from a Fisher linear discriminate.

3. Iris Authentication System

Iris authentication system is composed by four stages: image acquisition, segmentation, coding, and matching. The following figure shows the different steps of the approach.

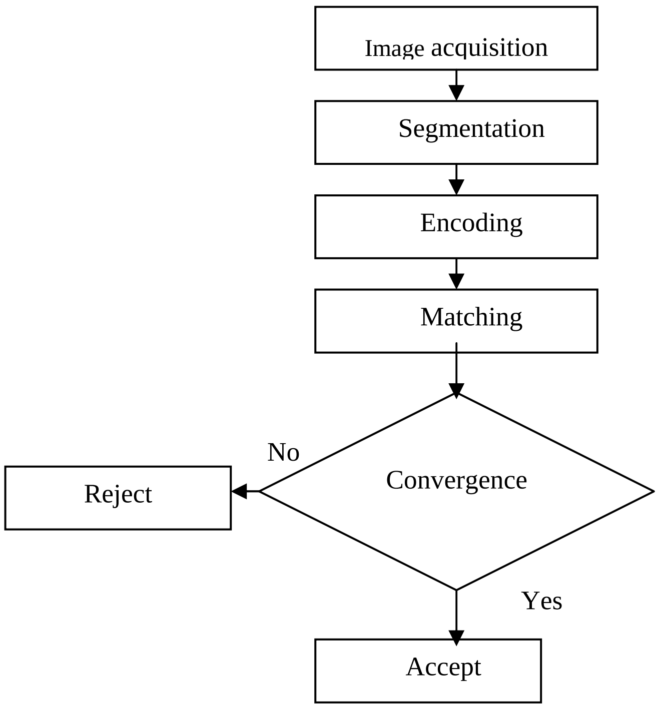


Fig. 1. Iris authentication system.

Our approach is a combination of Daugman's and Wildes's systems. Indeed, in the phase of segmentation, we use the Wildes method (Hough transform). In the coding phase , we employ the Daugman's approach (Gabor wavelet) .

3.1. Experimental Data Base

In the experimental works, we use the CASIA data base version 1.0

3.2. Iris localization

The following diagram illustrates the stages of iris localization.

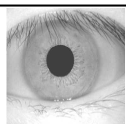
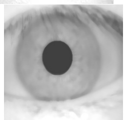
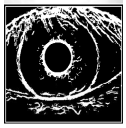
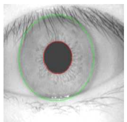
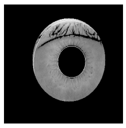
Step	result
Reading of the image	
Filtering by the median filter	
Edge Detection of contours using Sobel	
Application of the Hough transforms to determine the center of pupil (x0, y0), the radius r0 and the center of the iris (x, y) and the radius r	
Posting of the results **(iris)**	

fig. 1. Iris localization Diagram

3.3. Feature Encoding

This phase continent two stages: normalization and encoding

3.3.1 Normalization

In this step the isolated iris part is unwrapped into a rectangle, to do that we transform the Cartesian coordinates of the iris image I (X, Y) to the polar coordinates I(ρ, θ). This is illustrated in the following equations:

$$\theta \in [0 \quad 2\pi]\ \rho \in [0 \quad 1],\ I(x(\rho, \theta), y(\rho, \theta)) \rightarrow I(\rho, \theta) \qquad (3)$$

$$x(\rho,\theta) = (1-\rho)x_p(\theta) + \rho x_p(\theta). \quad (4)$$

$$y(\rho,\theta) = (1-\rho)y_p(\theta) + \rho y_i(\theta). \quad (5)$$

$$x_p(\theta) = x_{p0}(\theta) - r_p * \cos(\theta). \quad (6)$$

$$y_p(\theta) = y_{p0}(\theta) - r_p * \sin(\theta). \quad (7)$$

$$x_i(\theta) = x_{i0}(\theta) - r_i * \cos(\theta). \quad (8)$$

$$y_i(\theta) = y_{i0}(\theta) - r_i * \sin(\theta). \quad (9)$$

Where r_p and r_i are respectively the pupil and the iris radius, whereas ($x_p(\theta)$, $y_p(\theta)$) and ($x_i(\theta)$, $y_i(\theta)$) the coordinates of the pupil and iris in the θ direction. The θ value belongs to [0; 2pi], ρ belongs to [0; 1].

The result of the normalization is show in the figure below:

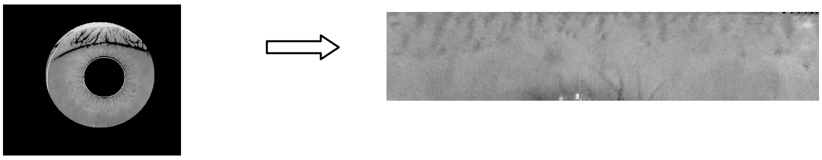


Fig. 2. Unwrapped iris

3.3.2 Encoding

The extraction process is completed by the use of 2D Gabor wavelets .Gabor wavelets are used for calculation of the code. The Gabor wavelet are particular wavelets types which contain Gaussian functions, modulated by complex sinusoids. The 2D Gabor wavelet are given by the following equation [5]:

$$H = \int_\rho \int_\phi e^{-i\omega(\theta_0-\varphi)} e^{-(r_0-\rho)^2/\alpha^2} e^{-(\theta_0-\varphi)^2/\beta^2} I(\rho,\varphi)\rho \, d\rho \rho \phi. \quad (10)$$

The equation below is locally applied to the image:

$$h_{\{Re, Im\}} = \mathrm{sgn}_{\{Re, Im\}} \int_\rho \int_\phi e^{-i\omega(\theta_0-\varphi)} e^{-(r_0-\rho)^2/\alpha^2} e^{-(\theta_0-\varphi)^2/\beta^2} I(\rho,\varphi)\rho d\rho d\varphi. \quad (11)$$

Where sgn is:
1 if the element corresponding of H is greater than zero.

0 if the corresponding element of H is equal to zero.

The operation is locally repeated on the entire iris surface in order to extract a code of iris.

3.4. Matching

The final step in the authentication is the comparison of the iris codes .The comparison is based on the Hamming distance (HD). The Hamming distance is a fractional measure of the number of bits between two binary patterns. The test of matching is implemented by the simple Boolean Exclusive-OR operator (XOR) applied to the code of iris patterns. The equation of the Hamming distance is as follows.

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j (XOR) Y_j . \quad \textbf{(12)}$$

Xj, Yj are two iris codes

The performance of biometric systems is measured qualified and expressed using different rates [7]. We have the following definitions:

FRR: the false rejection rate, FAR: the false acceptance rate.

$$\text{FRR} = \frac{\text{false rejection numbers}}{\text{Number of attempts}} . \quad \textbf{(13)}$$

$$\text{FAR} = \frac{\text{false acceptance numbers}}{\text{Number of attempts}} . \quad \textbf{(14)}$$

$$\text{accuracy} = 100 - \frac{\text{FAR} + \text{FRR}}{2} . \quad \textbf{(15)}$$

In his works, Daugman, tests a very large iris models number (up to 3 million iris images) and deduced that the maximum Hamming distance which exists between the two iris belonging to the same person is 0.32 [6]. We adopted this threshold in this work. So, the decision is as follows:
If HD <= 0.32 then it is the same person.
If HD > 0.32 then it is a different person.

4. Experimental Results

The execution of the biometric system is estimated by measuring the false acceptance rate (FAR) and the false rejection rate (FRR).We plot the curve of FAR and FRR according to the subjects' number.

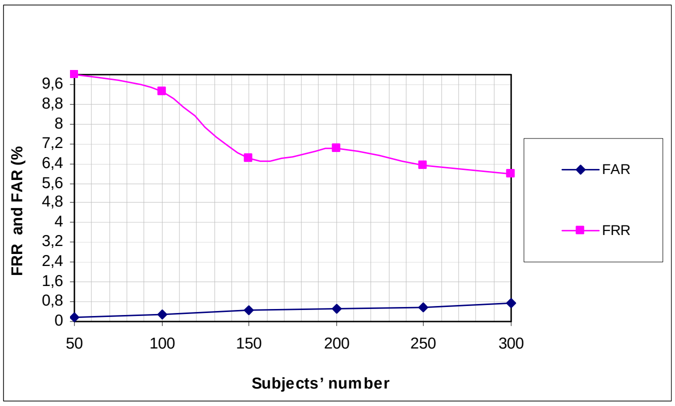


Fig. 5. Curve of FRR and FAR according to subjects' number

The Figure 3 shows that more the subjects' number increases, more the FAR increases, on the other hand the FRR decreases. In these types of systems, it is impossible to decrease the two types of errors at the same time. It is one of the reasons which justified the introduction of the multimodal biometrics systems since it is possible to decrease the two types of error at the same time.

In the following table we measure the authentication rate.

Table 1. Accuracy of individual recognizers

Method	Accuracy (%)
Daugman	99.97
wildes	100
Our Approche	95.6

In this work, the accuracy of individual recognizers is 95.6 %.The authentication rate is different from 100% due to bad lighting, occlusion by the eyelids, the noises or inadequate positioning of eye in the CASIA data base version 1.0. Besides Daugman used a larger data base of image, and this explains the fact that he has obtained the highest rate of recognition.

$$H(x_c, y_c, r) = \sum_{j=1} h$$

with

$$h(x_j, y_j, x_c, y_c, r)$$

5. Conclusions

In this paper, an efficient method for personal authentication by means of human iris patterns is developed. In the proposed approach, the Daugman and the Wildes systems are combined. For that, we use Hough transform to localize the iris, the Gabor wavelet to code it, and the Hamming distance to compare two iris codes. As a result, we have increased the security level by decreasing the false acceptance rate to 4%. The system found out has a 95.6 % authentication rate. These results can be improved by using larger image database for test with high quality. From the experimental results, we are convinced that the proposed system is appropriate to various real applications like its integration in a multi-modal authentication system.

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