Study of Two Different Methods for Iris Recognition Support Vector Machine and Phase Based Method

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Abstract:

The iris recognition is a kind of the biometrics technologies based on the physiological characteristics of human body, compared with the feature recognition based on the fingerprint, palm-print, face and sound etc, the iris has some advantages such as uniqueness, stability, high recognition rate, and non-infringing etc. The iris recognition consists of iris localization, normalization, encoding and comparison. In this paper two different methods of iris recognition mechanism are analyzed. One is support vector machine and other is the Phase based method. Experimental results and data sets of both methods are also discussed. This paper also showed the table for the performance result iris methodologies.

Keywords: *Biometric recognition system, Phase based method, Support vector machine (SVM).*

1. INTRODUCTION

Iris recognition is a biometric-based method of identification. This method has many advantages, such as unique, stability, can be collected, non aggressive, etc. The iris recognition's error rate is the lowest in most biometric identification method. Now many research organizations at home and abroad spend a lot of time and energy to do research of iris recognition [13]. Biometric recognition refers to the process of matching an input biometric to stored biometric information. In particular, biometric verification refers to matching the live biometric input from an individual to the stored biometric template about that individual [1]. Examples of biometrics include face images, fingerprint images, iris images, retinal scans, etc. Thus, image processing techniques prove useful in the biometric recognition. The field of biometrics utilizes computer models of the physical and behavioral characteristics of human beings with a view to reliable personal identification. The human characteristics of interest include visual images, speech, and indeed anything which might help to uniquely identify the individual.

Most current authentication systems are password based making them susceptible to problems such as forgetting the password and passwords being stolen. One way to overcome these problems is to employ biometrics (e.g., fingerprints, face, iris pattern, etc.) for authentication. Another important application is to match an individual’s biometrics against a database of biometrics. An example application of biometric identification is the matching of fingerprints found at a crime scene to a set of fingerprints in a database [11]. Authentication problem has narrower scope, but the matching technologies are applicable to both verification and identification problems [10]. Many biometric sensors output images and thus image processing plays an important role in biometric authentication. Image preprocessing is important since the quality of a biometric input can vary significantly. For example, the quality of a face image depends very much on illumination type, illumination level, detector array resolution, noise levels, etc [3]. Preprocessing methods that take into account sensor characteristics must be employed prior to attempting any matching of the biometric images. The use of biometric systems has been increasingly encouraged by both government and private entities in order to replace or increase traditional security systems. The word iris is generally used to denote the colored portion of the eye. It is a complex structure comprising muscle, connective tissues and blood vessels. The image of a human iris thus constitutes a plausible biometric signature for establishing or confirming personal identity [6]. Further properties of the iris that makes it superior to finger prints for automatic identification systems include, among others, the difficulty of surgically modifying its texture without risk, its inherent protection and isolation from the physical environment, and it’s easily monitored physiological response to light [5]. Additional technical advantages over fingerprints for automatic recognition systems include the ease of registering the iris optically without physical contact beside the fact that its intrinsic polar geometry does make the process of feature extraction easier [4]. Boles and Boashash [2] proposed a novel iris recognition algorithm based on zero crossing detection of the wavelet transform, this method has only obtained the limited results in the small samples, and this algorithm is sensitive to the grey value changes, thus recognition rate is lower. In another method followed by Jie Wang [7] the iris texture extraction is performed by applying wavelet packet transform (WPT) using Haar wavelet. The iris image is decomposed in to sub images by applying WPT and suitable sub images are selected and WPT coefficients are encoded. One more technique to extract the feature is Haar wavelet decomposition. Tze Weng Ng, Thein Lang Tay, Siak Wang Khor [8], has proposed Haar wavelet decomposition method for feature extraction. It acquires an accuracy using complex neural network matching method. Coefficients obtained from the decomposition of are then converted to binary codes to be used on calculation of hamming distance for matching purpose. Zhonghua Lin, Bibo Lu [9], has proposed iris recognition based on the optimized Gabor filters. The recognition rate is high, the recognition speed is guaranteed. Iris recognition will need in future for security. Iris recognition has many advantages comparing other biometric techniques:

1.1Uniqueness

Dissector F. H. Adler suggested the uniqueness of iris originally in 1965. The visible features in an iris include the trabecular meshwork of connective tissue, collagenous stromal fibres, ciliary processes, contraction, and freckle. These textures ensure that different persons have distinct iris. The probability of two persons' irises being the same is lower than10^{-35}. Even though they are twins, their irises are quite different. This fact is the reason why we use iris to recognize personal identity.

1.2Reliability

Iris is an inner organ in our eyes and protected by eyelid, lash and cornea. Unlike finger and palm, it is seldom hurt and the error of recognition caused by scar will never happen. In this sense, iris recognition is much better than fingerprint and palm-print recognition. Furthermore, our irises matured when we were one year old and would not change in our life.

1.3Against artifice

A living eye's pupillary diameter relative to iris diameter in a normal eye is constantly changing, even under stead illumination. The pupillomotor response could provide a test against artifice.

II. STEPS OF IRIS RECOGNITION SYSTEM

It is the process of acquiring high definition iris images either from iris scanner or precollected images. These images should clearly show the entire eye especially iris and pupil part. Then Major steps are followed:-

2.1 Segmentation

A technique is required to isolate and exclude the artifacts as well as locating the circular iris region. The inner and the outer boundaries of the iris are calculated.

2.2 Normalization

Iris of different people may be captured in different size, for the same person also size may vary because of the variation in illumination and other factors. The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have Characteristic features at the same spatial location.

2.3 Feature extraction

The significant features of the iris must be encoded so that comparisons between templates can be made. Most iris recognition systems make use of a band pass decomposition of the iris image to create a biometric template. Iris provides abundant texture information. A feature vector is formed which consists of the ordered sequence of features extracted from the various representation of the iris images.

2.4 Matching of an Image

To authenticate via identification (one-to-many template matching) or verification (one to- one template matching), a template created by imaging the iris is compared to a stored value template in a database. If the Hamming distance is below the decision threshold, a positive identification has effectively been made e.g. a hamming distance of 0 would result in a perfect match.

III. SUPPORT VECTOR MACHINE (SVM)

Support Vector Machines (SVMs) [19] as pattern classification techniques which are based on iris code model which the feature vector size is transformed to one-dimension vector which reduces to 1 x 480 by using averaging techniques contains the average value to recognize an authorized user and unauthorized user. SVM is a relatively new learning machine technique, which is based on the principle of Structural risk minimization (minimizing classification error). A SVM is binary classifier that optimally separates the two classes of data. There are two important aspects in the development of SVM as classifier. The first aspect is determination of the optimal hyper plane which will optimally separate the two classes and the other aspect is transformation of non-linearly separable classification problem into linearly separable Fig1 shows linearly separable binary classification problem with no possibility of miss-classification data. Let **x** and y be a set of input feature vector and the class label respectively. The pair of input feature vectors and the class label can be represented as tuples $\{x_i, y_i\}$ where $i = 1,2,\ldots,N$ and $y = \pm 1$. In the case of linear separable problem, there exists a separating hyper plane which defines the boundary between class 1 (labeled as y = 1) and class 2 (labeled as y = -1). The separating hyper plane is:

$$w.x + b = 0 \qquad (1)$$

Which implies

$$y_i(w.x_i + b) \geq 1, i = 1,2,\ldots,N \qquad (2)$$

Basically, there are numerous possible values of {w, b} that create separating hyper plane. In SVM only hyper plane that maximizes the margin between two sets is used. Margin is the distance between the closest data to the hyper plane.

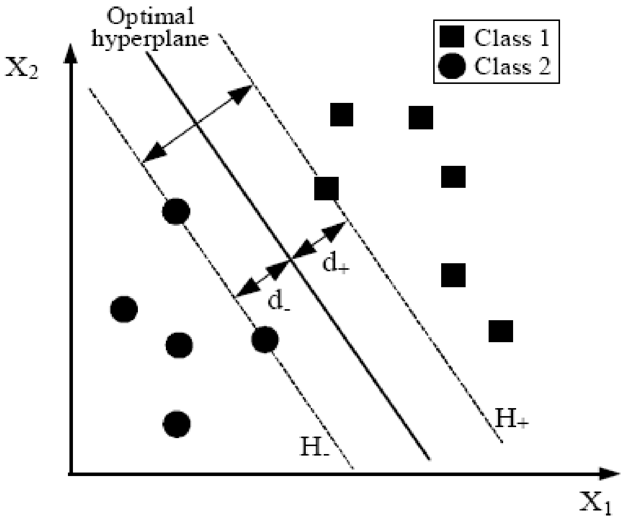

Figure1. SVM with linear separable

The margins are defined as d+ and d-. The margin will be maximized in the case $d+ = d-$. Moreover, training data in the margins will lie on the hyper planes H+ and H-.

$$(d+) + (d-) = \frac{2}{\|w\|} \qquad (3)$$

As H+ and H- are the hyper planes in which the closest training data to the optimal hyper plane, then there is no training data which fall between H+ and H-. This means the hyper plane that separates optimally the training data is the hyper plane which minimizes $\|w\|^2$, the minimization of $\|w\|^2$ is constrained by equation(1). When the data is non-separable, slack variables, ε_j, are introduced into the inequalities for relaxing them slightly so that some points allow lying within the margin or even being misclassified completely. The resulting problem is then to minimize,

$$\tfrac{1}{2}\|w\|^2 + \left(\sum_i L(\varepsilon_j)\right) \qquad (4)$$

Where C is the adjustable penalty term and L is the loss function. The most common used loss function is linear loss function, $L(\varepsilon_i) = (\varepsilon_i)$ The optimization of (3) with linear loss function using Lagrange multipliers approach is to maximize,

$$L_D(w, b, \alpha) = \sum_{i}^{N} \alpha_i \text{-½} \sum_{i=1}^{N} \sum_{i=1}^{N} \alpha_i \alpha j . y_i y j < x_i . xj > \quad (5)$$

Subject to

$$0 \leq \alpha_i \leq C \quad (6)$$

And

$$\sum_{i}^{N} \alpha_i y_i \quad (7)$$

Where α_i is the Lagrange multipliers. This optimization problem can be solved by using standard quadratic programming technique. Once the problem is optimized, the parameters of optimal hyper plane are,

$$w = \sum_{i}^{N} \alpha_i y_i x_i \quad (8)$$

As matter of fact, α_i is zero for every x_i except the ones that lie on the margin. The training data with non-zero α_i are called as support vectors. In the case of a non-linear separable problem, a kernel function is adopted to transform the feature space into higher dimensional feature space in which the problem become linearly separable. Typical kernel functions commonly used are listed in table 1.

Kernel	$K(X, X_i)$
Linear	$X^T . X_j$
Polynomial	$(X^T . X_j + 1)^d$
Gaussian RBF	$exp\left[- \left\| \frac{x_i x_j}{2\sigma^2} \right\|^2 \right]$

Table1. Formulation for kernel function

3.1 Performance measurement

This system in general makes four possible decisions; the authorized person is accepted, the authorized person is rejected, the unauthorized person (impostor) is accepted and the unauthorized person (impostor) is rejected. The accuracy of the proposed system is then specified based on the rate in which the system makes the decision to reject the authorized person and to accept the unauthorized person. False Rejection Rates (FRR) is used to measure the rate of the system to reject the authorized person and False Acceptance Rates (FAR) used to measure the rates of the system to accept the unauthorized person. Both performances are can be expressed as:

$$FRR = \frac{NFR}{NAA} \times 100\% \quad (9)$$

$$FAR = \frac{NFA}{NIA} \times 100\% \quad (10)$$

NFR is referred to the numbers of false rejections and NFA is referred to the number of false acceptance, while NAA and NIA are the numbers of the authorized person attempts and the numbers of impostor person attempts respectively. Furthermore, low FRR and low FAR is the main objective in order to achieve both high usability and high security of the system.

3.2 Data sets and experimental results

The Chinese Academy of Sciences–Institute of Automation (CASIA) eye image database is used in the experiment. To evaluate the effectiveness of the proposed system, a database of 42 grayscale eye images (7 eyes with 6 different images for each eye) was employed. About 30 grayscale eye images with 5 unique eyes are considered as authorized users and the others are impostors. For each eye, 6 eye images were captured in two different sessions with one month interval between sessions (three samples are collected in the first session and others three in second sessions) using specialized digital optics developed by the National Laboratory of Pattern Recognition, China. Infra-red lighting was used in acquiring the images, hence features in the iris region are highly visible and there is good contrast between pupil, iris and sclera regions.

The performance of biometric systems is usually described by two error rates: FRR and FAR. Hence, the effectiveness of the proposed system in testing phase is evaluated based upon FRR and FAR values. The FAR is calculated based on the close set and open set. In the close set, the typing biometric of an authorized person uses other authorized person identity. On other hand, the open set is referred as typing biometric of the impostors use authorized person. The obtained feature vector of iris code comprises matrix of 20 x 480. This feature vector consists of bits 0 and 1. It was observed in all the experiments conducted that the feature vector size which containing high dimensionality often contributed to high FRR and FAR values with long processing time. To overcome this problem, feature vector size is transformed to one-dimension vector which reduces to 1 x 480 by using averaging techniques contains the average value. SVMs are classifiers which have demonstrated high capability in solving variety of problems that include the object recognition problems. Experimental results of training and testing based on iris code using SVMs are discussed. In developing user models based on iris code, a SVM with polynomial kernel function of order 8 is used. Each authorized user has its own SVM–based model characterized by a set of support vectors. By using quadratic programming in the MATLAB environment, appropriate support vectors are determined. The penalty term C of 10^{15} is used to anticipate misclassified data. Table 2 shows the training performance when the SVM is employed to develop user's models based on their iris code.

Authorized User	Training Time(sec)	Classification Results (%)
User1	0.0781	100
User2	0.0781	100
User3	0.0625	100
User4	0.1094	100
User5	0.0781	100
Average	0.0812	100

Table2. Training performance of iris code

These results indicate that all of the SVM–based user models give perfect classifications as there are no errors in recognizing all the users. Besides, all of the SVM– based models can be trained in a very short time of about 0.1 second. A series of experiments is conducted using the testing data which have not been used during the training phase. Table 3 shows the testing performances of the SVM-based authorized user models. The SVM–based authentication gives very good results for FAR of close set and open set conditions. This implies that the proposed system is well protected from attacking by impostors. In contrast, the FRR values are very high percentage with an average value of about 19.80%. Hence, the system seems to have poor usability. Experimental results show that the first, second and fourth users produce maximum FRR values of about 33%.

Authorized User	FRR (%)	FAR (%) Close set	FAR (%) Open set
User1	33	0	0
User2	33	0	0
User3	0	0	0
User4	33	0	0
User5	0	0	0
Average	19.80	0	0

Table3. Testing performance of iris code

IV. PHASE BASED METHOD

4.1 Daugman integrodifferential operator

The phase based method recognize iris patterns based on phase information. Phase information is independent of imaging contrast and illumination. J.Daugman [12, 14] designed and patented the first complete, commercially available phase-based iris recognition system in 1994. The eye images with resolution of 80-130 pixels iris radius were captured with image focus assessment performed in real time. The pupil and iris boundary was found using integrodifferential operator given in following Equation:

$$max_{r}, x0, y0 \left| G(r) * \frac{d}{dr} \int_{r}, x0, y0 \frac{I(x,y)}{2\Pi r} ds \right| \qquad (11)$$

Where I(x, y) is the image in spatial coordinates r is the radius, (x0, y0) are centre coordinates, the symbol * denotes convolution and G σ(r) is a Gaussian smoothing function of scale σ. The centre coordinates and radius are estimated for both pupil and iris by determining the maximum partial derivative of the contour integral of the image along the circular arc. The eyelid boundaries are localized by changing the path of contour integration from circular to actuate. The iris portion of the image I(x) is normalized to the polar form by the mapping function I(x(r, θ), y(r, θ)) → I(r, θ) where r lies on the unit interval [0, 1] and θ is the angular quantity in the range [0, 2Π]. The representation of iris texture is binary coded by quantizing the phase response of a texture filter using quadrature 2D Gabor wavelets into four levels. Each pixel in the normalized iris pattern corresponds to two bits of data in the iris template. A total of 2,048 bits are calculated for the template, and an equal number of masking bits are generated in order to mask out corrupted regions within the iris. This creates a compact 256-byte template, which allows for storage and comparison of iris.

The recognition in this method is the failure of a test of statistical independence involving degrees of freedom. Iris codes are different for two different samples. The test was performed using Boolean XOR operator applied to 2048 bit phase vectors to encode any two iris patterns, masked by both of their bit vectors. From the resultant bit vector and mask bit vectors, the dissimilarity measure between any two iris patterns is computed using Hamming Distance (HD), given in the following equation:

$$HD = \frac{(codeA \circledast codeB) \odot maskA \odot maskB}{maskA \odot maskB} \qquad (11)$$

Where code A, code B are two phase code bit vectors and mask A, mask B are mask bit vectors. The HD is a fractional measure of dissimilarity with 0 representing a perfect match. A low normalized HD implies strong similarity of iris codes.The work by Xianchao Qui [15] used 2D Gabor filters for localization. The filter response vectors were clustered using vector quantization algorithms like k-means. The experiments were conducted on CASIA-Biosecure iris database consisting of images captured from Asian and non-Asian race groups. In Martin‘s method, the iris circumference parameters are obtained by maximizing the average intensity differences of the five consecutive circumferences.

In Masek‘s method, the segmentation was based on the Hough transform. The phase data from 1D Log-Gabor filters was extracted and quantized to four levels to encode the unique pattern of the iris into a bit-wise biometric template. Xiaomei Liu [16] reimplemented Masek‘s algorithm in C that was originally written in Matlab. Continuing the Daugman‘s method, Karen vollingsworth [17] has developed a number of techniques for improving recognition rates. These techniques include fragile bit masking, signal-level fusion of iris images, and detecting local distortions in iris texture. The bits near the axes of the complex plane shift the filter response from one quadrant to adjacent quadrant in presence of noise. In the fragile bit masking method, such bits called as the fragile bits are identified and masked to improve the accuracy. The signal-level fusion method uses image averaging of selected frames from a video clip of an iris. Local texture distortions occurs with contact lenses with a logo, poor-fit contacts and edges of hard contact lenses, segmentation inaccuracies and shadows on the iris. These are detected by analyzing iris code matching results. The 20x240 normalized images were covered with 92 windows each of size 8x20. Fractional HD was computed for each window. The location of windows with highest fractional HD was identified and removed from further calculations. The effect of dilation was studied by collecting datasets of images with varying degrees of dilation. The data was divided into subsets with small pupils, medium pupils and large pupils. The subset of data with large pupils showed worst performance with EER at an order of magnitude greater compared to that of small pupil data set. The visibility in the iris area is reduced and greater part of iris is occluded by eyelids which provide less information for iris code generation. Following table shows the performance result of Daugman's algorithm and other algorithms of iris recognition.

Group	EER	FAR/FRR	Overall accuracy
Wides et al	1.76	2.4/2.9	95.10
Avila	3.38	0.03/2.08	97.89
Tisse	5.94	1.84/8.79	96.61
Li Ma	4.73	0.02/1.98	98.00
Daugman	0.95	0.01/0.09	99.9
Boles	8.13	0.02/1.98	94.33
Hamed Ranjzad	2.1	1.6/1.2	98.1
Kaushik Rai	0.92	0.03/0.02	99.5

Table4. Performance results of Iris recognition methods

V. CONCLUSION

This paper concluded that the Support Vector Machine was adopted as classifier in order to develop the user model based on his/her iris code data. Experimental study using CASIA database is carried out to evaluate the effectiveness of the proposed system. Based on obtained results, SVM classifier produces excellent FAR value for both open and close set condition. Thus, the proposed system seems in a good level of security. Phase based method recognize the iris pattern based on the phase information. Phase information is independent of imaging contrast and illumination. Continuing Daugman's method, Karen Vollingsworth has developed a numbers of techniques for improving the recognition rates. In fragile bit masking method, fragile bits are identified and masked to improve the accuracy. The signal level fusion method uses image averaging of selected frames from video clip of an iris. Local texture distortions occurs with contact lenses with a logo, poor-fit contacts and edges of hard contact lenses, segmentation inaccuracies and shadows on the iris. These are detected by analyzing iris code matching results. The experiments were conducted on CASIA-Biosecure iris database consisting of images captured from Asian and non-Asian race groups. The performance results are based on the error rates: False Acceptance Rate (FAR) and False Rejection Rate (FRR); Equal Error Rate (EER) and the overall accuracy. Table 4 shows that Daugman's method gives the maximum accuracy with respect to FRR and FAR, 0.01/0.09 and overall accuracy 99.9%.

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