Biometric Iris Recognition System using Multiscale Feature Extraction Method

K. Harini, G. Yamuna, V. Santhiya

Abstract: By an growing demand for security systems, identification of individuals based on biometric techniques has been a major role of research and education. Biometric recognition examines unique behavioral characteristics, such as an iris, face, retina, voice, fingerprint, hand geometry etc. The iris is one of the highly consistentmethods that used to identify individuals because it is fixed and does not change throughout life. This features have led to increasing importance in its use for biometric recognition. In this study, we proposed a system combiningDiscrete Wavelet Transformation and Principal Component Analysis forfeature extraction process of an iris. The idea of using DWT behind PCA is to decrease the resolution of the iris pattern. The Discrete Wavelet Transform (DWT) is depend on sub-band codingwhichreduces the computation time and resources required. PCA is used for further extraction. Our experimental calculation supports the efficient performance of the proposed system.

Keywords: Biometrics, Iris Recognition, PCA, Daugman's Rubber Sheet Model, DWT, Hough Transform, Hamming Distance.

I. INTRODUCTION

Biometric recognition implies the learning of identifying anindividuals with their unique or special physical qualities or behavioral features. Among the different types of biometric method, Iris recognition is one of the most popular biometric technique [1]. The power of recognitionand rapid iris detection has driven it into use in extensive applications e.g., Unique ID in India. Biometric iris recognition is the process of recognition a person by studying the unique pattern of the iris in order to authenticate the character of an individual Moreover it is impossible to find two persons have the same iris features even for the twins. The iris is the area which is usually brown or blue colored circle. In any iris recognition system high quality cameras are used often to capture iris image, this is to get more accuracy in detection iris. Cameras used for iris scanning is kept in fixed location or it may be portable.The iris scanner is used to collect various biometric features in eye which are unique for each individual.

K. Harini*, P.G., Department of Engineering (Communication Systems) Annamalai University, Tamil Nadu, India.
Dr. G. Yamuna, Professor and Head, Department of Electronics and Communication Engineering, Annamalai University, Tamil Nadu, India.
V. Santhiya, P.G., Department of Engineering (Communication Systems) Annamalai University, Tamil Nadu, India.

The scanners then produce a digital representation of the data that was stored in computer database. Uniqueness, stability are considered as one of the advantages if iris recognition.

II. METHODOLOGY

In this paper, extracting features from the irisimage is the most important stage in iris recognition system;
Especially this system dependson the features that are extracted from iris pattern. Theapproach used to improve feature extraction is combining Discrete Wavelet Transformation(DWT) and
Principal Component Analysis(PCA) This will obtain the key features of an iris and thus reducing the image resolution and in turn the runtime for classification that is required for the resultant iris patterns. Iris recognition systemcommonly consists of the following steps shown in fig 1.Imageacquisition, Iris segmentation, Normalization, Feature extraction andImage Classification. In our SystemHough transform is used for iris segmentation process. After the segmentation process the iris region is cut into rectangular block with equal dimensions using Daugman's rubber sheet model. A combined PCA and DWT were applied for feature extraction process. These steps are briefly explained below.
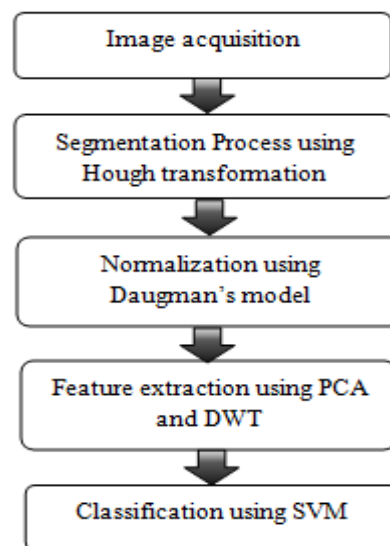

Figure 1:Data flow diagram

A. Dataset Selection

Image acquisition is the initial step in biometric iris recognition method, i.e., the capturing of high-quality iris images from the subject.In this paper, CASIA Iris Image Database Edition 1.0 is used to implement the proposed system.

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CASIA-IrisV1 includes 756 iris images from 108 eyes with resolution of 320×280 [2].Theimages are high quality and convenient toevaluatethe iris recognition system. Moreover, images are completely free of noise and characterized by homogeneity and inclusiveness making it easier in iris segmentation stage.

Image Pre-Processing

High performance of iris recognition system is achieved by overcoming some of the most importantobstacles, such as choosing the applicable database and unifies dimensions of the image, and recruits a sufficient number of images in each experiment. The technique used for preprocessing of the image is described below. This process helps in enhancing the image.

Image Resizing

Image resizing means changing the image size from smallest to largest and from largest to smallest in order to solve the problem of a difference image sizes in a single database. This leads to get the equal number of features from all images. In this thesis, decreasing the size of the images is carried out, because the databases use contain large and varying sizes images. Moreover, decreasing of the size of the images helps to decrease the handling time, and hence increases the system performance. The original image of the CASIA database which its original size is (320×280pixels), and the resultant image after this stage will have new size that is equal to (160×140 pixels).

Noise Removal

Images can be affected by several noises, the noises can be categorized under two sections, periodic noise and random noise. periodic noise in an image is from electrical or electromechanical interference during the image acquiring process. Random noise is variation of brightness or colour information in the images captured. To remove these noises, images are passed through the median filters. Median filter is very popular for reducing certain types of noise.

B. Segmentation

Iris segmentation refers to an detection of the boundaries of iris region and pupil region in eye image in order to eliminate the surrounding area. This stage helps in extracting the features from iris for individual identification in a correct and clear manner. In other words, the major aim of segmentation is eliminating non useful regions such as the parts surrounding the iris (eyelids, eyelashes and skin) [3] shown in Figure 2. The segmentation process determines the iris boundaries and pupil boundaries and then converts this part to a suitable template in normalization stage. The first approach uses edge detection and Hough Transform for segmentation [4]. The second approach uses different types of techniques to detect the iris boundary like Camusand Wildes operator and Integro-Differential operator.
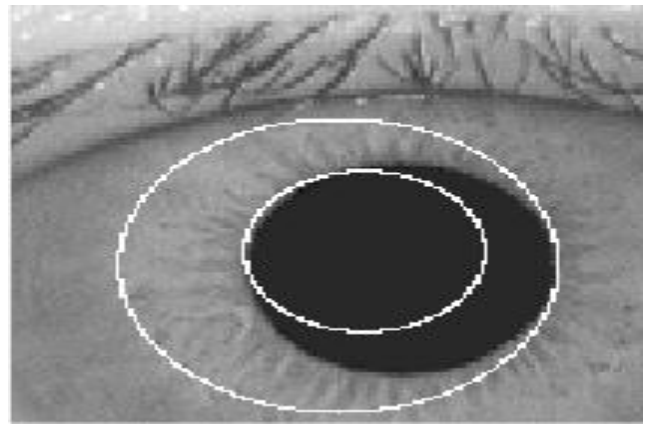

Figure 2:Detected iris

Hough transform

Hough Transform techniques are used in segmentation stage to determinethe portion of iris. It can be considered as the mapping function. Each point in image space is converted into a curve or line in Hough space. Hough transform can be used in detecting the border of a curve which better fits the edge point. The operator used for edge detection such as Roberts cross, Sobel and canny edge detector.In an image testing, the Hough space center coordinates of the point(s) of edge segments is (xc,yc) and the radius r of circle passing through the edge point. The Hough transform for a circular boundary and a set of retrieved edge points (xj,yj) where j = 1…, n is given by:

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

Where

$$h(x_j , y_j , x_c , y_c , r) = \begin{cases} 1, if \ g(x_j, y_j, x_c, y_c, r) \\ 0, otherwise \end{cases} = 0$$

And

$$g(x_j, y_j, x_c, y_c, r) = (x_j - x_c)^2 + (y_j - y_c)^2 - r^2$$

The Hough transform have some faults, while processing edge detection it fails to identify some curves it fails to identify some circles. To overcome this faults threshold value is developed. The Hough transform is computationally extensive, leading to low speed efficiency. It might not be applicable for real time applications.

C. Iris Normalization And Unwrapping

Once the iris is segmented successfully and other area are neglected from the image, after that normalization process occurs. Normalization is used to transform the iris part to a particular dimension in order to make easier for feature extraction step[5]. so that two images of the same iris in different conditions will have distinctive qualities at equal distance and same spatial direction. After normalizing the doughnut shaped iris region is achieved to have constant radius, as clearly shown in Figure 3, the centers of the iris and the pupil are not concentric.
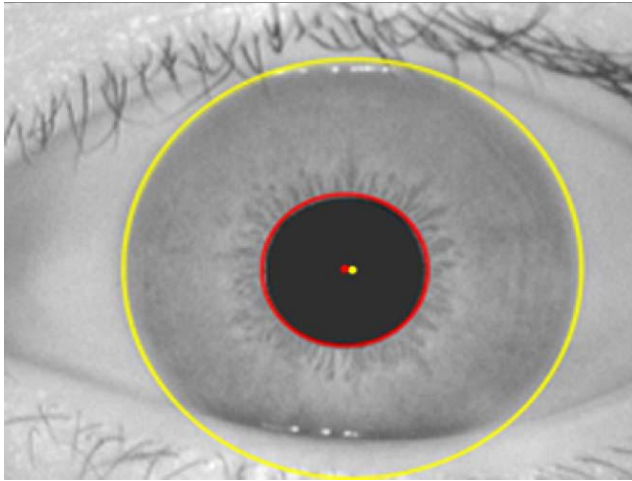
Figure 3: non concentric pupil and iris

Daugman's Rubber Sheet Model

The rubber sheet model remaps each point within the iris region to a pair of polar coordinates.The homogenous rubber sheet model used for pupil dilation, and non-concentricpupil displacement, it does not compensate for rotational inconsistencies.The homogeneous rubber sheet model was established by J.Daugman. where r is the radius on the interval [0,1], and$\theta$is the angle between the interval [0,2Pi]. Then the normalized iris is converted into a rectangular region.
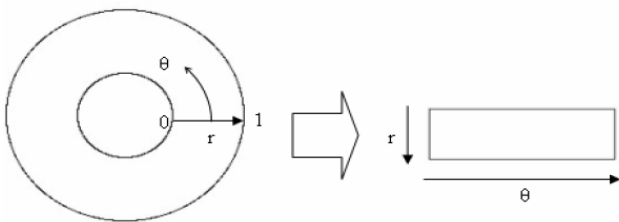

Figure 4: J,Daugman's Rubber Sheet Model

Using this rubber sheet approach for normalizing and unwrapping the iris region (Figure 6), the center point of the pupil is measured as the reference point, and radial vectors pass through the iris region [6]. The angular resolution is defined as the number of radial lines passingthrough the iris region.Since the pupil is non-concentric to the iris, a remapping or rescaling is required to rescale points depending on the angle around the circle. This is shown in the below equation

$$r' = \sqrt{\alpha\beta} \pm \sqrt{\alpha\beta^2 - \alpha - r_1^2}$$

With

$$\alpha = o_x^2 + o_y^2$$

$$\beta = \cos\left(\pi - arc\tan\left(\frac{o_y}{o_x}\right)\right) - \theta$$

where o_x , o_y represent the displacement of the centre of the pupil relative to the centre of the iris, and r' represents the distance between the edge of the pupil and edge of the iris at an angle θ around the region, and rI is the radius of the iris.

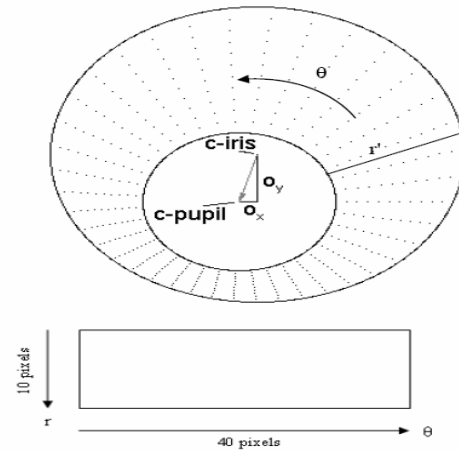This remapping procedure indicates the radius of the iris region as a function of the angle (θ). Shown in Figure 5.

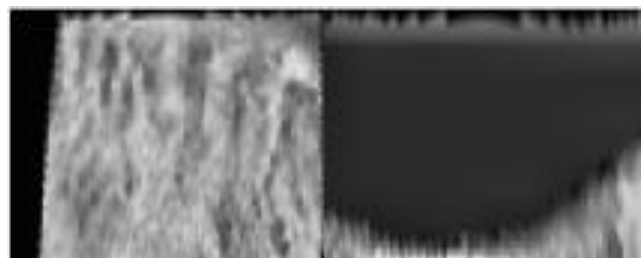**Figure 5: Finding the Radial and Angular Resolutions**

Figure 6: Normalized iris

D. Feature Extraction

The useful features are extracted by transforming the image with the help of some mathematical techniques. PCA and DWT are two such techniques, which are discussed in this section.

Principal Component Analysis

Principal component analysis (PCA) is a statistical technique that can be used as an unsupervised feature extraction method. It diagonalizes the covariance matrix of the image by eigenvalue decomposition. The eigenvalue is a kind of measure of the variance of the variable. The higher eigenvalue indicates the greater contribution to the information [7]. Therefore, only those variables are considered as features that correspond to higher eigenvalues. These orthogonal variables are known as principal components. PCA produces the uncorrelated principal components with decreasing variance. Only those principal components form the feature set that account for the most of the variance.

Discrete Wavelet Transform (DWT)

Wavelets are effective mathematical tools for signal processing in time-frequency domain at different scales, resolutions, and shifts. The wavelet represents a signal in terms of their basis functions known as mother wavelet. It is capable of obtaining time information as well as frequency information. Its digital counterpart is known as discrete wavelet transform(DWT)[8].

InDWT, wavelet is represented by a pair of lowpass and highpass filters. DWT is multi-resolution decompositions which will be used to analyze signals and images. Gabor and Haar wavelet is determined as the mother wavelets. From the survey it is noted that Haar wavelet is 0.9% better than the result with Gabor wavelet. Thus iris code or iris template is obtained.

Figure 7 : Feature extracted using PCA and DWT

Hamming Distance (HD)

After producing the iris pattern of the two eye image, need to compare this two eye template to see if any pairing occurs. Slight error occurs on processing the image from image acquisition to image classification. Thus a threshold is needed. Here hamming distance is used as threshold value.The Hamming distance proposed by Daugman gives a measure the bits that are similar between two eye patterns. It is used for the comparison of iris templates in the recognition stage[9].Therefore, the Hamming distance can conclude whether the two patterns were generated from the same iris image or from different iris. Hamming distance HD is given by Equation.

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

Where X and Y are the twobit patterns that is compared. So basically, the bit pattern of X is different than that bit pattern of Y, the result is 1, if the bit pattern of both X and Y is similar then the result will be 0.Finally the result is divided by N which is the total number of bits comprising the iris code.This will not happen in practice if normalization is not perfect.Anyway there will be alwaysa small quantity ofnoise undetected.As a conclusion, the greater the Hamming distance (nearer to 1), more likely two patterns are dissimilar. And the closer the distance the more likely the two patterns are to be similar . Thus the iris bit patterns

ofeach people is independent due to the reality that the iris is unique for every individuals,Moreover, it is impossible to find two persons have the same iris features even for the twins. The greater the accurate threshold value the smaller the error probability. Note that the results are not much accuracywhen they taken in unfavorable conditions that is image acquired from low pixel cameras or at different distances, andunfavorablelighting conditions.
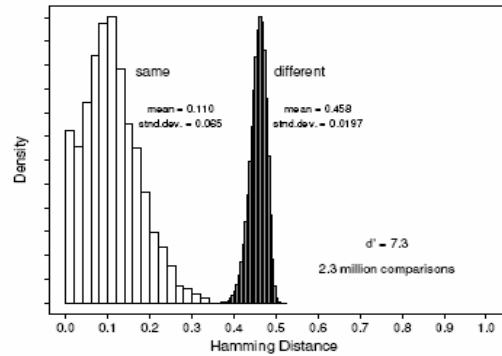

Figure 8: Iris Recognition Under Moderatelyunsuitable conditions.

Better results were obtained when iris recognition process take place in suitable conditions, by capturing the image from high quality camera and with same distance and lightning conditions.These results are shown in Figure 9.
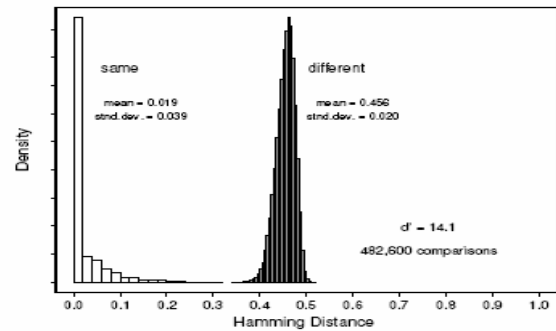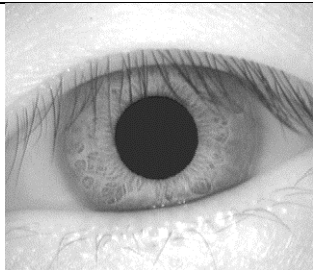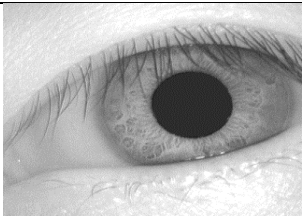

Figure 9: Iris Recognition Under suitable Conditions

	Image 1	Image 2	Hamming value	Inference
Test 1			0.183	templates are from same eye.
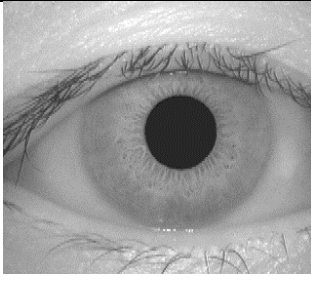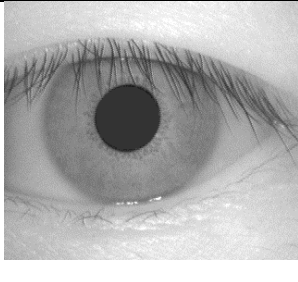
Test 2			0.255	templates are from different eye.
	(i)	**(ii)**	**(iii)**	**(iv)**

Figure 10: (i) Training image, (ii)Testing image, (iii) Hamming distance, (iv) Inference

A. Classification by SVM

The SVM is used as a classifier. The implementation is done in Matlab and SVM is implemented withMatlab interface of the well-known LIBSVM tool. the SVM method is used to classify the three iris region images into real and presentation attack classes.Thus, three probabilities are obtained to classify that the iris belong to presentation attack or real iris. Another SVM layer is used to combine the information or results from three regions of eye to classify the input iris images into real or presentation attackedimage [10].The results presented in terms of classification accuracy which is determined as the percentage of the correctly classified images during testing phase. The inference are show in Figure 10. The overall classification accuracy (OA) is calculated as follows.

$$Overall\ Accuracy = \frac{n(sucessful\_classification)}{n(test\_set)}$$

$$Average\ Accuracy = \frac{1}{N}\sum_{i=1}^{N} E[i]$$

where E[i] is accuracy for ith cluster.

III. RESULTS AND DISCUSSIONS

In matching process we have to compare two image by loading two eye image. The Support Vector Machine is used for classifying the similarity between two iris templates by hamming distance value. If hamming distance value is lesser than 0.2, both the eye samples are from the same eye. If the value is greater than 0.2 the eye samples are not from the same eye. This inference was tabulated in the below figure 10.

IV. CONCLUSION

The proposed system recognizes the iris of the persons in the dataset based on the features extracted using Principal Component Analysis (PCA) based on Discrete Wavelet Transformation (DWT). The extracted features are based on the DWT which is statistical features extracted from the image. The extracted features were optimized using Genetic algorithm. The proposed system gives accuracy which is higher than the existing algorithms which identifies that the misclassifications are reduced to a greater extend.To make the study more useful and effective by working on optimization of the code, so that the segmentation software can run in real time applications. And it can also be further used in detecting faces.

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AUTHORS PROFILE

K. Harini, is a student of Annamalai University, Chidambaram she completed her B.E degree in Electronics and Communication Engineering and currently pursuing her post graduation in engineering (Communication Systems) at Annamalai University.

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Dr. G. Yamuna, is working as a Professor and Head in Electronics and Communication Engineering, Annamalai University. She has 27 years of teaching and research experience. She has published nearly 75 papers in International journals and 38 papers in National and International conferences. Her field of specialization includes Signal processing, Video processing, Information security, Wireless communication systems and Antenna design.

V. Santhiya, is a student of Annamalai University, Chidambaram. She completed her B.E. degree in Electronics and Communication Engineering from Jeppiaar SRR Engineering College, Chennai. She is currently pursuing post graduation in engineering(Communication Systems) at Annamalai University.