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Haar Wavelet based Iris Recognition System for Secure Access using MATLAB

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ABSTRACT: In the modern world, a reliable personal identification system is required to control the access in order to secure areas or materials. Biometric recognition is a process of identifying a person by his biological characteristics which is unique in nature. Iris recognition is one of the most accurate biometric identifier used to identifying a person by the textural pattern of iris of their eyes. This paper shows and analyses the results of iris recognition system. The iris recognition system consists of a segmentation algorithm to locate the circular iris region using canny edge detection and hough transform. Then only left and right portions of iris are normalized instead of complete iris region. Haar wavelet is used to extract the discriminant features from the iris to generate the biometric template which is then compared using hamming distance to identify a person. Iris recognition is gaining importance due to its high reliability, ease of use, accuracy, and safety in controlling access to high-security areas reducing the possibility of illegal access.

KEYWORDS: Biometrics, Normalisation, Haar Wavelet Transform, Template Matching, Hamming distance.

I. INTRODUCTION

Number of systems require genuine personal identification schemes to confirm or determine the identity of a person requesting their services so that only authorized users can access the system. For example secure access to any place (building, laboratory, Data centre etc), computer systems, electronic data security, e-commerce, medical records, laptops, mobile phones, and ATMs. Some commonly used biometric identifiers are Fingerprint, Face, Retina, Hand geometry, Palm prints, voice and Iris. A biometric system captures and stores the biometric information from the physical characteristics and then compares it with the scanned biometric. Iris is a colored area in the eye with pupil in its center and surrounded by the white sclera and covered by transparent cornea. Iris of the eye functions like the diaphragm of a camera, controlling the amount of light reaching the back of the eye by automatically adjusting the size of the pupil. The Iris pattern fully developed at the age of 1 year and then remains stable throughout the life. The average diameter of the iris is 12 mm, and the pupil size can vary from 10% to 80% of the iris diameter. According to studies the iris pattern remain stable over the entire life of a person and there is very low probability of the existence of two irises that are same, i.e. one in 10^{72} [2]. Fig 1 shows front view of eye with iris and its different parts.

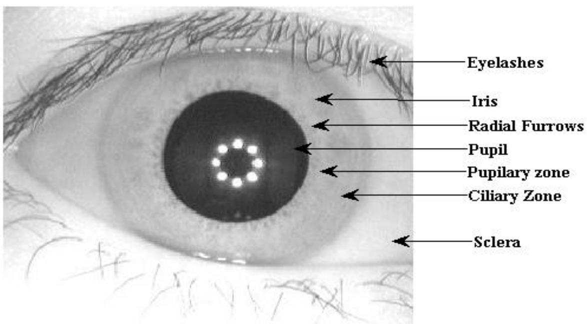

Fig. 1: Front view of human eye

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Iris Recognition uses the rich textural pattern present in the iris of human eye which is the most unique and stable biological characteristic of a person because of the large variability of the iris pattern between two persons [1]. In the present paper we have normalized only some part of iris instead of complete iris region. Haar wavelet transform is used for feature extraction which gives better results as compared to other algorithms.
Paper is organized as follows. Section II describes the work done by various researchers in the field of iris recognition. The proposed algorithms for various stages of iris recognition are given in Section III. Section IV shows the result of various stages. Finally, Section IV presents conclusion.

II. RELATED WORK

John Dougman [4] has implemented the first automated iris recognition system for person identification based on failure of statistical test of independence. Daugman used integro-differential operator for segmentation of iris from eye image and a multiscale quadrature two- dimentional(2-D) Gabor filter to demodulate phase information of an iris image to create an iriscode for authentication by comparing the Iriscode stored in database. Wildeset. Al. [5] proposed a segmentation algorithm in which edge map is constructed first then hough transform is used to detect the inner and outer borders of the iris also, the upper and lower boundaries of the eyelid are identified using parabolic curves. Encoding was done using Laplacian of Gaussian filter (LOG) and normalized correlation was used for matching. Boles et al. [17] designed a system to handle noisy conditions. Dissimilarity function was used to compare one-dimensional (1-D) signals obtained from zero-crossings of the wavelet transform at various resolution levels over concentric circles on the iris, with model features using different S. Lim [7] has made the use of competitive learning Neural Network for matching of two iris codes, 2-D Haar wavelet is used for encoding purpose. Li Ma [8] uses a bank of spatial filters, whose kernels are suitable for iris recognition, which are used to capture local characteristics of the iris so as to produce discriminating texture features. The nearest center classifier is implied to improve computational efficiency and classification accuracy. Libor Masek[9] proposed a method which involves modified version of Kovesi's Canny edge detection MATLAB function with hough transform. 1-D log Gabor filter is used for feature extraction and hamming distance for matching. R. Y. Dillak [12] proposed a method which involves preprocessing using amoeba median filter and gaussian filter to enhance the effective area of the iris. And then modified CHT method is used for segmenting the iris area. The features like maximum probability, correlation, contrast, energy, homogeneity, and entropy are then extracted using multiple 3D-GLCM; which is the advanced version of 2D GLCM. Finally, these features are trained using Elman Recurrent Neural Network to obtain the accuracy.

III. PROPOSED ALGORITHM

The iris recognition is a method of authenticating a person by extraction and comparison of textural pattern of iris of his/her eyes. Fig 2 shows the block diagram of iris recognition system. The useful information from the unique iris patterns can be extracted using image processing techniques and then the results can be encoded into a biometric template which can be stored in a database for future comparisons. For authenticating a person his biometric template is compared with all the other pre-existing templates in the database using a matching algorithm. The system consist of following stages:

1. Image Acquisition
2. Iris Segmentation/Localisation
3. Normalisation
4. Feature Extraction
5. Matching/Comparison

1. Image Acquisition

Acquiring the images of Iris is the most important stage in the recognition system because the accurate recognition depends on the quality of image. Images with good resolution and sharpness are needed with required intensity. There are number of iris databases available e. g. CASIA, UBIRIS, IIT Delhi iris database etc. In this paper we use publicly available Iris database from Chinese academic of science CASIA-IrisV1which has 756 iris images from 108 eyes and 7 images for each eye. All images are stored as BMP format with resolution 320*280. [14].

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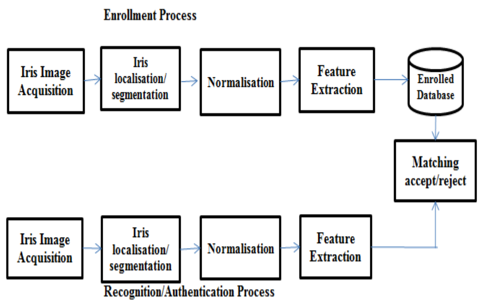

Fig. 2: Iris Recognition System

1. Iris Segmentation

The process of detecting the iris region in eye image is called segmentation. Here we have used circular Hough transform which is a standard computer vision algorithm used to identify simple geometric objects (lines, circles) in the image. The image is segmented by first detecting the edges in the image. For this canny edge detection is used. Gradients are biased in the vertical direction for the iris-sclera boundary, and for iris-pupil boundary Vertical and horizontal gradients were weighted equally. Then hough transform is used to detect circles in the eye image. The Hough transform for the iris-sclera boundary is performed first then for the iris-pupil boundary since the pupil is always within the iris region, to make the circle detection process efficient and accurate. From the edge map, votes are cast in Hough space for the parameters of circles (centre coordinates X and Y, and the radius R) passing through each edge point. Any circle can be defined according to the equation

$$X^2+Y^2=R^2 \quad (1)$$

A maximum point in the Hough space will represent the radius and centre coordinates of the circle defined by the edge points. We have to set the maximum and minimum value of radius in hough transform. For the CASIA database, iris radius values ranges from 90 to 150 pixels, while the pupil radius ranges from 28 to 75 pixels [9]. The output of segmentation is an image with circles on inner and outer boundaries of iris.

2. Normalization

The iris which is circular in shape can vary in dimensions from person to person. This is due to different factors such as pupil dilation caused by different illumination levels, head tilt, rotation of eye within the eye socket, different distance from which image is taken and rotation of camera. Normalization is a process of converting the iris image into fixed dimension image for comparison.Normalization process will convert all the images into a fixed dimension by unwrapping it from circular coordinates to polar coordinates. For this Dougman's Rubber sheet model is the best method. This model maps all point within the iris region to polar coordinates (r, θ), where θ is the angle [0, 2π] and r is on the interval [0, 1].

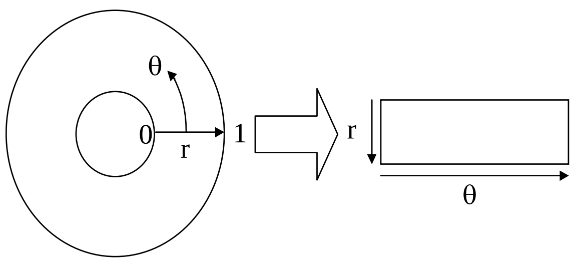

Fig. 3:Normalization process of the Iris

The center of the pupil is taken as a reference point and to convert the points on the Cartesian scale to the polar scale a remapping formula is used which is,

$$I(x(r, \Theta), y(r, \Theta)) \longrightarrow I(r, \Theta) \quad (2)$$

With

$$x(r, \Theta) = (1-r)\, x_p(\Theta) + r x_i(\Theta) \quad (3)$$
$$y(r, \Theta) = (1-r)\, y_p(\Theta) + r y_i(\Theta) \quad (4)$$

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where, I(x, y) is the iris image with Cartesian coordinates (x, y), (r, θ) are the corresponding normalized polar coordinates, and x_p, $y_p$and x_i, y_i are the coordinates of the pupil and iris boundaries along the Θ direction. Normalization produces a 2D array with angular resolution on horizontal dimensions of and radial resolution on vertical dimensions.

Since in most cases the upper and lower parts of the iris area are occluded by eyelid, it was decided to use only the left and right parts of the iris area for iris recognition. Therefore, the whole iris [0, 360^o] is not transformed in the proposed system. Only left and right portions are taken into consideration ignoring both upper and lower eyelid areas.

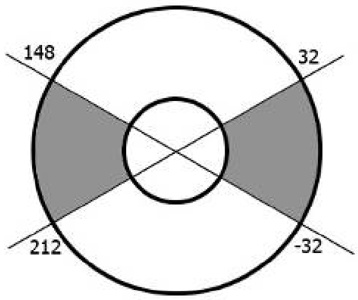

Fig. 4: Normalizing only left and right portion of iris

Due to this the time required to detect upper and lower eyelids and polar transformation is saved.

3. Feature Extraction

The most important task in any biometric system is extraction of the most discriminating information for accurate recognition of individual. Here we have used Haar wavelet as feature extraction technique. The Wavelet transform breaks an image into four sub-sampled images. The results consist of one image that has been low-pass filtered in horizontal and vertical both directions (cA) called approximation coefficients, one that has been high-pass filtered in both directions (cD) called diagonal coefficient, one that has been low-pass filtered in the vertical and high-pass filtered in the horizontal (cH) called horizontal coefficient and one that has been low-pass filtered in the horizontal and high-pass filtered in the vertical (cV) called vertical coefficient. We obtain the 5-level wavelet tree showing all detail and approximation coefficients of one normalized image. When comparing the results using the Haar transform with the wavelet tree obtained using other wavelets we found that the Haar wavelet gave slightly better results. First we have applied 2D DWT with Haar (upto 5thlavel). Then to construct the feature vector we have used 4th level, 5th level decomposition details. Feature vector is then converted in binary form using two and four level quantization, form because it is easy to compare two binary codes as compared to numbers. After this we will get a binary template of the iris image which is stored in the database and compared at the time of authentication.

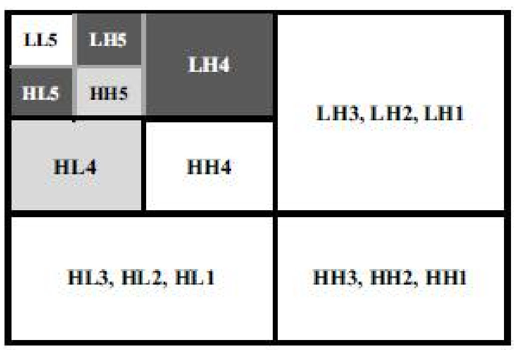

Fig 5: Quantization of feature vector (black region indicate two level quantization and gray region indicate four level quantization)

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4. Matching

While authenticating a person we have to compare his iris data with the codes stored in database to find out if they represent the same person or not. For this Hamming distance is used which gives the difference between two binary codes using EX-OR operator. The hamming distance between two binary words is calculated as,

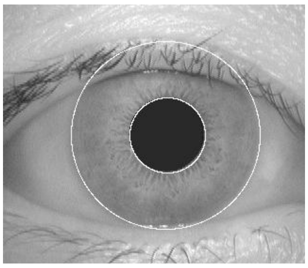
$$HD=\frac{1}{N}\sum_{i=1}^{N} A(i) \oplus B(i) \qquad (5)$$

Where, A and B are the coefficients of two iris vectors and N is the size of vector. The iris template is shifted right and left by 8 bits to avoid rotation inconsistencies. It may be easily shown that scrolling the template in polar coordinates is equivalent to iris rotation in Cartesian coordinates. John Dougman [4] tested a large iris database and conclude that maximum hamming distance exists between two iris codes of same person is 0.32 which is used as a threshold in the matching process.

If HD<= 0.32 – Same person (6)

If HD > 0.32 – different person (7)

IV. Results

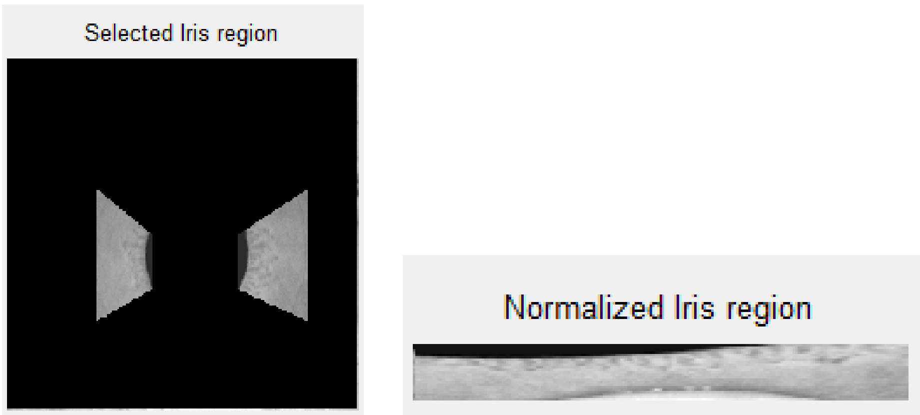


	X-coordinates	Y-coordinates	Radius
Iris	140	173	100
Pupil	140	75	40

Fig 5: Segmented Iris images

Table 1: centre coordinates and radius of iris in fig 5

The output of segmentation stage is the radius and centre (x and y) coordinates and of iris and pupil circles and image with circles drawn on the boundaries.



(a) **(b)**

Fig 6: (a) Selected iris region (b) Normalized Iris image

A constant number of points are chosen along each radial line, so that a constant number of radial data points are taken, irrespective of how narrow or wide the radius is at a particular angle. The radial resolution is taken 32 and angular resolution 80.

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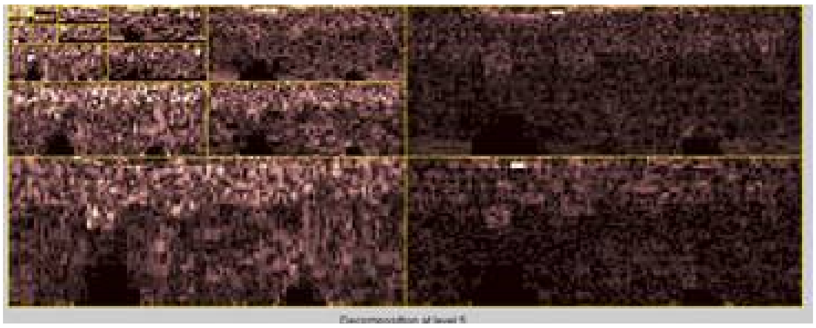

Fig. 7: 5 level Haar Wavelet decomposition applied to normalized iris image

The Haar wavelet is particularly suitable for implementing high-accuracy iris verification/identification systems, as the feature vector length is at least with respect to other wavelets.

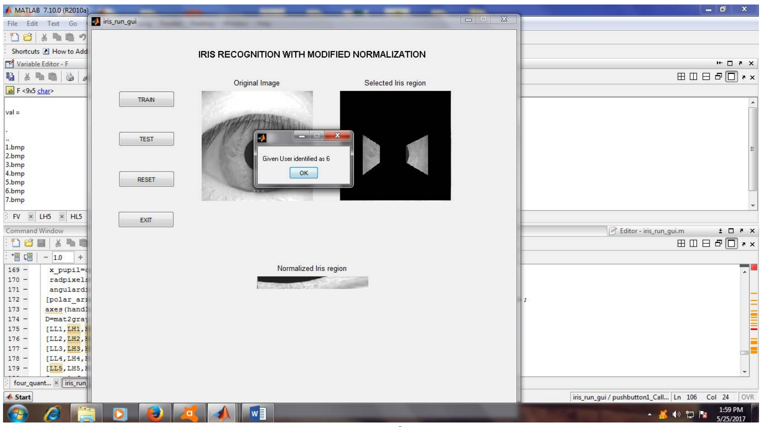

Fig 8: Selected Iris region from iris image in GUI

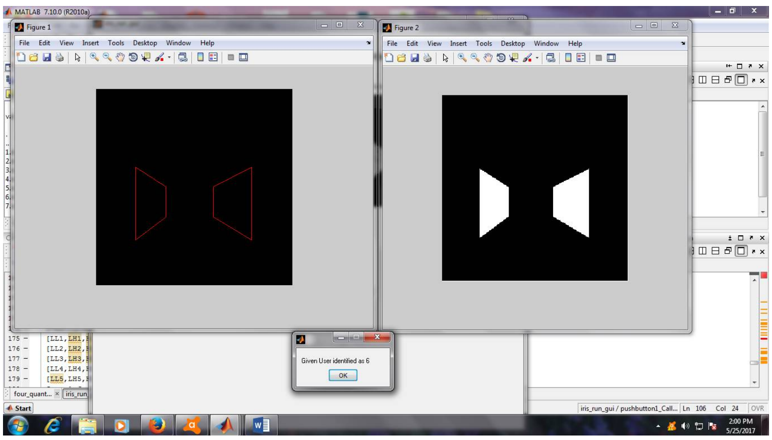

Fig 9: Normalized image and person identification.

To verify a person the TEST button is pressed which will load the image and calculate the feature vector for it. The feature vector is matched with the stored feature vectors and match is found using hamming distance.

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V. CONCLUSION

The iris recognition system proves to be very efficient and promising technique as it gives accurate and reliable results to verify the identity of a person. Hough transform with canny edge detector is best suited for segmentation of the iris because of efficient localization. The Haar wavelet transform which is used for feature extraction has a number of advantages, it is simple, fast, memory efficient and reversible compared to other wavelets and the feature vector is small. The Iris recognition system can effectively differentiate various persons by identifying their irises and provide a very good security against intruders.

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