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A Novel Method for Iris Recognition Using Fusion of Wavelets and DFT

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***Abstract*—A robust approach for iris recognition using wavelet based feature extraction and decision level fusion is proposed. In this method, circular Hough transform is used for iris segmentation and Daugman's rubber sheet model for normalization. For feature extraction, a combination of Haar wavelet decomposition and spectral transformation of 1D log Gabor wavelet transform is used. Discrete Fourier transform (DFT) is used as spectral transformation tool. The spectral transformation reduces the redundancy of the feature vectors, which adds the recognition rate. Euclidean distance classifier is used for classification and decision level fusion is employed. The experimental results shows that the proposed method gives better performance. CASIA database is used for evaluation.**

***Index Terms*— Iris recognition, Haar wavelet, 1D log gabor wavelet, Euclidean distance, decision level fusion.**

I. INTRODUCTION

Iris recognition is one of the most accurate and reliable biometric system for human identification and authentication because iris has unique features and its patterns vary from person to personand remains constant throughout the life. Even identical twins has different irides. In an iris recognition system, features of iris are extracted and stored as templates. Then these templates are compared with the features of the input iris features during the enrollment process. Then a match score is generated which indicates their degree of similarity and dissimilarity. There are many methods for human identification based on iris. Daugman [1] proposed a method which uses an integro-differential operator for segmentation and the 2D Gabor filter was used for feature extraction. Wildes [2] proposed an alternative method for segmentation which uses an edge detection operator and circular Hough transform. In this method, the isotropic band pass decomposition derived from the application of Laplacian of Gaussian (LOG) filters is used. Wu and Wang [3] proposed an improved surface matching algorithm where intensity variations are considered were matching feature surfaces are moved to one equivalent gray plane. Ali, Salami and Wahyudi [4] proposed a matching algorithm based on support vector machine. A method for analyzing noisy iris images was proposed by Szewczyk [5]. This method concentrated on the feature extraction process which was done using reverse biorthogonal wavelet transform.

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Himanshu and Anamika [6] proposed a method where support vector machine and Hamming distance approach were combined. In this method Haar wavelet and Gabor wavelets are used for feature extraction. Prabhakar [7] proposed a method for multimodal 2D and 3D face recognition using block based curvelet features. In this method, decision level fusion is used where the scores arecalculated using KNN classifier. Most of the iris recognition systems uses only a single feature for the verification purpose and the accuracy of such systems are very low. In order to increase the accuracy multiple features are extracted. Here Haar wavelet features and 1D log Gabor wavelet features are used. In this work, segmentation of iris is performed using circular Hough transform. Then parabolic Hough transform is used for the detection of eyelids. After segmentation, Daugman's rubber sheet model is used for normalization. Then Euclidean distance classifier is used for classification. The classifiers output are then fused. There are three types of fusion viz. template level fusion, score level fusion and decision level fusion. Here decision level fusion is used. The block diagram of the proposed method is shown in Fig. 1.

II. PROPOSED METHOD

A. Segmentation

Segmentation is the first step in an iris recognition system. Segmentation of iris is done by isolating the iris from other parts of the input eye image. Fig. 2 shows an input eye image. For this process, the centre and radius of the iris and pupil are calculated using circular Hough transform. Circular Hough transform is used to deduce the centre and radius coordinates of circles present in an image. This can be used to find the centre and radius of the iris and pupil circle. When a number of points on the perimeter of the iris and pupil are known, these edge points are used to find the centre and radius. To find the centre (xc, yc) and radius r, edge points are calculated using canny edge detection technique. Using these edge points (x_i, y_i), i = 1, 2 …n Hough transform can be calculated. Hough transform is obtained as,

$$H(x_c, y_c, r) = \sum_{i=1}^{n} h(x_i, y_i, x_c, y_c, r) \tag{1}$$

$$h(x_i, y_i, x_c, y_c, r) = \begin{cases} 1 & if\, g(x_i, y_i, x_c, y_c, r) = 0 \\ 0 & otherwise \end{cases} \tag{2}$$

where,

$$g(x_i, y_i, x_c, y_c, r) = (x_i^2 - x_c^2) + (y_i^2 - y_c^2) - r^2 \tag{3}$$

The coordinate triplets (x_c, y_c, r) which gives maximum value for the Hough transform $H(x_c, y_c, r)$ are chosen as the centre point and the radius of the circle.

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Once the iris is localized, rest of the portions are removed by multiplying the localized image with a mask. Fig. 3 (a) shows a segmented iris. After segmentation, next step is the detection of the eyelids. The lower and upper eyelids are detected using two search regions whose widths are calculated as,

Width of search region = radius of iris - radius of pupil (4)

Since the eyelid part is present in the upper or lower horizontal region, a horizontal edge map was used in order to get the edge image of the eye image. Then parabolic Hough transform was used to detect lower and upper eyelids. The rotation factor applied to the Hough transform is,

$$(\sin\theta(x-h)+\cos\theta(y-k))^2 - a\big(\cos\theta(x-h) - \sin\theta(y-k)\big) = 0 \quad (5)$$

where (h, k) are the vertex points of the parabola, θ is the rotation angle and a represents the curvature of the parabola. Fig. 3 (b) shows the eyelid detection.

B. Normalization

The next stage in an iris recognition system is normalization. In this process, the segmented iris image is converted from Cartesian coordinates to polar coordinates i.e., the localized iris is converted to a fixed size rectangular block with radius as the width and the length varies from 0 to 360^o. Daugman's rubber sheet model [8] is used for this purpose. It is a linear model which assigns each iris pixels a pair of real coordinates (r, θ). The mapping of iris coordinates I(x, y) from Cartesian coordinate to polar coordinate can be represented as

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \quad (6)$$

where,

$$x(r,\theta) = (1-r) * x_p(\theta) + r * x_r(\theta) \quad (7)$$

$$y(r,\theta) = (1-r) * y_p(\theta) + r * y_r(\theta) \quad (8)$$

$(x_p(\theta), y_p(\theta))$ are the points on the pupil boundary and $(x_r(\theta), y_r(\theta))$ are points on the outer perimeter of the iris. After normalization, pixels occluded with eyelashes are removed using the information from the pixels which are non-occluded by the eyelashes. For that, first we have to decide whether the pixels in the normalized image are occluded by eyelashes or not. Then a 5x5 median filter is applied for all those pixels which are occluded by the eyelashes. In the 5x5 neighborhood, only those pixels which are not occluded are selected. Then all the pixel values are sorted in ascending order and then the center pixel is taken. Then the occluded pixel is replaced by this center pixel value. Fig. 3(c) shows the normalized iris image.

C. Feature extraction

In this work, two methods are used for feature extraction. In the first method, a 4 level Haar wavelet decomposition is used. We applied Haar wavelet decomposition to the normalized iris image of size 64x512. This decomposition is done at four levels to extract the feature vectors.

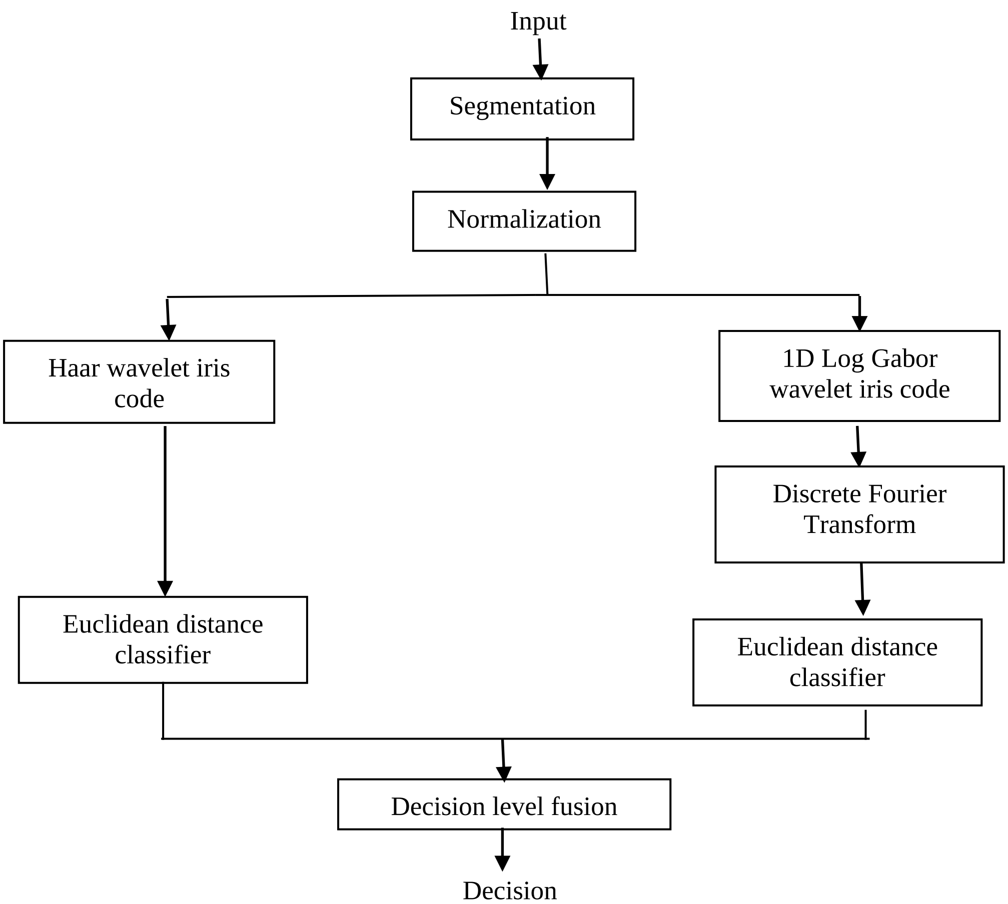

Figure 1. Block diagram of the proposed method

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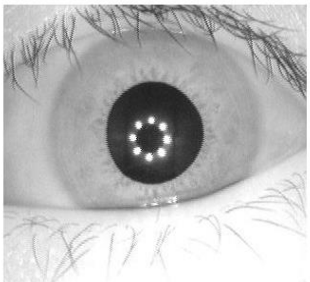
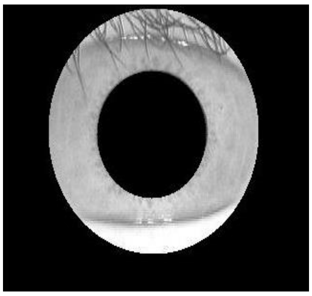
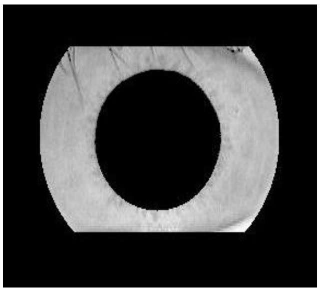


Figure 2. Input eye image



3 (a)



3 (b)

3 (c)

Figure 3. (a) Segmented iris, (b) Eyelid detection, (c) Normalized iris

When a wavelet transform is applied to an image, it is passed through a low pass filter and a high pass filter and the image is divided into four sub regions such as LL, LH, HL, and HH. The sub region LL contains the maximum energy of the input image. Hence it is chosen as the input to the next level of decomposition. Thus the wavelet decomposition is performed separately at four levels with previous level LL sub region as the input. As the level of decomposition is further increased, the accuracy of the system remains constant. In this work, the coefficients of the fourth decomposition level (LL4) low pass filter are taken as the feature vectors which is given to the classifier. This region contains 4x32 = 128 features. In the second method, we applied a 1D log Gabor wavelet transform to the normalized iris image. In order to perform 1D log Gabor wavelet transform, 2D normalized iris image is broken down into a number of 1D signals. Then the 1D log Gabor wavelet is convolved with these 1D signals. Each row of the normalized iris is considered as a 1D signal which is convolved with the Gabor wavelet. The angular direction which corresponds to the columns of the normalized iris is taken rather than the radial one. The intensity values of the areas where the noises are known are replaced with the average value of the surrounding pixels. The output of the filter is phase quantized which produces two bits of data for each phasor. The output of phase quantization is a gray code, where only one bit changes while going from one quadrant to another. A bitwise template is produced as a result of the encoding process, where DFT is applied. In order to perform DFT, fast Fourier transform is applied. Absolute values of the output of DFT is taken as the second feature vector which is given to the second classifier.

D. Matching

In the matching stage, Euclidean distance classifier is used. The distance between two templates are calculated which will produce the similarity score. The distance is calculated by the equation,

$$Distance = \sqrt{(T_1 - T_2)^2} \quad (9)$$

where T1 and T2 are the templates to be matched. In order to increase the accuracy of the system, we fused the information from both the classifiers. Here we used decision level fusion. In this fusion technique, decisions from both the classifiers are used to get the final decision. The Boolean OR operator is applied to the decisions from both the classifiers in order to increase the accuracy.

III. EXPERIMENTAL RESULTS

The proposed method was implemented using MATLAB 8.0 in Windows 8 operating system with Intel Core i5 processor, 2.60GHz and 4GB RAM. The eye images required for the study were downloaded from Iris – Interval of CASIA Database. It consists of 249 subjects out of which 75 subjects were selected for the study. Training phase was done using 1, 2 and 3 images respectively. Accuracies for the fusion of haar wavelet and FFT of Gabor wavelet was also calculated. It was found that accuracy of the proposed system has increased than the accuracy of thefusion of Haar wavelet and Gabor wavelet and the individual methods. A comparison of accuracies obtained for individual features and their fusion are shown in Table 1, Table 2, Table 3 and Table 4. Fig. 4 and Fig. 5 shows the graphical comparison of accuracies of individual features and their fusion.

IV. CONCLUSION

A reliable and efficient method for iris recognition using combined wavelet and DFT was proposed in this paper. Haar wavelet decomposition at level 4 and DFT of 1D log Gabor wavelet was used to extract features of normalized iris image. The DFT was implemented using FFT. These features wereclassified using Euclidean distance classifier. Fusion of the features were done using decision level fusion. In this work, parabolic Hough transform and median filter was used to remove the eyelashes and eyelids from the normalized irisimage. The proposed system was compared with the fusion of Haar wavelet and Gabor wavelet without FFT. Theproposed recognition system has better recognition rate and thus efficient for identification.

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TABLE I. COMPARISON OF ACCURACIES FOR 1 TRAINING DATA

Subjects	Total No. of Samples	Accuracies		
		Haar	FFT of Gabor	Fusion
10	100	57	33	68
25	250	40.4	24.4	48
50	500	32.4	17.8	36.2
60	600	30.67	17.33	34.16
75	750	29.33	16.8	31.867

TABLE II. COMPARISON OF ACCURACIES FOR 2 TRAINING DATA

Subjects	Total No. of Samples	Accuracies		
		Haar	FFT of Gabor	Fusion
10	100	68	49	79
25	250	61.6	41.6	66
50	500	54	36	57.4
60	600	51.33	34.5	54.16
75	750	49.86	33.2	55.53

TABLE III. COMPARISON OF ACCURACIES FOR 3 TRAINING DATA

Subjects	Total No. of Samples	Accuracies		
		Haar	FFT of Gabor	Fusion
10	100	75	60	79.5
25	250	75.2	54	78
50	500	65.6	47	68.4
60	600	63.83	46.33	67.33
75	750	61.49	45.68	64.8

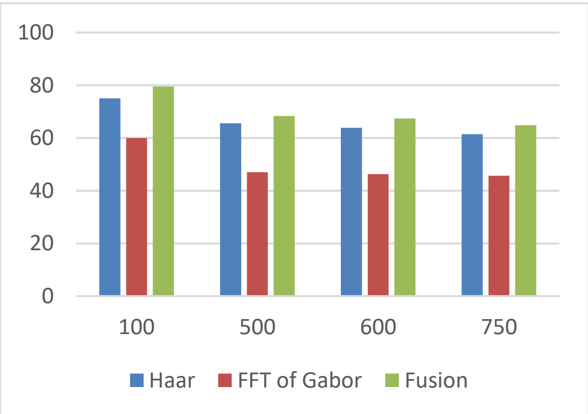

Figure 4. Comparison of accuracies of proposed method

TABLE IV. COMPARISON OF ACCURACIES FOR PROPOSED METHOD WITH FUSION OF HAAR AND GABOR FOR 1 TRAINING DATA

Subjects	Total No. of Samples	Accuracies	
		Fusion of Haar and Gabor (without FFT)	Proposed Method (with FFT)
10	100	62	68
20	200	49.5	53.5
40	400	35.25	38
50	500	34.6	36.2
60	600	33.33	34.16

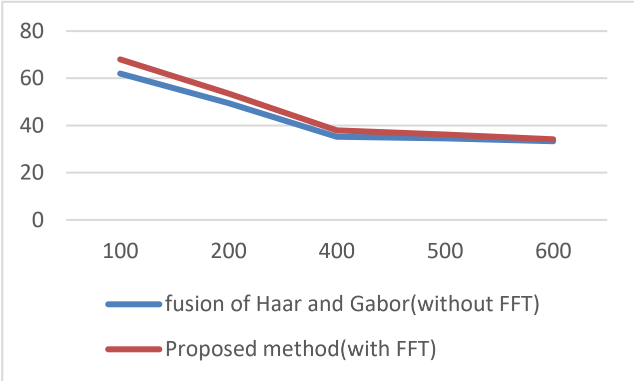

Figure 5. Comparison Of Accuracies Of Proposed Method (With Fft) With Fusion Of Haar And Gabor(Without Fft)

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