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Iris Recognition System Based on Statistical Feature Analysis Using Haar Wavelet

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***Abstract*— Iris recognition is the most reliable biometric identification system with highest accuracy level. This paper includes preprocessing, segmentation, normalization, Haar wavelet decomposition, statistical feature extraction and feature matching. The matching of two iris patterns is done using hamming distance. Experiments are done using the eye images from CASIA database (Chinese Academy of Sciences). Implementation is done using MATLAB.**

***Keywords*—preprocessing, segmentation, Haar wavelet, feature extraction, feature matching.**

I. INTRODUCTION

A biometric system is identification of an individual based on characteristics or certain unique features of the individual. Biometric-based methods are well secure in identifying an individual. Iris recognition is a biometric method of identifying an individual based on their iris patterns. The irises of the left and right eye of the same individual are unique. Hence iris recognition technology is becoming an important biometric solution for people identification. Iris recognition system is applied in Immigration system, Military, secure access to bank accounts, and secure financial transactions.

II. BLOCK DIAGRAM OF THE PROCESS

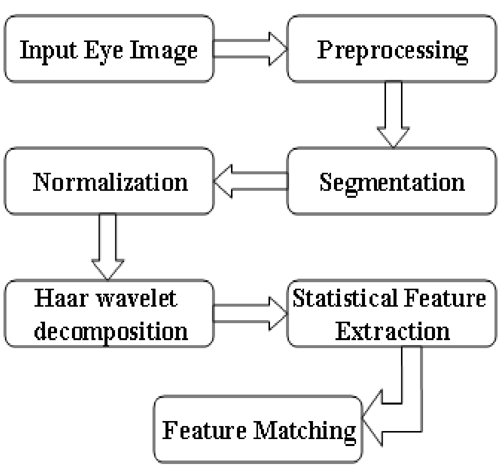


Fig. 1. Block diagram of Haar Wavelet method

III. PREPROCESSING

Preprocessing is the initial stage in iris recognition. The histogram graph is obtained for the input eye image. The histogram graph shows the tonal distribution of the given input image. Then Histogram Equalization is done to the input image to enhance the image for further process and it is also used for adjusting the contrast of the image using the image's histogram [11].

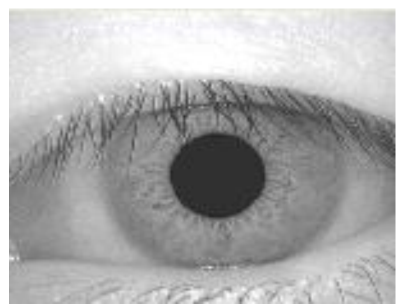
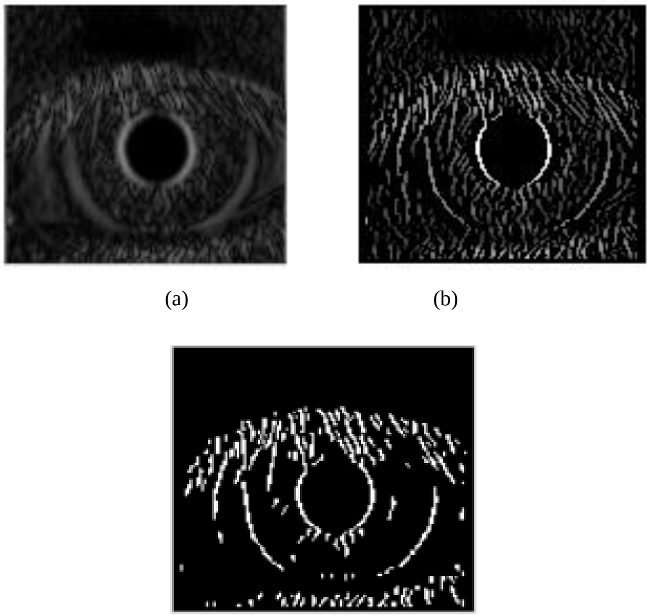


Fig. 2. Human eye image

IV. SEGMENTATION

Segmentation processes is done to separate the iris from the eye image. The iris inner and outer boundaries are located by finding the edge image using the Canny edge detector [1]. The advantage of Canny edge detector over other edge detectors is that there is very less probability of not marking any real edges and marking unwanted edges. It uses a filter based on the first derivative of a Gaussian, hence the result is a slightly blurred version of the original image. Canny edge detector mainly involves three steps such as, finding the gradient, adjust gamma correction, non-maximum suppression and the hysteresis thresholding. The threshold values that have been used are 0.19 and 0.2 (low and high threshold respectively).

Adjust gamma correction controls the overall brightness of an image i.e. it adjusts the image gamma value. After the edge directions are known, non maximum suppression is applied to trace along the edge in the edge direction and suppress any pixel value that is not considered to be an edge. Hysteresis thresholding eliminates the weak edges below the low threshold.



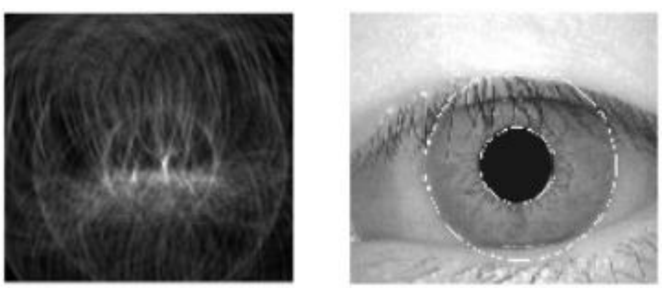
(a) (b) (c)

Fig. 3. (a) Adjust gamma correction, (b) Non-maximum suppression, (c) Canny edge image

A. Hough transform

The circular Hough transform can be employed to deduce the radius and centre coordinates of the pupil and iris regions [7]. Taking the edge pixels as the centre coordinates x_c and y_c, and with the desired radius *r*, circles are drawn according to the equation

$$x_c^2 + y_c^2 - r^2 = 0 \qquad (1)$$



(a) (b)

Fig. 4. (a) Hough circle, (b) Segmented iris

V. Normalization

Iris normalization is done to improve the precision of matching. Thus the segmented iris region is converted to polar coordinate for further process.

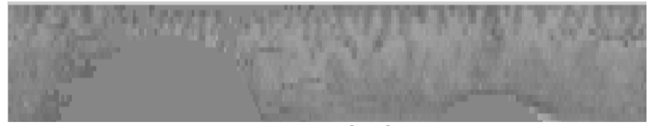


Fig. 5. Normalized iris

VI. Haar Wavelet Decomposition

Haar wavelet is an image compression technique that uses the basis of wavelet transform where the information of an image is divided into approximation and detail subsignals [5]. For an input represented by a list of 2^n numbers, the Haar wavelet transform pairs up the input values, stores the difference and passes the sum. Consider a 1D image with a resolution of 4, having values [6 4 5 7]. First, the pixels are paired together [(6 4) (5 7)] and the average is obtained as [5 6] (lower resolution image). The detailed coefficient is obtained by differencing the paired values, hence it is obtained as [1 -1]. Thus the transformed matrix will be of [5 6 1 -1]. Now consider the 2D image as follows.

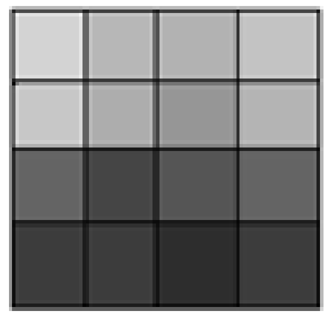


Fig. 6. A 4x4 image

$$\begin{bmatrix} 210 & 230 & 220 & 235 \\ 200 & 220 & 210 & 235 \\ 120 & 97 & 117 & 120 \\ 99 & 97 & 93 & 100 \end{bmatrix}$$

Fig. 7. 2D array representing the Fig. 6

By transforming the rows of the matrix, the following array is obtained.

$$\begin{bmatrix} 223 & -3 & -10 & -7 \\ 216 & -6 & -10 & -12 \\ 113 & -5 & -11 & -1 \\ 97 & 1 & 1 & -3 \end{bmatrix}$$

Fig. 8. Array after transforming each row

By transforming the columns of the matrix, the following array is obtained.

$$\begin{bmatrix} 162 & -3 & -8 & -5 \\ 57 & -1 & -2 & -3 \\ 3 & 1 & 0 & 2 \\ 8 & -3 & -5 & 1 \end{bmatrix}$$

Fig. 9. Final transformed matrix

Thus the left top element i.e. 162 is the overall average of all elements of the original matrix and the rest of the elements are the detailed coefficients. Finally, the decomposed image using Haar wavelet is obtained.

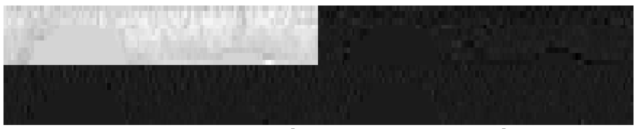


Fig. 10. Decomposed image using Haar wavelet

VII. Statistical feature extraction

Statistical features like mean, median, variance and standard deviation are determined from the decomposed image. Mean is obtained by dividing the sum of all energies by the maximum energy. Median is obtained by arranging all the energies in ascending order and taking the middle value. The square root of variance gives the standard deviation.

The extracted features are stored in the database for identification process. Using these features, an image can be viewed as a feature vector.

VIII. Feature matching

Feature matching is done using the effective method called hamming distance, which is used to match the two iris templates. The Hamming distance gives a measure of how many bits are the same between two bit patterns. Using the Hamming distance of two bit patterns, decision can be made as to whether the two patterns were generated from different irises or from the same one. In comparing the bit patterns *X* and *Y*, the Hamming distance, *HD*, is defined as the sum of disagreeing bits (sum of the exclusive-OR between *X* and *Y*) over *N*, the total number of bits in the bit pattern.

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j (XOR) Y_j \qquad (2)$$

If the hamming distance is 0, then the two templates are generated from the same iris or from different irises.

IX. Sample results

The experiment was done using hundred eye images from CASIA iris database. The normalized iris image is decomposed using Haar wavelet and the statistical features like mean, median, variance and standard deviation are computed. Sample results using three eye images from the database and two images that are not in the database are shown in the following tables.

TABLE I. Statistical feature values of database image

Database Image	Mean	Median	Variance	Standard deviation
1.bmp	0.015664	0.026614	25.8985	5.0891
2.bmp	0.015656	0.032188	30.8418	5.5535
3.bmp	0.015683	0.064244	29.7123	5.4509

TABLE II. Values of image not in database

Image not in database	Mean	Median	Variance	Standard deviation
4.bmp	0.015676	0.053731	22.791	4.774
5.bmp	0.015658	0.031275	24.9356	4.9936

The hamming distance calculated for the eye images that are in the database are found to be 0. Thus it is authenticated. The hamming distance value for the eye images that are not in the database are as follows.

Minimum Hamming distance, 4.bmp = 0.063166
Minimum Hamming distance, 5.bmp = 0.045013

Since the values are not equal to 0, it is unauthenticated.

X. Conclusion

This paper has presented an iris recognition system using an effective edge detection method. Automatic segmentation was achieved by canny edge detection through the use of the Hough transform for localizing the iris and pupil regions, occluding eyelids. Next, normalized iris is decomposed using Haar wavelet decomposition and statistical features were computed. Finally the two irises were matched using hamming distance. With the 100 eye images that are taken randomly from the CASIA database, we got the success rate of 99%, where as the error was due to some distortion while capturing the image.

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Vol:1 Issue:1 ISSN 2278 - 215X

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