Feature Extraction Enhancement Techniques in Iris Biometrics Recognition Security System

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Abstract— The accuracy of an iris recognition system is largely dependent upon the technique employed in encoding the local phase of the iris texture so as to extract maximum information. The earliest and most commonly used Gabor wavelets yield a local phase representation distributed over several scales and orientations generating extremely efficient feature vectors. One of the very promising attempts at obtaining a useful phase information is from the field of analytic signals and wavelets. In this paper, we suggest that the distinctive ability of the discrete wavelets to simultaneously extract local phase and orientation can be exploited with improved feature extraction for iris recognition applications. In order to test the effectiveness of the proposed method, the reconstructions obtained using discrete wavelet phase are compared with the Gabor and Fourier counterparts. The analysis has been done via Image Processing, Computer Vision and Wavelet Toolbox in MATLAB.

Key words: Iris Recognition; DWT (Discrete Wavelet Transform); HD (Hamming Distance); CHT (Circular Hough Transform)

I. INTRODUCTION

Biometrics is the reliable, secure authentication tool for systems where controlled access to physical assets is provided by recognizing the individual either based on physiological or behavioural characteristics. Biometric authentication is widely used for security, access control systems and enrolment programs [3]. Security is an important aspect in our daily life. Humans have distinctive and unique traits which can be used to distinguish them from other humans, acting as a form of identification. A number of traits characterizing physiological or behavioural characteristics of a human can be used for biometric identification. These include face, facial thermograms, fingerprint, iris, retina, hand geometry, odour/scent as physiological characteristics and voice, signature, typing rhythm, gait as behavioural characteristics [4][5][9]. The critical attributes of these characteristics for reliable recognition are the variations of the selected characteristic across the human population, uniqueness of these characteristics for each individual, their immutability over time (Jain et al.,1998). All such attributes are satisfied by the human iris. Iris is a thin, circular structure in the eye. It has a rich and complex texture that remains very stable throughout life. Iris patterns have a high degree of randomness in their structure [4]. This is what makes them unique. Iris as a biometric feature is much less susceptible to damage and not affected by environmental condition, being a protected internal organ; than other systems and thus may act as an ideal password [9]. Also the human iris is immutable over time. From one year of age until death, the patterns of the iris are relatively constant (Jain et al., 1998, Adler,1965). Amongst all the biometric recognition systems iris is the promising solution because of its uniqueness, reliability and stability over the lifetime. Even the genetically identical twins have different Iris textures.

IRS acquires the image of eye; extracting the Iris region from the image to determine the unique texture for individual identification during the verification phase and matches it with the database created in enrolment process.

II. IRIS RECOGNITION

The various stages of processing involved in the design of Iris recognition system are:

- Image Acquisition
- Iris Localisation via Edge Detection
- Iris Segmentation via Feature Extraction
- Iris Normalization
- Feature Extraction
- Pattern Matching

A. *Image Acquisition*

The iris image should be rich in iris texture as the feature extraction stage depends upon the image quality. The images for this work have been captured from IIT Delhi Standard Iris Database. Real time capture has been implemented using Raspberry Pi NoIR Camera V2 module which is a CMOS sensor used for infrared vision enabling efficient capture under low illumination conditions.

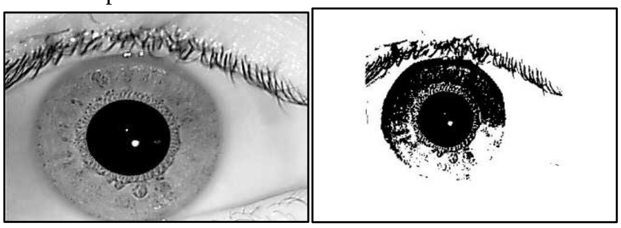
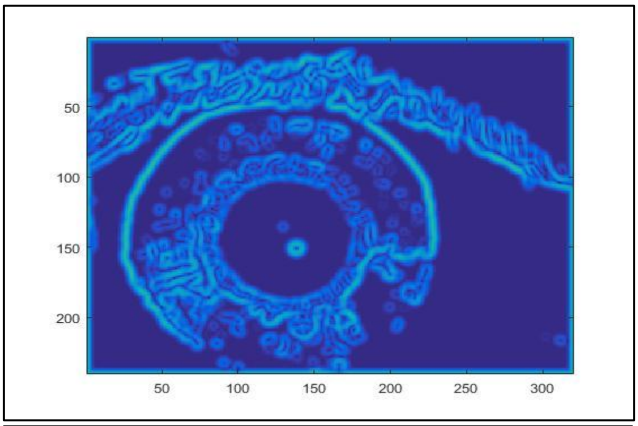
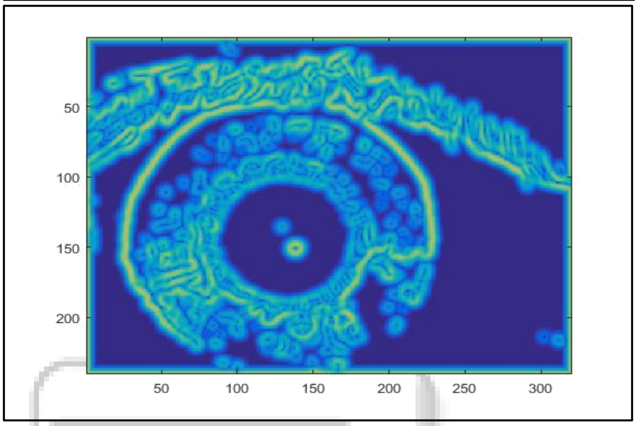


Fig. 1: Original eye image and its binary conversion

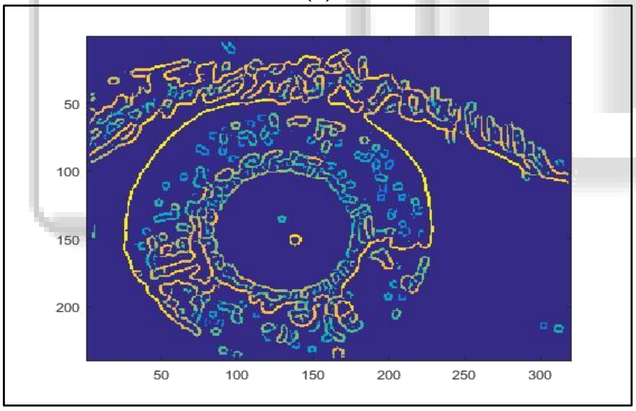
B. *Iris Localization via Edge Detection*

Canny Edge Detector is being employed for detecting edges in a binary image (converted from original bitmap image) or a grayscale image (for other image formats). Before this Gaussian filtering (σ = 1.5) is done for deblurring and noise removal. Gamma Thresholding (γ = 2) is applied for contrast enhancement. Non-maximum suppression and hysteresis thresholding with two thresholds (T1 = 0.3, T2 = 0.2) is applied to the detected edges for finding the local maxima and suppressing the inconsequent edges. In hysteresis thresholding technique, two threshold levels are tested for better removal of background noise in case of connected image space (adjacent edges).

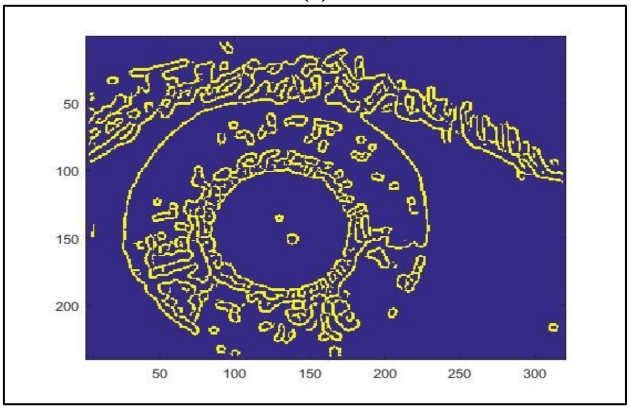




(b)



(c)



(d)

Fig. 2: The Edge Detection process: Images, in sequence, after (a) Canny Edge Detection, (b) Gamma Thresholding, (c) Non-Maximum Suppression and (d) Hysteresis Thresholding

C. Iris Segmentation via Feature Extraction

The boundaries of iris and pupil are detected via modified Circular Hough Transform which gives better efficiency and much less computational time than the traditional CHT. The boundary points of each circle are detected along with center and radius. Edges for eyelashes and eyelid are removed as noise using suitable algorithms.

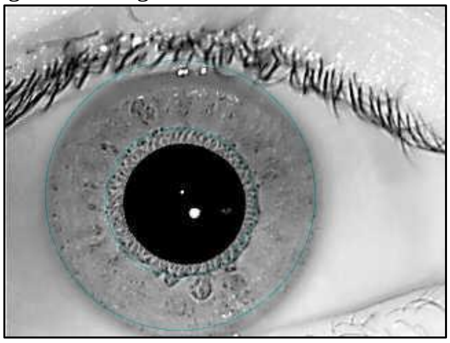


Fig. 3: Iris Segmentation

D. Iris Normalization

Once the iris region is segmented, the next stage is to normalize this part, to enable generation of the iris code and their comparisons. Since variations in the eye, like optical size of the iris, position of pupil in the iris, and the iris orientation change person to person, it is required to normalize the iris image, so that the representation is common to all, with similar dimensions.

Normalization process involves unwrapping the iris and converting it into its polar equivalent. It is done using Daugman's Rubber sheet model. The center of the pupil is considered as the reference point and a Remapping formula is used to convert the points on the Cartesian scale to the polar scale.

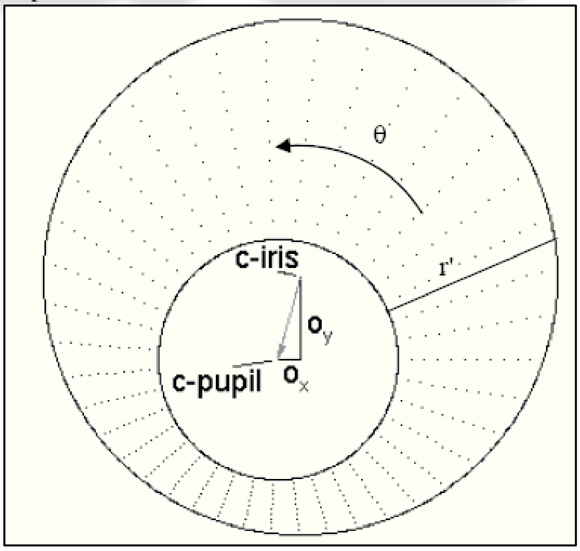


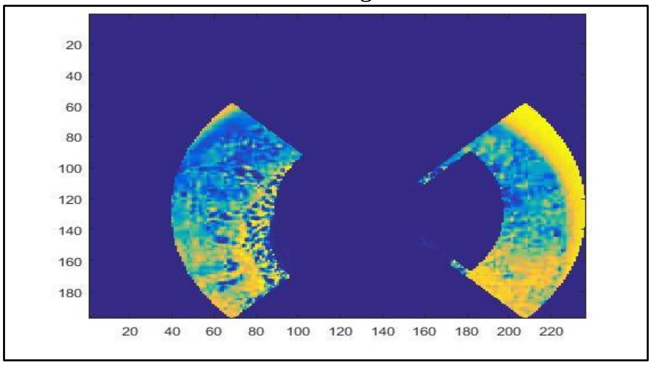
Fig. 4: The normalization process

$$r' = \sqrt{\alpha\beta} \pm \sqrt{\alpha\beta^2 - \alpha - r_I^2} \quad (1)$$

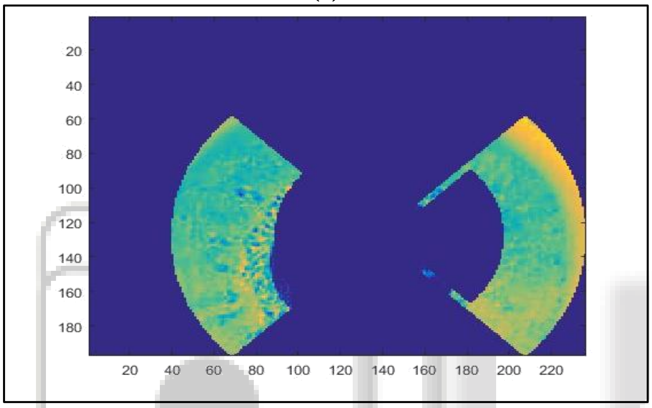
$$\alpha = o_x^2 + o_y^2$$

$$\beta = \cos\left(\pi - \arctan\left(\frac{o_y}{o_x}\right) - \theta\right) \quad (2)$$

The radial resolution was set to 40 and the angular resolution to 2400 pixels. For every pixel in the iris, an equivalent position is found out on polar axes. Afterwards the noisy image is equalized. The normalized image was then interpolated into the size of the original image, by using the interp2 function. The pixels in the normalized image that yield a NaN, are divided by the sum to get a normalized value in rectangular dimensions.



(a)



(b)

Figure.5. (a) 2 rings containing phase information in polar form, (b) Equalised image

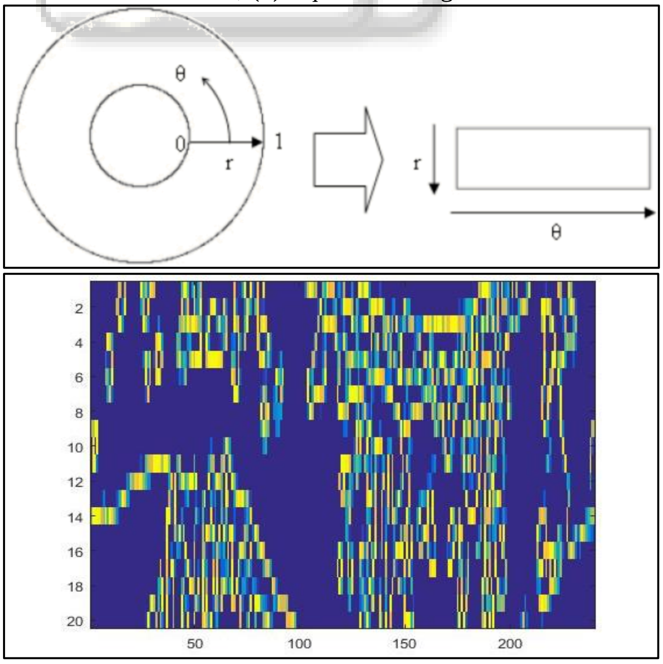


Fig. 6: Iris unwrapping into constant rectangular dimensions (Normalised template)

E. *Feature Encoding*

The most important step in automatic iris recognition is the ability of extracting some unique attributes from iris, which help to generate a specific code for each individual. Gabor and wavelet transforms are typically used for analyzing the human iris patterns and extracting features from them.

In this much important step the most discriminating feature (i.e.phase) in the iris pattern is extracted. The phase is used as it is not affected by contrast, camera gain, or illumination levels. The phase characteristic of an iris can be described using 256 bytes of data using a polar coordinate system.

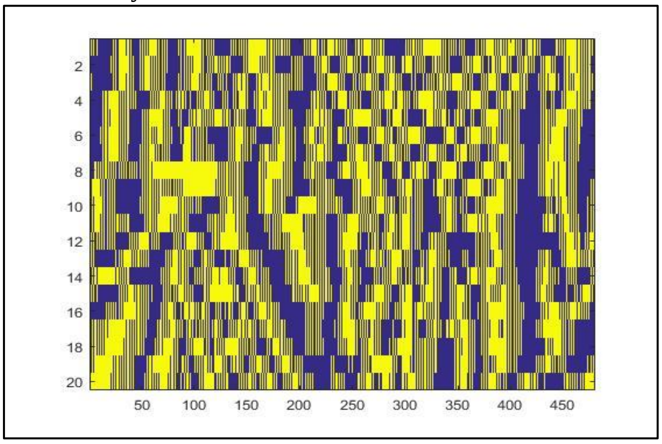


Fig. 7: Gabor Encoding

It has been proved that, in general, the magnitude of a signal has the information about the energy profile of the signal where-as its phase has information about its overall structure. The phase in the Fourier domain (which we refer to as the Fourier phase in rest of the paper) is the easiest way to be recovered. In the case of a randomized texture, as is present in the iris, the phase information at a specific area in the image is required for accurate classification. This problem of customized localization of various attributes of an image is solved by the application of wavelets. John Daugman has shown that the phase obtained from the application of complex wavelets to a textured image captures the structural information to effectively extract the phase. The only disadvantage of the Fourier phase representation towards texture classification is that it gives a global phase information which means that the exact spatial location/area which exhibits this phase cannot be recovered. Discrete Wavelet Transform filter solves this problem as it captures both frequency and location information (location in time).

- A 2D DWT is applied with Haar up to 5-level decomposition.
- Using 4th level, 5th level decomposition details the feature vector is constructed.
- The details extracted from the previous step are binarized.
- These feature vectors are stored.

The two-dimensional DWT leads to a decomposition of approximation coefficients at level j in four components: the approximation at level j + 1, and the details in three orientations (horizontal, vertical, and diagonal)

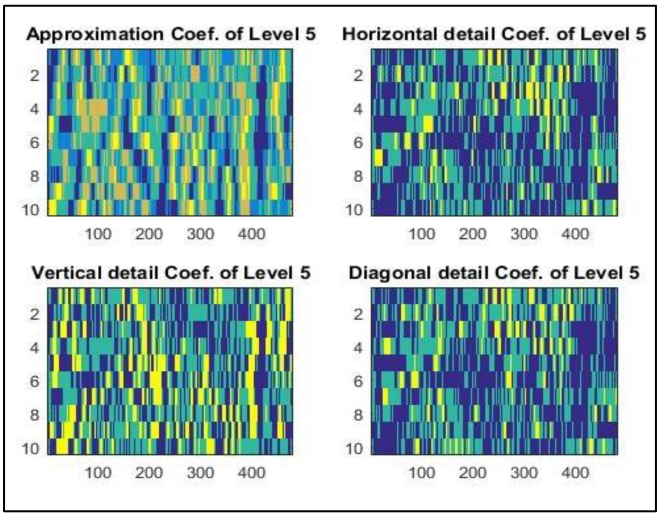


Fig. 8: DWT (Haar) Level 5 decomposition of the normalized image

F. Feature Matching (Pattern Matching)

After DWT decomposition, a template is generated. This template is matched with a stored one using either of the following methods:

- Hamming Distance
- Shifting Bits Algorithm
- Artificial Neural Networks
- Support Vector Machines
- K- means classifier

In this work, we have utilized the traditional Hamming Distance approach. The test of matching is implemented by the simple Boolean Exclusive-OR operator (XOR) applied to the encode feature vector of any two iris patterns. The XOR operator detects disagreement between any corresponding pair of bits. Let A and B be two iris representations to be compared and N be total number of bits, this quantity can be calculated as:

$$HD = \frac{1}{N}\sum_{j=1}^{N} \boldsymbol{A_j} \oplus \boldsymbol{B_j} \quad (3)$$

The smallest value amongst all these values is selected, which gives the matching.

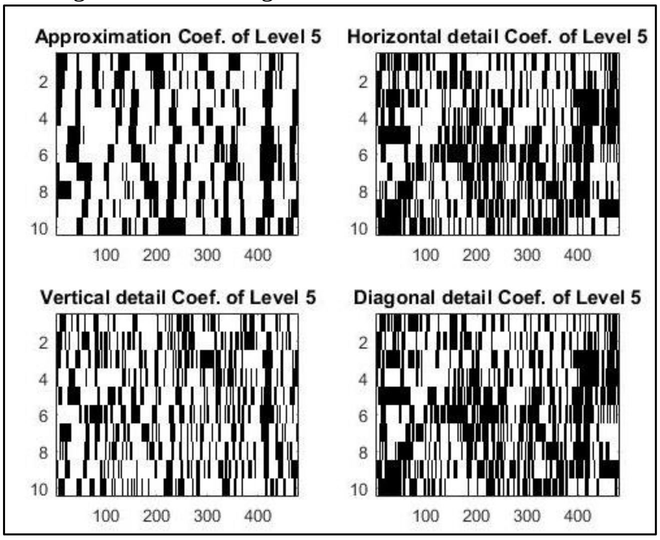


Fig. 9: Quantized Binary Image for matching

III. RESULTS & CONCLUSION

The DWT is more efficient than other algorithms as it considers the coefficients in Horizontal, Vertical and Diagonal directions. The performance indices were measured for 30 images from the database for each filter. The accuracy of algorithm is nearly equal to 90% for the stored images. Given below is the comparative evaluation:

Filter	ERR		FRR (%), FAR=1.0%	FRR(%), FAR=0.1%
Gabor	8.49		22.83	38.30
Log Gabor	13.64		28.11	35.47
DWT (Haar)	4.78		9.71	11.43

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