IRIS RECOGNITION USING DISCRETE WAVELET TRANSFORM

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ABSTRACT

Iris recognition is known as an herently reliable technique for human identification. In this paper, a DWT based quality measure for iris images is proposed. It includes preprocessing, feature extraction and recognition. The preprocessing steps such as conversion of color to gray image, histogram equalization and segmentation are carried out to enhance the quality image. The area of interest is selected from which the features are extracted and polar to rectangular conversion is applied. Features are extracted using DWT the templates are generated and match with the stored one using hamming distance and the FAR and FRR is calculated. The algorithm is tested on iris images of UPOL and CASIA. The accuracy of algorithm is found to be equal to 100% while FAR and FRR is equal to 0% as it donot accept the image which is not present in the database (unauthorized person) and donot reject the authorized person. The DWT is consider for recognition process as it is less affected by pupil dilation and illumination along with this it works better in noisy conditions.

KEYWORDS: *Biometrics, DWT, hamming distance, histogram, iris recognition, segmentation.*

I. INTRODUCTION

In recent years, biometric personal identification is in growing state of world, not only that it is the hot cake of both academician and industry. Traditional methods for personal identification are based on what a person possesses (Identity card, physical keyed, etc.) or what a person knows (a secret password) any how these methods have some pitfalls. ID cards may be forged, keys may be lost, and password may be forgotten. Thus Biometrics –Based human authentication systems are becoming more important as government and corporations worldwide deploy them in such schemes as access and border control, driving license registration, and national ID card schemes. The word “biometrics” is derived from the Greek words bio (life) and metric (to measure). The iris has unique features and is complex enough to be used as a biometric signature. It means that the probability of finding two people with identical iris patters is almost zero. According to Flom and Safir the probability of existence of two similar irises on distinct persons is 1 in $10^{72.}$ The DWT is used for iris recognition propose. The proposed iris recognition system is designed to handle noisy conditions as well as possible variations in illumination and camera to face distance. The input image is preprocessed to extract the portion containing iris and then the features are extracted using DWT [2], [6], [15].

The iris is well protected internal organ of the eye, located behind the cornea and the aqueous humor, but in front of the lens. The human iris begins to from during the third month of gestation. The structure is complete by the eight month of gestation, but pigmentation continues into the first year after birth. It is stable, reliable and is unrelated to health or the environment. The iris grows from the ciliary body and its color is given by the amount of pigment and by the density of the iris tissue that means from blue to black. The iris is a protective internal organ of the eye. It is easily visible from yards away as a colored disk, behind the clear protective window of the cornea, surrounded by the white tissue of the eye. It is the only internal organ of the body normally visible externally. Thus iris is unique, universal, easy to capture, stable and acceptable [8], [9].

The organization of manuscript is as follows:

II) Methodology
III) Results
IV) Conclusion

II. METHODOLOGY

Iris recognition requires four main steps-

- Capture Image.
- Preprocessing, it includes segmentation that isisolating the iris from the image.
- Feature extraction and generation of template is done using DWT.
- Comparison of these templates is done with the stored one using hamming distance. If the template is match than the person can access the authenticated system.

i) Capture Image:

The first step is to collect the iris images. Generally the images are captured using 3CCD camera working at NIR.The distance between eye and camera should be equal to 9cm and the approximate distance between user and infrared light is about 12cm. To capture the rich details of iris patterns, an imaging system should resolve a minimum of 70 pixels in iris radius. A resolved iris radius of 80–130 pixels has been more typical used. Mono chrome CCD cameras (480x640) have been used because NIR illumination in the700–900-nm band was required for imaging to be unintrusive to human. Here the algorithm is tested on iris images of UPOL and CASIA database which are downloaded from net. On these images various preprocessing steps are carried out[5].

ii) Preprocessing:

In this the first step is to convert the color image to gray scale. In this color of an image is converted to a shade of gray by calculating the effective brightness or luminance of the color and using this value to create a shade of gray that matches the desired brightness. The effective luminance of a pixel is calculated with the following formula: [16].

$$\mathrm{Y} = 0.3\mathrm{RED} + 0.59\mathrm{GREEN} + 0.11\mathrm{Blue} \tag{1}$$

After this histogram equalization is carried out. Histogram is a useful tool to analyze the brightness and contrast of an image. It shows how the intensity values of an image are distributed and the range of brightness from dark to bright. An image can be enhanced by remapping the intensity values using the histogram. Also, histogram is used to segmentize an image into the several regions by thresholding. The histogram of a segmented image H[n] is then computed. Since the segmented image contains primarily zero pixel values, and the pupil itself has very low values, the histogram is modified to remove the effects of these pixels. This modification is described as: [7], [16].

$$H_1[n] = \begin{cases} 0, & n < 20 \\ H_o[n], & 20 \le n \le 230 \\ 0, & n > 230 \end{cases} \tag{2}$$

The value of H[n] can be obtained as:

$$H[n] = \frac{255}{Max - Min} \times (V - Min) \tag{3}$$

Histogram equalization is done to adjust the intensity. We store the number of pixels (frequencies) of same intensity values into a histogram array, which is commonly called "bin". For an 8-bit gray scale image, the size of histogram bin is 256,because the range of the intensity of 8-bit image is from 0 to 255[16].

$$x^t = T(x)\sum_{i=0}^{x} n_i . \frac{\max.\mathrm{int}\, ensity}{N} \tag{4}$$

where: n_i is the number of pixel at intensity i, N is the total number of pixel in the image. (0-255)

The boundary of pupil and iris is recognized using canny edge detector as it has low error rate, response only to edge and the difference between obtained and actual present edge is less. It considers the gradient change between pupil to iris and iris to sclera. The area of pupil is separated and the region of interest is selected i.e. the area from which features are extracted to avoid noise present at boundary. The polar to rectangular conversion is applied and then features are extracted using discrete wavelet transform. The templates are generated and match using hamming distance and if match the match ID is displayed. The block diagram of the system can be shown as follows: [1].

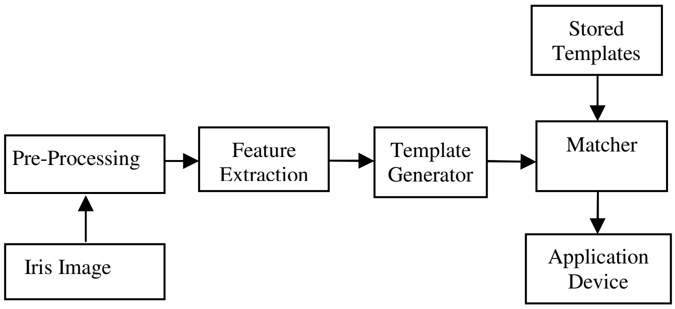


Figure 1. Block diagram of the system

The canny edge detector internally follows certain steps:
It applies Gaussian filter to filter out any noise by: [18], [19].
Smooth by Gaussian:

$$S = G_\sigma * I \tag{5}$$

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \tag{6}$$

Compute x and y derivatives:

$$\nabla S = \begin{bmatrix} \frac{\partial}{\partial x} S & \frac{\partial}{\partial y} S \end{bmatrix}^T = \begin{bmatrix} S_x & S_y \end{bmatrix}^T \tag{7}$$

Compute gradient magnitude and orientation:

$$|\nabla S| = \sqrt{S_x^2 + S_y^2} \tag{8}$$

$$\theta = \tan^{-1} \frac{S_y}{S_x} \tag{9}$$

Canny edge operator:

$$\nabla G_\sigma = \begin{bmatrix} \frac{\partial G_\sigma}{\partial x} & \frac{\partial G_\sigma}{\partial y} \end{bmatrix}^T \tag{10}$$

$$\nabla S = \begin{bmatrix} \frac{\partial G_\sigma}{\partial x} * I & \frac{\partial G_\sigma}{\partial y} * I \end{bmatrix}^T \tag{11}$$

We can find the edge by considering gradient change. For this the mask is computed on the image, and the gradient change calculated.

$$|G| = |Gx| + |Gy| \tag{12}$$

$$\theta = \tan^{-1}\frac{G_y}{G_x} \tag{13}$$

Once the edge direction is known, the next step is to relate the edge direction to a direction that can be traced in an image. So if the pixels of a 5x5 image are aligned as follows: [18], [19].

x	x	x	x	x
x	x	x	x	x
x	x	a	x	x
x	x	x	x	x
x	x	x	x	x

Figure 2. Matrix for detecting edge

Then for a pixel there are only four possible directions i.e. 0°(in the horizontal direction), 45°(along the positive diagonal), 90°(in the vertical direction), or 135°(along the negative diagonal). Hence we need to resolve the edge into one of these directions depending on which direction it is closest to (e.g. if the orientation angle is found to be 3 degrees, make it zero degrees). For this take a semicircle and dividing it into 5 regions as shown in Figure 2.Therefore, any edge direction falling within the range 0° to 22.5° & 157.5° to 180° is set to 0°. Any edge direction falling in the range 22.5° to 67.5° is set to 45°. Any edge direction falling in range 67.5° to 112.5° degrees is set to 90°. And finally, any edge direction falling within the range 112.5° to 157.5° is set to 135°.

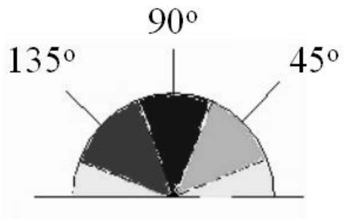


Figure 3. Angle quantization

The pixels which do not have maximum value are suppressed using the formula:

$$M(x,y)=\begin{cases} |\nabla S|(x,y) & \text{if } |\nabla S|(x,y)>|\nabla S|(x',y') \\ & \& \, |\nabla S|(x,y)>|\nabla S|(x'',y'') \\ 0 & \text{otherwise} \end{cases} \tag{14}$$

Where, (x', y') and (x", y") are the neighbors of (x, y) along the direction normal to an edge. Hysteresis thresholding is done at the last. That is if the gradient of pixel is above the threshold than it is consider as edge pixel else not, and if it is in between low and high value then declare it an edge pixel if and only if it is connected to an edge pixel directly or via pixels between low and high [18], [19].

After this the image is converted into rectangular template by using polar to rectangular conversion also called as rubber sheet model. It reduces the effect of pupil dilation and inconsistence in the distance. It consists of a pair of real coordinates (r, θ) where 'r' is on the unit interval [0, 1] and 'θ' is of [0, 2π]. The remapping of the iris image from raw Cartesian coordinates (x, y) to the dimensionless non concentric polar coordinate system (r, θ) can be represented as: [3]

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \tag{15}$$

Where x(r, θ) and y(r, θ) are defined as linear combinations of both the set of pupillary boundary points (($x_p(\theta)$, $y_p(\theta)$)) and the set of limbus boundary points along the outer perimeter of the iris ($x_s(\theta)$, $y_s(\theta)$) bordering the sclera, both of which are detected by finding the maximum of the operator (1) as:

$$x(r,\theta) = (1-r)x_p(\theta) + rx_s(\theta) \tag{16}$$

$$y(r,\theta) = (1-r)y_p(\theta) + ry_s(\theta) \tag{17}$$

Since the radial coordinate ranges from the iris inner boundary to its outer boundary as a unit interval, it inherently corrects for the elastic pattern deformation in the iris when the pupil changes in size [3], [14].

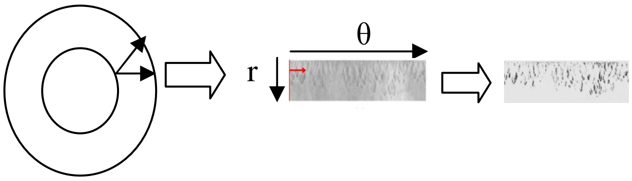
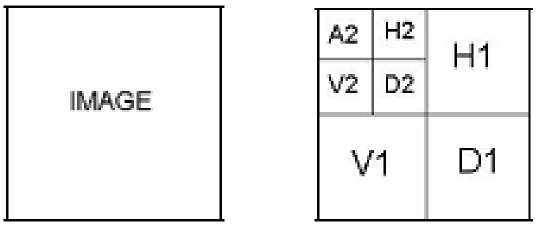


Figure 4. Polar to rectangular conversion

iii) Feature Extraction:

The DWT analyses a signal based on its content in different frequency ranges. Therefore it is very useful in analyzing repetitive patterns such as texture. The 2-D transform decompose the original image into different channels, namely the low-low, low-high, high-low and high-high (A, V, H, D respectively) channels. The decomposition process can be recursively applied to the low frequency channel (LL) to generate decomposition at the next level. Figure5 (a) - (b) show the 2-channel level-2 dyadic DWT decomposition of an image. The LP and HP filters are used to implement the wavelet transform. The features are computed as the local energy of the filter responses. A local energy function is computed consisting of a non-linearity, by rectifying the filter response and smoothing. In rectification the negative amplitudes is transform to corresponding positive amplitudes. For this the Gaussian filters are applied [2], [10], [11].



(a) (b)

Figure 5. Level 2-dyadic DWT decomposition of an image

In encoding stage, two level Discrete Wavelet Transformation (DWT) is applied on the above segmented and normalized iris region to get approximation and detail as 0 i.e. all black pixels as shown in Figure6. 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) [4], [13].

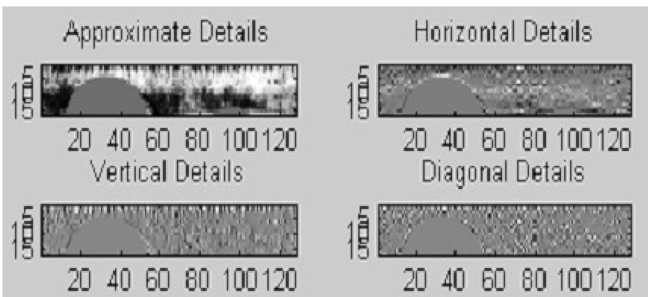


Figure 6. Approximation and detail coefficients of the normalized iris image

iv) Template Matching:

The formed templates are match with the stored one using Hamming distance.The HD is used to decide whether the image (template formed) is of same person or not. 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 comparedand N be total number of bits, this quantity can be calculated as: [4]

$$HD = \frac{1}{N}\sum_{j=1}^{N} A_j \oplus B_j \tag{18}$$

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

III. RESULTS

The code for iris recognition is implemented in MATLAB 7.0 (Company- Simulink). The downloaded image (original color image) is shown in Figure 7. This image is converted into gray image and histogram equalization is carried out on it and the enhance image is shown in Figure 9. The canny edge detector is applied to detect the edge of pupil and iris as displayed in Figure 10. To separate the area of pupil the radius of the pupil should be known for this start tracing from left hand side and when flag is equal to '1' stop and mark the start point in the same fashion trace from right hand side and mark the end point and divide the distance by 2 to get the centre point this is the fake point hence to get the true centre point again start tracing from the fake point in left, right, up and down direction (i.e. x and y axis) up till the edge of pupil. Draw the perpendicular to this which will pass through the centre (property of circle) this indicates the true centre point as shown in Figure 11 and Figure 12.
After this the area for feature extraction is selected refersFigure 13. The above area is converted into rectangular template using polar to rectangular conversion as shown in Figure 14. After this the features are extracted using DWT which generates four templates approximate, horizontal, vertical and diagonal as shown in Figure 15. The templates are quantized and the binary image is displayed in Figure 16. Equation 19 shows the match ID of the person.

Figure7. Original image

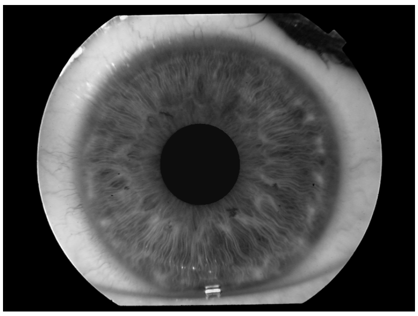


Figure8. Gray scale image

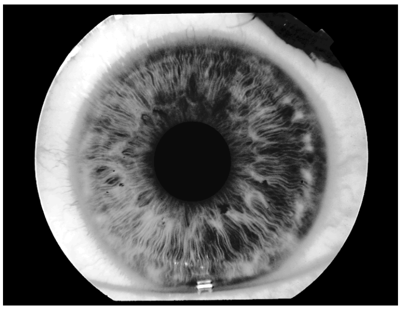


Figure9. Histogram equalization

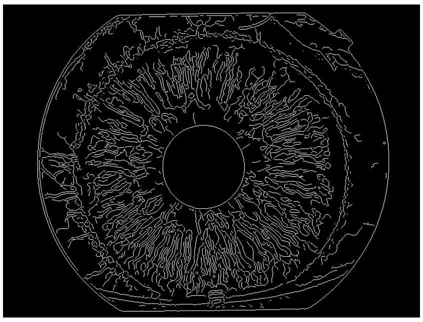


Figure 10. Canny edge detector

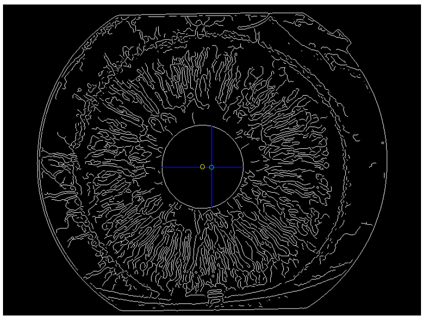


Figure 11. Two centres

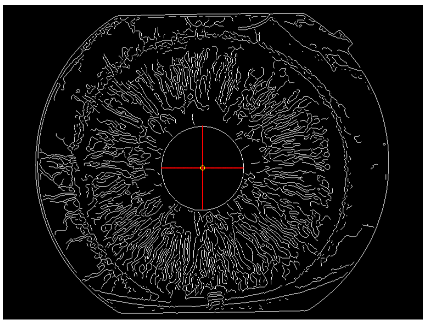


Figure 12. Centre and radius of pupil

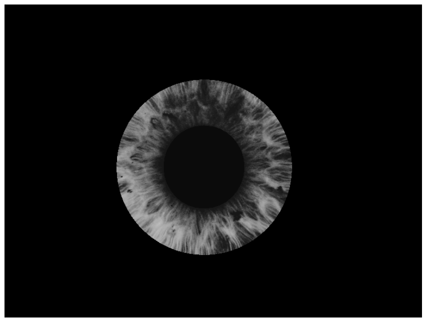


Figure 13. Region of interest

Figure 14. Polar to Rectangular conversion

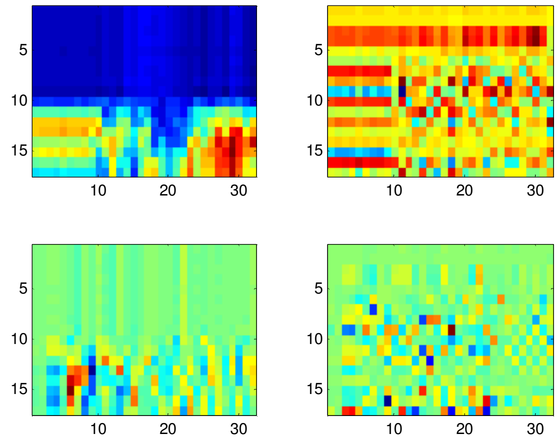


Figure 15. DWT decomposition of an image

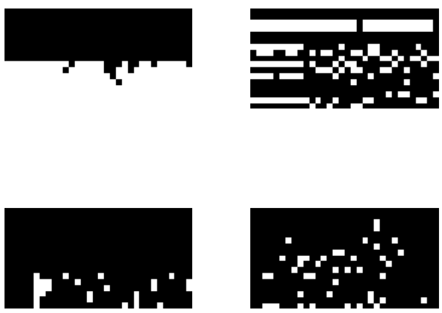


Figure16. Quantized binary image.

Match ID of person displayed as follows:

$$\text{Recognized\_with} = 1 \tag{19}$$

IV. Conclusion

The DWT is more efficient than other algorithm as it consider the coefficients in H, V and D direction. The algorithm is tested on UPOL and CASIA database both the database consist of 102 images. The accuracy of algorithm is equal to 100% as it showed correct ID for the stored images in database. While FAR is equal to 0% as it dose not accept image which is not present in the database. To test FAR 20 different images are applied (image not present in database) for which it showed ID equal to 00 i.e. unauthorized person. Along with this FRR is also equal to 0% as it showed correct ID for all the images which are present in database in other words it don't reject the image which is present in the database. The performance of DWT on UPOL and CASIA is as follows:

Table 1. Performance of DWTon UPOLand CASIA images.

		Database	
		UPOL (102 imagesin database)	**CASIA (102 images in database)**
Performance Parameter	**Accuracy**	100% (Tested on 102 images ID successfully detected)	100% (Tested on 102 images ID successfully detected)
	FRR	0% (Since it detects the correct ID for the images which are present in database)	0% (Since it detects the correct ID for the images which are present in database)
	FAR	0% (We have applied 20 images which are not present in database it don't accept the image)	0% (We have applied 20 images which are not present in database it don't accept the image)

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