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Iris Recognition by Complex Wavelet Transform

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Abstract- ***Personal identification has become the need of modern day life. The identification must be fast, automatic and foolproof. Biometrics has emerged as a strong alternative to identify a person compared to the traditional ways. Also biometric identification can be made fast, automatic and is already foolproof. Among other biometrics, Iris recognition has emerged as a strong way of identifying any person. The probability that any two iris of different person match is one in seven billion. Also the iris of any person remains unaltered throughout the lifetime and it is less susceptible to damage since it an internal organ. In this paper, first the iris is segmented using linear approach. The iris recognition system is composed of many steps. Namely, capturing the iris patterns; determining the location of the iris boundaries; converting the iris boundary to the polar coordinate system; extracting the iris code based on complex wavelet transforms; and classification of the iris code. There are many methods proposed for iris recognition by many researchers. The proposed system based on complex wavelet transform for iris recognition system with high performance and acceptance, rejection capabilities is described.***

Key Words- **Biometrics, Complex Wavelet, Feature Extraction, Haar Wavelet, Iris Pattern, Iris Template.**

I. INTRODUCTION

The word iris is generally used to denote the colored Portion of the eye. It is a complex structure comprising muscle, connective tissues and blood vessels. The image of a human iris thus constitutes a plausible biometric signature for establishing or confirming personal identity. Further properties of the iris that makes it superior to finger prints for automatic identification systems include, among others, the difficulty of surgically modifying its texture without risk, its inherent protection and isolation from the physical environment, and it's easily monitored physiological response to light. Additional technical advantages over fingerprints for automatic recognition systems include the ease of registering the iris optically without physical contact beside the fact that its intrinsic polar geometry does make the process of feature extraction easier. J. Daughman proposed the first successful implementation of iris recognition system in 1993. This work though published more than fifteen years ago still remains valuable since because it provides solutions for each part of the system. It is worth mentioning that most systems implemented today are based on his work [1]. They are based on Gabor wavelet analysis in order to extract iris image features. It consists in convolution of image with complex Gabor filters. As a product of this operation, complex coefficients are computed. In order to obtain iris signature, phasors are evaluated and coded by their location in the complex plane. However the Daughman's method is patented which blocks its further development [2].

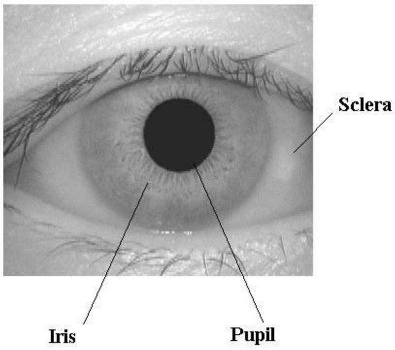

Fig. 1: The location of iris in eye.[10]

In another approach suggested, by Lye Wil Liam and Ali Chekima in their paper, the iris image is pre processed for contrast enhancement. After preprocessing, a ring mask is created and moved through the entire image to obtain the iris data. By using this data the iris and pupil are reconstructed from the original picture. Using the iris center coordinate and radius, the iris was cropped out from the reconstructed image. The iris data is transformed into a rectangular shape. Using a self organized feature map the iris pattern is matched. The network contains a single layer of Euclidean weight function. Manhattan Distances are used to calculate the distance from a particular neuron X to the neuron Y in this neighborhood. The Manhattan Distances without a bias and a competitive transfer function is used to upgrade the weight [3].

II. IRIS RECOGNITION SYSTEM

A typical Iris Recognition system basically consists of following main modules as shown below,

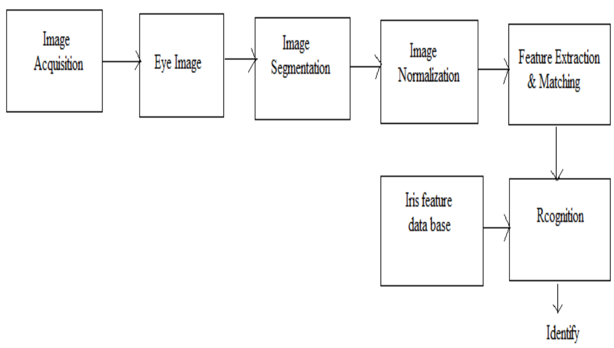

Fig. 2: Steps in iris recognition system

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III. IMAGE ACQUISITION

It is to capture a sequence of iris images from the person concerned using a specifically designed sensor. Since, the iris is fairly small and exhibits abundant features under infrared lighting, capturing iris images of high quality is one of the major challenges for practical applications. While designing an image acquisition apparatus the factors that must be taken into consideration is the lighting system, the positioning systems and physical capture system.The eyes images taken from the CASIA (Institute of Automation Chinese Academy of Science) iris database are 280*320 pixels grayscale image, there are 108 classes of irises, each iris class is composed of 7 samples taken in two sessions so resulting in a total of 756 eye images. ASIA Iris database uses a special camera that operates in the infrared spectrum of light, not visible by the human eye, second iris image data base is SJTU (Shanghai Jiao Tong University) it contains 1000 grayscale eye images of resolution 372*245 pixels size [7].

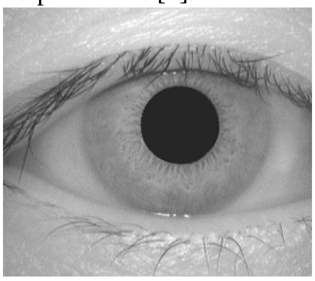

Fig. 3: Sample image of eye from CASIA iris database [10]

IV. IRIS SEGMENTATION

The next stage of iris recognition is to isolate actual iris region in an eye image, the eyelids and eyelashes normally occlude the upper and lower parts of the iris region. Also, specular reflections can occur within the iris region corrupting the iris pattern. A technique is required to isolate and exclude these artifacts as well as locating the circular iris region. The success of segmentation depends on the imaging quality of eye images, the CASIA iris database do not contain specular reflections due to use of near infra-red light for illumination, The segmentation step detects the boundaries of iris region, In segmentation, firstly edges from the input eye image are detected using the edge detector, there are number of algorithms for iris segmentation the two important algorithm used mostly are, 1.Canny edge detector and Hough transform. 2. Linear Approach [5].

Linear Approach: A fast algorithm for detecting the boundaries between pupil and iris and also sclera and iris has been proposed. To find the boundary between the pupil and iris, we must detect the location (centre coordinates and radius) of the pupil. The rectangular area technique is applied in order to localize pupil and detect the inner circle of iris. The pupil is a dark circular area in an eye image. A rectangular area is used to accurately detect the location of the pupil. Searching starts from the vertical middle point of the iris image and continues to the right side of the image. A threshold value is used to detect the black rectangular area [4].

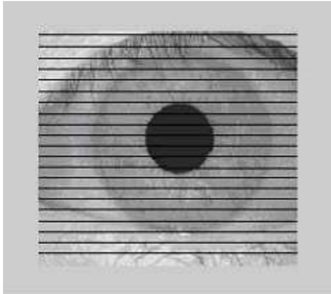

Fig. 4: The result of detecting rectangular area [4]

In Figure 5 the circle represents the pupil, and the rectangle that is inside the circle represents the rectangular black area. The border of the pupil and the iris has a much larger grayscale change value. Using a threshold value on the iris image, the algorithm detects the coordinates of the horizontal boundary points of (x1, y1) and (x1, y2), as shown in Figure 5.3. The same procedure is applied to find the coordinates of the vertical boundary points (x3, y3) and (x4, y3). After finding the horizontal and vertical boundary points between the pupil and the iris, the following formula is used to find the centre coordinates (xp, yp) of the pupil.

$$x_p = (x_3 + x_4)/2 \quad , \quad y_p = (y_3 + y_4)/2 \qquad (1)$$

The same procedure is applied for two different rectangular areas. In case of small differences between coordinates, the same procedure is applied for four and more different rectangular areas in order to detect a more accurate position of the pupil Centre. After determining the centre points, the radius of the pupil is computed using equation (2).

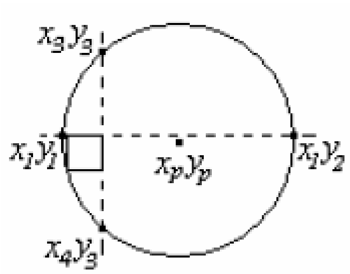

Fig. 5: Finding the centre of the pupil [6]

$$r_p = \sqrt{(x_c - x_1)^2 + (y_c - y_1)^2} \quad \text{or}$$

$$r_p = \sqrt{(x_c - x_3)^2 + (y_c - y_3)^2} \qquad (2)$$

Because of the change of grayscale values in the outer boundaries of iris is very soft, the current edge detection methods are difficult to implement for detection of the outer boundaries. In this paper, another algorithm is applied in order to detect the outer boundaries of the iris. We start from the outer boundaries of the pupil and determine the difference of sum of grayscale values between the first ten elements and second ten, elements in horizontal direction. This process is continued in the left and right sectors of the iris. The difference corresponding to the maximum value is

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selected as boundary point. This procedure is implemented by the following formula [6].

$$DL_i = \sum_{i=10}^{y_p-(r_p+10)} (S_{i+1} - S_i)$$

$$DR_j = \sum_{j=y_p+(r_p+10)}^{right-10} (S_{j+1} - S_j) \qquad (3)$$

Here DL and DR are the differences determined in the left and right sectors of the iris, correspondingly. xp and yp are centre coordinates of the pupil, rp is radius of the pupil, right is the right most y coordinate of the iris image. In each point, S is calculated as in equation (4)

$$S_j = \sum_{k=j}^{k+10} I(i,k) \qquad (4)$$

Where i=xp, for the left sector of iris j= yp-(rp+10), and for the right sector of iris j=yp+ (rp+10). Ix (i,k) are grayscale values. The centre and radius of the iris are determined using,

$$y_s = (L+R)/2 \ , \quad r_s = (R-L)/2 \qquad (5)$$

L=i, where i correspond to the value max (|DLi|) R=j, where j correspond to the value Max (|DRj|).

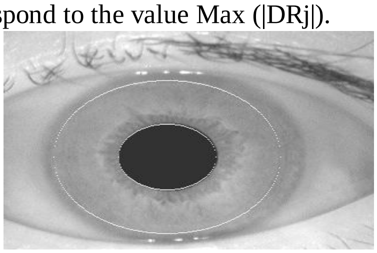


Fig. 6: Iris detected image by linear approach [10]

V. IRIS NORMALIZATION

The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location. Another point of note is that the pupil region is not always concentric within the iris region, and is usually slightly nasal. This must be taken into account while trying to normalize the 'doughnut' shaped iris region to have constant dimensions [4].The rubber sheet model takes into account pupil dilation and size inconsistencies in order to produce a normalized representation with constant dimensions. In this way the iris region is modeled as a flexible rubber sheet anchored at the iris boundary with the pupil centre as the reference point. The homogenous rubber sheet model remaps points within the iris region to a pair of polar coordinates (*r*, *θ*) where r is on the interval [0, 1] and *θ* is angle [0,2*π*] as shown in Figure 7. The remapping of the iris region from Cartesian (x, y) coordinates to polar (r, θ) coordinates is given by,

$$\begin{aligned} & I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \\ & x(r,\theta) = (1-r)x_p(\theta) + r x_i(\theta) \\ & y(r,\theta) = (1-r)y_p(\theta) + r y_p(\theta) \end{aligned} \qquad (6)$$

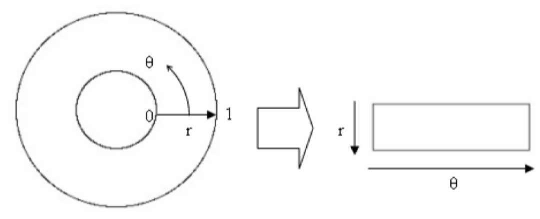


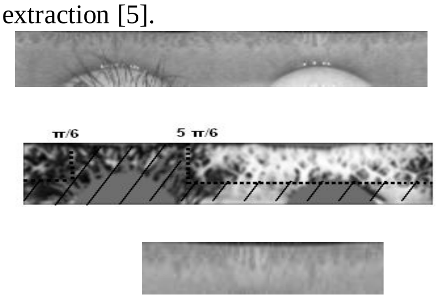
Fig. 7: Rubber sheet model [4]

Where, I(x, y) is the iris region image, (x, y) are the original Cartesian coordinates, (r,θ) are the corresponding normalized polar coordinates, x_p, y_p and x_i, y_i are the coordinates of the pupil and iris boundaries along the θ direction.

Fig. 8: Template generated after normalization

VI. EYELID AND EYELASH REMOVAL

The normalized eye image contains eyelids and eyelashes as a part of original eye image, it acts as a noise data, so it causes difficulty in iris recognition process. To remove this noise a algorithm is proposed to crop the iris template to suitable size, the algorithms crops the iris template to one fourth of its size, and stored these template as a iris template for feature extraction [5].



(a)

(b)

(c)

Fig.9: (a) Iris template with eyelid and eyelash (b) Region of interest in feature extraction (c) Iris template generated after removal of eyelid and eyelash.

VII. APPLYING WAVELET AND COMPLEX WAVELET TRANSFORM

Wavelet transforms are used to extract the feature of normalized iris image, wavelet coefficients vectors are used as a feature for iris recognition, four types of wavelet coefficients e.g. vertical, horizontal, approximate and detail can be used, here simple Harr wavelet is used,

(a) (b)

(c) (d)

Fig. 10: (a) Horizontal (b) Vertical (c) Approximate and (d) Detail coefficients of Haar wavelet transform for iris template.

Wavelet transform has three main disadvantages, Shift sensitivity, Poor directionality and Absence of phase information, these disadvantages can be overcome by complex wavelet. Complex Wavelets Transforms use complex valued filtering that decomposes the real/complex signals into real and imaginary parts in transform domain. The real and imaginary coefficients are used to compute amplitude and phase information, just the type of information needed to accurately describe the energy localization of oscillating functions. Here complex frequency B-spline wavelet is used for iris feature extraction A complex frequency B-spline wavelet is defined by

$$\psi(x) = \sqrt{f_b}\left(\mathrm{sinc}\left(\frac{f_b x}{m}\right)\right)^m e^{2i\pi f_c x} \qquad (7)$$

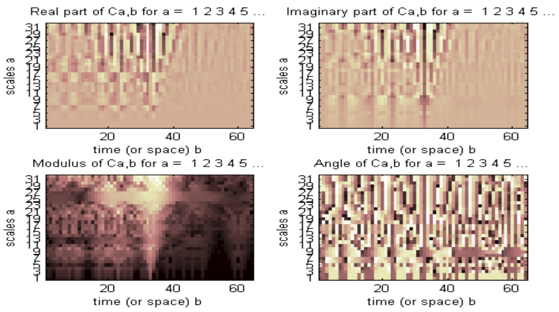


Fig.11: Complex Frequency B-Spline wavelet coefficients for iris template. [11]

VIII. EXPERIMENTATION AND RESULTS

The iris templates are matched using different angles 210,240,280,320 and 350 degrees and it is observed that as angles increases percentage of matching also increases the better match is observed at angle 350 which is 93.05%.Further by detecting eyelids and eyelashes the iris image is cropped and iris template is generated for matching purpose the results obtained is better than previous results the matching score is 95.30%.

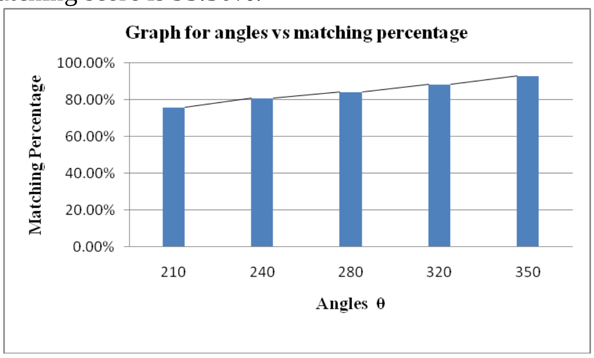


Fig.12: Graph for angles verses matching percentage of iris images

IX. CONCLUSION

In this paper using complex wavelet, different coefficient vectors are calculated. Minimum distance classifier was used for final matching. The smaller the distance the more the images matched. It is observed that for the complex wavelets the results obtain are good than the simple wavelet because in complex wavelet we get both phase and angle also real and imaginary coefficients, so we can compare all these parameters for iris matching purpose.

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