© 2017 IJSRST | Volume 3 | Issue 6 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Critical Literature Survey on Iris Biometric Recognition

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ABSTRACT

This paper presents the review of iris biometric recognition system which is used for identification and authentication of human being. Iris is internal (externally visible) part of body. Due to the uniqueness and stability of iris it has been considered as more reliable for security system. The iris recognition system composed of procedure of iris recognition system image acquisition, localization, segmentation, normalization, feature extraction, template generation and pattern matching. This paper describes different techniques used in performing the steps involved in iris recognition. Iris recognition technique is quantifiable, durable, and highly reliable so it accomplishes the basic tenant of ideal biometric technology.

Keywords: Iris Biometric Recognition, Image Acquisition, Localization, Segmentation, Normaiization, Feature Extraction, Template Generation, Pattern Matching.

I. INTRODUCTION

The biometric system uses the unique Physiological and structural characteristics of human being to identify the particulars. These characteristics are fingerprints, retina, face texture, iris, voice pattern etc. In the past decade, iris recognition technology has become the most popular biometric technique for authentication and identification of human being because of its stability and uniqueness in structure.

The Iris is circular shaped structure in eye. An iris layer is formed after six month of birth and becomes stable after one year and remains unchanged for lifetime. Iris contains many feature, rings freckles ridges, corona, a zigzag collarette and crypts [1].

The background of the iris biometric recognition system is described in the following sections.

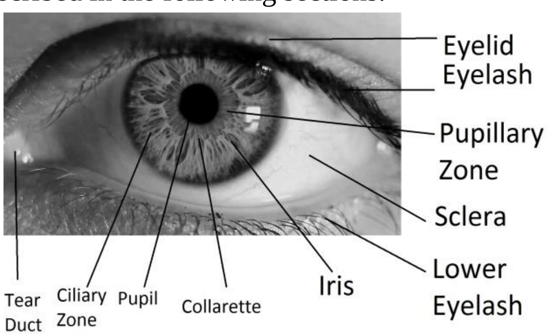

Figure 1: Eye image

A. Background

Iris biometric recognition technology has been developed in the 80s and its first working methodology is proposed by J. Daugman [2]. Since all the biometric recognition techniques has not offered suitable recognition rates (FAR & FRR) and in iris recognition system the probability of finding two people with identical iris pattern is almost zero. So this technology is providing better solution for human identification [4].

In iris biometrics system J. Daugman[5] proposed the integro-differential operator for localization of iris. This algorithm provides separation of pupil and circular iris region [3]. It also searches for the lower and upper eyelid arc. For this the integro differential operator searches the pixels which are on the circular path and has the maximum changes in their values. The integro differential operator is applied repeatedly to achieve accurate localization. Eyelids are localized in a parallel manner. The integro-differential operator is implemented as variant of the Hough transform. The primary derivatives of the image are used to search the geometrics features. Although it operates on raw derivative information, so it provides robustness against problem of thresholding that comes in Hough transform.

However, the integro-differential operator has some limitations. It does not work when eye image contains some noise like reflections.

The Iris pattern recognition was firstly proposed by Alphonse Bertillon for personal identification. After that in 1987, they work with John Daugman to create software for iris recognition [6]. Further research has been carried out by W.Boles'[7], R.Wildes'[8], R.Sanchez- Reillo's[9] to distinguishes pattern matching algorithm and iris features representation. R.Wildes' present a solution in which (i) iris localization is performed by Hough transform, (ii) representation of spatial features of the iris by laplacian pyramid with multi scale decomposition, and (iii) matching procedure is accomplished by customized normalized correlation.

W.Boles' developed 1-D representation of the gray level image of iris and then perform the wavelet transform zero-crossings of the obtained representation. Effective matching is computed by original dissimilarity functions that enable selection of relevant information.

J.Daugman's and R.Sanchez-Reillo's systems deployed the system exploiting integro-differential operators to find outer and inner boundaries of iris, The peculiar binary vectors comprising iris codeTM has been extracted by utilizing Gabor filters and the average Hamming distance between two codes is determined by using a statistical logical XOR matcher. The next section provides the outline of this paper.

B. Outline:

This paper contains the methodology and techniques of iris biometric recognition system which has been proposed since past years. The paper is fragmented in four sections. Section 2 provides the general framework on iris technology describing the basic components of iris biometric recognition system detailing the related study on different issues and features of technology proposed till present. Section 3, provides the application areas of iris biometric recognition. Section 4 concludes the paper.

II. GENERAL FRAMEWORK OF IRIS BIOMETRIC RECOGNITION SYSTEM

The fig. 2 shows the framework of iris biometric recognition system. This includes six major steps mentioned in diagram. In the image capturing stage eye image is captured by the use of digital cameras. The noise reduction is performed in preprocessing stage before advancing to iris segmentation. Iris segmentation is generally performed by Hough transform and John Daugman Integro-differential operator. After segmentation, feature extraction is performed which searches region of interest (ROI) that contain iris pattern. After that template is generated and store in database. Iris pattern matching is performed by calculating Hamming distance.

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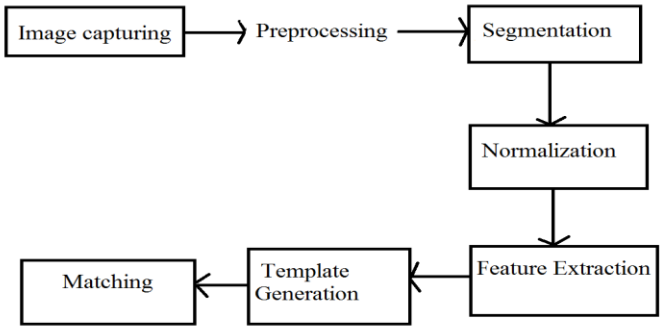

Figure 2: General Framework

The Iris biometric recognition process elaborated following six steps which are given in fig 2.

1. Image Capturing or acquisition
2. Image Segmentation
3. Iris Normalization
4. Feature Extraction
5. Template Generation
6. Matching Algorithm

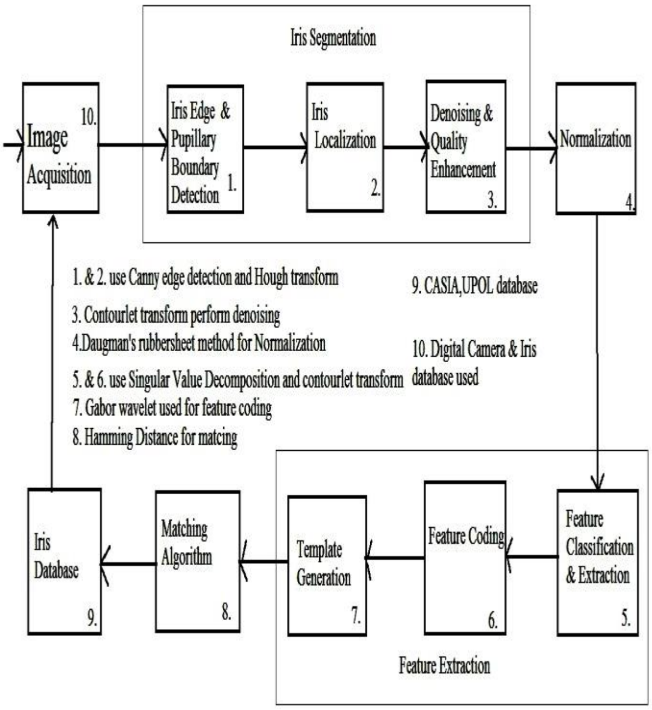

Figure 3: Iris recognition process

A. Image Capturing/Acquisition:

The automated iris recognition system captures a series of iris image of human eye with minimum noise by digital cameras. it should take care that pupil and iris in the image are clearly visible. Sometimes due to environmental effects images are not clear and thus create difficulty in iris recognition. So specially designed cameras are used in bad environment conditions[8]. For experimental purpose there are many iris databases available on internet such as CASIA, LEI and UPOL for testing purpose.

B. Iris Segmentation and Localization:

The feature information for iris recognition is stored in iris pattern [10]. It is necessary to separate iris region and other part of eye image. This isolation can be performed by finding the inner and outer contours of iris boundary [11]. The Hough transform is used to find out parameter of common geometric object. Line arc and circles are common parameters of objects in an image. The midpoint coordinates and radius of iris region and pupil are calculated by circular Hough transformation.

Wildes proposed an algorithm for automatic segmentation is based on circular Hough transform [8].

In this algorithm the first derivative of intensity value of an eye image is calculated to generate an edge map of this image and a threshold is assigned. In Hough space vote are casted from the edge map for the parameters of circle passing by every edge point. These parameters are radius r and the centre coordinates of the circle i.e. pc and qc, By the use of these parameter any circle can be created according to the equation.

$$pc2+qc2 = r2 \qquad (1)$$

A most extreme point in the Hough space will relate to the centre and radius of the circle which characterizes the edge points, parabolic hough transform is applied by following equation to find the eyelids.

$$(- (p-h_j) \sin\theta_j + (q-k_j) \cos\theta_j = a_j ((p-h_j) \cos\theta_j + (qk_j) \sin\theta) \qquad (2)$$

The main work of iris segmentation is to differentiate the useless data like sclera and pupil from iris region and extract the region of interest (ROI) [12]. Thus we describe papillary boundary detection and Iris edge detection as following:

1) Pupillary Boundary detection: The algorithm [13] detects the center of the pupil and two radial coefficients because the pupil is not always a perfect circle.

To detect the pupil, apply a step threshold to iris image which is given by,

$f(x) = g(x) > 70:1$

$g(x) \leq 70:0$

Here g(x) is the actual image and f(x) is the threshold image. Pixels have intensity value higher than the experimental value of 70 in a grey scale i.e. 0 to 255 which are converted to 1 that is white, Pixels with intensity value smaller than or equal to 70 are converted to 0 that is black. Below mentioned figure 4 represent the pupil image created by threshold value of pixels. Meanwhile, the eyelashes are also satisfying the threshold provision.

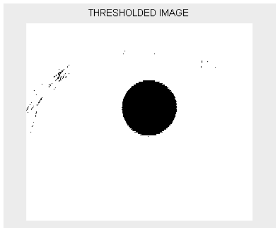

Figure 4: Threshold Image [13]

To remove the region of eyelashes, the area of 8 connected pixels having value equal to one is detected. The result of CASLA database shows that an area having value equal to 2500 is enough for the area of pupil [13]. Thus following condition applied to segment pupil of iris and to derive centroid:

For every Region G

If AREA(G) < 2500

Assign all pixels of G to 0

Figure 4 depicts the threshold image where the Freeman's Chain Coding approach is implemented for cropping the eyelashes in the image [12].

2) Iris Edge Detection: The further step is to detect the curve of the iris after detecting the pupil. The position of the pupil is already detected and it is also known that the outer perimeter is concentric with it [13].

The basic concept behind the detection of iris is to draw the horizontal imaginary lines which crosses complete image that passes through the pupil's center [12]. The figure depicts the horizontal line which passes through the pupil's center of the pupil. For each pixel of the horizontal line, the intensities are also shown graphically in the figure.

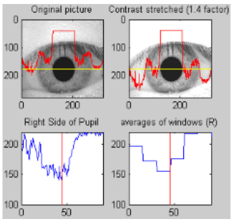

Figure 5: Iris Edge Detection [13]

C. Iris Image Denoising By Contouelet Transform

There are two popular methods for iris image segmentation: canny edge detector and Hough transformation. But this paper present an additional method in iris segmentation i.e. contoulet transform. The working of canny edge detector is described in three phases [16]. The first phase is about Noise attenuation. The image edge can be damaged by noise. For noise reduction a two dimensional image convolves with Gaussian window. The next stage finds the edge that used Gradient image. Every region has a higher gradient which is picked as the edge. The final phase is to expel pixels that are somewhat prone to be the edge.

The image denoicing can be performed by countorlet transform. Do and Vetterli [14] introduces the approach of the Contourlet Transform (CT). The key element of this technique is that they support multi directional, multi resolution image with different aspect ratios to provide sharp and smooth curves in the images [15]. After denoising, edge of image is founded by canny edge detector. And at last stage Hough transformed is performed that illustrate regular shapes of iris with its external and internal boundaries. Utilizing Contourlet transform for image denoising causes blurred or obscured image [16].

By the use of contourlet transform degradation is arise in the quality of image so it becomes little blurred. This problem becomes serious when image becomes more noised. This creates a challenge to locate the inner and outer boundaries of iris. Thus it should be necessary to have an image with basic quality for feature extraction. Recent experiments show contourlet transform attain better segmentation when different noises are used and also show the result with or without contourlet transform. This comparison shows that contourlet transform attain better segmentation rate [16].

D. Normalization Stage:

Normalization is performed to convert the iris coordinates in polar coordinates to rectangular iris template to make it constant and persistent against the effect of changing the size of pupil. Once the outer and inner circles of iris are localized, these values are taken as input to the Daugman's Rubber-sheet model. Daugman’s rubber sheet model performed the conversion of iris region into rectangular strip.

E. Feature Extraction:

After pre-processing of image, feature extraction is carried out on normalized iris image. The pyramidal and directional filter with level two sub-bands is used to extract feature from iris image. Wavelet transforms, Fourier transform and Gabor wavelet are one dimentional transform which are generally used. 1D transform have been used to capture the edge of image, but these transforms does not offer good contours. Thus contourlet transform is used for feature extraction of iris image. The technique starts with discrete domain for sampled data to obtain smooth countours of iris image. The band pass image generated through laplacian pyramid to directional filter bank to protect the captured directional information of iris image from the leak of low frequency component.

The authors in [17] performed feature extraction in two stages. In the first stage biorthogonal wavelet transform is used such that feature vector is created by LL band. In second stage singular value decomposition coefficients are created for extracting iris data. In the field of matrix computation, singular value decomposition is a powerful tool because it provides robustness to numerical errors [19]. So this method is recommended to decompose and separate the data into optimal signal and the noise element. In [18], SVD coefficients are obtained for normalized iris image which further utilizing this feature vector for calculations.

In [13], the first step derives the region of interest (ROI) after implementing segmentation technique. In the second step, the features are extracted to perform dimensionality reduction. The features of Iris images are extracted by changing the polar coordinates into the Cartesian coordinates with the help of radial resolutions having 10 pixels and angular resolutions with angles varying from 00 to 3600.The pixels on one of the side of the iris are gathered to produce one reduced iris image

[13]. In this way, the unwanted information is removed to reduce the dimension of the iris image.

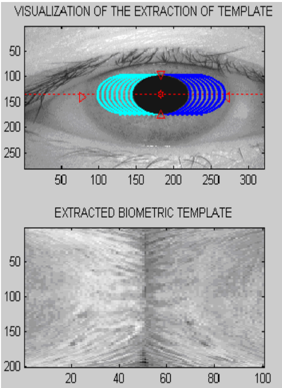

Figure 6: Extraction of the Biometric Template [13]

F. Feature Coding:

Feature encoding uses the important attribute for categorization. For correct recognition of individual, the dominating information which is present in an iris image should be extracted with an accurate method [8]. Iris region is encoded in [6] to create iris code. The author applied Gabor wavelets and 1dimentional log Gabor wavelet on iris region to create iris code.

G. Matching Algorithm:

When the iris code is generated, next step is to compare this code with the stored iris template and find matches. Comparison is done by hamming distance in which each bit is compared with other. It is calculated on the basis of difference in the bits of two template .bits of two templates are matches according to their positions [20]. If all bits are matched then comparison gives zero as a result and both iris templates are precisely same. But if comparison scores one as a result it means both irises are different. Weighted Euclidean distance technique can also use for pattern matching.

III. APPLICATIONS OF IRIS BIOMETRIC RECOGNITION

1) Finance and banking: In banking and financial organizations iris recognition is used rather than other technology because it is less time consuming. The use of iris recognition improves the standard of service and the customer or user will free from document verification process for identification which is more time consuming.
2) Healthcare and welfare: Healthcare management application uses the biometric identification to identify the accurate patient which provides a high accuracy then other biometric technique. The iris recognition provides removal of delicacy in medical record of a person.
3) Immigration and border control: The airport security plays very important role for border security of a country. For security purpose the iris recognition technique is used in many countries like in united state airport security system.
4) Public safety: Some law enforcement agencies save the criminal data to track them. These law enforcement agencies use the saved biometric data of criminal record to enhance the security of public. Utilizing the security and accuracy of iris recognition system these agencies track the terrorist & criminals.
5) Point of sale and ATM: The vulnerable POs terminal is hacked by a hacker for the regular payment. For this activity they are using the skimmers. These skimmers are installed at terminal which reads and transmits the information of swiped card. To recover this we can use a iris recognition system on all swipe or ATM machines so that hacker never use the information of particulars.
6) Hospitality and tourism: Iris recognition is also used in hospitality and tourism to overcome the unwanted access of a user in hotel room. The hotel security system stores the guest iris image at the concierge’s desk. When a customer is trying to enter in room the image of iris is matched by the database. The image of iris is deleted when the customer checked out from the hotel.

IV. CONCLUSION

For the purpose of identification of human being Iris biometric recognition system has proved its importance. This paper offers review on existing technologies for iris recognition proposed by various researchers. Iris localization and segmentation, wavelets are used impressively and Gabor filters are used for coding. There are two other popular techniques for segmentation: canny edge detector and Hough transform. But after adding Contourlet transform with the Hough transform and canny edge detector gives better results in segmentation which rates up to 100 percent. The comparison of result shows that this method for segmentation gives much better result for iris image segmentation with high accuracy and efficiency which maintain the basic quality of image. For iris normalization daughman's rubber sheet model achieves better result by reducing dimensional inconsistencies. Feature extraction is done by combination of contorlet transform and SVD. contourlet transform with the help of multidirectional filter bank, Whereas the result of SVD is calculated by changing SVD dimension and using number of classes. This recommends a future possibility on researching a enhanced computationally efficient and robust classifier which can handle more number of classes for iris pattern recognition. In the last stage hamming distance algorithm accomplish in well manner with good results. The literature review emphasized on the need of Iris recognition in order to provide security due to rapid growth of digitized information.

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