A Comprehensive Review on Iris Recognition Methods

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***Abstract* - The necessity for the biometrical security has been increased in order to give security and safety from the theft, frauds, etc. Iris recognition acquired a considerable value amongst all the biometrics-based systems. It is utilized used for surveillance and authentication for detecting individuals and proving an individual's identity. The present article discusses the various stages of recognizing iris images, which include acquiring, segmenting, normalizing, extracting features, and matching. The model of a typical iris recognition system of the eye is described and the results of its work are presented. The present study will investigate the comparative performances from various methods on the feature extraction for the accuracy of the iris recognition.**

Index Terms - Biometrics, Iris Recognition, Image processing, DWT, CT, LBP.

I. Introduction

Biometrics can be defined as a science that is used to establish the human identity through the use of the behavioural or physical features, like fingerprints, face, iris, palm prints, voice and hand geometry. Systems of iris recognition, particularly, keep acquiring a greater deal of interest due to the fact that the rich texture of their is presents a strong biometrical cue for the recognition of the individuals. There aren't any two identical iris patterns, even between the right and left eye of the same person, and even the irises of the identical twins. From the persons first year of the life until death, the iris patterns are rather constant throughout the life-time of a person [1][2].

The bio-authentication base is the fact that the information of the authentication may be produced from a group of the distinctive biological human features. Which include the static biometrics like the retinal pattern, fingerprints, hand geometry and iris; and the dynamic biometrics like hand writing, voice, and key-stroke patterns. The benefit of those approaches are in the fact that they are not dependent upon a thing which must be remembered by the user like a PIN code or a Password or a thing that is possessed by the user like a token or a smartcard [3].

Amongst all of the human characteristics, the iris pattern has been considered as the method with the highest accuracy for the authentication of individuals [4]. Iris can be defined as the annular part which is enclosed between the white sclera and the black pupil, the iris contains variable-size hole that is referred to as the pupil. It presents the visible property that has been represented as the iris texture. Fig1illustrates the human eye structure: eyelid, iris, sclera, limbus, and pupil [5].

The present study presents iris recognition system application as one of the methods of user authentication. The features of the iris pattern recognition will be overviewed then evaluated.

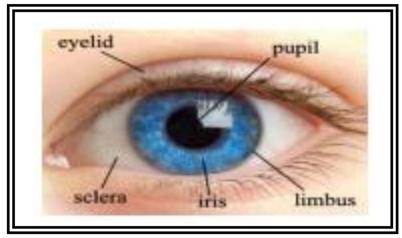

Fig 1. Human eye image

The remaining of this study has been organized as follows: Sections 2 provides a brief review of literature. Section3 discusses the iris recognition, which is followed by the result and discussions in section 4 while section 5 the conclusions of this review paper.

II. LITERATURE REVIEW

G. Savithiriet al.[6]discussed the Local Binary Pattern, Gabor Wavelet, Histogram of Oriented Gradient approaches for the extraction of the features on certain iris portion to improve the iris recognition system efficiency. The fundamental goal of this study is showing that it is enough choosing a half iris portion for the recognition of the authentic users and for the rejection of the imposters rather than the entire iris extension. AalaaAlbadarneh et al. [7]this study presented a system of iris recognition for the authentication of the users. They have reviewed and assessed4 features of iris pattern recognition, which include HOG (i.e. Histogram of Oriented Gradients), Discrete Cosine Transform (DCT), combined Gabor and GLCM (i.e. Grey level Co-occurrence Matrix).Ajmi S J et al. [8]Another transform technique namely contourlet transform (CT) that is a new 2 D wavelet transform extension, employs the combination of directional filter bank and laplacian pyramid. The feature vector build using CT reflex the directional information of iris. This iris recognition also performs feature extraction using HoG. Whose feature vector is computed by dividing an iris image in to blocks and there after computing the gradient followed by histogram.

EvairSevero et al. [9] this paper defined the problem of iris location as delimitating the smallest squared window which encompasses the area of the iris. For the purpose of building

an iris location benchmark, which annotate (squared bounding boxes of their is) a sliding window detector that has been based upon the features from HOG and a linear SVMs classifier as well as a deep learning based detector that has been fine-tuned from the object detector of YOLO.N. V. Suvorov et al. [10] This article explains the mathematical model of iris pattern biometric identification and its characteristics. Besides, there are analysed results of comparison of model and real recognition process. To make such analysis there was carried out the review of existing iris pattern recognition methods based on different unique features vector. .BasmaAmmour et al. [11]. This study proposed a new method of the feature extraction for multi-modal biometrical system with the use of the features of face–iris. The feature extraction of their is is performed with the use of a sufficient multi-resolution 2-D Log-Gabor filter for capturing the textural information in a variety of the orientations and scales. However, facial traits are calculated with the use of the powerful SSA (i.e. singular spectrum analysis) approach in conjunction with wavelet transformation.

III. Iris Recognition

The approaches of the image processing are utilized for the extraction of the distinctive pattern of their is from a digital eye image, and encoding it to a biometrical template that has been stored in a data-base. The processing steps have been illustrated in Figure (2).

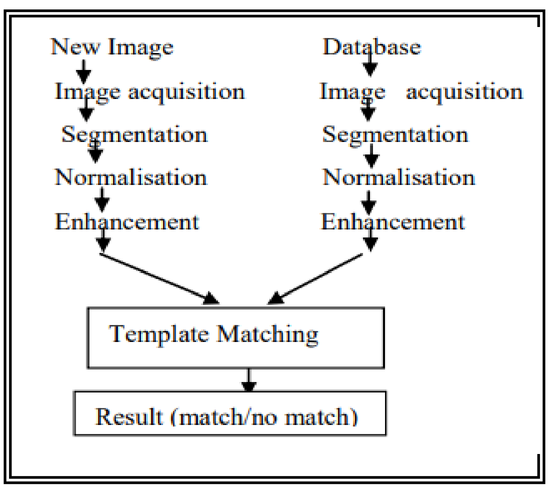

Fig. 2 Iris image processing

A. Image Acquisition

An individual wishing to access a system is needed for the capturing of their iris image. It is one of the critical steps in the system of iris identification, due to the fact that all of the following steps like the extraction of the features and matching algorithm will be influenced with the quality of the data-set images. An especially modelled sensor is needed for capturing the structure of the iris. The issue that is related to this step is the uneven distribution of the light which results from the variation of the lighting. In addition to that, the viewpoint of the image capturing has to be taken under consideration very well throughout this step [12].

B. Segmentation and boundary detection

This step is utilized for the isolation of the actual area of the iris from the digital image for removing any irrelevant part. Which may be accomplished through initially fitting a line to the lower and the upper eye-lids with the use of the linear Hough transformation. Other methods that are based upon the boundary localization; iris 2 circles may be found with the use of some approaches like the canny edge detection, Hough transformation, chain code and linear thresholdding[12].The localization may be applied as well to an area of the iris like the collaret area that has the complicated and highly significant structure of the iris, with the use of the centre and the radius for the two previous circles [13].

C. Image Normalization

The normalization of the iris can be described as the process that is used to remove the noise from iris images by the use of various filter types. The normalization is done at the first step because the presence of noise in the image leads to improper iris code. A Gaussian filter may be utilized efficiently for the removal such type of the noise from the images, which filter is viewed to be having the optimal balance between blurring and noise removal [8].

The annular area of the iris is transformed to rectangular area throughout the process of the analysis of the texture of the iris. The benefit of this step lies in the fact that in the case where the part of the iris is transformed to polar coordinates, it has fixed dimensions. In addition to that, for the purpose of overcoming the inconsistencies of the imaging. Daugman remaps every one of the pointsin the area of the iris to a pair of polar coordinates (r, θ) where θ is angle $[0, 2\pi]$ and r is ranges in [0, 1] [14].

D. Iris Enhancement

The normalized image of the iris has a low level of the contrast and non-uniform lighting which results from the position of the light source. The image requires being improved for compensating for those aspects. The analysis of the local histogram has been implemented to normalized image of the iris for the reduction of the uneven illumination effect and obtaining and image with well-distributed texture [15][16]. The areas of the reflection are identified by the values of the high intensity near 255. A simple operation of the thresholding may be utilized for the removal of the noise of reflection.

E. Feature extraction

Interesting structure the iris has much information on the texture. For the purpose of recognizing users precisely only the important iris characteristics have to be obtained. The characteristics in the iris image are classified to 3categories. Initially, the spectral features like the gradient and color. Second, geometrical features like the shape, size and edge. Third, the textural features such as the homogeneity and pattern. The features may be obtained from a part of the structure of the iris like the furrows, freckles, corona and zigzag collarette area, which has been considered as the most complicated iris part and it has the most significant characteristics [13]. The extraction of the features is implemented with the use of the variety of the algorithms like the Gabor Wavelet that uses the wavelets for the data decomposition in the area of the iris to elements at another resolution. A wavelet bank is applied to the area of the iris; the result is encoded for the purpose of providing a distinctive iris pattern representation [13]. The zero-crossings of the 1-D wavelets and the Laplacian of Gaussian may be utilized as well used for the extraction of the features [17].

The LBP features showed quite a good performance in a variety of the applications, which include the classification and segmentation of the texture, surface inspections and image retrieval. Texture analysis operator of the LBP has been defined as a measure of the gray-scale invariant texture which is obtained from a general texture definition in the local neighbourhood [6].

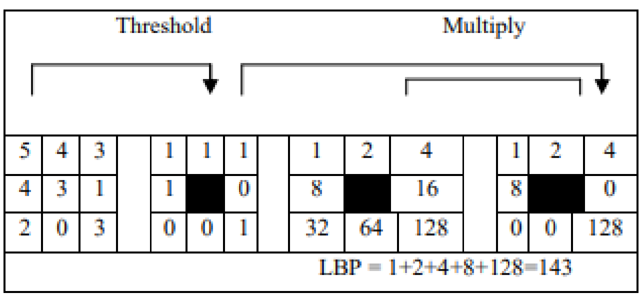

Fig. 3 original code of the LBP and a contrast measure Calculating

An LBP code for a pixel's 8-neighborhood are is created from the multiplication of the values of the threshold with the weight values provided to corresponding pixels and summing result up, fig. 3 explain these calculations. Due to the fact that, by definition, the LBP has not been variant to the uniform gray scale variations, it has been supplemented with an orthogonal local contrast measure. Fig. 4 illustrates the way the measure of contrast has been obtained. The mean value of gray level values that are under the central pixel is subtracted from the mean value of gray level values that are above (or equal to) central pixel. The 256 bin histogram of labels that are calculated over any image may be utilized as a descriptor of the texture [6].2-DLBP and local contrast measure distributions may be utilized as the features. Every iris image may be taken under consideration as a micro-pattern 'composition that may be found sufficiently from the operator of the LBP. The iris is split to M small non-overlapping areas R0, R1, R2….. RM. improved histogram of features, which are characterized as:

$$H_{i,j} = \sum_{x,y} I(f_1(x,y) = i)\; I((x,y)\epsilon R_j \quad \dots\dots\dots (1)$$

Where i=0, 1…L-1, j=0,1,….M-1. The histogram of the obtained features describes the local binary pattern for global iris images.

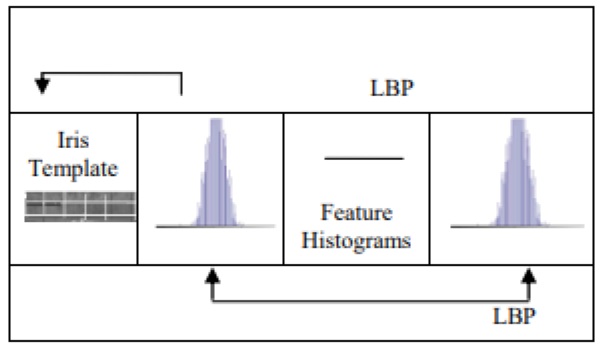

Fig. 4 Iris Recognition based LBP

HOG is utilized as appearance feature. The representation of the HOG [6] has a number of the benefits. It can capture the structure of the gradient which is characteristic of a human shape. First magnitude M in eq. (2) and direction θ in eq. (3) of gradients can be calculated with the use of the following equation:

$$M(x,y) = sqrt(f_x(x,y)^2 + f_y(x,y)^2) \;\dots.(2)$$

$$\theta(x,y) = tan^{-1}\left({f_y(x,y)}/{f_x(x,y)} \right) \dots..(3)$$

where $f_x(x,y)=L(x+1,y)-L(x-1,y)$, $f_y(x,y)=L(x,y+1)-L(x,y1)$ *and* $L(x,y)$ is the brightness of pixel.

In the DWT, signal energy is concentrated to certain coefficients of the wavelet. It is responsible for the conversion of the images in to a group of the wavelets. And it may be saved more efficiently compared to the pixel blocks. Representing signal in time scale is obtained by using digital filtering. The two dimensional transformation decomposes the initial image to a variety of the channels, which are low-high, low-low, high-high and high-low. This de-composition may be implemented on the low-low channel for the generation of the de-composition at the following level [8].

Contourlet Transform (CT) The 2-D wavelet transform extension is known as contourlet transform. It composed of directional filter bank and multiscale. The contourlet expansion contains basis images with different orientations in several scales and flexible aspect ratios. So it is capable of capturing the smooth contours effectively. It is the combination of Directional Filter Bank (DFB) and Laplacian Pyramid (LP). Laplacian Pyramid performs sub band decomposition of images and DFB performs the analysis of the detail image. The DFB has been modelled for capturing the input image's high frequency directionality and it has been poor on the handling of the low frequency contents, which is why, LP is combined with DFB, in which the input image' slow frequency is eliminated prior to the application of the DFB [8].

GLCM describes the information concerning the adjacent interval, direction, and variations of the amplitude of image gray-level. The approach of the GLCM has been utilized sufficiently utilized in numerous feature extraction applications [7].

F. Iris Authentication

This step used to verify the identity. The computed template of the iris requires performing the matching with stored template in data-base for the purpose of getting a decision of the authentication. The algorithms of recognition which are often utilized as one of the methods of the pattern matching for the verification of the identity of an individual are: Normalized Correlation, Weighted Euclidean Distance, Hamming Distance, and Support Vector Machines [14].

Euclidean distance — Metric for measuring the minimum distance between two vectors iris code. It's computed between 2 template vectors by [6].

$$p_1(x_1,y_1) and\ p_2(x_2,y_2) = sqrt\{(x_2-x_1)^2+(y_2-y_1)^2\} \dots\dots (4)$$

where P_1 (x_1 , y_1) represents the 1st image of the iris with x and y pixel coordinates, P_2 (x_2 , y_2) represents the 2nd image of the iris with x & y pixel coordinates.

Hamming distance (HD) measures the number of the bits that are the same between patterns of 2 bits. The utilization of HD of 2-bit patterns, it is possible to make a decision about whether the 2 patterns have been produced from the same one iris or from 2 different ones. In the comparison of the X & Ybit patterns, HD, has been characterized by eq5. Which can be defined as the summation of the disagreeing bits (i.e. the summation of XOR between X & Y) over N, which represents the total number of the bits in the pattern.

$$HD = 1/N \sum_{J=1}^{N} X_J (XOR) Y_J \dots\dots\dots (5)$$

In the case where2 bit patterns have been entirely independent, like the templates of the iris that have been produced from a variety of the irises, HD between both patterns have to be= 0.50. Which takes place due to the fact that the independence is implying the 2-bit patterns are entirely random, which is why, there's a 0.50likelihood to set any of the bits to 1, and the other way around. Which is why, 50% of bits will agree and the rest will not agree between those 2 patterns. In the case where 2 patterns have been obtained from one iris, HD between those two will approach 0, due to the fact that they're considerably associated and bits have to agree between both codes of the iris [18].

SVMs can be defined as a binary classifier which is capable of optimally separating both data classes, it has been based upon the model of the iris code where the size of the feature vector is converted into a 1-D vector [19].

The presented research is focused upon the task of the feature extraction. It examines different type of feature extraction, different types of matching methods, and segmentation approaches for finding which gives the highest precision.

IV. RESULT AND DISCUSSIONS

Tables (1) explain different feature extraction methods, segmentation methods and matching process of iris recognition, gathered from different references specialized in iris recognition. Some of these papers explain all recognition process (segmentation methods, feature extraction and matching process) while the others focus on feature extraction method.

TABLE 1
PERFORMANCE COMPARISON OF THE FEATURE EXTRACTION APPROACHES

Ref. no.	Iris segmentation	Feature extraction	Matching process	FAR (%)	FRR (%)	Recognition Rate (%)
[10]	Not explained	DWT method	Hamming distance	4.25	4.25	91.5
[10]	Not explained	CWT method	Euclidean distance	2.25	2.25	95.5
[10]	Not explained	Gabor filter method	Hamming distance	1.25	1.25	97.5
[8]	Not explained	DWT method	Not explained	0.78	1.1	98.02
[8]	Not explained	CT(contourlet transform)	Not explained	0.78	0.78	98.4
[8]	Not explained	HOGHistogram of Oriented Gradients (HoG).	Not explained	0	0.78	99.2
[7]	region growing segmentation	HOG	Euclidean distance	---	---	20
[7]	region growing segmentation	Gabor +DCT	Euclidean distance	---	---	76
[7]	region growing segmentation	GLC M	Euclidean distance	---	---	96
[7]	region growing segmentation	Gabor+DCT ,and GLCM	Euclidean distance	---	---	92
[7]	region growing segmentation	Combined All features in [7]	Euclidean distance	---	---	92
[20]	Daugman'sIntegro-Differential Operator	HOG	KNN	---	---	100
[20]	Daugman'sIntegro-Differential Operator	LBP	KNN	----	---	99.55
[20]	Daugman'sIntegro-Differential Operator	GLCM	KNN	---	---	90.63

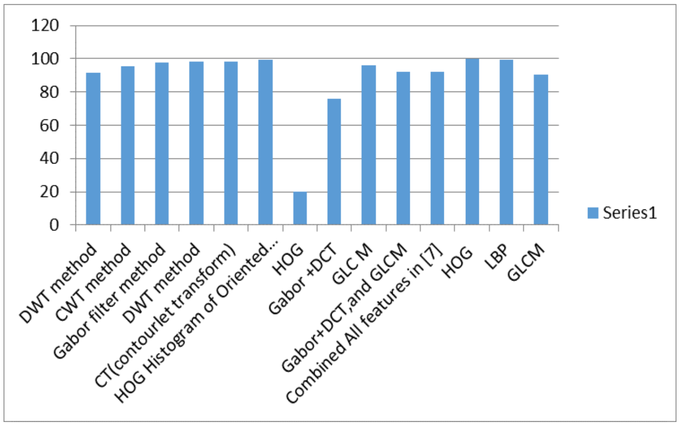

Fig. (5) Accuracy value for different type of feature extraction

From figure (5) can see the HOG method give highest accuracy when it used with Daugman'sIntegro-Differential Operator segmentation method and KNN matching process.

CONCLUSION

The biometric identification of people has now acquired a key importance in the world, in such areas as security, access control and forensics. Recognition by the iris of the eye is one of the rapidly developing biometric methods that stand out for its unique characteristics and accuracy. Iris recognition is the procedure which is utilized to recognize a person by analyzing the visible structure of the iris, a comparison of which can be used for biometric authentication and identification of people. This article discusses the various stages of recognizing iris images, which include acquiring, segmenting, normalizing, extracting features, and matching. The model of a typical iris recognition system of the eye is described and the results of its work are presented. This research studied the comparative performances from a variety of the methods on the feature extraction for the recognition of the iris (DWT method, Gabor filter method, CT(contourlet transform), HOG Histogram of Oriented Gradients, Gabor +DCT, GLC M, Gabor+DCT, and GLCM, LBP). It is clear that the HOG method give highest accuracy which is 100% when it used with Daugman'sIntegro-Differential Operator segmentation method and KNN matching process.

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