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A Close Approach to Iris Recognition System

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***Abstract*:** *Iris recognition, a relatively new biometric technology, has great advantages such as variability, stability and security, thus it is the most promising for high security environments. Among its applications are border control in airports and harbors, access control in laboratories and factories, identification for Automatic Teller Machines and restricted access to police evidence rooms. There have been several implementations of security systems using biometric, especially for identification and verification cases. The term "biometrics" is derived from the Greek words bio (life) and metric (to measure). The pattern used in the biometric is the iris pattern in human eye. The iris pattern has been proved unique for each person. A literature review of the most prominent algorithms implemented in each stage is presented. This paper provides a review of major iris recognition researches.*
Keywords: *Iris Recognition, Human eye, Normalization, Iris Localization, Matching.*

I. Introduction

Biometric recognition is an emerging technology which employs the physiological and behavioral characteristics to identify an individual. The physiological characteristics include the iris, fingerprint, face and hand geometry. Voice and signature are categorized as the behavioral characteristics. Among these, the human iris is an annular region between the sclera (the white portion of the eye) and the pupil (the darkest portion of the eye). Iris is gaining lots of attention due its unique pattern. The patterns that give uniqueness to the iris are the coronas, furrows, stripes and so on [1]. These patterns thus, distinguish the individual as the genuine and the imposter, and make the iris recognition particularly the promising solution.

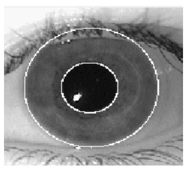
Iris recognition is a method of biometric authentication that uses pattern-recognition techniques based on high resolution images of the irises of an individual's eyes [16]. The main stages of an iris recognition system are: image pre-processing which consists of iris localization, iris normalization; iris feature extraction and template matching [13][15]. It is necessary to obtain the iris region to carry out the feature extraction and the matching. Eyelids and the eyelashes that may cover the iris region are detected and removed. The normalization step is the conversion of Cartesian co-ordinates to the polar co-ordinates. Various image enhancement algorithms can also applied in order to compensate the non uniformity and low contrast characters in the iris portion. Feature extraction is the process of extracting texture from the region of interest and then using these features as parameters for comparing two iris templates. The significant features of the iris are obtained for accurate identification purpose.

Template matching compares the user template with the templates from the dataset or the trained dataset using a matching metric. The matching metric will give the measure of similarity between two iris templates. This paper discuses the algorithmic implementation in each stage. Iris image capture stage will not be discussed in this paper. The rest of the stages are discussed next sections including image preprocessing, iris feature extraction and template matching.

II. Iris Segmentation

Iris segmentation is the process of separating the iris from the eye image.

(a)



(b)

Fig. 1 Iris localization (a) Original iris image. (b) Localized iris image.

1.1 Iris Localization

Iris localization [20][19] is the first step in the pre-processing stage of the iris recognition systems. It detects the inner and outer boundaries of the iris as shown in fig.1. Both the inner and the outer iris boundaries are considered as circles [5]. The center of iris and pupil are calculated in this process. The various kinds of the iris localization algorithms will be considered in this section. These algorithms are – Bisection method, Discrete Active contour model, concentric circular enhancement technique, Integro Differential operator, Black hole search method.

2.1.1 Bisection Method. This method is used to locate the center of the pupil [4]. The center of the pupil is used as a reference to detect the inner and outer boundary of the iris. Firstly, the edge detection method is applied to extract the edge information. Using two points on the same edge component, the perpendicular is drawn. This is repeated for every two points on the same edge component and the point where the maximum perpendiculars meet is considered as the center point of the pupil. A virtual circle is drawn with reference to the center of the pupil and the radius is increased within the certain range. The two circles with the largest number of edge points will be considered as the inner and outer boundaries of the iris.

Disadvantage: This method is affected by the non-uniformity (high intensity areas) caused due to light. As a result of which the inner boundary cannot be localized accurately.

2.1.2 Discrete active contour model. This is used to locate the iris. What is contour-It is defined as the set of the n vertices connected as a simple closed curve. The movement of the contour is caused by the internal and external forces on the vertices. The internal forces expand the contour into perfect circle. The external forces push the contour inward. The movement of two forces continues till the equilibrium is obtained [13]. The average radius and center of the contour obtained are the parameters of the iris boundary.

Disadvantage: This method is affected by the specular reflections from the cornea.

2.1.3 Concentric Circular Enhancement Technique. External Noise is removed by blurring the intensity image. But too much blurring may dilate the boundaries of the edge. Thus a special smoothing filter such as median filter is used on the original intensity image. This type of filtering eliminates sparse noise while preserving image boundaries. The histogram equalization is used to enhance the contrast of the image. Then the enhanced image is used to find the outer iris boundary by drawing the concentric circles, of different radii from the pupil center and intensities lying over the perimeter of the circle are summed up. Among the candidate iris circles, the circle having the maximum change in intensity w.r.t to the previous circle steps of concentric circular enhancement [12].

2.1.4 Integro Differential Operator. It is used for locating the inner and outer boundaries of the iris as well the upper and lower eyelids. The operator computes the partial derivative of the average intensity of circle points, with respect to increasing radius, r. The operator is accurate because it searches over the image domain for the global maximum. It can compute faster because it used the first derivative information [1].

2.1.5 Black Hole Search Method It is used to compute the center and area of the pupil. Since the pupil is the darkest region in the image, [9] this approach applies threshold segmentation method to find the region. Firstly, a threshold is defined to identify the dark areas in the iris image. The dark areas are called as "black holes". The center of mass of these black holes is computed from the original image. The area of the pupil is the total number of those black holes within the region. The radius of the pupil can be calculated from the circle area formula.

III. Iris Normalization

Iris can be captured in different size with varying pupil size. Due to illuminations, the size of the pupil may change. This normalized iris code will affect the feature extraction and comparison phenomena. Normalization is converting the circular iris into rectangular block so that it has the constant diameter to enhance performance. Various methods can be used for normalization.

3.1 Virtual Circles. In this method, the iris images are first scaled to have constant diameter so that when comparing two images, one is considered as the reference image. This method works differently to the other techniques, once the two irises have the same dimensions, features are extracted from the iris region by storing the intensity values along virtual concentric circles, with origin at the centre of the pupil. A normalization resolution is selected, so that the number of data points extracted from each iris is the same [13]. This is essentially the same as Daugman's rubber sheet model; however scaling is at match time, and is relative to the comparing iris region, rather than scaling to some constant dimensions. The rotational invariance obtained is not discussed completely by Boles.

3.2 Daugman's Rubber Sheet Model. The homogenous rubber sheet model devised by Daugman [1] remaps each point within the iris region to a pair of polar coordinates (r,Θ) where r is on the interval [0,1] and θ is angle [0,2π].The non –concentric polar representation is normalized to a fixed size rectangular block[10].

IV. Iris Feature Extraction

In this, the features are extracted which can be further used for comparison and to calculate the accuracy. The extracted features will be used to generate a biometric template.

4.1 Gaussian filter. Laplacian filters are used to encode features by decomposing the iris region. The Laplacian pyramid is realized from the filtered image. This pyramid has four levels. The compressed data is used to obtain the significant data. The compressed data can be stored as the iris code [10].

4.2 Wavelet transforms. Wavelet transform decomposes the iris region into the components with different resolutions. The wavelets are the small waves of varying frequency and limited duration. Wavelet transformation is better than the Fourier transformation. In Fourier, the frequency remains same with the time. The commonly used wavelets are haar, symmlet, Mexican Hat wavelet. A bank of wavelet filters is applied to the normalized iris region. Each filter works with each wavelet defined by scaling functions. The output of the filters generates the iris code [4][6].

4.3 Gabor filters. There are various kinds of Gabor filters. Gabor filters impulse response by a harmonic function. Each pattern is demodulated to extract its phase information using 2 D Gabor Wavelet [7]. The phase information is quantized into four quadrants in the complex plane. Each pixel is demodulated into two bits code in the template. The phase information is extracted as the feature.

4.4 Corner detection technique. Corner points can be detected from the normalized iris image using the co-variance matrix of change in intensity at each point [12].

4.5 Discrete Cosine Transformation. In this feature are extracted by the difference of discrete cosine transform (DCT) coefficients of rectangular patches. The normalized image is divided into 8*12 patches. The average over width is windowed using a hanning window to reduce the effects of noise. This coding technique is simple and has low complexity [8].

4.6 Hilbert transforms. It is used to extract significant information from iris texture [2].

V. Matching

The templates generated need a matching metric. This metric measures the similarity between intra class and inter class comparisons

5.1 Euclidean distance. It is used to compare two templates to identify the iris. It is defined as the measure of similarity between two templates. It is calculated using Pythagoras theorem to obtain the distance between two points [14][17].

5.2 Nearest Feature Line. Nearest feature line is an efficient classification method in template matching stage [20]. Feature line passes through any two feature points of the same class. The feature line extracts more variations of the feature vector than the feature point. The distance from a feature point to the feature line is calculated.

5.3 K-D tree Matching. It is a very effective method that is used in terms of search methods [3]. Major drawback of K-D tree is only limited number of iris codes can be loaded in the tree because the search efficiency decreases with increase in the tree size.

VI. Discussions

Most researchers use the publically available iris database for experiments. The important one is CASIA [11] with many versions and MMU [18]. These usually contain the grayscale eye images.

VII. Conclusion

This paper provides a review of well known researches on iris recognition. The algorithms used in this recognition system are categorized into four stages-iris segmentation, iris normalization, and feature extraction and matching. The performance of each algorithm affects the accuracy of the system.

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