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IRIS RECOGNITION – AN EFFECTIVE HUMAN IDENTIFICATION

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ABSTRACT

In this paper, we characterize the basic concepts and techniques used to create and evaluate an Iris Recognition System. We aim to discuss whether and how we can make iris recognition easier. A fusion mechanism and a Circular Hough Transform are being implemented to detect the iris' boundaries in the eye's digital image. The Haar wavelet is used in order to extract the deterministic patterns in a person's iris in the form of a feature vector. By comparing the quantized vectors using the Hamming Distance operator, we can determine finally whether two irises are similar or not. The purpose of 'Iris Recognition' is to recognize a person from his/her iris prints. In fact, iris patterns are characterized by high level of stability and distinctiveness. Every individual has a unique iris and the difference even exists between identical twins and between the left and right eye of the same person. The first step is image acquisition. Then, the pictures' size and type are manipulated. Once the preprocessing step is achieved, it is necessary to localize the iris and unwrap it. Here, we can extract the texture of the iris using Wavelets. Finally, the coded image is compared with the already coded iris in order to find a match or detect an imposter.

Keywords

Bilinear Transformation, Biometrics, Hough Transform, Iris Recognition.

1. Introduction

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Iris recognition is treated as the most reliable biometrics and has been widely applied in public and personal security areas. However it is recommended that the users have to cooperate with the iris cameras to make their iris images well captured. The restricting factors of iris image acquisition are analyzed and the optical formulas are derived. Then the solutions of state-of-the-art iris recognition systems are reviewed and summarized.

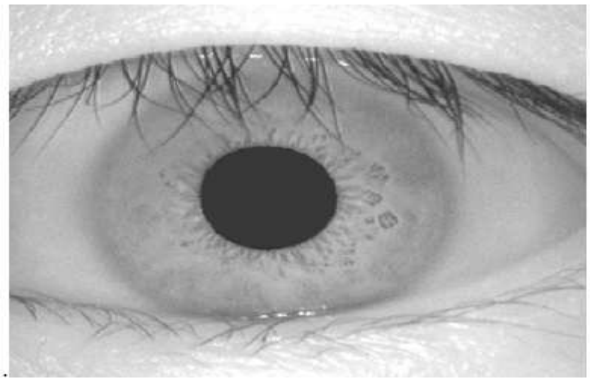

Fig. 1 *– Iris Image*

One of the most dangerous security threats is the impersonation, in which somebody claims to be somebody else. The security services that counter this threat are identification and authentication. The verifier can be identified and authenticated by what he knows (password), by what he owns (passport) or by who he is (Biometrics). The current trend in the research world is headed towards Biometrics since the level of security is highly increased. The most popular biometric features are based on individual's signatures, retinal, faces, iris, fingerprints, hand and voices. As in any other automated recognition technique the IRIS-recognition system has to compare a newly acquired IRIS pattern against existing patterns already stored in the system. The IRIS pattern can be extracted from eye images. The first stage would be an alignment process in order to eliminate variation in scale and rotation. The features that can be used could be based on local orientation, phase or special frequency information. The properties of the **Iris** that enhance its suitability for use in automatic identification include:

- Protected from the external environment
- Impossibility of surgically modifying without the risk of vision
- Physiological response to light.
- Ease of registering its image at some distance

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The major applications of this technology so far have been: substituting for passports (automated international border crossing); aviation security and controlling access to restricted areas at airports; database access and computer login; premises access control; hospital setting including mother-infant pairing in maternity wards; “watch list” screening at border crossings; and it is under consideration for biometrically enables National identity Cards. IRIS recognition is forecast to play a role in a wide range of other applications in which a person’s identity must be established or confirmed. These include electronic commerce, information security, entitlements authorization, building entry, automobile ignition, forensic and police applications, network access and computer applications, or any other transaction in which personal identification currently relies just on special possessions or secrets (keys, cards, documents, passwords, PINs). The matching performance of **Iris** recognition systems can be improved when quality is considered. Daugman applied the 2-D focus assessment to eliminate out-of-focus IRIS images [2].

2. Techniques used in Iris Recognition

The three main stages of an Iris recognition system are image preprocessing, feature extraction and template matching.

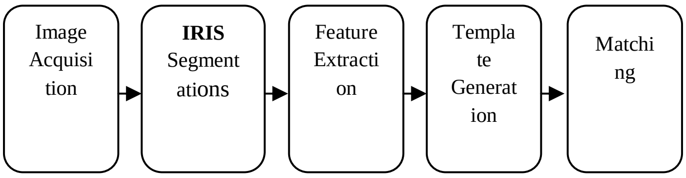

Fig. 2 *Typical recognition system*

The Iris image needs to be preprocessed to obtain useful Iris region. Iris localization detects the inner and outer boundaries of Iris. Eyelids and eyelashes that may cover the Iris region are detected and removed. Iris normalization converts Iris image from Cartesian coordinates to Polar coordinates. The normalized Iris image is a rectangle image with angular resolution and radial resolution. The Iris image has low contrast and non-uniform illumination caused by the position of the light source. All these factors can be compensated by the image enhancement algorithms. Feature extraction uses texture analysis method to extract features from the normalized Iris image. The significant features of the Iris are extracted for accurate identification purpose. Template matching compares the user template with templates from the database using a matching metric. The matching metric will give a measure of similarity between two Iris templates. It gives a range of values when comparing templates from the same Iris, and another range of values when comparing templates from different Irises’. Finally, a decision of high confidence level is made to identify whether the user is an authentic or not.

2.1 Image preprocessing

Iris image preprocessing is divided into three steps: IRIS localization, IRIS normalization and Image enhancement.

2.1.1 Iris localization

IRIS localization detects the inner and outer boundaries of the IRIS. Both the inner and outer IRIS boundaries can be approximately modeled as circles. The center of IRIS does not necessarily concentric with the center of pupil. In this IRIS localization is important because correct IRIS region is needed to generate the templates for accurate matching. Five IRIS localization algorithms would be discussed in this section. They include Integro-differential operator, Hough transform, Discrete Circular Active Contour, Bisection method and Black hole search method.

2.1.1.1 Integro-differential operator

Integro-differential operator is used for locating the inner and outer boundaries of IRIS, as well as the upper and lower eyelids [1], [2].The operator computes the partial derivative of the average intensity of circle points, with respect to increasing radius. After convolving the operator with Gaussian kernel, the maximum difference between inner and outer circle will define the center and radius of the IRIS boundary. For upper and lower eyelids detection, the path of contour integration is modified from circular to parabolic curve. The operator is accurate because it searches over the image domain for the global maximum. It can compute faster because it uses the first derivative information.

2.1.1.2 Hough transform

Since the inner and outer boundaries of an IRIS can be modeled as circles, circular Hough transform is used to localize the IRIS [3]-[6]. Firstly, edge detector is applied to a gray scale IRIS image to generate the edge map. The edge map is obtained by calculating the first derivative of intensity values and thresholding the results. Gaussian filter is applied to smooth the image to select the proper scale of edge analysis. The voting procedure is realized using Hough transform in order to search for the desired contour from the edge map. Assuming a circle with center coordinate (xc,yc) and radius r, each edge point on the circle casts a vote in Hough space. The center coordinate and radius of the circle with maximum number of votes is defined as the contour of interest. For eyelids detection, the contour is defined using parabolic curve parameter instead of the circle parameter. The disadvantage of Hough transform algorithm is that it is computationally intensive and therefore not suitable for real time applications. It requires a threshold value to generate the edge map. The selected threshold value may remove some critical edge points and result in false circle detection.

2.1.1.3 Discrete circular active contour

Active contour model has been used to localize IRIS [7], [8]. The contour is defined as a set of *n* vertices connected as a simple closed curve. The movement of the contour is caused by internal and external forces acting on the vertices. The internal forces expand the contour into a perfect circle. The external forces push the contour inward. The contour moves under the influence of the internal and external forces until it reaches equilibrium. The average radius and center of the contour obtained are the parameters of the IRIS boundary. The discrete circular active contour search for the IRIS boundary is affected by the specular reflections from the cornea. Therefore, image preprocessing algorithm is required to remove the specular reflections.

2.1.1.4 Bisection method

In both [9] and [10], the bisection method is used to locate the center of the pupil. The center of the pupil is used as reference to detect the inner and outer boundaries of the IRIS. Firstly, edge detection is applied to the IRIS image to extract the edge information. For every two points on the same edge component, bisection method is applied to draw the perpendicular lines to the center point. The center point with maximum number of line intersections is selected as the center of the pupil. A virtual circle is drawn with reference to the center of the pupil and the radius is increased within a certain range. Two virtual circles with the largest number of edge points are chosen as the inner and outer boundaries of the IRIS. Bisection method is affected by the non-uniform illuminations and glasses reflections. As a result, the IRIS inner boundary cannot be localized accurately. Similar to the discrete circular active contour method, image preprocessing algorithm is needed to remove the high intensity areas caused by illuminations and reflections.

2.1.1.5 Black hole search method

Black hole search method is used to compute the center and area of a pupil [11], [12]. Since the pupil is the darkest region in the image, 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 global image. The area of 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. Black hole search method is not suitable for IRIS image with dark IRIS. The dark IRIS area would be detected instead of the area of pupil.

2.1.1.6 Eyelid and eyelash detection

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Eyelids and eyelashes may cover the **IRIS** region. Eyelids can be detected using texture segmentation and Daubechies wavelets method. The eyelashes detection algorithms consist of Gabor filter, variance of intensity and combination of both edge and region information.

Eyelid detection

Texture segmentation is adopted to detect upper and lower eyelids in [15]. The energy of high spectrum at each region is computed to segment the eyelashes. The region with high frequency is considered as the eyelashes area. The information of the pupil position is used in upper eyelashes segmentation. The upper eyelashes are fit with a parabolic arc. The parabolic arc shows the position of the upper eyelid. For lower eyelid detection, the histogram of the original image is used. The lower eyelid area is segmented to compute the edge point of the lower eyelid.The lower eyelid is fit with the edge points.

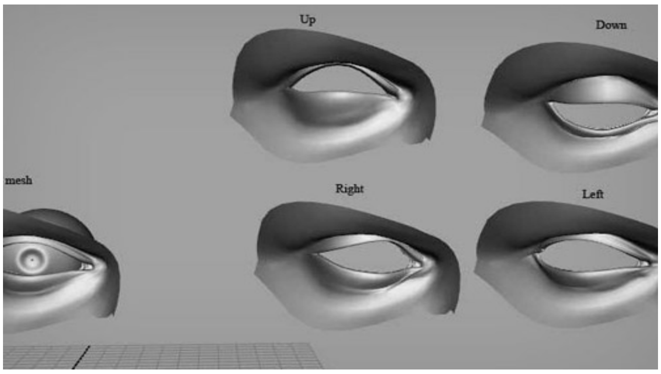

Fig.3 *- Eyelid Detection*

In [16], the Daubechies wavelets method is used to decompose the original image into four bands, HH, HL, LH and LL. Canny edge detection is applied to the LH image. To minimize the influence of eyelashes, canny edge detector is tuned to horizontal direction. The edge points that are close to each other are connected to detect the upper eyelid. The longest connected edge that fits with a parabolic arc is taken as the upper eyelid. To detect lower eyelid, the steps are repeated with lower **IRIS** boundary area.

Eyelash detection

Gabor filter and variance of intensity approaches are proposed for eyelash detection [17]. The eyelashes are categorized into separable eyelashes and multiple eyelashes. Separable eyelashes are detected using 1D Gabor filters. A low output value is obtained from the convolution of the separable eyelashes with the Gabor filter. For multiple eyelashes, the variance of intensity is very small. If the variance of intensity in a window is smaller than a threshold, the center of the window is considered as the eyelashes. According to [18], both the edge and region information are used for noise detection. To speed up IRIS segmentation, the IRIS is roughly localized using filtering, edge detection and Hough transform. The localized IRIS is normalized to rectangular block. A bank of Gabor filters is used to extract the edge information based on phase congruency. The obtained edge information is combined with the region information to detect the eyelashes and pupil noise regions.

2.1.2 IRIS Normalization

IRIS may be captured in different size with varying imaging distance. Due to illumination variations, the radial size of the pupil may change accordingly. The resulting deformation of the IRIS texture will affect the performance of subsequent feature extraction and matching stages. Therefore, the IRIS region needs to be normalized to compensate for these variations.

2.1.2.1 Homogeneous rubber sheet model

The homogeneous rubber sheet model algorithm remaps each pixel in the localized IRIS region from the Cartesian coordinates to polar coordinates [1], [2]. The non-concentric polar representation is normalized to a fixed size rectangular block. The homogenous rubber sheet model accounts for pupil dilation, imaging distance and non-concentric pupil displacement. However, this algorithm does not compensate for the rotation variance.

2.1.3 Image enhancement

The normalized IRIS image has low contrast and non-uniform illumination caused by the light source position. The image needs to be enhanced to compensate for these factors. Local histogram analysis is applied to the normalized IRIS image to reduce the effect of non-uniform illumination and obtain well-distributed texture image [19],[6].

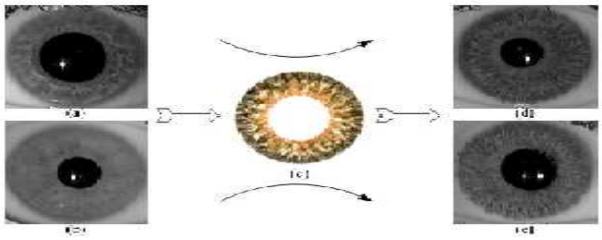

Fig. 4 *– Image enhancement*

Reflections regions are characterized by high intensity values close to 255. A simple threshold operation can be used to remove the reflection noise [18].

2.2 Feature extraction

In this stage, texture analysis methods are used to extract the significant features from the normalized IRIS image. The extracted features will be encoded to generate a biometric template.

2.2.1 Gabor filters

2D Gabor filters are used to extract IRIS features in both [1] and [2]. Gabor filter's impulse response is defined by a harmonic function multiplied by a Gaussian function. It provides optimum localization in both spatial and frequency domains. Each pattern is demodulated to extract its phase information using quadrature 2D Gabor wavelets. The phase information is quantized into four quadrants in the complex plane. Each quadrant is represented with two bits phase information. Therefore, each pixel in the normalized image is demodulated into two bits code in the template. The phase information is extracted because it provides the significant information within the image [20]. It does not depend on extraneous factors, such as imaging contrast, illumination and camera gain [2]. A Log Gabor filter which is Gaussian on a logarithmic scale is proposed by [21]. It has strictly band pass filter to remove the DC components caused by background brightness [22].

2.2.2 Wavelet transform

Wavelet transform decomposes the IRIS region into components with different resolutions. The commonly used wavelets are Daubechies, Biorthogonal, Haar and Mexican Hat wavelet [9], [13], [14], [16], [23]-[25].The advantage of wavelet transform over Fourier transform is that it has both space resolution and frequency resolution. The features are localized in both space and frequency domains with varying window sizes. A bank of wavelet filters is applied to the normalized IRIS region. Each filter is tuned for each resolution with each wavelet defined by scaling functions. The output of the filters is encoded to generate a compact biometric template.

2.2.3 Laplacian of Gaussian filter

Laplacian of Gaussian filters are used to encode feature by decomposing the IRIS region [3], [26]. The filtered image is realized as a Laplacian pyramid. A cascade of Gaussian-like filters is applied to the image. The Laplacian pyramid is constructed with four levels to generate a compact biometric template. This approach compresses the data to obtain significant data. The compressed data can be stored and processed effectively.

2.3 Template matching

The templates generated from the feature extraction stage need a corresponding matching metric. The matching metric compares the similarity between the templates. A threshold is set to differentiate between intra-class and inter-class comparisons.

2.3.1 Hamming distance

Hamming distance is defined as the fractional measure of dissimilarity between two binary templates [1], [2]. A value of zero would represent a perfect match. The two templates that are completely independent would give a Hamming distance near to 0.5. A threshold is set to decide the two templates are from the same person or different persons. The fractional hamming distance is sum of the exclusive-OR between two templates over the total number of bits. Masking templates are used in the calculation to exclude the noise regions. Only those bits in the templates that correspond to '1' bit in the masking template will be used in the calculation. The advantage of Hamming distance is fast matching speed because the templates are in binary format. The execution time for exclusive-OR comparison of two templates is approximately 10µs [2]. Hamming distance is suitable for comparisons of millions of template in large database.

2.3.2 Weighted Euclidean distance

Weighted Euclidean distance is used to compare two templates to identify an **IRIS** [19]. The templates are composed of integer values. Weighted Euclidean Distance is defined as a measure of similarity between two templates. It is calculated using Pythagorean Theorem to obtain the distance between two points. An **IRIS** template is compared with all templates in the database. The two templates are matched if the Weighted Euclidean Distance is a minimum.

2.3.3 Normalizes correlation

Normalized correlation between two representations is calculated for goodness of match [3], [26]. It is defined as the normalized similarity of corresponding points in the **IRIS** region. The correlations are performed over small blocks of pixels in four different spatial frequency bands. Normalized correlation accounts for local variations in image intensity. However, normalized correlation method is not computationally effective because images are used for comparisons.

3. General Problem

In a non ideal system, some images may not even contain an eye but these images still go through the entire iris process which is unnecessary and time consuming. In case of noisy images, the algorithms may produce a false match.

Noisy images are produced due to:

1. Gaze: caused due to face expressions.
2. Occlusions: caused due to incomplete information (half eye).
3. Blurring: caused when a moving image is captured.
4. Reflections: caused by contact lenses.

4. Conclusion

The Iris Recognition system is based on algorithms which work on ideal images. So there is scope of improvement in existing algorithms to make the IRIS recognition accurately possible on noisy images. Develop algorithms such that iris code requires less storage so that **iris** based biometrics can be implemented at ATMs and other public places.

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