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Novel Algorithm for Iris Biometrics Using Fast Wavelet Transforms

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Abstract

Iris recognition is a potential tool in secure personal identification and authentication system which has the properties such as uniqueness, non-invasiveness and stability of human iris patterns. The method proposed in this paper, differed from the existing work in the segmentation phase where segmentation is done using a different morphological method. Also, comparison is done between the traditional Hough transform and the proposed method, for their accuracy in detecting the pupil and iris region. The localized iris image is then normalized and Mallat's fast wavelet transform is used for feature extraction. The obtained iris templates are compared using Hamming distance. The algorithm proposed in this method provides accurate features as well as simple and fast iris analysis. Digitized grayscale images from Chinese Academy of Sciences-Institute of Automation (CASIA) database were used for determining the performance of the proposed system.

Keywords: Biometrics, Iris Segmentation, Iris template, Fast wavelet, hamming distance

Introduction

Due to the rapid development of communication technologies and internet, authentication has become a problem. Identification PIN numbers or passwords are not suitable for all cases. The best method to correctly identify and recognize a person is to use biometric techniques where a person is identified based on his/her physiological and behavioral traits. It has received significant attention as it has many advantages over traditional methods in security, credibility, universality, performance and convenience. They include face, finger print, eye, voice, speech recognition and so on. Biometric analysis through iris offers high level of accuracy. The human iris is an annular region between the pupil and sclera as shown in Fig.1 Generally, iris has many properties that make it an ideal biometric recognition component: (i) a unique characteristic of very little variation over a life's period yet, and (ii) genetic independence. Irises not only differ between identical twins, but also between the left and right eye. Another important characteristic, which makes iris difficult to fake, is its comparisons of measurements taken a few seconds apart will detect a change in iris area; if the light is adjusted whereas a contact lens or picture will exhibit zero change. Iris recognition systems are the most accurate; because iris pattern is formed before three years of age and is unchanged through one's life so it will remain stable over time. Moreover, each person has a unique iris pattern. It is extremely data-rich physical structure and physical protection by a transparent window (cornea); that does not

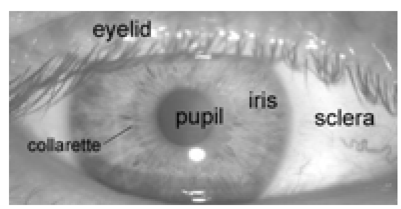

Fig.1 Front view of human iris

Inhibit external view ability. These properties make iris recognition a promising solution for personal Identification. The general iris recognition system includes i) image acquisition ii) iris pre-processing, iii) feature extraction and iv) matching. The iris pre-processing stage includes iris segmentation and normalization process. This paper is organized as section II) Iris pre-processing, III) Normalization, IV) Feature extraction, V) Matching and VI) Conclusion.

Iris Pre-Processing

The digital eye image used to verify the proposed system is obtained from Chinese academy of institutions of automatic science (CASIA) iris

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databases. Beginning with a 320x280 pixel photograph of the eye took from 4 centimeters away using a near infrared camera. The near infrared spectrum emphasizes the texture patterns of the iris making the measurements taken during iris recognition more precise. CASIA iris image database (version 1.0) includes 756 iris images from 108 eyes as shown in Fig.2. The iris pre-processing includes two stages i.e. iris segmentation and normalization.

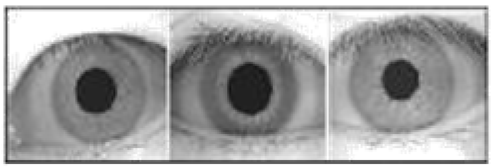

Fig.2 Sample CASIA images

The iris segmentation process involves the segmenting the region of iris from the digital eye image. The iris is a thin circular part which lies between the pupil and sclera. Upper and the lower part of the iris are usually occluded by top and bottom eyelids and eyelashes. Both the inner and the outer boundary of the iris can be approximately taken as a circle. We used an intensity threshold method to detect the boundary of the pupil considering the point that the pupil is usually darker than its surroundings.

Existing System

This method involves two processes in detecting the edges. The purpose of edge detection is to decrease the number of points in the search space for the objects. First, Canny edge detector is to maximize the signal to noise ratio and minimize the false positives in edge detection as shown in Fig.3a).Secondly, the Hough transform is applied which gives three parameters of the circle(x_0, y_0 ,r) by using which we find the pixel coordinates lying in the circle .The Hough transform is very tolerant of gaps in the actual object boundaries or curves.

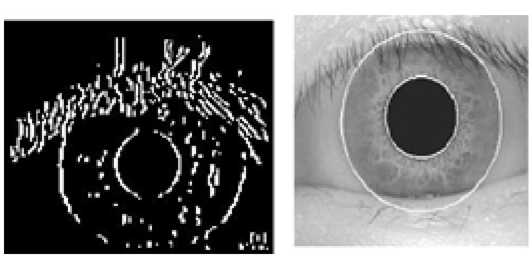

Fig.3 Hough transform (a)edge image and (b) segmented iris image

Proposed System

The digital eye image is first Binarized. The threshold level was selected using gray level histogram of the iris image. In order to remove the noisy effect of eyelids and eyelashes in Binarized image, we apply morphological operation. First, a disk operator is applied to erode the image and the same disk operator is used to dilate the image in order to get a rough pupil region. Canny edge detector is used to get the boundary of the pupil region as shown in Fig 4b).To find the center and radius we have to locate the point of pupil. After locating the bottom point, horizontal lines are drawn at regular intervals which create a set of intersecting points between the horizontal points and pupil boundary as shown in Fig.4c). Finally, the line which is longest is concluded as the radius.

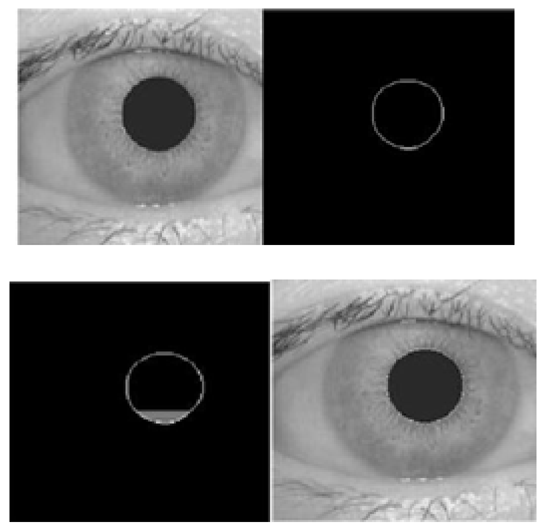

Fig 4 a) original image b) edge detected binary image c) intersecting of horizontal lines d) pupil boundary detected.

Iris Outer Edge Detection

The first step to locate the outer iris boundary is to remove the external noise by blurring the image using median filter. After filtering, the contrast of image is enhanced to have sharp variation at image boundaries using histogram equalization. This contrast-enhanced image is used for finding the outer iris boundary by drawing concentric circles, as in Fig 5 b)of different radii from the pupil center and the intensities lying over the perimeter of the circle are summed up. Among the candidate iris circles, the circle having a maximum change in intensity with respect to the previous drawn circle is the iris outer boundary

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Fig 5(a) Contrast enhanced image (b) concentric circle of different radii (c) localized iris image

The contrast between the iris portion and the eyelids are used to identify the iris portion, which is not occluded, by the eyelids. By, calculating the average intensities of pixel in the iris portion, in radial direction from the center of pupil we can find the iris portion not occluded by the eyelids.A modified unsharp masking is used to detect the eyelashes in the iris portion. This is done in two steps. First, the difference between the original image and Gaussian smooth image is calculated. Finally, the high frequency components in the iris image are retained. All of the high frequency components are digital enhanced to show the strong edge points. The edge points that fall within the inner and the outer boundaries of iris are considered as eyelashes.After, segmenting the iris using the existing and proposed system the obtained images are analyzed for their accuracy. 100 images from the database are passed through both segmentation codes. The results are analyzed and compared.

Normalization

Different people have different iris sizes. Even size of the iris captured from one person may be different due to illumination variations. To solve this problem, the localized iris part is transformed into polar coordinates system to overcome imaging inconsistencies. The annular iris region is transformed into rectangular region. The Cartesian to polar transform of the iris region is based on the Daughman's Rubber sheet model.This model is used to unwrap the iris region. In this mode the centre of the pupil is considered as the reference point. The iris ring is mapped to a rectangular block in the anti-clockwise direction. Radial resolution is the number of data points in the radial direction. Angular resolution is the number of radial lines generated around iris region. Using the following equation the doughnut iris region is transformed to a 2D array with horizontal dimensions of angular resolution and vertical dimension of radial resolution.The following formulas perform the transformation:

$$\mathbf{Y_p(\Theta) = Y_{p0}(\Theta) + r_p \sin(\Theta)} \qquad (1)$$

$$\mathbf{x_i(\Theta) = x_{i0}(\Theta) + r_i \cos(\Theta)}$$

$$\mathbf{y_i(\Theta) = y_{i0}(\Theta) + r_i \sin(\Theta)} \qquad (2)$$

Where I(x,y) is the iris region, (x,y) and(ρ,θ) are the Cartesian and normalized polar coordinates respectively, (x_p,y_p) and (x_i,y_i) are coordinates on pupil and limbus boundaries along the θ direction, (x_{p0}, y_{p0}), (x_{i0}, y_{i0}) are the coordinates of pupil and iris centers.

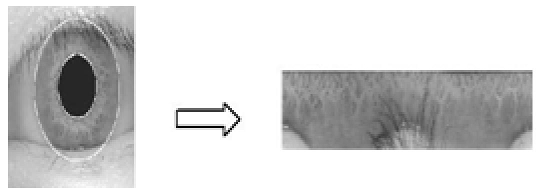

Fig 6 Normalized iris image Segmented Image Iris template

The upper portion of normalized iris provides most useful texture information for recognition and this region seldom contains the occlusion of eyelids. These zones are truncated to avoid other patterns not including in the iris texture.

Feature Extraction

In order to obtain rich details of iris patterns, 1-D dyadic wavelet transform is applied to iris template. The vector resulting for each scale is concatenated in a unique vector for computation of the zero-crossing representation, which leads to the feature vector. For computation of the wavelet transformation, Mallet's fast wavelet transforms (FWT) approach has been considered.Unfortunately, the down-sampling stage that follows each filter provides the worst performance results when compared to a zero-insertion in intermediate vectors. Therefore, the resulting vector does not have the same length as the initial vector, wherein its length is the initial length multiplied by the number of levels the transformation performs. Once the dyadic wavelet is computed, the resulting vector is simplified by using its zero-crossing representation. Then, the zero-crossing representation converts the vector into a binary representation, wherein "1" represents a positive value and "0" represents a negative value, for each vector component. The number of levels used for the wavelet transform is a critical parameter, as it greatly influences the authentication performance results. Upto eight levels are used in this paper.

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Matching

The most employed matching algorithm has been the Hamming distance, as was initially proposed by Daughman [5]. The Hamming distance is described by the following equation:

$$\mathbf{HD (A, B) = 1/L\ i \sum [0, L] (p_i \circledR yi)} \quad (3)$$

Where L is the vector length p_i and y_i are the i^{th} component of the template and sample vector, respectively, which are XORed in the equation. If the distance obtained is below a predefined threshold level, the studied sample is considered to belong to the user whose template is being studied.

Conclusion

In this paper, novel method for personal identification and verification by means of human iris patterns is presented. To process the iris patterns in an efficient way against existing methods, two simple and effective methods for iris segmentation has been given and compared. A morphology operation based approach to edge detection which deals with binary images has been used. Working with binary image instead of grayscale, decreased the edge detection process's time and cost while the traditional method occupies more space and time. We used eight levels in fast wavelet transform for feature extraction and generated a binary vector for each individual. Binary coding in feature extraction stage causes the matching process more quickly and easily.

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