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Research Article

Iris Recognition System Using PCA Based on DWT

Humayan Kabir Rana[1], Md Shafiul Azam[2] and Mst Rashida Akhtar[3]

[1]*Department of CSE, Green University of Bangladesh, Bangladesh*
[2]*Department of CSE, Pabna University of Science and Technology, Bangladesh*
[3]*Department of CSE, Varendra University, Bangladesh*

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***Corresponding author**

Humayan Kabir Rana, Department of CSE, Green University of Bangladesh, Bangladesh,
Email: humayan.pustcse@gmail.com

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Abstract

The Biometric recognition is the study of identifying individuals based on their unique physiological or behavioral characteristics, includes iris, face, fingerprint, retina, vein, hand geometry, hand writing, human gait, signature, keystrokes and voice. Among the biometrics, an iris has unique structure and it remains stable over a person life time. So that iris recognition is regarded as the most accurate and reliable biometric recognition system.

In this paper, we proposed a technique that uses Principal Component Analysis (PCA) based on Discrete Wavelet Transformation (DWT) for selecting feature of iris templates to increase the efficiency of iris recognition. Basically, the idea of DWT is to convert the iris image into four frequency band. We are using one frequency band instead of four and applying PCA for further feature extraction. Experiments with iris images from the CASIA database present good results, showing that the proposed combination strategy of feature extraction is suitable for increasing accuracy of iris recognition.

Introduction

Biometric technology deals with recognizing the identity of individuals based on their unique physical or behavioral characteristics [1]. Physical characteristics such as iris, face, fingerprint, retina, vein and hand geometry or behavioral characteristics such as hand writing, human gait, signature, and keystrokes have unique, accurate and stable information about a person and can be used in authentication applications. The developments in science and technology have made it possible to use biometrics in applications where it is required to establish or confirm the identity of individuals [2]. The increasing demand for enhanced security in the daily life has directed the improvement of the reliable and intelligent person identification system based on biometrics. The traditional identification systems based on cards or passwords can be broken by losing or stealing cards and forgetting passwords. So, there is a need for biometric identification systems identify humans without depending on what person possesses or what person remembers. Applications such as passenger control in airports, access control in restricted areas, border control, database access and financial services are some of the examples where the biometric technology has been applied for more reliable identification and verification [2]. In the field of financial services, biometric technology has shown a great potential in offering more comfort to customers while increasing their security. As an example, banking services and payments based on biometrics are going to be much safer, faster and easier than the existing methods based on credit and debit cards. Although there are still some concerns about using biometrics in the mass consumer applications due to information protection issues, it is believed that the technology will find its way to be widely used in many different applications [3]. Compared to passwords, biometric technologies offer more secure and comfortable accessibility and have dealt with problems such as forgetting or hacking passwords [3] (Figure 1).

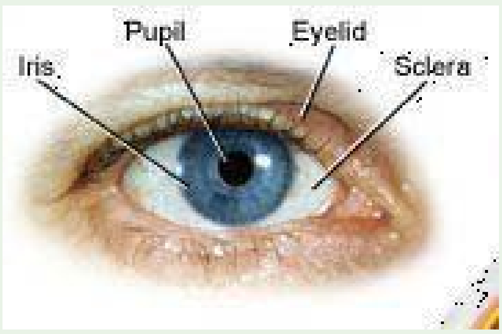

Figure 1: The Outer Structure of Human Iris.

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In general, the iris recognition systems consist of following steps: (i) image acquisition, (ii) iris segmentation (iii) normalization, (iv) feature extraction and (v) iris matching. In this paper, segmentation is achieved using Hough transform for localizing the iris and pupil regions. The segmented iris region is normalized to a rectangular block with fixed polar dimensions using Daugman's rubber sheet model. The selection of the optimal feature subset and the classification has become an important issue in the field of iris recognition. So that we have emphasized the feature extraction and selection of optimum features for the matching of two iris templates and proposed a straight forward technique that combines PCA and DWT together. The Euclidean distance is used for classification the similarity between the iris templates.

Methodology

In this section, the methodology for iris recognition is discussed. Figure 2 shows the system processes that have been used for iris recognition.

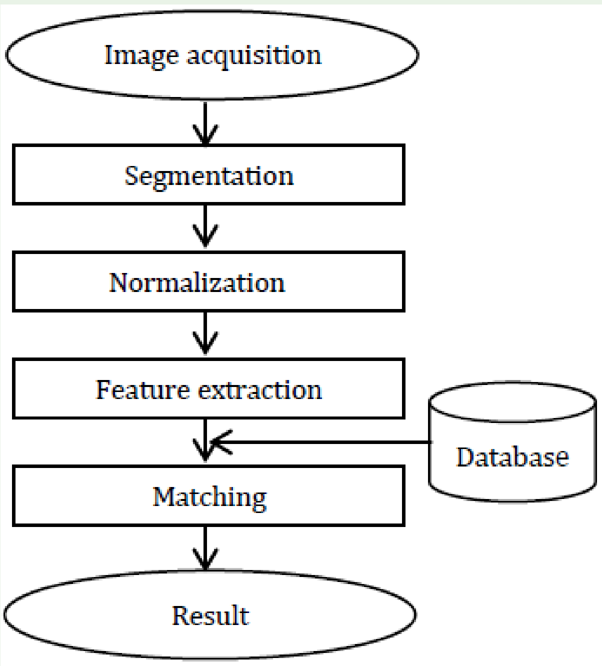

Figure 2: Block Diagram of Iris Recognition System.

Image acquisition

The first step of iris recognition is image acquisition deals with capturing sequence of high quality iris images from the subject using cameras and sensors. These images should clearly show the entire eye especially iris and pupil part [4], and then some preprocessing operation may be applied to enhance the quality of image e.g. Obtain images with sufficient resolution and sharpness. In this paper, CASIA-Iris V4 database is used instead of capturing eye images. CASIA-IrisV4 is an extension of CASIA-IrisV3 and contains six subsets. The three subsets from CASIA-IrisV3 are CASIA-Iris-Interval, CASIA-Iris-Lamp, and CASIA-Iris-Twins respectively. The three new subsets are CASIA-Iris-Distance, CASIA-Iris-Thousand, and CASIA-Iris-Syn. CASIA-IrisV4 contains a total of 54,601 iris images from more than 1,800 genuine subjects and 1,000 virtual subjects. All iris images are 8 bit gray-level JPEG files, collected under near infrared illumination or synthesized. Some statistics and features of each subset are given in table 1. The six data sets were collected or synthesized at different times and CASIA-Iris-Interval, CASIA-Iris-Lamp, CASIA-Iris-Distance; CASIA-Iris-Thousand may have a small inter-subset overlap in subjects [5].

Iris segmentation

The next step of iris recognition is iris segmentation, is a process to isolate the actual iris region in a digital eye image. The iris region, shown in figure 1, can be approximated by two circles, one for the iris/sclera boundary and another, interior to the first, for the iris/pupil boundary. Hough Transformation is used to locate the circular iris region.

Hough transformation: It is an algorithm used to compute the parameters of the geometric objects (lines and circles) in an image. The circular Hough transform can be used to find the center coordinates and radius of the iris and pupil regions. This technique is generally used to find shapes of the objects by a voting procedure within the classes available. In the segmentation algorithm, an edge map is created by computing the gradients (first derivatives of intensity values) in an eye image. For each edge pixel in the edge map, the surrounding points on the circle at different radii are taken and votes are cast for finding the maximum values that constitute the parameters of circles in the Hough space [6]. The center coordinates and the radius are computed using the following equation:

$$\chi_c{}^2 + y_c{}^2 - \gamma^2 = 0 \qquad (1)$$

The maximum point corresponds to the radius 'r'; the center coordinates (x_c ,y_c)of the circle are given by the edge points in the Hough space.

To perform the edge detection, derivatives (gradients) are taken in the vertical direction for detecting the iris-sclera boundary, in order to reduce the influence of the eyelids that are horizontally aligned [6]. Taking only the vertical gradients for locating the iris boundary will reduce influence of the eyelids when performing circular Hough transform, and not all of the edge pixels defining the circle are required for successful localization. Not only does this make circle localization more accurate, it also makes it more efficient, since there are less edge points to cast votes in the Hough space [6] (Figure 3).

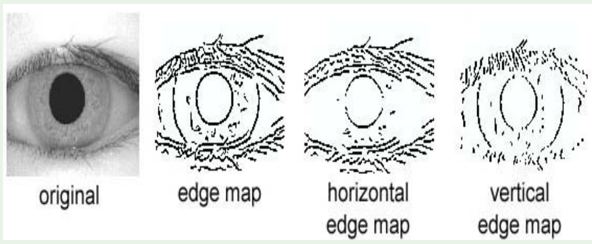

Figure 3: Segmentation Using Hough Transformation.

Normalization

Once the iris region is successfully segmented from an eye image, the next stage is to transform the circular iris region into a fixed size rectangular block. The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location [7]. In this paper Daugman's rubber-sheet model is used to normalize iris image.

Daugman's rubber-sheet model: The most widely used method for iris normalization is Daugman's rubber-sheet model [8], which converts the iris to a rectangular block over a doubly dimensionless non-concentric polar coordinate system. The Daugman's rubber sheet model finds for every pixel in the iris, an equivalent position on the polar axes (r,θ) where r is the radial distance and θ is the rotated angle at the corresponding radius. The radial resolution is described as the number of data points in the radial direction while the angular resolution is the number of radial lines generated around the iris region. Using equation 2,

$$I\left[x(r,\theta), y(r,\theta)\right] \rightarrow I(r,\theta) \quad (2)$$

The iris region is transformed to a 2D array with horizontal dimensions corresponding to the angular resolution and the vertical dimension to radial resolution shown in Figure 4.

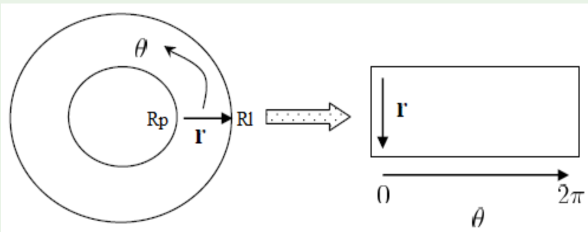

Figure 4: Daugman's Rubber-sheet Model.

Where I(x,y) corresponds to the iris region, (x,y) and (r,θ) are the Cartesian and normalized polar coordinates, respectively. θ ranges from 0 to 2π and r from Rp to Rl. x(r,θ) and y(r,θ) are defined as linear combinations of pupil boundary points.

Feature extraction

The most important step in iris recognition is feature extraction. Feature extraction is a process of finding the most discriminating information present in an iris pattern. The recognition rate and run time of matching of two iris templates mostly depends on feature extraction technique.

Proposed Technique for Feature Selection

We have a little contribution in feature extraction process. A technique is used to produce iris feature that increases the efficiency of matching. To create the feature, we firstly applied DWT on the normalized iris image. DWT transformation converts normalized iris image into four frequency sub band as LL, LH, HL and HH as shown in figure 5. Where range of frequency is represented as LL < LH < HL < HH. The feature or characteristics of iris is represented by low frequency coefficients or LL sub band [11] so this sub band is considered for applying PCA.

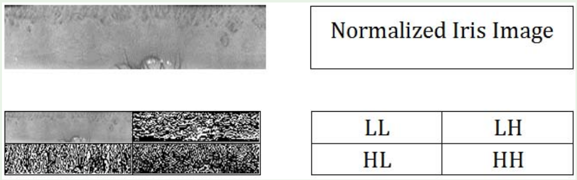

Figure 5: Iris Template Using One Level DWT.

PCA finds the most discriminating information present in LL sub band feature shown in Figure 6, and the resulting feature matrix is passed into classifier.

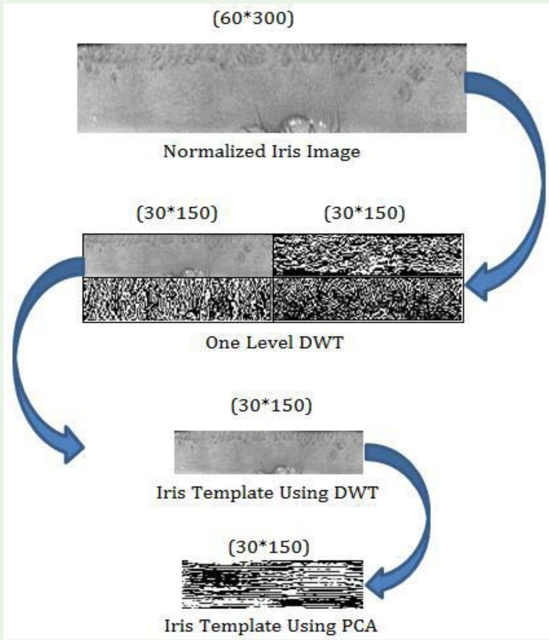

Figure 6: Iris Template Using PCA based on DWT.

Discrete wavelet transformation: The term wavelet transformation is explained as decomposition of the data or the image into wavelet coefficients, comparing the detail coefficients with a given threshold value, and shrinking these coefficients close to zero to take away the effect of noise data [9]. The image is reconstructed from the modified coefficient which is known as the inverse discrete wavelet transformations [10]. DWT transformation converts the image into four different frequency sub band as LL, LH, HL and HH as shown in figure 5. Where range of frequency is represented as LL < LH < HL < HH. The feature or characteristics of iris is represented by low frequency coefficients or LL sub band so LL frequency sub band can be extracted for feature reduction [11].

Principle component analysis: One of the most important techniques in image representation and feature extraction is Principle Component Analysis (PCA). It is a way of identifying patterns in iris, and expressing the data in such a way as to highlighting their similarities and differences [12]. PCA is appropriate when measurements are obtained on a number of observed variables and a smaller number of artificial variables called principle components is developed that will account for most of the variance in the observed variables. The principle components may then be used as predictor or criterion variables in subsequent analysis.

The steps of principle component analysis include:

i) The iris templates are converted into a one dimensional column vector.

ii) The mean of each vector is given in equation:

$$xm = 1/N\sum_{k=1}^{N} xk \tag{3}$$

iii) The mean is subtracted from all of the vectors to produce a set of zero mean vectors given in equation:

$$x_z = x_i - x_m \tag{4}$$

Where, x_z is the zero mean vectors, x_i is each element of the column vector, x_m is the mean of each column vector.

iv) The Covariance matrix is computed using equation:

$$c = [x_z T * x_z] \tag{5}$$

v) The Eigen Vectors and Eigen values are computed using equation

$$[c - \gamma i]e = 0 \tag{6}$$

Where, γ's are the Eigen value and e's are the Eigen vectors.

vi) Each of an Eigen vectors is multiplied with zero mean vectors x_z to form the feature vector. The feature vector is given in equation:

$$f_i = [x_z]e \tag{7}$$

Matching

The template generated in the feature extraction stage needs a matching metric to measure the similarity between two iris templates. This metric gives one range of values when templates generated from the same eye are compared and another range of values when templates generated from different person's eye are compared; so that we can decide as to whether the two templates belong to the same or different persons.

Euclidean distance classifier: K-Nearest Neighbor is the simplest of all classifiers that classifies objects based on the nearest training neighbors in the feature space. It uses Euclidean distance as a distance metric. This classifier can be used to compare two templates, especially if the template is composed of integer values. Object is classified or recognized based on the majority number of its neighbors, and is assigned to the class that is most common among its k nearest neighbors. If 1-nearest neighbor is considered, then the object is assigned to the class of its first nearest neighbor; generally larger values of k are considered to reduce the effect of noise on the classification. In terms of Euclidean distance, the difference, d between the enrolled iris templates and matching iris template k, is given as [13,14]:

$$d = \sqrt{\sum_{i=0}^{i=m} \left(s(i) - k(i)\right)^2} \tag{8}$$

Algorithm

Problem definition

The iris is used to authenticate a person. This algorithm is to find a person is authenticated or not by using iris.

The objectives are

This algorithm recognized a person using iris segmentation, normalization, DWT, PCA and Euclidean Distance Classifier is given in table 1.

Table 1: Algorithm of Iris Recognition System.

Input: Eye image
Output: Recognition of a person
Step 1: Read the eye image.
Step 2: Iris segmentation using Hough Transformation.
Step 3: Iris normalization using Daugman's model.
Step 4: The DWT is applied and the approximation band is considered.
Step 5: PCA is applied on approximation band to form feature vector.
Step 6: Form the signature vector of each image.
Step 7: Perform steps 1 to 6 for test image.
Step 8: Match/Non match decision is obtained using Euclidean Distance Classifier.

Experimental Results and Discussion

In this section, the proposed method was evaluated on CASIA iris database and the results are reported. 40 iris images of 40 individuals were enrolled in our system database for evaluating the performance and Intel core-i5 3.30GH processor, 4GB RAM, windows-7 operating system and matlab2013a tools were used as experimental platform. We used PCA Based on DWT to select the feature vector of iris images and got 92.6% accuracy of our proposed feature selection technique. The experimental results are shown in table 2.

Jyotipoonia [15] tested DCT and DWT feature extraction technique on iris images of CASIA database. They got 75% and 82% accuracy of DCT and DWT respectively.

Pravin S. Patil [16] tested PCA feature extraction technique on images of eyes from 30 persons of CASIA database. They got 90.2% accuracy of PCA (Table 2 and Figure 7).

Table 2: Results and Comparison with other Techniques.

Sl.	Methods	Avg. Recognition Rate (%)
1.	DCTfeature extraction technique based iris recognition [15]	75%
2.	DWT feature extraction technique based iris recognition [15]	82%
3.	PCA based recognition [16]	90.2%
4.	Proposed Feature selection Technique	92.6%

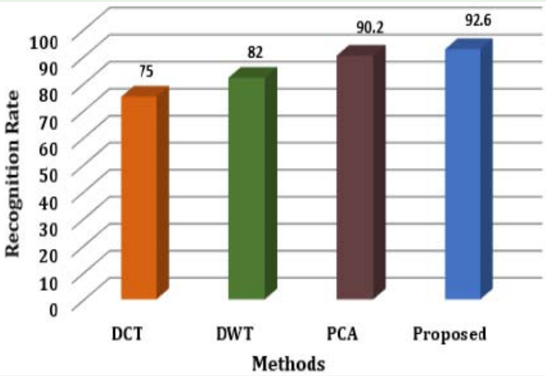

Figure 7: Comparison of the Accuracy of Several Feature Extraction Techniques.

Conclusion

Iris recognition system is a rising field of information technology that uses human iris to identify them. By calculating the iris feature, it is possible to identify each individual in a population. The reason why iris recognition is an attractive field is due to the fact that iris feature cannot be forgotten or lost, they are difficult to copy, share and distribute and they require the person to be present at the time of authentication.

Experimental results have demonstrated that the proposed method achieves good performance in accuracy. This confirms that the proposed combination strategy of feature extraction is suitable for increasing accuracy of iris recognition.

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