Performance Analysis of Iris Recognition System

Ruqaiya Khanam, Zohreen Haseen, Nighat Rahman and Jugendra Singh

Abstract A biometric system offers automatic identification of an individual based on a unique feature or characteristic possessed by the individual. Iris recognition is regarded as the most reliable and accurate biometric identification system available. Although iris identification system is based on pattern recognition technique but due to poor iris boundary detection and high computational time in previous work, we used neural network and discriminant machine learning technique to obtained high accuracy. In this work, we implement neural network and discriminant analysis of machine learning method for iris recognition in iris images to implement in day-to-day life, using MATLAB 2016a. The emphasis will be only on the software for performing recognition and not hardware for capturing an eye image. The proposed method gives better recognition rate than SVM technique with less computational complexity. Neural network and discriminant methods are used for matching and finding recognition accuracy. Thus, the accuracy obtained from neural network is 94.44%, whereas from discriminant analysis the accuracy obtained is 99.99%.

Keywords Iris recognition · Neural network · Machine learning

1 Introduction

The advancement of technology and expand importance of security have gained more awareness toward biometric identification system. Biometric systems are used based

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on face, iris, fingerprint, gait parameter, etc. Application of biometric systems is used for unique identity, border security, airport security, etc. Biometric identification is the process of an automatic identification based on characteristic or unique feature of an individual or a person. In 1980s two ophthalmologists, Leonard Flom and Aran Safir proposed that even in twins no two irises are alike thus making them a good biometric. By 1994, the algorithms have been developed and patented and further now used as the basis for iris recognition systems [1, 2]. The iris starts to develop in third month of gestation and complete its structure by the eighth month, however, pigment accretion continues to the first postnatal years. Each individual has a unique iris even the left and right eye of a particular individual differs in iris. Through the strategies of image processing, uniqueness of an iris pattern can be extracted from digitized image of the eye and thus encode it into a biometric template, which saved in database. This biometric template contains a mathematical representation of the unique data stored in the iris and enables comparisons to be made between templates.

2 Related Work

The first scientist who developed the algorithm for iris recognition system was Daugman integrodifferential operator was used for iris localization and for iris normalization rubber sheet model of Daugman was used. The matching of two iris codes was done by Hamming distance. Lim proposed an efficient method of personal identification having high level of stability and distinctiveness. In this paper, Haar wavelet is used to extract the features from iris image. Navjot provides the review of existing methods as proposed by various researchers for iris recognition. Mohd. Tariq proposed an algorithm by using 1D Gabor filter for the extraction of feature, normalizing, and segmenting the iris and pupil boundaries of eye from database images. Further, Proenca proposed a method which encloses three main parts that are eye detection, iris segmentation, and discrimination of noise-free iris texture. An algorithm implemented by Mayank was used to enhance both accuracy and speed of iris recognition. Samir relates a GACs (Geodesic Active Contours) with an iris segmentation scheme which extract the iris from nearby structures. The scheme invokes iris texture further assisted by local and global properties of the image. Zhaofeng presented an algorithm for both fast and accurate iris segmentation. FAWAZ is known for proposing multi-algorithmic approach to enhancing the security of iris recognition system and can be achieved by fusing the data acquired at the feature level and applying the K-nearest neighbor classifier (K-NN).

3 Background Theory of Proposed Work

3.1 *Biometric Technology*

Biometric generally describes a characteristic or a process. For automatic recognition, it is used. Its framework provides a programmed recognition of a person taking same kind of special elements or trademark governed by the person. A biometric system generally involves three modules as: recognition, verification, identification (Fig. 1).

Sensor Module: It defines the connection of the human with the system and thus vital to the execution of the biometric system.

Feature Extraction and Quality Assessment Module: The quality of the biometric data attained by the sensor is assessed for feature extraction. During enrollment, the extracted feature is stored in the database known as "template", representing the identity of an individual.

Matching Module: The identity of an individual is verified by comparing the template to the input (query) biometric data of an individual.

Decision-Making Module: This is to verify an exact identity or to provide ranks to the enrolled identities. Usually, the match score is compared against the "threshold" to determine the authenticity of an individual.

3.2 *The Human Iris*

To control the amount of light entering through the pupil is the function of iris. The average diameter of the iris is 12 mm, and the pupil size can vary from 10 to 80% of the iris diameter [3]. The pigmentation of iris depends on genetics which determines its color.

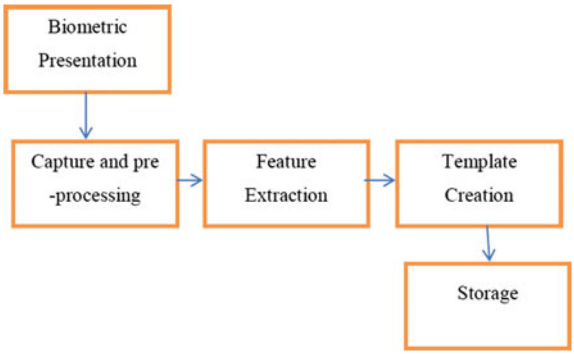

Fig. 1 Working of biometric system

3.3 Different Recognition System

Biometric recognition, or biometrics, refers to the automatic identification based on anatomical or behavioral characteristic or unique feature of an individual. Some of the recognition systems are fingerprint recognition, speech recognition, iris recognition.

3.4 Work Methodology

Steps in Iris Recognition System

Image Acquisition: It is the first step of the image processing and can be defined as recovering an image from some source. High-quality image acquisition techniques are used for iris recognition to make accurate models of different surfaces.

Image Preprocessing: It aimed to enhance ability to interpret quantitatively image components. It removes low-frequency noise, normalizes the intensity of individual images, and removes reflections.

Segmentation: The accomplishment relies on upon the imaging nature of images of eye. Because of the exertion of close infrared light for enlightenment, images in the CASIA iris database [4] do not contain specular reflections.

Normalization: The next stage after iris region segmentation is to change the iris region, so it has fixed measurements to allow comparisons. There are dimensional irregularities between eye images due to extending of iris created by pupil expansion from shifting levels of brightening. The normalization methodology will create iris regions, which have the same measurements, so two photos of the identical iris under exclusive conditions will have characteristic features at the same spatial area.

Feature Encoding and Matching: The template that is created in the feature encoding procedure will require a relating matching metric, which allow comparison between two iris templates (Fig. 2).

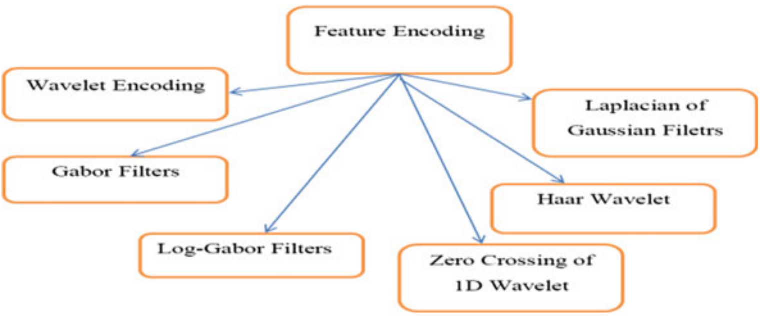

Fig. 2 Technological perspectives in feature encoding module

- **Feature Encoding Algorithms**: Wavelets can be deployed to decompose the information in iris region into constituent that show up at different resolutions.
- **Gabor Filters**: Daugman encodes iris pattern data by using 2D variant of Gabor filters. A 2D Gabor filter over the image space (x, y) is represented as:

$$G(x, y) = \mathrm{e}^{-\pi\left[(x-x_\mathrm{o})^2/\alpha^2+(y-y_\mathrm{o})^2/\beta^2\right]}\mathrm{e}^{-2\pi i[u_\mathrm{o}(x-x_\mathrm{o})+v_\mathrm{o}(y-y_\mathrm{o})]}$$

where $(x_\mathrm{o}, y_\mathrm{o})$ is position in the image, (α, β) is the effective width and length, and $(u_\mathrm{o}, v_\mathrm{o})$ determine modulation, which has spatial frequency. $\omega_\mathrm{o} = \sqrt{\left(u_\mathrm{o}^2 + v_\mathrm{o}^2\right)}$.

- **Haar Wavelet**: Oppenheim and Lim [5] use the wavelet change to extract features from the iris region. From multi-dimensionally filtering, a feature vector with 87 estimations is featured. Since every estimation has a real value expanding from −1.0 to +1.0, the feature vector is sign quantized so that any positive value is represented by 1 and negative by 0.

3.5 *Matching Algorithms*

Matching Algorithms are used for verification as well as identification functions. Three algorithms which are repeatedly used in iris recognition technology discussed below are:

- **Hamming Distance**: The measure of same number of bits between two bit patterns is given by hamming distance. The hamming distance for two bit patterns X and Y is defined as the sum of discarding bits (sum of the exclusive-OR between X and Y) over N, the total number of bits in the bit pattern.

$$\mathrm{HD} = \frac{1}{N}\sum_{i=1}^{N} X_i(\mathrm{XOR})Y_i$$

- **Weighted Euclidean Distance**: In order to compare two templates composed of integer values WED is used. The metric is employed by Zhu et al. [6] and is specified as

$$\mathrm{WED} = \frac{1}{N}\sum_{i=1}^{N} (f_i - f_i^{(k)})^2/(\delta_i^{(k)})^2$$

where f_i is the ith feature of the unknown iris, and $f_i^{(k)}$ is the ith feature of iris template, k and $\delta_i^{(k)}$ is the standard deviation of the feature in iris template k.
- **Normalized Correlation**: It is represented as

$$\sum_{i=1}^{n}\sum_{j=1}^{m}(p_1[i,j]-\mu_1)(p_2[i,j]-\mu_2)/nm\sigma_1\sigma_2$$

where p_1 and p_2 are two images of size $n \times m$, μ_1 and σ_1 are the mean and standard deviation of p_1, and μ_2 and σ_2 are the mean and standard deviation of p_2.

4 Proposed Work and Techniques Used

The implementation of proposed work is shown in Fig. 3.

4.1 Feature Extraction Technique

The feature map of iris image is extracted with the help of Daugman rubber sheet model which is used for the normalization of image and then Haar wavelet is used for the feature extraction.

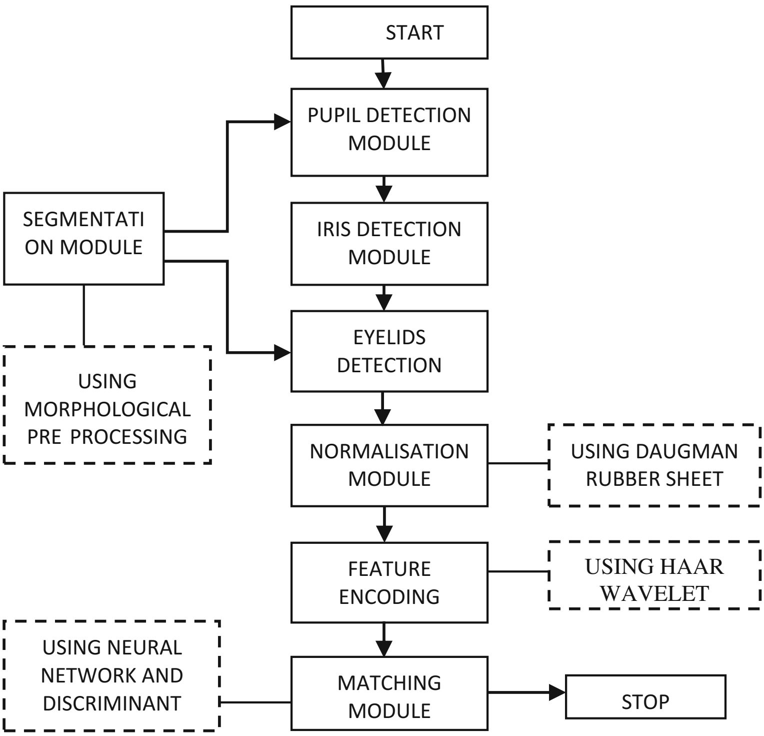

Fig. 3 Flow chart of proposed algorithm

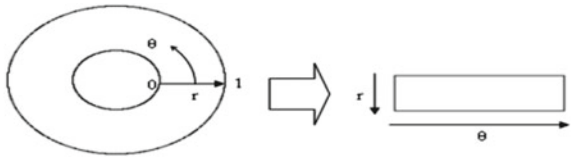

Fig. 4 Daugman's rubber sheet model

Daugman's Rubber Sheet Model: The homogenous rubber sheet model elaborate by Daugman relocates every point inside the iris area to a couple of polar directions (r, θ) where r is on the interval [0, 1] and θ is angel $[0, 2\pi]$ (Fig. 4).

The relocating of iris region from Cartesian coordinates (x, y) to the normalized non-concentric polar representation is modeled as

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta)$$

With, $x(r,\theta) = (1-r)x_p(\theta) + rx_1(\theta)$

$$\mathrm{y}(r,\theta) = (1-r)y_p(\theta) + ry_1(\theta)$$

where, $I(x, y)$ is iris region picture, (x, y) are the Cartesian coordinates, (r, θ) are the relating standardized polar directions, and are the directions of the pupil and iris limits along the θ direction.

4.2 Matching and Accuracy Determination

In this proposed work, the accuracy of the feature extraction is determined with the help of discriminant analysis and neural network.

Machine Learning Algorithm: A type of artificial intelligence learning algorithm which helps the computers the ability to learn without being clear-cut programmed. There are various types of machine learning algorithm: supervised, unsupervised, semi-supervised, reinforce.

5 Experimental Result

Every first image in result modules represent our best performance as when we compare characteristically features of our first image with others we find considerable difference in image quality but the catch is that for most of images taken we have got such technical results which are relevant to our above assumptions. Outputs or results are shown in sequential manner (Fig. 5).

The image is shown in Fig. 6 is binarized behavior of original iris grayscale images. The image of this type is used for further segmentation of iris and then its localization.

In Fig. 7, the image quality indicates a good level of clarity in the image representation. The background is noise free and representations of pixels are 0. This is a standard image which will be used for masking and making the image noise free.

The current image has been used to show the red circles that are marked in the image. Here when the image is seen highlighted with circles, the radii so evaluated are marked only for a certain region or at an angular area shown in Figs. 8 and 9.

Fig. 5 Image after binarization of iris image

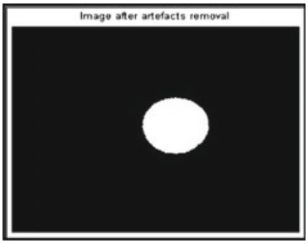

Fig. 6 Image after artefacts removal

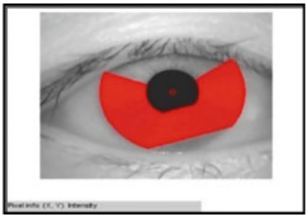

Fig. 7 Original iris image holding the red circles with a certain angle

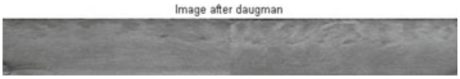

Fig. 8 Image after Daugman filtering

Fig. 9 Detailed, approximated, horizontal, and diagonal components of wavelets

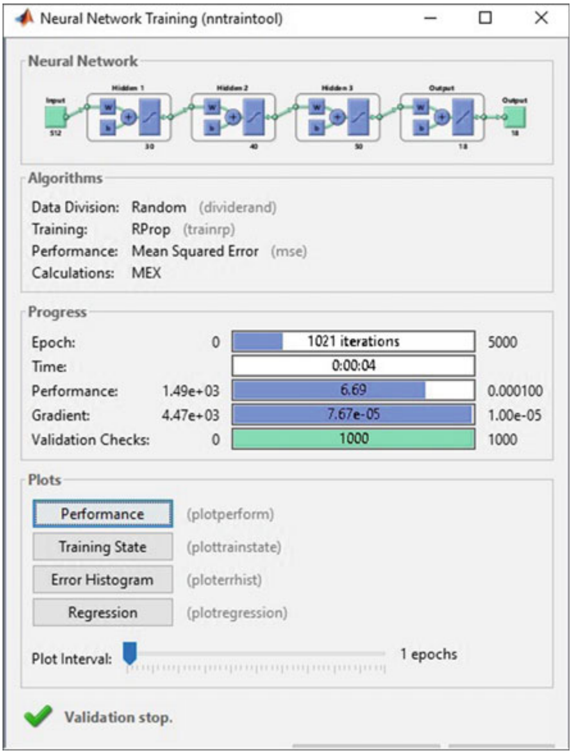

Fig. 10 Image shows neural network training

To enable the transform of circular region into a horizontal region the image so calculated is divided in two regions. Now if Fig. 10 is compared to Fig. 9, the circular iris region will be considered as polar coordinates and then the red marked semicircles are reduced to Daugman Cartesian coordinates. The image so seen here is a combination of left and right region of iris.

This image is imperative reason being that image here is a segmented image or partitioned image which will reduce the image size to either half dimension or to a lower dimension. If this wavelet analysis is done then ultimate aim of the image is to calculate the results as features to identify the prime features. In this research the approximate image seen at the upper left corner will be reduced and used, the total pixels will be approximately 512.

The feature of four images of subject 1 selected shown by number of columns, here the number of images will be four and for each image 100 prime features are shown out of 512. If calculations are traced, the features are evaluated using Haar wavelet.

5.1 Accuracy Measurement and Comparison with Other Technique

Accuracy Measurement: In this supervised learning is used which is a part of machine learning. The techniques neural network and discriminant analysis are coming under supervised learning and they are used to measure the accuracy in the present work.

Discriminant analysis is a categorization method. It concludes that different classes produce data, based on different Gaussian distributions:

- To create a classifier, the fitting function evaluates the parameters of a Gaussian distribution for each class.
- To estimate the classes of new data, the trained classifier finds the class with the smallest misclassification cost.

Figure 11 shows the comparisons between two techniques used in the work for the calculation of accuracy of the features abstracted from the images of iris of the given subjects. The techniques used are (1) discriminant analysis of machine learning algorithm and (2) neural network.

The accuracy obtained from the neural network is 94.44%, whereas from discriminant analysis the accuracy obtained is 99.99%.

The comparison of results obtained from the research work is well described in Table 1. Accuracy of the features of human iris images has been derived in this

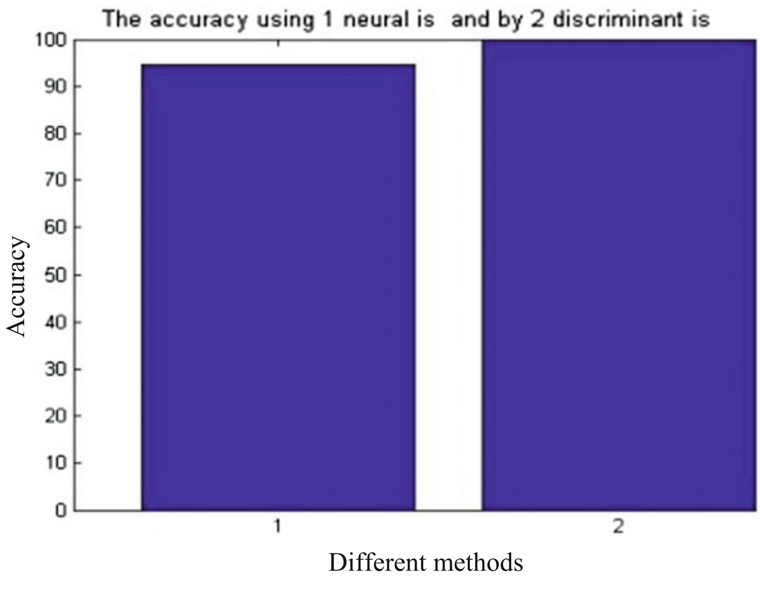

Fig. 11 Matching accuracy of two mentioned methods

Table 1 Recognition accuracy with different feature vector on CASIA image database

Methodology	Accuracy (%)	False acceptance rate (%)
SVM with Haar	91.33	8.66
Hamming distance	99.60	0.33
SVM with 1D log Gabor	99.65	0.33
Proposed work 1 (Haar + neural network)	94.76	5.21
Proposed work 2 (Db1 + neural network)	94.76	5.22
Proposed work 3 (Haar + discriminant analysis)	99.99	0.01
Proposed work 4 (Db1 + discriminant analysis)	99.99	0.01

proposed work after enhancing the acquired images of different subjects obtained from the CASIA data source [7].

6 Conclusion

In this proposed work, an efficient technique for recognition and feature extraction was explained. The crisscross collarette region of iris was picked because it is the most significant region of iris complex layout due to which high acknowledgment rate has been taken out. Haar wavelet and Daubechies wavelet were used for evicting out the features; these extracted features were utilized in the iris recognition which was using the feedforward neural network technique for recognition. The proposed system also used the discriminant analysis approach for the matching stage with the use of same extracted feature. This also gives better recognition rate than SVM technique with less computational complexity. The performance accuracy of present work is best in the favor of CASIA as well as check image database. So for both identification and verification, the proposed work is efficient.

7 Experimental Result

Every first image in result modules represent our best performance as when we compare characteristically features of our first image with others we find considerable difference in image quality but the catch is that for most of images taken we have got such technical results which are relevant to our above assumptions.

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