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A Propitious Iris Pattern Recognition Using Neural Network Based FFDTD and HD Approach

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***Abstract*– A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual. An iris recognition system is a highly secure and confidence biometric identification system. In this paper, the iris recognition system is considered by using a neural network based Feed forward distributed time delay and Hamming Distance (HD). Hough transform is the standard algorithm used for segmenting the iris patterns. Daugman's rubber sheet model is used for normalization and unwrapping. Gabor filter is used for feature extraction. There are few public and freely available databases. For the purpose of research and development the system is tested on a CASIA database which contains nearly 4500 iris images.**

***Index terms*– Biometric System, Daugman's Rubber Sheet Model, Feed Forward Distributed Time Delay (FFDTDNN) and Hamming Distance (HD)**

I. INTRODUCTION

A biometric system is a system that is used to identify a person with the help of information relating to him.

Biometrics can be classified into two types, namely, Physiological and behavioral. The various biometric technologies include fingerprint, palm print, face recognition, retina scan, iris recognition and behavioral include signature, voice and key stoke. Among these biometric technologies iris recognition system is considered as the most reliable and of high performance technique due to its unique patterns. Some examples include an airport scanning device, a bio-password, crime detection, identifying individual, ATM machines, crime control etc.

In recent years, drastic improvements have been accomplished in iris recognition which is a biometric recognition technology that utilizes the pattern recognition techniques based on the high quality images of iris. In this paper, an improved partial iris recognition system is considered which is more accurate and reliable technology. A human iris is a region between the pupil and sclera as shown in the Fig1. The iris pattern not only differs between individuals but also varies between the left and right eye of the same individual. Even identical twins possess different iris patterns [1].

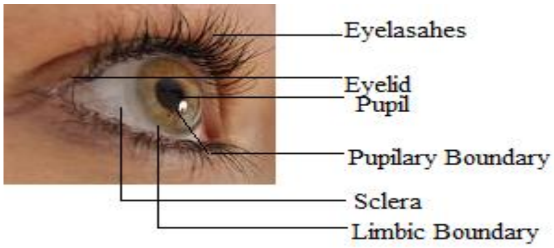


Fig. 1: Front view of human eye

An iris recognition system consists mainly of four stages which include segmentation, normalization, feature extraction and comparison. There are various approaches for iris recognition, involves two processes: Enrollment and Identification. In the enrollment process, the iris features are recorded in the database. In the identification process the system attempts to confirm an individual identity by matching the previously enrolled images present in the database. All publicly deployed iris recognition system acquires images of iris in near infrared ray or under ordinary light.

In 1936, Frank Burch, an ophthalmologist, proposed an idea regarding iris recognition. Aram Safir and Leonard Flom patented the idea and asked Daugman to create an algorithm for that. John Daugman is known for his biometric identification, for the development of the fundamental algorithm as described in [2] and followed it up with the enhancement of the algorithm in [3], [4]. The iris is segmented using Integro-Differential Operators. For the purpose of normalization Daugman's Rubber sheet model which remaps each point within the iris region to a pair of polar coordinates (r,θ). Gabor filter and hamming distance are used for feature extraction and matching. The eyelids are detected using the linear Hough Transform method and Parabolic Hough Transform method [5]. An alternative approach was proposed by Wildes [6] using the Hough transform to localize irises. In the method proposed by Wildes, an edge map of the image is first obtained by thresholding the magnitude of the image intensity gradient.

Dolly Choudhary, Ajay Kumar Singh, Shamik Tiwari have proposed the k-nearest neighbor classifier which is one of the most basic classifiers for pattern recognition or data classification and is a supervised training algorithm [8]. An efficient use of Biorthogonal wavelet in [9] was to encode iris information. It minimizes the noise of the iris image using inband thresholding where it is done for each sub band to provide better mapping and encoding of iris information. In [10] an iris recognition, an algorithm based on Gabor filter with Estimated Fractral dimension was implemented. C.W. Tao et al. decomposed the normalized iris region using Multichannel Gabor filter. Li Ma, Yunhong Wang, Tieniu Tan in [11] implemented the multichannel Gabor filter with six frequencies and four orientation bands to decompose an iris image. They have proposed a texture analysis and local variation analysis methods to extract the iris features.

N. Ritter implemented the Active contour method in [12] for localizing the pupil in an eye image. Boles and Boashash [13] used Zero crossing representation of 1D dyadic wavelet for encoding the iris region. Lim et al compare the accuracy rate of HAAR Wavelet and Gabor filter and showed that Haar wavelet has better performance when compared to Gabor filter. Petru Radu, Konstantinos Sirlantzis, et al implemented the multiple classifier technique to cope with noisy color iris images. Kaushik Roy and Bhattacharya proposed technique that is based on SVM [15]. M. Gopikrishnan et al. implemented the iris recognition system for both partial and full template using Hamming distance and Neural network based techniques [16] - [20].

In this paper an improved iris recognition system based on a combined Feed forward distribution time delay and Hamming distance approach is proposed where the template size ranges as 20 X 480 pixels. Hough transform is the standard algorithm used for iris localization. The Rubber sheet model is used for normalization of the iris region which remaps the iris region into a pair of polar coordinates. Gabor filter is used for feature extraction and two different matching classifiers such as Feed forward distribution time delay (FFDTDNN) and the hamming distance is proposed for this iris recognition system. The CASIA database which contains nearly 4500 iris images is used for the proposed methodology. The accuracy of the proposed system is calculated in terms of Arithmetic Mean and Standard deviation.

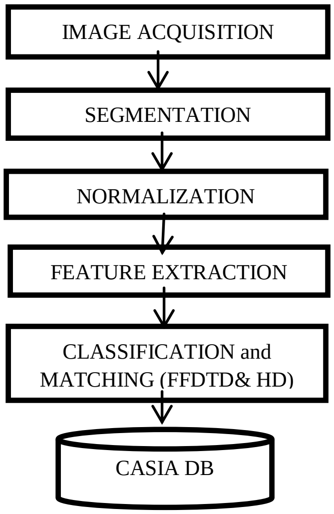


Fig. 2: Iris recognition process

The general process of iris recognition system includes the following stages namely image acquisition, segmentation, normalization, feature extraction, classification and matching as shown in Fig. 2.

II. SEGMENTATION

The first and the most difficult part in the process of iris recognition system is the segmentation process. In this stage, the region of the iris in the digital image obtained through infra-red ray or by ordinary light has to be located. Hough transform proposed by Wildes is used to locate the iris region. Then the interfering parts such as eyelids and eye lashes are detected and removed using the parabola detection technique and filters as shown in the Fig 4. In CASIA database iris image are captured under near infra-red ray which does not have many reflections when compared to other databases.

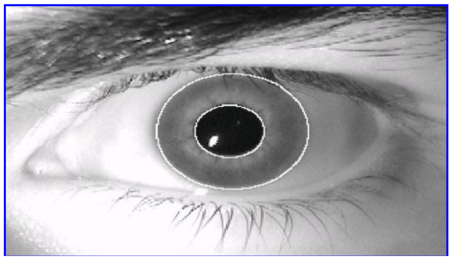


Fig. 3: Detection of Iris region

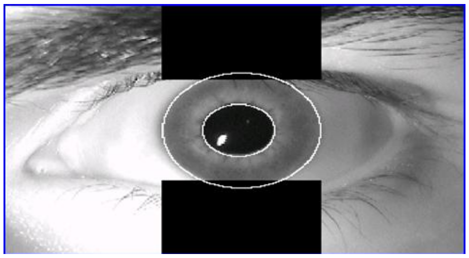


Fig. 4: Removal of eye lashes and eyelids

A. Hough Transform

Hough transform is the standard computer vision algorithm which is used to determine the parameters of sample geometric objects as line and circles present in the image and remove the interfering eye lashes and eyelids. The eyelids can be detected using the linear Hough Transform method and Parabolic Hough Transform method. The method calculates the total number of edge points in every horizontal row inside the search regions. The horizontal row with the maximum number of edge points is selected as eyelid boundary. The Circular Hough Transform is used to deduce radius, centre coordinates of the pupil and iris region. The radius r and the centre coordinates (a, b) are defined by the parametric equations as follows:

$$x = a + r\cos\theta \quad (1)$$

$$y = b + r\sin\theta \quad (2)$$

The Hough function implements the Standard Hough Transform (SHT). The Hough transform is designed to detect lines, using the parametric representation of a line:

$$rho = x * \cos\theta + y * \sin\theta \qquad (3)$$

The variable rho is the distance from the origin to the line along a vector perpendicular to the line. Θ is the angle between the x-axis and this vector.

III. NORMALIZATION

After segmentation, the iris region is transformed into a fixed dimension and the process is known as Normalization. The normalization scheme is to transform the segmented iris image from Cartesian coordinate into polar coordinates (r,θ). This process is often called iris unwrapping. John Daugman's Rubber sheet model is used for the purpose of normalization as shown in the Fig. 5.

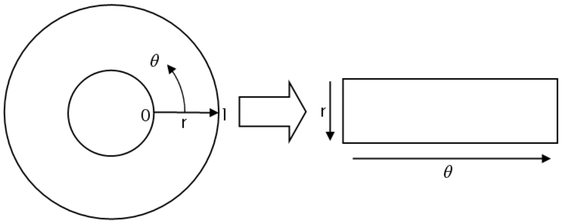


Fig. 5: Daugman's Rubber sheet model

For every pixel present in the normalized image, decision has to be taken on whether the pixel is occluded by eyelash or not. The image of same eye under different lighting conditions has different noise patterns since the pupil region of eye shrinks and expands under exposure to lights. The normalized iris region is shown in the Fig. 6.

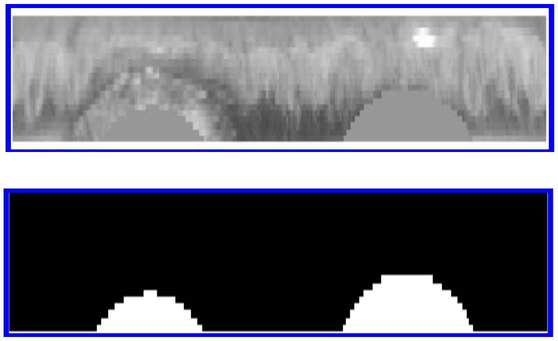


Fig. 6: Normalized iris region with noise patterns

IV. FEATURE EXTRACTION

In order to extract distinct features from an iris image, a proper algorithm must be used as well as a suitable method for recording those features before a feature template can be defined. After the normalization process, the 2D normalized template is divided into a series of 1D signals. In this proposed system, a Gabor filter is used for feature extraction. The two binary templates which represent the signature of iris is used for the coding process where the normalized template is converted into binary digits 0's and 1's as shown in Fig. 7. Each row corresponds to a circular ring on the iris region. The angular direction is taken rather than the radial one, which corresponds to the columns of a normalized pattern. The encoding process produces a bitwise template containing a number of bits of information, and a corresponding noise mask which corresponds to corrupt areas within the iris pattern.

A two-dimensional (2D) even Gabor filter can be represented by the following equation in the spatial domain:

$$G(x,y;\theta,f) = exp\left\{-\frac{1}{2}\left[\frac{x'^2}{\delta_{x'}^2} + \frac{y'^2}{\delta_{y'}^2}\right]\right\}\cos 2\pi f x' \quad (4)$$

$$x' = x\cos\theta + y\sin\theta \qquad (5)$$

$$y' = y\cos\theta - x\sin\theta \qquad (6)$$

Where f is the frequency of the sinusoidal plane wave along the direction θ from the x-axis, δ x' and δ y' are the space constants of the Gaussian envelope along x' and y' axes respectively.

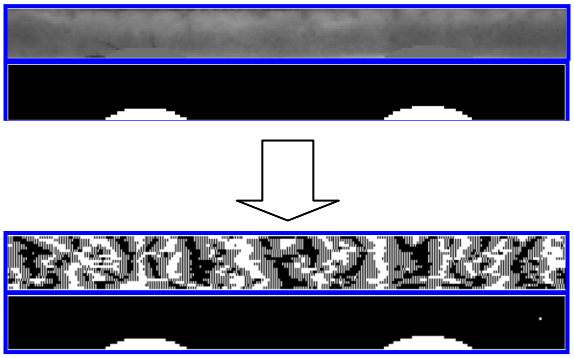


Fig. 7: Coding Process

As a result the iris code is constructed by demodulating the iris pattern using Gabor filter to extract the unique features of the region. Since the rubber sheet model proposed by Daugman makes use of polar coordinate for normalization the Gabor filter is given as follows:

$$H(r,\theta) = e^{-i\omega(\theta-\theta_0)}e^{-(r-r_0)^2/\alpha^2}e^{-i(\theta-\theta_0)^2/\beta^2} \qquad (7)$$

Where (α, β) represent width and length and ($r_{0,}$ θ_0) represent the center frequency of the filter.

V. MATCHING AND CLASSIFICATION

After generating the iris code for the normalized iris region, check has to be made whether the two templates obtained matches with the database or not. The matching process helps to identify an individual whether the person is an enrolled user or not in the database. For the purpose of matching and classification, the proposed partial iris recognition system makes use of the Neural network based Feed forward distribution time delay (FFDTDNN) and Hamming Distance (HD) approach. The features obtained from Gabor filter are trained and tested using the Neural Network Toolbox.

A. Hamming Distance

Hamming distance is the approach used for the matching purpose in the iris recognition system. It measures the similarity between two bit patterns and to find the inter and intra class. Hamming distance metric is deployed to provide a decision whether two patterns are generated from different iris or from same iris. The Hamming distance can be defined as:

$$Hamming\ Distance = \frac{1}{N}\sum_{i=0}^{N} x_i \oplus y_i \qquad (8)$$

Where x and y are the two templates and N is the total no of bits in the template.

If the two bit patterns are from the same iris, the hamming distance between them will be equal to zero and, if they are from different iris, the hamming distance between them will be 0.5. To account rotational inconsistencies, when the HD of two templates is calculated, one template is shifted left and right bit wise. Only the lowest value from the calculated HD is taken since it corresponds to the best match between two templates.

B. Feed Forward Distributed Time Delay Neural Network

Feed forward distributed Time delay neural network (FFDTDNN) is an artificial neural network architecture whose primary purpose is to work on sequential data. The FFDTDNN units recognize features independent of time-shift and usually form part of a larger pattern recognition system. In the Neural network toolbox, the type of the network can be selected for training the input data and analyzing the performance of iris recognition system. The layout of feed forward distributed time delay neural network is shown in the Fig 8. The sample performance results of the feed forward distributed time delay neural network is shown in the Fig. 10.

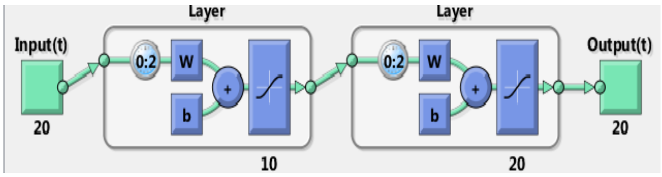
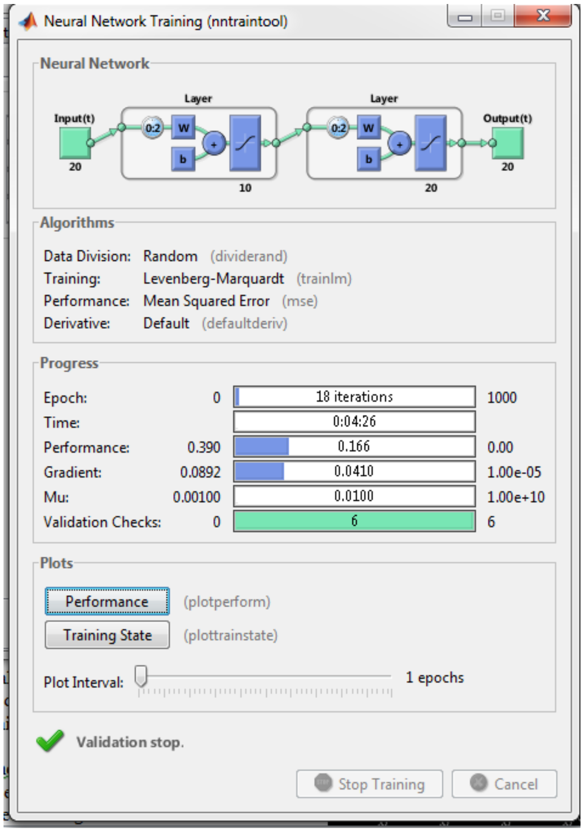


Fig. 8: Layout of Feed Forward Distributed Time Delay neural network

Based on the classification and matching algorithm results, the performance of the Feed forward distribution time delay and Hamming distance is calculated.



Algorithms

Data Division: Random (dividerand)
Training: Levenberg-Marquardt (trainlm)
Performance: Mean Squared Error (mse)
Derivative: Default (defaultderiv)

Progress

Epoch:	0	18 iterations	1000
Time:		0:04:26	
Performance:	0.390	0.166	0.00
Gradient:	0.0892	0.0410	1.00e-05
Mu:	0.00100	0.0100	1.00e+10
Validation Checks:	0	6	6

Plots

Performance (plotperform)
Training State (plottrainstate)
Plot Interval: 1 epochs

✓ Validation stop.

Fig. 9: Training the Neural Network

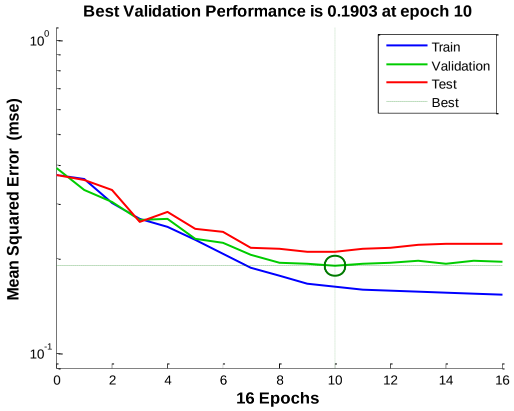


Fig.10: Neural network training performance results

VI. EXPERIMENTAL RESULTS

The proposed method is implemented using MATLAB in the windows 7 operating system with Intel Core i3 Processor, 2.20 GHz and 4GB RAM. The Mean and the Standard Deviation values for the CASIA (Chinese Academy of Sciences) database are calculated.

A. Results on CASIA Database Images

In this paper nearly 200 binary template patterns have been used for training and testing purposes. The iris recognition system was compared with the two classification and matching algorithms, namely, Feed Forward Distributed Time Delay Neural network and Hamming Distance. The comparison results of the iris recognition system in terms of Mean and Standard Deviation is depicted in Table 1. The better performance results of the feed forward distributed time delay neural network compared to Hamming distance can be seen.

Table 1: Comparison between 200 Binary Template Patterns Experimental Results

PERFORMANCE METRIC	Methodology	Res1	Res 2	Res 3	Res 4
MEAN	HD	0.31653	0.30080	0.28451	0.31212
	FFDTDNN	0.15822	0.15233	0.15897	0.15688
SD	HD	0.05419	0.03458	0.03590	0.05358
	FFDTDNN	0.01696	0.01558	0.01427	0.01436

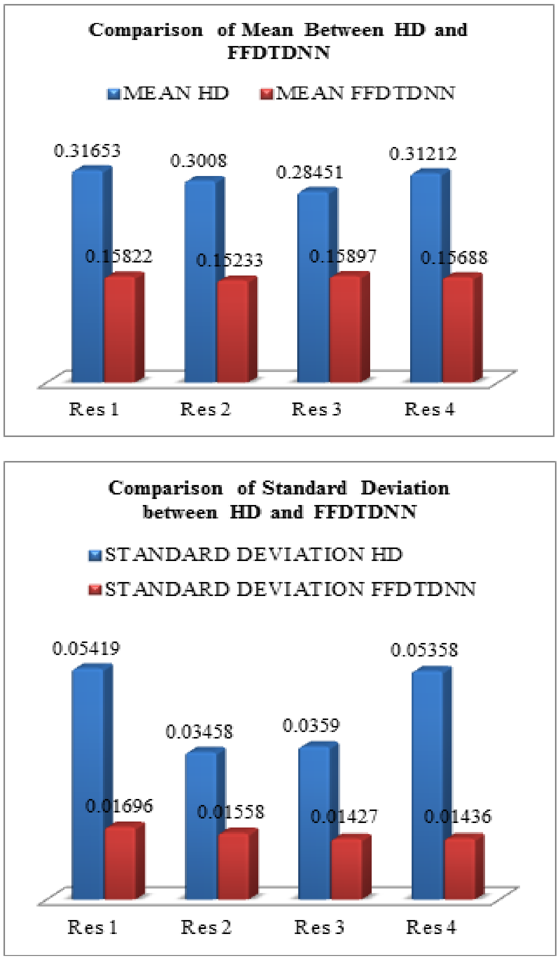


Fig. 11: Comparison Results between HD and FFDTDNN

VII. CONCLUSION

In this paper an effective approach for iris recognition system is presented. Hough transform is used for segmentation of the iris region. Gabor filter is used for extracting the important features of the iris region. These are used for classification and matching purposes. In this work the experimental results are made for the Hamming Distance and Feed forward distributed time delay neural network to identify the better performance results for iris recognition and identification purposes. The results have shown that the Feed forward distributed neural network has better performance results when compared to hamming distance. Thus the Feed forward distributed time delay neural network may be more efficient in the case of iris recognition and verification.

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