Iris Recognition based on Wavelet Transform and Probabilistic Neural Network

Azade Bastani [1]
[1]Department of Computer Engineering, Behbahan Khatam Alanbia University of Technology, Behbahan, Khozestan, Iran

***Abstract*—In this paper, we propose an iris recognition system using wavelet decomposition method and probabilistic neural Network (PNN) to analyze the pattern of a human iris. In the feature extraction part, unrolled iris images are filtered using wavelet transform for four times. Iris recognition is then performed by using PNN. The recognition rate of 98.37% is achieved on CASIA database.**

***Keywords*— Iris Recognition, Discrete Wavelet Transform, Probabilistic Neural Network,**

I. INTRODUCTION

Iris recognition is one of the main applications of machine vision that is widely attended in recent years that can be used in ID validity, Identity recognition and so on. Iris patterns are unique, and most evidently cannot be changed, so among all potential biometric methods that make use of face, fingerprint and voice, iris recognition remains the most reliable biometric authentication that is unrivaled when used for security usages [1], [2]-[3].

The designed recognition system has three stages. At first stage, some preprocessing methods which include determining the boundary of the iris within the eye image using Canny edge detection, Circular and linear Haugh Transform and histogram equalization is applied for image enhancement.

At the next stage using the Haar wavelet decomposition iris features from available images extracted. The last stage to feature classifying makes use of a probabilistic neural network to test designed system. Figure1 shows the diagram of our method.

II. PREPROCESSING STAGE

It is so important to use the preprocessing methods that lead to good recognition. In this stage the boundary of the iris within the eye image has been detected, remapped to a rectangle block and finally has been equalized for improving its contrast.

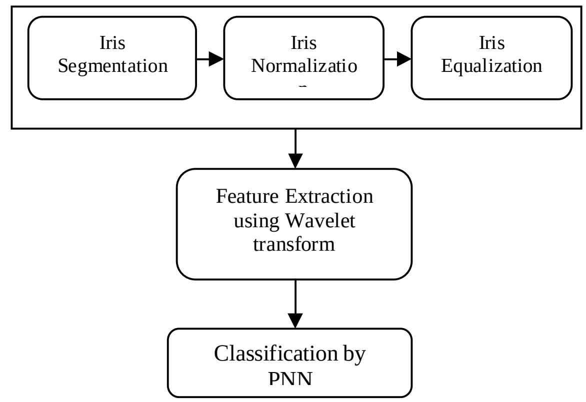

Fig. 1: Diagram of iris recognition

A. *Iris segmentation*

The first step in the preprocessing stage is to separate iris from eye, it is necessary to get the inner boundary and the outer boundary of iris.

Applying one of the edge detection techniques can get an edge map of the iris image to enable determining all boundaries of the iris. In this work, we used the Canny edge detection technique.

The next step after determining the edge points is to apply a circular Hough transform to detect the two circles of the iris/sclera (outer) and iris/pupil (inner) boundary. After that by the use of linear Hough transform, the properties of the upper and lower eyelids could be obtained if they exist.

B. *Iris Normalization*

The images of iris taken at different time or in different place have many differences. Due to illumination variations, the radial size of the pupil may change accordingly. Therefore, the iris region needs to be normalized to compensate the difference and improve the precision of matching, so iris normalization is necessary.

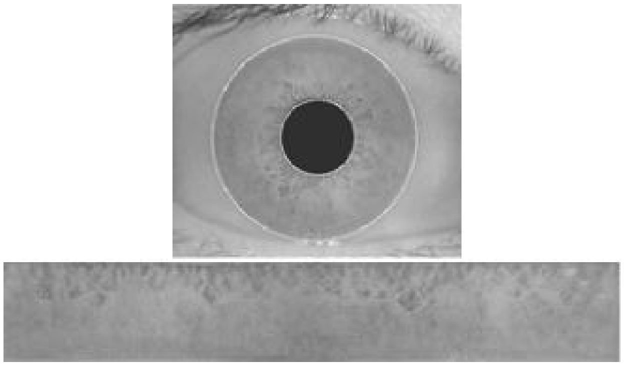

Fig.2. Normalizing the iris image to a strip

Normalization maps each pixel in the localized iris region from the Cartesian coordinates to polar coordinates. Iris area is obtained as a normalized strip with regard to iris boundaries and pupillary center. In this paper, iris area is illustrated on a rectangular block of 52*256. Figure 2 shows the iris image after normalization.

C. *Histogram equalization*

The last step in the preprocessing stage is to apply histogram equalization. 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. Histogram equalization is used to equalize the details of irises in dark regions to increase the rate of identification. Fig. 3 shows an example of histogram equalization.

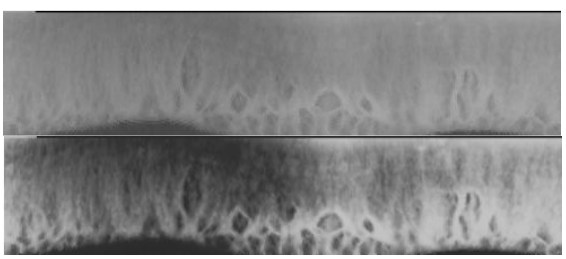

Fig.3. Iris image before and after contrast equalization

III. Feature Extraction

Feature extraction is defined as a process that converts images into unique, distinctive and compact form. To design a good iris recognition system, employing a proper method in the feature extraction is important. In this work, the wavelet transform have been used.

A. *Wavelet transform*

Wavelet transform is a popular method for image processing applications especially in the recent decade. Two-dimensional wavelet transform leads to decomposition an image into four sub-bands. These sub-bands are an approximation of original image, horizontal changes, vertical changes and diagonal changes that have a different resolution with the original image named $L_j, D_{j\ vertical}, D_{j\ horizontal}, D_{j\ diagonal}$, where j show the level of transform. Noise reduction and image reconstruction from transformed image are of advantages of this transform. In image processing lower resolution image can be used to reduce computations. In this study Haar, Daubechies and Symlet mother wavelets have been tried and obtained results for each one have been compared with the others. L_4 has been selected for feature vector because approximation subband possesses most of the energy content and contains the significant features.

IV. Iris Recognition

In recognition step the extracted features should be matched with the other feature vectors to identify the person who has this iris. In this work Probabilistic Neural Network (PNN) has been used for matching and recognition.

A. *Probabilistic Neural Network*

Probabilistic Neural Network (PNN) is a widely used classification methodology that is based on feed-forward architecture and has been used in several applications in bioinformatics. PNN is much faster and more accurate than MLP.

The probabilistic neural network is a subset of RBN and can estimate the functions properly. We used a PNN with four layers of dedicated nodes which includes Input layer, Pattern layer, Summation layer, Output layer. Figure 4 shows the structure of PNN [4]-[5].

Input nodes distribute components of the input X .The number of input nodes is equal to size of input vector X .

Input nodes are fully connected with the next layer of pattern nodes. . The PNN requires one pattern node for every pattern in the training set. The i th pattern node activation function is:

$$y_i = \exp(-(X_i - X)^T (X_i - X) / 2\delta^2) \qquad (1)$$

Where X_i is the i th training pattern, and δ is the smoothing parameter of the Gaussian kernel. In this layer the distance vector is estimated who show distance between each pattern and input vector

In the third layer each summation unit is corresponding to a category which sums the outputs y_i of connected pattern units.

The output layer predicts the target class by finding largest probability among all class probabilities that result in summation layer.

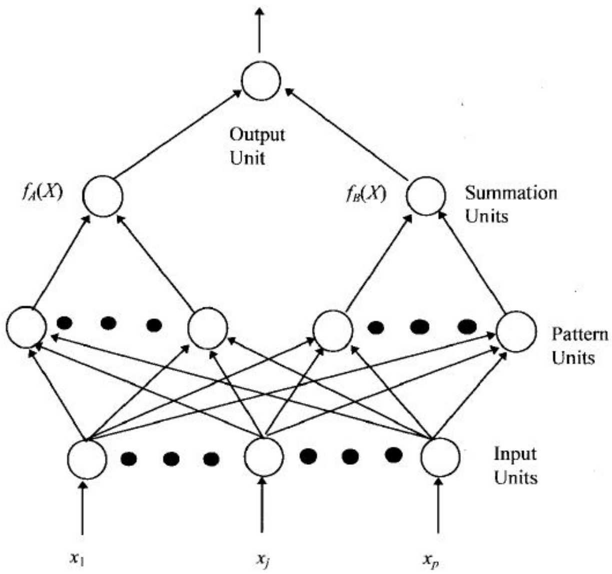

Fig.4. Structure of PNN

V. EXPERIMENTAL RESULTS

ASCIA-iris-V3-Interval database images have been used for implementing and evaluating of proposed method. This database was funded by Chinese Academy of Sciences' Institute of Automation.

In this work, preprocessing methods mentioned above have been applied on iris images. Haar, Daubechies and Symlet mother wavelets have been tried in feature extraction step.

The results of recognition rate using PNN, for different mother wavelet have been summarized in table 1. According to table 1 the Haar wavelet has better performance than the others.

TABLE1. RECOGNITION RATE OF DIFFERENT MOTHER WAVELET

method	Recognition Rate%
Ma[7]	89.37
Boles[8]	92.64
Daugman[3]	99.99
proposed method	98.37

To compare our method with other methods some popular systems that performed their results on CASIA were used. Results are given in Table 2. According to this table our system has a better performance compared with the two first methods. As opposed to Daugman method, which its feature dimension is 2024[6], our proposed method uses 52 features.

TABLE 2. RECOGNITION RATE IN DIFFERENT METHODS

method	Recognition Rate%
Ma[7]	89.37
Boles[8]	92.64
Daugman[3]	99.99
proposed method	98.37

VI. CONCLUSION

This paper presented an iris recognition method based on wavelet transform and Probabilistic Neural Network. Among different mother wavelets, the Haar wavelet gives the best performance. Using PNN classifier, the best result 98.37% obtained with Haar wavelet. The results showed that precision of the proposed method is comparable with other existing methods.

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