Research on Iris Recognition Based on the BP Neural Network

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Abstract

Iris recognition is the high confidence personal identification technology among the other biometrics recognition. This is not only because the iris's unique feature, but also due to its stability that the iris is immune to age and environment. In this paper, we design a feed forward neural network and use the back propagation algorithm to explore an elementary iris recognition system model. 10 iris samples are used as the recognition objects. The experiment demonstrates that though the recognition model is simply constructed, it has a high recognition rate and the recognition speed is reasonable. The proposed methodology provides a convenient way for iris recognition.

Keywords: iris recognition, artificial neural network, back propagation algorithm, image processing

1. Introduction

At present, iris recognition is used in various fields due to its significant advantages: (1) Iris is human's internal organization which is covered with a transparent membrane (cornea). For this reason, it is hard to be changed. However, fingerprint is apt to be blurred after a few years manual labor and can be forged by fingerprint paster. (2) Iris is quite smooth as its geometry shape is only controlled by two cooperative muscles (sphincter pupillae and dilator pupillae). Therefore, the shape of iris is easier to be predicted. (3) Like the texture of fingerprint, the texture of iris is random determined in the period of gestation. Many factors can influence the formation of iris so the error probability of matching is quite low even though it is not testified technically that the iris's texture is absolutely unique[1,2]. (4) Iris scanning is as simply as taking photograph. It can be processed from 10cm to several meters. Thus, the measured object needs not to touch the scanner.

Many applications of iris recognition are used. For instance, Canada Border Services Agency introduces CANPass program[3]. Netherlands, Arab, Britain and Germany also apply the iris recognition technology into immigration clearance. Meanwhile, many scientists have devoted to relevant study[4]. Boles and Boashash built a 1D representation of the gray level signature of the iris and applied it to zero-crossing of the dyadic wavelet[5]. Ma, Wang, and Tan used a bank of Gabor filters to capture the iris profile[6]. Poursaberi generated a binary code representation of the iris and used a minimum Euclidian distance for matching[7].

In this paper, an algorithm that simplifies the procedure of recognition is proposed. Our approach is characterized by: (1) Image pre-processing is used so as to avoid using complex mathematical algorithms. (2) The BP neural network is adopted. (3) Use grayscale value of each pixel for learning and recognition.

The paper is organized as follows: Section 2 discusses the reason of using iris as object and the status quo of iris recognition technology. In section 3, the related and background of artificial neural network is reviewed. Section 4 presents the pre-processing of 10 iris samples, the design of the BP neural network, the application of the entire recognition system model and the experiment results. Finally, section 5 draws some conclusions.

2. Iris Recognition

2.1. *Biological characteristics of iris*

The iris is the colored, thin, circular structured muscle within the eye, which regulates the size of the pupil and thus controls the amount of light that enter the eye. The iris begins to form as soon as the third month of gestation. By the eighth month, the structures that creating the iris patterns are largely completed. However, pigment accretion can continue during the first postnatal years. Because the iris patterns are formed randomly, even genetically identical twins will not have the same iris patterns[8]. Fig.1 shows the iris image and its position in the eye.

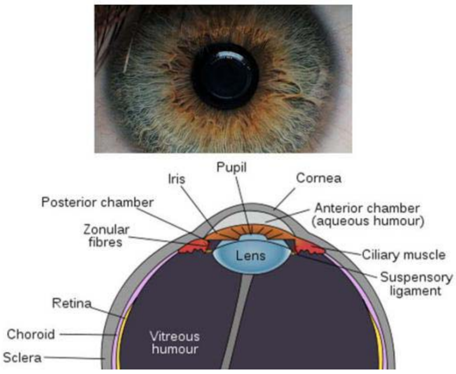

Fig. 1. Iris and its position in the eye

2.2. *The history of the iris identification*

The French ophthalmologist Alphonse Bertilon (1885) is considered to be the first for iris identification based on its color[9]. In 1985, ophthalmologists Leonard Flom and Aran Safir proposed that no two irises are exactly the same, and they got the patent application in 1987[10]. Then they cooperated with Dr. John Daugman[11], a computer scientist of the University of Cambridge, UK, and developed an algorithm to automatically identify the human iris. In 1993, the Defense Nuclear Agency began to test and deliver a prototype unit, which was successfully completed by 1995 due to the combined efforts of Flom, Safi and Daugman.

After that, many scientists have devoted themselves to the relevant study, such as R.Wildes[12], W.Boles[13] and R.Sanchez-Reillo[14] proposed different algorithms. In 1995, the first commercial products became available[15]. Many companies began to develop their own iris recognition algorithm. For example, L-1 Identity Solution which was established in 2006 provides all service and solution concerning human identification. Oki also provides a variety of security system based on iris identification.

3. Neural Network

3.1. *Biological neuron*

Neuron is the basic unit of structure and function of the nervous system, Fig. 2 shows a typical neuron structure.

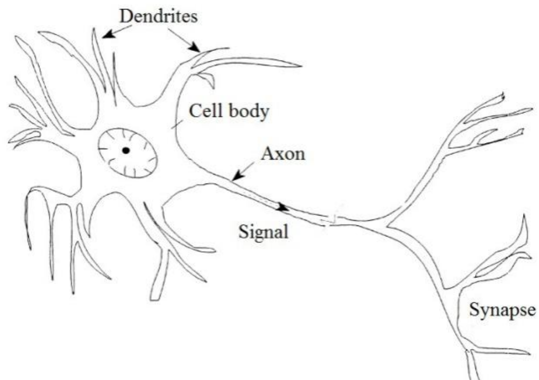

Fig. 3. Biological neuron

When a neuron is stimulated and excited, exciting will be converted into a signal and be conveyed to synapse through axon. After the rapid diffusion of chemical molecules defused by the synapse in the synaptic space, the neighboring neurons generate new impulses and pass them to the next neurons in the same way.

This simplified mechanism of signal transfer constituted the fundamental step of early neurocomputing development[16].

3.2. *Artificial neuron*

Artificial neuron simulates the nonlinear characteristics of biological neuron (multiple input and single output). In 1943, McCullon and Pitts proposed the McCulloh-Pitts neuron model (shown in Fig. 3). The mathematical expression is:

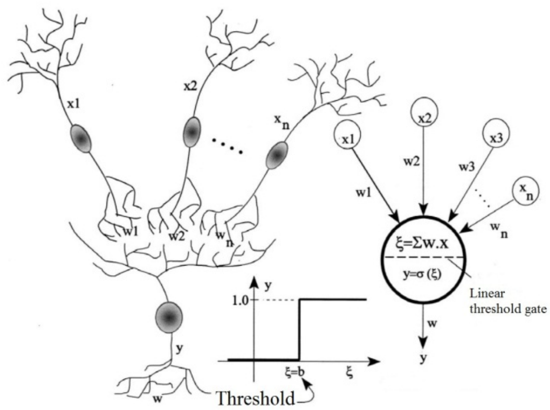

Fig. 2. Artificial neuron model

$$y = \sigma(\xi) \tag{1}$$

$$\xi = \sum_{i=1}^{n} w_i x_i - b \tag{2}$$

x_i (i=1,2,...,n) is the input signal from other neurons; w_i (i=1,2,...,n) presents the weight between two neuron; b is the threshold of the neuron[17], y is the output of the neuron; $\sigma(\cdot)$ is the activate function. The output y is 0 or 1, which presents suppression or exciting respectively.

$$y = \sigma(\xi) = \begin{cases} 1, & \xi \geq 0 \\ 0, & \xi < 0 \end{cases} \tag{3}$$

3.3. *Multilayer feedforward neural network*

In 1985, Rumelhart and McClelland research group proposed the multilayer feedforward theory and the error back propagation algorithm base on parallel distributed information processing. The BP neural network may contain one or several hidden layers (Fig.4).

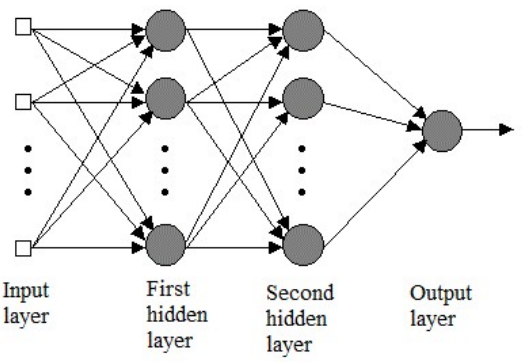

Fig. 5. Multilayer neural network

4. Application on Iris Recognition

4.1. *Pre-processing of raw images*

Ten different colored iris images are selected to be pre-processed[18-20] to grayscale images (shown in Fig.5)

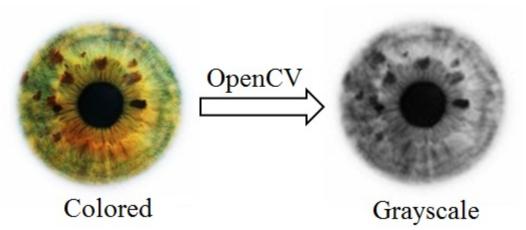

Fig. 6. Image processing

and extracted the grayscale pixel features as the inputs to the neural network. All the iris images are processed by OpenCV, and converted the size to 100×100 pixels.

4.2. *Neural network design*

First, get the input and target samples of the neural network. We treat the processed image as a 100×100 matrix, each element stores the grayscale pixel value as shown in Eq. (4). After that, the matrix is converted into a 10000×1 column vector that is treated as the input vector of the neural network (Fig. 6).

$$\begin{bmatrix} v001001 & v001002 & \cdots & v001099 & v001100 \\ v002001 & v002002 & & v002099 & v002100 \\ \vdots & & \ddots & & \vdots \\ v099001 & v099002 & \cdots & v099099 & v099100 \\ v100001 & v100002 & \cdots & v100099 & v100100 \end{bmatrix} \tag{4}$$

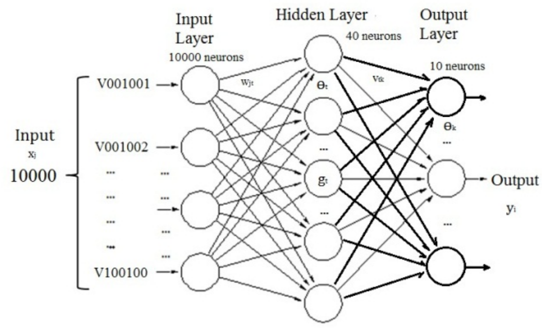

Fig. 4. The input of network

Thus, the input layer of neural network has 10000 neurons. Learning assumes that each input vector is paired with a target vector representing the desired output; together they are called a learning pair[21]. In this study, 10 learning pairs would be required, so the output layer neurons is 10. Output results are restored in a 10×1 column vector.

For the number of hidden layer neurons, we refer to the empirical formula Eq.(5). After that, we delete the hidden neurons whose influence is little and then set the final hidden layer neurons number as 40.

$$n_2 = \sqrt{n_1 + n_3} + c \tag{5}$$

Here, n_1, n_2 and n_3 are the numbers for the input, hidden and output layer neurons.

4.3. *Neural network learning*

The learning rate η and learning times are 0.4 and 5000 respectively. All the weights (w_{jt}, v_{tk}) and threshold values (θ_t, θ_k) must be initialized to small random decimals before staring the learning process.

Training the BP neural network follows the five steps:

(1) Select the learning pair (X^p ,Y^p) from the 10 pairs.

$$X^p = (x_1, x_2, \ldots, x_m)^T \tag{6}$$

$$Y^p = (Y_1, Y_2, \ldots, Y_n) \tag{7}$$

(2) Calculate the hidden and output vector of the neural network by Eq.(8) and Eq.(9) respectively.

$$g_t = f\left(\sum_{j=1}^{m} w_{jt} x_j - \theta_j\right) \ (t = 1,2,\cdots,a) \tag{8}$$

$$y_k = f\left(\sum_{t=1}^{a} v_{tk} g_t - \theta_k\right) \ (k = 1,2,\cdots,n) \tag{9}$$

(3) Calculate the general errors of each layer of neural network, δ_k^p and δ_t^p .

(4) Adjust the weights of the network.

$$v_{tk}(n+1) = v_{tk}(n) + \eta \cdot \sum_{p=1}^{P} \delta_k^p \cdot g_t^p \tag{10}$$

$$w_{jt}(n+1) = w_{jt}(n) + \eta \cdot \sum_{p=1}^{P} \delta_t^p \cdot g_j^p \tag{11}$$

$$\theta_k(n+1) = \theta_k(n) + \eta \cdot \sum_{p=1}^{P} \delta_k^p \tag{12}$$

$$\theta_t(n+1) = \theta_t(n) + \eta \cdot \sum_{p=1}^{P} \delta_t^p \tag{13}$$

(5) Repeat steps 1 through 4 for the 10 pairs until the sum squared error in Eq.(14) for the entire set is acceptable low.

$$E = \sum_{p=1}^{P} \sum_{k=1}^{n} (Y_k^p - y_k^p)^2 / 2 \tag{14}$$

The result of the neural network learning is illustrated in Fig. 7. After 3000 times training, the sum squared error is acceptable low.

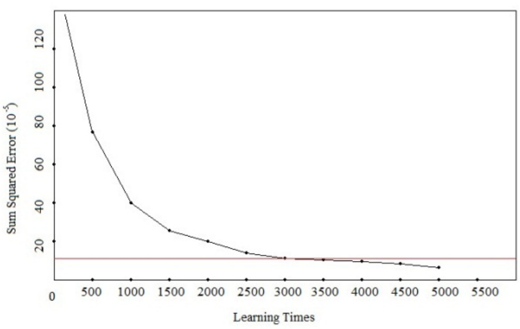

Fig. 7. Sum squared error for 5000 times learning

4.4. *Recognition and results*

Recognition requires the steps[22]: in Fig. 8, (1) Click the menu 'File' on the left top corner, to load the original grayscale iris images. The 10 images are displayed. (2) Select the region of iris model (as the 100×100 region) from the 10 iris images then generates the model. After this step, 10 iris models will be converted to 10 matrixes and displayed below the original images (circled in Fig. 8).

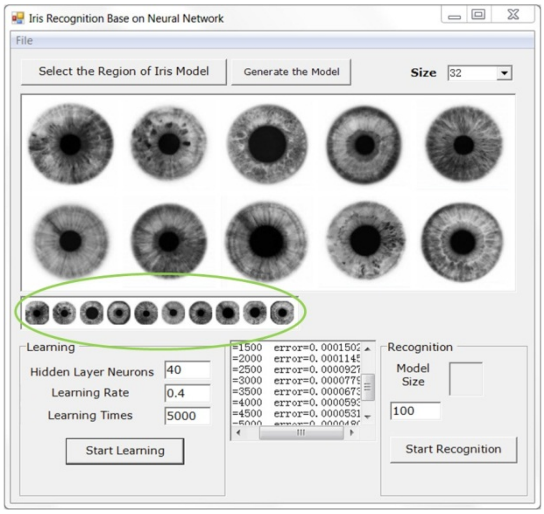

Fig.8. Neural network learning

(3) Train the neural network by clicking the button "Start Learning", and the training procedure is also shown in Fig.8. (4) Click the button "Start Recognition" to recognize whether the selected iris is one of those 10 irises or not.

The recognition procedure is shown in Fig.9 and the recognized object is marked by the square. The experiment result shows the match rate is 99.946% for the selected object.

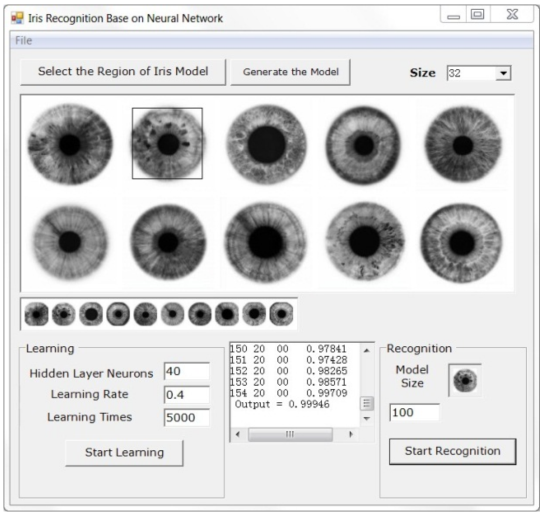

Fig.9. Recognition results

5. Conclusion

In this paper, we design a neural network and used the back propagation algorithm to develop an elementary iris recognition system. The experiment demonstrates that the system has an ideal identification rate. With the development of the demand of identity recognition, this system can be applied in many fields such as security check and entrance guard.

In this study, the extraction of the basic features of the iris mainly utilize image processing, future research will use more shape and structural characteristics of the iris itself as the feature values.

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