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Application of BP Neural Network in the Fingerprint Identification

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Abstract. Fingerprint identification is an individual recognition technology, which is based on the uniqueness and invariance of persons' fingerprint characteristics. In recent years, this means of identification has made substantial progress and development, which is one of the most mature technology in the development of biometric. Fingerprint identification has been widely used in social life and production fields. However, due to a variety of noise, there is a great deal of difficulty in the process of fingerprint identification and confirmation. This paper uses BP neural network for fingerprint feature extraction and recognition, discusses the network to set the initial weights of the principle, and puts forward the selection of principle of hidden layer number of neurons, reduces training time and calculated amount to improve the identification of accuracy.

Keyword: Pattern recognition; Neural network; Fingerprint identification; Back Propagation

1. Introduction

With the development of electronic commerce, smart cards and other technologies, people put forward higher requirements for the identification of accuracy, practicality and safety than the traditional way. Because of the body's physiological or behavioral characteristics of exclusivity, and the advantages of invariance and scalability, researchers turn to look the biological recognition technology. Based on the person's features like fingerprints, face and voice, researchers develop a variety of biometric identification technologies, such as fingerprint identification, face recognition, voice recognition and so on. In all kinds of biometric identification technologies, the fingerprint identification with its unique advantages becomes the current hot spot, which is also the most mature development.

Studying the automatic fingerprint identification technology, involves anatomy, fuzzy mathematics, topology, mathematics, combinatorial mathematics, pattern recognition, digital image processing, database and so on, which is the applied research based on basic research. In the subject, it belongs to the category of pattern recognition and artificial intelligence. The automatic fingerprint identification technology is one of the important parts of the new identification technology.

2. The Principle of Fingerprint Recognition

Automatic fingerprint identification system is a typical example of the biological characteristics identification system, which mainly includes fingerprint collection technology, fingerprint image processing technology and fingerprint matching technology. The system has two possible working states of register and validation, as shown Fig. 1 and Fig. 2.

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Fingerprint entry: the more common practice is using the crystal fingerprint terminal or optical fingerprint terminal to collecting digital fingerprint image. The image size is 256×256 or 512×512 commonly.

Pre-treatment: including usually sense of pretreatment and image quality evaluation. The goal is to reduce the noise or other interference, to improve the quality of the fingerprint image, such as getting more clear lines. It is including image segmentation, pattern, filter enhancement, binarization, thinning, etc. For different system, you can choose different combinations of preprocessing steps to achieve optimal results. While the image quality assessment is to ensure overall system's stability and reliability.

Handling characteristics: extracting partial or total of characteristics fingerprint, getting ready for Matching with template.

Matching: comparing fingerprint characteristics that will be identified with characteristics database, and then finding the best matching and getting the matching result.

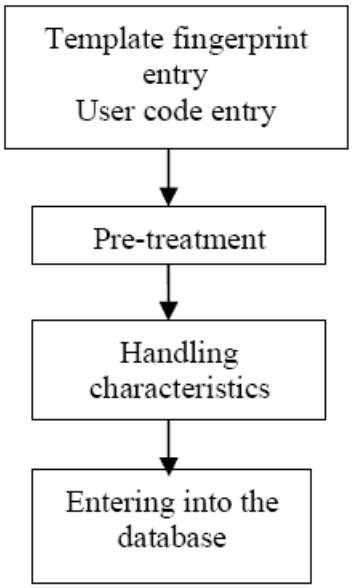

Figure1.Register

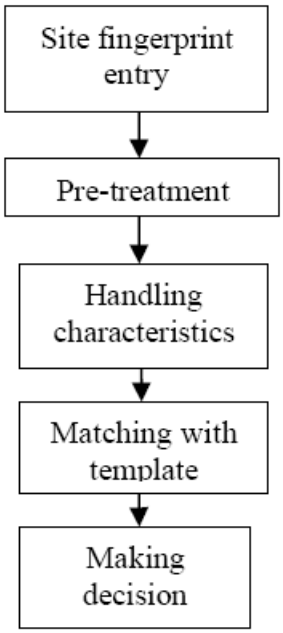

Figure2.Validation

3. The Principle of Neural Network

Neural network is the set of single parallel processing elements, which originates from the biological neural system. In the nature, network functions are mainly determined by the ganglion. We can change the weight of the connection point to train the neural network to accomplish a specific function. The general neural network is adjustable or trainable, so that a particular input can get the required output, show as Fig. 3.Here, the network adjusts according to the comparison of the output and the target, until the network output matches with target.

3.1 The principle of neural network.

Back Propagation (BP) neural network is proposed by Rumelhart and McClell in 1985. The basic principle of the algorithm is to use the output error to estimate the output layer's direct leading layer's error, and then use this error to estimate the previous layer, layer by layer, and we get all the other layers' error estimates. BP neural network is one of the most widely used neural network model. When the actual output is inconsistent with the given input, the gradient descent algorithm can be used to fix the old bond strength between layers, until it satisfies the given input-output relationship. The network is self-organization's neural network toward meeting a given input-output relationship. BP network consists of input layer, hidden layer and output layer, and adjacent layers are connected with neure, layer neurons with no connections. Show as Fig. 4.

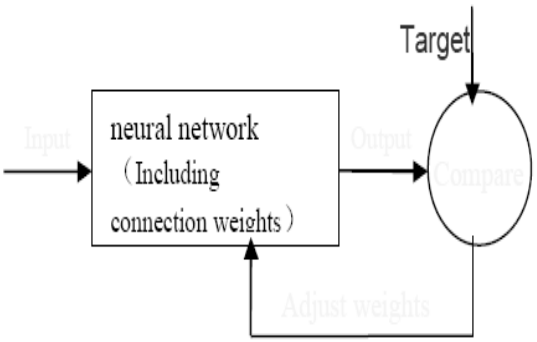

Figure3. The basic structure of neural network

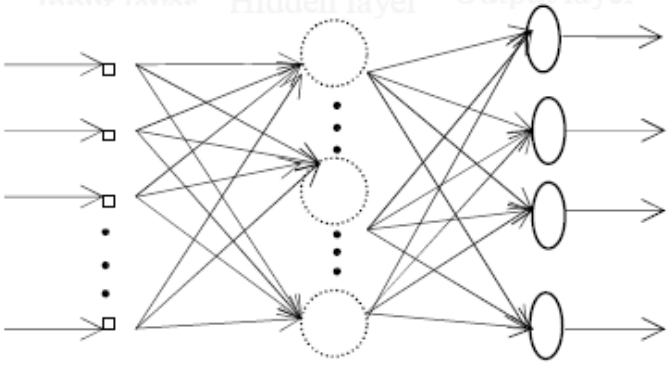

Figure4. BP neural network model

3.2 The learning algorithm of BP network.

BP network learning process is the neural network changes the network connection weights in the stimulation of the outside input samples, so that the output of the network constantly closes to the desired output. The core idea of the algorithm is to make output error some form of hidden layer toward input layer inversely layer by layer. Its nature is dynamic adjustment of the connection weights. Relationship between input Eq.1 and output Eq.2 :

$$net = p_1\omega_1 + p_2\omega_2 + ... + p_n\omega_n . \tag{1}$$

$$y = f(net) = \frac{1}{1+e^{-net}} . \tag{2}$$

ω: Connection weights between the former layer and the neuron. net: The total input that neurons receive. y : The output of neuron. Under the action of the function $f(\cdot)$ produces the output y . $f(\cdot)$ takes for the function $Sigmoid$:

$$y = f(n) = \frac{1}{1+e^{-n}} . \tag{3}$$

The character of function $Sigmoid$: value field y∈(0, 1); Nonlinearity; Monotonic; Infinitely derivable; When | n | is small, it can be approximated by a linear function; When | n | is large, it can be approximated by a threshold function. Therefore, The BP network learning algorithm can be summarized:

First step: Set variables and parameters. $f(\cdot)$: Active function, $y(k)$:Network real output, $t(k)$: Desired output, μ :Learning rate, k :Number of Iterations, e :The error between actual output and expected output.

Second step: Initialization. Set the value of each component of weight vector as between random numbers (0, 1), $k = 0$

Third step: Input a group of training samples, $p(k) = [p_1, p_2, ..., p_m]$, and then give its expected output.

Fourth step: Calculate the layer's actual output Eq.4.

$$y(k) = f(\sum_{i=0}^{m} p_i \omega_i) . \quad (4)$$

Fifth step: Compute D-value between expected output and actual output:

$$e = t(k) - y(k) . \quad (5)$$

Sixth step: Judge the current output according to the error.If all the sampling error is zero or less than the preset value, the algorithm is end. Otherwise, value= value +1, and use Eq.6 to adjust the weights:

$$\omega(k+1) = \omega(k) + \mu e p(k) . \quad (6)$$

Then turn to the third step into the next round calculation.

Seventh step: After the network training reaching steady state, for subsequent identification.

3.3 Structural design of application system.

The choice of fingerprint image samples.The fingerprint identification system normalizes the collected fingerprint image into the same size bitmap, as a sample of BP network. Because of the light environment's interference and fingerprint-gathering position changing, the normalized images have some differences. In some cases, the selection of Samples affects the recognition rate of the whole BP network. Therefore, this paper presents the principles of sample selection: uniformly selecting a sample; selecting similar samples as possible as we can; the changing rate of adjacent samples is less than precision error. Experiments show that good sample can improve the training speed.

In the network training time, samples are established according to different situations, and then the weight will be saved. In the identification phase, different weights will be used to identify.

The choice of parameters of the neural network. Multi-layer network has more neural nodes and connection weights, so that the amount of calculation increases and the ability of Network's induction and generalization decline. If the three-layer BP neural network hidden layer neurons characteristic function f has arbitrary order derivative, the number of hidden layer neurons is large, and output neuron belongs to linear function, and then single output three-layer BP neural network can approximate any continuous function. This system Relates to the classification of small categories, so it only need a hidden layer of three-layer BP neural network. The number of input layer neuron nodes is determined by the normalized image pixel size. That is to say, the number of input layer neuron nodes: $n = a \times b$ .Here, a, b represent the image's width and height.

In the BP network, the function of hidden layer is to extract feature for the input pattern, and then it will pass the extracted features to the output layer. The hidden layer and the input layer are connected by weights. If the number of hidden layer neurons is too small, you can't make network set up the complex determine boundary. While if the number of hidden layer nodes increases to a certain amount, the computational complexity will increase and the Network training convergence speed will be reduced, so the generalization ability will deteriorate. Here we use the Kolmogorov theorem: If neural network, which is single hidden layer, has N has input nodes, the number of hidden layer's nodes is 2N+1.

The number of output layer's nodes is determined by the network's output form and decision rule.

The initial value of BP network weights comes from random digit in (-1,1),and the learning rate range,which determine the changing amount of weights that each cycled training generate,is (0.01,0.8).

4. Feature extraction and experiment

Biometric systems typically include the following process: collecting,decoding, comparing and matching. The advantages of using fingerprint recognition are convenient,reliable and easily acceptable.The process of fingerprint identification includes capturing fingerprint image, extracting feature of fingerprint image, feature values comparing and matching.

Fingerprint identification consists of registration and verification process. During the registration process, users need to collect fingerprints firstly, and then feature extraction is done automatically through automatic image processing algorithms, and extracted features will be saved into the database or other designated place as templates. Users collect fingerprints again. Then the computer system does feature extraction. Compare

fingerprint characteristics that will be identified with characteristics database, and then find the best matching and get the matching result. Sometimes, the user may enter other auxiliary information to help the system match. Such as user name, account password etc.

The aforementioned method is applied on 200 different fingerprint samples' experiment, 100 fingerprint samples in which are as training data and the remaining is testing data. First, the training data learns and save up learning outcomes. And then fingerprint's testing data is identified .The result is shown in Table1.The experimental result show that BP neural network can effectively do fingerprint feature extraction and recognition, which has some applying value.

Table 1 The experimental result

Training number	Examining number	Mistaken number	Recognition rate
100	100	2	98%

5. Conclusions

Fingerprint is unique Bioinformatics to each person, which has the invariance in one's life. This paper describes the application of BP neural network in the fingerprint identification and lets us know the importance of neural network in life. And making use of advantages of BP neural network classification ability and learning ability achieve fingerprint feature extraction and recognition.

Fingerprint identification has security and convenience, which avoid the risks of password and card. It will be widely used in the field of security technology.

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