Neural Network Based Automatic Fingerprints Classification Algorithm

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***Abstract*—It Presented one neural network based automatic fingerprints classification algorithm. Fingerprint features extracted through resolving directed graph are input into neural network to be classified. Weight coefficients of network connection are studied and optimized based on the genetic algorithm. Test results show that its performance is excellent and the total accurate classification rate reaches up to 93.12%. Research in the paper is significant to fingerprint identifications applied in large-scale information security authentication systems such as bank saving network system and network exchange system.**

Keywords- fingerprint identification , automatic classification algorithm, neural network

I. INTRODUCTION

As an effective and important means to verify members' identity, fingerprints identification technology has extensive applications in the fields of information security to ensure people's legal rights and interests, timely prevent and hit crime events and maintain country safety and society stability [1,2]. According to global ridgeline and line-feature of the fingerprint center area, fingerprints are generally categorized into five kinds: left loop, right loop, whorl, tented arch and arch [3]. Generally, fingerprints features include overall features and minutiae features. The process of fingerprints identification is: one fingerprint is categorized according to the overall feature and contrasted according to the minutiae feature to find corresponding fingerprint in the fingerprints database. At present, fingerprints classification algorithms are mainly based on models, structures, frequency domain and syntax. A good algorithm must have good performance such as rotation invariability, translation invariability and insensitivity to fingerprint distortion. The key points of developing fingerprints classification algorithm include what features and what classification strategy to be selected [4,5]. Aiming to the low fingerprints classification rate in existing large-scale fingerprints identification authentication systems, an automatic classification algorithm based on neural network and genetic algorithm is presented. Test results show the effectiveness and reliability of this algorithm.

II. AUTOMATIC CLASSIFICATION ALGORITHM

Figure 2 shows the three-layer forward feedback network framework used in automatic fingerprints classification algorithm. It's composed of input-layer, interim-layer and output-layer [6]. Firstly, fingerprint samples are categorized according to the fingerprint global features. Then, overall fingerprint features are extracted and input into the network framework to be trained. Next, in the genetic algorithm of the interim-layer, weight coefficients of network connection are studied iteratively according to trained target functions to find the optimum one. Finally, fingerprints classification results are output through the output-layer.

A. Trained target function

Output of each element in the inter-layer can be represented as:

$$h_j = f\left[\sum_{i=0}^{l-1} V_{ij} x_i - D_j\right] \tag{1}$$

Output of each element in the output-layer can be represented as:

$$y_k = f\left[\sum_{j=0}^{m-1} W_{jk} h_j - D_k\right] \tag{2}$$

Trained target function can be represented as:

$$J = \frac{1}{P}\sum_{P=1}^{P}\sum_{k=0}^{n-1} S_{Pk} \tag{3}$$

Where, i, j, k presents the input-layer, interim-layer and output-layer, respectively, l, m and n presents element number and x_i, h_j, y_k represents the parameter of each corresponding layer. V_{ij} is the weight coefficient transmitted from the input-element to the interim-element. W_{jk} is the weight coefficient transmitted from the inter-element to the output-element. D_j 、 D_k is the threshold value of the interim-element and output-element, respectively. P is the number of trained samples. S_{Pk} is the square value of the error between the expected output and the practical output.

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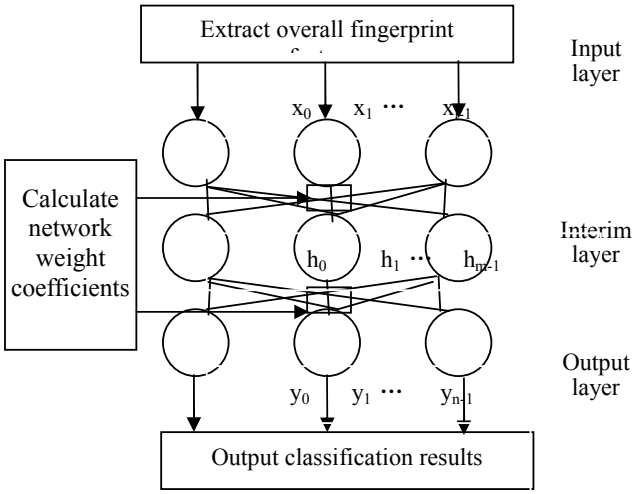

Figure 1. Framework of the three-layer forward feedback network

B. *Samples suitability degree*

Because individual selection probability is proportional to the suitability degree, the definition pattern of the suitability degree function has great effects on genetic algorithm. There is strict mapping relation between the suitability degree function and the target function. The suitability degree function is expressed as:

$$f_i = \begin{cases} C - J & (J < C) \\ 0 & (J \geq C) \end{cases} \quad (4)$$

Where, C = Max (J).

C. *Training flow*

The flow of the network-training algorithm is shown in Figure 3. Initial sample number produced randomly is 50. Copy, exchange and variation are accomplished through genetic operation. Copy is to improve global constringency efficiency of the algorithm, it's basic principle is that copy probability is proportional to the suitability degree, i.e. the bigger the suitability degree of the individual has, the bigger probability it will be copied to next generation. Exchange is to compose a new individual sample and search effectively in the sample space to avoid losing effective gene. Variation works mainly where some effective genes has lost.

If weight coefficients of the neural network are fixed after they are trained, the network will become a prototype classification device. Classification results can be got through inputting fingerprints images into it, as shown in Fig.4. Due to inherent fault tolerance of the network, actual classification results can be got even global features input are beyond the trained samples group.

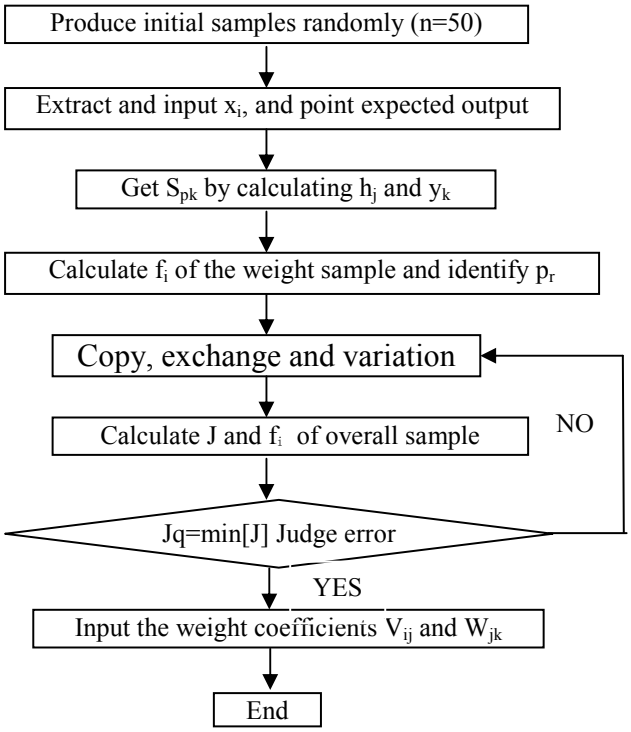

Figure 2. Flow of network-training algorithm

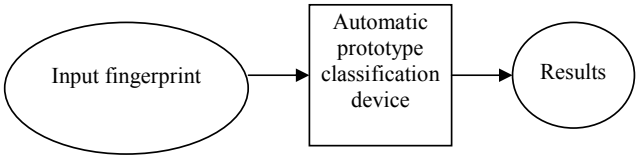

Figure 3. Principle of classification device

III. TESTS

100 fingerprint images are chosen as samples to perform network weight coefficients training. After the weight coefficients meet the constringency requirement, 480 fingerprint images with good quality are elected to compose fingerprints database. Original fingerprints are chosen based on the natural palms distribution, i.e. left loop, right loop, whorl, tented arch and arch accounts for 17.08%, 36.05%, 31.87%, 8.12% and 6.88%, respectively. Test results derived from the classification algorithms based on models and neural network, respectively, are listed in Table 1. From the data, it can be known total accurate classification rate of the neural network based is 93.12%. For every kind of fingerprint, accurate classification rate of the neural network based is higher than the models based, which sufficiently verifies the efficiency of the new algorithm [4].

Due to the diversity of the fingerprints texture, complexity and blur characteristics of the fingerprints classification systems, generally, 10~15% fingerprints can't be classified accurately in conventional fingerprint classification methods, which greatly affects the application significance of the classification algorithm. Accurate classification rate of the new automatic classification algorithm based on the neural network is greatly improved to ensure the classification stability and reliability, which make it possible to be extensively applied in large-scale information security authentication systems such as bank saving network system and network exchange system.

TABLE I. **COMPARISON BETWEEN TWO ALGORITHMS**

Fingerprint type		Left loop	Right loop	Whorl	Tented arch	Arch	Total accurate classification rate
Actual	Quantity	82	173	153	39	33	
	Ratio to the total/%	17.08	36.05	31.87	8.12	6.88	
Models based	Quantity	71	154	133	33	30	87.71%
	Accurate classification rate/%	86.58	89.01	86.92	84.61	90.90	
Neural network based	Quantity	78	159	143	37	30	93.12%
	Accurate classification rate/%	95.12	91.91	93.46	94.87	90.9	

IV. CONCLUSIONS

Aiming to some application limitations of the large-scale information security verification systems, such as huge capacity of the fingerprints database and low identification rate, a new automatic fingerprints classification algorithm based on neural network and genetic algorithm is presented. Fingerprints global features extracted through resolving directed graph are input into neural network to be classified. Weight coefficients of network connection are chosen to study and optimize through genetic algorithm. Initial test results show that performance of the automatic classification algorithm is good and the total accurate classification rate reaches up to 93.12%, which makes it possible to be extensively applied in automatic fingerprint identification systems.

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