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Fingerprint Identification and Verification System by Minutiae Extraction Using Artificial Neural Network

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Abstract— The proposed Fingerprint Identification and verification System is biometric identification methodology that uses digital imaging technology to obtain, store, and analyze fingerprint data. Here we want introduced a new method for fingerprint identification technology by minutiae feature extraction using back-propagation algorithm. For an input image, the local ridge orientation is estimated and the region of interest is located. Then, ridges are extracted from the input image, refined to get rid of the small speckles and holes, and thinned to obtain 8-connected single pixel wide ridges. Minutiae are extracted from the thinned ridges and refined using some heuristics. A feature extractor finds minutia features such as ridge end, bifurcation, short ridge and spur from the input fingerprint images. The digital values of these features are applied to input of the neural network for training purpose. For fingerprint recognition, the verification part of the system identifies the fingerprint based training performance of the network. Finally experimental result shows that the number of recognized sample rate of our proposed method is 95% which is much better than the existing fingerprint verification system using artificial neural network (92.5%)..

Index Terms— Biometric, Fingerprint, Minutiae, Artificial Neural Network, Back propagation Algorithm.

1 INTRODUCTION

FINGERPRINTS have been in use for biometric recognition since long because of their high acceptability, immutability and individuality [1]. Biometrics techniques are divided into two categories i.e. Physiological (fingerprints, face, iris, DNA, retina, voice, hand geometry, palm print, retinal scan etc.) and Behavioral (gait, signature etc). These physiological or behavioral Characteristics are used for human identification on the basis of their universality, uniqueness, permanence and collectability [7]. Fingerprint is the oldest process to detect human identity. In a recently published World Biometric Market Outlook (2005-2008), analysts predict that the average annual growth rate of the global biometric market is more than 28%, by 2007. The technologies that would be included in this are fingerprint technology by 60%, facial & iris by 13%, keystroke by 0.5% and digital signature scans by 2.5% [2]. So it can be state that automatic fingerprint identification system is an efficient method to recognize human identity. Here we propose a new method which will identify and verify fingerprint image using back propagation neural network with other attractive feature.

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2 FINGERPRINT

A fingerprint is the feature pattern of one finger (Figure 1). Each person has his own fingerprints with the permanent uniqueness.

Fig. 1 Fingerprint image acquired by an Optical Sensor

A fingerprint is composed of many ridges and valleys. Fingerprints are not distinguished by their ridges and valleys, but by Minutia, which are some abnormal points on the ridges [3] (Figure 2).

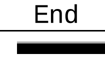
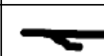
Feature	Short Ridge	Ridge End	Bifurcation	Spur
Sample				

Fig. 2 Minutia (Short Ridge, Ridge end, Bifurcation and Spur)

Minutiae

The most evident structural characteristic of a fingerprint is the pattern of interleaved ridges and valleys that often run in parallel; at local level, other important features called minutiae refer to ridge discontinuities. Most minutiae can be individuated by their shave. Such as bridge are like "H", bifurcation like "Y" etc.

Artificial Neural Network

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. There are three layers (input, hidden and output) in the network. To train the network, an algorithm is used such as back propagation [8].

Afsar et al [5], proposed a Gabor filter based method to enhance the input fingerprint image. But it has some drawbacks -it is slightly higher computational cost, more time consuming. A common problem of the MGF is fail when image regions are contaminated with heavy noises.

Chaur-Chin Chen and Yaw-Yi Wang [6] was implemented an automatic fingerprint identification system (AFIS) with the use of fingerprint classification and minutiae pattern matching. But it has some drawbacks- It is used for small database and only minor rotations and translations from one fingerprint to another may exist.

Rashid and Hossain, [4] was proposed a method of fingerprint identification system using back propagation algorithm. But it has some drawbacks. It can not remove false minutiae.

Objective

Our proposed method reduces almost noise of fingerprint images. It also reduces time complexity of fingerprint image enhancement process. It is capable of handling large fingerprint database by using neural network. We can get the result of the fingerprint matching very fast. Our system correctly matches the fingerprint image. It is an efficient method of fingerprint verification system by minutiae extraction using artificial neural network.

Fingerprint Image Pre Processing

Fingerprint Image Enhancement Using Contrast Image Enhancement Technique

We want to enhance fingerprint image of our system using contrast image enhancement technique of spatial domain method. After that histogram equalization and contrast-limited adaptive histogram equalization are performed.

Binarization-based Minutia Extraction:

In this step the gray-scale fingerprint image (8 bits per pixel, 256 gray levels) is converted into a binary form (1 bit per pixel, 0 or 1).

Estimation Block Direction Of Fingerprint Image

In this step the block direction was estimated for each block of the fingerprint image with WxW in size (W is 16 pixels by default). The algorithm is:

$tg2ß = 2 \sum \sum (g_x * g_y) / \sum \sum (g_x^2 - g_y^2)$ for all the pixels in each block.

Here we considered gradient values along x-direction (gx) and y-direction (gy) as cosine value and sine value. After finished with the estimation of each block direction, those blocks without significant information on ridges and furrows are cut off based on the following formulas:

$$E = \{2 \sum \sum (g_x * g_y) + \sum \sum (g_x^2 - g_y^2)\} / W*W*\sum \sum (g_x^2 + g_y^2)$$

Then we extract the minutia features from the region of interest using morphological operations (open and close). After that ridge thinning is applied to eliminate the redundant pixels of ridges till the ridges are just one pixel wide.

Marking Minutia Features

After the fingerprint ridge thinning, marking minutia points is relatively easy. In general, for each 3x3 window, if the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch .If the central pixel is 1 and has only 1 one-value neighbor, then the central pixel is a ridge ending. Similarly rests of the minutiae features are marked. Together with the minutia marking, all thinned ridges in the fingerprint image are labeled with a unique ID for further operation.

Post Processing

False Minutia Removal

False minutiae can significantly affect the accuracy of matching if they are simply regarded as genuine minutia. So some mechanisms of removing false minutia are essential to keep the fingerprint verification system effective.

1. If the distance between one bifurcation and one termination is less than D and the two minutiae are in the same ridge. Remove both of them. Where D is the average inter-ridge width representing the average distance between two parallel neighboring ridges.
2. If the distance between two bifurcations is less than D and they are in the same ridge, remove the two bifurcations.
3. If two terminations are within a distance D and their di-

rections are coincident with a small angle variation. And they suffice the condition that no any other termination is located between the two terminations. Then the two terminations are regarded as false minutia derived from a broken ridge and are removed.

4. If two terminations are located in a short ridge with length less than D, remove the two terminations.

My proposed procedures in removing false minutia have two advantages. One is that the ridge ID is used to distinguish minutia and the false minutia are strictly defined comparing with those loosely defined by other methods. The second advantage is that the order of removal procedures is well considered to reduce the computation complexity.

Unify Terminations And Bifurcations

Each minutia is completely characterized by the following parameters at last:

(i) x-coordinate , (ii) y-coordinate and (iii) orientation.

Fingerprint Image Matching:

From the above process we get feature matrix of each fingerprint Image. These feature matrixes are used as input data set of neural network. We fixed target output based on average feature value of fingerprint image. After that we train the network for each fingerprint image. A program should be developed to training the neural network for fingerprint identification system, which take the input data from the input file and reduce the error between the accepted output and the actual output. When the error will generate the weight file, and we will get the accepted output for our fingerprint identification system then training process will be stop. The training process will generate the weight file, which contains the weights of the neurons of the network. After complete the training process, we will get the weights of the neurons for the neural network that will be save in the weight file. The weight file will need for testing the fingerprint identification system.

Then we simulate the network with the sample of fingerprint image and got a desired output. Error is calculated from the distance between target and desired output value. Then the weights are adjusted to reduce this error. In the multi-layer networks, there are many weights connecting each input to an output, and each of these weights contributes to more than one output. The back-propagation algorithm is sensible approach to dividing the contribution of each weight. As in the network-training algorithm, it tries to minimize the error between each target output and the output actually computed by network. The size of the training vector sets was expanded from its initial position. The minutiae positions used to make up the training and testing sets were randomly separated to test the generalization properties of these back propagation networks. Training was performed with a variety of sub-sampling strategies. The generalization properties of these networks were then tested by applying the testing data sets. Finally selected high performance networks were fully tested by convolving them with the entire image.

Architecture Of Neural Network

Input Layer

Input layer used to input fingerprints data from the input file, which is nothing but 0's and 1's and transfer the data to the hidden layers.

Hidden Layer

The middle layers between input layer and output layer is hidden layer. Hidden layer used to calculate the weight of neurons from its previous layer and generate a signal with the help of activation function, $\varphi(\sigma)=1/(1+\varepsilon-\sigma)$, and transfer the signal to the next layer.

Output Layer

Final layer of neural network is output layer. The output layer used to show the result of the fingerprint matching. The number of output layers may be one or more.

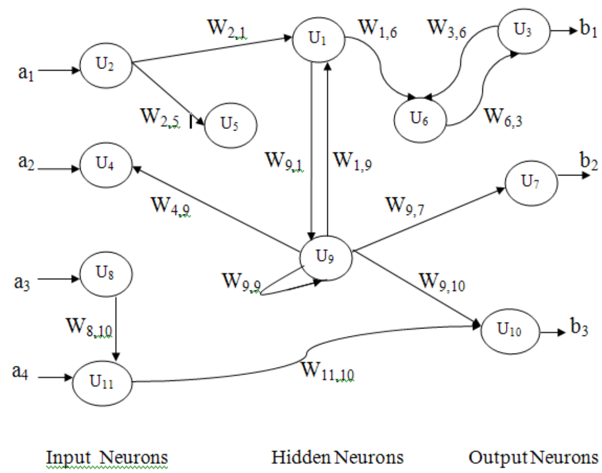


Fig. 3 An example of a complicated network

Back Propagation Algorithm

1. Initialize the weights $w_{ij}^{(k)}$ to small random values, and choose a positive constant c.

2. Repeatedly set $x_1^{(0)}, \ldots, x_{M_0}^{(0)}$ equal to the features of samples 1 to N, cycling back to sample 1 after sample N is reached.

3. Feed forward step. For k=0,.., k−1, compute

$$x_j^{(k+1)} = R\left(\sum_{i=0}^{M_k} w_{ij}^{(k+1)} x_i^{(k)}\right)$$

For nodes j=1,..., . We use the sigmoid threshold function R(s) **=1/(1+e^{-s}).**

$$\delta_j^{(k)} = x_j^{(k)}\left(1 - x_j^{(k)}\right)\left(x_j^{(k)} - d_j\right)$$

For layers **k=K-1,..., 1** compute

$$\delta_i^{(k)} = x_i^{(k)}\left(1 - x_i^{(k)}\right)\left(\sum_{j=1}^{M_{k+1}} w_{ij}^{(k+1)} \delta_j^{(k+1)}\right)$$

for **i =1,..., M_k.**

5. Replace $w_{ij}^{(k)}$ *by* $w_{ij}^{(k)} - c x_i^{(k-1)} \delta_j^{(k)}$ for i , j, k.

6. Repeat steps 2 to 5 until weights $w_{ij}^{(k)}$ cease to change significantly.

2. EXPERIMENTAL RESULT

Minutiae points from 40 fingerprints in database FVC2002 (DB1_a) has been extracted.
In our proposed method we extract four minutiae features using MORPHOLOGICAL operation. Then we applied thinning algorithm to eliminate redundant pixels. In our post processing step we remove false minutiae and unifying minutiae features. Above process are more helpful to recognize a fingerprint image most accurately. Rashid and Hossain, [4] was proposed a method without using false minutiae removal and it can detect only four minutiae features. The comparison (table 1.1) with our method is given bellow. Table values shows that our proposed approach is much efficient and can extract real minutiae features in much better way and in grater number than [4]'s method. The proposed method takes less time and detects very few false minutiae.

TABLE 1.1

Experimental data of fingerprint verification system	**Result without using false minutia removal**	**Result using false minutia removal (our proposed method)**
No. of person	40	40
No. of fingerprint samples for each person	4	4
Total No. of fingerprint samples	160	160
No. of recognized samples	148	152
No. of unrecognized samples	4	6
No. of false recognized samples	8	2
Accuracy of the system (%)	92.5	95

% of Accuracy of the system

$$= \frac{\text{Total No. of recognized Fingerprint samples}}{\text{Total No. of fingerprint samples}} *100$$

$$= \frac{152}{160} *100$$

= 95

Input of back propagation neural network for training is provided from extracted features. This is called feature matrix. During the training period we increased the number of neuron for same image and get less error than previous step (table 1.2). It also reduced time for a successful matching. Then we verify or simulate a fingerprint image in the trained network. Extracted features of this fingerprint image then verify with stored trained weight and threshold values. A fingerprint image is recognized based on less difference between the value of target output and desired output. A fingerprint matching arguments are shown in table 1.3

Graph 1.1: Comparison Graph

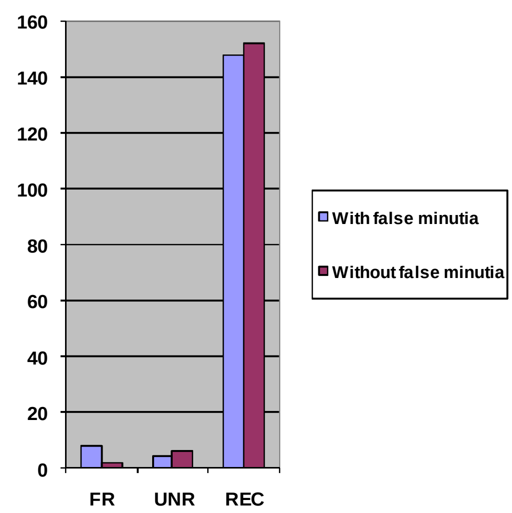


TABLE 1.2

Step	Sample	No of neuron	Target output	Desired output	Error	Matching
1	101_1.tif	10	190.4185 226.4448 -0.9060	190.4185 226.4448 -0.90599	3.3196e-008 1.1996e-008 -1.4225e-005	YES
	101_2.tif		190.4185 226.4448 -0.9060	226.0592 226.4448 -0.90599	-35.6407 1.4144e-008 -1.3681e-005	YES
	101_3.tif		190.4185 226.4448 -0.9060	226.4448 226.4447 -0.90599	-36.0263 4.4543e-008 -1.4296e-005	YES
2	101_1.tif	20	190.4185 226.4448 -0.9060	190.4185 226.4448 -0.906	2.0082e-009 9.9019e-007 -5.9873e-007	YES
	101_2.tif		190.4185 226.4448 -0.9060	224.7791 226.4448 -0.906	-34.3606 1.5025e-006 -6.0879e-007	YES
	101_3.tif		190.4185 226.4448 -0.9060	225.4432 226.4447 -0.906	-35.0247 5.8403e-005 -5.9749e-007	YES
3	101_1.tif	30	190.4185 226.4448 -0.9060	190.4185 226.4448 -0.906	1.0863e-008 1.1003e-006 -6.5726e-007	YES
	101_2.tif		190.4185 226.4448 -0.9060	223.397 226.4448 -0.906	-32.9785 3.4926e-006 -6.6867e-007	YES
	101_3.tif		190.4185 226.4448 -0.9060	224.4438 226.4448 -0.906	-34.0253 1.5983e-005 -6.5585e-007	YES

TABLE 1.3

Experimental data of fingerprint verification system	**Result without using false minutia removal**	**Result using false minutia removal (our proposed method)**
No. of person	40	40
No. of fingerprint samples for each person	4	4
Total No. of fingerprint samples	160	160
No. of recognized samples	148	152
No. of unrecognized samples	4	6
No. of false recognized samples	8	2
Accuracy of the system (%)	92.5	95

3 CONCLUSION

In this paper we have discussed about fingerprint verification system and the minutiae feature extraction .We have also mentioned some previous related works that is done on fingerprint identification and their drawbacks. The process is described in a very short way based on their basic principles. We have also discussed proposed model architecture of fingerprint verification system by minutiae extraction using artificial neural network. The model architecture is designed to reduce time complexity while working with large fingerprint database

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