Fingerprint identification Based on Skeleton Minutiae extraction

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Abstract— **The most used biometrics for human identification is fingerprint, based on the minutiae or bifurcation. In this paper, extracted features based on minutiae points and there direction. The features have been used as a set of descriptors for the fingerprint data. This set of descriptors is fed to the backpropagation neural network for the purpose of fingerprint recognition. It is found that the process of preprocessing and the method of constructing input data for neural network have great effects on producing good results in the recognition rate.**

Keywords- fingerprint identification, minutiae extraction, backpropagation neural network

I. INTRODUCTION

Biometrics is the science of verifying the identity of an individual through physiological measurement or behavioral traits[1]. Fingerprint is the most widely used biometric system and have a very important role in forensic and civilian application, so it will continue to be used with many governments' legacy systems.

The most widely and well-known used method for fingerprint is minutiae extraction method. Minutiae of fingerprint include ridge bifurcations, ridge ending, short ridge and enclosure[2].

In [3] the clustering algorithm and new supervised recurrent neural-network is used to detect similar features groups from multiple template images that generated from the same finger. In [4] the optical wavelet transform used as a preprocessor for an artificial neural network. The achieved capabilities include limited shift-, rotation, scale- and intensity-invariance, also edge- enhancement filter performed to improves the ability of the system. Mori and maltoni [5] presented an approach to minutiae filtering based on a neural network. The minutiae neighborhoods extracted and normalized with respect to rotation and scale. They employed the neural classifier to perform the neighborhoods classification. , which topology has been designed to exploit the minutiae duality.

In this paper, extracting minutiae (bifurcation and ridge ending) from an input fingerprint image to produce a feature set by using minutiae point direction . Using the extracting feature to feed to neural network. Section (II) in this paper, concerns with the main fundamental concept to understand the idea of Identification system using fingerprint and fundamental about extracting feature from minutiae. Also, in this paper the properties of neural network were discussed. Section (III) introduce the flow of the enrollment and identification phase of proposed identification algorithm. Then, the preprocessing and minutiae extraction were presented, an identification approaches was described and how the system databases store the template record of all individuals that have access to the system. In, section (VI), the experimental results were discussed in detail, the effect of neural network parameter was explained. Finally, Section (VII) summarizes the conclusions.

II. MATCHING FINGERPRINT MINUTIA

Fingerprint matching techniques can be placed into two categories: minutiae-based and correlation based. Minutiae-based techniques first find minutiae points and then map their relative placement on the finger. While correlation-based method is able to overcome some of the difficulties of the minutiae-based approach. However, it has some of its own shortcomings. Correlation-based techniques require the precise location of a registration point and are affected by image translation and rotation[6].

A fingerprint image differs from scan to scan by some combination of two dimensional translation, rotation, and scaling; and a three dimensional 'rolling', which occurs when the user does not place his finger at the same elevation from scan to scan[7].

Artificial Neural Networks have been applied to many problems, and have demonstrated their superiority over classical methods when dealing with noisy or incomplete data. One such application is the authentication. This extracted information (stored in a hidden layer) preserves the full information obtained from the external environment. In this paper, the backpropagation neural network was adopted since it has been successfully applied to many pattern classification problems including authentication.

The structure of the backpropagation neural network consists of three layers: first layer input neurons which are fully connected to the hidden layer. The last layer is the output layer consisting of 8 neurons which represent the binary encoding for ID of the person's fingerprint. All three layers are fully feed forwarded trained. The activation function, where the unipolar sigmoid function is used.

In this work variant number of hidden node have been tested to reach the best training results. Also effects of learning rate value were tested.

III. PROPOSED APPROACH

The proposed system as shown in Figure (1) consist of three main steps : preprocessing, feature extraction and neural network (testing and training). The first step is removing noise from the image may be corrupted during the fingerprint image capture, using binarization technique to convert gray-scale to black and white image, after that confirm filtering and thinning on an image.

The second step extracting minutiae, and determine the direction of the minutiae point then the features stored in a database as a template. In the last step the extracted feature, fed forward back propagation neural network and training the neural network, the adjusted weight is used to identify finger print image.

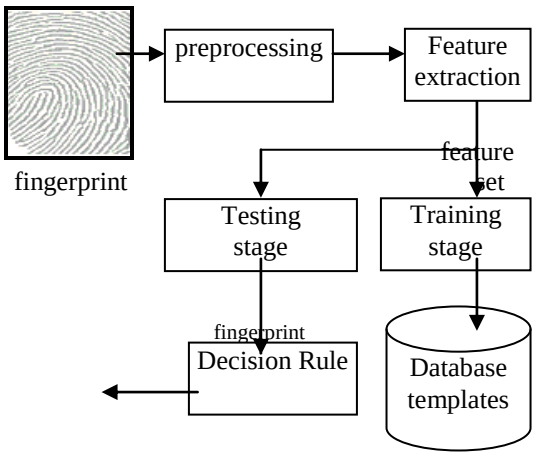

figure 1. illustrates the layout of the proposed identification system based on fingerprint.

IV. PRE-PROCESSING

The initial step in the proposed identification system is computing the binary image from the input gray scale fingerprint image, by applying threshold value. As the image may have various grey-level value due to non-uniformity of the ink intensity, non-uniform contact with the sensors by users or changes in illumination and contrast during image acquisition process. Adaptive threshold can be used to binaries fingerprint images, binarization depends on the comparison result of grey-level value of each pixel with local mean[8]:

$$IB(x,y)=\begin{cases}1 & if\ \ f(x,y)\le \ \ 1/W\sum_{i=-1}^{1}\sum_{j=-1}^{1}f(x+i,y+j)\\ 0 & \text{Otherwise}\end{cases} \quad \ldots.(1)$$

Where f(x,y) is a gray-level at (x,y), and W is the widow size, the black pixels are denoted by zero while white pixels are represented by one.

After binarization, another major preprocessing technique for image is implemented which is the thinning method is often called skeletonization to get an image of single pixel width with no discontinuities, each ridge is thinned to its centre pixel, and singular pixels are eliminated.

V. MINUTIAE EXTRACTION

Most fingerprint minutia extraction methods are thinning- based where the skeletonization process converts each ridge to one pixel wide. Minutia points are detected by locating the end points and bifurcation points on the thinned ridge skeleton based on the number of neighboring pixels[9].

The concept of Crossing Number (CN) is widely used for extracting the minutiae [10]. The crossing number for a pixel P is:

P4	P3	P2
P5	P	P1
P6	P7	P8

$$CN = 1/2\sum_{i=1}^{8}\left|P_i - P_{i+1}\right| \quad \ldots\ldots\ldots\ldots\ldots\ldots.(2)$$

where Pi is the binary pixel value in the neighborhood of P with Pi = (0 or1) and P9=P1.

The skeleton image of fingerprint is scanned and all the minutiae are detected using the following properties of CN as shown in table(1):

Table (1) Crossing number's property.

CN	Property
0	Isolated point
1	Ending point
2	Connective point
3	Bifurcation point
4	Crossing point

Then depending on the value of CN the minutiae point which have ending or bifurcation property are taken into consideration as shown in figure(2).

In the proposed method, the minutiae points locations, and their considered direction from the 8 directions (N,S,W,E,NE,NW,SE,SW) are recorded then they used to construct the database depending of the number of recorded minutiae point and their direction.

The next step, the points with the code of it is direction will be stored in database which representing of fingerprint image, this will be as the first layer of the network which

associated with the components of the input vector and fed forward backpropagation neural network.

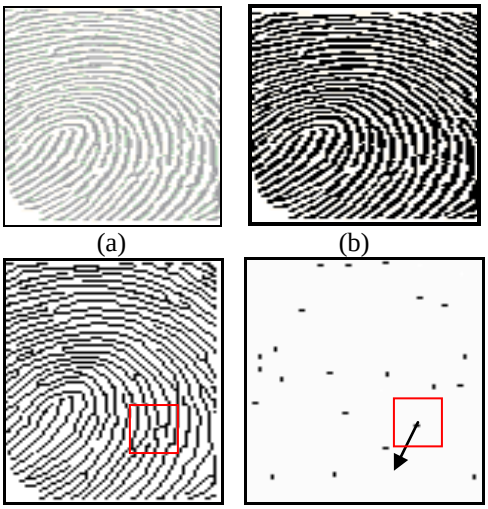

Figure 2.) (a) original image in gray ,(b) binarization image to black-white(c) thinning black-white image, and (d) determine the minutia point with direction SW.

In this paper, the skeleton image of the fingerprint has been scanned, and all types of points in the image depending on the CN values from the Table(1) has been found. The location (x,y), and the direction of each point with CN value equal to (1 or 3) were recorded in the matrix.

First the processing of selecting points is start randomly, for each random point P(i,j), the proposed algorithm will search for the points from the recorded points in the matrix depending on the direction of the point P(i,j), for example if considered direction is N for point P so the searching process is done for points located at (x,y) where x< i also for NE and NW taken the same points, while the considered direction is S, SE, and SW the searching process is done for point located where x>i as shown in the figure (3), this process will be repeated for all the points have the above condition. Where, for direction E the condition y <j is taken , and for direction W the condition y > j is taken.

The function used to determine the value for each node of the input layer in the neural network is :

G(P(i,j)) =abs((j-i) * D

where D is value for direction code. The pseudo code for determine the direction of each ending and bifurcation points is as following:

```
Suppose P is the checked point and P1 to P8 are
neighborhood pixels
 if CN =3 then
     if P1 &P3& P7 = 1 then Direction=W
     elseif P1 &P3& P5=1 then Direction=S
     elseif P1 &P7& P5=1 then Direction=N
     elseif P3 &P5& P7=1 then Direction=E
     elseif P4 &P3& P5=1 then Direction=SE
     elseif P3 &P2& P1=1 then Direction=SW
     elseif P3 &P5& P6=1 then Direction=NE
     elseif P4 &P8& P5=1 then Direction=NW
 endif
 if CN =1 then
      if P1 = 1 then Direction=W
     elseif P3=1 then Direction=S
     elseif P7=1 then Direction=N
     elseif P5=1 then Direction=E
     elseif P4 =1 then Direction=SE
     elseif P2=1 then Direction=SW
     elseif P6=1 then Direction=NE
     elseif P8=1 then Direction=NW
 endif
```

VI. EXPERIMENTAL RESULTS

In the experiments, the scanned fingerprint with size (170 x170) is used. To evaluate the performance of the proposed algorithm, randomly 450 samples were selected from the fingerprint database which consist of (750 fingerprint image for 150 persons), for each subject (5) fingerprint images.

In the proposed system the maximum 10 value of function g() for each fingerprint image were selected to training neural network, with different number of hidden nodes, the weight are adjusted, and the output is the binary ID number for a person represented by 8 output nodes.

The recognition rates for training neural network are all approaching 100%. While recognition rates in percentage on testing data are about %87, the effect of numbers of input nodes and the number of hidden nodes in recognition rate are shown in Table (2).

Table(2) The effect on hidden node on recognition rate.

No. of input node	recognition rate % proposed system				Recognition % rate traditional method
	Hidden 7 nodes	Hidden 10 nodes	Hidden 12 node	Hidden 15 nodes	Hidden 10 nodes
10	65	68	71	75	60
15	67	70	73	79	63
18	71	75	78	84	66
20	75	81	83	87	71

The effectiveness of this approaches is shown by the improvement in fingerprint verification accuracy, comparing the traditional system that matching the minutiae point and there location.

VII. CONCLUSION

Fingerprint minutiae and a neural network with backpropagation training algorithm are appropriate to use for an identification system. The proposed system which extracted feature based on minutiae point and considered direction, have a good effective and efficient in recognition system. Improving the accuracy and the ability of the proposed system to get more minutiae points can be done by performing and testing various enhancement filter to the fingerprint image.

The experimental results have shown that the best average recognition rate is 85% with learning rate is 0.01 , 15 hidden nodes, and 20 input node shows a great powerful recognition performance.

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