AN AUTHENTICATION SYSTEM USING FINGERPRINT MINUTIAE EXTRACTION AND NEURAL NETWORK

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Abstract

Fingerprints have been the mostly used biometrics for human authentication, based on the minutiae or bifurcation. In this paper, the triangle shapes are used to extract features based on minutiae point. 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 geometric shapes has great effects on producing good results in the recognition rate.

<u>Keywords</u> : fingerprint recognition, 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 and produce a feature set by using geometry shape. 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 Authentication 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, we present preprocessing and minutiae extraction, an authentication 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.
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II. Matching Fingerprint Minutiae

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 5 neurons whose output uses to binary encoding ID of 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 Approch

The proposed system as shown in Fig.(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, constructing triangle shape from the minutiae point and the feature 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.
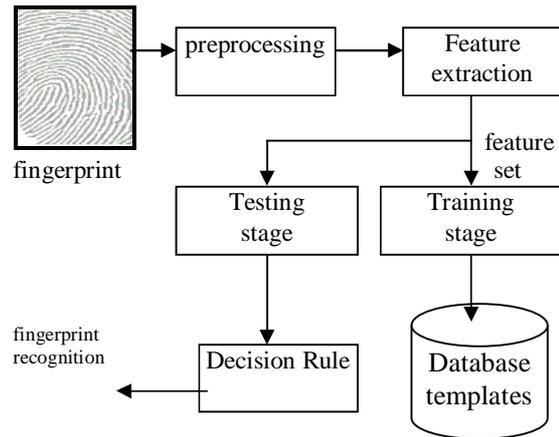

Fig.(1): Illustrates the layout of the proposed Authentication system based on fingerprint.

IV. Preprocessing

The initial step in the proposed authentication 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]:

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

....(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

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

where Pi is the binary pixel value in the neighborhood of P with P_i = (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 Fig.(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 triangle shape depending of the number of recorded minutiae point and their direction.

The next step is calculating the area of each triangle, after getting the triangle area values, they are sorted in descending order, the first 10 areas will be stored in database which representing of fingerprint image, this will be as the first layer of the network which

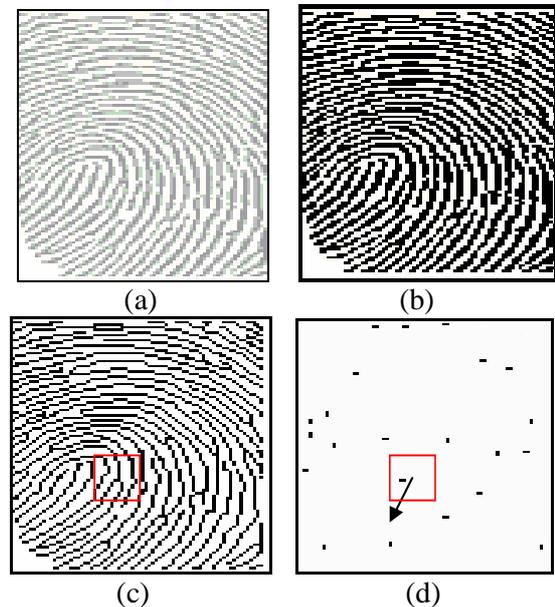associated with the components of the input vector and fed forward backpropagation neural network.

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

For each point P(i,j), the proposed algorithm will select two points from the recorded points 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 two 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 then the distance calculated between P and the another two points in order to be suitable for creating the triangle as shown in the Fig. (3), this process will be repeated for all the two points that have the above condition.

The following two equations are used to find the distance between the points and area of triangle:

$$D = \sqrt{(y2 - y1)^2 + (x2 - x1)^2} \quad \text{...............} \quad (3)$$

$$TArea = \frac{1}{2} AB \sin \theta \quad \text{...............................} \quad (4)$$

Where A and B is distance between P(i,j) and the two points , a θ is angle between A and B
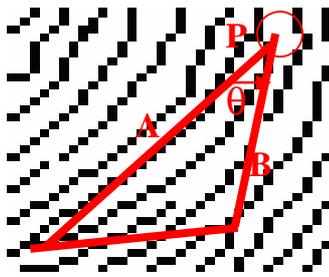

Fig.(3) : Constructing triangle from bifurcation minutiae point.

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
```

The following pseudo code for creating triangle:

```
Suppose P in location (i,j) ,and P,PF,PS are points
to create the triangle.
 IF direction  P(i,j) =S or SE or SW then
  For x=i+1 to imagewidth
   For y= 1 to imagehieght
    Select two points PF(x,y),PS(x,y)
      with    CN=1 or  CN=3
       Create triangle from points
       P(i,j),PF(x,y),PS(x,y)
    Calculate area of triangle by Eq.(4)
    Recording the area in matrix
   end
 endif
ELSE if direction P(i,j)= N or NE or NW then
   While i-1 > 0
    For y= 1 to imagehieght
       Select two points  PF(i,y),PS(i,y)
         with CN=1  or CN=3
       Create triangle from points
          P(i,j),PF(i,y),PS(i,y)
       Calculate area of triangle by Eq.(4)
       Recording the area in matrix
       i=i-1
     end
   Endwhile
endif
```

So for direction E we take y <j, and for direction W we take y > j.

VI. Experimental Results

To evaluate the performance of our algorithms, we randomly select 60 sample, for each subject (3) fingerprint images from our fingerprint database which consist of 80 fingerprint image for 20 persons. In the experiments, the scanned fingerprint with size (170 x170). In the proposed system the minimum 10 areas of triangles for each fingerprint image, they used in training stage, with different number of hidden nodes, the weight are adjusted, and the output is the binary ID number for a person represented by 5 output nodes.

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

The recognition rates for training neural network are all approaching 100%. While recognition rates in percentage on testing data are about %90, and in traditional minutiae-based matching algorithm are %75, the effect of numbers of triangle's area value for

triangles 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 3 nodes	Hidden 5 nodes	Hidden 10 node	Hidden 12 nodes	Hidden 10 nodes
3	71	75	78	79	68
5	73	79	83	84	72
7	76	80	87	87	74
10	79	84	90	90	75

VII. Conclution

Fingerprint minutiae and a neural network with backpropagation training algorithm are appropriate to use for an authentication system. The proposed system which constructing the triangle shapes from the 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 90% with learning rate is 0.01 , 10 hidden nodes, and 10 input node shows a great powerful recognition performance.

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الخلاصة

يعتبر بصمة الابهام احد الانظمة الاكثر استخداما لتحديد هوية الشخص اعتمادا على خواص (minutiae) لبصمة الاصابع. تم استخدام اشكال الهندسية لانتزاع الخواص اعتمادا على نقاط (minutiae). استخدمت هذه الخواص كمجموعة من المواصفات(descriptor) لبيانات بصمة الاصابع. تم استخدام هذه المجموعة من المواصفات لتغذية الشبكة العصبية ذات نشر استرجاعي لغرض تمييز بصمة الاصابع. وكذلك وجدت ان عملية ما قبل المعالجة وطريقة بناء الاشكال الهندسية لها تأثير كبير للحصول على نتائج جيدة في نسبة التمييز و زمن التنفيذ.