Fingerprint Recognition using Prepared Codebook and Back-propagation

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Abstract

The aim of this work, focus on the problem of reducing the classification fingerprint features that has been entered to the neural network. An algorithm was introduce to work with prepared codebook to code and normalized the input samples of the back-propagation method. The main advantages of preparing codebook are the simplicity of its idea and its high speed processing. This method has been tested on the FCV2002 fingerprint database. The recognition accuracy is 94% and the equal error rate (EER) is 2.1%

Keyword: fingerprint recognition, codebook, back-propagation, termination ,bifurcation.

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1. Introduction

Fingerprint recognition is one of the most diffused biometric techniques used in automatic personal recognition (recognition can be grouped into verification and identification) [1, and 2]. Skin on human fingertips contains ridges and valleys which together forms distinctive patterns. These patterns are fully developed under pregnancy and are permanent throughout whole lifetime. Prints of those patterns are called fingerprints. Injuries like cuts, burns and bruises can temporarily damage quality of fingerprints but when fully healed patterns will be restored. Through various studies it has been observed that fingerprint is based on two basic premises, first *persistence*: the basic characteristics of fingerprints do not change with time; and second *individuality*: the fingerprint is unique to an individual [1, and 3]. Most common minutiae that are found in fingerprints can be seen in Figure 1.a. After a closer examination there can be seen that the two most important minutiae are *termination,* shown in Figure 1.b, which is the point at which a ridge terminates and *bifurcation*, which are points at which a single ridge splits into two ridges, where the rest of the minutiae are only combinations of those two types. Real fingerprint can been seen in Figure 1.c, where the dark lines (black) are the *ridges* and light lines (white) are the *valleys* [1, 3 and 4].

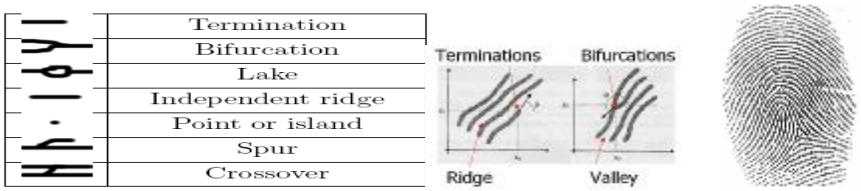


Figure 1 Common Minutiae

The termination and bifurcation has played important roles in most fingerprint processing techniques. It is widely used in fingerprint recognition systems which based on minutiae matching [1, 5, 6, 7, and 8]. Also, it has been used in fingerprint classification [9], fingerprint enhancement [10]. Many researches indicate the suitability of connecting neural network with fingerprint processing [9, 11, 12, 13, and 14]. The testing database for our work was available by [15], where it is been used in [1, 16, and 17]. So no acquisition stage is implemented.

Our fingerprint recognition algorithm can be divided into three main tasks; Figure 2 shows these three tasks:

1. **Minutiae extraction.**
2. **Prepared codebook used for all the samples images.**
3. **Classification using Back-propagation neural network.**

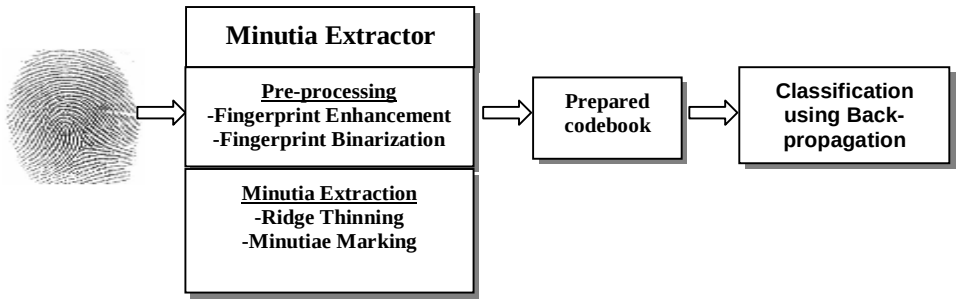


Figure 2 Fingerprint Recognition System

The outline of this paper consists of: *Section 2* shows the minutia extractor and the explained of the pre processing step. *Section 3* explained the prepared codebook initialized.

Section 4 **shows the backpropagation algorithm.** ***Section 5*** **illustrates the result of our algorithm. Finally, in** ***section 6*** **some conclusionand summary are shown.**

2. Minutia Extractor

To implement a minutia extractor, the following stages or approaches are widely used by researchers. They are pre-processing, and minutia extraction stage (as shown in Figure 2).

2.1 Pre-processing

The pre-processing stage for fingerprint image includes the locally adaptive threshold binarization method. Since quality of fingerprints is varying, the grayscale image of the fingerprint will be more or less disturbed and noisy. Therefore binarization is performed in a way that it has enhancing effects on the fingerprint image. A locally adaptive binarization method is performed to binarize the fingerprint image. The mechanism of transforming a pixel value to one if the value is larger than the mean intensity value of the current block (32x32) to which the pixel belongs [3]. The binarizing function is performed in 32x32 local areas as a unit, to allow the binary image to have the same intensity distribution of 0's and 1's. This function is basically responsible for eliminating binarization noise [18].

2.2.1 Ridge Thinning

A more effective and faster minutiae extraction realization can be achieved by minimizing data that represents minutiae without corrupting it. Since minutiae are determined only by discontinuities in ridges, they are totally independent of ridges thickness. Ridge thinning is to eliminate the redundant pixels of ridges till the ridges are just one pixel wide. Each application of thinning operation removes one or two pixels from the thickness of

binary image objects [3 and 19]. We used the built-in morphological thinning function in MATLAB. We repeated this operation until the image stop changing (until stability). The thinned ridge map is then filtered by other three morphological operations to remove some:
1. *Isolated* by the *Clean filter* which remove isolated or individual pixels with value (1's) surrounded by values (0's), (as shown in Figure 3.a.)
***2. Spikes* points by the *Spur filter* works by removing the end points of lines, without removing small objects completely (as shown in Figure 3.b).**

3. *H breaks* remove H-connected pixels as in Figure 3.c .

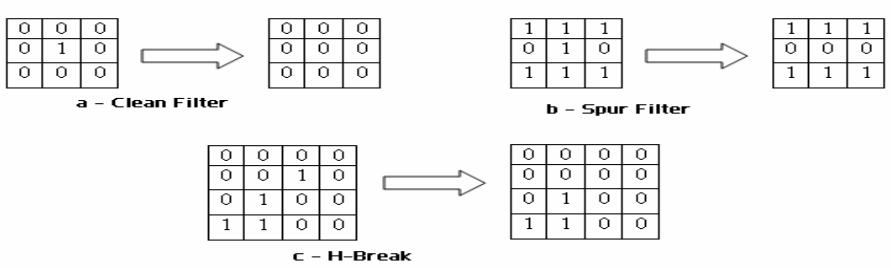


Figure 3 Morphological Operations

2.2.2 Minutia Marking

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 (Figure 4.a), but when it has only 1 one-value neighbor, then the central pixel is a ridge ending (Figure 4.b). With the use of BWLABEL we determine the region of the ending and the branch .

0	1	0
0	1	0
1	0	1

a. Bifurcation

0	0	0
0	1	0
0	0	1

b. Termination

Figure 4 Minutia points

3. Prepared codebook

One of the most recurrent dilemmas in pattern recognition applications is at which level the invariance must be dealt with: that is, whether the extracted features should be normalized or the classifier itself should be tolerant to feature variations [19]. In this work we normalize the minutiae position (termination and bifurcation) by prepared codebook.

Figure 5 shows the algorithm that has been used for coding and normalizing the 256x256 blank_image. The 256x256 blank_image include 0, 1 and 2 values, where 1 means termination pointed, 2 means bifurcation point. The input to the algorithm is 4x4 block and the output one value. The prepared codebook is used to decompose the map256x256 into map64x64. If the vector do not exits in the prepared codebook then it will be include to it. The prepared codebook is generated from a set of blocks and new add blocks during the decomposing of the new blocks.

4. Classification with Back-propagation

Backpropagation (BP) is a supervised learning and multilayer neural network algorithm. It is a powerful mapping network that has been successfully applied to a variety of problems. The BP training algorithm is an iterative gradient algorithm; it adjusts the weights of the connections in the network so as to minimize the measure

of the mean square error between the actual output and the desired output. It requires continuous differentiable nonlinearities. An input vector is presented to the network by setting the states of the input units. Then, the states of the units in each layer are determined by applying equations to the connections coming from lower layers. All units within a layer have their states set in parallel, but different layers have their states set sequentially, starting at the bottom and working upwards until the states of the output units are determined [19].

Convert Algorithm with the prepared codebook

1. If (" x block(x,4x4) Ù zero(x)) à 0 where zero(x) means all the pixel are zero
2. If (" x block(x,4x4) Ù term(x)) à 1 Where term(x) means there exist one termination point in the block
3. If (" x block(x,4x4) Ù bifur(x)) à 2 Where bifur(x) means there exist one biturcation in the block
4. If (" x block(x) Ù Set1(x)) à 3 (near termination and bifracation)
5. If (" x block(x) Ù Set2(x)) à 4 (far_1pixels termination and bifracation)
6. If (" x block(x) Ù Set3(x)) à 5 (far_2pixels termination and bifracation)
7. If (" x block(x) Ù~(zero(x) Ùtermination(x) Ùbifrication(x) ÙSet1(x) ÙSet2(x) ÙSet3(x))
Ù add (block(x),codebook) Ù Increment(codebook,n+1) à n

Where block(x) is a block of 4x4 pixel

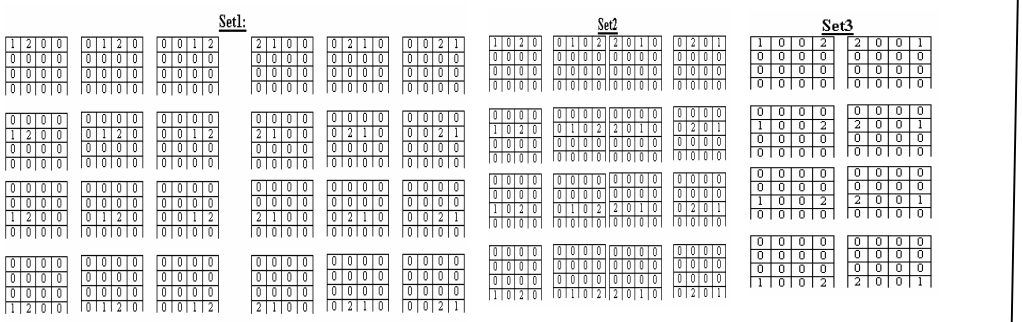


Figure 5 Prepared Codebook

In BP each neuron is composed of two unitsas shown in Figure 6. First unit adds products of weights coefficients and input signals. The second unit realise nonlinear function, called neuron activation function. Signal *e* is adder output signal, and *Y = f(e)* is output signal of nonlinear element. Signal *Y* is also output signal of neuron.

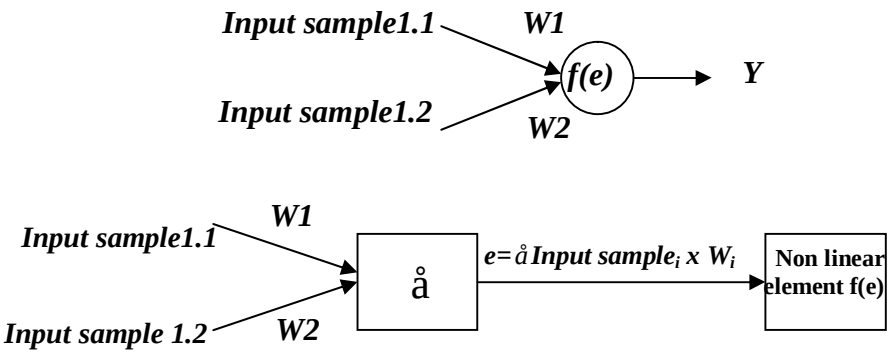


Figure 6 Backpropagation neuron unit

To teach the neural network we need training data set. The training data set consists of input signals assigned with corresponding target (desired output). The network training is an iterative process. In each iteration weights coefficients of nodes are modified using new data from training data set. Each teaching step starts with forcing both input signals from training set. After this stage output signals values can determine for each neuron in each network layer. Figure 7 shows the Bapck-propagation with three layers. In this paper, the activation function of each node uses a sigmoid function, i.e., which are $f_x = \frac{1}{1+e^{-x}}$

characterized by the fact that its slope must approach zero as the input gets large.

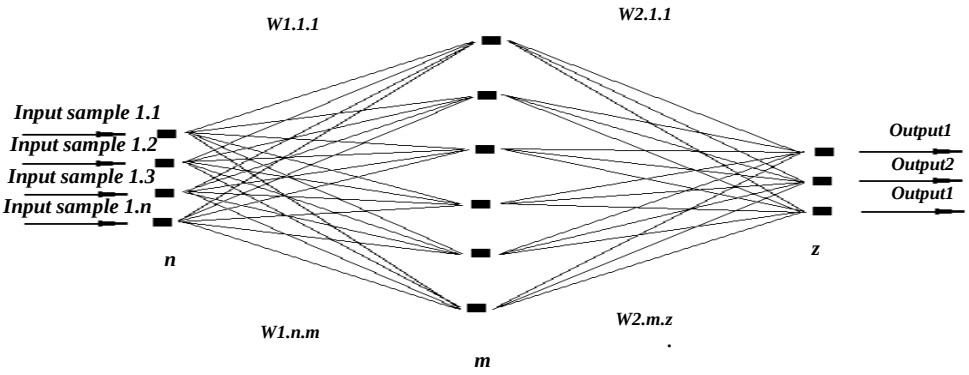


Figure 7 Neural networks with one hidden layers

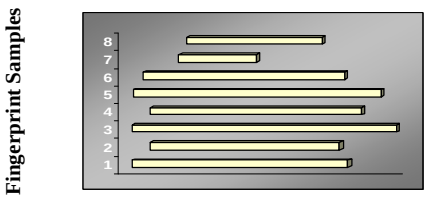
Therefore it is a continuous activation, mostly chosen from [0, 1] or [-1,+1] , three layers been used. The input samples to the network are 64x64 input samples, the hidden layer contained 101 neurons, and output consists of 8 outputs.

5. Performance Result

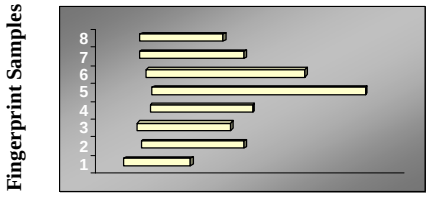
Our system was tested on the Finger Verification Competition 2002 edition (FVC2002) fingerprint databases. Typically, the performance of biometric systems is measured in terms of false acceptance rate (FAR) and false rejection rate (FRR). FAR measures the ration of impostors who are incorrectly accepted as legitimate users, while FRR measures the ratio of valid users who are rejected as

imposters. Since there are two distributions (legitimate and impostor), ROC curve can be easily obtained by varying the threshold value t which designates whether an acquired biometric systems. It is clear that the lower the ERR, the more accurate the system will be [22].

There are some individual's samples can't be enrolled into the system database, because the quality of their captured fingerprints was too poor to pass the quality checking. Figure 8 shows an example of accepted fingerprint, where each sample has been analyzed to show the relation between bifurcation and termination. Figure 9 shows example of the rejected fingerprint. In each accepted fingerprint samples we choose accepted and rejected samples. The accepted and the rejected of each fingerprint samples determine by the average of the different between the number of the termination and the bifurcation of all the fingerprint samples in each fingerprint, each fingerprint will be compared with this vale.

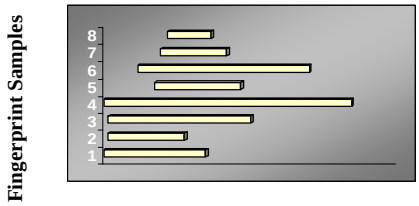


a-101x

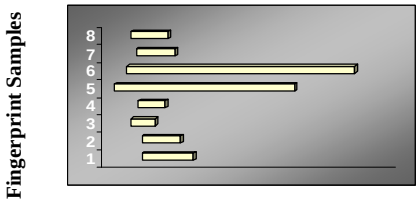


b-107x

Figure 8 Accepted fingerprint FVC2002, DB3, fingerprint a.101x, b.107x



a-106x



b-109x

Figure 9 Rejected fingerprint FVC2002, DB3, fingerprint a. all samples of 106x, b.109x

6. Summary and conclusion

The recognition performances achieved by using the proposed algorithm, first the minutiae have been detected then they have been normalized by the prepared codebook. A number of k images from each individual finger have been used as the training set. Whereas, other sample from the same finger have been used for testing.

This paper present the step for the fingerprint recognition system, the system was implemented using MATLAB 7. The performance of fingerprint recognition system relies critically on the image quality. The normalize step save the position of the minutiae by using the general prepared codebook. Using general prepared codebook gives all the training samples with the same feature of the equal coded pattern, so a recognition rate 93% and EER 2.3%was obtained.

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تمييز بصمة الأصبع باستخدام كتاب الرموز المعد

م.م.نداء فاضل محسن*

المستخلص

يتناول البحث مشكلة تقليل تصنيف البيانات الخاصة بخصائص بصمة الأبهام التي تم ادخالها الى الشبكة العصبية ,, حيث تم ايجاد خوارزمية تستخدم مع كتاب الرموز codebookالمعد لترميز العيانات الداخلة لطريقة خوارزميات التنقل Backpropagation Codebook(وهي خوارزميات تعتمد انتشار الأخطاء من الخلف الى الأمام لضبط اوزان الشبكة) وجعلها طبيعية.
الفائدة الرئيسة من اعداد كتاب الرموز preparing codebookهي سهولة الفكرة وسرعة المعالجة . وقد تم اختبار هذه الطريقة على قواعد البيانات الخاصة بالتحقق من الأصبع في طبعته2002. كانت دقة التميز (94%). وتساوي نسبة الخطأ equal error rate(2.1%).

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