Fingerprint Authentication System Using Back-Propagation

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ABSTRACT

Fingerprint is a very much important in identification and authentication. In many occasion it necessary to check for fingerprints (fps). But working with a huge number of fps and recognize correctly is tough job. So it is important to use automatic fps identification process. Again fps may be change as age growths and growth of structure.

1. INTRODUCTION

The recognition of human fingerprint [1], [10] is a complex problem since a wide range of variation exists among the shape of finger of young people who are 18 years old. Different approaches have been employed by studding different characteristics of finger to recognize them correctly. How ever human recognition process involves multiple ways of feature extracting and several learning process.

Automatic finger identification System (AFIS) [7], [9] is very popular security system to identify or recognize the right person because the fingerprint are unique and constant .The recognition scheme proposed in this paper has been employed to classify fingerprint for different ages people (Even children's). Here the proposed system discussed for Automatic Fingerprint Identification System (AFIS) using Artificial Neural Network (ANNs), because the principles of neural networks are closely related to such areas as pattern recognition, signal processing and artificial intelligence.

From history, we see fingerprint have been using in mankind from the early civilization probably in 3000 BC. People had knowledge about these complex patterns found on the human hand and fingers, as because palm print has been found on the slab of clay in the tomb of Egyptian king Tut en Khamen. But the actual research has begun on this field of fingerprint image analysis after development of computer technology and various pattern recognition theories with the help of advance computer technology, Automatic fingerprint Identification System (AFIS) has attracted wide attention among the researchers since 1969.

2. PATTERN OF FINGERPRINT & DATA

We know the difference between human brain and machine or computer intelligence is that, human brain perceive everything as a pattern, whereas machine or computer perceive everything in data. In another word, human brain can recognize patterns and computer can recognize the fingerprint in data by using Automatic fingerprint Identification System (AFIS) .As we know computer can understand everything which is converted in 0 and 1. Hence at first we need to convert human fingerprint pattern/image into data, which is contains only 0's and 1's. After capture the image in individual figure.

2.1 Analysis Fingerprint Image

After fingerprint image analysis, we see computerized image [4], [5] is divided into regions that correspond to various objects in scene, or possibly to parts of these objects. The size shapes and orientations of the objects might be ensured. In human fingerprint image, ridges and valleys are very important object for identify or recognize .The ridges and valleys shape into different patterns, indicate the type of fingerprint .On fingerprint the ridges and valleys are almost parallel to each other. Basically, a fingerprint is direction oriented pattern formed by ridge flow .In fingerprint the characteristic of flow images changes smoothly.

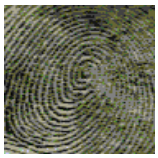

Figure 1: Fingerprint image using ridges and valleys.

2.2 Coding Fingerprint Image

Usually a high-resolution live scanner is used to coding the finger print image from an individual figure. The Federal Bureau of Investigation (FBI) is digitizing the nation's fingerprint database at 500 pixels per inch in both row and column with 8bits of grayscale resolution .At this rate, a single fingerprint card turn into about 10 MB of data.

Figure 2: A sample fingerprint image measuring 768 x 768 pixels.

For coding the fingerprint image, we need a live scanner of 500 pixels per inch in both row and columns, which represent the fingerprint image by 0's and 1's. I fingerprint image coding 0's represent the valleys and 1's represent the ridges .So, we can use a two dimensional array to represent a human fingerprint image by assigning the value of 0's for the valleys and 1's for the ridges.

Figure 3: A core type of fingerprint image.

Represent the core type of fingerprint image. Fingerprint image cording by 0's and 1'sfrom the individual's finger, which is shown in figure (4) and figure (5).

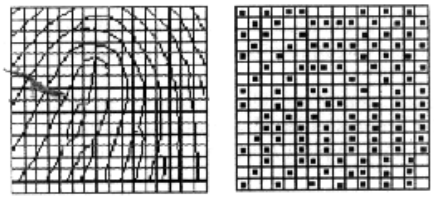

Figure 4: Fingerprint image into 16 rows and 16 columns.

1010110000101010
0101001111010101
1010010000101010
0100101111010101
1001000000101010
0010011110010101
0100100001001010
1001001100100101
1001010110010101
0010101001010101
0011010101010101
0101010101010101
1010010101010101
0010011010101010
0100100101101010
1001001010101010

Figure 5: Fingerprint image by 0's and 1's into 16*16 Pixels matrix of figure 4.

2.3 Fingerprint Image Compression

Various techniques can be used for fingerprint image compression. Fingerprint image may be considered to consist of a 0 and 1 at each pixel in binary form. If the finer print image were scanned pixel by pixel from left to right and top to bottom to create a string of sequences of 0's and 1's, one would usually see many relatively long runs of 0's and 1's. A way to take advantage of this would be store or send only the information that tells where each new run begins or the length of each run. This technique is called run length encoding of fingerprint image data. Using run length encoding technique, a better algorithm can be developed.

2.4 Noise Reduction Of Finger Print Image

There will be some noise of scanner bring high resolution at the time of taking fingerprint image .The scanner being high resolution that is it would introduce some unexpected dots in image from dust or sweat under the finger, which is one of the most potential problem. Other noises happened, when finger not placed properly for fingerprint upon the scanner .The quality of image becomes different, when taking image of the same finger depending on the pressure applied to the scanner. Some time the lines of the fingerprint become thicker with the high pressure and some time not so thick with the low pressure, although these two images are taken from the same finger, which is shown in figure (5)

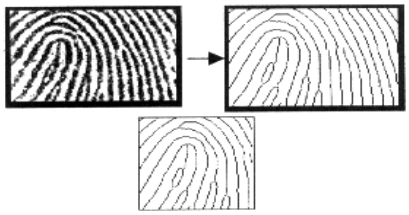

Figure 6: Fingerprints Thinning and Clipping.

3. BACKPROPAGATION ALGORITHM

Training a multi-layer linear threshold network is complicated by the fact that a small change in one of the weights will usually not affect the output the outputs of the network [2], [3] at all. So steepest descent methods are not feasible. The output from a node will be affected only if one of the weights changes at one layer. The output at the next layer may not necessarily change, so the final outputs are very resistant to most small weight changes.

3.1 The Back Propagation Algorithm

1. Initialize the weights $\omega_{ij}^{(k)}$ to small random values, and choose a positive constant c.
2. Repeatedly set $\xi_1^{(0)},\ldots,\xi_{M0}^{(0)}$ equal to the features of samples 1 to N ,cycling back to sample 1 after sample N is reached.
3. Feed forward step. For $\kappa=0,..,\kappa-1$,compute

$$\xi_j^{(k+1)}=\phi\left(\sum_{i=0}^{M_\kappa}\omega_{i\varphi}^{(\kappa+1)}\xi_i^{(\kappa)}\right),$$

For nodes $\varphi=1,\ldots,M_{\kappa+1}$. We use the sigmoid threshold function $\phi(\sigma)=1/(1+\varepsilon^{-\sigma})$.

4. Back-propagation step. For the nodes in the output layer, $\varphi=1,\ldots,M_\kappa$, compute

$$\delta_\varphi^{(\kappa)}=\xi_\varphi^{(\kappa)}(1-\xi_\varphi^{(\kappa)})(\xi_\varphi^{(\kappa)}-\delta_\varphi).$$

For layers k=K-1,…,1 compute

$$\delta_i^{(\kappa)}=\xi_i^{(\kappa)}\left(1-\xi_i^{(\kappa)}\right)\sum_{j=0}^{M_{\kappa+1}}\omega_{i\varphi}^{(\kappa+1)}$$

For $i=1,\ldots,M_\kappa$.

5. Replace $\omega_{i\varphi}^{(\kappa)}$ by $\omega_{i\varphi}^{(\kappa)}-\chi\delta_\varphi^{(\kappa)}\xi_i^{(\kappa-1)}$ for i,φ,κ.

6. Repeat steps 2 to 5 until weights $\omega_{i\varphi}^{(\kappa)}$ cease to change significantly.

4. PROPOSED AFIS

The proposed Automated Fingerprint Identification System (AFIS) is biometric identification (ID) methodology that uses digital imaging technology to obtain, store, and analyze fingerprint data. In this paper I have introduced a new method for fingerprint identification technology by using back-propagation algorithm. Back-propagation algorithm may be used in four different aspect of fingerprint identification system. Firstly, it can be used for accuracy in AFIS, that how often will the AFIS make a correct match among the fingerprint image for different age's people. Secondly, it can be used for speed in AFIS, that how fast we can get the result of the fingerprint matching. Thirdly, it can be used for reduce volume of search space. Fourthly, it can be used for upgrade the AFIS.

4.1 Neural Network Model For Afis

The accuracy and the speed of the fingerprint identification system are fully depends on neural network model. It's very important to select a neural network model for the best performance. Three types of layers of neurons will be necessary to implement the fingerprint identification system, and necessary layers of the neural network are input layer, hidden layers, and output layer.

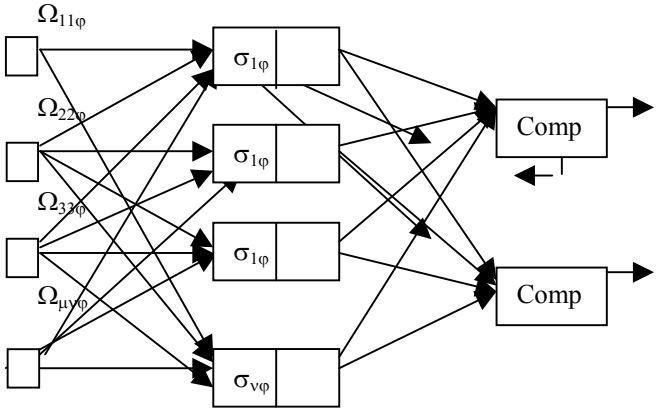

Figure 7: Sketch of multi-layer neuron with one hidden layer and one output layer deriving back-propagation algorithm

4.1.1 Input Layer
The first layer of neural network is input layer. Input layer used to input fingerprints data from the scanner or input file. This layer contains the neurons in number of scanner's pixel numbers. e.g. a live scanner of 500 pixels per inch in both row and column, the number of number of input layer will be 500. The neurons at input layer takes the fingerprint image in data, which is nothing but 0's and 1's from the scanners input file and transfer the data to the hidden layers.

4.1.1 Hidden Layer
The middle layers between input layer and output layer is hidden layer. The number of hidden layers will be the half of its previous layer. Hidden layer used to calculate the weight of neurons from its previous layer and generate a signal with the help of activation function, $\phi(\sigma)=1/(1+\varepsilon^{-\sigma})$, and transfer the signal to the next layer.

4.1.3 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. Usually it's depends on the number of peoples. If any of the output neurons have a positive value or 1, then the fingerprint image is match, which is saved in database file. Else, if all the output neurons have the negative value or 0, then the fingerprint image doesn't match with the fingerprint image, which is saved in database file.

4.2 Training For Afis

Without train the neural network we can't get the accepted output result, hence training is very important for the artificial neural network. Training setup the weight for neurons in the network. Training is such a network proceeds the same way as for perceptions: example input are presented to network, and if the example inputs are presented to the network, and if the network computes an output vector that matches the target, nothing is done. If there is an error (difference between output and target), 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 perception-training algorithm, it try to minimize the error between each target output and the output actually computed by network.

For this proposed fingerprint identification system, an input file needed, which contains the input data of the fingerprint images and the output results. The output result is the output layer neurons accepted data. 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.

4.3 Testing For Afis

Testing for Automatic Fingerprint Identification System (AFIS) is nothing but matching of fingerprints. Basically testing is use to match the fingerprint image between two or more fingerprint images. Testing process is very simple than training process. Testing process doesn't takes long time like the training process. Actually testing process is very faster and takes a very short time. Testing process will take the digital data of the fingerprint image by the scanner and give the result of the fingerprint matching by the output layer neurons.

4.4 Improvement Of Afis

This paper is the improvement of Automatic Fingerprint Identification System (AFIS). As the database of the fingerprint is very large and database searching is necessary for fingerprint matching in fingerprint identification system, so the efficient

search technique should be used to prune the database to reduce the search space. But in this proposed system, there is no need for any search technique. Because the train neural network doesn't use any search technique. Therefore, this will be faster then the other process, which is using searching technique.

Data compression is another issue of fingerprint identification system, because the fingerprints are adding to the database in a large volume. In this paper, a new technique has been introduced for fingerprint data compressing, which is called run length encoding of fingerprint image data.

In this proposed system, it's also easy to upgrade the fingerprint identification system. To upgrade the system, we just have to train neural network again. For example, there are 10 people in existing system and another 4 people came as new comer's in existing system. Then newcomer's fingerprint image data will be added in to the input file with accepted output result. After that training process will be complete for 10+4=14 people. And also generate a new weight file. Finally, new existing system ill be ready for testing of matching the fingerprint image

5. CONCLUSION

There are several contemporary AFIS, also our proposed algorithm works well. Especially for persons of every ages. Relationships in finger prints among the family hierarchies can also be formed using this sort of AFIS.

APPENDIX

a) Input File

Fingerprint digital data for the fingerprint image in 8-row-8-column with the accepted output result of 16 output neurons.

1 1 1 1 1 1 0 0 (1st Person's fingerprint digital image)
1 1 1 1 1 0 0 0
1 1 1 1 1 1 0 0
1 1 1 1 1 1 1 0
1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1
0 1 1 1 1 1 1 1

1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 (Accepted output for the 1st person)
1 0 1 0 1 0 1 1 (2nd Person's fingerprint digital image)
1 1 0 1 0 0 1 1
1 1 1 0 0 1 1 1
1 1 1 1 0 0 0 0
1 0 0 1 1 0 0 1
1 1 1 1 1 1 0 1
0 0 0 0 1 1 1 1
0 0 0 0 1 1 1 1
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 (Accepted output for the 2nd person)

b) Weight File

After execute the program of AFIS, we get this type of weight file. The weight file can be very long. In this paper a small part of the weight file has been shown.

[Weights for input layer to hidden layer]

.000606 -0.035276 -0.090857 -0.003659 -0.042563 -0.077889 -0.124040 -0.039797 -0.055192 -0.082984 -0.118564 -0.091613 -0.066753 -0.044870 -0.050394 -0.084747

[Weight for hidden layer to output layer]

0.294348 1.291186 -0.023057 0.132722 1.281326 1.506776 1.585510 1.117441 1.399538 1.022415 1.846003 0.919032 1.739551 0.320497 -0.024943 1.361784
0.874348 1.191186 1.356943 0.012722 0.421326 0.126776 1.325510 0.057441 0.379537 0.622415 1.046003 1.079032 -0.000449 0.800498 1.375057 0.841784

REFERENCES

[1] Lefteri H. Tsoukalas, Purdue University, and Robert E. Uhrig, The University of Tennessee. *"Fuzzy and Neural Approaches in Engineering"*.

[2] B.Yegnanarayana, Professor, Department of Computer Science and Engineering, Indian Institute of Madras, Chennai. *"Artificial Neural Network"*

[3] Simon Haykin, Hamilton, Ontario, February, 1998. *"Neural Networks"*

[4] Bart Kosko, University of Southern California. *"Neural Networks and Fuzzy Systems"*

[5] Stuart J. Russell and Peter Norvig *"Artificial Intelligence A Modern Approach"*.

[6] Sergios Theodoridis, Departments of Informatics, University of Athens, Greece, and Konstantinos Koutroumbas, The Greek Telecommunications Organization, Athens, Greece. *"Pattern Recognition"*.

[7] Earl Gose, Department of Electrical Engineering and Computer Science, University of Illinois at Chicago, and Richard Johnsonbaugh Steve Jost, School of Computer Science, Telecommunications and Information Systems, DePaul University. *"Pattern Recognition and Image Analysis"*.

[8] D.C. Douglas Hung, Ching-Yu Huang, and Jane H.C. Cheng, Computer Vision Lab, Department of Computer and Information Science, New Jersey Institute of Technology, Newark, NJ 07102. dhung@cis.njit.edu

[9] C.M Brislawn, J.N. Bradeley, R.J. Onyshczak, T.Hopper, "The FBI compression standard for digitization fingerprint image ", Proc. SPIE, Vol.2847, Denver,Aug. 1996

[10] "Online-fingerprint verification using direct minuatiae Extraction" In-gu Bae at al, Dept of Computer Engineering, Kyungpook National University, Taegum Korea 702-701