The Study of Adoption of Neural Network Approach in Fingerprint Recognition

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ABSRACT
Fingerprint identification and verification are one of the well established methods for implementing security aspects. This technique has become mature due to lots of research in this area. One more feature of artificial intelligence is clubbed with image processing for fingerprint that is artificial neural network. ANN is used at different levels in fingerprint recognition. In this paper we will study the use of neural network approach in fingerprint recognition at different stages.

General Terms
Multimodal Biometrics, Neural Network, Pattern Recognition,

Keywords
Fingerprint recognition, artificial neural network, backpropagation network, fuzzy logic, LCNN, Biometrics

1. HISTORY AND INTRODUCTION TO FINGERPRINT RECOGNITION

Biometrics, the word is well known in the area of authentication and authorization now a day. The technology uses different human traits for identification and verification. We can consider two types of biometrics technologies based on physical and behavioral traits. Biometrics technologies based on physical traits include fingerprint, face, iris, retina, ear shape, hand geometry, palmprint etc.. Biometric technologies based on behavioral traits include voice, keystroke, gait recognition etc..

Among all these technologies, fingerprint recognition is the oldest biometric recognition technology. It is in the use since ancient times. It was not until the late sixteenth century that the modern scientific fingerprint tech- technique was first initiated. In 1684, the English plant morphologist, Nehemiah Grew, published the first scientific paper reporting his systematic study on the ridge, furrow, and pore structure in fingerprints. In the late nineteenth century, Sir Francis Galton conducted an extensive study on fingerprints. He introduced the minutiae features for fingerprint matching in 1888.

In the early twentieth century, fingerprint recognition was formally accepted as a valid per- personal identification method and became a standard routine in forensics. Fingerprint identification agencies were set up worldwide and criminal fingerprint databases were established. Various fingerprint recognition techniques, including latent fingerprint acquisition, fingerprint classification, and fingerprint matching were developed. For example, the FBI fingerprint identification division was set up in 1924 with a database of 810,000 fingerprint cards [1].

Now a day, two widely used approaches for fingerprint recognition are minutiae based and correlation based. As each fingerprint is unique in reference to various available on it, so we can adopt any one of the two methods.

To reduce the complexity, fingerprints are classified into five classes based on curve pattern in the fingerprint. These classes are 1. Right loop 2. Left loop 3. Arc 4. Tented Arc 5. Whorl. It reduces total number of comparisons during the matching phase and time is also reduced.

2. NEURAL NETWORK

Neurons are biological elements present in the human brain. They perform information processing in the brain. The network of interconnected neurons is known as neural network. A neural network is composed of a number of nodes, or units, connected by links. Each link has a numeric weight associated with it. The architecture can be made up of multiple layers. It is also called multilayer feed forward network. The fig. of multilayer feed forward network is shown below:

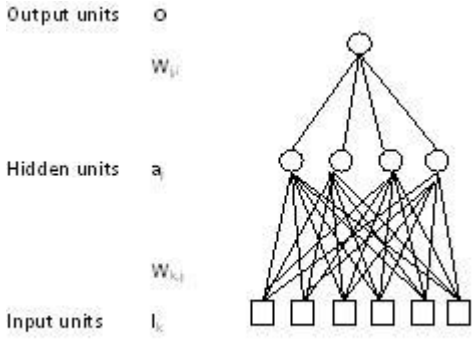

Fig 1: Multilayer Feed Forward Network

The most popular method for learning in multilayer networks is called back-propagation. You can perform learning in back propagation network.

Learning in such a network proceeds in this way: example inputs are provided to the network, and if the output vector of network computing matches the target, nothing is done. If there is an error (i.e. a difference between the output and target), then the weights are adjusted to reduce this error [2].

Now a day, neural network concept is used in every area of information technology to improve the performance of the system. We will study the use of neural network approach in fingerprint recognition in this paper.

3. IMPLEMENTING NEURAL NETWORK APPROACH IN FINGERPRINT CLASSIFICATION

There are several reasons to prove that neural network approaches are remarkably well suited for fingerprint problems. First, fingerprints form a very specific class of patterns with very peculiar flavor and statistical characteristics. Second, neural networks can avoid some of the drawbacks inherent to other more conventional approaches. Third, neural networks are robust, adaptive, and trainable from examples. This is particularly important as fingerprint images can include several different sources of deformation and noise ranging from the fingers and their positioning on the collection device. [13]

The neural network concept was first implemented by Leung, Engeler, and Frank (1990) [3]. They introduced a neural network-based approach where a multi-layer perceptron analyzes the output of a rank of Gabor filters applied to the gray-scale image. The image is first transformed into the frequency domain where the filtering takes place; the resultant magnitude and phase signals constitute the input to a neural network composed of six sub-networks, each of which is responsible for detecting minutiae at a specific orientation; a final classifier is employed to combine the intermediate responses.

Maio and Maltoni (1998b) [4] used a shared-weights neural network to verify the minutiae detected by their gray-scale algorithm [5]. The minutiae neighborhoods in the original gray-scale image are normalized, with respect to their angle and the local ridge frequency, before passing them to a neural network classifier, which classifies them as termination, bifurcation, and non-minutia.

A typical three-layer neural network architecture has been adopted, where a partial weight sharing allows the termination/bifurcation duality to be exploited (Fig. 2). In fact, the weight sharing requires the same type of processing to be performed by the first layer of neurons both on the positive and the negative neighborhoods. This network has more degrees of freedom with respect to a three-layer (26-10-2) perceptron trained both on the positive and the negative versions of the same neighborhood, and used twice for each classification.

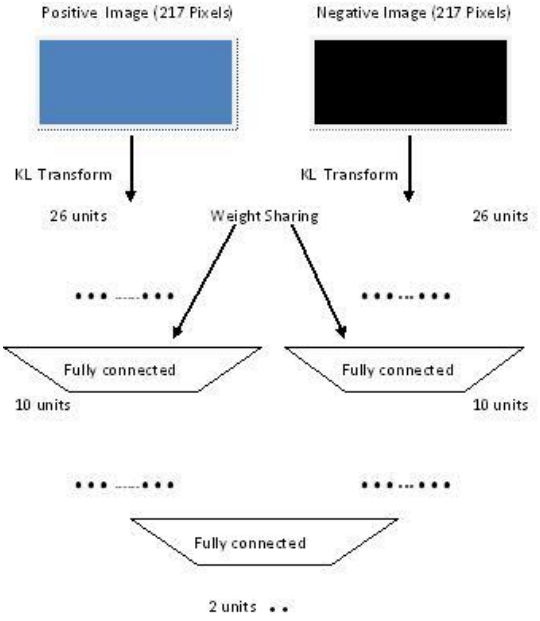

Fig 2: The neural network architecture to classify gray-scale minutiae neighborhoods into termination, bifurcation, and non-minutiae (Maio and Maltoni, 1998b). ©IEEE.

Most of the existing fingerprint classification methods can be coarsely assigned to one of these categories: rule-based, syntactic, structural, statistical, neural network-based and multi- classifier approaches.

In 1990s the neural network based fingerprint classification method became successful with compare to traditional methods. Most of the proposed neural network approaches are based on multilayer perceptrons and use the elements of the orientation image as input features (Hughes and Green (1991) [6], Kamijo, Mieno, and Kojima (1992) [7], and Pal and Mitra (1996) [8]). Kamijo (1993) [9] presents an interesting pyramidal architecture constituted of several multilayer perceptrons,

Jain, Prabhakar, and Hong (1999) [10] train 10 feed forward neural networks to distinguish between each possible pair of classes. Some researchers proposed the use of self-organizing neural networks. In Moscinska and Tyma (1993) [11], a Kohonen map is trained to find delta points, and a rule-based approach is applied for the final classification; in Halici and Ongun (1996) [12] a multilayer self-organizing map provides the classification.

Now let us see some work carried after 1990s. J. Urias, D. Hidalgo, P. Melin, O. Castillo proposed a new method for response integration in modular neural networks using type-2 fuzzy logic [14]. Biometric authentication is used to achieve person recognition. Biometric characteristics like face, fingerprint, and voice are used. A modular neural network of three modules is used. Each module is a local expert on person recognition based on each of the biometric features. The response integration approach of the modular neural network has the objective of integrating the responses of the modules to enhance the recognition rate of the individual modules.

The results of a type-2 fuzzy logic approach for response integration has shown higher performance over type-1 fuzzy logic approaches.

Wang, H.; Min, L.Q. & Liu, J. proposed the cellular neural/nonlinear network (CNN) as a powerful tool for fingerprint feature extraction. They presented two theorems for designing two kinds of CNN templates. These two theorems provided the template parameter inequalities to determine parameter intervals for implementing the corresponding functions [15].

Sitalakshmi Venkataraman proposed a Grid-based neural network framework for adopting multimodal biometrics with the view of overcoming the barriers of performance, privacy and risk issues that are associated with shared heterogeneous multimodal data centre. The framework combines the concept of Grid services for reliable brokering and privacy policy management of shared biometric resources along with a momentum back propagation ANN (MBPANN) model of machine learning for efficient multimodal fusion and authentication schemes. [16]

C. Park, M. Ki, J. Namkung, and J.K. Paik suggested that introducing momentum backpropagation ANN improves the accuracy. [17]

B. Jayaraman, C. Puttamadappa, E. Anbalagan, E Mohan and Srinivasrao madane suggested back propagation algorithm to obtain higher accuracy in fingerprint recognition. They implemented ANN after minutiae filtering step and back propagated in to the network , until the desired performance of the authentication mechanism. [18]

Fawaz Alsaade suggested resilient back propagation training algorithm to combine information from separate modalities to provide complementary data. His experimental investigations involved the recognition mode of verification in mixed quality data conditions. He deployed this at score level and found that system error can be reduced considerably [19].

3.1 Effect on Performance

Mehran Yazdi, and Kazem Gheysari performed experiments of classification of fingerprint with feed forward neural network approach. They used two databases and they trained the neural network. They were able to achieve 99.02 % accuracy in classification with four classes. Anil Jain, Salil Prabhakar and Lin Hong trained a multilayer feed forward network using a quick propagation training algorithm. The neural network was having 20 neurons in one hidden layer, 192 neurons at input layer and five output neuron for five classes. They were able to achieve 86.4% accuracy for five class problem. For four class problem they achieved the accuracy of 92.1%[21].

4. CONCLUSION

In this paper, we have seen various approaches for adoption of neural network approach. In the decade of 1990s it became popular due to its impact on performance, on accuracy and thus on reducing error rate. The concept is still one of the trustworthy ways for improving performance. This concept is popular not just for fingerprint, but also other identification methods can be implemented with this. We can use neural network at different levels of authentication and authorization process. ANN is also implemented with multibiometrics. With backpropagation network we can adjust threshold value to reduce error rate and reducing FAR and FRR. In future, some new directions will get open to use the concept of ANN.

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