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Biometric Fingerprint Indentification Using Artificial Neural Network

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Abstract

Fingerprint recognition is one such area that can be used as a means of biometric verification where the ANN can play a critical rule. Fingerprint identification is mainly used in artificial intelligence. It is popular because of their easy access, low price of fingerprint sensors, non-intrusive scanning, and relatively good performance. In recent years, significant performance improvements have been achieved in commercial automatic fingerprint recognition systems. The fingerprint of an individual is unique and remains unchanged over a lifetime. No two persons have the same set of fingerprints. This property makes fingerprints an excellent biometric identifier. So it is one of the popular and effective means for identification of an individual and used as forensic evidence.

Keywords

Artificial Neural Network; Fingerprint; Biometrics, Feature Extraction, Image Acquisition

I. Introduction

Fingerprints have been used for over a century and are the most widely used form of biometric identification. Fingerprint identification is mainly used in artificial intelligence. It is popular because of their easy access, low price of fingerprint sensors, non-intrusive scanning, and relatively good performance. In recent years, significant performance improvements have been achieved in commercial automatic fingerprint recognition systems. The fingerprint of an individual is unique and remains unchanged over a lifetime. No two persons have the same set of fingerprints. This property makes fingerprints an excellent biometric identifier. So it is one of the popular and effective means for identification of an individual and used as forensic evidence. A fingerprint is formed from an impression of the pattern of ridges on a finger. A ridge is defined as a single curved segment and a valley is the region between two adjacent ridges. Typically, there are two prominent types of minutiae (ridge ending and ridge bifurcation) that constitute a fingerprint pattern. The minutiae which are the local discontinuities in the ridge flow pattern provide the features that are used for identification. Details such as the type, orientation and location of minutiae are taken into account when performing minutiae extraction [1]. Here, we propose a Fingerprint Recognition System (FRS) based on Artificial Neural Network (ANN). The rest of the paper is organized as follows: Section II provides the brief description of a generic fingerprint recognition system. Section III provides the background principles related to the working of the proposed model. All experimental results and related discussion is provided in section IV-V. This paper is concluded by summing up the work in section VI. Some of the relevant literatures are cited between [6]-[7].

II. Basic Theoritical Aspects Related to the Proposed System

Here we briefly cover the basic theoretical aspects related to the work.

A. Fingerprint

These are graphical flow-like ridges and valleys present on the surface of human fingers [3]. A ridge ending is defined as the ridge point where it ends abruptly. A ridge bifurcation is defined as the ridge point where a ridge diverges into branch ridges. A fingerprint can be represented by the minutiae locations, types and attributes like orientation. A good quality fingerprint image typically has about 40 to 100 minutiae, but a dozen of minutiae are considered sufficient to identify a fingerprint pattern [2].

B.Fingerprint Recognition

It is one of the popular biometric techniques. It refers to the automated method of verifying a match between two fingerprint images. It is formed by the ridge patterns of the finger [2]. Figure 1. shows an image of the fingerprint structure.

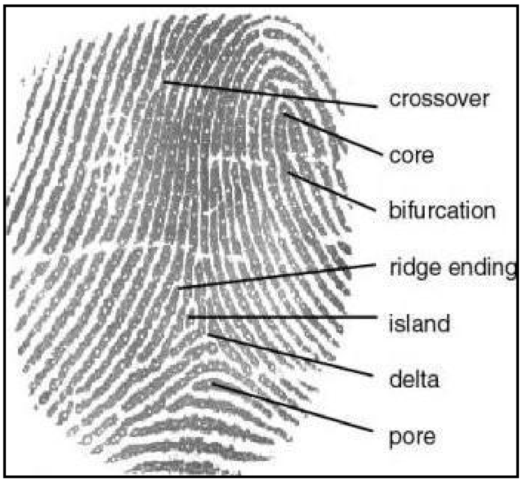

Fig. 1: A Fingerprint Sample Image

B. Artificial Neural Network

It is a soft computing tool that can learn patterns and predict. A neural network is a biologically inspired method of computation. Neural networks used for computation should appropriately be called Artificial Neural Network(ANN)s. These only resemble the parallel computation generated by the biological neural network which is the basics of human learning.

III. System Model

A generic ANN based Fingerprint Recognition System in block diagram form is shown in Figure 2.

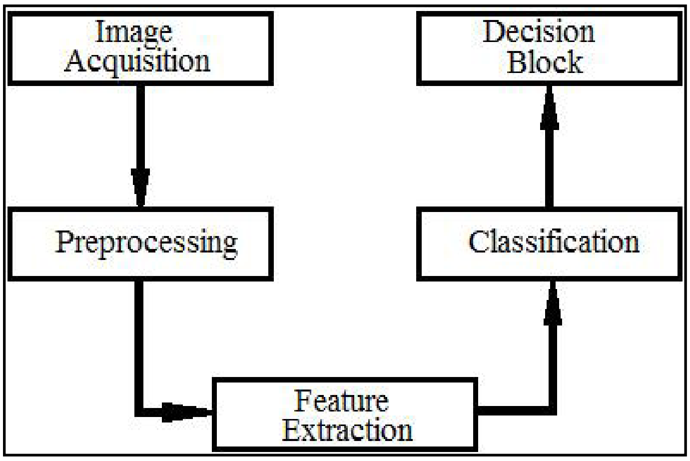

Figure 2: Process logic of the Complete System

It involves the following modules:

1. Image Acquisition

An image can be captured by a digital scanner, digital camera, sensor etc. It involves recording of a scene by a camera, sampling and quantization and storing it in a computer for manipulation. The best of digital image capture record represents loss of data as the sampling process involved in digitization selects samples at specific intervals only.

2. Image Preprocessing Stage

It includes various stages which should be taken for making an image suitable for manipulation and interpretation by subsequent stages. The steps include removal of noise and variation of intensity recorded, sharpening, improving the contrast and strengthening the texture of the image. Another important aspect is image restoration which extracts image information from a degraded form to make it suitable for subsequent processing and interpretation [2].
Feature extraction: It is a process through which certain vital information and details of an image section is captured for subsequent interpretation.

3. Classification

This is the key component of fingerprint recognition system and determines the system‟s performance to a large extent. In this proposed model an Artificial Neural Network is used as classifier for recognition. It can generate multiple classes and decision boundaries and it produces the correct result by classifying the feature extracted templates and matching these features with known patterns in the feature database.

IV. Design and Implementation of the Proposed System

In this work the focus is to implement the system that provides reliability, accuracy and reduced overall match speed.
The steps of the algorithm of the system model is shown in Figure 3.

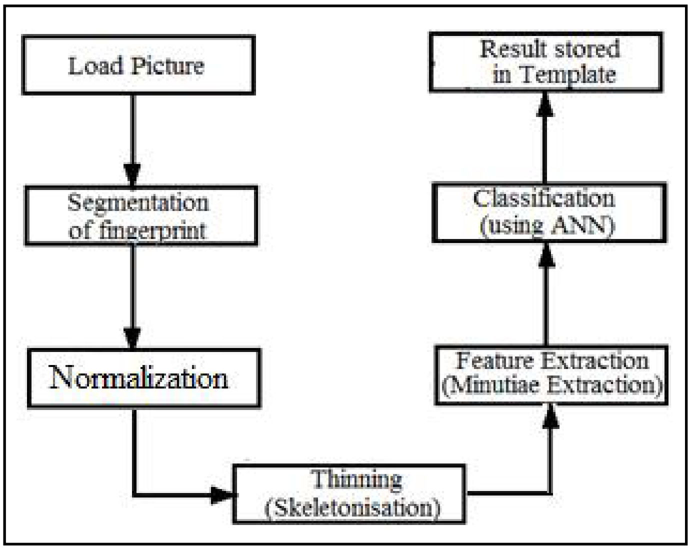

Figure 3: System Model Design

In this proposed model, a multi stage approach is used. These stages are image acquisition, image preprocessing, thinning, feature extraction, classification and decision.
Fingerprint image preprocessing includes image segmentation, normalization, ridge orientation estimation, ridge frequency estimation, thinning etc. Image segmentation is the process of separating the foreground regions in the image from the background regions. The foreground regions correspond to the clear fingerprint area containing the ridges and valleys, which is the area of interest. The background corresponds to the regions outside the borders of the fingerprint area, which do not contain any valid fingerprint information. When minutiae extraction algorithms are applied to the background regions of an image, it results in the extraction of noisy and false minutiae. Thus, segmentation is employed to discard these background regions, which facilitates the reliable extraction of minutiae. The segmented images are then normalized. Image normalization is required to standardize the intensity values in an image by adjusting the range of gray-level values so that it lies within a desired range of values.
After normalization, we have done the thinning process. Thinning is a morphological operation that successively erodes away the foreground pixels until they are one pixel wide. A standard thinning algorithm [7] is employed, which performs the thinning operation using two sub iterations. This algorithm is accessible in MATLAB via the „thin‟ operation under the „bwmorph‟ function. The application of the thinning algorithm to a fingerprint image preserves the connectivity of the ridge structures while forming a skeletonised version of the normalized image.
The thinned images are next considered for the minutiae feature extraction. The minutiae feature extraction algorithm which extracts the main minutiae features required for matching two fingerprints. Here, Crossing Number (CN) method is used for minutiae extraction of fingerprints [8]. The ridge pixel can be divided into bifurcation, ridge ending and non-minutiae point based on it. The CN algorithm is working on pixel representation „1‟ or „0‟, but the decision of minutiae point can be selected for each pixel value. CN method extracts the ridge endings and bifurcations from the skeleton image by examining the local neighborhood of each ridge pixel using a 3x3 window. The CN for a ridge pixel P is given by:

$$CN = 0.5 \sum_{i=1}^{8} |P_i - P_{i+1}|, \; P_9 = P_1 \quad (1)$$

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Where P_i is the pixel value in the neighborhood of P. For a pixel P, its eight neighboring pixels are scanned in an anti-clockwise direction as follows:

P4	P3	P2
P5	P	P1
P6	P7	P8

After the CN for a ridge pixel has been computed, the pixel can then be classified according to the property of its CN value. With this formula, if CN=1 it corresponds to the end point and if CN=3, it corresponds to Bifurcation point of minutiae. Other properties of CN are described in Table I. In applying this algorithm, border area may be ignored, since there is no need to extract minutiae point on border area of the image that will gives more false minutiae points.

Table I: Properties of CN

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

After a successful extraction of minutiae, they are stored in a template, which may contain the position, direction, type and quality of the minutiae. In this proposed model ANN is used as classifier for recognition. Here, a feed forward back propagation neural network is configured for the classification of the fingerprints. For the fingerprint approach, the ANN input layer has 160 neurons and is trained for 200 to 3000 epochs. The results obtained are average values of atleast fifteen trails for the epochs considered.

V. Experimental Details and Results

The performance of FRS is analyzed in terms of computational speed and reliability. The overall computational time taken by the system is reduced to a greater level. A total of 40 identical fingerprint images have been provided to the system for training, validation and testing of the system. After extensive training, the system is subjected to certain variations with signal to noise ratio (SNR) range between 0 to 3dB to achieve robustness and proper recognition. The ANN considered is configured using the specifications shown in Table II.
The default performance function for feed forward neural network is mean squared error (mse) which is the average squared error between the network outputs and the target outputs.

Table II: ANN Specifications

Input Data Size	Fingerprint with CN features of length 160
SNR	0 to 3dB
ANN type	MLP with two hidden layers. First hidden layer 1.25 times the length of feature vector and second hidden layer 0.75 times the length of feature vector.
ANN training method	Back propagation with Levenberg-Marquardt optimization
Average training epochs	MLP-200 to 3000
Mean Squared Error(MSE) goal	10^{-4}

The MSE plot shown by the ANN during training while configuring the FRS is shown in Figure 4. Original, thinned and minutiae extracted fingerprints are shown in Figures 5 to 7. The tested results of recognition for various training epochs for the FRS is shown in Table III. The epochs are between a few hundreds to a few thousands and the success rate is around 84 to 94%.
Computation time is counting based on tic/toc command from Matlab, a command to start stopwatch timer and measure the time required for the operation between tic and toc statements. The training time required is between 35 to 38 seconds for a set of ten samples each. The results are derived by performing fifteen trials for each of the sample sets and the average results quoted. The strength of the proposed system is its speed, computational efficiency, robustness, decision and high precision which shall make it suitable for certain application.

Table III: Average Success Rates Achieved Between a Few Numbers of Training Epochs

Epochs	% Success rate of FRS
200	84
500	92
1000	93
2000	93.6
3000	94

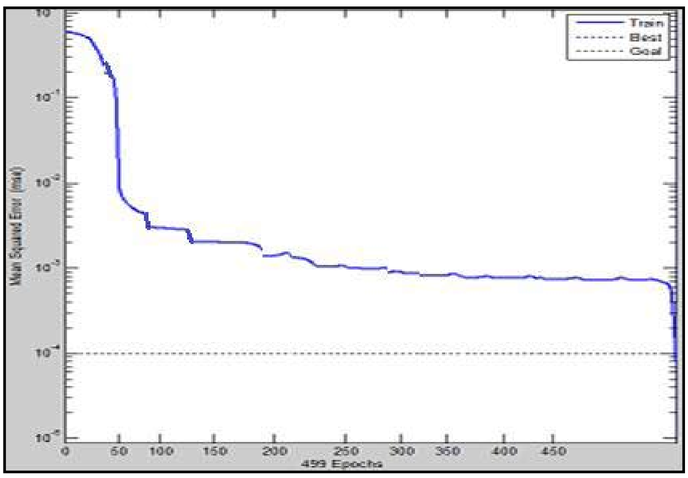

Figure 4: MSE plot

Figure 5: Original Fingerprint image

Figure 6: Thinned Fingerprint image

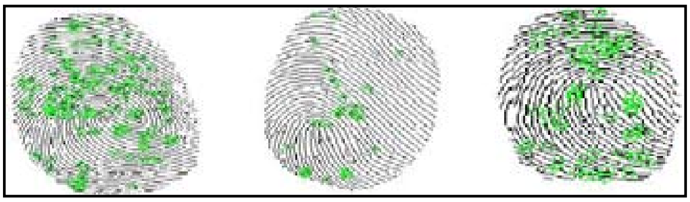

Fig. 7: Minutiae Extracted Fingerprint

VI. Conclusion

The specialty of the work is associated with the fact that if the ANN is configured properly it can tackle the variations in the fingerprint images and that way provides the insights for developing a system which requires these samples as inputs for verification and authorization. A system designed to provide authentication decision using these inputs can be a reliable means of verification as has been observed from experimental results.

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Biography:-

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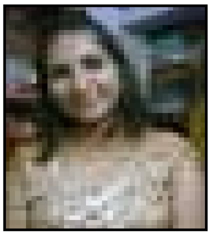

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