Neural Network based Fingerprint Classification

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Abstract: ***This paper introduces a new approach of fingerprint classification system based on ANN. Most automated fingerprint identification system uses prior classification of fingerprint using minutiae as feature. But in such methods the performance of minutiae extractions relies heavily on an enhancement algorithm and also it needs improvement as they are limited to the number of classable data. Thus many fingerprints are classified together, taking a long time to match and verify a given fingerprint. So instead of classification using minutiae we proposed a classification system that is based on individual features like singular point. Singular point detection is very robust and reliable, which overcomes the problem about rotation and translation. Classification efficiency is improved using Back Propagation Algorithm because we don't need to compare an input fingerprint image to all registered fingerprint images. The algorithm is tested accurately and reliably for many fingerprint images in FVC2004 database.***

Keywords: Fingerprint Classification, Singular point, Feature Extraction, Neural Network, Matlab**.**

1. Introduction

In last few years identification of fingerprint is widely used in many applications like identification of person. Fingerprint [7] classification is the process of dividing a huge amount of fingerprint database within which the input fingerprint is first determined and next to that a classification [10] is carried out to observe the set of same class. A database usually contains a number of fingerprints with different number of individual features. The identification of input fingerprint within this database becomes an extremely long process. Therefore classification of fingerprint can help to increase the speed of identification. The input fingerprint is classified among the set of classes of fingerprint database. In this way each fingerprint only need to match against the corresponding class contained in database. Many fingerprint classification methods have been proposed till now like orientation field flow curves method and quality based method [1] [2]. Few of them shows graph based representation and few of them shows structural representation [3]. Here in this work we use a standard fingerprint database FVC 2004 to classify fingerprint images into six classes arch, tented arch, right loop, left loop, whorl and twin loop using back propagation algorithm .

2. Methodology

A Number of different techniques are used for automatic classification of fingerprint [15]. These classifications based on:

- Singular Point [4]
- Syntactic or Grammar Based [5]
- Mathematical Model [6]

The most natural topology for analyzing fingerprint images is the topology of curves created by the ridge and valley structures. This necessitates the use of the analysis of properties of the curves or curve features. The approach presented in this paper is combination of biometric and Gabor filter.

3. Fingerprint Classification

The approach for fingerprint classification involves (i) the extraction of features of given fingerprint image, (ii) Feature Orientation (iii) labeling of each oriented fingerprint in to six class like arch, tented arch, right loop, left loop, twin loop, whorl. The fingerprints have been traditionally classified into categories based on information in the global patterns of ridges. Fingerprint classification provides an important indexing mechanism in a fingerprint database. An accurate and consistent classification [16] can greatly reduce fingerprint matching [9] time from a large database. We present a fingerprint classification algorithm [18] which is able to achieve a better accuracy. Efforts in automatic fingerprint classification [20] have been exclusively directed. Figure 2 shows fingerprint classification architecture that has shown classification of fingers into six classes. It consist of user interface to provide interaction for user with system, the system database is the collections of the recorded data and enrolment module and authentication module is present for system input and verification of the fingerprint image given by user. A fingerprint classification system should be invariant to rotation, translation, and elastic distortion of the frictional skin. In addition, often a significant part of the finger may not be imaged (e.g., dabs frequently miss deltas) and the classification methods requiring information from the entire fingerprint may be too restrictive for many applications. A number of approaches for fingerprint classification have been developed.

A. Fingerprint sensing

There are two primary methods of capturing a fingerprint image:

1) Inked (off-line) and
2) Live scan

The most popular technology to obtain a live-scan fingerprint image is based on optical frustrated total internal reflection (FTIR) concept.

B. Classification

The fingerprint classifications start with the orientation of input image followed by the Ridge Extraction [11]. This image is used for singular Point [19] extraction [13] to train neural network by thinning.

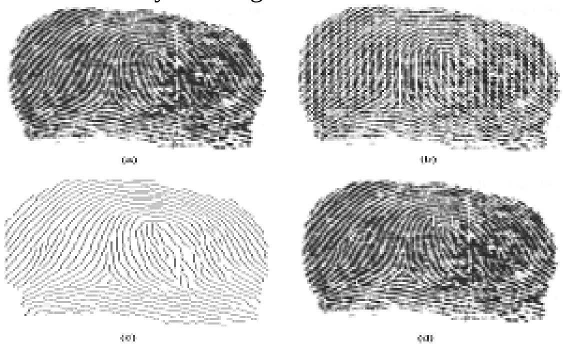


Figure 1. Orientation field, thinned ridges, minutiae and singular points. (a) Gray scale image. (b) Orientation field. (c) Thinned ridges. (d) Minutiae (.), Core (u), and Delta (D).

4. Functional System

A. Image Acquisition

A number of methods are used to acquire fingerprints [17]. Among them, the inked impression method remains the most popular one. Inkless fingerprint scanners are also present eliminating the intermediate digitization process. Fingerprint quality is very important since it affects directly the singular point extraction algorithm. Two types of degradation usually affect fingerprint images:

1) The ridge lines are not strictly continuous since they sometimes include small breaks (gaps);

2) Parallel ridge lines are not always well separated due to the presence of cluttering noise. The resolution of the scanned fingerprints must be 500 dpi while the size is 640 x 480.

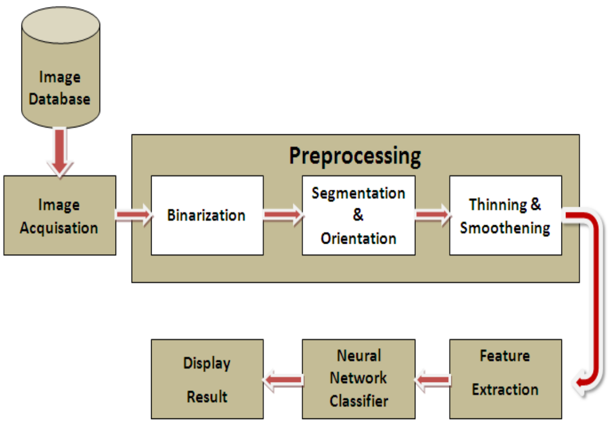


Figure 2. System Architecture of Fingerprint Classification.

B. Edge Detection

An edge [8] is the boundary between two regions with relatively distinct gray level properties. The idea underlying most edge-detection [14] techniques is on the computation of a local derivative operator such as 'Roberts', 'Prewitt' or 'Sobel' operators. In practice, the set of pixels obtained from the edge detection algorithm seldom characterizes a boundary completely because of noise, breaks in the boundary and other effects that introduce spurious intensity discontinuities. Thus, edge detection algorithms typically are followed by linking and other boundary detection [21] procedures designed to assemble edge pixels into meaningful boundaries.

C. Segmentation

Once the preprocessing was done, it was necessary to find the region of interest within the images, where the *67* feature extraction would take place. The segmentation was divided into two different processes. The first sample images of each class of fingerprints were converted from gray-scale to binary through a fixed threshold value. The binary images were then submitted to morphologic operations of erosion and dilation, respectively, leaving in the image a single area of black pixels corresponding to the center of the region of interest. The next step was the detection of the boundary rectangle of the resulting black area, whose geometric center would be the center of a 640 x 480 pixels square image to be cropped from the corresponding preprocessed images. The central 320 x 240 pixels region of the first cropped image was stored as a reference region to be used in the cropping process of the remaining images.

D. Thinning

An important approach to representing the structural shape of a plane region is to reduce it to a graph. This reduces the ridges to a central line without changing the shape of image. This reduction may be accomplished by obtaining the skeleton [12] of the region via thinning (also called skeletonising) algorithm.

The thinning algorithm while deleting unwanted edge points should not:

•Remove end points.

•Break connectedness

•Cause excessive erosion of the region.

E. Feature Extraction

A feature extractor finds the core point and delta point from the input provided by pre-processing. The overall flowchart of a typical process is depicted in Figure 4. It mainly consists of three components.

1. Orientation field estimation,
2. Ridge extraction, and
3. Singular point extraction and post processing.

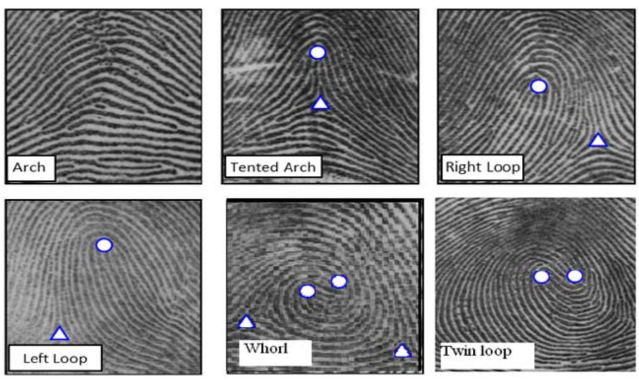


Figure 3. Core points on different fingerprint pattern

F. Filter

Gabor filter based features have been successfully and widely applied to face recognition, pattern recognition and fingerprint enhancement. The family of 2-D Gabor filters was originally presented by Daugman (1980) as a framework for understanding the orientation and spatial frequency selectivity properties of the filter. Daugman mathematically elaborated further his work. In a local neighbourhood the gray levels along the parallel ridges and valleys exhibit some ideal sinusoidal shaped plane waves associated with some noise.

G. Back propagation Neural Network

The training of a back propagation net involves three stages: the feed forward of the input training patterns, the calculation and back propagation of the associated error and the weight adjustments. After the net has been trained, its application involves only feed forward phase.

5. Metlab Implementation

The design stage of the project involved developing cooperative classification algorithm using the MATLAB programming language and MATLAB GUI for the easy utilization of system. MATLAB was chosen as the design tool of choice, due to the high level nature in which MATLAB is developed.

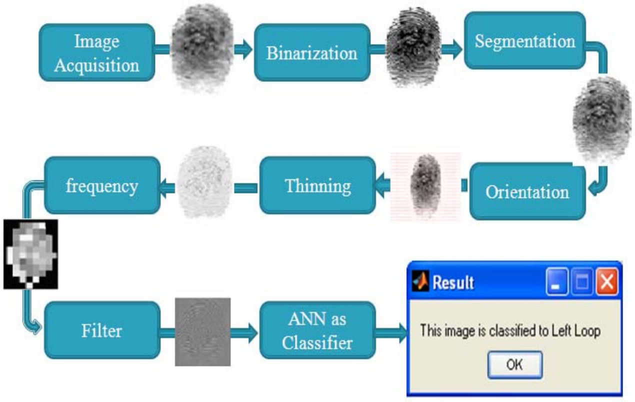
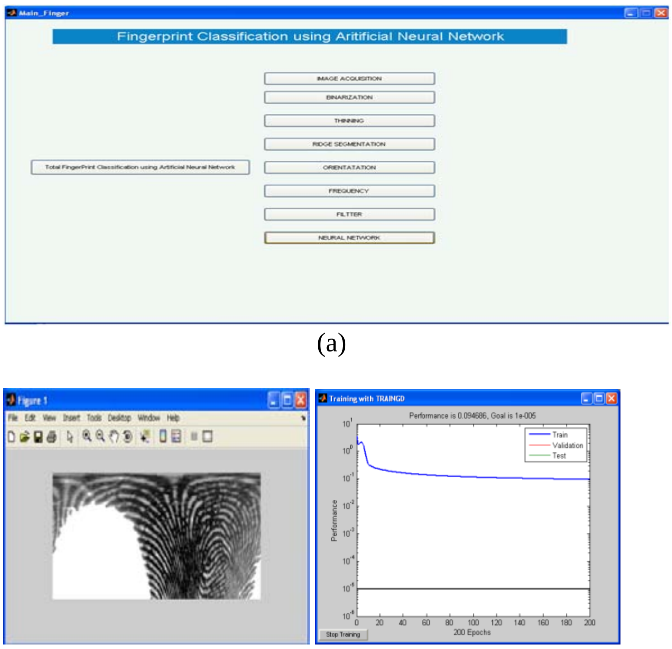


Figure 4. Fingerprint Classification Algorithm

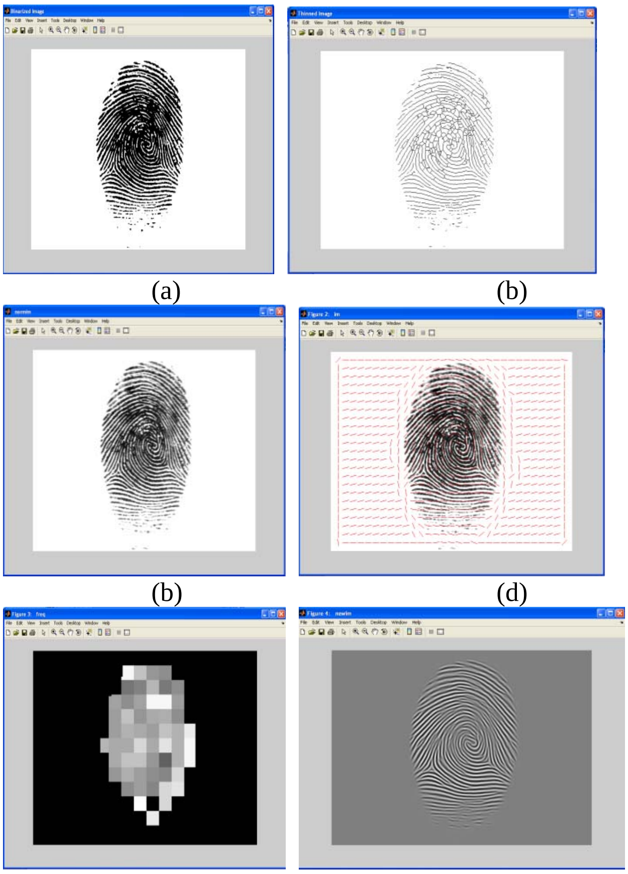


(a)

(b) (c)

Figure 5. Software Implementation (a) GUI (b) Extraction (c) Training

6. Output Result



(a) (b)

(b) (d)

(e) (f)

Figure 6. Output windows (a) Binarization (b) Thinning (c) Segmentation (d) Orientation (e) Frequency (f) Filter.

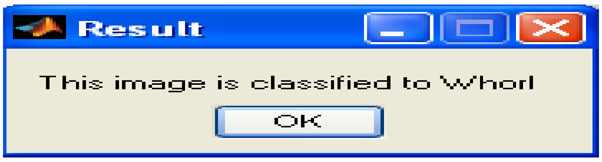


Figure 7. Classification Result

7. Conclusion

The methodology presented in previous section was validated on standard database. The database contains total 536 images while created database contain 100 images which are classified in to five classes like arch, right loop, left loop, whorl and twin loop successfully. The classification result given by the system with minimum of rejection ratio is very accurate. It is obvious that presented method has greatly improved fingerprint image classification accuracy. Simulation results verified that the proposed algorithm is accurate and effective.

Images Type	Number of Images Tested	Correct Classification	Result
Whorl	20 * 8 = 160	144	89.60%
Left Loop	20 * 8 = 160	145	89.75%
Right Loop	20 * 8 = 160	145	89.75%
Twin Loop	2 * 8 = 16	12	75.40%
Arch	5 * 8 = 40	36	89.60%
Average Result			86.82%

Figure 8. Standard Database Result

Images Type	Number of Images Tested	Correct Classification	Result
Whorl	5 * 4 =20	20	100%
Left Loop	5 * 4 =20	20	100%
Right Loop	5 * 4 =20	20	100%
Twin Loop	5 * 4 =20	17	85%
Arch	5 * 4 =20	18	90%
Average Result			95%

Figure 9. Created Database Result

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