Fingerprint Minutiae Extraction using Fuzzy Logic

Pankaj Mohindru, Ph.D
Department of Electronics and Communication
Punjabi University

Govind Sharma
Department of Electronics and Communication
Punjabi University

Pooja
Department of Electronics and Communication
Punjabi University

ABSTRACT
Fingerprints, the oldest and most widespread biometric identification system are commonly used for criminal investigation in forensic Science; there is minute statistical theory on the Rareness of fingerprint minutiae. A critical step in studying the statistics of Fingerprint minutiae is to reliably extract minutiae from the fingerprint images. However, fingerprint images are rarely of perfect quality. They may be degraded and corrupted due to variations in skin and impression conditions. Thus, image Enhancement techniques are employed prior to minutiae extraction to obtain a more reliable estimation of minutiae locations.

Keywords
Enhancement, Fuzzy inference system, region of interest, binarization

1. INTRODUCTION
Fingerprints identification, a well-known biometric identification system has wide application in this modernize world. Fingerprints of an individual person are unique and remain static over lifetime. Fingerprints consist of impression of pattern of ridges and valleys on the finger. Ridges define single curved segments and valleys are the region between two ridges. The local discontinuities between the ridges known as minutiae provide features that are used for identifying person. Extraction and correction of such minutiae are thus primary. By the American National Standards Institute proposes four classes of minutiae: ending, bifurcation, trifurcation, and undetermined [4]. Most fingerprint identification systems are based on minutiae matching, and there are two minutia structures that are most prominent: ridge endings and ridge bifurcations [5].

Fingerprints images obtained from various sources may consist of noise or have poor visibility that can cause extraction faults, such as rejection of true minutiae and acceptance of fault minutiae. A good quality fingerprint image consists of 20 to 80 minutiae. Various mathematical algorithms are previously designed to reduce these effects but they cannot handle such faults properly. In this paper we proposed a fuzzy logic enhancement method at preprocessing stage of minutiae extraction and a post processing method for removing false minutiae. Fuzzy logic provides human reasoning capabilities to capture uncertainties that cannot be described by precise mathematical models [6].

This paper is organized into the following sections. Section 2 is an overview of related work, Section 3 describes the model of the minutiae extraction method, Section 4 contains results, and finally Section 5 gives conclusions.

2. OVERVIEW
Fuzzy Logic is a powerful problem solving methodology in the past few years. It shows a rapid growth in the applications of Fuzzy logic, especially in the image processing applications, such as edges detection, feature extraction, classification and clustering [3]. In 2003 Vijayaprasad.PI, Ashraf Gasim and Elsid Abdalla, proposed a new algorithm to improve fingerprint image quality by using Neuro-fuzzy technique. It was very difficult to detect minutiae point from bad quality fingerprint image [1]. In 2006 Rossini Velour submitted a report in University of Texas El Paso on the topic of Fingerprint recognition using Fuzzy inference techniques. She develops the fingerprint recognition system using fuzzy inference techniques. The two principle components in this recognition system are the administrator, where templates are stored and the fingerprint recognizer. Here do not use the intermittent steps of Image processing techniques like enhancement the image and reduction of the noise [2].

3. IMPLEMENTATION
First five steps shown below create an image ready for minutiae extraction. There are different methods proposed for enhancing an image at the preprocessing stage but we used a method proposed by [7] to make the image suitable for post processing.

The data flow graph for minutiae extraction is shown in figure 1:

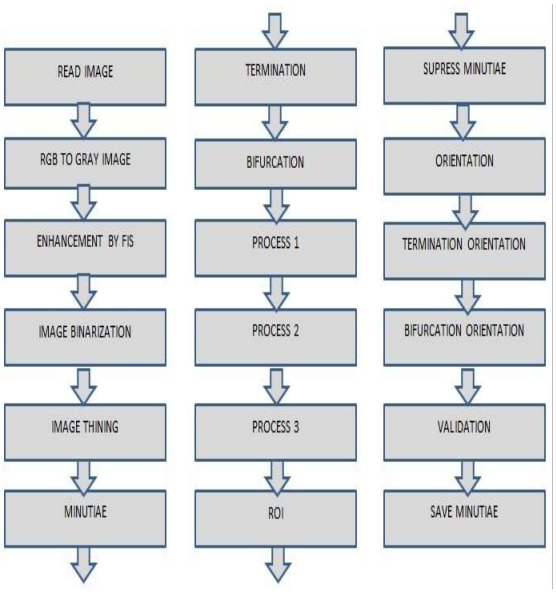


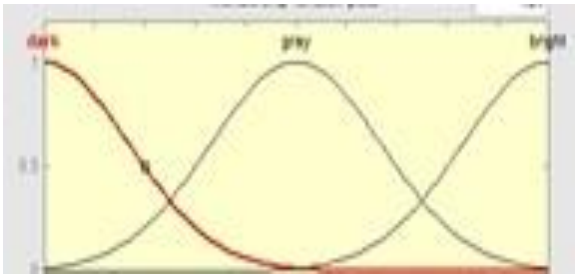
Figure 1 Data flow graph for minutiae extraction

3.1 Image Enhancement by FIS

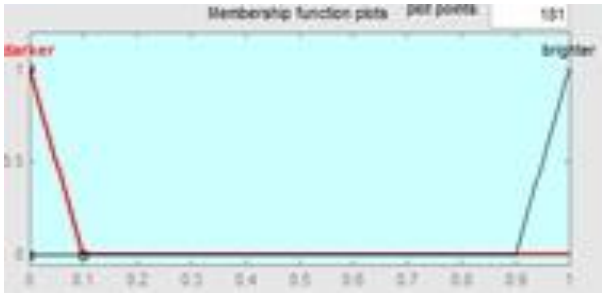
The innumerable steps involved the enhancement of fingerprint images are:

- Read the original image
- Convert it into gray scale image if it is RGB
- Calculate the size of original image in the form of matrix M x N
- Generate Fuzzy inference system editor
- Apply fuzzy inference Engineering
- Normalization of pixel values of image
- Passing parameters to the FIS(type-1)

The input and output membership functions used in the generation of FIS are shown in figurev2:



Input membership functiins



Output membership functions

Figure 2 Input and Output MFs

The Fuzzy rules that allow evaluating the input variables, so that the exit image displays the enhanced version of the image are:

1. If(gray level image is dark), then (gray level image is darker)
2. If (gray level image is gray), then (gray level image is gray)
3. If (gray level image is bright), then (gray level image is brighter)

After enhancement the image is converted into binary image that contains only 0 and 1 as pixel values. The next step involves thinning the image to one pixel so that minutiae can be extracted easily.

3.2 Minutiae extraction

Fingerprint consists of two types of minutiae, ridge terminations and ridges bifurcations. Minutiae relative positions are used for comparisons. Therefore it is evident that more accurate the minutiae, more accurate will be the fingerprint recognition system. The process for extracting the minutiae is same as explained in [7]. Crossing number is used to identify the minutiae points in fingerprint image. These are calculated as half of the sum of differences between the intensity values of adjacent pixels.

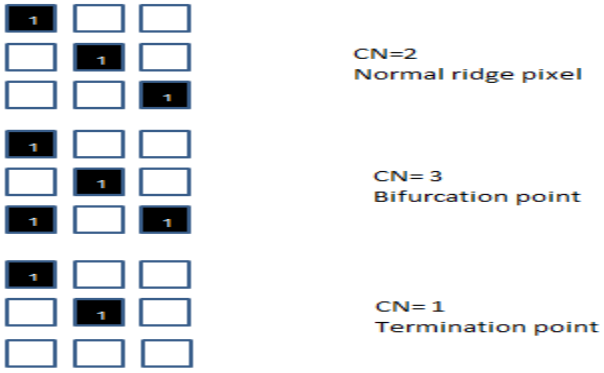


Figure 3 Cross Number and type of Minutiae

3.3 Minutiae Post-processing

The Minutiae extracted from this process contains large number of false points. Removal of such false points called as spurious minutiae is important. We are going to process them. Processing depends upon the Euclidian distance (D) between the two points.

Process1

If the distance between the termination and bifurcation point is smaller than D, remove that minutiae.

Process 2

If the distance between the two bifurcations is smaller than D remove that bifurcation.

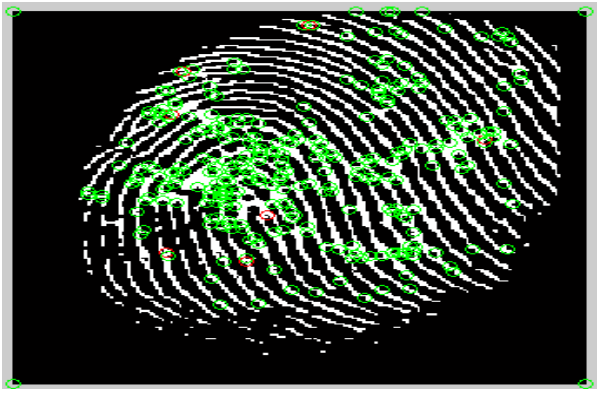
Process 3

If the distance between the two terminations is smaller than D remove that termination.

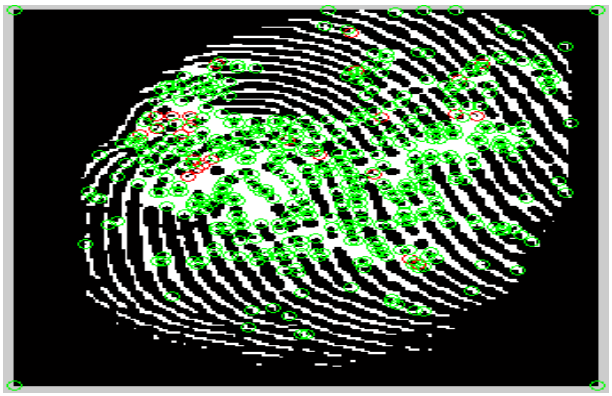
ROI (Region of interest)

We have to determine a Region of interest of the input image so that the minutiae external to that ROI will be removed.

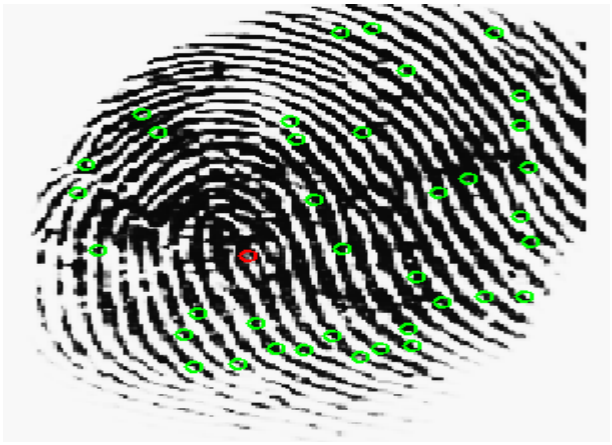
4. RESULTS



(a)



(b)



(c)

(d)

Figure3. (a) Minutiae extraction with Fuzzy pre-processing (b) Normal minutiae extraction (c) True minutiae with fuzzy enhancement after post processing (d) True minutiae without fuzzy enhancement after post processing

The difference between the original image and enhanced image can be examined using histogram shown in figure 4(a) and 4(b). Figure 4(b) represents better contrast and brightness values then figure 4(a).

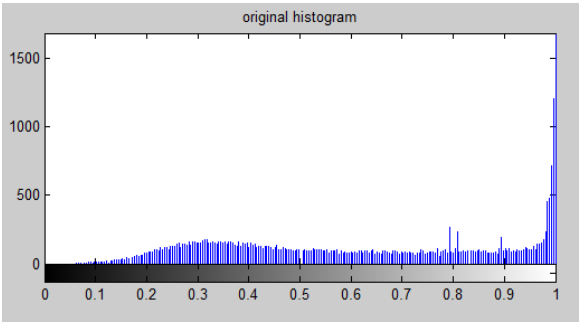


Figure 4(a) Histogram of original image

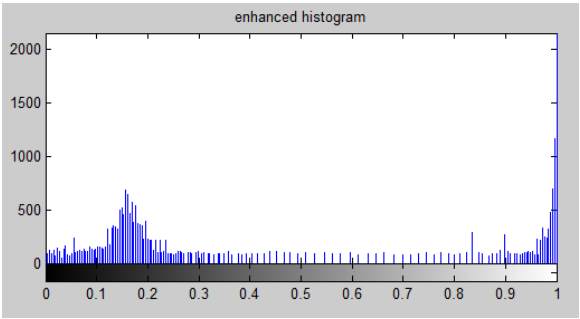


Figure 4(b) Histogram of enhanced image

5. CONCLUSION

Analyzing the figure 3 (a), (b), (c), (d) it is concluded that with fuzzy logic as pre- processing algorithm increases the chances of select true minutiae and reduces the chances of rejecting true minutiae thereby increases the accuracy of the fingerprint recognition system.

6. REFERENCES

[1] Vijayaprasad.P and Ashraf Gasim Elsid Abdalla "Applying Neuro-Fuzzy Technique to the Enhanced Fingerprint image", 2003.

[2] Roshini Velamuri Guide: Sarkodie-Gyan Thompson "Fingerprint recognition using Fuzzy inferencing techniques" April 20, 2006.

[3] Zadeh, L.A., "Fuzzy Sets", Journal of Information Sciences, Vol. 8, pp. 33- 353, 1965

[4] Prabhakar, S.; Jain, A.K.; Jianguo Wang; Pankanti, S.; Bolle. R.; "Minutiae Verification and Classification for Fingerprint Matching" Conference on, Volume: 1, 2-7 Sept. 2000.

[5] Haiping Lu; Xudong Jiang; Wei-Yun Yan; "Effective and efficient Fingerprint Image Post processing" Conference on, Volume: 2, 2-5 Dec 2002.

[6] Yang Gao, Meng Joo Er, "Online Adaptive Fuzzy Neural Identification and Control of Class of MIMO Nonlinear systems" IEEE Transaction on Volume: 11, Issue: 4, Aug. 2003.

[7] Mukti Dubey, Prof. Sandeep Sahu, "Fingerprint Minutiae Extraction and Orientation Detection using ROI (Region of interest) for fingerprint matching" IJSER on Volume 5, issue 1, January-2014.