

# BIOMETRIC: AN APPLICATION TO RECOGNIZE THE FINGERPRINT

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## Abstract

Human fingerprints are rich in details called minutiae, which can be used as identification marks for fingerprint verification. The goal is to develop a complete system for fingerprint verification through extracting and matching minutiae. To achieve good minutiae extraction in fingerprints with varying quality, preprocessing in form of image enhancement and linearization is first applied on fingerprints before they are evaluated. Many methods have been combined to build a minutiae extractor and a minutiae matcher. Minutiae-marking with false minutiae removal methods are used in the work. An alignment-based elastic matching algorithm has been developed for minutiae matching. This algorithm is capable of finding the correspondences between input minutiae pattern and the stored template minutiae pattern without resorting to exhaustive search. Performance of the developed system is then evaluated on a database with fingerprints from different people.

**Keywords:** *minutiae, ridges, pattern, histogram, minutiae extraction.*

## INTRODUCTION

With the rapid evolution of information technology, people are becoming even more and more electronically connected. As a result, the ability to achieve highly accurate automatic personal identification is becoming more critical. Examples of these systems include secure access to buildings, computer systems, laptops, cellular phones and ATMs. In the absence of robust authentication schemes, these systems are vulnerable to the impostor. Traditionally, passwords and ID cards have been used to restrict access to systems. However these approaches having number of disadvantages like tokens may be lost, stolen, forgotten, or misplaced; PIN may be forgotten or guessed by impostors. Security can be easily breached in these systems when a password is given to an unauthorized user or a card is stolen by an impostor; further, simple passwords are easy to guess. Fingerprint based identification has been one of the most successful biometric techniques used for personal identification. Each individual has unique fingerprints. A fingerprint is the pattern of ridges and valleys on the finger tip. A fingerprint is thus defined

by the uniqueness of the local ridge characteristics and their relationships. Minutiae points are these local ridge characteristics that occur either at a ridge ending or a ridge bifurcation.

### **Problem definition**

The two main categories of fingerprint matching techniques are minutiae-based matching and pattern matching. Pattern matching simply compares two images to see how similar they are. Pattern matching is usually used in fingerprint systems to detect duplicates. The most widely used recognition technique, minutiae-based matching, relies on the minutiae points: specifically the location and direction of each point.

This paper proposes a simple and effective approach for Biometric fingerprint image enhancement and minutiae extraction based on the number of occurrence and orientation of the local ridges and minutiae points. Automatic and reliable extraction of minutiae from fingerprint images is a critical and important step in fingerprint matching. The quality of input fingerprint images plays an important role in the performance of automatic identification and verification algorithms. This paper presents a fast fingerprint enhancement and minutiae extraction algorithm which improves the clarity of the ridge and valley structures of the input fingerprint images. Minutiae points are these local ridge characteristics that occur either at a ridge ending (the point where the ridge ends abruptly) or a ridge bifurcation (the point where the ridge splits into two or more branches). Minutiae detection becomes a difficult task in low quality fingerprint images contains noise and contrast deficiency result in pixel configurations similar to that of minutiae. A complete minutiae extraction scheme for automatic fingerprint recognition systems is presented.

The proposed method uses improving alternatives for the image enhancement process, leading consequently to an increase of the reliability in the minutiae extraction. Traditionally, commercial applications have used knowledge-based systems (e.g., PINs and passwords), government applications have used token-based systems (e.g., ID cards and badges), and forensic applications have relied on human experts to match biometric features. Biometric systems are being increasingly deployed in large-scale civilian applications.

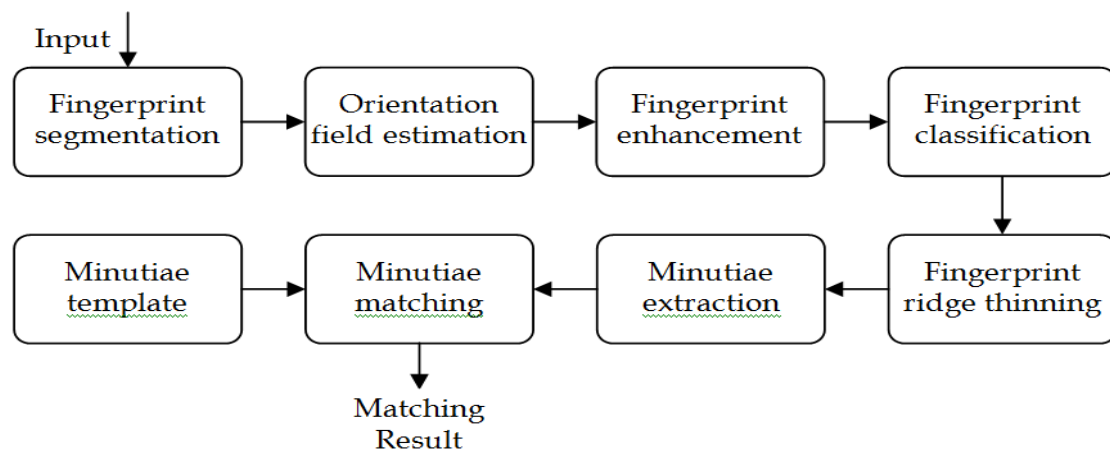
### **Disadvantages of existing system**

- For some people it is very intrusive, because is still related to criminal identification.
- It can make mistakes with the age (is not appropriate with children, because the size of their fingerprint changes quickly).
- Sometimes image compression is required, which is not possible.
- Scanner is unable to identify the fingerprint due to poor image quality caused by dirt, breaks etc...

The main advantage of the proposed system is as follows.

- Very high accuracy.
- Is the most economical biometric PC user authentication technique.
- it is one of the most developed biometrics
- Easy to use.
- Small storage space required for the biometric template, reducing the size of the database memory required

**The working of biometric system.**



## Fingerprint as biometric

Fingerprints have one of the highest levels of reliability and have been extensively used by forensic experts in criminal investigations. A fingerprint, which is the flow of ridge patterns in the tip of the finger. The ridge flow exhibits anomalies in local regions of the fingertip (Figure), and it is the position and orientation of these anomalies that are used to represent and match fingerprints. Although not scientifically established, fingerprints are believed to be unique across individuals, and across fingers of the same individual. Even identical twins having similar DNA, are believed to have different fingerprints.

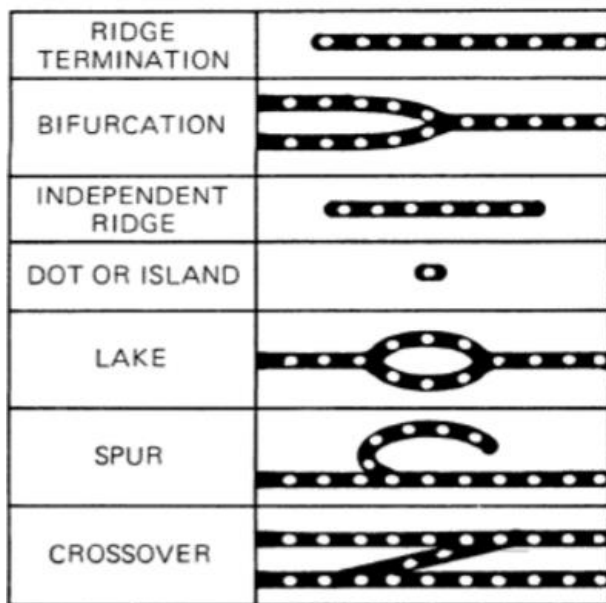
## Fingerprint features

Fingerprint is an impression of the epidermal ridges of a human fingertip. It has three levels of features, namely pattern, minutiae points and pores. Shape of ridges is used for recognition purposes. Features refers to specific friction ridge paths, overall flow of the friction ridges and major ridge path deviations ridge characteristics called minutiae like ridge endings, lakes, islands, bifurcations, scars, incipient ridges, and flexion creases.

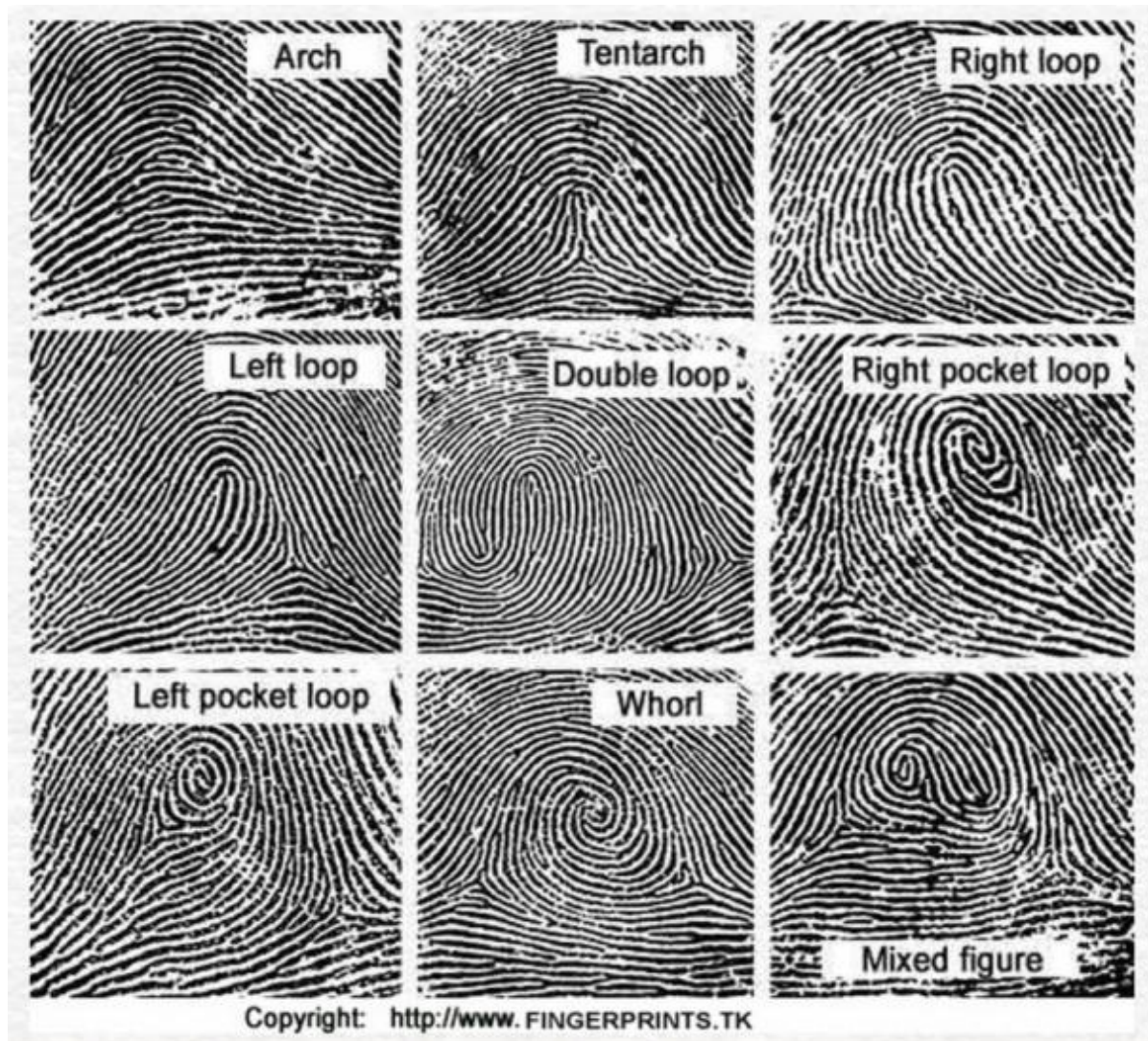
**Minutiae:**

Minutiae, in fingerprinting terms, are the points of interest in a fingerprint, such as bifurcations (a ridge splitting into two) and ridge endings. Examples are:

- a.) ridge endings - a ridge that ends suddenly.
- b.) ridge bifurcation - a single ridge that divides into two ridges
- c.) short ridges, island or independent ridge - a ridge that commences, travels a short distance and then ends
- d.) ridge enclosures - a single ridge that bifurcates and reunites shortly afterward to continue as a single ridge
- e.) spur - a bifurcation with a short ridge branching off a longer ridge
- f.) crossover or bridge - a short ridge that runs between two parallel ridges



## Types of fingerprint



## Pre-processing

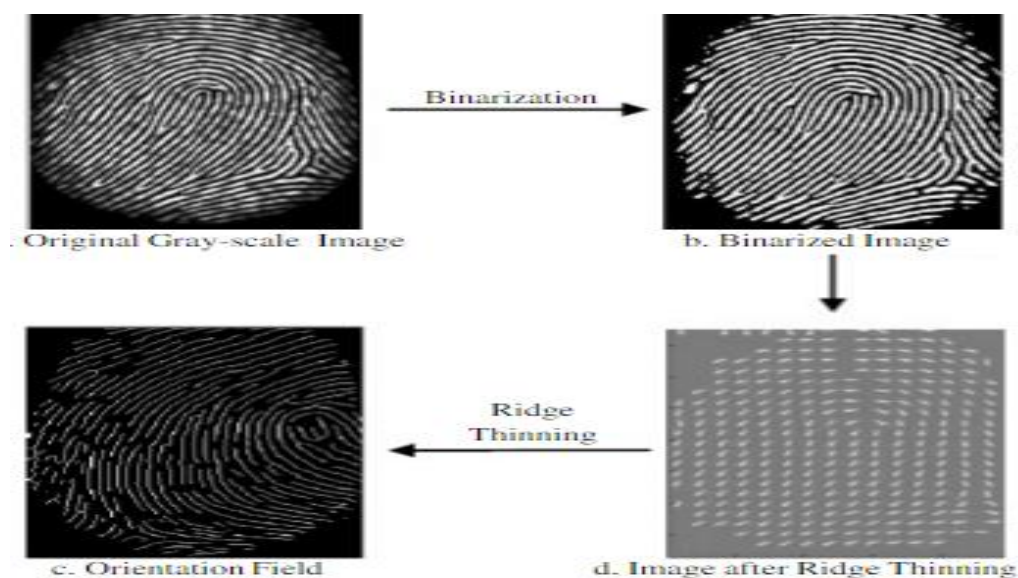
Since the fingerprint images acquired from scanner or any other media are not in good quality. So those images have to be enhanced for increasing the contrast between ridges and valleys and for connecting the false broken points of ridges due to insufficient amount of ink. Originally, the enhancement step was supposed to be done using the canny edge detector. But after trial, it turns out that the result of an edge detector is an image with the borders of the ridges highlighted. Using edge detection would require the use of an extra step to fill out the shapes which would consume more processing time and would increase the complexity of the code, as shown in figure.



### *Edge detection*

Pre-processing helps in enhancing the quality of an image by filtering and removing unnecessary noise. There are 2 more steps to improve the best quality of an image, those are minutiae extraction and false minutiae remove. During enhancement, “noise” caused by such things as dirt, cuts, scars, and creases or dry, wet or worn fingerprints is reduced, and the definition of the ridges is enhanced.

The minutiae extraction is done by applying the ridge thinning algorithm, which is used to remove the redundant pixel of ridges. As a result the thinned ridges of a fingerprint image marked with a unique ID. This makes further operations easy. After the minutiae extraction step, false minutiae removal was also necessary. The lack of amount of ink & the cross link among the ridges could cause false minutiae that led to inaccuracy in fingerprint recognition.



### *Minutiae extraction from fingerprint image*

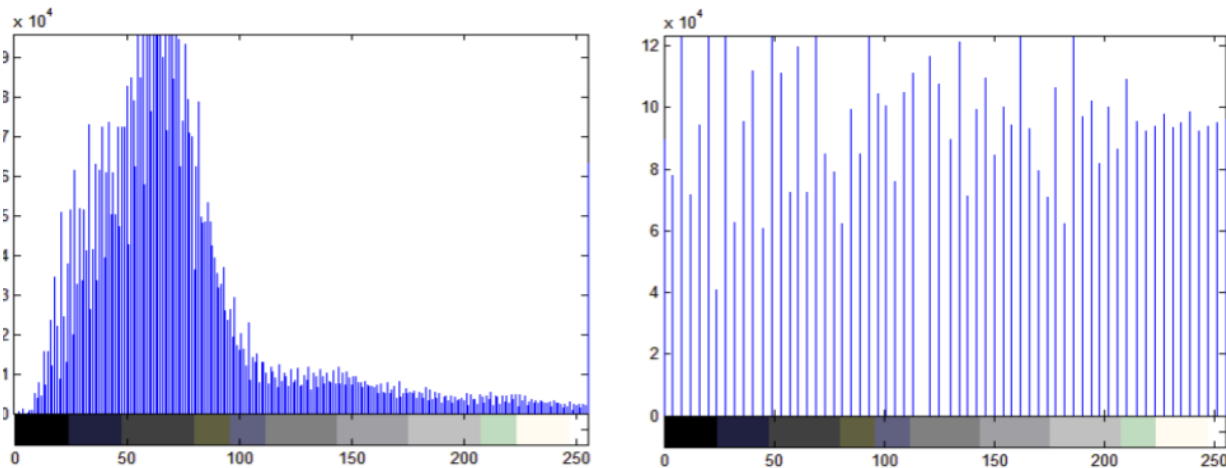
## **Fingerprint Recognition**

Fingerprint recognition technology extracts features from impressions made by the distinct ridges on the fingertips. The fingerprints can be either flat or rolled. A flat print captures only an impression of the central area between the fingertip and the first knuckle; a rolled print captures ridges on both sides of the finger. An image of the fingerprint is captured by a scanner, enhanced, and converted into a template.

Scanner technologies can be optical, silicon, or ultrasound technologies. Approximately 80 percent of vendors base their algorithms on the extraction of minutiae points relating to breaks in the ridges of the fingertips. Other algorithms are based on extracting ridge patterns.

### Histogram Equalization:

Histogram equalization is to expand the pixel value distribution of an image so as to increase the perceptual information. The original histogram of a fingerprint image is shown in Figure.



### Fingerprint Image Binarization:

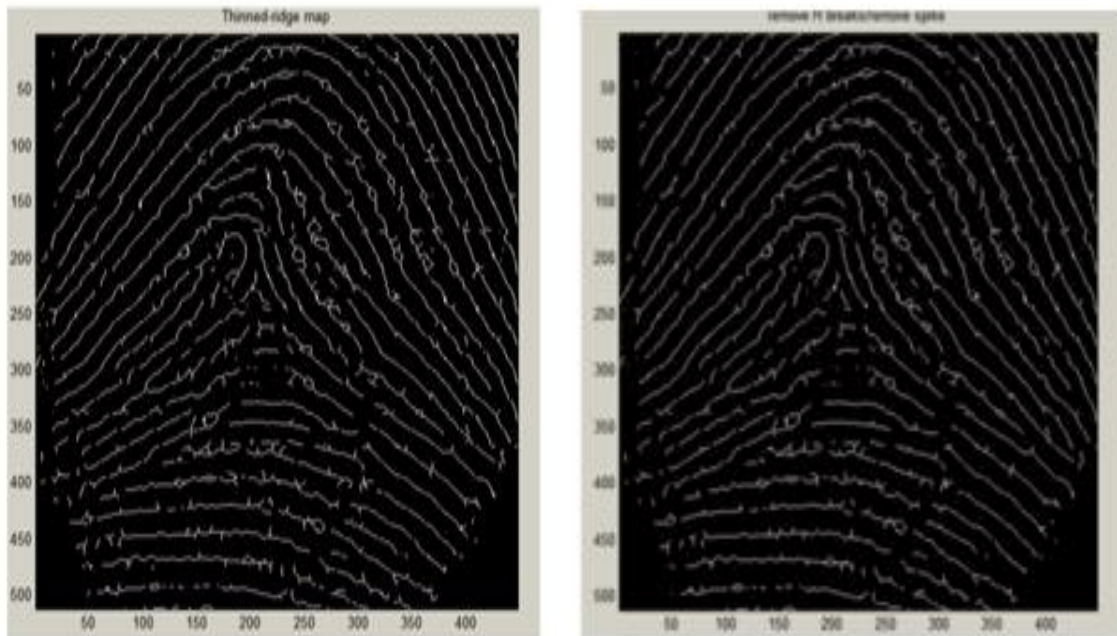
In this step, a greyscale fingerprint image is converted into binary image by fixing some threshold value. Typically, an object pixel is given a value of “1” while a background pixel is given a value of “0.” Finally, a binary image is created by colouring each pixel white or black, depending on a pixel's label (black for 0, white for 1). In this method, the image is divided into blocks (16x16), and the mean intensity value is calculated for each block, then each pixel is turned into 1 if its intensity value is larger than the mean intensity value of the current block to which the pixel belongs.



*After Binarization*

**Minutiae extraction**

Fingerprint Ridge Thinning is to eliminate the redundant pixels of ridges till the ridges are just one pixel wide. An iterative, parallel thinning algorithm is used. In each scan of the full fingerprint image, the algorithm marks down redundant pixels in each small image window (3x3) and finally removes all those marked pixels after several scans. The thinned ridge map is then filtered by other Morphological operations to remove some H breaks, isolated points and spikes. In this step, any single points, whether they are single-point ridges or single-point breaks in a ridge are eliminated and considered processing noise.



**Thinned image**

**Image after removing H Breaks and Spikes**

**Minutia Marking:**

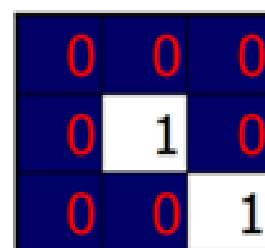
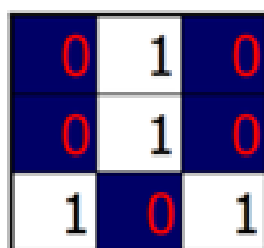
After the fingerprint ridge thinning, marking minutia points is become very easy. The Crossing Number (CN) concept is widely used for extracting the minutiae. In general, for each 3x3 window, if the central pixel is 1 and has exactly 3 one-value neighbours, then the central pixel is a ridge branch. If the central pixel is 1 and has only 1 one-value neighbour, then the central pixel is a ridge ending i.e., for a pixel P, if  $Cn(P) = 1$  it's a ridge end and if  $Cn(P) = 3$  it's a ridge bifurcation point.

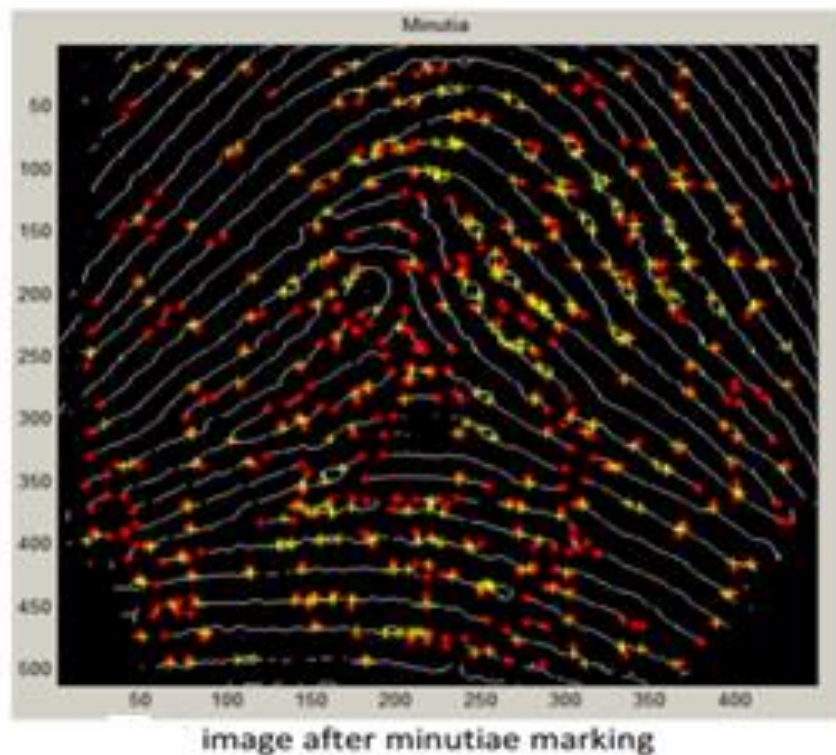


Triple Bifurcation

counting termination

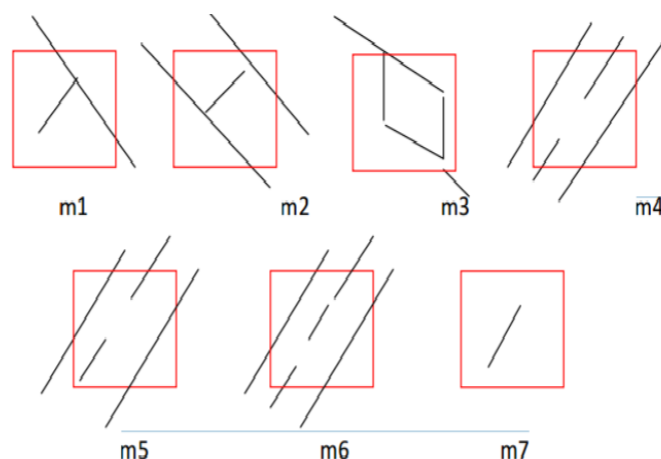
branch

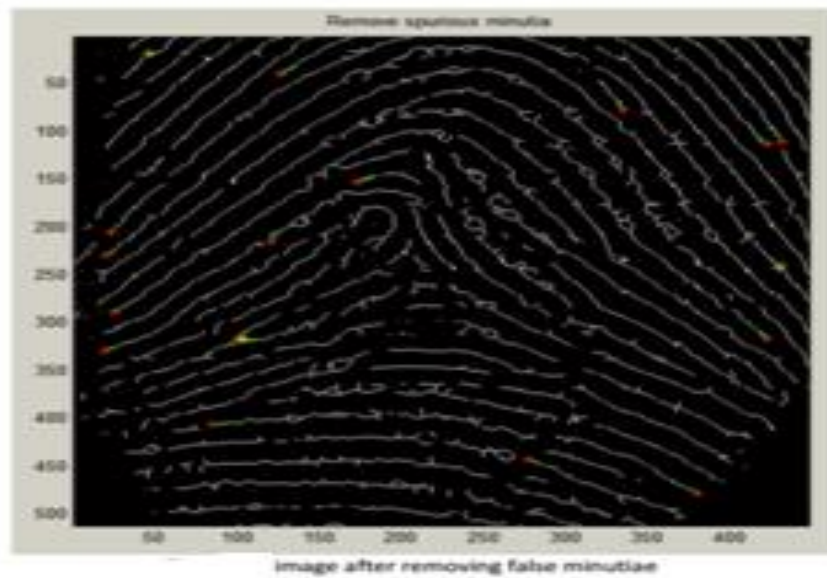




### False Minutia Removal:

The pre-processing stage does not usually fix the fingerprint image in total. For example, false ridge breaks due to insufficient amount of ink and ridge cross connections due to over inking are not totally eliminated. Actually all the earlier stages themselves occasionally introduce false minutia. These false minutiae will affect the accuracy of matching. So some mechanisms of removing false minutia are essential to keep the fingerprint verification system effective. Seven types of False Minutia Structures are shown in the figure. m1 is a spike piercing into a valley. In the m2 case a spike falsely connects two ridges. m3 has two near bifurcations located in the same ridge. The two ridge broken points in the m4 case have nearly the same orientation and a short distance. m5 is alike the m4 case with the exception that one part of the broken ridge is so short that another termination is generated. m6 extends the m4 case but with the extra property that a third ridge is found in the middle of the two parts of the broken ridge. m7 has only one short ridge found in the threshold window.





**After removing false minutiae**

## Match Stage

The matching algorithm for the aligned minutia patterns needs to be adaptive since the strict match requires that all parameters same for two identical minutiae which is impossible to get when using biometric-based matching. This is achieved by placing a bounding box around each template minutia. If the minutia to be matched is within the rectangle box and the direction difference between them is very small, then the two minutiae are regarded as a matched minutia pair. Each minutia in the template image either has no matched minutia or has only one corresponding minutia. The final match ratio for two fingerprints is the number of total matched pairs divided by the number of minutia of the template fingerprint. The score is  $100 \times \text{ratio}$  and ranges from 0 to 100. If the score is larger than a pre-specified threshold (typically 80%), the two fingerprints are from the same finger.

## Conclusion

Though pattern based matching is most used in fingerprint recognition, minutiae based matching system, which is more detailed and gives more accurate result than pattern based matching technique is the best approach in fingerprint recognition. By using minutiae based matching system we can achieve even more accurate result than any other techniques. As a future enhancement to existing system, a non-contact 3D fingerprint scanner can be used worldwide, which take a digital approach to the analog process of pressing or rolling the finger. Use of non-contact or touch less scanner prevents the damage that might cause by dirt, small particle that resides in the fingertip of user.

## **Bibliography**

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