# FINGERPRINT EXTRACTION BASE ON MINUTIAE

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A THESIS SUBMITTED IN FULFILMENT OF THE
REQUIREMENTS FOR THE AWARD OF THE DEGREE OF
BACHELOR OF COMPUTER SCIENCE & NETWORKING

FACULTY OF COMPUTER SYSTEMS & SOFTWARE ENGINEERING
UNIVERSITI MALAYSIA PAHANG

APRIL 2010

# ABSTRAK

Saat ini, kaedah pengenalan konvensional seperti SIM, pasport, kad ATM dan PIN kod tidak memenuhi tuntutan ini keperluan masa kini. Biometrik pada umumnya, dan pengesahan sidik jari automatik pada khususnya, menyediakan solusi efisien untuk masalah pengenalan moden ini. Sidik jari telah digunakan selama berabad-abad sebagai suatu cara untuk mengenalpasti orang-orang. Sidik jari individu adalah unik dan tetap tidak berubah selama masa hidup.Teknik pencocokan sidik jari dapat dibahagikan ke dalam dua kategori, berdasarkan hal-hal kecil dan korelasi berasaskan. Detail teknik berasaskan mata pertama menemukan hal-hal kecil dan kemudian peta penempatan relatif mereka pada jari. Namun, ada beberapa kesulitan ketika menggunakan pendekatan ini. Sulit untuk mengekstrak mata butiran tepat ketika sidik jari berkualiti rendah. Selain kaedah ini tidak mengira pola global ridge dan kerut. Korelasi kaedah berasaskan mampu mengatasi beberapa kesukaran dari hal-hal kecil berasaskan pendekatan. Namun, mempunyai beberapa kelemahan sendiri. Korelasi teknik berasaskan memerlukan lokasi yang tepat titik registrasi dan dipengaruhi oleh penterjemahan imej dan putaran. Pra-pemprosesan dan pengolahan pasca turun sidik jari akan dipaparkan melalui GUI (Graphical User Interface) dalam tahap akhir.

## ABSTRACT

Nowadays, conventional identification methods such as driver's license, passport, ATM cards and PIN codes do not meet the demands of this wide scale connectivity. Automated biometrics in general, and automated fingerprint authentication in particular, provide efficient solutions to these modern identification problems. Fingerprints have been used for many centuries as a means of identifying people. The fingerprints of individual are unique and are stay unchanged during the life time. Fingerprint matching techniques can be placed into two categories, minutiae-based and correlation based. Minutiae-based techniques first find minutiae points and then map their relative placement on the finger. However, there are some difficulties when using this approach. It is difficult to extract the minutiae points accurately when the fingerprint is of low quality. Also this method does not take into account the global pattern of ridges and furrows. The correlation-based method is able to overcome some of the difficulties of the minutiae-based approach. However, it has some of its own shortcomings. Correlation-based techniques require the precise location of a registration point and are affected by image translation and rotation. The pre-processing and post-processing of the fingerprint extraction will be shown via GUI (graphical user interface) in the final stage.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Fingerprints have been used for many centuries as a means of identifying people while because it remains unchanged during lifetime and fingerprint recognition is the technology that verifies the identity of a person based on the fact that everyone has unique fingerprints because the texture for each human is different. It is one of the most heavily used and actively studied biometric technologies.

Fingerprint matching techniques can be placed into two categories, minutiae-based and correlation based. Minutiae-based techniques first find minutiae points and then map their relative placement on the finger. However, there are some difficulties when using this approach. It is difficult to extract the minutiae points accurately when the fingerprint is of low quality. The correlation-based method is able to overcome some of the difficulties of the minutiae-based approach. However, it has some of its own shortcomings. Correlation-based techniques require the precise location of a registration point and are affected by image translation and rotation. The process extraction of the fingerprint will be show via a graphical user interface (GUI).

## 1.2 Problem Statement

i. Before the matching process can be done, the fingerprint must go through the identification part which is extraction of the fingerprint itself.

ii. Fingerprint matching techniques can be placed into two categories, minutiae-based and correlation based but using correlation based the small correlations are often interpreted as significant.

## 1.3 Objective

The objectives of this system are:

i. To develop a prototype of fingerprint extraction base on minutiae.

ii. To implement minutiae extraction technique.

## 1.4 Scope

This system is just a prototype system that uses image processing technique which is minutiae base technique in order to extract the fingerprint image. This fingerprint image will be load from the computer and the result of the image processing will be shown via graphical user interface (GUI). These systems only focus on image processing like in figure 1.1.

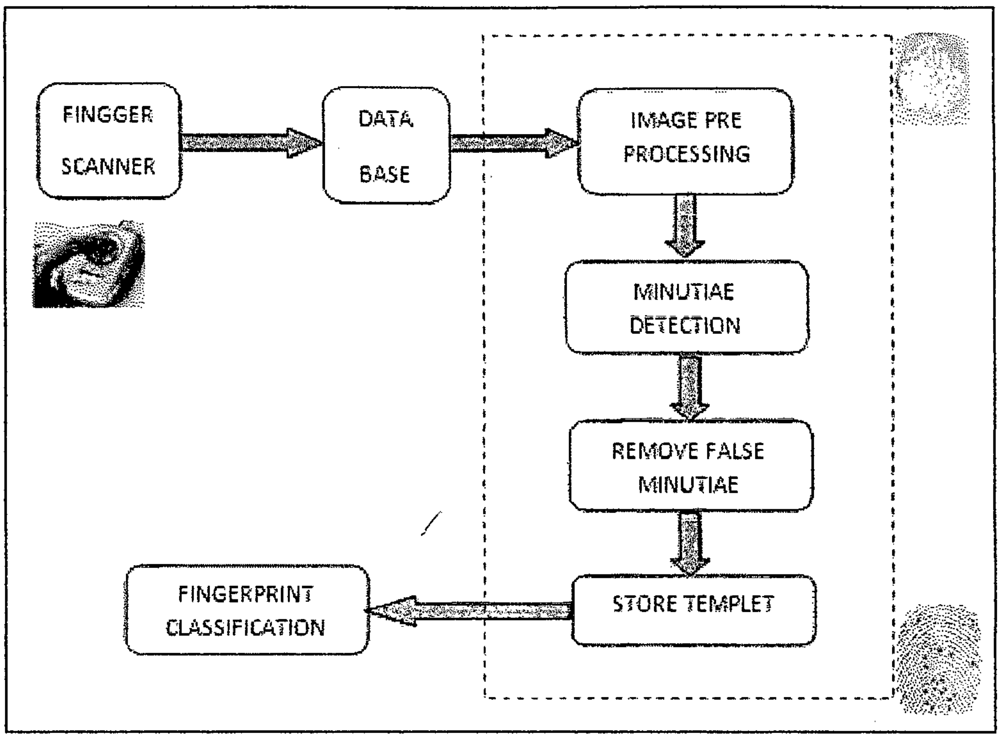


Figure 1.1: System scope

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Finger is a type of digit, an organ of manipulation and sensation found in the hands of humans and other primates. Normally humans have five digits on each hand (exceptions are polydactyly, hypodactyly and digit loss). The first digit is the thumb, followed by index finger, middle finger, ring finger, and little finger or pinky. The first digit is the thumb, followed by index finger, middle finger, ring finger, and little finger or pinky. Fingers are usually moved under conscious control. In humans, they are used for grasping, typing, grooming, writing and so on.

Meanwhile fingerprint is an impression of the friction ridges on all parts of the finger.[1] A friction ridge is a raised portion of the epidermis on the palmar (palm) or digits (fingers and toes) or plantar (sole) skin, consisting of one or more connected ridge units of friction ridge skin. These are sometimes known as "epidermal ridges" which are caused by the underlying interface between the dermal papillae of the dermis and the interpapillary (rete) pegs of the epidermis.

Fingerprint verification is A method of verification where involved a user matching a fingerprint against a single fingerprint link or similar with the identity that the user claims. Based on An Aid to the Authentication Process journal by Rodger Jamieson, Ph.D., CA, Greg Stephens and Santhosh Kumar stated that Biometrics use point of measurable uniqueness to determine identities and password are identity-nonspecific because it changeable and the possible of the similarity of the password is there [2].

## 2.2 Type of Fingerprint

A fingerprint is the feature pattern of one finger [Figure 2.1]. It is believed with strong evidences that each fingerprint is unique. Each person has his own fingerprints with the permanent uniqueness [3] so fingerprints have being used for identification and forensic investigation for a long time.

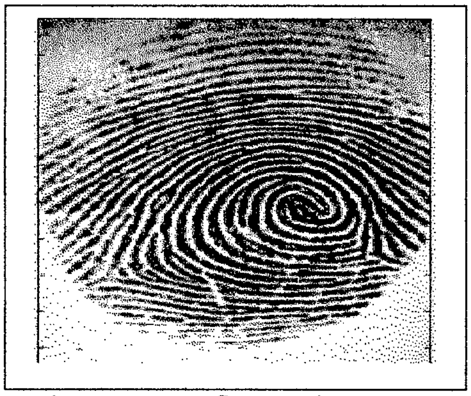

Figure 2.1: A fingerprint Image

Then this project will recognize the fingerprint types. Fingerprints are the result of minute ridges and valleys found on the hand of every person. In the fingers and thumbs, these ridges form patterns of loops, whorls and arches [figure 2.2] as below.

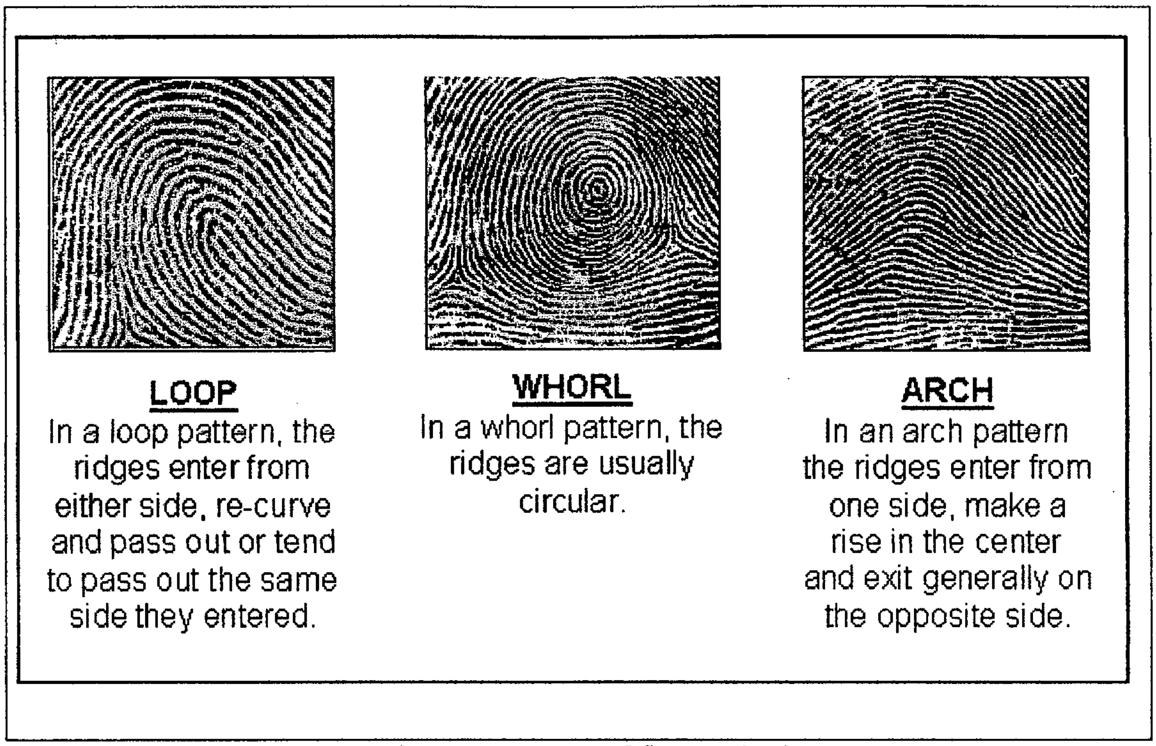


Figure 2.2: Type of fingerprint image

According to Figure 2.3, a fingerprint is composed of many ridges and furrows. These ridges and furrows present good similarities in each small local window, like parallelism and average width.

However, shown by intensive research on fingerprint recognition, fingerprints are not distinguished by their ridges and furrows, but by Minutia, which are some abnormal points on the ridges[4]Among the variety of minutia types reported in literatures, two are mostly significant and in heavy usage: one is called termination, which is the immediate ending of a ridge; the other is called bifurcation, which is the point on the ridge from which two branches derive.

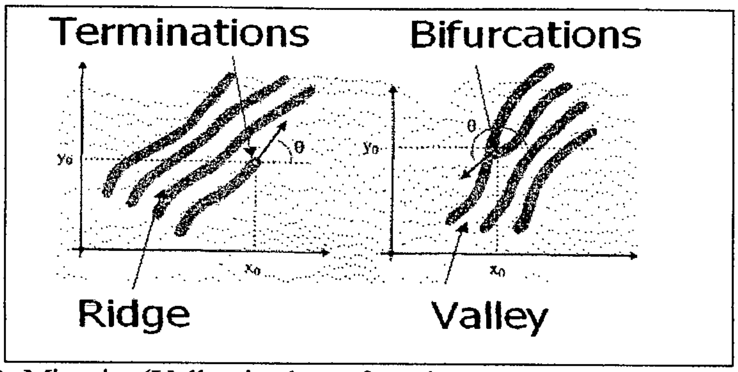


Figure 2.3: Minutia. (Valley is also referred as Furrow, Termination is also called Ending, and Bifurcation is also called Branch)

## 2.3 Fingerprint Recognition

The fingerprint recognition problem can be grouped into two sub-domains: one is fingerprint verification and the other is fingerprint identification [figure 2.4]. In addition, different from the manual approach for fingerprint recognition by experts, the fingerprint recognition here is referred as AFRS (Automatic Fingerprint Recognition System), which is program-based.

Fingerprint verification is to verify the authenticity of one person by his fingerprint. The user provides his fingerprint together with his identity information like his ID number [5]. The fingerprint verification system retrieves the fingerprint template according to the ID number and matches the template with the real-time acquired fingerprint from the user [4]. Usually it is the underlying design principle of AFAS (Automatic Fingerprint Authentication System).

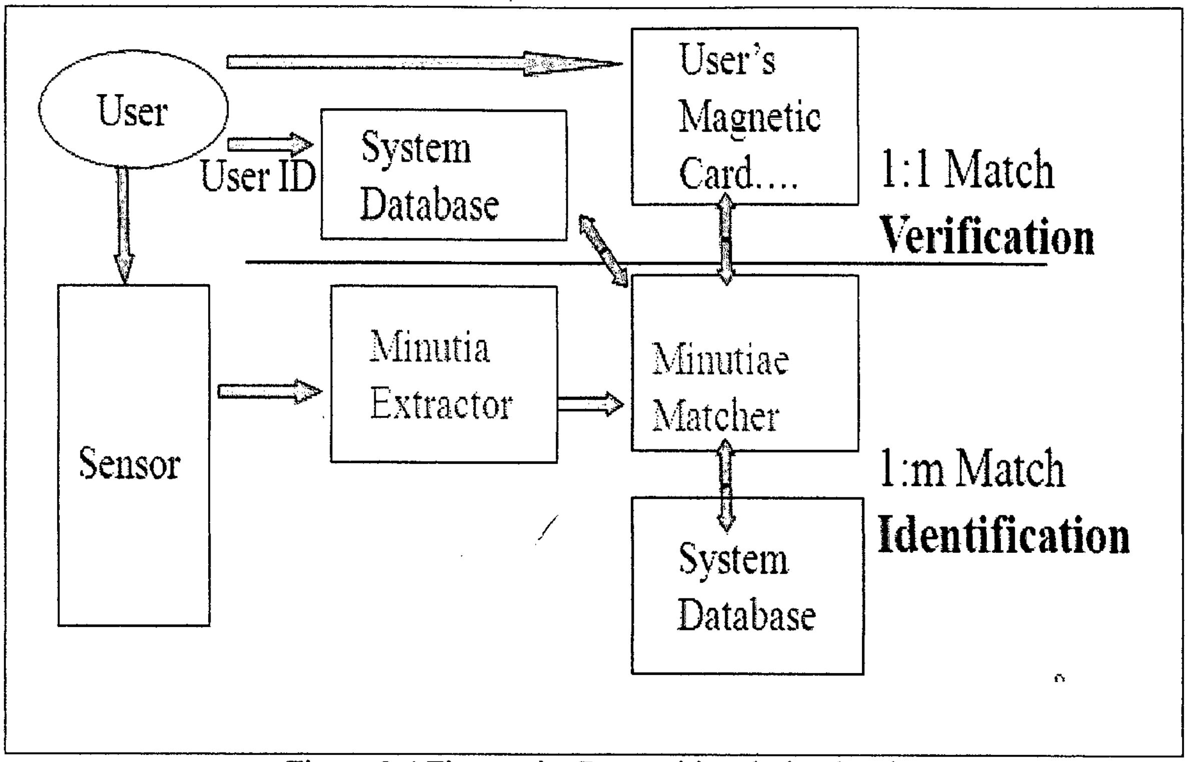

Figure 2.4 Fingerprint Recognition design level

Fingerprint identification is to specify one person's identity by his fingerprint(s). Without knowledge of the person's identity, the fingerprint identification system tries to match his fingerprint(s) with those in the whole fingerprint database [6]. It is especially useful for criminal investigation cases. And it is the design principle of AFIS (Automatic Fingerprint Identification System).

However, all fingerprint recognition problems, either verification or identification, are ultimately based on a well-defined representation of a fingerprint. As long as the representation of fingerprints remains the uniqueness and keeps simple, the fingerprint matching, either for the 1-to-1 verification case or 1-to-m identification case, is straightforward and easy.

### 2.3.1 Image Acquisition

The first stage of any vision system whether for identification or verification is the image acquisition stage. Nowadays, the automated fingerprint verification systems use live-scan digital images of fingerprints acquired from a fingerprint sensor. These sensors are based on optical, capacitance, ultrasonic, thermal and other imaging technologies.

The optical sensors are most popular and are fairly inexpensive. These sensors are based on FTIR (Frustrated Total Internal Reaction) technique. When a finger touches the sensor surface (which actually is a side of a glass prism), one side of the prism is illuminated through a di used light. While the fingerprint valleys that do not touch the sensor surface re ect the light, ridges that touch the surface absorb the light. The sensor exploits this di erential property of light re ection to di erentiate the ridges (which appear dark) from the valleys.

The capacitive sensors utilize the principle associated with capacitance to form the fingerprint images. These sensors consist of a two-dimensional array of metal electrodes. Each metal electrode acts as one plate of a parallel-plate capacitor and the contacting finger acts as the other plate. When a finger is pressed on the sensor surface, it creates varying capacitance values which depend inversely on the distance between the sensing plate and the finger surface. The ridges thus have increased capacitance compared to valleys. This variation is then converted into an image of the fingerprint.

The Ultrasound technology based sensors are the most accurate of the fingerprint sensing technologies. It uses ultrasound waves and measures the distance based on the impedance of the finger, the plate and air. The thermal sensors are made up of pyro-electric materials, which generate a temporary electrical potential when they are heated or cooled. When a finger is swiped across the sensor, there is deferential conduction of heat between the ridges and valleys which is measured by the sensor.

One of the most essential characteristics of a digital fingerprint image is its resolution which indicates the number of dots or pixels per inch (ppi). The minimum resolution that allows the feature extraction algorithms to locate minutiae is 250 to 300 ppi.

### 2.3.2 Minutia Extractor

In minutia extractor there are three processes which are preprocessing, minutia extraction and post-processing like in figure 2.5 where in preprocessing there are three type of preprocessing that the developer can use which are image segmentation, image enhancement and image binarization. Meanwhile in Minutia extraction there is two type of process which is thinning or minutia marking and in post-processing the false minutia will be removed.

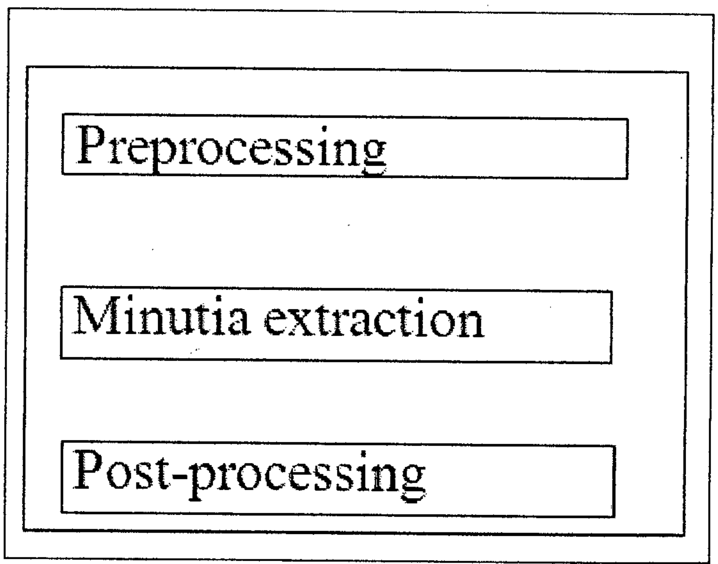


Figure 2.5 Minutia Extractor process

#### 2.3.2.1 Image Binarization

Fingerprint Image Binarization is to transform the 8-bit Gray fingerprint image to a 1-bit image with 0-value for ridges and 1-value for furrows [7]. After the operation, ridges in the fingerprint are highlighted with black color while furrows are white.

A locally adaptive binarization method is performed to binarize the fingerprint image. Such a named method comes from the mechanism of transforming a pixel value to 1 if the value is larger than the mean intensity value of the current block (16x16) to which the pixel belongs [Figure 2.6].

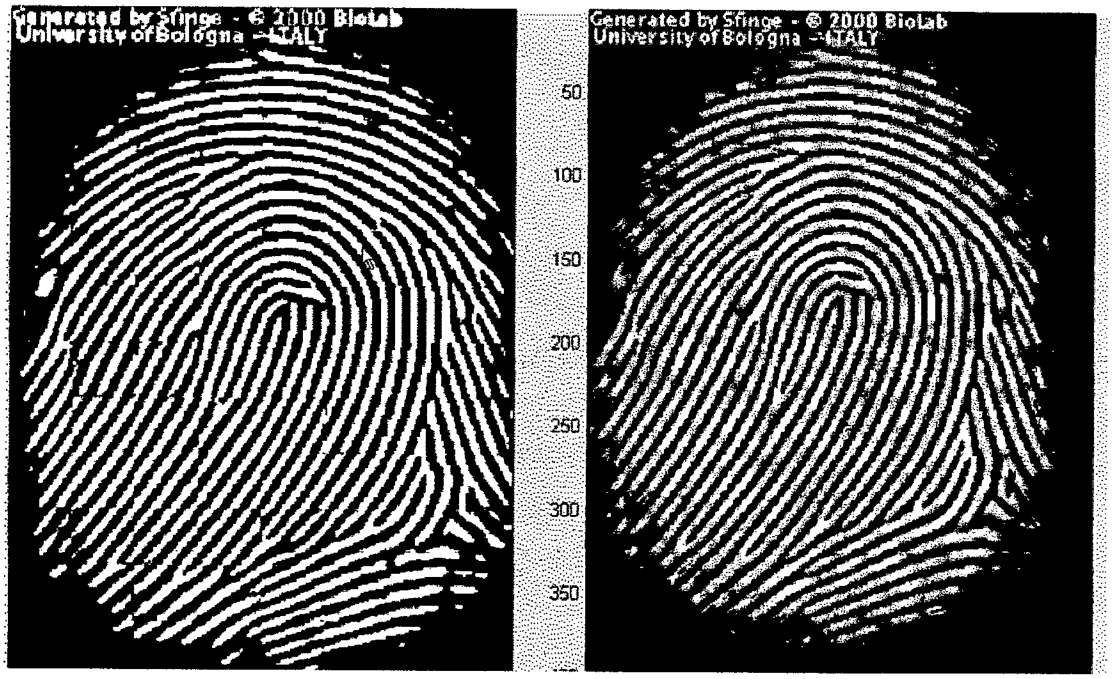


Figure 2.6: The Fingerprint image after adaptive binarization Binarized image(left), Enhanced gray image(right)

#### 2.3.3.2 Thinning

The thinning algorithm is based on ridge following. Such an algorithm which uses a priori knowledge about an image has a better probability of enhancing the required properties of the image. Ridges exist in all fingerprints and they form the features either by ending (ridge endings) or by forking (bifurcations). It is this fact we exploit in our algorithms. In our work we use black pixels as the ridges in fingerprints.

The thinning algorithms deal with just black pixels which are between two white pixels. Once a ridge is detected by the algorithm, thinning is done with following the ridge until the algorithm reaches the end of the ridge. Then it starts looking for a new ridge in the image. This is done until all ridges are found out in the binary image. The algorithm operates in the following stages.

Ridge Thinning is to eliminate the redundant pixels of ridges till the ridges are just one pixel wide [8] uses an iterative, parallel thinning algorithm. 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. In my testing, such an iterative, parallel thinning algorithm has bad efficiency although it can get an ideal thinned ridge map after enough scans.[9] Uses a one-in-all method to extract thinned ridges from gray-level fingerprint images directly.

Their method traces along the ridges having maximum gray intensity value. However, binarization is implicitly enforced since only pixels with maximum gray intensity value are remained. Also in my testing, the advancement of each trace step still has large computation complexity although it does not require the movement of pixel by pixel as in other thinning algorithms. Thus the third method is bid out which uses the built-in Morphological thinning function in MATLAB.

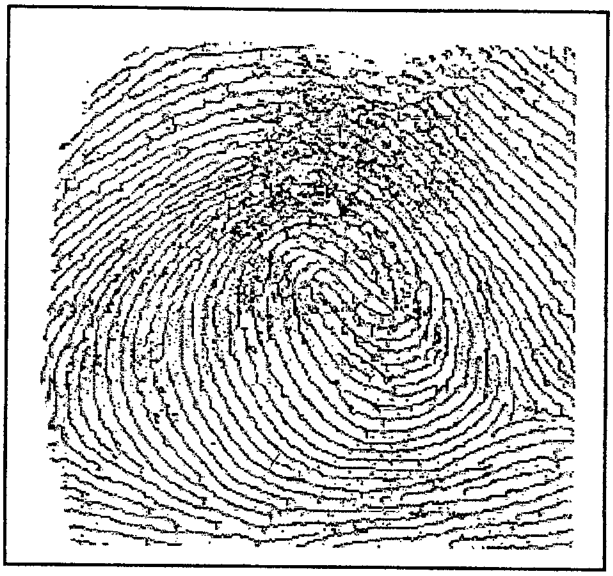

Figure 2.7: The Fingerprint image after thinning process

#### 2.3.3.3 Remove False Minutiae

In fingerprint recognition, the goal is too able to detect the minutiae point and to reduce the false minutiae in the fingerprint image. In order to remove false minutia, there are a few process that need to be going through which are minutia marking and false minutia removal. The procedures in removing false minutia are:

1. If the distance between one bifurcation and one termination is less than D and the two minutias are in the same ridge (m1 case). Remove both of them. Where D is the average inter-ridge width representing the average distance between two parallel neighboring ridges.
2. If the distance between two bifurcations is less than D and they are in the same ridge, remove the two bifurcations. (m2, m3 cases).
3. If two terminations are within a distance D and their directions are coincident with a small angle variation. And they suffice the condition that no any other termination is located between the two terminations. Then the two terminations are