FINGERPRINT RECOGNITION SYSTEM (PREPROCESSING)

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A report submitted in partial fulfilment
of the requirements for the award
of the degree of
Bachelor of Computer Technology (Software Engineering)

Faculty of Computer Systems & Software Engineering
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MARCH, 2005

ABSTRACT

Fingerprint recognition system was implementing for a long time in security system. Fingerprint is one of step to recognize the identity of person beside from signature because each person has a unique thumbprint although twin borne. The utilizing of this system is to enhance the security system in server room KUKTEM and only the authorized person will able to enter the room. This project develop prototype in concentrating on the preprocessing activities which are image acquisition, threshold and thinning. The objective of this project is to make a comparison between mean value and median value of threshold and make comparison between one pass and two pass algorithm of thinning. The prototype will only use 50 pieces gray scale JPEG image with the size of 240×240 pixels. The prototype will develop in the next chapter and the results will be discussed in the end of chapter.

ABSTRAK

Sistem pengecaman cap jari automatik telah lama digunakan dalam sistem keselamatan. Cap jari bagi setiap manusia adalah berbeza dan unik walaupun dilahirkan sebagai pasangan kembar. Sistem ini digunakan untuk mengatasi masalah keselamatan di bilik server KUKTEM dan hanya orang tertentu sahaja yang dibenarkan masuk ke bilik tersebut. Sistem ini membangunkan prototaip khususnya dalam aktiviti pemprosesan iaitu perolehan imej, imej ambangan dan penipisan imej. Objektif projek ini adalah untuk membuat perbandingan antara nilai purata dan nilai tengah bagi imej ambangan serta teknik satu laluan dan dua laluan bagi penipisan imej. Prototaip ini akan menggunakan 50 keping gambar kelabu JPEG bersaiz 240 x 240 pisel. Prototaip akan dibangunkan pada bab yang seterusnya dan keputusan akan dibincangkan pada akhir bab nanti.

TABLE OF CONTENTS

CHAPTER		TITLE	PAGE
		Declaration	i
		Dedication	ii
		Acknowledgement	iii
		Abstract	iv
		Abstrak	v
		Table of content	vi
		List of Tables	viii
		List of Figures	ix
		List of Symbols	xi
		Abbreviations	xii
		List of Appendices	xiii
1	**INTRODUCTION**		
	1.0	Introduction	1
	1.1	Problem statement	3
	1.2	Objective	4
	1.3	Scope	4
2	**LITERATURE REVIEW**		
	2.0	Introduction	5
	2.1	What is fingerprint	7
	2.2	What is fingerprint recognition	7
	2.3	Current system	7
	2.4	Techniques in fingerprint recognition system	9

	2.4.1	Image acquisition	9
	2.4.2	Threshold Techniques	11
	2.4.3	Thinning Techniques	13
3	**METHODOLOGY**		
	3.0	Introduction	17
	3.1	Software process	17
	3.1.1	Analysis	18
	3.1.2	Design	19
	3.1.2.1	Mean Value of Threshold	21
	3.1.2.2	Median Value of Threshold	21
	3.1.2.3	One Pass of Thinning	22
	3.1.2.4	Two Pass of Thinning	23
	3.1.3	Development	24
	3.1.4	Testing	28
4	**RESULT AND DISCUSSION**		
	4.0	Introduction	29
	4.1	Testing result for threshold techniques	29
	4.2	Testing result for thinning techniques	31
	4.3	Constraint	33
	4.4	Further research	33
5	**CONCLUSION**		
	5.0	Introduction	34
	5.1	Image Acquisition	35
	5.2	Threshold	35
	5.3	Thinning	35
	5.4	Conclusion	35
REFERENCES			37
APPENDICES A-C			39

LIST OF TABLES

TABLE NO.	TITLE	PAGE
3.1	Software Specification	24
3.2	Hardware Specification	25

LIST OF FIGURES

FIGURE NO	TITLE	PAGE
1.1	The various types of ridges patterns of fingerprint	2
1.2	Right loop of Fingerprint	2
2.1	An FTIR-based fingerprint sensor	10
2.2	Capacitive fingerprint sensor	11
2.3	Thinning Template	14
2.4	South demarcation	16
2.5	East demarcation	16
2.6	Corner of West Sea	16
2.7	North demarcation	16
2.8	West demarcation	16
2.9	Corner of South East	16
3.1	The Waterfall Model (Pressman, 2001)	18
3.2	Types of Fingerprint Images	19
3.3	Phase in Fingerprint Recognition System (Image Preprocessing)	20
3.4	Flow of threshold technique	20
3.5	Flow of thinning technique	20
3.6	Example the changes value to 0 and 1 of mean value	21
3.7	Example of the changes value to 0 and 1 of median value	22
3.8	The movement of thinning process in windows 3 x 3	23
3.9	Function to read list of image from file	25
3.10	Function that read size of image	25
3.11	Function to get mean value of pixels	26
3.12	Function to get median value of pixels	26

3.13	Function to convert value of pixel to 0 and 1	26
3.14	Function of One Pass Algorithm	27
4.1a	The results of threshold process	30
4.1b	Continue the results of Threshold process	31
4.2a	The results of thinning process	31
4.2b	Continue the results of thinning process	32

LIST OF SYMBOLS

e_x	-	Power
C	-	Continuant
L	-	Lowpass
H	-	Highpass
θ	-	Corner
ENT	-	Difficulty
CON	-	Comparison
ASM	-	Homogeny
IDM	-	Roughing
S	-	Mean
P	-	Mean each window
T	-	Value of Threshold
$F(u)$	-	Fast Fourier
σ	-	Spouse Sophisticated
g	-	Frequently Relative
q	-	Measuring distance
$\bar{x}$	-	Sum

ABBREVIATION

AFIS	-	Automatic Fingerprint Identification System
CMOS/CCD	-	Types of Camera
FFT	-	Fast Fourier Transform
FSR	-	Fingerprint Recognition System
FTIR	-	Frustrated Total Internal Reflection
GIF	-	Graphic Interchange Format
JPEG / JPG	-	Joint Photographic Experts Group
KUKTEM	-	Kolej Universiti Kejuruteraan & Teknologi Malaysia
MATLAB	-	Matrix Laboratory
Minutiae	-	The characteristic of fingerprint
Ms	-	Microsoft
NIST	-	National Institute of Standard and Technology
PNG	-	Portable Network Graphics
PDA	-	Personal Digital Assistant
RGB	-	Red / Green / Blue
TIFF/ TIF	-	TIFF - Tag Image File Format

LIST OF APPENDICES

APPENDIX NO	TITLE	PAGE
A	Threshold Images	39-48
B	Thinning Images	49-58
C	Gantt Chart	59-60

CHAPTER 1

INTRODUCTION

1.0 Introduction

A fingerprint is the feature pattern of one finger (Wu Zhili, 2002). It is believed with strong evidences that each fingerprint is unique. Each person has his own fingerprints with the permanent uniqueness. So fingerprints have being used for identification and forensic investigation for a long time. 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. 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.

The human fingerprint is comprised of various types of ridge patterns, traditionally classified according to the decades-old Henry system: left loop, right loop, arch, whorl, and tented arch (Figure 1.1). Loops make up nearly 2/3 of all fingerprints, whorls are nearly 1/3, and perhaps 5-10% is arches. These classifications are relevant in many large-scale forensic applications, but are rarely used in biometric authentication. Figure 2.1 shown image of fingerprint is a right loop (Wu Zhili, 2002).

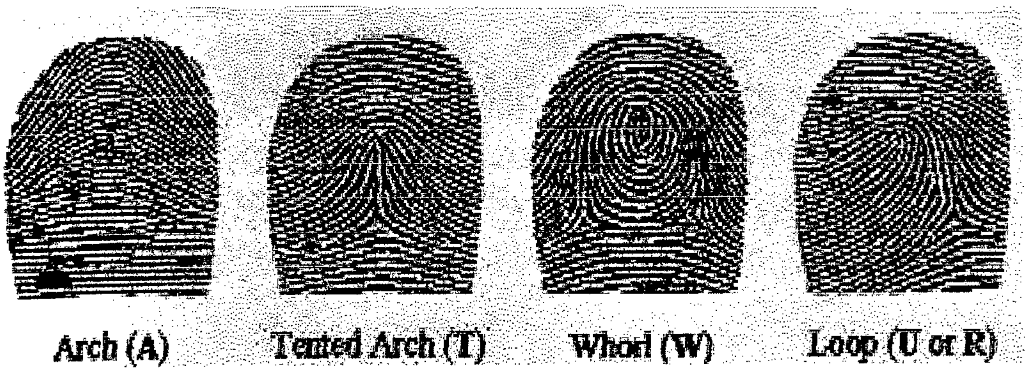

Figure 1.1 The various types of ridge patterns of fingerprint (T.Jea et. al, 2000)

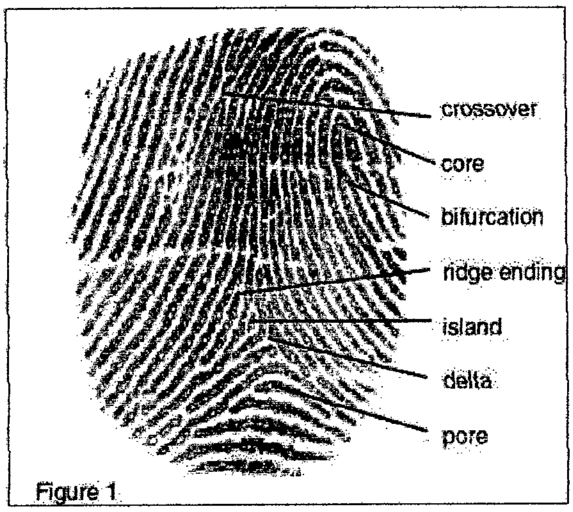

Figure 1.2 Right loop of Fingerprint (Wu Zhili, 2002)

In Fingerprint Recognition System (Preprocessing), there are 2 modules which is image preprocessing and recognition modules. In this paper, it will focus on preprocessing module. There are 3 stages in preprocessing, which are image acquisition, threshold and thinning. The purpose of preprocessing is to apply a smoothing operation, which is quite critical since binarization is going to be performed. Segmentation is then applied to detect ridges. Local threshold is therefore performed in order to obtain a binary image, e.g. an image where the ridges have the value "1" (black) and the valleys have the value "0" (white) or vice versa. A thinning is applied on the binary image to obtain one pixel thick lines. Finally, a scan of the last image is able to detect the feature points (Wu Zhili, 2002).

1.1 Problem Statement

Before this, traditional methods of personal authentication, such as keys, cards, PINs and passwords are becoming less convenient and less secure as they are under constant attack from more and more sophisticated cyber-criminals. The most mature, most widely accepted and therefore most often used biometric technology is fingerprint recognition.

Dactyloscopy, the science behind fingerprint identification, has been used in investigative forensics for more than a century. Within the past 20 years, the advancement of personal computers has made it possible to use fingerprint identification in civil applications, such as logical and physical access control.

While various biometric technologies have been introduced in the past decade, none has as strong and well-documented background as fingerprint recognition. Some of them quickly disappeared (such as retinal scanning), while others are slowly finding their place on the biometric map. For example, a maturing technology like voice recognition may have an advantage in telephone banking, but cannot compete with fingerprint recognition in the field of physical access control.

In addition to being accurate and convenient, fingerprint recognition has the highest user acceptance among competing technologies, and remains ahead in the number of units being deployed. Today, fingerprint-based authentication is by far the most often selected biometric security measure, dominating the majority of the market.

The scenario of application of smart cards also is implemented in Kolej Universiti Kejuruteraan & Teknologi Malaysia (KUKTEM). Currently KUKTEM uses smart card system to enter the server room. Although the Server Room is accessible to authorized staff, but other user can enter the room by using the authorized staff's smart card. To avoid from this situation, the Fingerprint Recognition System (Preprocessing) is develop to enhance the security system and only the authorized person will able to enter the room.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Fingerprinting was first used in a fashion in 14th century China as a method for parents to distinguish their children from those of others. Young children would have their feet and palms stamped in ink and then onto paper to create a record individual to the child.

Fingerprinting found a firm believer in William James Herschel (1958). It all started innocently enough. An employee of the East India Company, Herschel wanted a good way to seal a contract with a Bengali firm, and settled on using a handprint on the contract.

Two years later, Herschel became a magistrate at Nuddea. One of his official duties was to make sure that not only did natives of the area receive the pensions that were due them, but to prevent as much fraud as possible. High illiteracy rates, and therefore the inability to get a signature, drastically raised the potential for fraud. Remembering the success of the handprint, Herschel began requiring pensioners to use their fingerprint as a form of signature in order to receive the money due them. Fraud avoided, and a passion born. In 1877, Herschel requested permission to try his system in a small prison in Bengal, but was refused.

Meanwhile, Dr. Henry Faulds (1877) a Scottish physician working as the Surgeon Superintendent of Tsukiji Hospital in Japan, was also studying fingerprints, having become interested after seeing some in some ancient pottery work. In October 1880, he wrote a letter to the journal Nature describing his work with fingerprints. William Herschel wrote a letter in response for the next issue of the journal, and a feud ensued between these two pioneers.

Dr. Faulds continued his work, at one point writing Charles Darwin for his advice. Darwin instead provided Faulds with a contact to Sir Francis Galton, Darwin's cousin and noted anthropologist. Galton (1892) then began work on the problem of fingerprints as a means of identification, and of classification.

In 1892 Galton published Fingerprints, the first book on the subject. In it he stated his belief that fingerprints were unique and unchanging, making them ideal for identification. He warned however, that they would not provide heredity or racial clues (Caucasian fingerprints could not be immediately identified as such, in other words, nor would one know that the suspect was a member of the Smith family). His basic method of classification is still in use.

The use of fingerprints during this time was somewhat stagnant. In 1893 the British Home Office set up a committee to determine the best criminal identification system for Scotland Yard to use. After consideration, they recommended the Bertillon system, but to also use fingerprinting as a completely means of identification. How well this worked may be seen in that Faulds offered to begin a fingerprint division at Scotland Yard at his own expense three years later (in 1896), but was rejected.

Still the biometric of choice for most law agencies, the fingerprint is undergoing a major change for the first time in decades as scanners are beginning to rival ink prints in quality and affordability, Highly effective and relatively simple, the use of fingerprints as a viable biometric seems to be here for the long run (Arlene Courtney, 2002).

2.1 What is fingerprint

Fingerprint is an action to takes an image (either using ink or a digital scan) of a person's fingertips and records its characteristics. Whorls, arches, and loops are recorded along with the patterns of ridges, furrows, and minutiae. This information may then be processed or stored as an image or as an encoded computer algorithm to be compared with other fingerprint records (Arlene Courtney, 2002).

2.2 What is fingerprint recognition

Fingerprint recognition is one of Biometric recognition. Biometric recognition also consists of face, voice, eyes and etc. The usage of fingerprint recognition system nowadays is can be divided into three areas which is for security, as identification of individuals, for forensics, also as an identification method and for personal characteristics and dermatoglyphics, often involved with horoscopes and similar nonscientifically proven prophesies (Marie SandstrÄom, 2004).

2.3 Current system

Fingerprint recognition system for security reasons is popular now and has almost become synonym to biometric systems. Most law enforcement agencies in this world use Automatic Fingerprint Identification System (AFIS) today. This system have increased the productivity and greatly reduced the cost of hiring and training human fingerprint experts (Marie SandstrÄom, 2004).

New AFIS methodologies using live scan plain-impression fingerprint images as the basis for identification. The proliferation of plain-impression AFIS system is rapid and accelerating the state and federal level, in large-scale applications, including welfare, driver's licensing, border control, immigration and military personnel identification.

This new identification application is being treated as straightforward application of AFIS technology. Plain-impression AFIS applications are relatively new, with a few well-publicized success stories and no documented reports of significant problems. All AFIS vendors and several integrators currently offer applications that use plain-impression fingerprinting, which is an effective endorsement of the plain-impression technologies.

Furthermore, plain-impression AFIS applications are not nearly as complex as those in law enforcement, and the associated fingerprint scanners are simple and relatively inexpensive. Many, if not most, lab-collected prints look better than inked prints.

In fact, however, the new applications of AFIS technology, especially in welfare, are pressing the limits of AFIS capabilities. The new applications of plain-impression fingerprint technology depart from law enforcement applications in the use of radically reduced fingerprint information to minimize capture times and storage requirements, coupled with requirements for unprecedented levels of identification performance.

To ensure system performance, cost effectiveness and interoperability, the electronic plain-impression fingerprint scanners must produce consistently high quality fingerprint images, and must be subjected to rigorous standards of quality control, both in manufacture and in operation.

Recognizing the impact of image quality on all aspects of fingerprint identification, the FBI, in concert with the National Institute of Standard and Technology (NIST), has led the development of fingerprint image quality standards for law enforcement applications. The FBI has published a definitive set of Minimum Image Quality Requirement which is mandatory for submission of rolled-impression fingerprints to the FBI for law enforcement applications (Marie SandstrÄom, 2004).

2.4 Techniques in fingerprint recognition system

In this thesis, several techniques have been research to refine the techniques of fingerprint image using Preprocessing stages. This thesis also explains the prototype in developing fingerprint recognition application. The prototype is developing concentrating on the preprocessing activities which are image acquisition, filtering, threshold and thinning technique. These four activities will be explaining more in the next chapter.

2.4.1 Image Acquisition

Image acquisition is a process when user places his or her finger on a platen (also referred as a scanner) which is located on the top of most fingerprint recognition devices. Numerous of images finger are then captured. The important of this stage is to capture images of the center of the fingerprint, which contains many of the unique features. All of the captured images are then converted into black and white images.

Fingerprint image can divide into two techniques, which is an off-line or online (live-scan) image. An off-line image is typically obtained by smearing ink on the fingertip and creating an inked impression of the fingertip on paper. A live-scan image, on the other hand, is acquired by sensing the tip of the finger directly (Dr. David P. Beach, 2004).

Optical techniques is the first generation scanners, today variety of sensing techniques are used and almost of them belong to one of three groups: optical, solid-state and ultrasound (Marie SandstrÄom, 2004).

According to Marie SandstrÄom (2004), technologies today used optical and solid-state sensors. Solid-state sensors are now popular because of their compact size which facilities are embedding into laptop, cellular phones, smart cards and etc.

Marie Sandstrom (2004) state the advantage of optical sensors include withstanding temperature fluctuations (to some degree), a fairy low cost, resolutions up to 500 dpi, better image quality, and the possibility of larger sensing areas. The disadvantages of optical sensors are size and problems with latent prints, cuts, abrasions, calluses, and other damage, as well as dirt, grease and other contamination.

FTIR is one example of optical sensor. Today, the FTIR sensors have shrunk considerably in size and cost with help of the new CMOS technology. Since FTIR devices sense a three-dimensional surface, it is difficult to fool them with a photograph or image of a fingerprint. Latent prints are however still a problem. Furthermore, it is difficult to make a small enough FTIR device suitable to embed into a PDA or a mobile phone, even though they can be used in mouses and keyboards (Marie SandstrÄom, 2004).

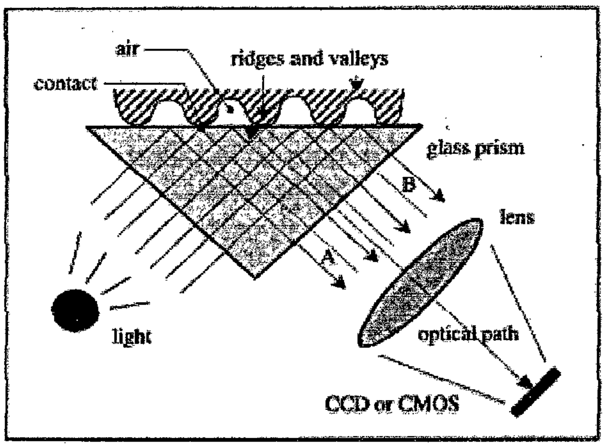

Figure 2.1 An FTIR-based fingerprint sensor (Marie SandstrÄom, 2004)

One example of sensors research by Marie SandstrÄom (2004) is using solid-state sensors. Solid-state sensors also known as silicon sensor, was first introduced to overcome the problems with size and cost of optical sensors. However, considering a high-security device, a large sensing area is needed, and thus the cost will in fact not be any smaller for solid-state sensors than for optical sensors.

All silicon sensors consist of an array of pixels, where each pixel is a tiny sensor itself. Four different types of silicon sensing techniques have been proposed to convert the physical information into electrical signals: capacitive, thermal, electric field, and piezoelectric.

A capacitive sensor consists of a two-dimensional array of micro-capacitor plates embedded in a chip (Figure 2.2). The finger skin works as the other side of each micro-capacitor plate (Marie SandstrÄom, 2004).

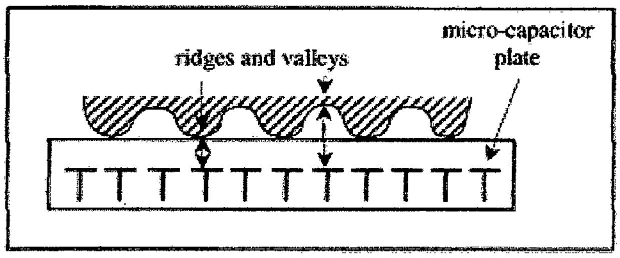

Figure 2.2 Capacitive fingerprint sensor (Marie SandstrÄom, 2004)

Thermal sensors are made of pyro-electric material that generates current based on temperature differentials. The temperature differentials between the skin (the ridges) and the air (in the valleys) are used to acquire the fingerprint image.

2.4.2 Threshold Techniques

The objective of threshold stage is to increase the dynamic range of the gray scale between ridges and valleys of the image. If the gray level of a pixel exceeds a threshold in the two filtered images, it is considered that the pixel belongs to a ridge; otherwise, it is assigned to a valley.

According to Zalili (2003), binary image is easier to analysis compare to gray scale image. However, it is difficult to convert the unripe image to binary image without enter the initial processing first. So, threshold was obtained to convert gray scale image to binary image.

According to research doing by Zalili (2003) refer to Awcock and Thomas (1996), technique threshold should consists three principal of criteria which is automatic, fast and robust. Automatic means didn't not use user interaction to determine the threshold values and supposedly fast in processing value of pixels to produce into background and front. Lastly, the techniques robust of threshold are suitable to apply to other images.

The best value of threshold is should have two binary values that are differently to make sure it easy to process. The selection of threshold values should be done and usually the results of the values are difficult. Usually, the simple values of threshold will be defined whether in manual or automatic ways. For the features images that complex, literature of histogram images is need to get the values of threshold.

Generally, threshold can be divided into two different categories which are normal threshold and various level of threshold (Gonzalez and Woods, 2002). Normal threshold will be used when the value of pixel image, $f(x, y)$ divided to two domain objects which are front and background. Then, the threshold value, T can define as two divider of main objects which is when value of pixel $f(x, y) > T$, so that it can define as point object. For value of pixel $f(x, y) \leq T$, then it will recognize as background point.

Various level of threshold is a value of pixel that exist for one image which $f(x, y)$ belongs to class object $T_1 < f(x, y) \leq T_2$. Point object will be gain when value of pixel $f(x, y) > T_2$ and when value of pixel $f(x, y) \leq T_1$ then it can be define as background point. This system will focus on two techniques of threshold which are mean value and median value. Then, the comparison between the two techniques will be discussed in chapter 4.

2.4.2.1 Mean Value of Threshold Technique

This technique will obtained value of threshold according to mean value that gets from overall values at histogram point. Each point at histogram is representing each pixel of value for one image. Values of each histogram point will combine and dividing into every amount of histogram point. The purpose is to get value of threshold, T with n was in every histogram point and $I(j)$ is value for each histogram point. Next is the changing process of each value of pixel to doing a representation 1 and 0. For value of pixel that less than value T will represent as 0 and 1 in other way.

$$T = \frac{\sum_{j=1}^{n} I(j)}{n} \qquad (2.1)$$

2.4.2.2 Median Value of Threshold Technique

Usually this technique gets threshold values according to middle point of histogram point. Each value for histogram point will stacked following, $X_{(1)}<X_{(2)}<\ldots X_{(n)}$ and next is value of middle point as threshold values, T will gets (Ron de Beer, 1997). When value of T was gain, total of 0 values and 1 value will be doing. For value of pixel more than T value, it can represent as 1 value and if less, it cam represent as 0 values.

$$X_{(1)} < X_{(2)} < \ldots X_{(n)} \qquad (2.2)$$

2.4.3 Thinning Techniques

Thinning is to reduce the widths of ridges down to a single pixel for minutiae detection. It is of two types Iterative thinning and non iterative thinning methods. The thinning must be performed without modifying the original ridge.

Literature of thinning was study for a long time and several of algorithms are developing such as Skeletonization Algorithm and thinning algorithm. Techniques that used in Skeletonization Algorithm are according to Medial Axis Transform. In Thinning Algorithm have two techniques which are One Pass Thinning Algorithm (Jang and Chin, 1987) and Two Pass Thinning Algorithm (Zhang and Suen, 1984).

2.4.3.1 One Pass Thinning Algorithm

This algorithm produce by Chin et al (1987) that only used one pass to thin binary image. Many thinning process used 3 x 3 templates for thinning procedure. In this algorithm, two template is used which are one for thinning and other one is for repairing.

This algorithm is use for binary image. Method that used to reduce all pixels in image that suitable with thinning template can refer to Figure 2.3. Then, the process will continue until no more changes happen to the image.

0	0	0
1	1	1
x	1	x

0	1	x
0	1	1
0	1	x

x	1	x
1	1	1
0	0	0

x	1	0
1	1	0
x	1	0

x	0	0
1	1	0
x	1	x

0	0	x
0	1	1
x	1	x

x	1	x
0	1	1
0	0	x

x	1	x
1	1	0
x	0	0

Figure 2.3 Thinning Template