"I have read this report and in my opinion, it is suitable in term of scope and quality for the purpose of awarding The Bachelor Degree in Electronic Engineering (Computer Engineering)"

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Date : 5 MEI 2006

FINGERPRINT VERIFICATION

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This Draft Report Is Submitted In Partial Fulfillment of Requirement for the Bachelor Degree of Electronic Engineering (Computer Engineering)

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April 2005

"I hereby declared that this report is the result of my own effort as clearly stated in the source of reference"

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ACKNOWLEDGEMENTS

I would like to appreciate Madam Anis Suhaila Bt. Mohd Zain for her support and help during this project.

ABSTRACT

Fingerprints are part of the human identity. Fingerprints are the most mature biometric; automated method of recognizing a person based on physiological or behavioral characteristics, technology. This project will try to verify human fingerprints and make a comparison. Image analysis of the fingerprints is based on analyzing events on the fingerprint, known as '*minutiae*'. Events where the locations and types of ridges meet, divide, begin, end and damaged will be used in matching process. Since the knowledge has been introduced, fingerprints are widely used in security system and identification system. In this thesis, I will firstly discuss the methodology and implementation of techniques for fingerprint image segmentation, image enhancement, and minutiae extraction.

ABSTRAK

Cap jari merupakan salah satu daripada identiti manusia. Cap jari adalah teknologi biometrik tertua, iaitu kaedah pengenalpastian identiti seseorang berdasarkan fisiologi atau sifat kelakuan. Projek ini akan cuba mengenalpasti cap jari manusia dan membuat perbandingan. Analisis imej cap jari adalah berdasarkan struktur pada cap jari tersebut, dikenali sebagai '*minutiae*'. Struktur di mana lokasi dan jenis alur bertemu, berpisah, bermula, berakhir, dan rosak akan digunakan di dalam proses perbandingan. Sejak pengetahuan ini ditemui, cap jari telah digunakan secara meluas di dalam sistem keselamatan dan sistem pengesahan identiti. Di dalam laporan ini, saya akan mulakan dengan membincangkan kaedah dan penggunaan teknik untuk proses segmentasi imej, baikpulih imej dan pengesanan titik '*minutiae*'.

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LIST OF ABBREVIATIONS

FVC2002	-	Fingerprint Verification Competition 2002
ID	-	Identification
CCD	-	Charge-Coupled Device
CMOS	-	Complementary Metal Oxide Semiconductor
dpi	-	Pixel per Inch
CN	-	Crossing Number
GUI	-	Graphical User Interface

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Each person has unique fingerprints. Fingerprint is widely used in identification system and security system. Fingerprint verification was one of the most reliable security systems. Since decades, this knowledge has been used in crime investigation and banking business.

The main features on a fingerprint are based on global ridge and furrow structure that form a special pattern and minutiae details associated with local ridge and furrow structure. Minutiae are defined as an event where the locations and types of ridges that is essential part in verification process. From these two features, there a many ways that can be implemented to analyze and extract the fingerprint images. A verification is made when two fingerprints needs to be conformed either they are matched or not.

1.2 PROJECT OBJECTIVE

The objective of this project is to analyze and match a fingerprint image. Digital image processing concept will be implemented in the algorithm. There are four steps in executing the algorithm, which are, image segmentation, image enhancement, minutiae extraction, and minutiae matching. A suitable graphical user interface will be also included in this project. The idea of this project is to analyze the use of minutiae detail

features in a fingerprint image. Image noise is removed in image segmentation and enhanced during image enhancement. The goal is to match two fingerprints based on the minutiae extraction of the fingerprint. Another objective of this project is to expand knowledge in digital image processing and train programming skills.

1.3 SCOPE OF PROJECT

The scope of project will decide the limitation in completing this project. It is important to make sure the project follows as planned. I decided that there are 2 parts of applications, which are:

a) Software

MATLAB program will be used in executing the project algorithm. The image processing toolbox provides some function that could be used in analyzing the fingerprint image. The program can also create the graphical user interface for the verification process.

b) Algorithm

A fingerprint image will be used in verification process. Since this project does not apply any use of hardware or more specifically fingerprint image sensor, the image used is a sample of fingerprint image taken from Fingerprint Verification Process 2002 (FVC2002) database. The image contains all the information that any sensor can capture.

. During the verification process, four steps are involved. Image segmentation will remove noise from the image. Image enhancement will improve the image reliability. Minutiae extraction will find the critical criteria that will be used in matching process

and finally minutiae matching that will find match based on minutiae extraction between two images.

A simple graphical user interface will be created to show those four steps. The interface will show either the two fingerprint image is match or not.

1.4 PROBLEM STATEMENT

I found some problems that I will face during this project. Since I am not taken the digital signal processing subject, it will be a hard challenge to complete the whole project. I am also not too familiar with MATLAB software except for the basic calculations.

In analyzing an image, removing noise is a critical part. It should be the first step before making any move. There are many kind of noise for a poor image and it makes the matching process becomes nearly useless. Poor image may contain false and spurious minutiae that will affect the minutiae extraction process. So I decide to use an average quality of an image which is also taken from fingerprint sensor. This is fair to analyze the noise removing and poor minutiae extraction.

1.5 METHODOLOGY

The basic methodology will be used are presented in the flow chart below:

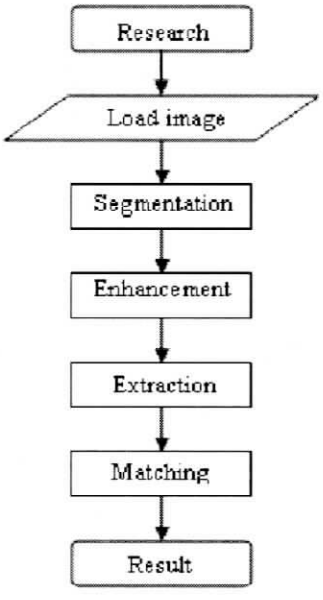

Figure 1.1: The basic flowchart

Flowchart above gives a simple procedure in this project. Fingerprint images will be loaded from a sample fingerprint image taken from Fingerprint Verification Competition database. The image is then analyzed using above steps and saved as a template. Segmentation process will determine a biometric signal in the image where ridges and valleys exist. Then, the image signal will be enhanced and the minutia events will be extracted. Finally, the sample image will be compared with the templates. A result will show a matching percentage and matching result whether it can match or not.

CHAPTER II

LITERATURE REVIEW

2.1 OVERVIEW

This chapter will discuss about literature review to provide insight into the project background and previous work related to the project development and implementation.

2.2 BIOMETRIC BACKGROUND

The term "*biometric*" is derived from the Greek words where bio means life and metric means to measure. Biometric can be defined as an automated method of recognizing a person based on physiological or behavioral characteristics. These characteristics are significantly unique. Some of the characteristics are fingerprint, face, iris, voice, and hand geometry. Since decades, biometric recognition has been used widely. Most of the application goes to security and privacy.

2.3 LITERATURE REVIEW

2.3.1 What is Fingerprint Verification

Fingerprint represents identity for each human. There are many kinds of methods that can be implemented to recognize human fingerprint. Human fingerprint structure composed of ridges and furrows. These structure designed human fingerprint differently from each other.

Figure 2.1: Human fingerprint

However, there is more important thing in analyzing human fingerprint. It is called as *minutiae*. *Minutiae* are a set of ridge bifurcation and ridge termination that are used in fingerprint recognition. Ridge termination is the point where a ridge ends. Ridge bifurcation is the point on the ridge from which two branches divide. Those points are critical in matching and challenging in detecting.

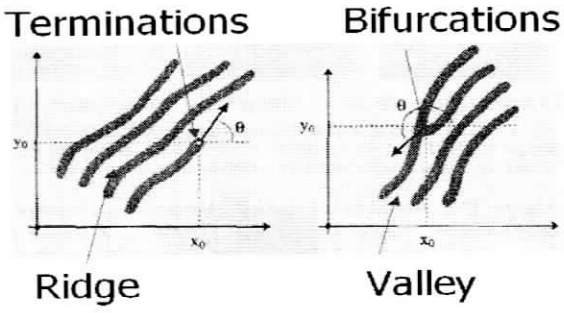

Figure 2.2: Structure of ridge, valley, termination (ridge ending), and bifurcation

In fingerprint recognition system, there are 2 categories, which are identification and verification [1]. Fingerprint identification searches a large database to identify a person. This method is widely used in criminal investigation cases. Fingerprint verification is mainly to confirm a person who he or she claims to be by verifying using a single database record. The person provides his or her identity information such as ID number. A verification system will load the fingerprint template based on the ID number and matches the template in the same time.

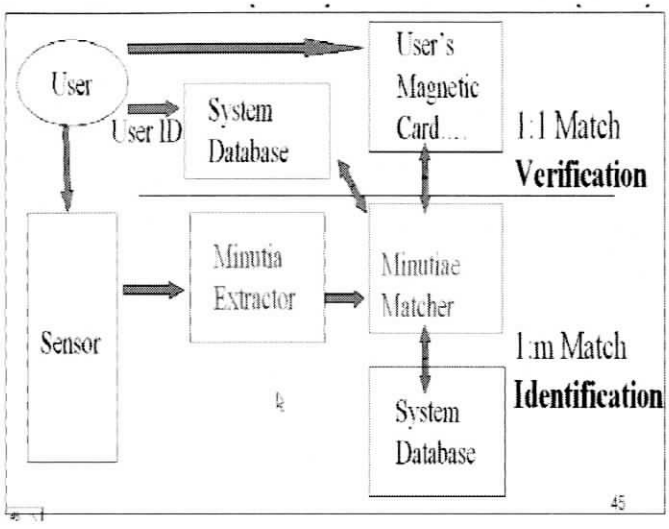

Figure 2.3: Verification vs. Identification

There are two approaches in fingerprint verification process. These approaches also can be implemented in fingerprint identification.

The first approach is *minutiae* matching based. This method represents a fingerprint by its structure features, such as terminations and bifurcations. *Minutiae* approach has been used extensively in currently verification products. I also will implement this approach in this project.

The second approach is image based. Global ridges and furrow structures forms a special pattern in the central region of the fingerprint [1]. This method has its own reliability on recognition system. I will not concentrate on this approach since I will implement the *minutiae* based approach.

Before verification process can be executed, the fingerprint image must go through a pre-processing stage. This pre-processing stage is needed to produce the best image structure and suitable for *minutiae* detection. A fingerprint image is not as reliable as the real fingerprint. So, the image must be processed to enable minutia detection and then find the matching *minutiae*. The pre-processing stages in verification system are listed as follow:

2.3.2 Fingerprint Image Acquisition

Fingerprint acquisition is done by capturing a fingerprint image using a fingerprint image sensor. Optical sensors are the best optional since they have a high efficiency and acceptable accuracy than any sensors. A prism or lens system focuses the image on a CCD or CMOS sensing element. The image resolution can be controlled independently of the sensing element active area. Nevertheless, if the user fingerprint is too dirty and defected, the captured image is still in poor quality.

Solid state technology uses a two dimensional array matrix of micro-cells that is built in a silicon chip and directly touched by the finger. Each micro-cell represent as a tiny sensor that capable in reading a fingerprint pixel. The size of the scanner sensing area is exactly the same as the size of the silicon area. This solid state sensor is also known as capacitive sensor.

Solid state sensor has a greater miniaturization of the scanner that can be integrated into mobile phones, palms, or pen drive. On the other hand, optical sensor has many other advantages compared to the capacitive sensor. Among their advantages is larger sensing area, longer lifetime, easier and low cost in maintenance.

For my project, I will be using image from the fingerprints provided by Fingerprint Verification Competition 2002 (FVC2002). Therefore, there will be no acquisition stage. The image is taken from Database 1 that use optical sensor "TouchView II" by Identix Lab. Image size is 360 x 364 pixels with 500 pixels per inch (dpi) resolutions. The images provided have an average quality so that it is fair to analyze the image before executing the matching process.

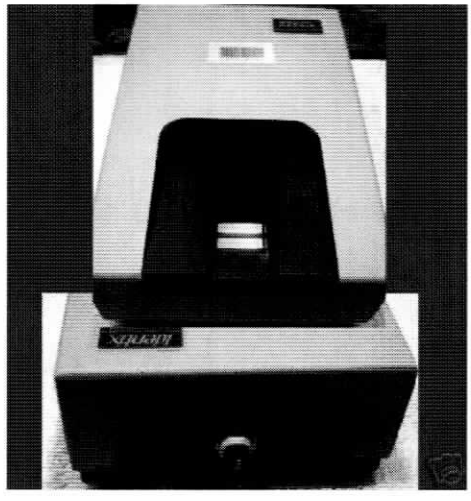

Figure 2.4: TouchView II optical sensor

2.3.3 Image Segmentation

The purpose of segmentation process is to distinguish an object from the background [2]. Four popular approaches for intensity image are thresholding techniques, edge-based methods, region-based techniques, and connectivity-preserving relaxation methods.

Threshold techniques make decision based on local pixel information. This technique is effective when the intensity levels of the objects fall squarely outside the range of levels in the background. Unfortunately, blurred region boundaries can disturb the segmented image.

Edge-based methods are centered on contour detection. The weakness of this method is in connecting the broken contour line together. Blur region in image can easily make this method useless in segmentation.

A region-based method usually partitioned an image into connected regions by grouping neighboring pixels that has similar intensity levels. Adjacent regions are then merged under the same criteria involving the sharpness of region boundaries.

2.3.3.1 Fingerprint Image Segmentation

Segmentation in fingerprint can best be defined as a process to remove the background from the foreground image of the fingerprint. Background image refers to the areas that are not used in analyzing the fingerprint image. This area commonly lies around the fingerprint image. The background area also can be defined as the noisy area at the borders of the image [3]. Foreground refers to the areas that contain important

biometric information such as global ridge and furrow structure or minutia detail associated with the local ridge and furrow structure.

I found several approaches to segment a fingerprint image from my literature study. In [3], the fingerprint image is extracted based on pixel feature. These features are the coherence, the local mean, and the local variance of the fingerprint image. The coherence gives a measure how well the gradients are pointing in the same direction. In [4], the fingerprint is partitioned in blocks of pixels. Then, each block is categorized based on the distribution of the gradients in that block. In [4], the composite method is extended by excluding blocks with a gray-scale variance that is lower than some threshold. Another simple but still reliable method is morphological operations. MATLAB software provides a useful function that can remove noise or background from an image. However, morphology operation does not suitable for fingerprint image that contain high noise.

2.3.4 Image Enhancement

The purpose of image enhancement is to improve image's perception of information for human viewers or to provide a better image for other automated image processing techniques. Image enhancement can be divided into two broad categories:

- Spatial domain methods, which operate directly on pixels.
- Frequency domain methods, which operate on the Fourier transform of an image.

In Spatial domain method, image enhancement can be categorized into several subsections which are grey-scale manipulation, histogram equalization, image smoothing, image sharpening, and high boost filtering.