FINGERPRINT RECONSTRUCTION BASED ON IMPROVED DIRECTIONAL IMAGE

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To my beloved parents, my parents-in law, my wife, my son

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ABSTRACT

Fingerprint has been used as a biometric feature for security reasons for centuries. Automated Fingerprint Identification System (AFIS) is one such authentication method used in wide range of application domains such as e-commerce and automated banking. Fingerprint image contains flow-like pattern called ridges which are separated by furrows. Ridge ending and bifurcation are two type of minutiaes used as basic features in AFIS. There are two approaches for minutiae extraction, namely conventional and direct. In the conventional approach, fingerprint images have to go through several processes including noise removal, enhancement, directional image computation, segmentation and thinning. Whereas, in the direct approach, the minutiaes are directly extracted from a gray scale image without going through all the above processes. Extracting minutiaes have been found to be an error prone process, depending on the quality of the fingerprint image. In the conventional approach, for instance, a low quality image will generate many artificial minutiaes which lead to errors in fingerprint matching. Similarly, in the direct approach, a bad quality image that contains scars, sweat spots and uneven ridges and furrows can lead to artificial minutiaes. This thesis presents a fingerprint image reconstruction algorithm using Directional Fourier filtering. Prior to the image reconstruction, a directional image is first computed using Mehtre technique and followed by a 3-tier enhancement processes viz. Histogram Equalization, High-pass filter and Median filter. By using the directional image as ridges orientations map, its original fingerprint image is filtered using the Directional Fourier filtering to produce a new fingerprint image. The reconstruction algorithm was tested with 500 fingerprint images. The results of the experiment is very promising.

ABSTRAK

Cap jari telah digunakan dalam bidang biometrik sejak berkurun dahulu. Sistem pengecaman cap jari automatik merupakan salah satu sistem yang digunakan dengan meluas dalam bidang e-dagang dan perbankan. Imej cap jari mengandungi corak aliran yang dikenali sebagai batas yang dipisahkan oleh lembah. Titik akhir dan titik cabang merupakan dua jenis *minutiae* yang digunakan sebagai ciri-ciri cap jari dalam sistem pengecaman cap jari automatik. Terdapat dua kaedah untuk pengekstrakan *minutiae* iaitu dikenali sebagai kaedah konvensional dan kaedah langsung. Dalam kaedah konvensional imej cap jari perlu melalui beberapa proses termasuk pembuangan kebisingan,pengiraan imej terarah,segmentasi dan penipisan. Manakala,dalam kaedah langsung *minutiae* diekstrak secara langsung daripada imej berskala kelabu tanpa melalui kesemua proses di atas. Proses pengekstrakan *minutiae* mudah terdedah kepada ralat,bergan tung kepada kualiti imej cap jari. Dalam kaedah konvensional,contohnya imej cap jari yang tidak berkualiti akan menghasilkan banyak *minutiae* palsu yang menyebabkan ralat dalam proses pengecaman. Manakala,untuk kaedah langsung imej cap jari yang tidak berkualiti iaitu yang mengandungi parut, liang peluh dan lebar batas yang tidak seragam juga menghasilkan *minutiae* palsu. Tesis ini membincangkan pembinaan semula imej cap jari dengan menggunakan algoritma penuras *Directional Fourier*. Untuk membina semula imej,pengiraan imej terarah pe rlu dilakukan terlebih dahulu dengan menggunakan teknik *Mehtre*,diikuti dengan 3-tahap pros es penambahbaikan iaitu *Histogram Equalization*,penuras *High-Pass* dan penuras *Median*. Dengan menggunakan imej terarah sebagai peta arah batas,imej asal cap jari kemudian dituras dengan menggunakan penuras *Directional Fourier* untuk menghasilkan imej baru. Algoritma ini telah diuji dengan menggunakan 500 imej cap jari. Hasil ujikaji adalah sangat memberansangkan.

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Since its first discovery until today, many researches has been carried out in fingerprint application. Many approaches has been introduced and upgraded in Automated Fingerprint Identification System. Fingerprint enahancement is among the field focusses. Fingerprint enhancement is very crucial in producing fingerprint image with high quality and free from noise. Based on the researches that are carried out, there generally are two approaches in fingerprint extraction. The first approach is the Conventional Approach and the second one is Direct From Gray Scale which was introduced by Maio and Maltoni (1997). In the Conventional Approach, the fingerprint image must go through a few processes before the minutiae extraction. These processes are fingerprint pre-processing, enhancement, directional image, segmentation, thinning and minutiae extraction. Meanwhile in Direct from Gray Scale Approach, all mentioned processes in Conventional Approach is discarded; fingerprint extraction is done by using Ridge Line Following Algorithm. Both approaches will be discussed in details in Chapter 2.

From the research, both approaches have its flaw and the flaw comes from the same factor that is the fingerprint image quality. For the Conventional Approach,

fingerprint enhancement which is less impressive spoiled the fingerprint identification especially in fingerprint thinning. A poor fingerprint image produces wrong skeleton fingerprint image that leads to the lost of its genuine features or structures. This resulted false in the minutiae creation and the failure of fingerprint identification. Meanwhile in second approach, fingerprint image quality is important in tangent calculation. It is used for trails the ridges. This ridge following process can be spoilt in the presence of noise such as sweat holes and scars.

1.2 Problem Statement

Fingerprint identification accuracy for Conventional Approach and Direct From Gray Scale heavily dependent on fingerprint image quality. Fingerprint image low qualities are caused by:

1. Ridge and furrow width that are not uniform.
2. Sweat holes on fingerprint image.
3. Scar effect that disrupt ridges and furrow flow.
4. Fingerprint image that contains random noise during image acquisitions.

The question is, what are the techniques that can be used to increase and enhance fingerprint image before fingerprint extraction process?

In fingerprint image enhancement, the directional image usage is very important. Direction for each ridge is obtained by using directional image calculation. The accuracy of ridge direction ensures the successful of fingerprint image enhancement. The production of Directional Image is based on the concept introduced by Mehtre and Murthy (1987). Is there any possibility that this directional image calculation will enhance the better directional image?

In obtaining fingerprint image that are free from noise, sweat holes, scar as well as increasing the ridges and furrows uniformity, this directional image is used with filtering technique in frequency domain for producing better fingerprint image. What is the filtering technique that can be use in getting new fingerprint image with high quality by using directional image?

1.3 Objective

In doing this thesis, there are three objectives. The objectives are:

1. Reconstruct scar effect and sweat holes into fine ridges and furrows
2. Increase the uniformity of the ridges and furrows width
3. Find the suitable approach for objective (1) and (2) above

1.4 Scope

This thesis will focus on the use of gray scale fingerprint images obtained through an optical scanner. The dataset will consist of 500 fingerprint images in various classes and noises.

This research focuses in fingerprint reconstruction based on improved directional image.

The result of the discussions focus only on successful fingerprint reconstruction. Time measurement is not applicable in this research.

1.5 Limitation

The test fingerprint images are limited to those that have been obtained from SecureTouch optical scanner.

1.6 Fingerprint Analysis

Fingerprint technology is one of the biometric technologies based on physical characteristic. The characteristic is differ from one person to another. The fingerprint technology has already been used in human identification for century. It has been successfully implemented in forensic, administrative, banking and in commerce sectors.

Fingerprints contain ridges and furrows. There are two major attributes that can be extracted from the fingerprint. They are known as local and global attributes. For global attribute, it uses the cores and deltas for fingerprints classification. The local attribute extracts fingerprints ridges information which is known as minutiae. They are used in fingerprint identification (Kasei et al. 1997). Figure 1.1 shows the fingerprint ridges and furrows.

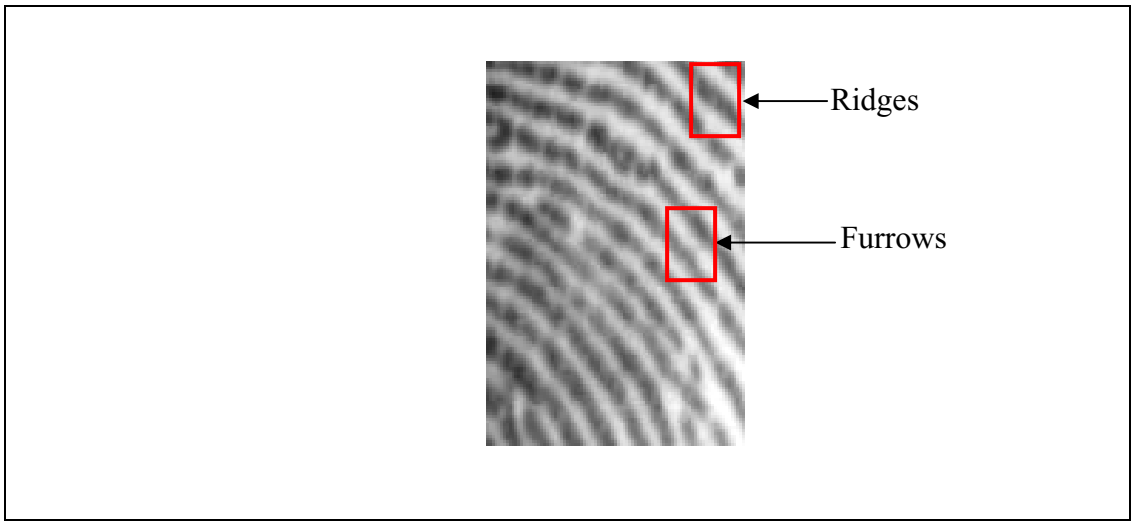

Figure 1.1 Fingerprints ridges and furrows

A bifurcation is a ridge divided or forked into two or more parallel ridges. A lake is the joining of two bifurcations in which one forms the left side and the other forms the right side. An island is a very short and independent ridge. The ridge ending is where a ridge begins and ends abruptly. A short ridge is a short and independent ridge, but not shorter than an island. From the Figure 1.2, all minutiaes derives from a basic minutiae, ridge ending and bifurcation.

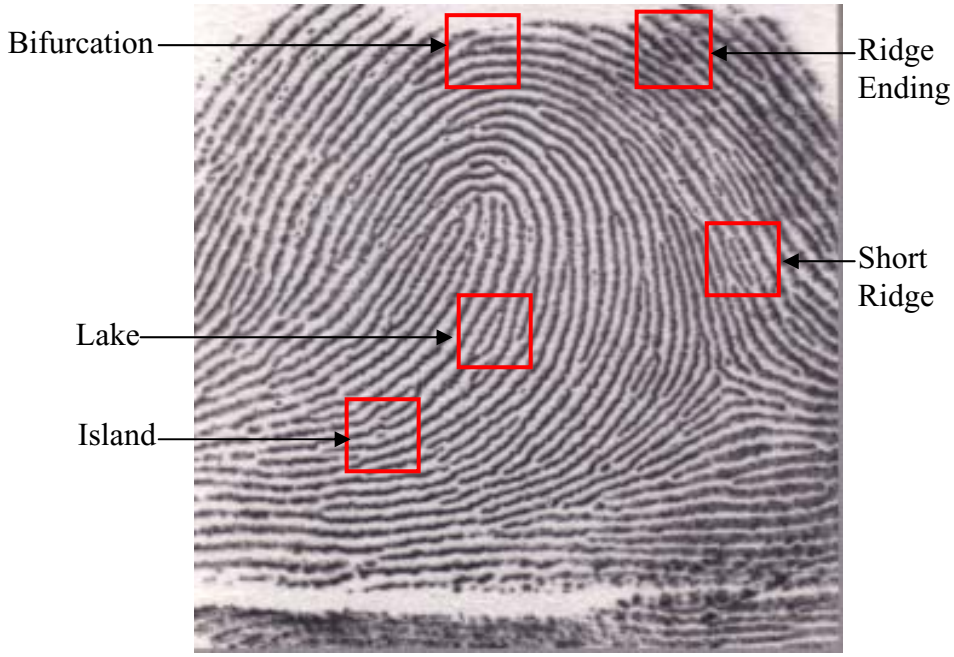

Figure 1.2 Fingerprint's minutiae

5.2 Contribution

1. Introduces Block Filtering by using Median Filter to filter wrong block direction and removes noise in Block Directional Image for obtaining accurate directional image.

2. New approach introduces the use of Histogram Equalization and High-Pass Filter in Mehtre Technique to increase fingerprint contrasts and enhance ridges and furrows structures in order to get a correct directional element for each ridges.

5.3 Future Work

1. To Find out the possibility for producing new fingerprint image without heavily depending on each element in directional image. This is because, it is hard to obtain directional image with 100% perfection. Therefore, a suitable approach to reconstruct fingerprint image should be explored.

2. According to Emiroglu (1998), a wavelet based Directional Filter design especially for fingerprint enhancement may be developed. Wavelet may enhance fingerprint image like Directional Fourier Filtering. This approach may reduce processing time.

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