UNIVERSITI PUTRA MALAYSIA

AN ALGORITHM FOR FINGERPRINT CLASSIFICATION USING TEMPLATE MATCHING TECHNIQUE

AHMED WATHIK NAJI AL-KAISSI

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Partial Fulfilment of the Requirement for the Degree of Master of Science

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In the name of God, Most Gracious, Most Merciful

Dedication

To My beloved and brave Parents, who have sacrificed a lot, for their support and Encouragement,

My beloved Wife and my clever Son for their

Encouragement and Love,

My Brother, Sister and my Friends.

Abstract thesis presented to the Senate of the Universiti Putra Malaysia in partial fulfilment of the requirement for the degree of Master of Science

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October 2002

Chairman: Abd Rahman Ramli, Ph.D.

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Automatic fingerprint classification has received considerable attention over the past decade. Despite significant progress in this field, there are still rooms for improving the classification operation by continuing study and research in this field. This thesis describes a study of fingerprint classification using template matching technique. We have classified the fingerprints in four groups according to their pattern, which are Arch, Left loop, Right loop, and Whorl. We have discussed and explained the specification and the limitations of the fingerprint classification (the effect of corrupted and rotated input fingerprints on the accuracy of the classification operation). The thesis has analysed the mentioned technique and evaluated its strengths and limitation by comparing this technique with the singularities technique. This research has also included the pre-processing stage, which consist of enhancement, segmentation, and thinning of fingerprints.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian keperluan untuk ijazah Master Sains

ALGORITMA BAGI PENGELASAN PENGECAMAN CAP JARI MENGGUNAKAN TEKNIK PEMADANAN ACUAN

Oleh

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Pengelasan pengecaman cap jari secara automatik telah mendapat perhatian yang meluas semenjak sedekad yang lepas. Walau bagaimanapun, masih terdapat ruang untuk mempertingkatkan operasi pengelasan dengan menjalankan kajian dan penyelidikan di dalam bidang ini. Tesis ini menerangkan mengenai kajian pengelasan pengecaman cap jari menggunakan teknik pemadanan acuan. Kami telah mengelaskan cap-cap jari ke dalam empat kumpulan utama Arch, Left loop, Right loop, and Whorl. Kami telah membincangkan dan menerangkan spesifikasi pengelasan pengecaman cap jari. Fokus kajian telah ditumpukan kepada pengaruh masukan data yang rosak disebabkan hingar dan putaran terhadap kejituan pengelasan. Tesis ini menganalisa teknik yang telah dibincangkan dan ia juga menilai kelebihan dan kekurangannya dengan membandingkan teknik ini dengan teknik 'singularities'. Kajian ini juga menyelidiki peringkat pra-pemprosesan yang mengandungi proses-proses peningkatan, pembahagian dan pengurusam cap-cap jari.

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I certify that an Examination Committee met on 28th October 2002 to conduct the final examination of Ahmed Wathik Naji Al-Qaissi on his Master of Science thesis entitled "An Algorithm for Fingerprint Classification Using Template Matching Technique" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malasia (Higher Degree) Regulation 1981. The Committee recommends that candidate be awarded relevant degree. Member for the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as partial fulfilment of the requirement for the degree of Master of Science. The member of the supervisory committee are as follows:

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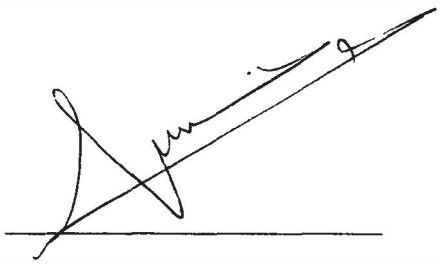
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions



AHMED WATHIK NAJI

Date: 27/11/2002

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CHAPTER I

INTRODUCTION

1.1 Introduction to Biometrics

Biometrics is a technology, which identifies a person based on his/her physiological or behavioural characteristics. It relies on "something which you are" to make personal identification and therefore we can inherently differentiate between an authorized person and a fraudulent impostor. Recently, biometrics technology has received a great deal of attention. Biometrics identifiers currently available are fingerprint, hand geometry, retinal pattern and facial image. Each of these has its advantages and disadvantages. Their applicability depends heavily on the application environment.

Fingerprints are imprints or impressions of patterns formed by friction ridges of the skin in the fingers and thumbs, these friction ridges flow in a certain direction and form a unique pattern on a fingerprint, the friction ridges from each human being can be positively identified through the comparison of fingerprints (Cowger 1983). Fingerprint also fulfils the permanence characteristic where the pattern of a person will not change as the time goes by. The biometrics system based on fingerprint may operate in one of the three modes:

I. Classification Mode.

II. Identification Mode.

III. Verification Mode.

A classification mode automatically classifies the input fingerprint according to their pattern class (Yuan 1998, Zhang 2001). The classification mode is very important because if the input fingerprint is misclassified definitely the input fingerprint will be unidentified.

An identification mode identifies the inputted fingerprint by searching the particular class (which has been selected by the classification mode) of the database for a match (Isenor 1986). It is a one-to-many comparison which matches the inputted fingerprint of a person against a given database to establish the identity of the person. Its goal is to determine whether the person is present in the database or not and then establish the identity of the person according to retrieved results.

A verification mode authenticates a person's identity by comparing the captured fingerprint with his/her own fingerprint template stored in the system (Asker 2000, Gunawardena 1991). It is a one-to-one comparison to determine whether the input fingerprint and a stored fingerprint template in the system are the same or not.

1.2 Objective of Thesis

The objective of this thesis is to make a study on the fingerprints classification using template matching technique, which classifies the fingerprints to four classes according to their pattern. These classes are Whorl, Left loop, Right loop, and Arch. Since the template matching technique is more feasible now due to the available of fast processors and it can be the alternative way of fingerprint classification which overcome the problem of singularities, we analyse the mentioned technique and evaluate its strengths and limitation, and study the effect of corrupted and rotated input fingerprints on the accuracy of the classification operation. The second objective of this thesis is to study the preprocessing stage and their effect on the accuracy of the classification operation.

1.3 Organization of Thesis

The thesis does a study of fingerprint classification using MATLAB. Chapter II introduces a historical overview of fingerprint. It explains pattern type of fingerprints, and explains the fundamental principles of fingerprint and their characteristics and representations. This chapter also reviews some of the algorithms that have been used in fingerprints classification and describes briefly the automatic fingerprint classification.

Chapter III discusses the fingerprint classification. It describes the steps involved in pre-processing stage. These include the enhancement of the fingerprint image that has been used to clarify and improve the clarity of the ridges, the extracting of the fingerprint feature from the noisy background, and the thinning or what is called skeletonization of the fingerprint binary image. The fingerprint classification using template matching and singularities techniques are discuss in this chapter also.

Chapter IV shows the result obtained from fingerprint classification and discusses the properties of the results. Finally, Chapter V is concerned with the concluding remarks (conclusion) and proposal for future work (recommendations).

CHAPTER II

LITERATURE REVIEWS

2.1 Introduction

Large number of fingerprints are collected and stored everyday in a wide range of applications including forensics, driver license registration, automatic teller machines (ATM), web commerce, point-of-sale terminals, entry authorization, personal identity systems for police and border patrol, credit card verification, and computer access control.

Fingerprint pattern is different for each person in the world even for a twin. Every person's fingerprint is unique and is a feature that stays with the person throughout his/her life (Zeena 2001). It also never changes since a person is born until the person is dead. It will change only if burned or cut, this makes the fingerprint the most reliable kind of personal identification because it cannot be forgotten, misplaced, or stolen. Fingerprint authorization is potentially the most affordable and convenient method of verifying a person's identity, the uniqueness of a fingerprint can be determined by the pattern of ridges and valleys as well as the minutiae points.

An automatic recognition of people based on fingerprints requires that the input fingerprint be matched with a large number of fingerprints in the database, so it is desirable to classify the fingerprint database into subclasses to reduce the search time.

The problem of the fingerprint classification are: missing the true singular point, getting false singular point, and error in processing the block directional image due to bad-quality fingerprint images (Zhang 2001).

The accuracy of fingerprints classification is very important because if the input fingerprint is misclassified definitely it will be unidentified due to matching with wrong class.

2.2 Fingerprint: A Historical Overview

The human palm and the inner skin of our foot are different form the rest of the skin, because of this characteristic, people are interested to find its advantages and usefulness.

When a person touches something, they will leave a thin layer of sweat on the surface of the thing. Sweat is produced from the continuous burning process in our body, which consists mostly of water (H_2O) and some mixture of salt (NaC1) and fat. After a while the water from the sweat will evaporate, leaving the salt and fat behind. The layer that is left produces fingerprint (Saferstein 1981).

There are two definite periods in the history of fingerprinting. The first period began when human beings became aware of fingerprints and uses them as a mean of individual signature. The second period is much more recent and began with the development of fingerprint coding and filing systems and techniques of searching for latent prints (Saferstein 1981).

De Forest (1983) stated in his book that the Chinese and Babylonians (Iraqis) used fingerprints on business contracts. While Saferstein (1981) said that evidence existed that the Chinese used the fingerprints to sign legal documents as far back as three thousand years ago. Also, Isenor and Zaky (1986) state that the early Egyptians and Chinese were known to have used the fingerprints to identify criminals and to record business transactions.

However, whether this use was performed for ceremonial custom or as a mean of personal identity remains a point of conjecture lost to history (Safersttein 1981). In any case, the examples of fingerprints techniques in ancient history are ambiguous, and the few that do exist certainly did not contribute to the development of fingerprinting techniques as known today.

The development of fingerprinting as a mean of individualization is attributed to the efforts of the pioneers in the field, for example:

As the chief magistrate of the Hooghly district in Juniper India William Hershel (1877) used fingerprints on native contracts; Henry Faulds (1880) is credited with the first fingerprint identification in law enforcement by obtain a conviction based on correctly identifying a greasy print left on an alcohol bottle and his research culminated in the establishment of a method for fingerprint classification; Sir Frencis Galton (1892) who published the first fingerprint classification system and established the individuality and permanence of fingerprints; Juan Vucetich (1904) who published his system of fingerprint identification, which helped him identify a murderer by studying fingerprints left on a door; Edward Henry (1910) who supervised the adoptation of Galton's system in Scotland Yard (Saferstein 1981 ; De forest 1983) .

Fingerprints are divided into three major classes on the basis of their general patterns: loop (Lift loop and Right loop), whorl, and arch (Kawagoe and Tojo 1984). Where sixty to sixty five percent of the population has loops, thirty to thirty five percent have whorl, and about five percent have arches (Saferstein 1981), as shown in the Figure 2.1.

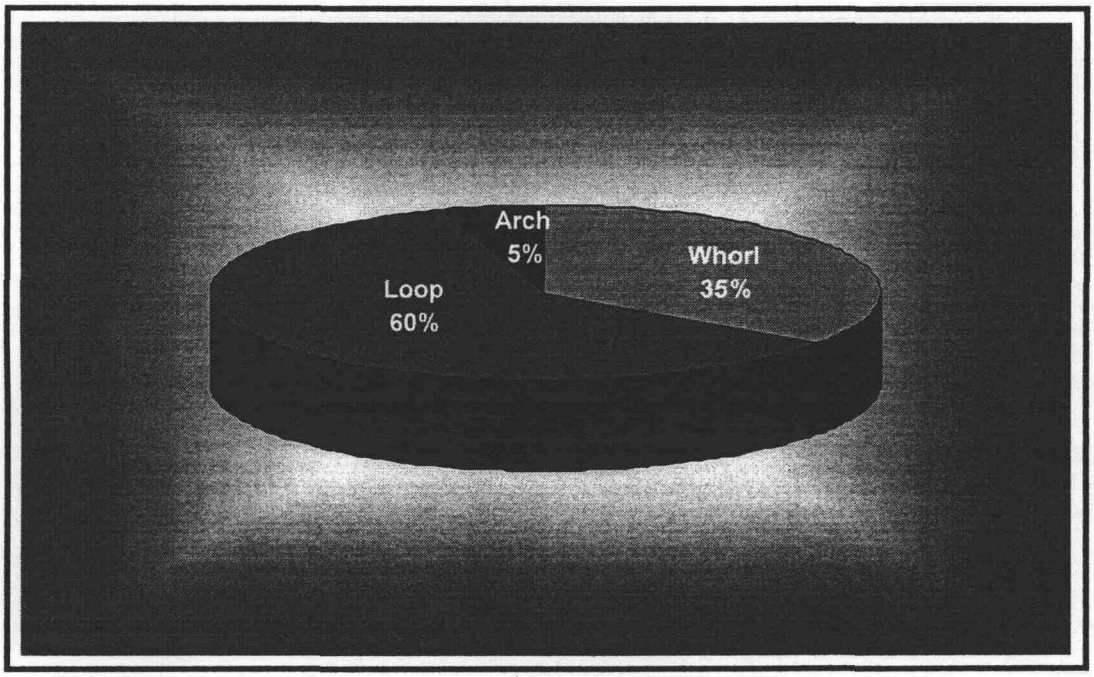

Figure 2.1: Fingerprints of Population

2.3 The Principles of Fingerprint

Saferstein (1981), Cowger (1983), and De Forest (1983) concluded in their works that the following three fundamental facts made the fingerprints a superlative method for personal identification and accepted by courts:

I. A fingerprint is an individual characteristic; no two fingerprints have yet been found to possess identical ridge characteristics. The probability for the existence of two identical fingerprint patterns in the world's population is extremely small. Not only this principle is been supported by theoretical calculations, but also just as importantly, it is verified by the millions upon millions of individuals who have their prints identified over the past 70 years, not two have ever been found to be identical.

II. A Fingerprint will remain unchanged during an individual's lifetime. The skin is composed of layers of cells. Those nearest the surface make up the outer portion of the skin known as the epidermis. The inner skin is known as the dermis. Looking at across section of the skin, a boundary of cells separating the epidermis and dermis is noted. It is the shape of this boundary which is made up of dermal papilla that determines the form and pattern of the ridges on the surface of the skin Once the dermal papillae developed in the human fetus, the ridge patterns will remain unchanged throughout life except to enlarge during growth.

III. Fingerprints have general ridge patterns that permit them to be systematically classified and identified.

2.4 Fingerprint Characteristics

A fingerprint is the pattern of ridges and furrows on the surface of a fingertip. The lines that create a fingerprint pattern are called ridges and the spaces (region) between the ridges are called falleys (Furrows), the points that occur at either a ridge bifurcation or a ridge ending are Minutiae points (Zeena 2001).

The flow of the ridges in a fingerprint forms various patterns, which can be used to classify the fingerprints. Figure 2.2 shows the features of the fingerprints and as follows (Cowger 1983):

I. *Bifurcation:* division of the ridge into two or more ridges. It is shown in the Figure 2.2 as the box with number 1.

II. *Core:* It is approximately the centre point of loop fingerprint. It is located within or on the innermost recurve. Arches do not have any core point. See Figure 2.2, box with number 2.