Faculty of Engineering

A New Bit-Plane Extraction Approach for Fingerprint Recognition Using Phase-Only Correlation Function

Florence Francis Lothai

Master of Engineering
2016

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A New Bit-Plane Extraction Approach for Fingerprint Recognition Using Phase-Only Correlation Function

Florence Francis Lothai

A thesis submitted

In fulfilment of the requirements for the degree of Master of Engineering

(Electronics and Computer)

Faculty of Engineering

UNIVERSITI MALAYSIA SARAWAK

2016

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citation, which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date: 10/10/2016

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DEDICATION

For my beloved family and friends

ABSTRACT

Fingerprint patterns are virtually unique and make human identifiable. Based on this fact, many researches have been conducted on fingerprint to create new or improved recognition systems. Due to the rapid growth of human population, larger capacity of databases are needed for the storage of fingerprints. With larger sizes of fingerprint images, bigger memory storage is needed and the cost for such memory is also higher. The focus of this thesis is on bit-plane extraction of a fingerprint image, which could reduce the file size of a grayscale image. Literature studies reveal that this method is commonly used in image compression and retrieval with limited research in fingerprint recognition. Combination of this method with Phase-Only Correlation (POC) function reduces computation time for a fingerprint recognition while improve the recognition rate. POC based recognition method is adopted because of its simplicity and ability to achieve high accuracy compared to other recognition algorithms, especially for low quality fingerprint image. There are two fingerprint databases used for evaluations, which are FingerDOS and a benchmark database, FVC2002-Db1a. A number of analyses are conducted to examine factors that might reduce the performance of the recognition system. Different rotation angles and cropping dimension are applied on the fingerprint to investigate the effects of misaligned fingerprints. The best bit-plane is selected based on the highest recognition rate produced by the system. From the experiment results, bit-plane 7 has the highest performance compared to other bit-planes. Since fingerprint recognition by using bit-plane image could perform as good as grayscale image, this system has the potential to reduce the storage requirement for fingerprint database.

Keywords: Bit-plane extraction, fingerprint recognition, Phase-Only correlation

Satu Pendekatan Baharu Pengekstrakan Bit-Satah Untuk Pengecaman Cap Jari Menggunakan Korelasi Fasa-Sahaja

ABSTRAK

Corak cap jari adalah sangat unik dan membolehkan manusia dikenalpasti. Berdasarkan fakta ini, banyak kajian telah dijalankan ke atas cap jari untuk mewujudkan sistem pengecaman baru atau yang lebih baik. Oleh kerana pertumbuhan populasi manusia yang semakin pesat, pangkalan data dengan kapasiti yang lebih besar diperlukan untuk penyimpanan cap jari. Dengan saiz imej cap jari yang lebih besar, penyimpanan memori yang lebih banyak diperlukan dan menyebabkan kos memori juga bertambah. Fokus tesis ini adalah mengenai pengekstrakan bit-satah imej cap jari, yang boleh mengurangkan saiz fail imej skala kelabu. Kajian menunjukkan bahawa kaedah ini biasanya digunakan dalam pemampatan dan pemerolehan semula imej dengan penyelidikan yang terhad dalam pengecaman cap jari. Gabungan kaedah ini dengan fungsi Korelasi Fasa-Sahaja (POC) bukan sahaja mengurangkan masa pengiraan untuk pengecaman cap jari, malah meningkatkan kadar pengecaman tersebut. Kaedah pengecaman berdasarkan fungsi POC digunapakai kerana kemudahan dan keupayaan untuk mencapai ketepatan yang tinggi berbanding algoritma pengecaman yang lain, terutama untuk kualiti imej cap jari yang rendah. Terdapat dua pangkalan data cap jari yang digunakan untuk penilaian, FingerDOS dan pangkalan data penanda aras, FVC2002-Db1a. Beberapa analisis dijalankan untuk mengkaji faktor-faktor yang mungkin mengurangkan prestasi sistem pengecaman. Sudut putaran dan dimensi pemotongan yang berbeza digunakan pada cap jari untuk mengkaji kesan cap jari tidak sejajar. Bit-satah yang terbaik dipilih berdasarkan kadar pengecaman tertinggi yang dihasilkan oleh sistem. Daripada keputusan eksperimen, bit-satah 7 mempunyai prestasi yang tertinggi berbanding bit-satah yang lain. Memandangkan *pengecaman cap jari menggunakan imej bit-satah adalah sebaik imej skala kelabu, sistem ini mempunyai potensi untuk mengurangkan keperluan penyimpanan untuk pangkalan data cap jari.*

Kata Kunci: *Pengekstrakan bit-satah, pengecaman cap jari, korelasi Fasa-Sahaja*

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LIST OF ABBREVIATIONS

2D DFTS	2-Dimensional Discrete Fourier Transforms
2D IDFT	2-Dimensional Inverse Discrete Fourier Transform
AMP	Advanced Multimedia Processing
BLOB	Binary Large Object
BMP	Bitmap
DC	District of Columbia
EER	Equal Error Rate
FA	False Accept
FAR	False Acceptance Rate
FBI	Federal Bureau of Investigation
FFT	Fast Fourier transform
FingerDOS	Fingerprint Database based on Optical Sensor
FMT	Fourier-Mellin transform
fn	False Negative
fp	False Positive
FPR	False Positive Rate
FR	False Reject
FRR	False Rejection Rate
FVC2002-Db1a	Fingerprint Verification Competition 2002 Db1a
GB	Gigabyte
GHz	Gigahertz
HTER	Half Total Error Rate

JPEG	Joint Photographic Experts Group
JPEG-LS	Joint Photographic Experts Group-Lossless Standard
kB	Kilobyte
LED	Light-Emitting Diode
LoG	Laplacian of a Gaussian
LSB	Least Significant Bit
MB	Megabyte
MSB	Most Significant Bit
POC	Phase-Only Correlation
PPI	Pixels per Inch
ROC	Receiver Operating Characteristic
ROI	Region of Interest
tn	True Negative
tp	True Positive
TPR	True Positive Rate

CHAPTER 1

INTRODUCTION

1.1 Background

The need for a faster, simpler and stronger authentication and identity management has led to the increasing usage of biometric applications in daily life. Biometric has replaced the traditional way of human recognition because biometric features cannot be copied or misplaced, and they basically represent the individual's bodily identity. Biometric is not only used in the society to reduce fraud and increase safety, but is also an interesting research topic in pattern recognition (Prabhakar et al., 2003).

Fingerprint is the most common biometric feature for human identification. Other biometric features such as face, eye retinas and irises, voice patterns, and hand measurements are also being researched recently, but they are not as popular as fingerprint (Bolle et al., 2013). According to Hassaballah and Aly (2015), it is hard to develop recognition techniques that are able to cope with skin aging, facial expression, and facial pose with respect to the camera for face recognition. In iris recognition, the researchers are concern with the presence of contact lenses, motion blur, and specular reflections that will deteriorate the performance of the iris based recognition system abruptly (Hajari & Bhoyar, 2015). In addition, a voice signal available for recognition is normally degraded in quality by communication channel and it is affected by factors such as a person's health and emotional state (Maltoni et al., 2009).

On the other hand, fingerprint is still a popular choice today because of its tremendous success in law enforcement applications in the past (Li et al., 2016). Moreover, the cost of fingerprint sensing devices is decreasing and access of inexpensive computing power is increasing over the years (Borah et al., 2015). These have resulted in a massive use of fingerprint-based person recognition in government, commercial, civilian, and financial domains (Maltoni et al., 2009).

The design of a fingerprint recognition system depends on the context of the application. Basically, a fingerprint recognition system can be categorized into two categories, verification system and identification system. In verification system, a person's identity is authenticated by comparing the captured fingerprint characteristic with her previously enrolled fingerprint reference template which is pre-stored in the system. For identification system, an individual is recognized by searching the entire enrollment template database for a match. The difference between the two systems is that a one-to-one comparison is done to verify an identity in a verification system, while a one-to-many comparisons is done to identify identity person in an identification system.

The choice of a fingerprint recognition algorithms is not just based on error rates. Accuracy is one of the important factors, however, many other factors are also involved such as cost, computational speed, acquirability, privacy, and ease of use (Bolle et al., 2013). Although many existing fingerprint recognition algorithms have higher accuracy and lower error rates, some of them require a higher cost, a more complicated recognition process, or have lower computational speed. Therefore, this research aims to propose a new fingerprint recognition approach with a simple mathematical derivation that is able to produce reasonable recognition rate and improvement in computational speed, as well as reducing the needs of large fingerprint database storage.

The focus of this research is on a relatively new image feature extraction approach, i.e., bit-plane extraction. Bit-plane extraction is chosen due to its advantages in using lesser memory storage and ability to carry useful information for recognition purposes. An image can be represented with lesser bits with smaller size by slicing the image into its certain bit-plane and compressed. Each bit level of the bit-planes carries different information which has the possibility to be widely used in fingerprint recognition. Bit-plane 7 is proposed to be the only bit-plane image to be used as input image in the proposed fingerprint recognition system.

In this research, a simple fingerprint recognition algorithm, i.e., Phase-Only correlation (POC) function is proposed to be combined with the bit-plane extraction approach. POC is chosen because of its simplicity and capability to recognize bit-plane image. A POC matching process is done by superimposing two fingerprint images and compute the correlation value by using a simple algorithm. The proposed fingerprint recognition system is able to reject almost all the unauthorized subjects which is crucial in fingerprint recognition applications. This process does not require complex algorithms to filter the minutiae of the fingerprint. Consequently, the computational speed of the recognition can be highly improved. This method is also able to produce a higher recognition rate compared to minutiae-based fingerprint recognition.

A new fingerprint database based on optical sensor is also created in this research as one of the validation database. This database has a better quality of fingerprint image compared to other existing fingerprint databases. In addition, image with finger displacement on the sensor plate is minimized. This helps in focusing the tests on fingerprint recognition rather than on overcoming alignment issues in the fingerprint images. Another feature of this database is to provide more samples per finger which makes it useful as testing dataset. There are 3600 fingerprint images available in the database which contains 60 subjects, each subject has images from six different fingers and 10 sample images per finger.