Faculty of Information and Communication Technology

CRYPT EDGE DETECTION USING PSO, LABEL MATRIX AND BI-CUBIC INTERPOLATION FOR BETTER IRIS RECOGNITION(PSOLB)

Nurul Akmal Binti Hashim

Master of Science in Information and Communication Technology

2017

CRYPT EDGE DETECTION USING PSO, LABEL MATRIX AND BI-CUBIC INTERPOLATION FOR BETTER IRIS RECOGNITION(PSOLB)

NURUL AKMAL BINTI HASHIM

A thesis submitted
in fulfilment of the requirements for the degree of Master of Science
in Information and Communication Technology

Faculty of Information and Communication Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

DECLARATION

I declare that this thesis entitle "Crypt Edge Detection Using PSO, Label Matrix and Bi-Cubic Interpolation for Better Iris Recognition (PSOLB)" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
Name	:	Nurul Akmal Binti Hashim
Date	:	

APPROVAL

I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of Master of Science in Information and Communication Technology.

Signature :

Supervisor Name : Associate Professor Dr. Abdul Samad Bin Shibghatullah

Date :

DEDICATION

To my beloved Ayah, Ummi and family...

ABSTRACT

Iris identification is an automatic system to recognise an individual in biometric applications. Human iris is an internal organ that can be accessed from external view of the body. Moreover, the structure of the iris is formed in a complete random manner and has unique features such as crypts, furrows, collarets, pupil, freckles, and blotches. In fact, no iris patterns are the same. The iris structure is stable which it means the location of the iris features is permanent at certain point. Nevertheless, the shape of iris features changes slowly due to several factors which include aging, surgery, growth, emotion and dietary habits. Recently, there has been renewed interest in iris features detection. Gabor filter, cross entrophy, support vector, and canny edge detection are methods which produce iris codes in binary codes representation. However, problems have occurred in iris recognition since low quality iris images are created due to blurriness, indoor or outdoor settings, and camera specifications. Failure was detected in 21% of the intra-class comparisons cases which were taken between intervals of three and six months intervals. However, the mismatch or False Rejection Rate (FRR) in iris recognition is still alarmingly high. Higher FRR also causes the value of Equal Error Rate (EER) to be high. The main reason for high values of FRR and EER is that there are changes in the iris due to the amount of light entering into the iris that changes the size of the unique features in the iris. One of the solutions to this problem is by finding any technique or algorithm to automatically detect the unique features. Therefore, a new model is introduced which is called Crypt Edge Detection which combines PSO, Label Matrix, and Bi-Cubic Interpolation for Iris Recognition (PSOLB) to solve the problem of detection in iris features. In this research, the unique feature known as crypts has been chosen due to its accessibility and sustainability. Feature detection is performed using particle swarm optimisation (PSO) as an algorithm to select the best iris texture among the unique iris features by finding the pixel values according to the range of selected features. Meanwhile, label matrix will detect the edge of the crypt and the bi-cubic interpolation technique creates sharp and refined crypt images. In order to evaluate the proposed approach, FAR and FRR are measured using Chinese Academy of Sciences' Institute of Automation (CASIA) database for high quality images. For CASIA version 3 image databases, the crypt feature shows that the result of FRR is 21.83% and FAR is 78.17%. The finding from the experiment indicates that by using the PSOLB, the intersection between FAR and FRR produces the Equal Error Rate (EER) with 0.28%, which indicated that equal error rate is lower than previous value, which is 0.38%. Thus, there are advantages from using PSOLB as it has the ability to adapt with unique iris features and use information in iris template features to determine the user. The outcome of this new approach is to reduce the EER rates since lower EER rates can produce accurate detection of unique features. In conclusion, the contribution of PSOLB brings an innovation to the extraction process in the biometric technology and is beneficial to the communities.

ABSTRAK

Iris adalah sistem automatik untuk mengenal pasti seseorang individu dengan menggunakan sistem komputer. Dalam tubuh manusia iris adalah unik dan mengambil masa yang lama untuk berubah. Corak Iris terbentuk dalam keadaan rawak dan mempunyai ciri-ciri unik seperti crypts, furrows, collarets, jeragat dan tompok. Tidak ada dua corak iris sepadan antara satu sama-lain walaupun mereka adalah kembar. Walau bagaimanapun, nilai kadar samarata ralat (EER) adalah masih tinggi di dalam sistem pengiktirafan iris. Ia berlaku apabila terdapat perubahan dalam iris kerana keadaan badan manusia contohnya seperti penuaan, pertumbuhan, emosi, makanan, dan pembedahan mata. Di dalam iris cirri-cirinya sentiasa berubah dan hal ini akan mewujudkan kesukaran dalam fasa perbandingan bagi menentukan sama ada seseorang itu asli atau tidak asli. Ia menunjukkan bahawa daripada projek sebelum in kegagalan dikesan dalam 21% daripada kes-kes perbandingan intra-kelas, yang diambil dalam tempoh masa tiga dan enam bulan. Salah satu penyelesaian untuk masalah ini adalah dengan mencari mana-mana teknik atau algoritma untuk mengesan ciri-ciri yang unik di dalam iris secara automatik. Oleh itu, model baru diperkenalkan dan dipanggil sebagai "A New Model of Crypt Edge Detection Using PSO and Bi-Cubic Interpolation" untuk menyelesaikan masalah pengesanan dalam ciri-ciri iris. Dalam kajian ini ia membentangkan penggunaan zarah swarm pengoptimuman (PSO) untuk memilih tekstur iris terbaik dan antara ciri iris unik dengan mencari nilai piksel mengikut pelbagai ciri yang dipilih. Sementara itu, teknik interpolasi bi-padu mewujudkan imej iris yang unik dan halus imej. Ciri-ciri yang unik seperti crypts telah dipilih dalam projek ini kerana akses dan kemampanannya. Untuk menilai pendekatan yang dicadangkan ini, kdar penerimaan ralat (FAR) dan kadar penolakan ralat (FRR) diukur dengan Akademi Sains China 'Institut Automation (Casia) pangkalan data untuk imej yang berkualiti tinggi. Untuk Casia versi 3 pangkalan data imej, telah menunjukkan bahawa keputusan FRR adalah 21.83% dan FAR adalah 78.17%. Percubaan dapatan menunjukkan dengan menggunakan "Crypt Edge Detection Using PSO, Label Matrix and Bi-Cubic Interpolation", persilangan antara FAR dan FRR menghasilkan Kadar Sama Rata Ralat (EER) dengan 0.28%, yang menunjukkan bahawa kadar kesilapan sama adalah lebih rendah daripada nilai sebelumnya, iaitu 0.38%. Oleh itu, kelebihan menggunakan model baru Crypt Edge Pengesanan Menggunakan PSO dan Interpolasi Bi-padu adalah ia mempunyai keupayaan untuk menyesuaikan diri dengan ciri-ciri unik dan iris menggunakan maklumat dalam ciri template iris untuk menentukan pengguna. Hasil daripada pendekatan baru ini adalah untuk mengurangkan kadar EER karena nilai EER lebih rendah boleh menghasilkan pengekstrakan tepat ciri unik. Kesimpulannya, sumbangan "Crypt Edge Detection Using PSO, Label Matrix and Bi-Cubic Interpolation" membawa inovasi yang di proses pengekstrakan teknologi biometrik dan memberikan manfaat kepada masyarakat.

ACKNOWLEDGEMENT

"In the name of Allah, most Gracious, most Compassionate".

First and above all, I praise to God, the almighty for providing me this opportunity and granting me the capability to proceed successfully. This thesis appears in its current form due to the assistance and guidance of several people. I would therefore like to offer my sincere thanks to all of them. PM Dr. Abdul Samad Shibghatullah, my main supervisor, my cordial thanks for accepting me as a master student, your warm encouragement, thoughtful guidance, critical comments, and correction of the thesis. I want to express my deep thanks to my co-supervisor Dr. Zaheera Zainal Abidin for the trust, the insightful discussion, offering valuable advice, for your support during the whole period of the study, and especially for your patience and guidance during the writing process.

Thanks also to all the members of Optimass laboratory group, for providing a good atmosphere in our lab and for useful discussions. My housemates thank you very much for making the atmosphere of our house as friendly as possible.

Hereby, I would like to thank you for everything. I cannot finish without thanking my family, warmly thank and appreciate ayah and ummi, for their material and spiritual support in all aspects of my life. I also would like to thank my brothers and sister, for they have provided assistance in numerous ways. I can just say thanks for everything and may Allah give you all the best in return.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ACO	:	Ant Colony Optimization
CASIA	:	Chinese Academic of Sciences Database
CBIR	:	Content Based Image Retrieval
EER	:	Equal Error Rate
FAR	:	False Acceptance Rate
FRR	:	False Rejection Rate
GA	:	Genetic Algorithm
GAR	:	Genuine Accept Rate
NN	:	Neural Network
PSO	:	Particle Swarm Optimization
PSOLB	:	Particle Swarm Optimization, Label Matrix and Bi-Cubic Interpolation
PSNR	:	Peak Signal Noise Ratio
HD	:	Hamming Distance

LIST OF PUBLICATIONS

Published in Journal

1. Hashim, N.A., Abidin, Z.Z. and Shibghatullah, A.S., 2017. Iris Feature Detection using Split Block and PSO for Iris Identification System. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, *9*(1-2), pp.99-102.)

Seminar/Workshop/Conference Paper

1. Hashim, N., ZainalAbidin, Z., Shibghatullah, A., AbalAbas, Z. and Yusof, N., 2016. A New Model of Crypt Edge Detection Using PSO and Bi-cubic Interpolation for Iris Recognition. In *Advanced Computer and Communication Engineering Technology* (pp. 659-669). Springer International Publishing.

Exhibition/Competition

1. Expo Penyelidikan Dan Inovasi (UTeMEX 2015) - Bronze

CHAPTER 1

INTRODUCTION

1.1 Background of Research

Biometric authentication is a form of identification and access control using human characteristic. It is commonly used for workstation, network, domain access, single sign-on, application logon, data protection, remote access to resources, transaction security, and web security. Well-known examples of biometric authentication schemes are voice recognition, palm print, face recognition, fingerprint, iris recognition, retina recognition and scent. Among many physical characteristics, iris recognition has received much interest, especially in the past few decades in the biometric technology field since it has unique and distinctive iris features for personal ident ification.

The richness and variability observed in the iris features are due to the agglomeration of multiple anatomical entities that composed its texture. Each iris has an exclusive feature that cannot be duplicated by others (Wayman, 1999). In fact, the internal organ of human iris contains a unique texture and the complex structure is suitable to be used as a biometric signature (J.Daughman, 2004). Moreover, the unique iris features in the eye structure are stable in parallel to age (R.Wildes, 1997).

The iris is located between the darker pupil and brighter sclera. The iris consists of a pigmented fibro vascular tissue which is known as stroma. The stroma connects a sphincter muscle and a set of dilator muscles in order to open it. It is divided into two major regions which are the pupillary and the ciliary zone.

The pupillary zone is the inner portion of the iris where the edges form the pupillary iris border. The ciliary zone is the outer portion of the iris which extends itself into the iris origin in the ciliary body. The region that separates the pupillary and scleric portions is designated as the collarette. This is typically in the region where the sphincter and dilator muscles overlap. An example of the eye anatomy image is shown in Figure 1.1 and Figure 1.2.

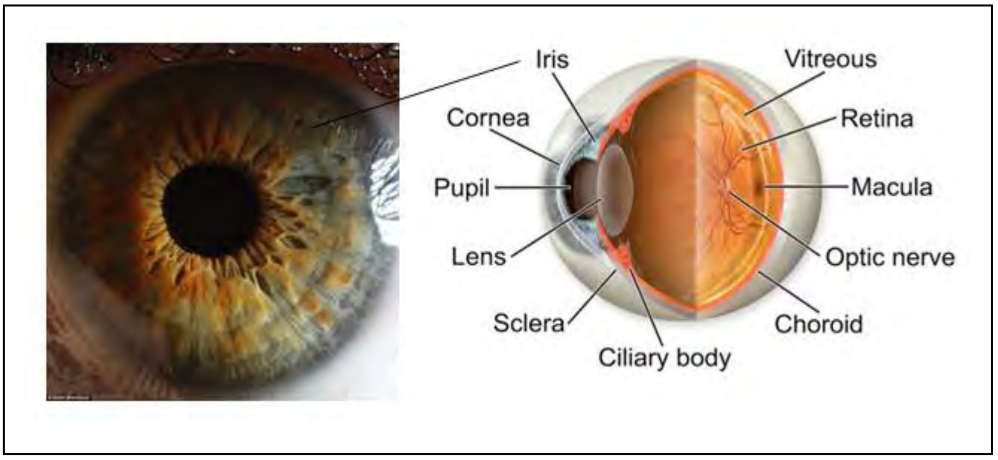

Figure 1.1: Eye anatomy image

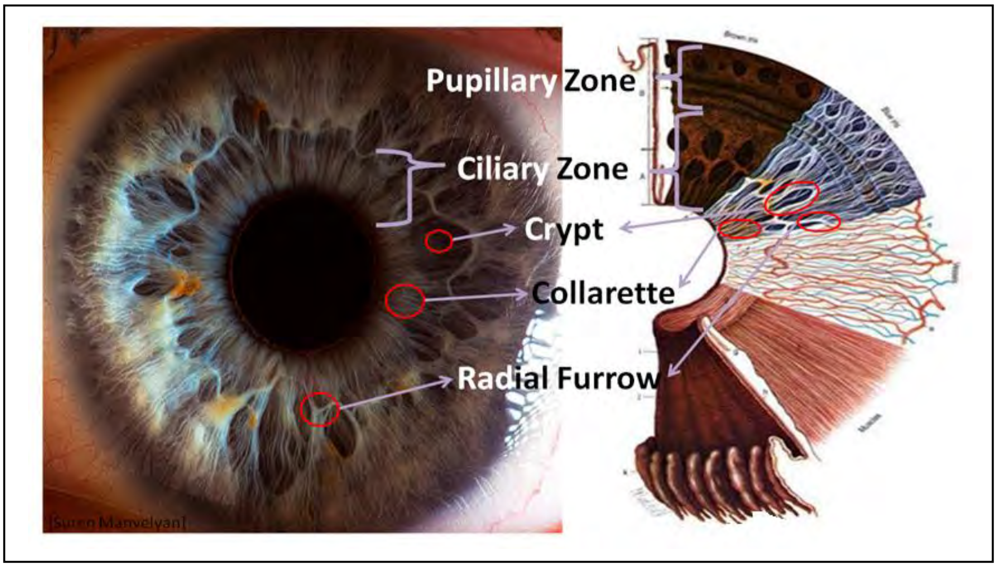

Figure 1.2: Features in iris

The iris begins to form during the third month of gestation and the structure is completed by the eight month. Although., it must be noted that pigmentation continues into the first year after birth. The visible features of the iris arise in the trabeculum which is a mesh-work of connective tissues with arching ligaments, crypts, contraction furrows, a corona and pupillary frill, coloration, and freckles. Although the anterior layer covering the trabecular framework creates the predominant iris texture is seen with visible light, additional discriminating information can be given by the location of all of these sources of radial and angular variation. Together, as mentioned by Daugman in the year 1989, they provide a distinguishable uniqueness to every individual.

Daughman in the 1990s has designed a model for iris recognition. It performs segmentation, normalisation, and feature comparison phases which produces iris codes as the signature comparison between the real-time and stored value. The overall model of iris recognition system is illustrated as in Figure 1.3. Basically, an iris recognition system consists of two main processes which are enrollment process and identification process. The enrollment processes is for a first time user who needs to save their eye data in the database, so that he or she can be used in the system later. The second process is the identification process which only involves the frequent user. The identification processes will repeat the first process and adds matching process at the comparison phase to identify the frequent user.

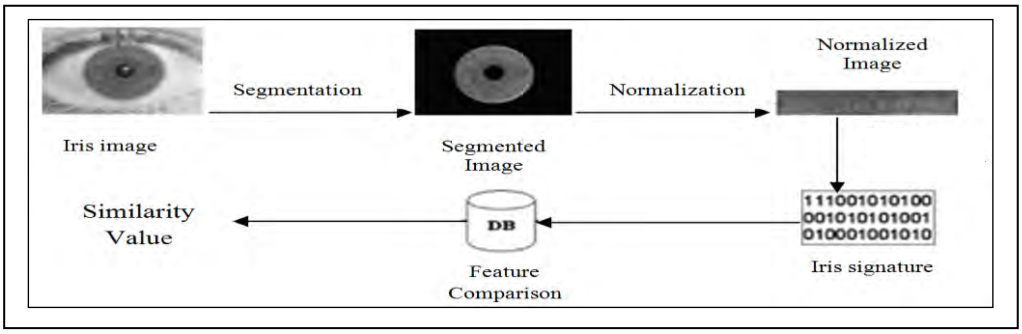

Figure 1.3: Micro-characteristics of human iris (Militello et al., 2009)

However, the mismatching conditions always occur during the comparison phase. Due to the mismatching, the number of non-genuine user has gradually risen. The non-genuine user is categorised into two types. The first type is someone who tries to penetrate the systems and pretends to be the original person. Meanwhile, the second type is when the system rejects the genuine user who wants to access the system. Typically, the second type of non-genuine user suffers from using the biometric system. Moreover, the rising number of non-genuine user has provided high equal error rates (EER).

Equal error rates (EER) is a value from the intersection of False Accept Rate (FAR) and False Rejection Rate (FRR). Generally, when the value of the EER is less than 1% and user identification value has reached 99%, the system is more accurate. There are several factors that can cause theEER value to be high. The most common factors that were raised by many researchers are technical issues. The technical problems are due to the occlusion, outdoor lighting, contact lens, spectacles, and light reflection.

Several studies have attempted to overcome the high value of EER (Daugman, 2007). Examples of issue which have been previously highlighted by other researchers are image enhancement(Almisreb et al., 2011), multiple biometric modality analysis(Chu, 2005; Chen et al., 2013), and swarm intelligence based feature extraction and feature detection(Castillo and Melin, 2012). Despite that, many past studies which have provided solutions are still incapable in reducing the EER value in iris problems.

The existing system lacks natural computational elements in iris recognition. It is an algorithm which falls under the area of artificial intelligence. The natural computational algorithms consist of artificial neural networks, artificial immune systems, evolutionary algorithms, and swarm intelligence. In swarm intelligence, the Particle Swarm Optimisation (PSO), Genetic Algorithms (GA), and Ant Colony Optimisation (ACO) are highly used in order to solve optimisation problems.

Thus, Particle Swarm Optimisation (PSO) has been studied is examined in this research. It is because PSO is one of the new heuristic algorithms that acts as a randomly generated population and utilises a fitness value to evaluate the population. In fact, PSO updates the population and searches for the optimum value with random techniques. PSO has more effective memory capability for each particle as it remembers its own previous and neighbourhood best value (Dg et al., 2012). The implementation is easier and require few parameters to be adjusted (Logannathan, 2012). In PSO, only the 'best' particle t shares the information to others. It is a one-way information sharing mechanism as the evolution is determined to provide the best solution.

Nevertheless, the performance of the PSO would be better if it is enhanced or combined with another method. Therefore, the purpose of this study is to fulfil the demand of achieving a lower EER rate in the iris recognition system. Due to this demand, a combination model of iris recognition using particle swarm optimisation with four other methods which are Label Matrix, Nearest Neighbour, Bilinear, and Bi-Cubic interpolation are understudied and lack empirical results. Label matrix is used to obtain the edge of crypts and differentiate the size of the crypt by RGB colours. Meanwhile, the other three techniques are techniques which interpolate a 2D image into a new size of an image . Thus, the output image quality will increase. According to the Peak Signal Noise Ratio (PSNR) values, the combination of these three techniques shows that Label Matrix and Bi-Cubic interpolation provides a better value of Peak Signal Noise Ratio (Hashim et al., 2016) as compared to the conventional techniques for iris image.

Therefore, the combinational approach of particle swarm optimisation (PSO), Label Matrix, and Bi-Cubic interpolation techniques in selecting one of the unique features in the iris which is crypt has been proposed. The particles in PSO searches for the most optimal crypt features in the iris texture.

Meanwhile, Label Matrix detects the edge of crypts and differentiate the size of the crypt by RGB colour while the Bi-Cubic Interpolation technique creates sharp and refined crypt images.

The overall idea of searching authentic iris features based on the shape of crypt from the PSO process is illustrated as in Figure 1.4.

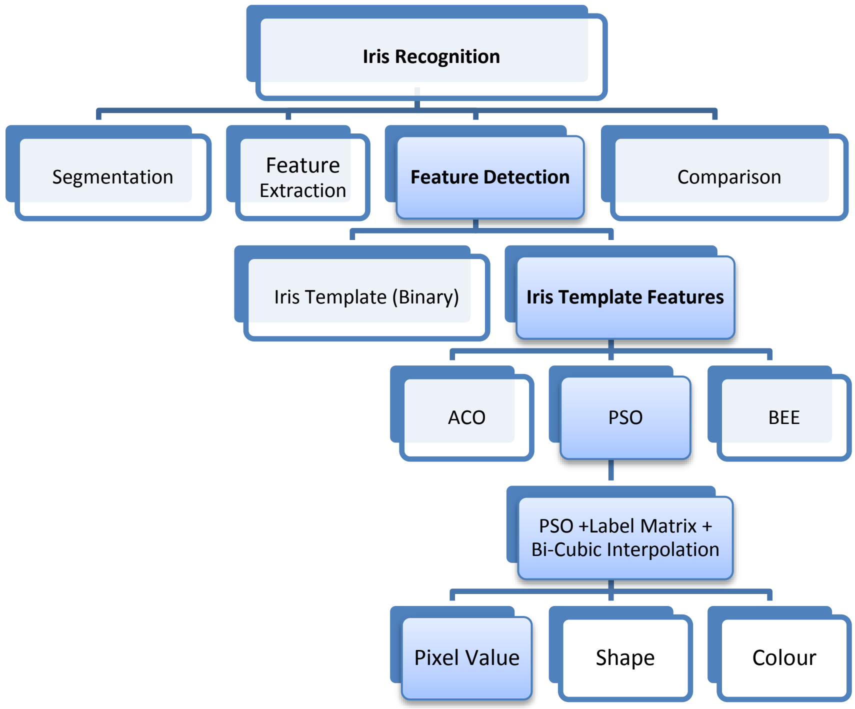

Figure 1.4: PSO Taxonomy

1.2 Problem Statement

The idea of Iris recognition has evolved since 1999 until 2016. Iris recognition is capable to identify the unique iris features in human eye such as crypt, blotches, radial furrow, and collaratte. These iris patterns determine the one-of-a-kind information as only a specific human iris contains a unique set of iris biometric data (Wayman, 1999). This is emphasised by the fact that even twins possess differences in iris patterns (Muron and Pospisil, 2000).

However, these unique iris features constantly yet slowly change based on human conditions such as aging, dietary habits, and surgery (Matey et al., 2010) which creates a main challenge in using iris recognition for verification purposes. The changes in unique iris features has also caused an increase in the percentage of false rejected rate (FRR) in the iris recognition system (Fenker et al., 2013) which in turn affects and raises the value of EER. In previous research, the failure was detected in 21% of intra-class that has been taken in intervals between three and six months. .

Several methods have been employed to achieve the primary goal of reducing the EER value. Examples of the methods which have been previously employed by other researchers are deblurring (Alonso-Fernandez et al., 2009), white noise insertion (Monro et al., 2007; Militello et al., 2009), image enhancement (Proença and Alexandre, 2010), compression (Daugman, 2006)and the selection of unique iris features are popular (Chen et al., 2013). However, the EER maintains high (Zaheera et al., 2014).

Thus, in this research, a new model has been introduced to overcome the crypt detection using natural computing elements for iris recognition. The model is a combination of Particle Swarm Optimisation (PSO), Label Matrix, and Bi-cubic Interpolation.

1.3 Research Question

Based on the problem statement, two research questions are identified which are as follows:

1. What are the appropriate techniques in searching the unique iris features in iris recognition?
2. How to evaluate the EER rate of iris recognition system?