REFLECTION REMOVAL AND FEATURE EXTRACTION TECHNIQUES IN NON-COOPERATIVE VISIBLE EYE IMAGES FOR IRIS RECOGNITION

ANIS FARIHAN MAT RAFFEI

UNIVERSITI TEKNOLOGI MALAYSIA

REFLECTION REMOVAL AND FEATURE EXTRACTION TECHNIQUES IN NON-COOPERATIVE VISIBLE EYE IMAGES FOR IRIS RECOGNITION

ANIS FARIHAN BINTI MAT RAFFEI

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Science (Computer Science)

Faculty of Computing
Universiti Teknologi Malaysia

SEPTEMBER 2013

To my beloved parents,

MAT RAFFEI B AB RAHMAN

AINUN BINTI SALLEH

ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to all my supervisors, Dr. Hishammuddin Asmuni, Dr. Rohayanti Hassan and Dr. Muhamad Razib Othman for their patience, guidance, encouragement, invaluable comments, and advice that made this research possible and completed early. I would like to thank all funders: GATES Scholars Foundation (GSF) of GATES BIOTECH Solution SDN. BHD. company (grant no. LTRGSF/SU/2011-04) and MyMaster Scholarship of Ministry of Higher Education Malaysia for their continuous sponsor of this research.

Finally, my deepest appreciation goes to my parent as they were the ones who encouraged me to pursue my MSc. With their greatest support and hope, came the strength to withstand the hardships that were encountered along this road. Eventually, I realize how achieving this MSc will not only fulfil their dreams that they had embedded in me, but mine as well. Their aspirations live in me, for it will be the one that will inspire me to achieve more great things in life ahead. Lastly, I would like to express my appreciation to ALLAH because He simplified all my business to complete this research.

ABSTRACT

Research on iris recognition system nowadays focuses on identifying a person in a non-cooperative environment by capturing an eye image in motion and at different distances. A visible wavelength illumination is used to capture the eye image which is believed to be safer to the eyes as excessive level of near infrared wavelength illumination can endanger the eye. However, the quality of data captured is very low and there are large reflections with different intensities in the eye image. These have caused incorrect segmentation of iris boundaries as well as the inability to extract texture features of an iris in a non-cooperative environment leading to a reduction in the iris recognition performance. The research proposed the development of two combined methods to improve the iris recognition system. The first combined method consists of line intensity profile and support vector machine and the second is a combination of multiscale sparse representation of local Radon transform. The former identifies and classifies between reflections and non-reflections whereas the latter performs three processes: reduces noise during down sample of normalized iris, extracts an iris texture in the different angles of orientation information and uses score combination of multiscale at the end of the process to increase the matching score. These two methods were tested against UBIRIS.v2 iris database and the results of iris recognition compared to the existing methods achieved an accuracy of more than 90%.

ABSTRAK

Penyelidikan ke atas sistem pengecaman iris pada masa kini memberi tumpuan kepada mengenal pasti seseorang dalam keadaan tidak koperatif dengan mengambil imej mata dalam pergerakan dan pada jarak yang berbeza. Satu gelombang pencahayaan tampak digunakan untuk mengambil imej mata yang dipercayai lebih selamat digunakan kepada mata kerana gelombang pencahayaan jarak dekat berasaskan inframerah yang berlebihan boleh membahayakan mata. Walau bagaimanapun, kualiti data yang diambil adalah sangat rendah dan terdapat pantulan yang besar dengan intensiti yang berbeza pada imej mata. Ini telah menghasilkan segmentasi sempadan-sempadan iris yang tidak tepat serta kegagalan untuk mengekstrak ciri-ciri tekstur iris dalam keadaan tidak koperatif yang membawa kepada pengurangan dalam perlaksanaan pengecaman iris. Penyelidikan ini mencadangkan pembangunan dua kaedah gabungan untuk meningkatkan sistem pengecaman iris. Kaedah gabungan yang pertama terdiri daripada gabungan garis intensiti profil dan mesin sokongan vektor dan yang kedua ialah gabungan daripada perwakilan pelbagai skala jarang transformasi *Radon* tempatan. Yang pertama mengenal pasti dan mengklasifikasi antara pantulan dengan bukan pantulan manakala yang kedua menjalankan tiga proses: mengurangkan ralat semasa pengurangan sampel normal iris, mengekstrak tekstur iris dalam pelbagai sudut maklumat orientasi dan menggunakan penggabungan skor dari pelbagai skala pada proses terakhir untuk meningkatkan skor padanan. Kedua-dua kaedah ini telah diuji terhadap pangkalan data iris UBIRIS.v2 dan hasil daripada pengecaman iris berbanding dengan kaedah-kaedah yang sedia ada telah mencapai ketepatan lebih daripada 90%.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

d	-	decidability
π	-	means
σ	-	standard deviations
n	-	total number of access
k	-	total number of candidate person
γ	-	red, blue and green intensities

LIST OF ABBREVIATIONS

ACC	-	Accuracy
ATM	-	Automated Teller Machine
BATH	-	University of Bath
BVC	-	First Biometrics Verification Competition
CASIA	-	Institute of Automation, Chinese Academy of Science
CPU	-	Central Processing Unit
DPI	-	Dots Per Inch
FAR	-	False Acceptance Rate
FRR	-	False Rejection Rate
GHz	-	Gigahertz
HD	-	Hamming Distance
HT	-	Hough Transform
ICE	-	Iris Challenge Evaluation
ID	-	Identification Card
ISO	-	International Organization for Standardization
LBP	-	Local Binary Pattern
LG	-	One Dimensional of Log Gabor Filter
LIP	-	Line Intensity Profile
LIPPNN	-	Line Intensity Profile and Perceptron Neural Network
LIPSVM	-	Line Intensity Profile and Support Vector Machine
LOI	-	Line of Interest
LRT	-	Local Radon Transform
MB	-	Mbyte
MMU	-	Multimedia University
MSLRT	-	Multiscale Sparse Representation of Local Radon Transform
NICE I	-	Noisy Iris Challenge Evaluation Part I

NICE II	-	Noisy Iris Challenge Evaluation Part II
NIST	-	National Institute of Standards and Technology
RAM	-	Random Access Memory
RANSAC	-	Random Sample Consensus
RGB	-	Red, Green and Blue
ROC	-	Receiver Operating Characteristic
SIFT	-	Scale Invariant Feature Transform
SLRT	-	Sparse Representation of Local Radon Transform
SRGB	-	Standard RGB
TIFF	-	Tagged Image File Format
TSR	-	Total Success Rate
UBIRIS.v1	-	University of Beira Interior version One
UBIRIS.v2	-	University of Beira Interior version Two
UPOL	-	University of Olomuc
WVU	-	West Virginia University

CHAPTER 1

INTRODUCTION

1.1 Background

Currently, almost every individual requires a security number or password to access an automated teller machine (ATM) or databases and identification card (ID) to pass through restricted areas such as the airport (Radman *et al.,* 2011) or security screening areas. However, many problems had occurred by using these conventional methods in identifying or authenticating a person as it can be easily forgotten, stolen or fraud by other individual (Radman *et al.*, 2011). In order to overcome these drawbacks, a reliable and strong recognition system is needed and therefore, a biometric recognition system has been introduced recently due to its higher security and speed, reliability, ease of use and difficulty of duplicating (Sonkamble *et al.*, 2010; Tan *et al.*, 2010; Sankowski *et al.*, 2010; Min and Park, 2009).

Biometric systems recognized persons using either their physiological, behavioral or both features (Mir *et al*., 2011; Sonkamble *et al*., 2010). The physiological features of biometrics are based on information derived from the direct measurement of a body part such as iris (Rankin *et al*., 2012), fingerprints (Akbari and Sadr, 2012), retina (Choras, 2010) and face (Wright *et al*., 2009), while the behavioral features of biometrics are based on the measurements and information extracted from human actions such as gait (Amin and Hatzinakos, 2012) and signature (Murab and Deshmukh, 2012).

Among those biometrics recognition systems, iris recognition system is believed as the most promising method in providing a higher accuracy in identifying a person where each individual has their very own unique iris pattern with higher degree of freedom (Jeong *et al.,* 2010). According to Park *et al*. (2007) and Daugman (2004), the chance of finding two persons that have the same identical irises is close to zero and most iris patterns remain stable over the life time. In addition, the left and right irises of an individual can be treated as separate unique identifier (Sonkamble *et al*., 2010).

There are four stages in iris recognition system: (i) image acquisition; (ii) iris preprocessing; (iii) iris feature extraction; and (iv) template matching. Firstly, in image acquisition stage, two types of illumination spectrum which is visible or near infrared may be used and to date, most of the commercial systems use the near infrared solution (Sankowski *et al.*, 2010). Next, the iris preprocessing stage consist of two steps namely segmentation and normalization. This preprocessing stage gives desirability and precise measurement of iris area in the image used for the iris feature extraction and matching stages. Then, in the feature extraction stage, the unique iris features (Radman *et al.,* 2011) are extracted followed by matching it with the other unique features of iris. Finally, the available databases of registered users which have been stored previously are evaluated (Sankowski *et al.*, 2010).

All the aforementioned stages of iris recognition system are possible source of errors resulting in inaccurate recognition of a person (Sankowski *et al.,* 2010). The current accurateness to identify a person is due to the implementation of methods for the eye images captured in cooperative environment setting and under near infrared wavelength illumination (Jeong *et al.,* 2010; Proenca *et al*., 2010). However, the performance of current methods is decreased when they are applied in the eye images captured in non-cooperative environment and under visible wavelength illumination. In the non-cooperative environment, the eye images are captured in the movement and at different distances while in the cooperative environment, the eye images are captured in the static position and at specific distances.

The National Institute of Standards and Technology (NIST) had promoted an Iris Challenge Evaluation (ICE) where focused on the eye images that captured under near infrared wavelength illumination and in the non-cooperative environment (Boddeti and Kumar, 2008; Miyazawa *et al*., 2008; Vasta *et al*., 2008). However, the excessive level of near infrared wavelength illumination for the non-cooperative environment could endanger the eye of a person as larger distances might require more near infrared wavelength illumination (Proenca *et al*., 2010). This is because, the normal usages of near infrared wavelength illumination is in the range of 700-900 nm (McConnon *et al*., 2010; Proenca *et al*., 2010).

Then, a Noisy Iris Challenge Evaluation Part I (NICE I) contest was formed exclusively to measure the effectiveness of iris segmentation of the eye images that were captured in non-cooperative environment and under visible wavelength illumination (Chen *et al*., 2010; Li *et al*., 2010; Sankowski *et al*., 2010; Tan *et al*., 2010). Still, the levels of realistic noises for the eye images have received criticisms. Due to those criticisms, a Noisy Iris Challenge Evaluation Part II (NICE II) contest was formed exclusively to evaluate the degraded visible wavelength iris images in the signatures encoding and matching stages (Tan *et al*., 2012; Santos and Hoyle, 2012). The performance of iris recognition for the database that captured in the non-cooperative environment and under visible wavelength illumination has showed significant results in this contest. The following two sections will discuss the challenges as well as current respective solutions, toward achieving accurate iris recognition. Research goal, objectives, scopes and significance ensue thereafter. The chapter ends with thesis organization.

1.2 Challenges of Iris Recognition

Although the current iris recognition technology could accurately identified a person, this system is recognized a person in cooperative acquisition environment and under near infrared wavelength illumination. In contrast, the performance of this system is decreased to identify a person in non-cooperative acquisition environment and under visible wavelength illumination. One of the reasons is due to the degraded data quality that caused incorrect localization of iris boundaries. Therefore, this issue befits as first challenge to iris recognition.

In order to localize the iris boundaries correctly in this acquisition environment, existing of reflections should be removed or reduced. Majorities of eye images captured in this acquisition environment contained reflections. The existing of reflections has caused disruption of iris boundaries detection although the method of iris segmentation is tolerant to ‘noise’ (Sankowski *et al.,* 2010; Li *et al.,* 2010; Labati and Scotti, 2010). Many existing reflection removal methods are able to remove or reduce the reflections. Unfortunately, those methods could not detect reflections that below the threshold values and falsely detected sclera area as reflections. These are due to the existing of reflections that is large and have different intensities. Hence, this issue has become second challenge to iris recognition.

The third challenge to iris recognition is extraction features of iris at different distances and contained reflections. The existing feature extraction methods are still unable to extract the iris textures in this condition due to their methods that could not reduce the level of noise and complexity of computation of iris feature extraction. As a result, this has caused decreasing of iris recognition performance in term of accuracy and decidability index.

1.3 Current Methods in Iris Recognition

In general, current methods for iris recognition can be categorized into three: image enhancement, feature detection and pattern recognition.

(i) Image enhancement method usually adjusts the digital eye image to make it more suitable for further analysis where noises such as reflections (Sankowski *et al*., 2010; Tan *et al*., 2010; He *et al*., 2009), off focus (Sazonova *et al*., 2011; Kang and Park, 2007), occlusion of eyelids and eyelashes (Mirza *et al*., 2009) are removed or reduced. Several approaches of image enhancement are used for example noise reduction approach (Park and Kang, 2004), filtering approach (Hosseini *et al*., 2010), interpolation approach (Aydi *et al*., 2011; Santos and Proenca, 2009), histogram equalization approach (Kumar *et al*., 2011) and thresholding approach (Dong *et al*., 2009; Du *et al*., 2009).

(ii) Feature detection method in iris recognition aims at evaluating extractions of eye image information and generating local selections at every eye image point whereby frequently in the form of isolated points, continuous curve or connected region. It can be divided into blobs approach (Jarujareet and Covavisaruch, 2010) and edges approach (Anitha *et al*., 2011). For blobs approach, it consists of laplacian of Gaussian (Chouhan and Shukla, 2010) and difference of Gaussian (Kang et al., 2010) while for edges approach, it consists of Canny (Patil and Patilkulkarani, 2009) and Sobel (Gupta *et al*., 2010) operators.

(iii) Pattern recognition method generally categorized the eye image according to the type of learning procedure used to generate the output value where it can be divided into classification approach (Shams *et al*., 2011; Patil and Subbaraman, 2011) and clustering approach (Azhar, 2011; Tsai *et al*., 2010). According to NICE II results competition, both approaches are able to enhance the performance of iris recognition (Bowyer, 2012).

1.4 Problem Statement

The solution for iris recognition in non-cooperative environment drawbacks is briefly explained as follows:

“Given a database of visible eye images that was captured at different distances and contained reflections, the challenge is to localize the iris boundaries accurately for this data condition. Moreover, existing of reflections that is large and have different intensities must also be removed or reduced to localize the iris boundaries correctly. Lastly, the method must be able to extract the iris features in this data condition to reduce the level of noise and complexity of computation in order to increase the accuracy, decidability index, cumulative match characteristic and area under curve."

Based on the above challenges, several causes will require to be answered by the possible solution. The first cause is incorrect localization of iris boundaries due to the degradation of data quality that was captured at different distances and contained reflections. It is discovered that many existing methods are able to localize the iris boundaries in good data quality which was captured at specific distance and contained less noise. However, due to those methods that are not tolerant to noise, those methods have led to improper localization of limbic and pupillary boundaries of iris. Thus, this study aims to provide a segmentation method that is tolerant to noise and able to localize the iris boundaries for this data.

The second cause is referring to the existing of reflections that is large and has different intensities in the eye images. Many existing reflection removal methods focused only on the small reflections that have intensities above the threshold values. However, intensities of reflections that are below than threshold value could not be detected and removed. In addition, sclera area tends to falsely identified as reflections due to the intensity pixel of sclera that has the same value with the threshold value. Therefore, this study aims to generate a method to detect the large reflections with different intensities. In addition, the proposed method is believed able to classify between reflections and non-reflections.

The third cause is related to the complexity of computation of iris feature extraction method due to the incapability of existing methods to extract the iris textures of eye images captured at different distances and contained reflections. Moreover, the existing methods are unable to reduce the level of noise during extraction of iris features which has caused decreasing of iris recognition accuracy. Thus, in this study, a method that could extract the iris features in this condition will be used where it could reduce the level of noise and complexity of computation of iris features.

1.5 Objective of the Study

In order to realize the goal of this study to solve the existing of reflections in order to get correct iris boundaries localization and to extract the iris features at different distance and contained reflections, several objectives need to be achieved:

(i) To identify iris segmentation methods to correctly localize the limbic and pupillary boundaries of iris for the eye images that captured at different distances and contained reflections.

(ii) To develop a fusion method of line intensity profile and support vector machine to identify and classify the reflections and non-reflections for the non-cooperative frontal visible eye images.

(iii) To expand a combined method of multiscale sparse representation of local radon transform in order to extract the iris texture for different distances of visible reflection eye images.

1.6 Scope of the Study

In this study, the eye images database of UBIRIS.v2 is used which was captured in the non-cooperative environment and under visible wavelength illumination. The eye images of this database were taken at distance of four to eight meters. There are several of 'noises' existed in the eye images for this database such as blurring, reflections and off-angles. But, the most common 'noise' in this database is reflections (McConnon *et al*., 2010). Thus, the eye images that contained large reflections with different intensities are randomly selected. About 1,000 eye images are used for the research purpose. A circular Hough transform is used to localize the limbic and pupil boundaries of iris during iris segmentation process. A fusing method of line intensity profile and support vector machine is applied to identify and classify reflections and non-reflections in the eye images. To evaluate the fusing method to remove reflections in the eye images, the 1,000 eye images are divided into left and right eyes where each sides has 500 eye images. A combined method of multiscale sparse representation of local radon transform is used to extract the iris features in this database. To evaluate the combined method to extract the iris features in the eye images, the 1,000 eye images are divided into different distances; from four to eight meters where each distance has 200 eye images. The iris recognition performance for the proposed methods are analyzed using equal error rate, decidability index, cumulative match characteristic, area under curve and accuracy. The scope of this study is simplified in Figure 1.1.

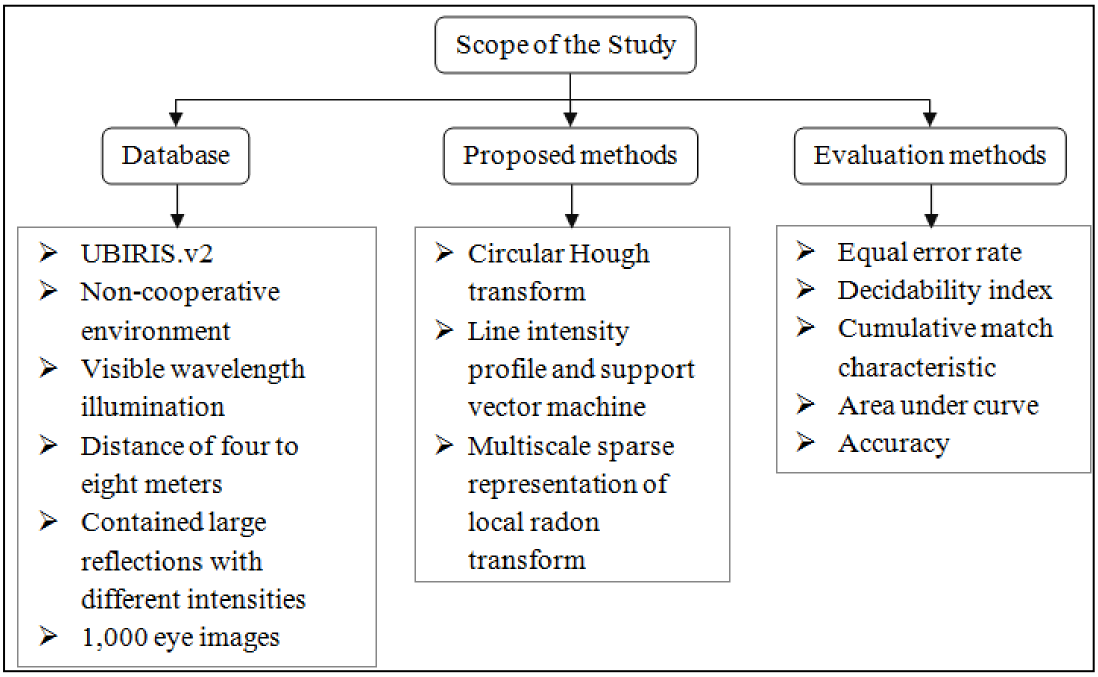

Figure 1.1 Scope of the study

1.7 Significance of the Study

The significance of this study can be divided into two main categories: (i) computational aspect; and (ii) security aspect. From computational aspect, the proposed method is intended to increase the performance of iris recognition for the database of eye images that was captured in non-cooperative environment and under visible wavelength illumination. It serves as an alternative for laboratory method to identify a person. From the security aspect, the former application of security system such as identification card, pin number and password is easily to be duplicate, forgot and stolen. Hence, the implementation of iris recognition is more reliable and secure. In border-crossing system, the iris recognition system is used to prevent illegal immigrants and former expellees from entering a country using fraudulent travel documents (Daugman and Malhas, 2004).

In addition, iris recognition provides crime reduction for school area where it identifies people who had been preauthorized to enter the schools (Cohn, 2006; Uchida *et al*., 2004). In the area of police, one of the usages of iris recognition is detecting a person who is under alcohol influence where due to alcohol consumption, pupil dilates or constricts which causes deformation in iris pattern (Arora *et al*., 2012). Smart cards are increasingly being used as a form of identification and authentication. Integration of iris recognition with the smart card has developed a high security access environment (Abdullah *et al*., 2011). The implementation of iris recognition for surveillance system has provided better acquiring of eye images with large capture volume (Bashir *et al*., 2008).

1.8 Organization of the Thesis

This thesis is organized into seven chapters. A general description on the content of each chapter in is given as follows:

(i) Chapter 1 defines the challenges, problems, current methods, objectives, scopes and significance of the study.

(ii) Chapter 2 reviews the main issues of interest, which iris recognition, non-cooperative iris images, iris segmentation techniques, iris reflection removal techniques and iris feature extraction techniques.

(iii) Chapter 3 presents the design of the computational method that supports the objectives of the study. This includes data sources, instrumentations and analyses.

(iv) Chapter 4 discusses the implementation of circular Hough transform in localizing the limbic and pupillary boundaries of iris for the eye images captured in the non-cooperative environment and under visible wavelength illumination.

(v) Chapter 5 describes the method of LIPSVM which fusing of line intensity profile and support vector machine to identify and classify the reflections and non-reflections in the non-cooperative visible eye images.

(vi) Chapter 6 explains the combined method of multiscale sparse representation of local radon transform to extract the iris features from the eye images captured at distance of four to eight meters and contained reflections.

(vii) Chapter 7 draws overall conclusions of the achieved results and presents the contributions of the study as well as recommends the potential enhancements for future study.

REFERENCES

Abdullah, M. A. M, Al-Dulaimi, F. H. A., Al-Nuaimy, W., and Al-Ataby, A. (2011). Smart Card with Iris Recognition for High Security Access Environment. *Proceedings of the Middle East Conference on Biomedical Engineering*. 21-24 February, Sharjah, United Arab Emirates: MECBME, 382-385.

Abiyev, R. H., and Kilic, K. I. (2011). Robust Feature Extraction and Iris Recognition for Biometric Personal Identification. In Zahid, R. (Eds.) Biometric Systems, Design and Applications. (pp.149-168). InTech.

Adam, M., Rossant, F., Amiel, F., Mikovicova, B., and Ea, T. (2008). Reliable Eyelid Localization For Iris Recognition. In Blanc-Talon, J., Bourennane, S., Philips, W., Popescu, D., Scheunders, P. (Eds.) Advanced Concepts for Intelligent Vision Systems. (pp.1062-1070). Juan-les-Pins, France: Springer Berlin Heidelberg.

Ahamed, A., and Bhuiyan, M. I. H. (2012). Low Complexity Iris Recognition Using Curvelet Transform. *Proceedings of the International Conference on Informatics, Electronics and Vision*. 18-19 May, Dhaka, Bangladesh: ICIEV, 548-553.

Akbari, N., and Sadr, A. (2012). Automation of Fingerprint Recognition Using OCT Fingerprint Images. *Journal of Signal and Information Processing*. 3(1): 117-121.

Almeida, P. D. (2010). A Knowledge-Based Approach to the Iris Segmentation Problem. *Image and Vision Computing*. 28(2): 238-245.

Amin, T., and Hatzinakos, D. (2012). Determinants in Human Gait Recognition. *Proceedings of the Canadian Conference Electrical and Computer Engineering*. 29 April- 2 May, Montreal, Canada: CCECE, 1-4.

Annapoorani, G., Krishnamoorthi, R., Giftyjeya, P., and Petchiammal@Sudha, S. (2012). Accurate and Fast Iris Segmentation. *International Journal of Engineering Science and Technology*. 2(6): 1492-1499.

Arora, S. S., Vasta, M., Singh, R., and Jain, A. K. (2012). Iris Recognition Under Alcohol Influence: A Preliminary Study. *Proceedings of the International Conference on Biometrics*. 29 March-1 April, New Delhi, India: ICB, 336-341.

Aydi, W., Masmoudi, N., and Kamoun, L. (2011). New Corneal Reflection Removal Method Used in Iris Recognition System. *World Academy Science, Engineering and Technology*. 53(1): 1068-1072.

Azhar, M. K. (2011). Iris Texture Recognition Using Co-Occurrence Matrix Features with K-Means Algorithm. *Journal of Al-Nahrain University*. 14(4):185-190.

Bashir, F. I., Casaverde, P., Usher, D., and Friedman, M. (2008). Eagle-Eyes: A System for Iris Recognition At A Distance. *Proceedings of the Conference on Technologies for Homeland Security*. 12-13 May, Waltham, Massachusetts: THS, 426-431.

Bastos, C. A. C. M., Ren, T. I., and Cavalcanti, G. D. C. (2010). Analysis of 2D Log-Gabor Filters to Encode Iris Patterns. *Proceedings of the International Conference on Tools with Artificial Intelligence*. 27-29 October, Arras, France: ICTAI, 377-378.

Bendale, A., Nigam, A., Prakash, S., and Gupta, P. (2012). Iris Segmentation Using Improved Hough Transform. In Huang, De-S., Gupta, P., Zhang, X., Premaratne, P. (Eds.) Emerging Intelligent Computing Technology and Applications. (pp. 408-415), Huangshan, China: Springer Berlin Heidelberg.

Birgale, L., and Kokare, M. (2010). Iris Recognition Without Iris Normalization. *Journal of Computer Science*. 6(9): 1042-1047.

Bodade, R., and Talbar, S. (2010). Dynamic Iris Localisation: A Novel Approach Suitable For Fake Iris Detection. *International Journal of Computer Information Systems and Industrial Management Applications*. 2(1): 163-173.

Boddeti, N., and Kumar, B. (2008). Extended Depth of Field Iris Recognition with Correlation Filters. *Proceedings of the Biometrics: Theory, Applications and Systems*. 29 September- 1 October, Arlington, Virginia: BTAS, 1-8.

Boukhari, A., Chitroub, S., and Bouraoui, I. (2011). Biometric Signature of Private Key by Reliable Iris Recognition Based on Flexible-ICA Algorithm. *International Journal of Communications, Network and System Sciences*. 4(12A): 778-789.

Bowyer, K. W. (2012). The Results of The NICE.II Iris Biometrics Competition. *Journal Pattern Recognition Letters*. 33(8): 965-969.

Broussard, R. P., Kennell, L. R., Ives, R. W., and Rakvic, R. N. (2008). An Artificial Neural Network Based Matching Metric for Iris Identification. *Proceedings of the Image Processing: Algorithms and Systems*. 3 March, 68120S-68120S-11.

Broussard, R. P., Rakvic, R. N., and Ives, R. W. (2008). Accelerating Iris Template Matching using Commodity Video Graphics Adapters. *Proceedings of the Biometrics: Theory, Applications and Systems*. 29 September - 1 October, Arlington, Nevada: BTAS, 1-6.

Chen, Y., Adjouadi, M., Han. C., Wang, J., Barreto, A., Rishe, N., and Adrian, J. (2010). A Highly Accurate and Computationally Efficient Approach for Unconstrained Iris Segmentation. *Image and Vision Computing*. 28(2): 261-269.

Cherabit, N., Chelali, F. Z., and Djeradi, A. (2012). Circular Hough Transform For Iris Localization. *Journal of Science and Technology*. 2(5): 114-121.

Choras, R. S. (2010). Hybrid Iris and Retina Recognition for Biometrics. *Proceedings of the Congress on Image and Signal Processing*. 16-18 October, Yantai, China: CISP, 2422-2426.

Chouhan, B., and Shukla, S. (2010). Analysis of Statistical Feature Extraction for Iris Recognition System Using Laplacian of Gaussian Filter. *International Journal of Applie Engineering Research*. 1(3): 528-535.

Cohn, J. P. (2006). Keeping an Eye on School Security: The Iris Recognition Project in New Jersey Schools. *National Institue of Justice*. 254.

Dalal, S., and Sahoo, T. (2012). A Selective Feature Matching Approach for Iris Recognition. *International Journal of Computer Applications*. 41(20): 34-39.

Daugman, J. (1994). U.S. Patent No. 5,291,560: Biometric Personal Identification System Based on Iris Analysis. Issue Date: 1 March 1994.

Daugman, J. (2001). Statistical Richness of Visual Phase Information. *International Journal of Computer Vision*. 45(1): 25-38.

Daugman, J. G (1993). High Confidence Visual Recognition of Persons by A Test of Statistical Independence. *IEEE Transactions of Pattern Analysis and Machine Intelligence*. 15(11): 1148-1161.

Daugman, J. G. (2003). The Importance of Being Random: Statistical Principles of Iris Recognition. Pattern Recognition. 36(2): 279-291.

Daugman, J. G. (2004). How Iris Recognition Works. *IEEE Transactions on Circuits and Systems for Video Technology*. 14(1): 21-30.

Daugman, J. G. (2007). New Methods In Iris Recognition. *IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics*. 37(5): 1167-1175.

Daugman, J. G., and Downing, C. (2001). Epigenetic Randomness, Complexity and Singularity of Human Iris Patterns. *Proceedings of the Royal Society*.

Daugman, J., and Malhas, I. (2004). Iris Recognition Border-Crossing System in the UAE. *International Airport Review*. 2.

Demirel, H., and Anbarjafari, G. (2008). Iris Recognition System using Combined Histogram. *Proceedings of the International Symposium Computer and Information Sciences.* 27-29 October, Istanbul, Turkey: ISCIS, 1-4.

Dong, W., Sun, Z., and Tan, T. N. (2009). A Design of Iris Recognition System At A Distance. *Proceedings of the Chinese Conference on Pattern Recognition*. 4-6 November, Nanjing, China: CCPR, 1-5.

Du, Y. Y., Arslanturk, E., Zhou, Z., and Craig, B. (2011). Video-Based Noncooperative Iris Image Segmentation. *IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics*. 41(1): 64-74.

Fu, B., Cai, Y-Y., and Yan, Y-H. (2010). Iris Detection and Extraction Based on Intgro-Differential Operator. *Proceedings of the International Conference on Apperceiving Computing and Intelligence Analysis*. 17-19 December, Chengdu, China: ICACIA, 266-270.

Gamassi, M., Lazzaroni, M., Misino, M., Piuri, V., Sana, D., and Scotti, F. (2004). Accuracy and Performance of Biometric Systems. *Proceedings of the Instrumentation and Measurement Technology Conference*. 18-20 May, Como, Italy: IMTC, 510-515.

Gawande, U., Zaveri, M., and Kapur, A. (2010). Improving Iris Recognition Accuracy by Score Based Fusion Method. *International Journal of Advancements in Technology*. 1(1): 1-12.

Ghanizadeh, A., Abarghouei, A. A., Sinaie, S., Saad, P., and Shamsuddin, S. M. (2011). Iris Segmentation using An Edge Detector Based on Fuzzy Sets theory and Cellular Learning Automata. *Applied Optics*. 50(19): 3191-3200.

Gupta, S., Doshi, V., Jain, A., and Iyer, S. (2010). Iris Recognition System Using Biometric Template Matching Technology. *International Journal of Computer Applications*. 1(2): 21-24.

He, Z., Tan, T. N., Sun, Z., and Qiu, X. (2009). Toward Accurate and Fast Iris Segmentation for Iris Biometrics. *Transactions on Pattern Analysis and Machine Intelligence*. 31(9): 1670-1684.

Hilal, A., Daya, B., and Beauseroy, P. (2012). Hough Transform and Active Contour for Enhanced Iris Segmentation. *International Journal of Computer Science Issues*. 9(6): 1-10.

Hollingsworth, K. P., Bowyer, K. W., and Flynn, P. J. (2011). Improved Iris Recognition Through Fusion of Hamming Distance and Fragile Bit Distance. *IEEE Transactions on Pattern Analysis and Machine Intelligence.* 33(12): 2465-2476.

Hollingsworth, K. P., Bowyer, K. W., and Flynn, P. J. (2009). Pupil Dilation Degrades Iris Biometric Performance. *Computer Vision and Image Understanding*. 113(1): 150-157.

Hosseini, M. S., Araabi, B. N., and Soltanian-Zadeh, H. (2010). Pigment Melanin: Pattern for Iris Recognition. *IEEE Transactions on Instrumentation and Measurement*. 59(4): 792-804.

Hsiung, T. W., and Mohamed, S. S. (2011). Performance of Iris Recognition Using Low Resolution Iris Image For Attendance Monitoring. *Proceedings of the International Conference on Computer Applications and Industrial Electronics*. 4-7 December, Penang, Malaysia: ICCAIE, 612-617.

Jang, Y. K., Kang, B. J., and Park, K. R. (2008). A Study on Eyelid Localization Considering Image Focus For Iris Recognition. *Pattern Recognition Letters*. 29(11): 1698-1704.

Jarjes, A. A., Wang, K., and Mohammed, J. (2010). Gvf Snake-Based Method for Accurate Pupil Contour Detection. *Informationl Technology Journal*. 9(8): 1653-1658.

Jarujareet, U., and Covavisaruch, N. (2010). An Improvement of Iris-Blob Map Approach for Iris Identification. *Proceedings of the International Conference on Electrical Engineering/Electronics Computer Telecommunications and Information Technology*. 19-21 May, Chiang Mai, China: ECTI- CON, 846-850.

Jeng, R-H., Chen, W-S., and Hsieh, L. (2012). Does Collarette of Iris Work For Recognizing Persons?. *Proceedings of the International Multi-Conference on Computing in the Global Information Technology*. 24- 29 June, Venice, Italy: ICCGI, 89-94.

Jeong, D. S., Hwang, J. W., Kang, B. J., Park, K. R., Won, C. S., Park, D-K., and Kim, J. (2010). A New Iris Segmentation Method for Non-Ideal Iris Images. *Image and Vision Computing*. 28(2): 254-260.

Jin, L., Xiao, F., and Haopeng, W. (2010). Iris Image Segmentation Based on K-Means Cluster. *Proceedings of the Intelligent Computing and Intelligent Systems*. 29-31 October, Xiamen, China: ICIS, 194-198.

Juneja, M., and Sandhu, P. S. (2009). Performance Evaluation of Edge Detection Techniques for Images in Spatial Domain. *International Journal of Computer Theory and Engineering*. 1(5): 1793-8201.

Kahlil, A. T., and Abou-Chadi, F. E. M. (2010). Generation of Iris Codes Using 1D Log-Gabor Filter. *Proceedings of the International Conference on Computer Engineering and Systems*. 30 November- 2 December, Cairo, Egypt: ICCES, 329-336.

Kang, B. J., and Park, K. R. (2007). Real-Time Image Restoration for Iris Recognition Systems. *IEEE Transactions on Systems, Man and Cybernetics, Part B: Cybernetics*. 37(6):1555-1566.

Kang, B. J., Park, K. R., Yoo, J-H., and Moon, K. (2010). Fuzzy Difference-of-Gaussian-Based Iris Recognition Method For Noisy Iris Images. *Optical Engineering*. 49(6): 067001-1-067001-10.

Kaur, B., and Garg, A. (2011). Comparative Study of Different Edge Detection Techniques. *International Journal of Engineering Science and Technology*. 3(3): 1927-1935.

Koh, J., Govindaraju, V., and Chaudhary, V. (2010). A Robust Iris Localization Method Using An Active Contour Model and Hough Transform. *Proceedings of the International Conference on Pattern Recognition*. Istanbul, Turkey: ICPR, 2852-2856.

Kong, W-K. K., and Zhang, D. (2001). Accurate Iris Segmentation Based on Novel Reflection and Eyelash Detection Model. *Proceedings of the International Symposium on Intelligent Multimedia, Video and Speech Processing*. 2-4 May, Hong Kong, China: ISIMP, 263-266.

Kulkarni, S. B., Hegadi, R. S., and Kulkarni, U. P. (2011). Improvement to Libor Masek Algorithm of Template Matching Method for Iris Recognition. *Proceedings of the International Conference and Workshop on Emerging Trends in Technology*. 25-26 February, Mumbai, India: ICWET, 1270-1274.

Kumar, A., and Chan, T-S. T. (2013). Robust Ear Identification Using Sparse Representation of Local Texture Descriptors. *Pattern Recognition*. 46(1): 73−85.

Kumar, A., Tak-Shing, C., and Chun-Wei, T. (2012). Human Identification from At-A-Distance Face Images Using Sparse Representation of Local Iris Features. *Proceedings of the International Conference on Biometrics*. 29 March- 1 April, New Delhi, India: ICB, 303-309.

Labati, R. D., and Scotti, F. (2010). Noisy Iris Segmentation with Boundary Regularization and Reflections Removal. *Image and Vision Computing*. 28(2): 270-277.

Li, H., Sun, Z., and Tan, T. (2012). Accurate Iris Localization Using Contour Segments. *Proceedings of the International Conference on Pattern Recognition*. 11-15 November, Tsukuba, Japan: ICPR, 3398-3401.

Li, P., Liu, X., Xiao, L., and Song, Q., (2010). Robust and Accurate Iris Segmentation in Very Noisy Iris Images. *Image and Vision Computing*. 28(2): 246-253.

Li, P., Liu, X., and Zhao, N. (2012). Weighted Co-Occurrence Phase Histogram For Iris Recognition. *Pattern Recognition Letters*. 33(8): 1000-1005.

Li, P., and Ma, H. (2012). Iris Recognition In Non-Ideal Imaging Conditions. *Pattern Recognition Letters*. 33(8): 1012-1018.

Li, W., Xie, M., and Yu, P. (2011). A Fast and Robust Method for Iris Localization using Light Spot. *Journal of Computational Information Systems*. 7(13): 4619-4627.

Lin, Z., and Lu, B. (2010). Iris Recognition Method Based on The Optimized Gabor Filters. *Proceedings of the International Congress on Image and Signal Processing*. 16-18 October, Yantai, China: CISP, 1868-1872.

Liu, X., Li, P., and Song, Q. (2009). Eyelid Localization in Iris Images Captured in Less Constrained Environment. In Tistarelli, M., Nixon, M. S. (Eds.) International Conference Advances in Biometrics. Lecture Notes in Computer Science. 5558. (pp. 1140-1149). Alghero, Italy: Springer Berlin Heidelberg.

Lu, P., Xiang, H., Dai, Y., and Zhang, W. (2010). Iris Detection and Marking Based on Haar Features. *Proceedings of the International Conference on Audio Language and Image Processing*. 23-25 November, Shanghai, China: ICALIP, 518-522.

Mahadeo, N. K., and Bhattacharjee, N. (2009). An Efficient and Accurate Iris Segmentation Technique. *Proceedings of the Digital Image Computing: Techniques and Applications*. 1-3 December, Melbourne, Australia: DICTA, 347-352.

Mahadeo, N. K., and Bhattacharjee, N. (2009). An Efficient and Accurate Iris Segmentation Technique. *Proceedings of the Digital Image Computing: Techniques and Applications*. 1-3 December, Melbourne, Australia: DICTA, 347-352.

Mahlouji, M., and Noruzi, A. (2012). Human Iris Segmentation for Iris Recognition in Unconstrained Environments. *International Journal of Computer Science Issues*. 9(1): 149-155.

Masek, L. (2003).Recognition of Human Iris Patterns For Biometric Identification. http://www.csse.uwa.edu.au/~pk/studentprojects/libor.

Matey, J. R., and Kennell, L. R. (2009). Iris Recognition-Beyond One Meter. In Tistarelli, M., Li, S. Z., Chellappa, R. (Eds.) Handbook of Remote Biometrics. (pp. 23-59). Springer London.

McConnon, G., Deravi, F., Hoque, S., Sirlantzis, K., and Howells, G. (2010). A Survey of Point-Source Specular Reflections in Noisy Iris Images. *Proceedings of the International Conference on Emerging Security Technologies*. 6-7 September, Canterbury, New Zealand: EST, 13-17.

McConnon, G., Deravi, F., Hoque, S., Sirlantzis, K., and Howells, W. G. J. (2011). An Investigation of Quality Aspects of Noisy Colour Images for Iris Recognition. *International Journal of Signal Processing, Image Processing and Pattern Recognition*, 4 (3):165-178.

Mehrabian, H., and Hashemi-Tari, P. (2007). Pupil Boundary Detection For Iris Recognition Using Graph Cuts. *Proceedings of the Image and Vision Computing*. December, Hamilton, New Zealand: IVC, 77-82.

Mehrotra, H., Badrinath, G. S., Majhi, B., and Gupta, P. (2009). An Efficient Iris Recognition Using Local Feature Descriptor. *Proceedings of the*

International Confference on Image Processing. 7-10 November, Cairo, Egypt: ICIP, 1957-1960.

Mehrotra, H., Majhi, B., and Sa, P. K. (2011). Unconstrained Iris Recognition Using F-SHIFT. *Proceedings of the International Conference on Information, Communications and Signal Processing*. 13-16 December, Nanyang Avenue, Singapore: ICICS, 1-5.

Min, T-H., and Park, R-H. (2008). Comparison of Eyelid and Eyelash Detection Algorithms For Performance Improvement of Iris Recognition. *Proceedings of the International Conference on Image Processing*. 12-15 October, San Diego, California: ICIP, 257-260.

Min, T-H., and Park, R-H. (2009). Eyelid and Eyelash Detection Method in the Normalized Iris Image using the Parabolic Hough Model and Otsu's Thresholding Method. *Pattern Recognition Letters*. 30(12): 1138-1143.

Mir, A. H., Rubab, S., and Jhat, Z. A. (2011). Biometrics Verification: A Literature Survey. *Journal of Computing and ICT Research*. 5(2): 67-80.

Mire, A. V., and Dhote, B. L. (2010). Iris Recognition System with Accurate Eyelash Segmentation and Improved FAR, FRR using Textural and Topological Features. *International Journal of Computer Application*. 7(9): 1-5.

Mirza, D. T., Imtiaz, A., and Khalid, A. (2009). A Robust Eyelid and Eyelash Removal Method and A Local Binarization Based Feature Extraction Technique for Iris Recognition System. *Proceedings of the International Multitopic Conference*. 14-15 December, Islamabad, Pakistan: INMIC, 1-6.

Miyazawa, K., Ito, K., Aoki, T., Kobayashi, K., and Nakajima, H. (2008). An Effective Approach for Iris Recognition Using Phase-Based Image Matching. *IEEE Transactions on Pattern Analysis and Machine Intelligence*. 30(10): 1741-1756.

Moosavi, S. M. S., Seyedzade, S. M., and Ayatollahi, A. (2010). A Novel Iris Recognition System Based on Active Contour. *Proceedings of The Iranian Conference on Biomedical Engineering*. 3-4 November, Isfahan, Iran: ICBME, 1-4.

Mostafa, E., Mansour, M., and Saad, H. (2012). Noncooperative Iris Segmentation. *International Journal of Computer Science Issues*. 9(1): 396-401.

Murab, S. A., and Deshmukh, V. (2012). An Empirical Study of Signature Recognition and Verification System using Various Approaches.

International Journal of Engineering and Advanced Technology. 2(2): 260-263.

Muthukrishnan, R., and Radha, M. (2011). Edge Detection Techniques for Image Segmentation. *International Journal of Computer Science and Information technology*. 3(6): 259-267.

Nabti, M., and Bouridane, A. (2007). An Effective Iris Recognition Syste, Based on Wavelet Maxima and Gabor Filter Bank. *Proceedings of the International Symposium on Signal Processing and Its Applications*. 12-15 February, Sharjah, United Arab Emirates: ISSPA, 1-4.

Nabti, M., Ghouti, L., and Bouridane, A. (2008). An Effective and Fast Iris Recognition System Based On A Combined Multiscale Feature Extraction Technique. *Pattern Recognition*. 41(3): 868−879.

Nappi, M., Marsico, M. D., and Riccio, D. (2012). Noisy Iris Recognition Integrated Scheme. *Pattern Recognition Letters*. 33(8): 1006-1011.

Narendra, V. G., and Hareesh, K. S. (2011). Study and Comparison of Various Image Edge Detection Techniques used in Quality Inspection and Evaluation of Agricultural and Food Products by Computer Vision. *International Journal of Agricultural and Biological Engineering*. 4(2): 83-90.

Ng, R. Y. F., Tay, Y. Y. H., and Mok, K. M. (2008). A Review of Iris Recognition Algorithms. *Proceedings of the International Symposium on Information Technology*. 26-28 August, Kuala Lumpur, Malaysia: ITSIM, 1-7.

Ng, T. W., Tay, T. L., and Khor, S. W. (2010). Iris Recognition Using Rapid Haar Wavelet Decomposition. *Proceedings of the International Conference on Signal Processing Systems*. 5-7 July, Dalian, China: ICSPS, V1-820-V1-823.

Panganiban, A., Linsangan, N., and Caluyo, F. (2011). Wavelet-Based Feature Extraction Algorithm for an Iris Recognition System. *Journal of Information Processing Systems*. 7(3): 425-434.

Park, H-A., and Park, K. R. (2007). Iris Recognition Based on Score Level Fusion by using SVM. *Pattern Recognition Letters*. 28(15): 2019-2028.

Patil, B. G., and Subbaraman, S. (2011). SVD-EBP Algorithm for Iris Pattern Recognition. *International Journal of Advanced Computer Science and Applications*. 2(12): 115-119.

Patil, C. M., and Patilkulkarani, S. (2009). Iris Feature Extraction for Personal Identification Using Lifting Wavelet Trasnform. *Proceedings of the* *international Conference on Advances in Computing, Control and Telecommunication Technologies*. 28-29 December, Trivandrum, Kerala: ACT, 764-766.

Patil, P. S. (2012). Iris Recognition Based in Gaussian-Hermite Moments. *International Journal on Computer Science and Engineering*. 4(11): 1794-1083.

Pawar, M. K., Mirajkar, G. S., and Patil, S. S. (2012). Comparative Analysis of Iris Segmentation Methods Along With Quality Enhancement. *Proceedings of the International Conference on Computing Communication and Networking Technologies*. 26-28 July, Ciombatore, India: ICCCNT, 1-8.

Proenca, H. (2011). Non-Cooperative Iris Recognition: Issues and Trends. *Proceedings of the European Signal Processing Conference*. 29 August-2 September, Barcelona, Spain: EUSIPCO, 1-5.

Proenca, H., and Alexandre, L. A. (2005). UBIRIS: A Noisy Iris Image Database. *Technical Report*. University of Beira Interior, Department of Computer Science.

Proenca, H., Filipe, S., Santos, R., Oliveira, J., and Alexandre, L. A. (2010). The Ubirisv2: A Database of Visible Wavelength Iris Images Captured On-The-Move and At-A-Distance. *IEEE Transaction on Pattern Analysis and Machine Intelligence*. 32(8): 1529-1535.

Radman, A., Jumari, K., and Zainal, N. (2011). Iris Segmentation: A Review and Research Issues. In Zain, M., Wan Mohd, W. M., El-Qawasmeh, E. (Eds.) Software Engineering and Computer Systems. (pp. 698-708). Kuantan, Pahang: Springer Berlin Heidelberg.

Radu, P., Sirlantzis, K., Howells, W. G. J., Deravi, F., and Hoque, S. (2011). Information Fusion For Unconstrained Iris Recognition. *International Journal of Hybrid Information Technology*. 4(4): 1-12.

Radu, P., Sirlantzis, K., Howells, W. G. J., Hoque, S., and Deravi, F. (2012). Image Enhancement vs Feature Fusion in Colour Iris Recognition. *Proceedings of the Emerging Security Technologies*. 5-7 September, Lisbon, Protugal: EST, 53-57.

Rankin, D. M., Scotney, B. W., Morrow, P. J., McDowell, D. R., and Pierscionek, B. K. (2010). Dynamic Iris Biometry: A Technique for Enhanced Identification. *BMC Research Notes*. 3(182): 1-7.

Rankin, D. M., Scotney, B. W., Morrow, P. J., and Pierscionek, B. K. (2012). Iris Recognition Failure over Time: The Effects of Texture. *Pattern Recognition*. 45(1): 145-150.

Rathgeb, C., and Adreas, U. (2010). Bit Reliability- Driven Template Matching In Iris Recognition. *Proceedings of the Pacific-Rim Symposium in Image and Video Technology*. 14-17 November, Nanyang Avenue, Singapore: PSIVT, 70-75.

Richard, Y., Ng, F., Tay, Y. H., and Mok, K. M. (2008). An Effective Segmentation Method For Iris Recognition System. *Proceedings of the International Conference on Visual Information Engineering*. 29 July- 1 August, Xian, China: VIE, 548-553.

Ross, A., and Sunder, M. S. (2010). Block Based Texture Analysis For Iris Classification and Matching. *Proceedings of the Conference Computer Society Workshop on Biometrics at the Computer Vision and Pattern Recognition*. 13-18 June, San Francisco, Carlifornia: CVPRW, 30-37.

Roy, K., and Bhacattacharya, P. (2007). Iris Recognition Based on Zigzag Collarette Region and Asymmetrical Support Vector Machines. In Kamel, M., Campilho, A. (Eds.) Image Analysis and Recognition. (pp. 854-865). Motreal, Canada: Springer Berlin Heidelberg.

Roy, K., and Bhattacharya, P. (2005). Iris Recognition With Support Vector Machines. In Zhang, D., Jain, A. K. (Eds.) Advances in Biometrics. (pp. 486-492). Hong Kong, China: Springer Berlin Heidelberg.

Roy, K., Bhattacharya, P., and Suen, C. Y. (2010). Unideal Iris Segmentation Using Region-Based Active Contour Model. In Campilho, A., Kamel, M. (Eds.) Image Analysis and Recognition. (pp. 256-265). Provoa de Varzim, Portugal: Springer Berlin Heidelberg.

Roy, K., Bhattacharya, P., and Suen, C. Y. (2011). Towards Nonideal Iris Recognition Based on Level Set Method, Genetic Algorithms and Asymmetrical SVMs. *Journal Engineering Applications of Artificial Intelligence*. 24(3): 458-475.

Ryan, W. J., Woodard, D. L., Duchowski, A. T., and Birshfield, S. T. (2008). Adapting Starburst For Elliptical Iris Segmentation. *Proceedings of the International Conference on Biometrics: Theory, Applications and Systems*. 29 September- 1 October, Arlington, Virginia: BTAS, 1-7.

Sabarigiri, B., and Karthikeyan, T. (2012). Acquisition of Iris Images, Iris Localization, Normalization, and Quality Enhancement for Personal Identification. *International Journal of Emerging Trends and Technology in Computer Science*. 1(2): 271-275.

Sankowski, W., Grabowski, K., Napieralska, M., Zubert, M., and Napieralski, A. (2010). Reliable Algorithm for Iris Segmentation in Eye Image. *Image and Vision Computing*. 28(2): 231-237.

Santos, G., and Hoyle, E. (2012). A Fusion Approach to Unconstrained Iris Recognition. *Pattern Recognition Letters*. 33(8): 984-990.

Santos, G., and Proenca, H. (2009). On The Role of Interpolation in The Normalization of Non-Ideal Visible Wavelength Iris Images. *Proceedings of the International Conference on Computational Intelligence and Security*. 11-14 December, Beijing, China: CIS, 315-319.

Sayeed, F., Hanmandlu, M., Ansari, A. Q., and Vasikarla, S. (2011). Iris Recognition using Segmental Euclidean Distances. *Proceedings of the Information Technology: New Generations*. 11-13 April, Las Vegas, Nevada, ITNG, 520-525.

Sazonova, N., and Schuckers, S. (2010). Fast and Efficient Iris Image Enhancement Using Logarithmic Image Processing. *Proceedings of the Biometric Technology for Human Identification VII*. 5 April, Orlando, Florida: SPIE, 76670K-76670K-9.

Sazonova, N., Schuchkers, S., Johnson, P., Lopez-Meyer, P., Sazonov, E., and Hornak, L. (2011). Impact of Out-Of-Focus Blur On Iris Recognition. *Proceedings of the Sensing Technologies for Global Health, Military Medicine, Disaster Response and Environmental Monitoring; and Biometric Technology for Human Identification*. 25 April, Orlando, Florida: SPIE,1-7.

Scotti, F. (2007). Computational Intelligence Techniques for Reflections Identification in Iris Biometric Images. *Proceedings of the International Conference on Computational Intelligence for Measurement Systems and Applications*. 27-29 June, Ostuni, Italy:CIMSA, 84-88.

Scotti, F., and Piuri, V. N. (2010). Adaptive Reflection Detection and Location in Iris Biometric Images by Using Computational Intelligence Techniques. *IEEE Transactions on Instrumentation and Measurement*. 59(7): 1825-1833.

Seif, A., Zewail, R., Saeb, M., and Hamdy, N. (2003). Iris Identification Based on Log Gabor Filtering. *Proceedings of the Midwest Symposium on Circuits and Systems*. 27-30 December, Cairo, Egypt: MWSCAS, 333-336.

Seong-Taek, L., Tae-Ho, Y., Kyeong-Soep, K. S., Kee-Deog, K. D., and Wonse, P. (2010). Removal of Specular Reflections In Tooth Color Image By Perceptron Neural Nets. *Proceedings of the International Conference on Signal Processing Systems*. 5-7 July, Dalian, China: ICSPS, V1-285-V1-289.

Shah, S., and Ross, A. (2009). Iris Segmentation Using Geodesic Active Contours. *IEEE Transactions on Information Forensics and Security*. 4(4): 824-836.

Shams, M. Y., Rashad, M. Z. Nomir, O., and El-Awady, R. M. (2011). Iris Recognition Based on LBP and Combined LVQ Classifier. *International Journal of Computer Science and Information Technology*. 3(50): 67-78.

Shamsi, M., and Kenari, A. R. (2012). Iris Boundary Detection Using An Ellipse Integro Differential Method. *Proceedings of the International Conference on Computer and Knowledge Engineering*. 18-19 October, Masshad, Iran: ICCKE, 1-5.

Shamsi, M., Saad, P. B., Ibrahim, S. B., and Kenari, A. R. (2009). Fast Algorithm For Iris Localization Using Daugman Circular Integro Differential Operator. *Proceedings of the International Conference of Soft Computing and Pattern Recognition*. 4-7 December, Malacca, Malaysia: SOCPAR, 393-398.

Shamsi, M., Saad, P. B., Ibrahim, S. B., Rasouli, A., and Nazeema, A. (2010). A New Accurate Technique for Iris Boundary Detection. *Journal Transactions on Computer*. 9(6): 654-663.

Sharma, D., and Kumar, A. (2011). Iris Recognition- An Effective Human Identification. *International Journal of Computing and Business Research*. 2(2):1-12.

Sharma, D., and Kumar, A. (2011). Iris Recognition-An Effective Human Identification. *International Journal of Computing and Business Research*. 2(2): 1-12.

Shin, K. Y., Nam, G. P., Jeong, D. S., Cho, D. H., Kang, B. J., Park, K. R., and Kim, J. (2012). New Iris Recognition Method For Noisy Iris Images. *Pattern Recognition Letters*. 33(8): 991-999.

Shylaja, S. S., Balasubramanya, K. N., Nischith, S. N., Muthuraj, R., and Ajay, S. (2011). Feed Forward Neural Network Based Eye Localization and

Recognition using Hough Transform. *International Journal of Advanced Computer Science and Applications*. 2(3): 104-109.

Sigut, J. F., and Sidha, S-A. (2011). Iris Center Corneal Reflection Method for Gaze Tracking Using Visible Light. *IEEE Transactions on Biomedical Engineering*. 58(2): 411-419.

Sonkamble, S., Thool, R., and Sonkamble, B. (2010). Survey of Biometric Recognition Systems and Their Applications. *Journal of Theoretical and Applied Information Technology*. 11(1): 45-51.

Szewczyk, R., Grabowski, K., Napieralska, M., Sankowski, W., Zubert, and M., Napieralski, A. (2012). Reliable Iris Recognition Algorithm Based on Reverse Biorthogonal Wavelet Transform. *Pattern Recognition Letters*. 33(8): 1019-1026.

Tajbakhsh, N., Misaghian, K., and Bandari, N. M. (2009). A Region-Based Iris Feature Extraction Method Based On 2D-Wavelet Trasnform. In Fierrez, J., Ortega-Garcia, J., Esposito, A., Drygajlo, A., Faundez-Zanuy, M. (Eds.) Biometric ID Management and Multimodal Communication. (pp. 301-307). Madrid, Spain: Springer Berlin Heidelberg.

Tan, C-W., and Kumar, A. (2012). A Unified Framework for Automated Iris Segmentation Using Distantly Acquired Face Images. *IEEE Transactions on Image Processing*. 21(9): 4068-4079.

Tan, T., He, Z., and Sun, Z. (2010). Efficient and Robust Iris Segmentation for Noisy Iris Images for Non-Cooperative Iris recognition. *Image and Vision Computing*. 28(2): 223-230.

Tan, T., Zhang, X., Sun, Z., and Zhang, H. (2012). Noisy Iris Image Matching by Using Multiple Cues. *Pattern Recognition Letters*. 33(8): 970-977.

Tsai, C. C., Taur, J. S., and Tao, C. W. (2009). Iris Recognition Using Gabor Filters Optimized by the Particle Swarm Technique. *Journal of Electronic Imaging*. 18(2): 921-926.

Tsai, C.-C. C., Lin, H.-Y. Y., Jin-Shiuh, S., and Tao, C.-W. W. (2010). A New Matching Approach for Local Feature Based Iris Recognition Systems. *Proceedings of the International Conference on Industrial Electronics and Applications*. 15-17 June, Taichung, Taiwan: ICIEA, 387-392.

Uchida , C. D., Maguire, E. R., Solomon, S. E., and Gantley, M. (2004). Safe Kids, Safe Schools: Evaluating the Use of Iris Recognition Technology in New

Egypt, New Jersey. *Final Report Submitted to the National Institute of Justice, Washington, DC*.

Vasta, M., Singh, R., and Noore, A. (2008). Improving Iris Recognition Performance Using Segmentation, Quality Enhancement, Match Score Fusion, and Indexing. *IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics*. 38(4): 1021-1035.

Verma, P., Dubey, M., Verma, P., and Basu, S. (2012). Daugman's Algorithm Method for Iris Recognition- A Biometric Approach. *International Journal of Emerging Technology and Advanced Engineering*. 2(6): 177-185.

Wang, F., Han, J., and Yao, X. (2007). Iris Recognition Based on Multialgorithmic Fusion. *Journal Transactions on Information Science and Applications*. 4(12): 1415-1421.

Wang, Q., Zhang, X., Li, M., Dong, X., Zhou, Q., and Yin, Y. (2012). Adaboost and Multi-Orientation 2D Gabor-Based Noisy Iris Recognition. *Pattern Recognition Letters*. 33(8): 978-983.

Wei, Z., Tan, T., and Sun, Z. (2007). Nonlinear Iris Deformation Correction Based on Gaussian Model. In Lee, S-W., Li, S. Z. (Eds.) Advances in Biometrics. (pp. 780-789). Seoul, Korea: Springer Berlin Heidelberg.

Wildes, R. P. (1993). Iris Recognition: An Emerging Biometric Technology. *Journal of Institute of Electrical and Electronics Engineers*. 85(9): 1348-1363.

Wright, J., Ma, Y., Mairal, J., Spairo, G., Huang, T., and Yan, S. (2010). Sparse Representation For Computer Vision and Pattern Recognition. *Proceedings of the Institute of Electrical and Electronics Engineers*. Piscataway, New Jersey: IEEE, 1031-1044.

Wright, J., Yang, A. Y., Ganesh, A., Sastry, S. S., and Ma, Y. (2009). Robust Face Recognition via Sparse Representation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*. 14(1): 210-227.

Wright, J., Yang, A. Y., Ganesh, A., Sastry, S. S., and Ma, Y. (2009). Robust Face Recognition via Sparse Representation. *Transactions on Pattern Analysis and Machine Intelligence*. 31(2): 210−227.

Wyatt, H. J. (2000). A 'Minimum-Wear-and-Tear' Meshwork For The Iris. *Vision Resolution*. 40(16): 2167-2176.

Xiangde, Z., Qi, W., Hegui, Z., Cuili, Y., Longcheng, G., and Xianyan, L. (2009). Noise Detection of Iris Image Based on Texture Analysis. *Proceedings of the*

Chinese Control and Decision Conference. 17-19 June, Guilin, China: CCDC, 2366-2370.

Yahya, A. E., and Nordin, M. J. (2008). A New Technique For Iris Localization In Iris Recognition Systems. *Information Technology Journal*. 7(6): 924-929.

Yahya, A. E., and Nordin, M. J. (2010). Improving Iris Segmentation By Specular Reflections Removable. *Proceedings of the International Symposium in Information Technology*. 15-17 June, Kuala Lumpur, Malaysia: ITSIM, 1-3.

Yu, L., Zhang, D., and Wang, K. (2007). The Relative Distance of Key Point Based Iris Recognition. *Pattern Recognition*. 40(2): 423-430.

Yu, L., and Zhou, X. (2012). A Novel Method for Iris Recognition Based in Zero-Crossing Detection. In Zhang, T. (Eds.) Instrumentation, Measurement, Circuits and Systems. (pp.509-517). Hong Kong, China: Springer Berlin Heidelberg.

Yuan, X., and Shi, P. (2005). A Non-Linear Normalization Model For Iris Recognition. In Li, S. Z., Sun, Z., Tan, T., Pankanti, S., Chollet, G., Zhang, D. (Eds.) Advances in Biometric Person Authentication. (pp. 135-141). Beijing, China: Springer Berlin Heidelberg.

Zhang, D. (2003). Detecting Eyelash and Reflection For Accurate Iris Segmentation. *International Journal of Pattern Recognition and Artificial Intelligence*. 1(6): 1025-1034.

Zheng, H., and Su, F. (2009). An Improved Iris Recognition System Based on Gabor Filters. *Proceedings of the International Conference on Network Infrastructure and Digital Content*. 6-8 November, Beijing, China: ICNIDC, 823-827.

Zhou, Y., and Ajay, K. (2010). Personal Identification from Iris Images Using Localized Radon Transform. *Proceedings of the International Conference on Pattern Recognition*. 23-26 August, Istanbul, Turkey: ICPR, 2840-2843.

Zhou, Y., and Kumar, A. (2010). Personal Identification From Iris Images Using Localized Radon Transform. *Proceedings of the International Conference on Pattern Recognition*. 23-26 August, Istanbul, Turkey: ICPR, 2840−2843.

Zhou, Z., Yao, P., Zhuang, Z., and Li, J. (2011). A Robust Algorithm For Iris Localization Based on Radial Symmetry and Circular Integro Differential Operator. *Proceedings of the Conference on Industrial Electronics and Applications*. 21-23 June, Beijing, China: ICIEA, 1742-1745.

Zhu, Y., Tan, T. N., and Wang, Y-H. (2000). Biometric Personal Identification Based on Iris Patterns. *Proceedings of the International Conference on Pattern Recognition*. 3-7 September, Barcelona, Spain: ICPR, 801-804.

Zuo, J., and Schmid, N. A. (2010). On A Methodology For Robust Segmentation of Nonideal Iris Images. *IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics*. 40(3): 703-718.