LOCALIZING NON-IDEAL IRISES VIA CHAN-VESE MODEL AND VARIATIONAL LEVEL SET OF ACTIVE CONTOURS WITHTOUT RE-INITIALIZATION

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A dissertation submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Science (Computer Science)

Faculty of Computing
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JULY 2013

This dissertation is dedicated to my family for their endless support and encouragement.

ACKNOWLEDGEMENT

First and foremost, I would like to express heartfelt gratitude to my supervisor **Prof. Dr. Ghazali Bin Sulong** for his constant support during my study at UTM. He inspired me greatly to work in this project. His willingness to motivate me contributed tremendously to our project. I have learned a lot from him and I am fortunate to have him as my mentor and supervisor

Besides, I would like to thank the authority of Universiti Teknologi Malaysia (UTM) for providing me with a good environment and facilities such as computer laboratory to complete this project with software which I need during process.

To my dearest wife Zuzan, my son Event and my siblings whose inspirational words and prayers gave me the strength to carry on. God have answered all your prayers, thank you all.

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ABSTRACT

Biometrics is the science of recognizing the identity of a person based on the physical or behavioral characteristics of the individual such as signature, face, fingerprint, voice and iris. With a growing emphasis on human identification, iris recognition has recently received increasing attention. Performance of iris recognition scheme depends on the isolation of the iris region from rest of the eye image. In this research, Iris as one of the components of an eye image is chosen due to its uniqueness and stability. Iris recognition scheme involves Acquisition, Localization, Normalization, Feature extraction and Matching. Iris localization is the most significant and crucial stage in iris recognition system, because it determines the inner boundary and outer boundary in an eye image. In conventional localization methods, the inner and outer boundaries are modeled as two circles, but in actual fact, both boundaries are near-circular contour rather than perfect circles. For this research, the non-ideal iris images which are acquired in unconstrained environments are used (i.e. image with bright spots, non uniform intensity, eyelids and eyelashes occlusion). Firstly, Gaussian filter is applied as pre-processing to reduce the iris image noises and then Chan-Vese model to detect the inner boundary and localize pupil region. Next, Gaussian filter is applied again to reduce the effect of eyelids and eyelashes for faster and easier detection of the outer boundary. Finally, Variational Level Set Formulation of Active Contours without Re-initialization is applied to localize the outer boundary. Experimental results of CASIA-Iris-Interval Version 3 database show that the performance of the proposed method is very encouraging with 98.39% accuracy rate.

ABSTRAK

Biometrik adalah sains untuk mengenalpasti identiti seseorang berasaskan ciri-ciri fizikal dan kelakuan individu seperti tandatangan, wajah, cap jari, suara dan iris. Kini, dengan bertambahnya penekanan terhadap pengenalan manusia, pengecaman iris mendapat banyak perhatian. Prestasi sistem pengecaman iris bergantung kepada pengasingan kawasan iris daripada imej mata. Dalam kajian ini, di mana iris merupakan salah satu komponen imej mata dipilih berdasarkan keunikan dan kestabilan yang ada padanya. Sistem pengecaman iris melibatkan pemilikan, petempatan, normalisasi, pengekstrakan ciri dan pemadanan. Petempatan iris adalah paling penting dalam sistem pengenalan iris ini kerana ia menentukan sempadan dalaman dan luaran imej mata. Dalam kaedah petempatan konvensional, kontur sempadan dalaman dan luaran di model kan sebagai dua bulatan, dimana kontur kedua-dua sempadan ini adalah tidak sempurnanya bulat. Dalam kajian ini, imej iris yang tidak ideal yang diambil dalam persekitaran yang terhad digunakan (iaitu imej yang mengandungi bintik cerah, itensiti tidak sekata, dan terlindung oleh kelopak dan bulu mata). Pertama, penapis "*Gaussian*" digunakan sebagai pra-pemprosesan untuk mengurangkan kekaburan imej iris dan selepas itu model "*Chan-Vese*" digunakan untuk mengesan sempadan dalaman dan kedudukan anak mata. Seterusnya, penapis "*Gaussian*" digunakan sekali lagi untuk mengurangkan kesan kelopak dan bulu mata serta mempercepatkan proses pengesanan sempadan Iuaran. Akhirnya kaedah "*Variational Level Set of Active Contours without Re-initialization*" digunakan untuk mengenalpasti perletakan sempadan Iuaran. Keputusan eksperimen menggunakan pangkalan data versi 3 "*CASIA-Iris-Interval*" menunjukkan prestasi kaedah ini adalah memberangsangkan dengan kadar ketepatan 98.39%.

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CHAPTER 1

INTRODUCTION

1.1 Overview

In the past centuries, body characteristics have used by humans such as face, voice, and so on to distinguish or know each other. Nowadays, security technology and the authentication of individuals are very vital and necessary for many different secure areas in our lives. Various kinds of Biometric technologies have been used in many countries in the world to identify the identity of the individuals in their various secure areas; for instance, passport control, resident buildings, some vital rooms in the buildings, International Airports, ATMs, and so on.

Biometric recognition is the automated recognition of individuals based on their behavioral and structural traits to identify the identity of the individuals (Jain *et al*., 2010). Behavioral characteristics such as: Voice, Signature, Keystroke and structural characteristics refer to traits that God created such as: Face, Fingerprint, Palm, Iris pattern, DNA, Vein, Retinal imaging, Hand Geometry, Ear and Odor. These are illustrated in Figure 1.1. Figure 1.2 depicts block basic diagram of a biometric system, where data computing sensors (i.e. behavioral and structural characteristics) as input, detects and isolates portions of digital signal emanated out of a sensor in Features Extraction then compare with the data in the database:

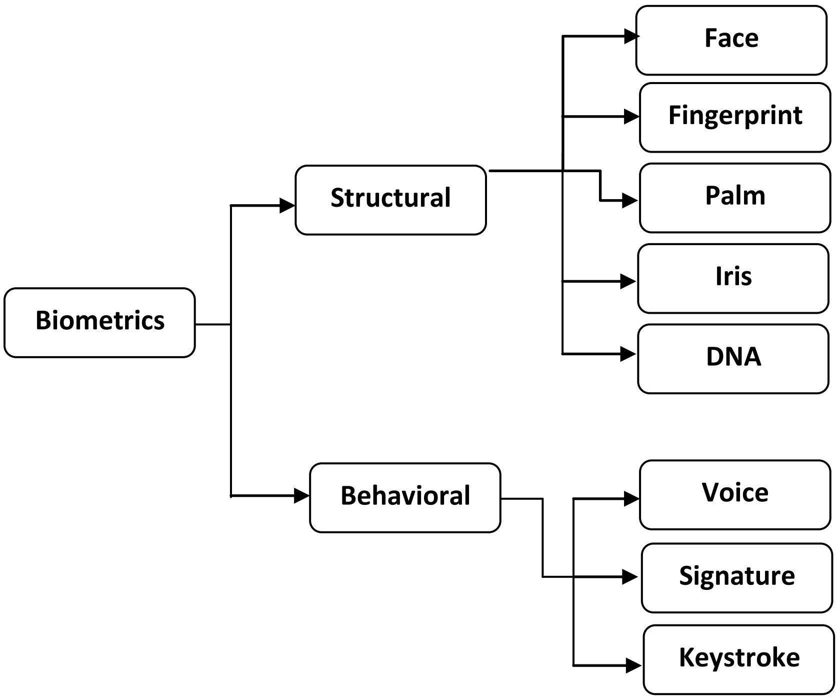

Figure 1.1 Different Types of Biometrics.

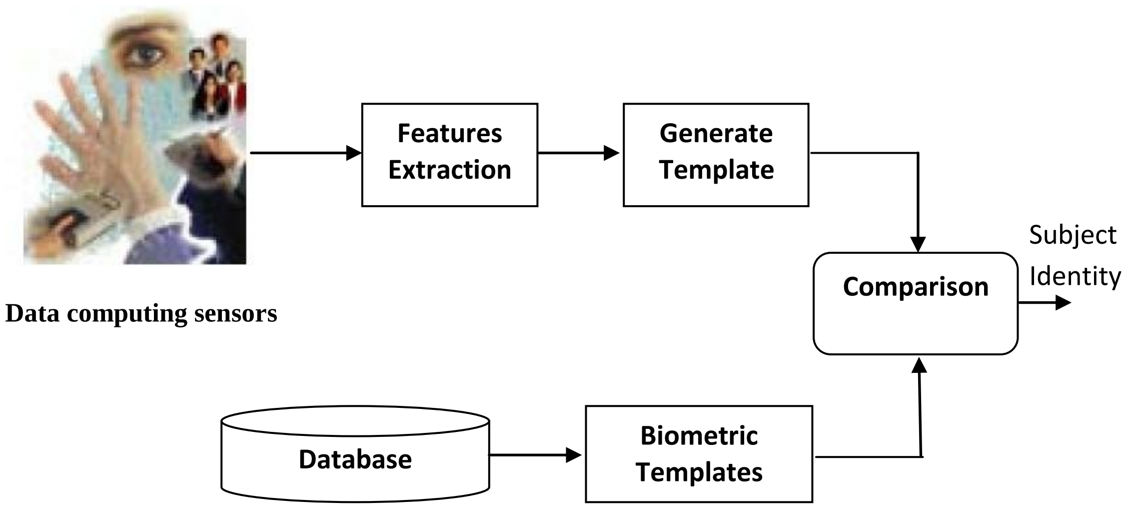

Figure 1.2 Basic Block Diagram of a Biometric System.

1.1.1 Why Iris?

There are many various types of biometrics and each one has its own strong points and weak points. To pick the right one to be highly fit for the special case, we picked Iris pattern because of its unique traits that two eyes are not the same even twins have different eyes as well as left and right irises for an individual. Moreover, Iris pattern has stability throughout the lifetime, because internal organ of the eye is protected by the cornea and aqueous humor (Daugman, 2003). Irises do not change even with age, expression, makeup, and pose. For all of the above reasons Iris pattern is measuring as the most secure and convenient biometric.

1.1.2 Iris Recognition

Iris recognition is a special kind of biometric system that relies on the uniqueness of the iris that it used for security purposes, because it has enormous latent for security in any field (Horst, 2006). Iris recognition is the process of distinguishing person by analyzing the pattern of the iris (Daugman, 2006). Iris recognition is becoming more stable and reliable than the other types of biometric for these reasons, such as: its error rate is extremely low, data-rich physical structure, genetic independence, highly protected by internal organ of the eye, and patterns apparently stable throughout lifespan (Daugman, 2004). Iris recognition scheme has four fundamental phases: First is Image Acquisition, the captured images composed of several elements such as: pupil, iris, sclera, eyelid, and eyelash. Second is Preprocessing, includes secluding the iris from the eye image which is called Iris Localization which uses to detect both boundaries of the iris that occlude by some useless information; for examples, hair, glasses, eyelids and eyelashes. Third phase are Feature Extraction and Generation of Template, using different kind algorithms. Final phase is Comparison of these templates, to decide who can access or who cannot access the authenticated system (Birgale and Kokare, 2009). Figure 1.3 depicts the block diagram of general iris recognition system:

In addition, all phases are important in iris recognition system but iris localization is one of the most critical and difficult phase (Shamsi *et al.*, 2009), because of any mistake made in this phase will result to inexact extraction of pattern which will be stored in the database and will lead to an unsuccessful system implementation (Nkole, 2012).

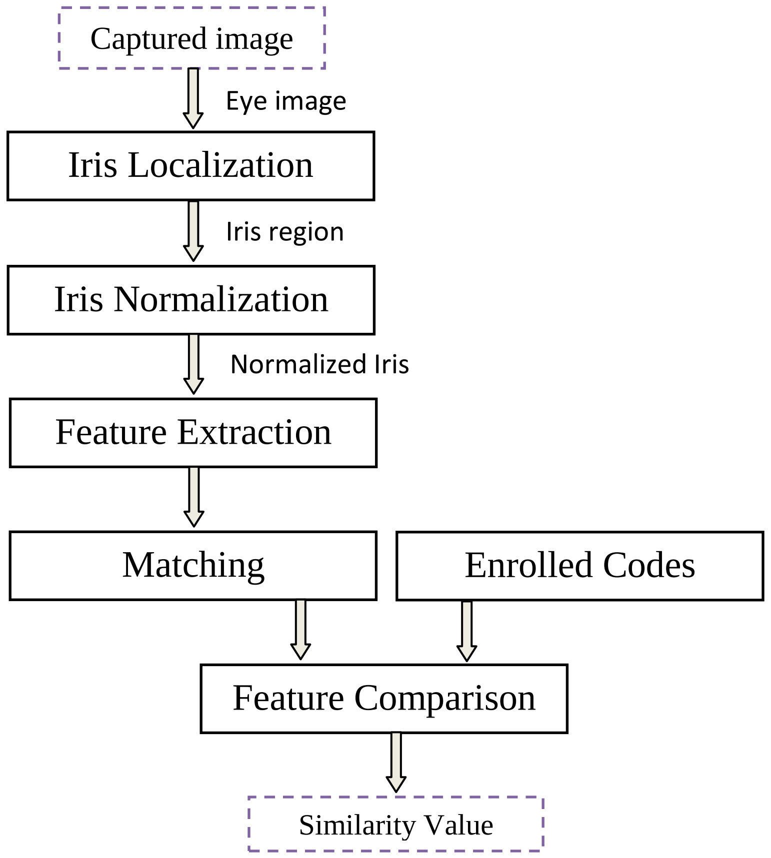

Figure 1.3 Daugman's Model for Iris Recognition Scheme.

1.2 Problem Background

There are five phases in Iris recognition system (according to Daugman Model for Iris recognition): Image Acquisition, Iris Localization, Iris Normalization, Feature Extraction, and Matching.

The iris images are collecting during the first phase (Birgale and Kokare, 2009). Generally, this phase carried several flaws and factors such as: blind person, hurry process, light intensity, distance between the iris camera and the eye, obscured by eyeglasses, eyelashes and eyelids. In spite of several iris image databases are available and most studies have used them; for examples, UBIRIS, MMU, UPOL, BATH, ICE, and WVU, but their iris images have different kind of noises and low resolution, because good quality of images require too much cost and large memory (Proenca and Alexandre, 2007).

The second phase is one of the most significant and difficult in the Iris recognition scheme is called Iris localization, because it defines two boundaries; the inner (pupil/iris) boundary and the outer (iris/sclera) boundary of the iris region in an eye image (Soltany *et al*., 2012). In the most cases, the outer (iris/sclera) boundary has low contrast signal in infrared light which makes the sclera often as dark as the iris, because inside the sclera consists of a lot of blood and hemoglobin in blood absorbs strongly in the near infrared spectrum (Daugman, 2006). There are several issues in Iris Localization phase that should be resolved; for examples, an off-axis gaze, blur, low quality and contrast, specular reflection, shadow, bright spot, unfocused image (Shamsi, 2011; He *et al*., 2009).

Integro-Differential Operator (IDO) used by Daugman to detect and find both inner and outer circles of the iris in (Daugman, 1993), but fourteen years later; after using Active Contour algorithm based on Discrete Fourier Series in (Daugman, 2007) he discovered that the inner (pupil) and outer (limbic) boundary were not circular shape absolutely. The 2D Gabor Wavelet also used by Daugman in (Daugman, 1993); to eliminate noises of the iris in an eye image that composed of eyelids and eyelashes, but ten years later in (Daugman, 2002); he discovered that the all useless information (noises) were not taken away entirely.

In 1997, Circular Hough Transform used by (Wildes, 1997) to localize both pupillary boundary and limbic boundary with edge detection, and his method using two parabolas arcs to lower boundary and upper boundary of the eyelid. There are many other authors and researchers used this methods; for instance, (Kong and Zhang, 2003), (Tisse *et al*., 2002), (Ma *et al*., 2002), and (Nkole, 2012) used Circular Hough Transform to localize irises as well. But using Hough Transform method has several weak points and the most important are: First, since the circular Hough transform uses threshold values for edge detection, critical edge points can be removed which can result in failure to detect circles. Also, the Hough transform algorithm is computationally time-consuming which makes it non-ideal for real time applications, and too many parameters need it (Wildes, 1997).

The Canny Edge Detection and Hough Circle Detection were used to localize the inner and outer boundaries by (Masek, 2003) for preprocessing, while (Shamsi, 2011) based on the assumption that since the pupil is black and that it is the center of the iris, and then used average square shrinking approach to localized the center of the pupil.

All the above algorithms try to find circle shapes to detect the pupillary (inner) and limbic (outer) boundaries, but active contour models assume that actually both boundaries are near-circular contour rather than perfect circle (Arvacheh and Tizhoosh, 2006). Later, (Daugman, 2007) proposed active contours model as an excellent approach to describe both pupil/iris (inner) boundary and iris/sclera (outer) boundary.

A few years ago, several authors and researchers focused on active contours model with both types region-based and edge-based. In 2009, Shah and Ross used geodesic active contours (GAC) model (Edge-based active contours model) to detect outer boundary (Shah and Ross, 2009). In 2010, Yahya and Nordin used Chan-Vese (CV) model (Region-based active contours model) to detect inner and outer boundaries (Yahya and Nordin, 2010). In 2012, Hilal *et al*. proposed Chan-Vese method (active contour without edges method) to detect the inner boundary and extract the pupil region in its real shape. First, the proposed method detects the iris/sclera (outer) boundary by using Circular Hough Transform. Then, Region-based active contour method (Chan-Vese method) is applied to localize the pupil region by using the circular pupil/iris (inner) boundary estimate as an initial contour (Hilal *et al*., 2012).

Mostafa *et al*. also proposed Chan-Vese method. In the first step, they also applied Circular Hough Transform then they used a numerically stable Direct Least Square-based elliptical fitting model to approximate the iris/sclera boundary. In the second step, they applied a modified Chan-Vese method to approximation exact pupillary and limbic boundaries. Hence, using both Hough Transform and Chan-Vese methods on one image at the same time occupies large memory space thereby resulting to a slow processing time (Mostafa *et al*., 2012).

Li *et al*. presented a new Variational Level Set of Active Contours without Re-initialization method to detect one or more desire objects in medical and real images especially those their boundaries are weak and strong noise (Li *et al*., 2005).

1.3 Problem Statement

Though, we can get iris in the captured image of eye, but simultaneously it contains other useless information around the iris region such as: pupil, eyelashes, eyelids, and sclera. So, localization stage is very important to demarcate iris region.

Although, most localization methods showed that inner (pupil/iris) and outer (iris/sclera) boundaries of the iris are perfect circles, but in fact, they have near-circular shape in the most cases. As a result, we applied Chan-Vese model and Variational Level Set of Active Contours without Re-initialization in this thesis.

There are several different kinds of noise to make iris recognition scheme poor performance; for instance, bright spot, eyelashes, and the lower and upper eyelids. In this dissertation, we intend to come up with an approach to overcome the problems of localization of iris images.

1.4 Research Question

The research question is:

How to localize the inner boundary and outer boundary of an eye image?

In view of the above question, the following issues have to be solved.

I. How to detect the inner boundary?
II. How to localize the pupil region?
III. How to localize of the iris?

1.5 Dissertation Aim

The main aim of this dissertation is to accurately localize iris in an eye image by enhancing the algorithms Chan-Vese model to localize pupillary boundary (inner – the black portion of the eye) as in (Hilal *et al*., 2012), and Level Set of Active Contours without Re-initialization to detect limbic boundary (outer – the white portion of the eye) depends on (Li *et al*., 2005).

1.6 Objectives of Study

To obtain the aims above, we have to do the following:

I. To reduce the eye image noise and the effect of eyelashes and eyelids.
II. To detect the boundary between pupil and iris and demarcate the pupil region from the eye image.
III. To localize the iris region and taking care of eyelashes and eyelids noise.

1.7 Research Scope

We focused on Iris Localization phase which involves detecting the iris and pupil in an eye image, and demarcating its inner (iris/pupil) and outer (iris/sclera) boundaries. Moreover, the main issue of this research is about noncircular both boundaries in the iris images due to camera position and off-angle gaze. The next issues are about blur images and occlusion due to eyelids and eyelashes decrease the iris localization accuracy. To ensure the performance of the proposed methods, the algorithms are tested and implemented on 404 non-ideal iris images from CASIA-iris-interval Version 3.

1.8 Research Framework

Our work is Iris Localization process that consists of: detecting of the pupil region, inner iris boundary localization, and outer iris boundary localization. Figure 1.4 shows the follow of data in Iris localization process.

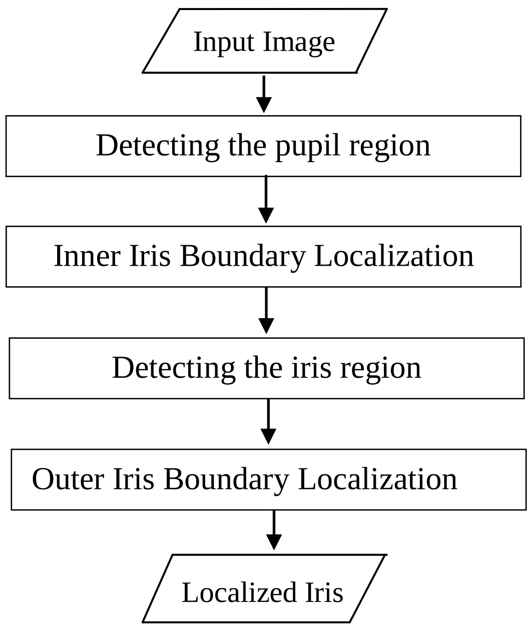

Figure 1.4 Research Frameworks.

1.9 Dissertation Organization

This research is arranged in chapters, Chapter one introduces the research title, explains the problem background highlights statement of problem, pin-point the research aim, establishes the objective of the study, discusses the scope of the research, hence the framework of the research and ended with the dissertation organization. The chapter two provides a detailed review of related literatures in Iris Localization while chapter three describes the methodology applied in the thesis.

Furthermore, chapter four describes the experimental outcome of how to detect inner boundary and localize pupil region using Chan-Vese model, and how to localize the iris region using Variational Level Set of Active Contours without Re-initialization. Finally, chapter five summaries the ideas of the dissertation, highlights the contributions and future works.

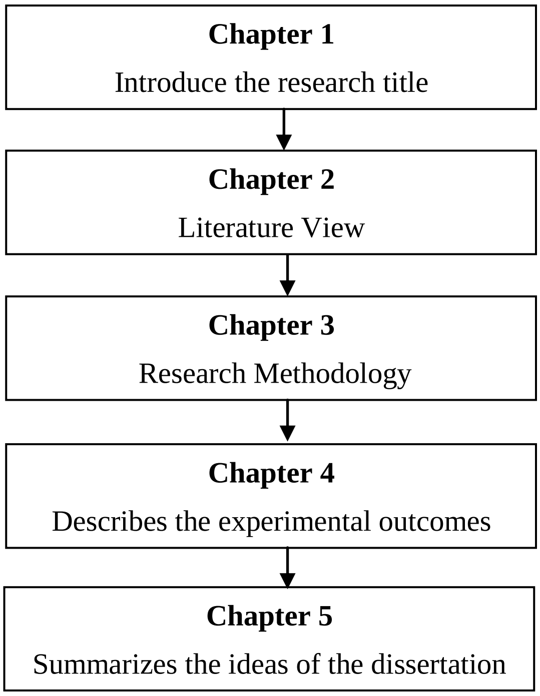

Figure 1.5 Organization of Dissertation.

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