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Adaptive Iris Recognition System

A thesis
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بِسمِ ٱللَّـهِ ٱلرَّحمنِ ٱلرَّحِيمِ

﴿ وَإِذَا سَمِعُوا مَا أُنزِلَ إِلَى الرَّسُولِ تَرَىٰ
أَعْيُنَهُمْ تَفِيضُ مِنَ الدَّمْعِ مِمَّا عَرَفُوا مِنَ الْحَقِّ ۖ
يَقُولُونَ رَبَّنَا آمَنَّا فَاكْتُبْنَا مَعَ الشَّاهِدِينَ ﴾

صَدقَ ٱللَّـهُ العَظيم

سورة المائدة
الآية (٨٣)

Chapter One
General Introduction

1.1 Introduction

The history of recognition for humans is as old as human-beings. With the improvement of technology and science in the today modern world, human activities and transactions have been growing tremendously. The authenticity of users has become an inseparable part of all transactions involving human computer interaction. Most conventional modes of an authentication are based on knowledge based systems i.e. “what we know” (e.g., *PIN*-code, password etc.) and / or token based systems i.e. “what we have” (e.g., driving-license, *ID*-cards, passport, etc.). Biometrics bring in stronger authentication capabilities by adding a third-factor, “who we are” based on our inherent physiological or behavioral characteristics [1].

The biometric systems have a following layout: it captures a sample of the feature, such as taking a digital image for face or iris recognition. This sample is then converted using some sort of mathematical functions into a biometric template. The biometric template will provide a normalized, efficient and highly discriminating representation of the feature, which can then be objectively compared with other templates in order to determine identity [2].

Iris as a biometric recognition of ID (Identification) takes formed active research area later 1992. The term for iris authentication means identifying iris eye image by computationally algorithms and it is used for example an identity. Among all biometric methods, iris authentication has been considered as the most accurate and dependable method for identity authentications. Iris authentication has become an actives research subject in the area of patterns-recognition because of its promising application values in personal ID (Identification). The iris recognitions take organized in several critical applications area, including homeland security, border control, rapid-processing of passengers, webs based services, national ID-cards, restricted access to privileged-information, missing child-ID, and welfares-distribution [3].

Human's eye iris is the circular part that is existing between the black-pupil and the white-sclera and it contains many characteristic minute part (e.g., crypts, freckles, furrows, coronas rings, etc.). These rich specifics of the eye iris, denoted as texture, and are unique for each person and to each eye and stay stable over a life-time, which makes the iris mainly useful for person authentications [4].

1.2 Biometric Technology

The biometric applications follow the procedure illustrated in Figure (1.1). A biometric system provides automatic recognition of an individual based on some sort of unique feature or characteristic possessed by the individual. Development of Biometric systems based on fingerprints, voice, facial features, hand geometry, handwriting, the retina [5], and the one presented in this work, the iris. The number of comparisons between the biometric sample and templates determines basic distinctions among the two modes of performing biometric recognition: verification and identification [6]. A perfect biometric is characterized by the use of features that is extremely unique so that the chances of any two people having the similar characteristics will be minimal, stabilized so that the features do not change over-time, and be simply captured in order to provide suitability to users, and stop misrepresentation of the features [5].

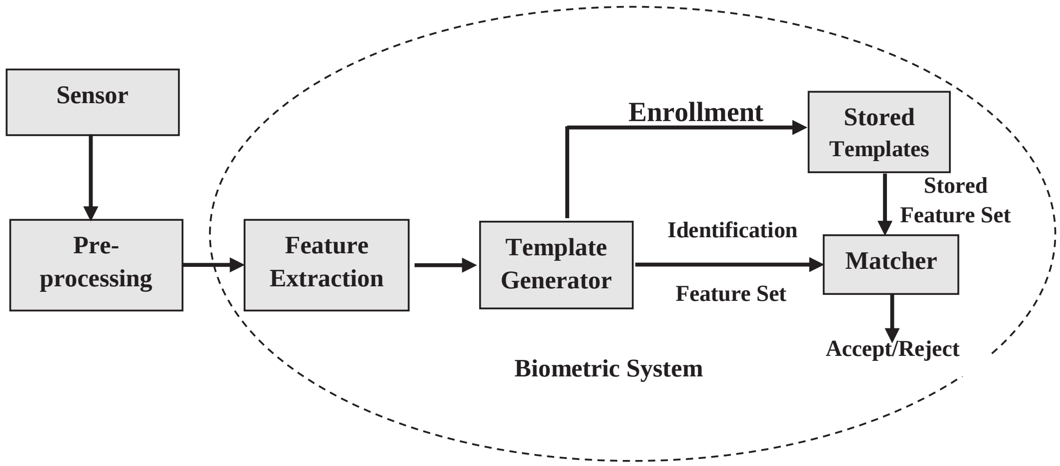

Figure (1.1): The basic block diagram of the biometric system [7].

1.3 Classification of Biometric Systems

Biometric systems can be classified according to six viewpoints as follows [6], [7]:

[1] Overt / Covert: If the user is aware of the acquisition of his biometric data, the application is defined as overt; otherwise, is defined as covert. This is clearly one of the most concerning characteristics of a biometric system, regarding the privacy issue [6], [7].

[2] Habituated / Non-habituated: When the majority of the people that interacts with the biometric system are everyday users, the recognition is performed in the habituated mode. If the average frequency of use from each user is low, the recognition is performed in the non-habituated mode [6], [7].

[3] Attended / Non-attended: The biometric recognition process is performed attended if the user is observed and guided by supervisors during the process. On the other hand, if the process is unsupervised, the process is considered to be none attended. In attended applications, biometric samples tend to be of a better quality compared to the ones acquired in a non-attended system were subject cooperation is non-existent [6], [7].

[4] Standard / Non-standard Environment: A standard environment involves that most conditions in the biometric system are controlled and the recognition takes place indoors within a constrained environment, otherwise, the use is called a non-standard environment. For example, customs and airport security systems are considered standard since the entire biometric recognition process is completed in a controlled environment [6], [7].

[5] Public / Private: If the users are not employees of the organization that owns the recognition system, the application is public; if the users are employees, the application is called private [6], [7].

[6] Open / Closed: If the system uses completely-proprietary formats, the application is considered closed. Otherwise, when the system is able to exchange data with others, it is called open and, once again, privacy and legal issues should be addressed [6], [7].

1.4 The Human Iris

The iris is a circular diaphragm, which lies between the cornea and the lens of the eye. The iris is perforated close to its center by a circular opening known as the pupil. The eye iris function is to supervision amount of light comings through the pupil, and this is done by the dilator and the sphincter muscles, which regulate the size for the pupil. The AVG (average) diameter of the eye iris is 12 mm, and the pupil size can change from 10% - 80% of the eye iris diameter [8] [9].

The eye iris contain a number of layers, lowest is the epithelium-layers, which hold dense pigmentation cells. The stromal-layers lies up the epithelium-layer and contains pigment cells', blood vessels, and the two eye iris muscles. The density of stromal pigmentation defines the color of the iris. The externally visual surfaces of the multi layered eye-iris includes two zone, which often differs in color. An outer ciliary-zone (outer boundary) and inner-pupillary zone (inner boundary), and these two zones are separated by the collaret's-which appears as a zigzag-pattern [9].Figure (1.2) show elements seen in a typical image.

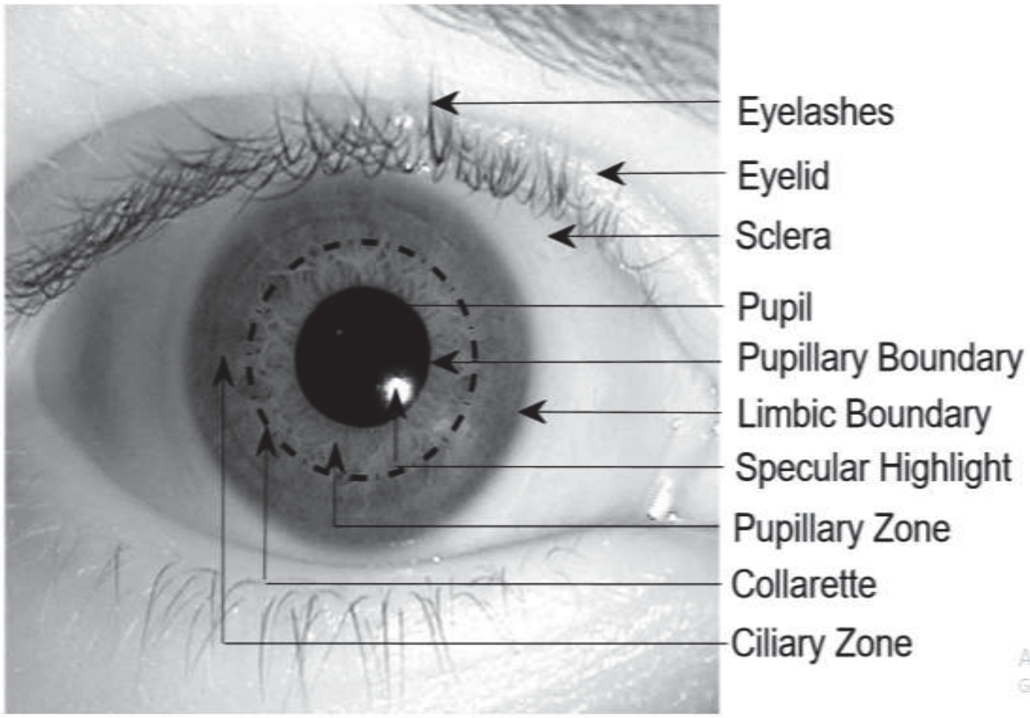

Figure (1.2): Shows elements seen in a typical iris image [10].

Varying in shades of brown, blue and green, no two irises are alike, not even within the same individual or identical twins. Glasses and contact lenses, even colored ones, do not interfere with the process. In addition, recent medical advances such as refractive surgery; cataract surgery and cornea transplants do not change the iris characteristics. In fact, it is impossible to modify the iris without risking blindness. And even a blind person can participate. As long as a sightless eye has an iris, that eye can be identified by iris recognition [10].

1.5 Advantages and Disadvantages of Iris as Biometrics

The major advantages and disadvantages of the IRS are [11], [12]:

1.5.1 Advantages of Iris as Biometrics for Recognition

Iris is well protected and an interior organ of the eye, the iris patterns are highly random, and it is assumed that no two individuals have the same iris pattern [11]. Iris is externally visible, and the iris-image acquisition is possible from a distance [12]. Iris patterns do not change throughout the life-time of a person, and it is assumed that each person has a unique iris pattern [11]. It is possible to encode the iris-pattern [12]. No evidence of genetic penetrance has been found in the structure of the iris. Therefore, the iris structure of both eyes of the identical twins is different [11].

1.5.2 Disadvantages of Iris as Biometrics for Recognition

There are some points of disadvantage [11]: It is difficult to capture the iris-image since the size of the iris is very small. The high quality camera is needed to acquire the iris images with an extensive apparatus setup. The iris could be partially occluded by upper and lower eyelids and obscured by eyelashes, reflections, and lenses. Iris image enrollment procedure takes more time since the iris image acquisition is a difficult task [12].

1.6 Iris Recognition Structure

An **IRS** commonly consists of five main stages. The block diagram of a typical iris recognition system is shown in Figure (1.3) [13].

1- Image Acquisition: Aims to capture the image of the eye. In order to illuminate the iris, an external NIR (Near Infrared) light source is often combined with the acquisition system. The acquisition module captures a series of iris images, then uses a scheme to evaluate image quality, selects one image with sufficient iris information, which then undergoes additional processing [13].

2- Iris Segmentation: it discovers and localizes both iris inner and outer boundaries. It also detects and removes eyelashes and eyelids that may occlude iris region. The integral - differential operator, is the traditional detection mechanism. Eye Iris segmentation is critical stage of any eye iris recognition system because inexactness in localizing the iris can severely degrade the systems matching accuracy and undermine the systems usefulness [13].

3- Iris Normalization: once iris boundaries have detected, the normalization module uses a rubber-sheet model to transform the iris texture from Cartesian to polar coordinates. The process often called iris unwrapping, it projects the segmented iris image into a rectangle block with angular and radial resolutions [13].

4- Iris Feature Extraction: iris texture is analyzed to extract the significant iris features within the normalized iris image [13].

5- **Iris Matching**: based on a matching metric, iris matching generates a match score by comparing the extracted iris template with saved iris templates in the database, then a decision is made to identify whether the extracted template is matched (authentic user) or rejected (imposter user) [13].

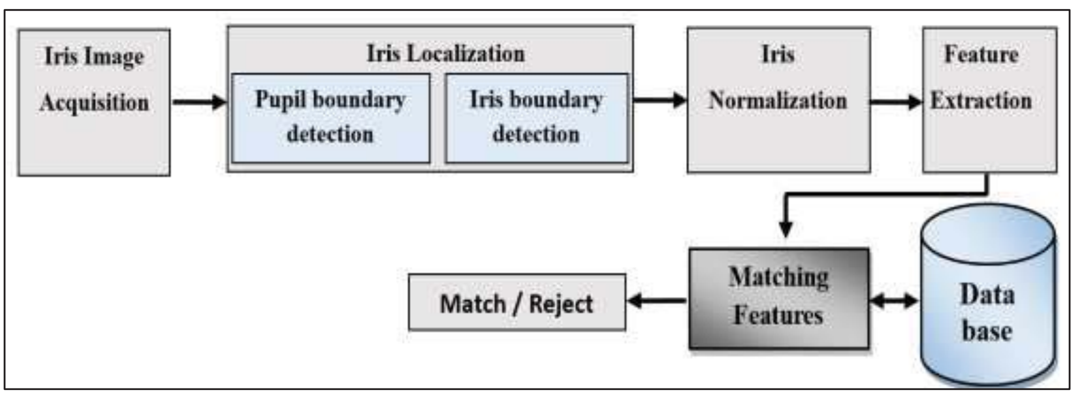

Figure (1.3): The block diagram of typical iris-recognition system [14].

1.7 Literature Survey

Several methods have been proposed for iris recognition: After a number of experiments and theoretical research, computer scientist *John Daugman* in a European country (*Cambridge University)* developed iris identification package and wrote his first assuring results in 1993. After on little similar works have inquired; such as *R.Wildes'* and *W.Boles'* systems.

1- ***J. Daugman***, 1993 [15], [16]: Established and patented the first actual processes to implement Iris Recognition System (IRS). His publications state the use of Near Infrared (NIR) illumination for image acquisition. NIR illumination not only remains nonintrusive to humans but helps to detect the detailed structure of stiffly pigment iris also. A system based on Integro-differential operators to find and detect the inner and outer boundaries of iris and phase code uses "Gabor filters" for iris recognition and it is reported that it has excellent performance on a diverse databases of large numbers of images, a statistical matcher (logical XOR operator) that analyses essentially the average HD (Hamming Distance) between two codes (bit to bit) test agreement is used for matching code. Tests proved that Daugman system is characterized by great precision and high-speed performance and has 99.90% accuracy rate.

2- ***Wildes*** et al., 1997 [17]: presented a system based on phase code using 2D-Transformation, and he has described a system for personal authentication based on automatic IRS. It relies on image registration and iris image matching, which is computationally very demanding. The prototype system also reports flawless performance with 520 iris images.

3- ***Daouk et al***., 2002 [18]: used a fusion mechanism for both a Canny Edge Detection scheme and a Circular Hough Transform to detect the iris boundaries in the eyes digital image. The Haar wavelet was applied in order to extract the feature patterns in a person's iris in the form of a feature vector. After that, the Hamming Distance matching was used to compare the quantized vectors. Finally, they tested this project on 60 pictures for CASIA (Chinese Academy of Sciences, Institute of Automation) database, and obtained an average of correct recognition of 93%.

4- ***Ganorkar and A. Ghatol,*** 2007 [19]: presented that the steps for implementing system are by capturing the iris-image and determining the site of iris-boundaries, translating iris boundary to the stretched polar coordinate system, and extracting the iris-code based on a textual analysis. This system was implementing and testing using data set of a number of sample of irises data with difference contrasts of quality. This developed algorithm performed satisfactorily on the CASIA Ver.1.0 iris image data base over, provided 93% accuracy.

5- ***A. Laith, A. Mohammed, and A. Ansam***, 2012 [20]: proposed an iris recognitions system-based on semantic-indexing. The proposed systemuses the concept-of Latent-Semantic-Indexing (LSI) for iris recognition. One technique of LSI is the Singular-Value-Decomposition (SVD). The SVD is an information retrieval uses numerical-decomposition methods to compute one characteristic value (i.e. SVD) for each iris image to be used as a recognitions-feature. The proposed system consists of two phases: the training and recognition. The training phases is responsible for storing the iris models in the database, while the task of recognition phases is to compute the similarity measure-between the SVD of the query iris image and SVDs of the iris images found in the database. The recognition decision-is made according to the normalized similarities and appeared as a-text message tells what the identity it is. The recognitions-rate was 96%.

6- ***Kaur et al***., 2013 [21]: proposed and analyzed two different methods of increasing iris recognition mechanism by iris localization, normalization, encoding, and comparison. The first is a support vector machine, and the second is the Phase-based method. In a first way, tested on 42 pictures for CASIA iris database and obtained of average FRR=19.8%, and average of FAR = 0%. While in a second way, used CASIA iris database and obtained of FRR = 0.01%, FAR = 0.09% and overall accuracy= 99.9%.

7- ***S. A. Ali***, 2014 [22]: proposed iris recognition method using different combinations of Haar wavelet, GLCM and Run Length Matrix (RLM) features for feature analysis and evaluation. The attained recognition rate was 99.2% for CASIA Ver1.0 and 97.35% for the left eye and 98.2% for right eye samples belong to CASIA Ver 4.0 database. For verification, the attained accuracy was 98.8% for CASIA Ver 1.0. For left iris samples belong to CASIA Ver4.0 database, the highest verification rate was 98.58% when using Haar features, while for right iris the highest verification rate was 98.7% when using Haar features.

8- **Jayalakshmi ,** 2014 [23] : proposed Fuzzy C-means and K-means algorithms for segmentation the iris-image from the eye. The two algorithms were applied, separately, and their performances are measured. The comparison between the results of both algorithms when applied CASIAVer1.0 database indicated the segmentation by applying Fuzzy C-means gave 98.20% of accuracy with low error rate within a considerable amount of time, while the K-means clustering algorithm took time to calculate and produced 84.98% accuracy rate.

9- ***Gupta and Kumar***, 2015 [24]: proposed iris segmentation technique to handle iris images (captured on less constrained conditions) with some types of noise (iris obstructions and specular reflection). The authors started their work implementation by K-means clustering to get the iris region; then delete small blocks and noise; followed by vertical CED for iris region; then CHT (Circular Hough Transform) to determine iris; remove noise (upper and lower eyelid) and localize and remove pupil. The proposed technique showed the 98.72% accuracy using CASIA-Iris Ver 4-interval databases samples of iris.

10- *Others Method*

Some other approaches have been proposed for iris localization but greatest of them are minor variations of integro-differential-operator or combination of edge detections and Hough-transform. For example, Cui et. al. [25] computed a wavelet transform and then used the Hough transforms to find the iris inner boundary while using the integro-differential-operator for the outer-boundary. Tain et. al. [26] used Hough-transforms after preprocessing of edge image. Masek et. al. [9] implemented an edge detection-method slightly different-from the canny operator-and then used a circular Hough-transforms for iris boundary extractions. Rad et. al. [27] used gradient-vector pairs in various directions to coarsely estimate positions of the circle and then used an integro-differential-operator to refine the iris boundaries. Basit [28] described an efficient method for personal identification based on the pattern of the human iris. It is composed of image acquisition, image preprocessing to make a flat iris then it is converted into Eigen iris and the decision is carried out using the only reduction of the iris in one dimension. By comparing the Eigen irises it is determined whether two irises are similar.

1.8 Contributions of this Work

1. In preprocessing and segmentation stages, the proposal of a more robust iris segmentation method is able to deal with highly noisy iris images capturing less brightness, less constrained conditions, and non-ideal environments. In this method [Iris Segmentation Based on Brightness Correction (*ISBC*)], and some newly proposed methods are used to deal with expected types of noise. On another hand, a new method is

developed for accurate inner iris (pupil) boundary localization is performed by using a new approach, called [Box Method (BM)] that is depending on choosing the largest object from many objects detected in the binary image to localize accurate pupil boundary. Three enhancement on the image after split image to zero's and one's, to localize accurate iris (outer) boundary of the image.

2. In iris normalization stage, adaptive method is developed for accurate iris normalization, performed by using the [Circular Distribution (*CD*)] that transforms of iris region to Polar Coordinate in a fixed size.

1.9 Problem Statement

Several problems emerged when building iris recognition system, could be classified as follows:

1- In the image acquisition the system considers CASIA database (Ver 1.0 and Ver 4.0-interval), these databases have many issues which affect performance systems such as light reflection, image quality is degraded because of low or high brightness image, blurring image and rotation image, as shown in Figure (1.4(a)).

2- Examples of problems with iris boundary localization stage suffer from how to find iris boundaries accurately, as shown in Figure (1.4(b)).

3- Iris normalization stage faces the challenge of how to find a method to transform the iris region into fixed shape and uniform size of irises despite the differences in sizes without any effect on the change of iris features in the iris region image.

4- Iris feature extraction stage problems focus on extracting unique important features from iris image and how to occlude the upper eyelashes and lower eyelid.

5- Pattern matching stage problems are to calculate iris template matching with iris templates stored in a large database in high-speed measurement and get accurate results with less error rate to system users.

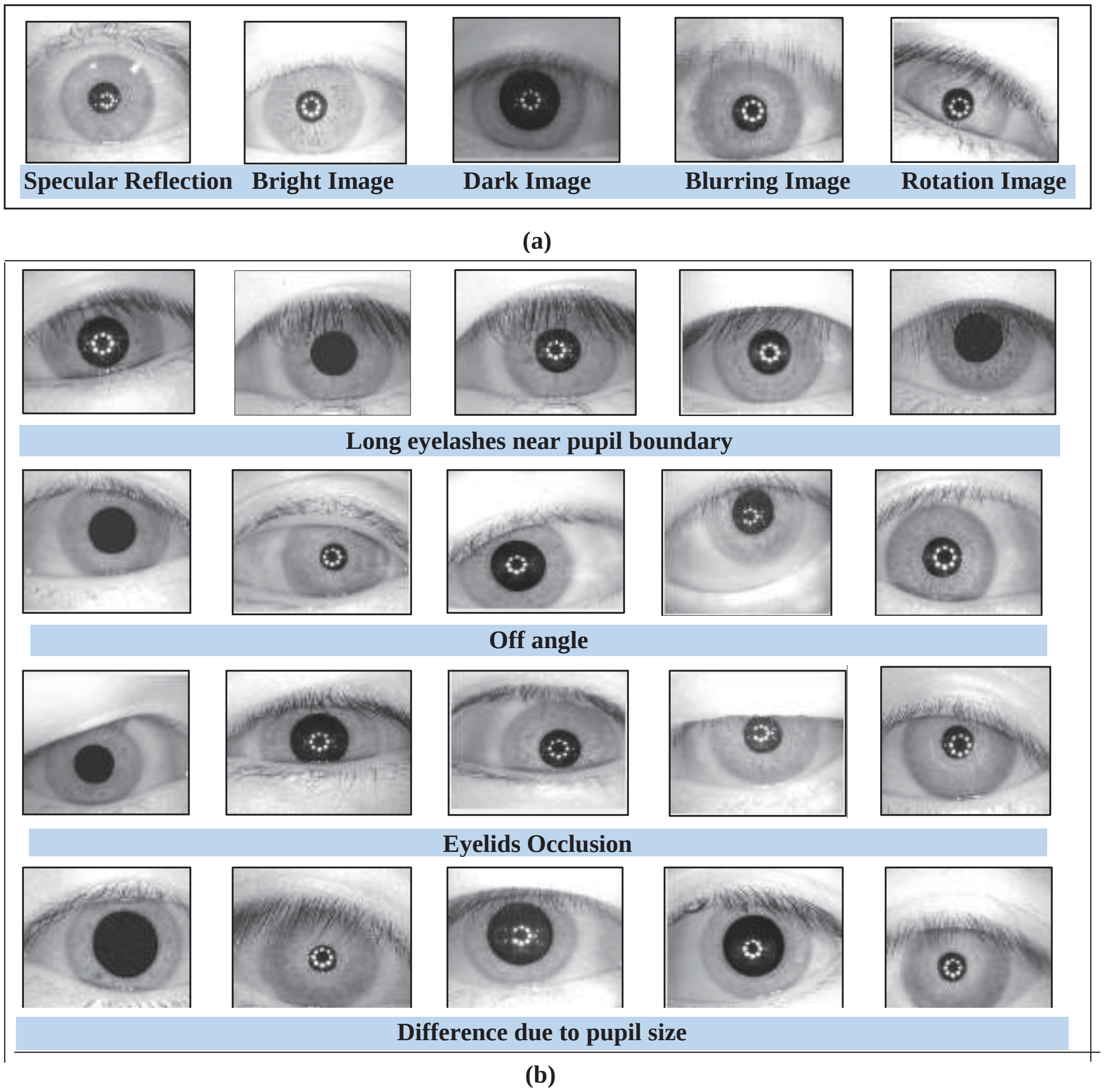

Figure (1.4): Examples of various effects on iris images.

1.10 The aim of Thesis

The aim of this thesis is to build a secure (reliable and accurate) iris authentication system, based on using textural features to achieve high recognition accuracy. To ensure efficient system performance many robust and fast algorithms will be introduced to accomplish the iris segmentation and authentication tasks from eye images captured in a non-excellent environment and less controlled circumstance. One of the main enhancement in preprocessing stage is brightness correction (*BC*) of the image to exceed some problem such as eyelashes close to the pupil. The proposed system using many accurate methods for localizing inner and outer iris boundary. The whole and principal objective aim to ensure a high level of the security system with less error rate as much as possible.

1.11 Thesis Layout

In addition to this chapter, the thesis has other four chapters deal with the proposed iris recognition technique and discuss some measures and tools that determine the efficiency of the recognition process. The following is a brief description of each one:

Chapter Two, Entitled: Theoretical and Background

This chapter presents the concepts related to biometrics technologies. It concentrates on presenting the relevant iris details, its properties, and anatomy. Also, brief descriptions are given for the image processing and texture analysis basic tasks that involved in the iris system.

Chapter Three, Entitled: The Proposed Iris Recognition System

This chapter presents the design and implementation steps of the presented system.

Chapter Four, Entitled: The Experimental Results and Tests

This chapter shows the test results then discusses the results to evaluate the performance of the established system.

Chapter Five, Entitled: Conclusions and Suggestions for Future Work

In this chapter, some derived conclusions and a suggestions list for the future work.