Iris Recognition System – A Review

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Abstract— **The iris recognition is a kind of biometrics technologies based on physiological characteristics of human body as compared with the feature based recognition of fingerprint, palm print, face and sound etc, the iris has some advantages such as uniqueness, stability, high recognition rate, and non-infringing etc. The iris recognition systems have made tremendous progress over the past decade, but further work remains to improve their accuracy in environments characterized by unfavorable lighting, large stand-off distances, and moving subjects. For the purpose of research and development of Iris recognition technology there are few public and freely available databases to have sample images. These iris databases contributes rich amount of iris images which were taken in different environments. In this paper we will discuss about the iris anatomy, history, general process, various implemented locations of system at international level, international competitions and publicly available iris image datasets.**

Keywords- Biometric, Iris Recognition, Databases, Segmentation, Localization, Normalization, Enhancement, Feature Extraction, Template, Matching.

I. INTRODUCTION

Due to the rise in terrorist attacks and tremendous growth in biometric technology, the need for infallible security systems has become a vital aspect in public security [1]. A biometric system provides automatic identification of an individual. Biometrics refers to the recognition of an individual on the basis of physiological and behavioral traits of an individual [2].Typical biometric technologies include fingerprint identification, face recognition, iris recognition etc. Among all technologies, Iris recognition is considered to be the most trustable and accurate biometric identification system available in the market today with existing large scale applications supporting databases in excess of millions of people.

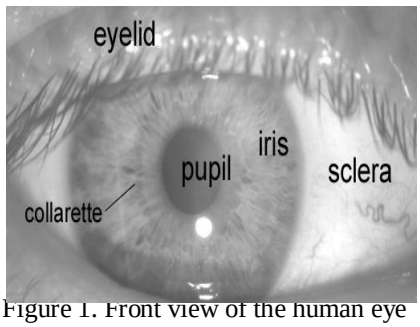

Figure 1. Front view of the human eye

The iris is a protected organ whose random texture is stable throughout the life [2] and hence can be used as an identity document offering a very high degree of identity assurance. Iris recognition is a method of biometric personal identification based on high-resolution images of human eyes. The human iris is an annular region between the pupil and sclera [2] as shown in Fig.1.

Irises not only differ between identical twins, but also between the left and right eye. No two irises are same. Iris pattern is formed during the first year of life and pigmentation of the stroma takes place for the first few years. Formation of the unique patterns of the iris is random and not related to any genetic factors. The only characteristic that is dependent on genetics is the pigmentation of the iris, which determines its colour. Epigenetic nature of iris patterns results in completely independent iris patterns. Even identical twins possess uncorrelated iris patterns.

II. HISTORY OF IRIS RECOGNITION SYSTEM[5]

TABLE-I. HISTORY OF IRIS RECOGNITION SYSTEM

Year	Description
1936	Ophthalmologist Frank Burch proposed the iris patterns concept as a method to recognize an individual.
1985	Drs. Leonard Flom and Aran Safir, ophthalmologists, proposed the concept that no two irides are same.
1987	Drs. Leonard Flom and Aran Safir, ophthalmologists, were awarded a patent for iris identification concept.
1993	The Defence Nuclear Agency began work to test and deliver a prototype unit which was successfully completed in 1995 with combined efforts of Drs. Flom, Safir, and Daugman.
1994	Dr. Daugman was awarded a patent for automated iris recognition algorithms.
1995	The first commercial products became available.
2005	The broad patent covering the basic concept of iris recognition expired.
2011	Dr. Daugman patent on Iriscodes expires.

The above table describes about the detail history of iris recognition system.

III. LITERATURE REVIEW

Dr.H.B.Kekre. et.al [1] proposed an iris recognition system which is based on vector quantization which includes Kekre's Fast Codebook generation algorithm. Its performance is compared with the Discrete Cosine Transform (DCT) as proposed VQ based system does not need any pre-processing and segmentation of the iris. The KFCG algorithm requires 99.99% less computations and gives accuracy of 89.10% outperforming DCT accuracy around 66.10%.

Shirke Swati D, Shirke Suvarna D and Gupta Deepak [2] explained about algorithms developed for recognizing person iris patterns had been tested in many field and laboratory trials, produces no false matches in several million comparison tests. They present an efficient Iris Code classifier built from phase features of Gabor wavelets bandwidths. The final iris classifier based on Levenshtein distance consists of a weighted contribution of weak classifiers. Experimental results show that the Levenshtein distance has better discrimination in comparing Iris Codes than the Hamming distance. IRIS Recognition is used of Identification, Authentication, and Scanning. Also, IRIS Is a Muscle which is placed in between Pupil and Sclera.

G. Savithiri, A.Murugan [3] explained about Iris recognition that has received increasing attention in departments which require high security. In this paper, they discussed about three techniques: Gabor Wavelet, Local Binary Pattern & Histogram of Oriented Gradient to extract features on specific portion of the iris for improving the performance of an iris recognition system. The main aim of this paper is to show that authentication of valid and rejection of invalid users can be done through using the half portion of instead of whole extension of the iris. The proposed methods like False Rejection Rate (FRR) and False Acceptance Rate (FAR) are evaluated. The experimental results show that on MMU iris database this technique produces good performance.

[4] Rishabh Parashar, Sandeep Joshi explained about Iris recognition which is considered to be most secure biometric approach as it is non-invasive and stable throughout life. For the purpose of research and development of Iris recognition technology there are few public and freely available databases to have sample images. These iris databases contributes rich amount of iris images which were taken in different environments. In this paper they discuss and compare the main characteristics of the public and freely available iris image databases to find the suitable one to test feature extraction method of iris recognition in non-cooperative environment. They also illustrate the types of noise that images from each database contain. Based on the analysis of these noise factors, they present the main motivations that led us to the construction of UBIRIS database and highlight the main factors in the comparison with the remaining ones.

IV. GENERAL PROCESS OF IRIS RECOGNITION SYSTEM [3]

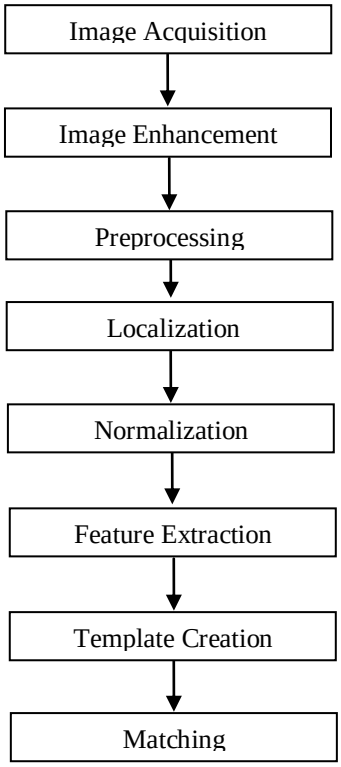

Figure 2.General Process of Iris Recognition

A. *Image Acquisition*

The image of the iris can be captured using a standard camera using both visible and infrared light and may be either a manual or automated procedure. The camera can be positioned between three and a half inches and one meter to capture the image. In the manual procedure, the user needs to adjust the camera to get the iris in focus and needs to be within six to twelve inches of the camera. This process is much more manually intensive and requires proper user training to be successful. The automatic procedure uses a set of cameras that locate the face and iris automatically thus making this process much more user friendly.

B. *Image Enhancement*

The normalized iris image has low contrast and non-uniform illumination caused by the light source position. The image needs to be enhanced to compensate for these factors.

C. *Image Preprocessing*

The Standard noise reduction and isolated peak noise removal techniques such as median-filtering and average filtering used to clear the noise and to make the iris textures good and clear. In practical applications of a workable system an image of the eye to be analyzed must be acquired first in digital form suitable for analysis.

D. Image Localization

Once the camera has located the eye, the iris recognition system then identifies the image that has the best focus and clarity of the iris. The image is then analyzed to identify the outer boundary of the iris where it meets the white sclera of the eye, the pupillary boundary and the centre of the pupil. This results in the precise location of the circular iris.

E. Image Normalization

Irises from different people may be captured in different size and even for the iris from the same person; the size may change because of the variation of the illumination and other factors such elastic deformations in iris texture affects the results of iris matching.

F. Feature Extraction

The iris is a thin circular part which lies between the pupil and sclera upper part of the pupil is usually occluded by top eyelid and eyelashes which their intensity is similar to pupil. On the contrary the lower part of pupil is rarely affected by any eyelids and eyelashes. The features of the iris can be extracted by different approaches for iris recognition.

G. Template Creation

Once the features are extracted using any one of the techniques, an iris image is transformed into a unique representation within the feature space. These features are stored which is known as Iris code for template creation

H. Matching

For matching, a bit-wise comparison is done.

V. TYPICAL APPLICATIONS OF IRIS RECOGNITION SYSTEM[2,6]

National border controls: The iris as a living passport, Computer login: the iris as a living password ,Cell phone and other wireless-device-based authentication, Secure access to bank accounts at cash machines, Ticketless travel; authentication of rights to services, premises access control(home, office, laboratory, etc), Driving licenses; other personal certificates, Entitlements and benefits authorization, Forensics; birth certificates; tracing missing or wanted persons, credit-card authentication, Automobile ignition and unlocking; anti-theft device.

VI. IMPLEMENTED COMMERCIAL IRIS RECOGNITION SYSTEM AT INTERNATIONAL LEVEL

TABLE II. INTERNATIONAL LEVEL

COMPANY	SYSTEM	LOCATION
Iris Guard [7]	Iris Expellee Tracking System	United Arab Emirates
BI2 Technologies [8]	Mobile Offender Recognition and Identification System	New York City Police Department
Irisid [9]	IrisAccess	New York World Trade Center, National Airport Security for Canada, Bio Lab Security, Equinox Fitness Club, York Country Prison.
Iritech [10]	Automated Border Control System	Amsterdam Airport Schiphol
Jiris [11]	JIRIS True Eye Access	KDNH Private Bank Korea
Smart Sensors Ltd [12]	MIRLIN SDK	_____
Neurotechnology [13]	Multi-Biometric Enrollment System	Mexican Tax collection
Crossmatch Technologies [14]	I SCAN 2	Military, National ID Programs

Table-II explains about the various companies at international level which implemented and deployed the iris recognition system at various locations.

VII. PUBLICLY AVAILABLE IRIS DATABASES[4]

A. Bath Database

The University of Bath (BATH) iris image database is constantly growing and at present contains over 16000 iris images taken from 800 eyes of 400 subjects. It results of a project which aims to build a "high quality iris image resource". The majority of the database comprises images taken from students and staff of the University of Bath the images are of very high quality, taken with a professional machine vision camera, mounted on a height-adjustable camera-stand. The illumination was provided through an array of infrared LEDs, positioned below the camera and set at an angle such that reflections were restricted to the pupil. Further, an infrared pass filter was used in order to cut out the daylight and other environmental light reflections on the irises region. So, this framework increases the images quality, while turned it less appropriate for the testing of iris recognition method.

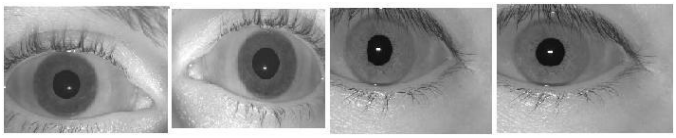

Figure 3.Examples of Iris Images from the BATH Database

B. CASIA Database[15]

Iris recognition has been an active research topic of the Institute of Automation from the Chinese Academy of Sciences. Having concluded about a lack of iris data for algorithm testing, they developed the CASIA image database. CASIA iris image database (version 1.0, the only one that we had access to) includes 756 iris images from 108 eyes, hence 108 classes. For each eye, 7 images are captured in two sessions, where three samples are collected in the first and four in the second session. Similarly to the above described database, its images were captured within a highly constrained capturing environment, which conditioned the characteristics of the resultant images. They present very close and homogeneous characteristics and their noise factors are exclusively related with iris obstructions by eyelids and eyelashes. Moreover, the post process of the images filled the pupil regions with black pixels, which some authors used to facilitate the segmentation task. So, this significantly decreased the utility of the database in the evaluation of robust iris recognition methods.

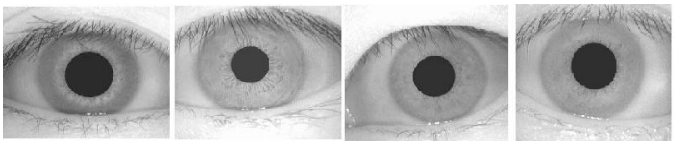

Figure 4.Examples of Iris Images from the CASIA Database

C. ICE Database

The Iris Challenge Evaluation (ICE) is a contest designed to measure the accuracy of the underlying technology that makes iris recognition possible. It is divided into two stages: first, it was asked to researchers and developers to participate in "iris recognition challenge problems" that might improve their recognition algorithms. Later, an opportunity to participate in a large-scale and independent evaluation will be given, through a new iris data set and a proper evaluation framework.

The ICE database is comprised of 2954 images, with a variable number of images per subject. Similarly to the remaining public iris databases, its images were captured having quality as the main concern and clearly simulate the users' cooperation in the image capturing. Therefore, the noise factors that the ICE database contains are almost exclusively related with iris obstructions and poor focused images. Interestingly, there are some images that were deliberately rotated. Also, some irises were partially captured.

Figure 5.Examples of Iris Images from the ICE Database

D. MMU Database[16]

The Multimedia University has developed a small data set of 450 iris images (MMU). They was captured through one of the most common iris recognition cameras presently functioning (LG Iris Access 2200). This is a semi-automated camera that operates at the range of 7-25 cm. Further, a new data set (MMU2) comprised of 995 iris images has been released and another common iris recognition camera (Panasonic BM-ET100US Authenticam) was used. The iris images are from 100 volunteers with different ages and nationalities. They come from Asia, Middle East, Africa and Europe and each of them contributed with five iris images from each eye. Obviously, the images are highly homogeneous and their noise factors are exclusively related with small iris obstructions by eyelids and eyelashes. It can be seen in figure 6.

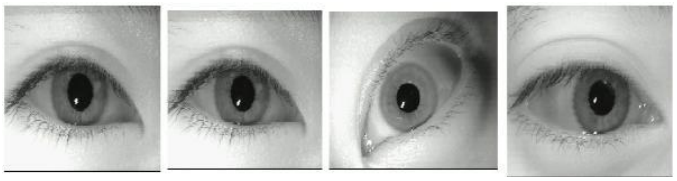

Figure 6.Examples of Iris Images from the MMU Database

E. UPOL Database[17]

The UPOL iris image database was built within the University of Palack´eho and Olomouc. Its images have the singularity of being captured through an optometric framework (TOPCON TRC50IA) and, due to this, are of extremely high

quality and suitable for the evaluation of iris recognition in completely noise-free environments. The database contains 384 images extracted from both eyes of 64 subjects (three images per eye). As can be seen in figure 2.5, its images have maximum homogeneity and inclusively the iris segmentation is facilitated by the dark circle that surrounds the region corresponding to the iris. Obviously, these characteristics make this database the less appropriate for the non-cooperative iris recognition research.

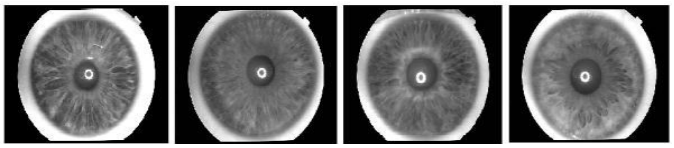

Figure 7.Examples of Iris Images from the UPOL Database

F. WVU Database

The West Virginia University 5 developed an iris image database (WVU) comprised of 1852 images from 380 different eyes. The number of acquisitions from each eye ranges between three and six and an OKI IrisPass-H hand-held device was used. Images of the WVU database were captured with less constraining imaging conditions and, due to this, incorporate several types of noise, such as iris obstructions, poor focused and off-angle iris images. However, there are few iris images with significant regions affected by specular and lighting reflections, which we believe to be the most common type of noise resultant of natural light imaging environments. It can be seen in figure 8. We stress that this was one of the major motivations that led us to decide about the need of a new and noisier iris image database, that later originated the UBIRIS database.

Figure 8.Examples of Iris Images from the WVU Database

G. UBIRIS Database[18]

After studying the above described iris databases, we concluded that none of them was suitable for the evaluation of robust iris recognition methods, those where noise identification and handling assumes higher relevance. Apart from the WVU database, that contains some noise factors but significantly lacks iris secular and lighting reflections, all the remaining databases were constructed within cooperative environments. This makes them more suitable for the preliminary evaluation of iris segmentation, feature extraction or comparison strategies, when the noise factors constitute an a priori obstacle to conclude about their merits.

Based on this, we decided to build a new public and freely available iris images database - UBIRIS - with a fundamental characteristic that distinguished it from the remaining ones: it is a ”noisy iris image database” and the noise factors are not only avoided but rather induced, in order to simulate the non-cooperative image capturing. UBIRIS database is comprised of 1877 images collected from 241 subjects within the University of Beira Interior 6 in two distinct sessions and constituted, at its release date, the world’s largest public and free iris database for biometric purposes.

H. IIT Delhi Database[19]

The IIT Delhi Iris Database mainly consists of the iris images collected from the students and staff at IIT Delhi, New Delhi, India. This database has been acquired using JIRIS, JPC1000 and digital CMOS camera in Biometrics Research Laboratory during Jan - July 2007 (still in progress). The image acquisition program was written to acquire and save these images in bitmap format and is also freely available on request. The currently available database consists of images taken from 224 users which are in bitmap (*.bmp) format. All the subjects in the database are in the age group 14-55 years comprising of 176 males and 48 females. The database consists of 1120 images which is organized into 224 different folders each associated with the integer identification/number. All these images were acquired in indoor environment having resolution of images 320 x 240 pixels.

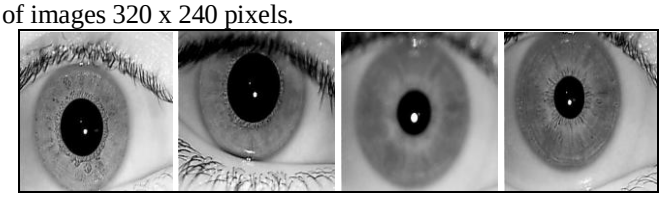

Figure 9.Examples of Iris Images from the IIT Delhi Database

VIII. INTERNATIONAL COMPETITIONS

A. ICE (Iris Challenge Evaluation) [20]

The Iris Challenge Evaluation (ICE) projects was conducted and managed by National Institute of Standards and Technology (NIST). The ICE 2005 was a developmental project for iris recognition technology. The ICE 2006 was the first large-scale, open, independent technology evaluation for iris recognition. The basic goals of the ICE projects were to gain progress in the development and advancement of iris recognition technology and assess its state-of-the-art capability. The ICE projects were freely accessible to academia, industry and research institutes.

- ICE 2006 Workshop

ICE 2006 evaluation consists of a large-scale, open, independent technology of iris recognition. ICE measured performance with sequestered data (data not previously seen by the researchers or developers) to guarantee an accurate assessment. A test methodology and standard dataset was employed so that all participants were evenly evaluated. The basic goal of ICE 2006 was to evaluate the state-of-the-art capability of automatic iris recognition technology and to establish a performance baseline against which to measure future progress. Results of this effort may provide a design input for future evaluations.

- ICE 2005 Workshop

ICE 2005 conducted an iris recognition challenge problem that was distributed to potential participants. The primary goal of recognition technology development project in ICE 2005 was to promote and advance iris recognition technology that supports existing iris recognition efforts in the U.S. Government.

B. IREX (Iris Exchange)[21]

The Iris Exchange (IREX) was started off at NIST in support of an expanded marketplace of iris-based applications based on standardized interoperable iris imagery. Initially, the work was to support the ISO/IEC 19794-6 standard and later the ANSI/NIST ITL 1-2007 Type 17 standard. Later on IREX has included dedicated activities in support of: standardization and iris image quality assessment (IREX II); performance of one-to-many algorithms (IREX III + IV); compression (IREX IV); instructions to personnel involved in iris image collection (IREX V) and time dependence of iris recognition (IREX VI).

- IREX VIII

NIST expects to coordinate IREX VIII to support implementation of the iris recognition option extended under NIST Special Publication 800-76-2. This activity of iris recognition algorithms constitutes a laboratory evaluation which is capable of producing and consuming conformant instances of ISO/IEC 19794-6:2011. The schedule for this activity is yet to be determined.

- IREX VI

NIST is glad to announce the completion of our initial investigation of iris recognition stability over time. The study is available as NIST Interagency Report 7948.

- IREX IV

IREX IV continues along the path of IREX III as an evaluation of one-to-many iris recognition for large-scale applications. IREX IV was commenced to serve two purposes: 1) to explore the potential for using cost functions for application-specific algorithm optimization; and 2) to support the ISO/IEC 19794-6 standard by defining a compression profile for the compact representation of iris images. NIST is glad to announce the availability of first part of the IREX IV evaluation report, NIST Interagency Report 7949. A second report on iris compression profiles will be coming shortly.

- IREX III

NIST deduce the IREX III evaluation of one-to-many iris algorithms in April 2012. IREX III was the first independent and public test of iris identification search technologies that used millions of images to validate results published in the academic literature that iris is a very powerful biometric. The final report and a chronology of the test are given on the IREX III homepage.

- IREX II IQCE (Iris Quality Calibration and Evaluation)

IREX II IQCE aims to evaluate the effectiveness of image quality assessment algorithms (IQAAs) that produce a scalar overall image quality in predicting the recognition accuracy of particular comparison algorithms (from the supplier of the IQAA), and of other algorithms. Furthermore, per the IREX I result that quality scores are not immediately interoperable; IQCE will establish a score calibration procedure for IQAAs.

- IREX I

IREX I was being conducted to address two issues: First is how far compression can be pushed before the accuracy of leading commercial matching algorithms begins to degrade. Second, the accuracy of iris images in compact polar form when it is prepared by one supplier and verified later by another. The program supports identity management applications where compact size and interoperability are of primary concern. These include federated identity credential or network-based applications.

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