section four

4

# Security Within Your Eyes

## - Iris Recognition Technology

"**'Eyes are the mirror of the soul',** the old Yiddish saying has become quintessential in today's society with the revolutionising Iris Recognition Technology achieving just that. Identity Theft has become the pinnacle of protection to individuals and governments around the world. Biometric solutions have lowered the risks of identity theft, but the nature of biometrics itself has its own unique disadvantages. As a person grows old, their physique changes and this poses extreme challenges in the accuracy of biometric identification systems. Iris structure on the other hand is a phonotypical feature with permanence providing the foundation for iris recognition technology."

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### 1 INTRODUCTION

Traditionally people identify a known individual in respect to appearance, speech and by contexts wherein their asserted identity is simply accepted [1]. In a more formal environment, where the individuals are strangers, identification has relied on unique possessions such as documents or secrets [1]. With the advancement in technology, the disadvantage with these unique possessions is that they enabled transactions but could not confirm the identity of the person who carried these possessions. This basic concern with traditional methods has been reduced using biometric technology. Currently the physiological features of face, finger print and iris have been internationally accepted for use to verify the identity of an individual.

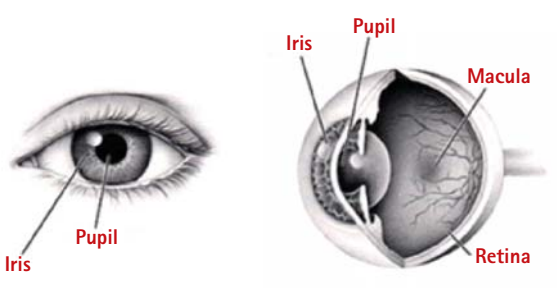


Figure 1: Iris Diagram [2]

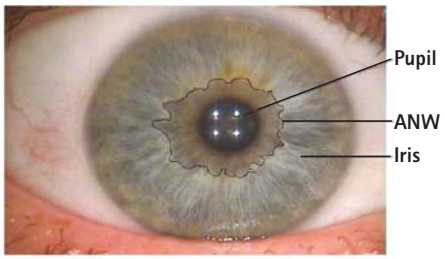


Figure 2: Iris Structure

Iris recognition technology is based on the ridges, furrow and striations that characterise the iris. The iris is the pigmented contractile membrane of the eye, suspended between the cornea and lens and perforated by the pupil. It regulates the amount of light entering the eye. The iris is the only internal organ that is routinely visible from outside. Its pattern develops during gestation and remains unchanged after birth. The patterns are extremely complex and are unique for every individual (even in fraternal or identical twins). There is no evidence for changes in iris pattern other than changes in pigmentation during the first year of life and freckles or variations caused by glaucoma treatments [1]. Patterns are easy to capture and encode using digital cameras and imitation is almost impossible.

Iris recognition is the only technology other than fingerprint capable of providing reliable one to one and one to many matching, therefore enabling deployment in a wide range of applications. Iris recognition is deployed in access control implementations, particularly those requiring high accuracy or hands-free operations; large-scale identification systems, such as those that enable entitlements issuance and customer-facing applications. The technology's resistance to false matching is an imperative in many industrial, financial and national security infrastructure environments.

## 2 BACKGROUND

The concept of using iris patterns for identification was initially proposed in 1936 by an ophthalmologist Frank Burch. Until 1987 the idea was fictionalised in movies and then two other ophthalmologists, Aran Safir and Leonard Flom patented this concept [3]. To make their patent viable, they had asked Dr John Daugman, a physicist and computer expert, to develop an applicable Gabor Wavelet based iris recognition algorithm which was awarded a patent in 1994. In 2005, the wide patent covering the basic concept of iris texture to be used for identification expired. Since then many companies have developed their own algorithms for iris recognition. Amongst these, a notable company that has done a lot of work on improving standards and formats for iris recognition is IriTech, Inc which proposed the multi-sector method for iris recognition[1].

[1] IriTech is a Virginia (USA) incorporated company, established in 2000. It is one of the two companies in the world that holds original patents on iris identification technology, "USPTO # 6,247,813" effective in 19 June 2001.

## 3 BEHIND THE TECHNOLOGY OF MULTI-SECTOR BASED IRIS RECOGNITION

Iris recognition biometrics positively identifies an individual by capturing a high resolution digital image of the iris of the eye. This process ensures that the technology is non-intrusive, meaning the individual verified does not have to have contact with the biometrics system hence eliminating communicable diseases. In achieving this, the technology also ensures that the template file generated is significantly small and therefore easier to store and retrieve. One of the key objectives is also to assure that False Acceptance Rate (FAR) is as low as possible. Current trials have shown probability in the region of $10^{-12}$ [4]. This means that if all the eyeballs on the planet were to be searched the probability of falsely accepting an enrolled identity is less than 1%. Iris recognition also enjoys one of the lowest False Rejection Rate (FRR) characteristics amongst biometric peers [4].

IriTech's technology starts with capturing digital images using four cameras; two are used for identifying an approaching individual's face and locating their irides (plural for iris) whereas the remaining two cameras capture the left and right iris images simultaneously once located by the previous cameras. The iris images are captured under infrared using black and white CCD image sensors. Colour CCD images can also be used as well.

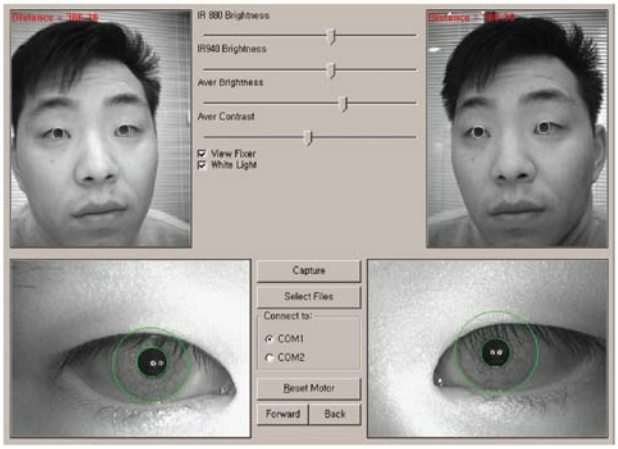


Figure 3: Capturing images

The algorithm analysis is based on the variable multi-sector method or non-circular segmentation which produces significantly more accurate results because of its ability to consider the effects of eyelashes and eyelids on iris images. For purposes of explanation only a single iris is shown in the following steps.

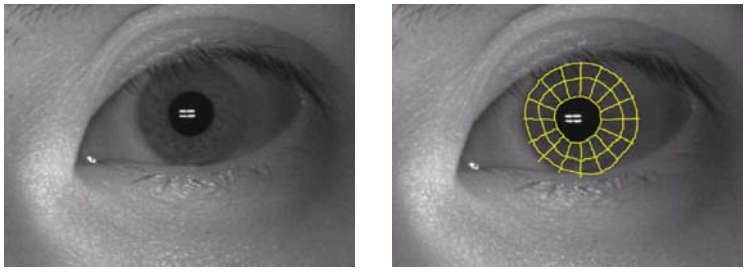

Figure 4: Boundary detection and sector extraction

The pupil and iris boundary are detected using the variable multi-sector method which defines the exact shape of the iris. With the boundary detected, the iris is extracted into sub-sectors so that each sector can be analysed individually. During the analysis, bad sectors caused by eyelids, eyelashes, reflection, tear and other obstruction are eliminated. The elimination of bad sectors is automatically confirmed with the relative change using an absolute threshold cut in energy in comparison with the neighbouring sectors and additional spectral pattern analysis.

Figure 5: Database Image (Rectilinear Format)

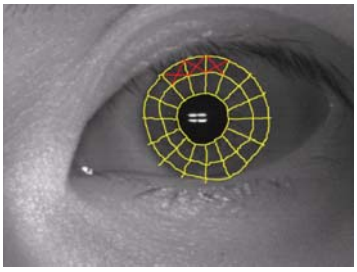

Figure 6: Polar Format

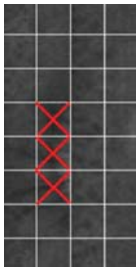

Figure 5 & 6: Database Image (Rectilinear Format) and Polar Format

The above said analysis is done in Rectilinear Format and either stored as such or unwrapped and converted into Polar Format, which leads to storage of only the iris details. When an image is presented for identification based on the stored data, the comparison is done sub-sector by sub-sector amongst the good sectors only.

The analysis is done based on frequency (wavelet) transform method and a logical (non-linear) decision process is taken for each sub-sector. The final decision weighs the sum of all sub-sector decisions. The overall decision requires a sum of minimum 10 sub-sectors out of the 32 (approximately 30%) for identification.

Figure 7: Identification Image (Rectilinear Format)

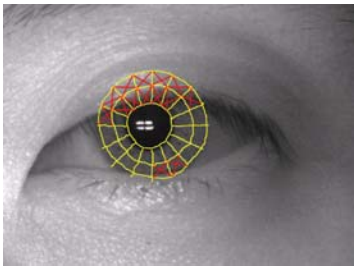

Figure 8: Polar Format

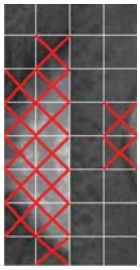

**Figure 7 & 8: Identification Image (Rectilinear Format) and Polar Format**

The challenge in iris image processing is to determine accurately the identity despite issues such as pupil dilation, blurry images, occlusions, reflections and different illuminations which causes poor quality images. This directly reflects in FAR and FRR results which qualifies the algorithm's accuracy.

## 4 GOVERNMENT EVALUATIONS

Biometrics was more affected by the events that unfolded in the United States of America on 11 September 2001 than any other technology, because many of the terrorists that were identified later were carrying falsified documents. Since then the need for biometrics has been specifically included in three pieces of legislation by the Congress: the USA Patriot Act, the Aviation and Transportation Security Act, and the Enhanced Border Security and Visa Entry Reform Act [5]. While the need for biometrics to physically secure sensitive institutions is unquestioned, the actual type of biometric data that should be used has been the subject of debate [5].

The inauguration of international passport standards by the International Civil Aviation Organization (ICAO) of the United Nations set the biometric candidates for use as facial recognition, fingerprint recognition and iris recognition. The large existing databases of fingerprints and ID card photos has placed fingerprint and facial recognition in the lead, but iris recognition is considered a contender because of its high level of accuracy and consistency. Due to the government's demand for real-world applicability, the National Institute of Standards and Technology (NIST) conducted and administrated the complete evaluation of iris technology's readiness for full scale deployments under the title Iris Challenge Evaluation (ICE). ICE Testing was conducted in two phases: ICE 2005 promoted the awareness and credibility of iris technology, and ICE 2006 was a complete evaluation of iris technology with the primary objective to establish the deployment of automatic iris recognition and to create a reference point for all future advances in the technology [6]. Using a closed database, this evaluation measured the one to one accuracy of various iris identification algorithms. Out of eight participants, IriTech was one of only three entities (two companies) able to complete this evaluation. The private database (ICE 2006) consisted of 29,056 right eye and 30,502 left eye iris images drawn from 240 subjects captured with an LG EOU 2200 camera.

## 5 STANDARDS OVERVIEW

There are two types of standards to determine support of interchangeability and interoperability. Current standards work in the area of iris recognition exists on both formal and informal levels. The formal standards bodies, also known as de jure organisations, include the official national standards bodies and internationally recognised bodies whereas the informal standards bodies involve industry consortiums otherwise known as de facto standards organisations [7].

### 5.1 Interchange Format

The major iris recognition standards are "ISO/IEC19794-6: 2005 Biometric Interchange Format - Part 6: Iris image data" and "ANSI/INCITS 379 - 2004 Iris Interchange Format". Both these standards define two alternative data formats, rectilinear and polar format for representing iris images. Rectilinear format specifies that the images stored may be raw or compressed form as specified in "ISO/IEC 15444: JPEG 2000 Image Coding System: Core Coding System", whereas the polar format specification requires per-processing and image segmentation steps which contains only the iris information making it much more compact for storage [8]. These standards also define data structures and headers to support storage of interoperable information and will provide interoperability amongst vendors by providing a compact method of human iris representation [9].

Figure 9: Rectilinear Image Format

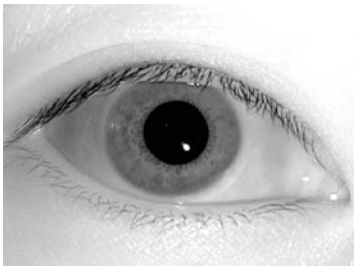

Figure 10: Polar Image Format

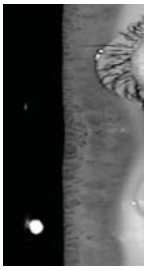

Figure 9 & 10: Rectilinear Image Format and Polar Image Format

### 5.2 Non-Circular Segmentation of Polar Image Format

When the US Congress passed into law the Aviation and Transport Security Act on 19 September 2001, the Transportation Security Administration (TSA) under US Department of Homeland Security created RTIC in 2005 to develop the common set of technical standards and processes necessary for an open, secure and industry drive Registered Traveler programme. This programme involved 68 airports and its authorities along with 47 service providers and its objective was to establish a privilege programme that expedites the passage of travellers through participating airports by using smart cards and biometrics to assure individuals' identity at the airport [10]. Iris Recognition, as a part of Facial and Fingerprint Recognition, was specified as using Rectilinear Image for enrolment and storage at a Central Information Management System (CIMS) and Unsegmented Polar Image Format for storage within the smart card [10]. Both the stored formats were to comply with the "ISO/IEC 19794-6: 2005".

Unsegmented (non-circular segmentation) Polar Image Format was proposed by IriTech as a more efficient and reliable format than the original image segmentation (circular) steps which were required after pre-processing the image. Since iris and pupil are ever slightly fluctuating in shape, they should not be segmented as a circle and calculations for recognition is less accurate when based on pupil centre to derive the circle centre.

Figure 11: Segmented (Circular) [11]

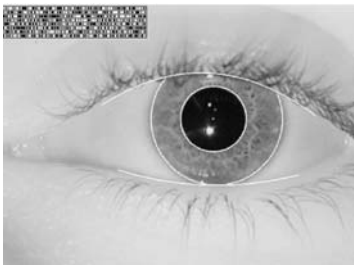

Figure 12: Unsegmented (Non-Circular) [12]

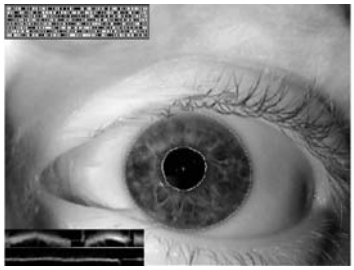

**Figure 11 & 12: Segmented (Circular) [11] and Unsegmented (Non-Circular) [12] image formats**

By comparing Figure 11 and 12, it is clearly noticeable that the pupil and iris boundaries are not perfect circles. Therefore by acquiring the pupil centre the localisation or boundary detection during the "polar unwrapping" creates indistinguishable mappings resulting in considerable mapping distortions in the segmented format [12].

## 5.3 Illumination Safety Standards

Another key factor affecting the performance of iris recognition systems is illumination because dark brown irides often record lighter with infrared photography than blue ones. The concentration of melanin pigment controls the hue of the iris hence the majority of the global population has dark iris colour that varies in different shades of brown to black [13]. Under normal lighting conditions it is very difficult to capture an image because the melanin absorbs visible light. For this reason, iris recognition systems use near infrared to illuminate the iris. This allows a much clearer image of the iris to be captured. On the other hand, a good percentage of the global population has light iris which vary in lighter shades of colour due to selective reflection and absorption from the iris' stormal components [13]. This type of iris is easily visible under normal illumination and sometimes very difficult to see its pattern under infrared light hence the illumination needs to be varied. The use of near infrared LED with wavelengths ranging from 780 nm to 940 nm is normally used for iris recognition applications.

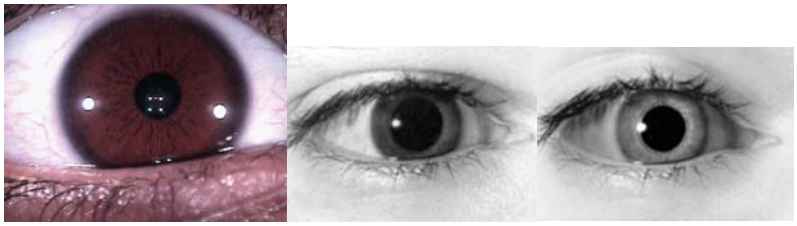

Figure 13: Brown iris pattern under normal and infrared illumination

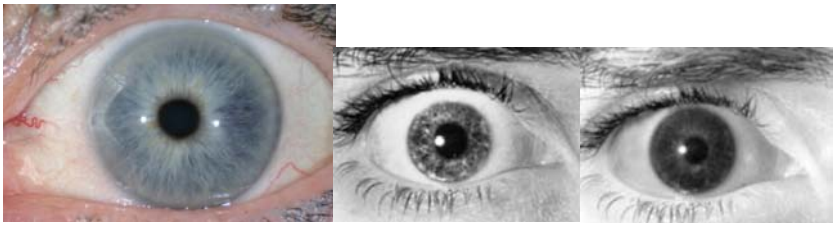

Figure 14: Blue iris pattern under normal and infrared illumination

Due to the extensive use of active (varying) infrared illumination, iris recognition systems must comply with the illumination safety standards "ANSI/IESNA RP-27.1-96" and "IEC 60825-1 Amend.2, Class 1 LED", the most recent worldwide standards in the illumination safety area, to ensure the safe use of illumination technology [14].

### 5.4 Informal Standards

Other standards such as "INCITS 398-2005 Common Biometric Exchange Formats Framework (CBEFF)", deal specifically with the data elements used to describe the biometric data in a common way. Another standard is the "INCITS 358-2002 BioAPI Specification" that defines the Application Programming Interface and Service Provider Interface for a standard biometric technology interface.

## 6 CONCLUSION

The iris recognition industry is still relatively new considering that it has migrated in a short period from fictional disposition to become automated and available for commercial use. In the past few years the evolution of the technology has been the stepping stone for a widespread deployment in curbing identity crimes. The need for growth and progress lies in the continuous research and testing with the determination and commitment of the industry, government evaluations, and standards bodies, to raise the bar for iris recognition systems. The future looks promising as the recognition algorithms become powerful and advanced camera technologies catch up to the price sensitive

consumer market. Governments are also exploring the possibility of deploying "Iris on the Move"concept with overcoming not just the technology but social issues such as privacy laws defined under their sovereign jurisdictions. All future transactions will be based on an individual's biological information in every aspect of our lives.

## 7 ACKNOWLEDGEMENTS

Many thanks to my mentor and technology partner, Dr Daehoon Kim, founder and visionary behind IriTech, Inc. Dr Kim is amongst the top pioneers in the field of Iris Recognition.

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