Iris Recognition: An Emerging Biometric Technology

SANJAY R. GANORKAR

Department of Electronics and Telecommunication Engineering

Sinhgad College of Engineering Pune, Pune University, Pune.

(INDIA) Pin code- 411041

ASHOK A.GHATOL

Vice Chancellor, Dr. Babasaheb Ambedkar Technological University, Lonere

Dist: Raigad, M.S.

(INDIA) Pin code- 411041

Abstract: In this paper, iris recognition as one of the important method of biometrics-based identification systems and iris recognition algorithm is described. As technology advances and information and intellectual properties are wanted by many unauthorized personnel. As a result many organizations have being searching ways for more secure authentication methods for the user access. In network security there is a vital emphasis on the automatic personal identification. Due to its inherent advantages biometric based verification especially iris identification is gaining a lot of attention. Iris recognition uses iris patterns for personnel identification. The system steps are capturing iris patterns; determining the location of iris boundaries; converting the iris boundary to the stretched polar coordinate system; extracting iris code based on texture analysis. The system has been implemented and tested using dataset of number of samples of iris data with different contrast quality. The developed algorithm performs satisfactorily on the images, provides 93% accuracy. Experimental results show that the proposed method has an encouraging performance.

Key-Words: Biometrics, Iris recognition, Iris normalization, personal identification, Iris localization.

1 Introduction

1.1 Overview

Today's e-security are in critical need of finding accurate, secure and cost-effective alternatives to passwords and personal identification numbers (PIN) as financial losses increase dramatically year over year from computer based fraud such as computer hacking and identity theft. Biometrics solutions address these fundamental problems, because an individual's biometric data is unique. An individual's behavioral or physiological characteristics have the capability to reliably distinguish between an authorized person and an imposter. Since biometric characteristics are distinctive, cannot be forgotten or lost and the person to be authenticated needs to be physically present at the point of identification. Biometric is inherently more reliable and are capable than traditional knowledge based and token based techniques. Biometrics includes fingerprints, retina, iris, voice, signatures, facial, thermogram, hand geometry, etc. Among all biometrics iris recognition has attracted a lot of attention because it has various advantages like greater speed, simplicity and accuracy as compared to other biometric techniques. Iris recognition relies on the unique pattern of the human iris to identify or verify and individual. In this paper we have implemented the algorithm [1], on the iris database and the results obtained are given in the paper.

1.2 Outline
This paper is organized as follows. The next section introduces the basic concepts of biometric technology. In the third section the iris structure is discussed. Various steps in iris recognition are discussed in fourth section. The fifth section shows the result of the implemented algorithm. Last section is the conclusion.

2 Basic Concepts

2.1 Verification vs Identification
Biometrics system can be used to verify and identify the person. The needs of environment will be dictated which system is chosen. The most common use of biometric is verification. Biometric system verifies user based on the information provided by the user. For example, when X enters her/his user name and password, the biometric system then fetches the template for X. If there is a match, the system verifies that the user is in fact X.

Identification is used to determine who the subject is without information from the subject. Identification is complicated because the system must perform a one-to-many comparison of images, rather than a one-to-one comparison performs by a verification system.

2.2 Biometric error analysis
All biometric systems suffer from two types of error: Type-1 is a false acceptance and Type-2 is a false rejection. Type-1 happens when biometric system authenticates an imposter. Type-2 means that the system has rejected a valid user. A biometric system's accuracy is determined by combining the rates of false acceptance and rejection.

A system that is highly calibrated to reduce the false acceptances may also increase the false rejection, resulting in more help desk calls and administrator intervention. Each error presents a unique administrative challenge. Therefore, administrators must clearly understand the value of the information or system to be protected, and then find balance between acceptances and rejection rates appropriates to that value. A poorly created enrollment template can compound false acceptance and rejection. For example, if a user enrolls in the system with dirt on his finger, it may create an inaccurate template that does not match a clean print. Natural changes in a user's physical traits may also lead to errors. The point of intersection is called the crossover accuracy of the system. As the value of the crossover accuracy becomes higher, the inherent accuracy of the biometric increases. Table (1) shows crossover accuracy of the different biometrics technology.

Biometrics	Crossover Accuracy
Retinal Scan	1:10,000,000+
Iris scan	1:131,000
Fingerprints	1:500
Hand Geometry	1:500
SignatureDynamics	1:50
Voice Dynamics	1:50

Table 1: Comparison of different biometric technology.

2.3 How a biometric system works.

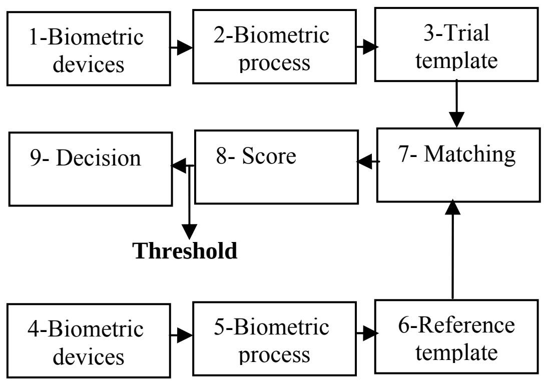

Figure 1: How a biometric system works

Figure (1) describes the process involved in using a biometrics system for security. It contains nine steps. (1) capture the chosen biometric; (2) process the biometric so as to extract and enroll the template; (3)store the template in a local repository, a central repository, or a portable token such as smart card;(4) live-scan the chosen biometric;(5)process the biometric and extract the biometric template;(6)store the reference template;(7) match the scanned biometric against stored templates;(8)provide a matching score to business applications with threshold value;(9)record a secure audit trail with respect to system.

3 Iris Structure

The iris is the colored part of the eye behind the eyelids, and in front of the lens. It is the only internal organ of the body, which is normally externally visible. These visible patterns are unique to all individuals and it has been found that the probability of finding two individuals with identical iris patterns is almost zero. Although the human eye is slightly asymmetrical and the pupil is slightly off the center [2], for the most practical cases we think of the human eye is symmetrical with respect to line of sight. The iris controls the amount of light that reaches the retina. Due to heavy pigmentation, light pass only through the iris via pupil, which contracts and dilates according to the amount of available light. Iris dimensions vary slightly between the individuals. Its shape is conical with the papillary margin located more interiorly than the root. A thickened region called the collarete divides the anterior surface into the ciliary and pupil zones.

Iris is made up of four different layers. The back layer is heavily pigmented and makes iris opaque so that light only reaches the eye through the pupil. The next layer contains the sphincter and the dilator muscles that allows for contraction and dilation. The third layer is the stroma, which is loosely connected tissue containing collagen, melanocytes, most cells and macrophases. The exterior layer is called the anterior border layer and is denser than the previous layer with more pigmentation. The color of the iris is created by different levels of light absorption in the anterior border layers, little pigmentation in this layer results in a blue appearance because light reflects from the back layer of the iris. The more pigmentation a person has in the anterior border layer, the darker is the iris. The original eye image is shown in fig.2.

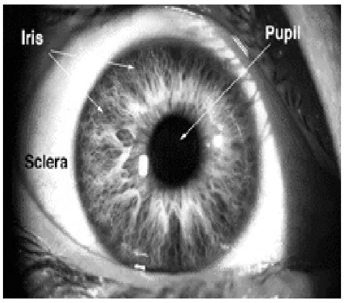

Fig.2: Original Eye Image

4 Algorithms

Many researchers have worked on various algorithms for iris recognition. Daugman [1,2,3] presented a system based on phase code using Gabor filters for iris recognition and reported that it has excellent performance on a diverse database of many images. Wildes [4] described a system for personal verification based on automatic iris recognition. It relies on image registration and image matching, which is computationally very demanding. Boles et al.[7] proposed an algorithm for iris feature extraction using zero crossing representation of 1-D wavelet transform. All these algorithms are based on grey images, and color information was not used. Because grey iris image can provide enough information to identify different individuals. In our method, the groundwork is based on John Daugman work.

The iris identification is basically divided in four steps.

1. Capturing the image
2. Defining the location of the iris
3. Feature extraction
4. Matching

4.1 Capturing the image

A good and clear image eliminates the process of noise removal and also helps in avoiding errors in calculation. 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. Here we have used the Chinese academy of sciences-Institute of automation [6] iris image database available in the public domain.

4.2 Defining the location of the iris

The next stage of iris recognition is to isolate the actual region in a digital eye image. The part of the eye carrying information is only the iris part. Two circles can approximate the iris image, one for the iris sclera boundary and another interior to the first for the iris pupil boundary. In preprocessing we do the segmentation. The segmentation consists of binary segmentation, pupil center localization, circular edge detection and remapping.

4.2.1 Binary Segmentation

For finding the pupil and limbus circular edges in the location of the pupil center is required. The segmentation is such that only pupil part is extracted.

4.2.2 Pupil Center Localization

For the binary-segmented image the row gradient is taken in one direction. The pixel location corresponding to maximum gradient is found out. Then row gradient is taken in the reverse direction. And the pixel location corresponding to maximum gradient is found out. Then similarly the distance for each row is calculated. Then maximum of all these distances is the distance corresponding to diameter of the pupil circle. The row corresponding to diameter gives us x_0 co-ordinate for pupil center. In the same way above procedure is repeated for column gradients and y_0 co-ordinate for pupil center.

4.2.3 Circular Edge Detection

Iris analysis begins with reliable means for establishing whether an iris is visible in the video image, and then precisely locating its inner and outer boundaries (pupil and limbus). Because of the felicitous circular geometry of the iris, these tasks can be accomplished for a raw input image I(x,y) by integrodifferential operators that search over image domain (x,y) for the maximum partial derivative, with respect to increasing radius 'r', of the contour integral of the I(x,y) along a circular arc 'ds' of radius 'r' and center co-ordinates (x_0,y_0).

$$\max_{(r,x_0,y_0)} \left| \frac{\delta}{\delta r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right| \qquad (1)$$

The complete operator behaves in effect as circular edge detector, that searches iteratively for maximum contour integral derivative with increasing radius at successively finer scales of analysis through three parameter space of center and radius (x_0, y_0, r) defining the path of the contour integration. In implementation, the contour fitting procedure is discretized, with finite differences serving for derivatives and summation used to instantiate integrals and convolutions. More generally, fitting contours to images via this type of optimization formulation is a standard machine vision technique, often referred to as active contour modeling. The located pupil and limbus boundaries are shown in the fig. 3

Fig. 3: The located pupil and limbus boundaries.

4.2.4 Remapping of the Iris

To make a detailed comparison between two images, it is advantageous to establish a precise correspondence between characteristic structures across the pair. The system under discussion compensates or image shift, scaling, and rotation. Given the systems' ability to aid operators in accurate self-positioning, these have proven to be the key degrees of freedom that required compensation. Shift accounts for offsets of the eye in the plane parallel to the camera's sensor array. Scale accounts for offsets along the camera's optical axis. Rotation accounts for deviation in angular position about the optical axis. Iris localization is charged with isolating an iris in a larger acquired image and thereby essentially accomplishes alignment for image shift.

The zones of analysis are established on the iris in a doubly dimensionless projected polar co-ordinate system. Its purpose is to maintain reference to the same region of iris tissue regardless both of pupillary constriction and overall image size, and hence regardless of distance to the eye and video zoom factor. This pseudo polar co-ordinate system is not

necessarily concentric, since for most eyes the pupil is not central in the iris.
A pair of dimensionless real co-ordinates (r, θ) where 'r' lies in the unit interval [0,1] and 'θ' is the usual angular quantity that is cyclic over [0,2π]. The remaping of the iris image I(x,y) from raw co-ordinates (x,y) to the doubly dimensionless non concentric polar co-ordinate system

$$I(x(r,\theta),y(r,\theta)) \rightarrow I(r,\theta). \quad (2)$$

Where x(r,θ) and y(r,θ) are defined as linear combinations of pupillary boundary points of the $(x_p(\theta),y_p(\theta))$ and the limbus boundary points along the outer perimeter of the iris $(x_l(\theta),y_l(\theta))$ bordering the sclera.

$$x(r,\theta)= (1-r)x_P(\theta) + rx_l(\theta) \quad (3)$$
$$y(r,\theta)= (1-r)y_P(\theta)+ ry_l(\theta)$$

The system uses radial scaling to compensate for overall size as well as a simple model of pupil variation based on linear stretching. This scaling serves to map Cartesian image coordinates to dimensionless polar image coordinates. The remapped iris pattern is shown in figure 4.

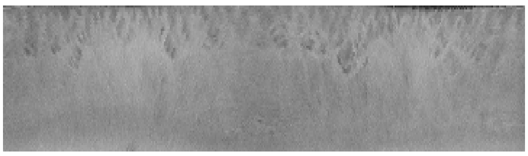

Fig. 4: Remapping of the Iris

4.3 Feature Extraction

The 2D Gabor filters used for iris recognition are defined in the doubly dimensionless polar Coordinate system(r,θ) as follow:

$$G(r,\theta)=e^{-i\omega(\theta-\theta_0)}e^{-(r-r_0)^2/\alpha^2}e^{-i(\theta-\theta_0)^2/\beta^2} \quad (4)$$

Where r and θ specify the location of the function across the zones of analysis of iris. The α and β are the multiscale 2D wavelet size parameters. And ω is the wavelet frequency. Each isolated iris pattern is then demodulated to extract its phase information using quadrature 2D Gabor wavelets. This encoding process is illustrated in Fig. 5.

Fig. 5: Encoded Iris pattern

4.4 Matching

Comparison of bit patterns generated is done to check if the two irises belong to the same person. Calculation of Hamming distance (HD) is done for this comparison. The Hamming distance is a fractional measure of the number of bits disagreeing between two binary patterns. Two similar irises will fail this test since distance between them will be small. The test of matching is implemented by the simple Boolean Exclusive-OR operator (XOR) applied to the 2048 bit phase vectors that encode any two iris patterns. Letting A and B be two iris representations to be compared, this quantity can be calculated as with subscript 'j' indexing bit position and ⊕ denoting the exclusive-OR operator.

$$\frac{1}{2048}\sum_{j=1}^{j=2048} A_j \oplus B_j \quad (5)$$

The result of this computation is then used as the goodness of match, with smaller values indicating better matches. John Daugman ,the pioneer in iris recognition conducted his tests on very large number of iris patterns (up to 3 millions iris images) and concluded that the maximum hamming distance that exists between two irises belonging to same person is 0.32.Since we were not able to access any large eyes database and able to collect only 51 images, we adopted this threshold and used it. The decision of whether these two images belong to same person depends upon following result.
If HD < = 0.32 decides that it is same person.
If HD > 0.32 decides that it is different person. (Or left and right eyes of the same person).

5 Results and Performance

We tested our project on 51 images. The algorithm is implemented in MATLAB 7. We have implemented the Daugman algorithm. The results are tested on the CASIA Iris image database version1. Pertaining to the general approach discussed in the previous sections, corresponding to pupil center localization, circular edge detection, iris encoding and matching the execution time for different process is as shown in table 2.

Process	Time in seconds
Localizing pupil center	0.174
Circular edge detection	1.155
Unwrapping the iris	1.966
Encoding iris features	1.067
Comparison of codes	0.000

Table 2: Execution time for different process.

6 Conclusions

We describe in this paper efficient techniques for iris recognition system with high performance. The iris recognition system is tested using CASIA image database. The segmentation is the crucial stage in iris recognition. We have used the global threshold value for segmentation. In the above algorithm we have not considered the eyelid and eyelashes artifacts, which degrade the performance of iris recognition system. The system gives adequate performance also the results are satisfactory. Further development of this method is under way and the results will be reported in the near future. Judging by the clear distinctiveness of the iris patterns we can expect iris recognition system to become the leading technology in identity verification.

7 Acknowledgements

I would like to express my gratitude to Chinese Academy of Sciences and Institute of Automation for providing the iris images database.

8 *References*

[1] J. G. Daugman, "High Confidence Recognition of Persons by a Test of Statistical Independence", *IEEE Trans. on PAMI*, Vol. 15, No. 11, pp. 1148-1161, 1993.

[2] Daugman, "How iris recognition works", *Proceedings of 2002 International Conference on Image Processing,* Vol. 1, 2002.

[3] Daugman, "Recognizing Persons by their Iris Patterns", *In Biometrics: Personal Identification in Networked Society,* Kluwer, pp.103-121, 1998.

[4] R. Wildes, "Iris recognition: an emerging biometric technology", *Proceedings of the IEEE*, Vol. 85, No. 9, September 1997.

[5] R. Wildes, J. Asmuth, G. Green, S. Hsu, R. Kolczynski, J. Matey, S. McBride, "A system for automated iris recognition", *Proceedings IEEE Workshop on Applications of Computer Vision*, Sarasota, FL, pp. 121-128, 1994.

[6] Chinese Academy of Sciences – Institute of Automation. *Database of 756 Greyscale Eye Images*. Version 1.0. http://www.sinobiometrics.com

[7] W. W. Boles, B. Bolash, " A human identification technique using images of the iris and wavelet transform", *IEEE transactions on signal processing*, Vol. 46, issue 4, pp11.85-1188, April 1998

[8] G. Williams, "IRIS recognition technology", *IEEE AES system Magazine,* pp. 23-29, April 1997.

[9] Jafar M.H. Ali, Aboul Ella Hassanien, "An Iris Recognition System to Enhance E-security Environment Based on Wavelet Theory," *Advanced Modeling and Optimization*, Volume5, Number 2, pp 93-104, 2003.

[10] S. R. Ganorkar, Dr. A. A. Ghatol, "Iris recognition: An emerging biometric technology", *Proceedings of international Conference ICSCI 2007, Hyderabad,* pp. 596-600, January 03-07, 2007.