Iris Recognition Based On Its Texture Patterns

M. Ezhilarasan, R. Jacthish, K.S. Ganabathy Subramanian and R. Umapathy

Department of Information Technology
Pondicherry Engineering College
Puducherry, India

Abstract- **A biometric system uniquely identifies and authenticates humans based on their physical or behavioural features. Iris recognition is one of the most reliable methods of biometric authentication that recognizes a person by pattern of the iris. No two irises are alike -not between identical twins, or even between the left eye and the right eye of the same person. The existing works on iris segmentation have been done considering the entire region of the iris. But the level of Iris texture detail typically degrades as one move away from the pupil. Hence considering the inner multi bands of iris will increase the accuracy level and also saves time.**

I. INTRODUCTION

In the present world with the advancing technologies, the necessity of security increases. So far we know the traditional security systems, such as the ID cards and passwords are still in existence. But yet they don't provide an individual's unique identification. For instance, the ID cards may be lost or the passwords may be forgotten. To overcome these unreliable security systems, the physiological and behavioral characteristics of individuals are used which paved the way for biometrics. The physiological characteristics (iris, retina, fingerprints, palm-prints, hand geometry) and behavioral characteristics (handwritten signature, voiceprint, gait, gesture, etc) are used as biometric traits.

To use biometrics as authentication mechanism, a three step process is required: an enrolment step, verification request step, and verification result step. Enrolment is the process of acquiring, digitizing and securely storing a biometric template for an individual. After enrolment, a verification request may then be made. A verification request is an attempt by someone to be verified or authenticated as being the person they claim to be. Once the verification request is made, the newly acquired template is compared against the one already stored, and an authorization result is returned which is positive or negative.

Biometrics finds its application in various fields such as Commercial, Government, Research and Military. Among the above mentioned characteristics, iris is the most reliable and unique trait and hence it is used to provide very high level of security especially in the case of military applications.

In this paper, first the approximate pupil center is detected by calculating the center of mass for the digitized eye image. Then the traversing pixel algorithm is applied to localize iris inner boundary. And to localize the iris outer boundary, Daugman's [1] Integro-differential operator is adopted.

In general, when detecting the iris part, the eyelid and eyelashes interfere and reduce the efficiency of the system, thereby affecting the FAR and FRR levels. It has been found that the level of iris texture degrades as one move away from the pupil boundary to the limbus boundary. Also by sectoring, the best bits [2] in the inner multi-bands on the left and right side are alone considered so that the interference of eyelid and eyelashes are completely ignored. From the results obtained by using only the best iris bits, the efficiency of the system is improved to a larger extent yielding better FAR and FRR levels when compared to the existing systems. Experimental results on CASIA V 1.0 iris image database (CASIA) and analysis of recognition results indicate that the proposed method is efficient and accurate.

Section II deals with the basics of Iris recognition where the basic steps of iris recognition are discussed. Section III deals with the existing works on iris recognition and their drawbacks. Section IV deals with our proposed model of the iris recognition systems. Section V deals with the Results and Discussions of proposed work. Section VI is the conclusion.

II. BASICS OF IRIS RECOGNITION

Iris recognition is one of the biometric systems which utilize iris texture patterns as a method of gathering unique information about an individual. It is considered to be one of the most reliable biometrics with some of the lowest false rejection and false acceptance rates and so it is less intrusive. Among the present biometric traits, iris is found to be the most reliable and accurate due to the rich iris texture patterns, persistence of features through the life time of an individual and it is neither duplicable nor imitable. The database used is CASIA. These characteristics make it more attractive for used as a biometric feature to identify individuals. The basic steps involved in iris recognition are as follows:

A. Eye Image Acquisition
B. Segmentation
C. Normalization
D. Encoding
E. Matching

A. EYE IMAGE ACQUISITION

The most important step in iris recognition is to obtain a good and clear eye image. It helps in noise removal and avoids errors in calculation.

This paper uses the eye images, provided by CASIA (Institute of Automation, Chinese Academy of Sciences). These images were taken solely for the purpose of iris recognition software research and implementation. Infra-red light was used for illuminating the eye, and hence they do not involve any specular reflections.

Since, the iris image should be rich in iris texture as the feature extraction stage depends upon the image quality; the image is acquired by 3CCD camera placed at a distance of approximately 9 cm from the user eye. The approximate distance between the user and the infrared light is about 12 cm. This removes specula reflection in eye images. Therefore, to capture a rich iris texture the system should have

- High resolution,
- Good sharpness and
- Good lighting condition.

B. SEGMENTATION

The purpose of segmentation is to isolate the actual iris region in a digital eye image. The success of segmentation depends on the imaging quality of eye images. The pre-segmentation process involves Gaussian smoothing to remove the noise.

Mathematically the Gaussian smoothing function can be represented as follows,

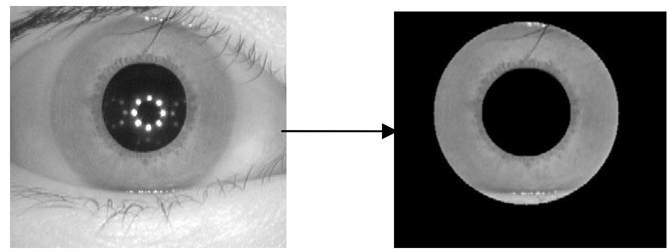
$$g(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \qquad (1)$$

Daugman [1] makes use of an integro-differential operator for locating the circular iris and pupil regions, and also the arcs of the upper and lower eyelids. The integro-differential operator is defined as,

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

Where,
I(x, y) is the eye image
r is the radius to be searched
Gσ(r) is a Gaussian smoothing function
s is the contour of the circle given by(r, x0, y0).

The operator searches for the circular path where there is maximum change in pixel values, by varying the radius and centre x and y position of the circular contour. The operator is applied iteratively with the amount of smoothing progressively reduced in order to attain precise localization. Eyelids are localized in a similar manner, with the path of contour integration changed from circular to an arc.



Input Image Output of Segmentation

Figure1: Segmentation of Iris

The Integro-differential can be seen as a variation of the Hough transform, since it too makes use of first derivatives of the image and performs a search to find geometric parameters. Since it works with raw derivative information, it does not suffer from the thresholding problems of the Hough transform. However, the algorithm can fail where there is noise in the eye image, such as from reflections, since it works only on a local scale.

C. NORMALIZATION

The homogenous rubber sheet model devised by Daugman remaps each point within the iris region to a pair of polar coordinates (r, θ) where r is on the interval [0, 1] and θ is angle [0,2π].

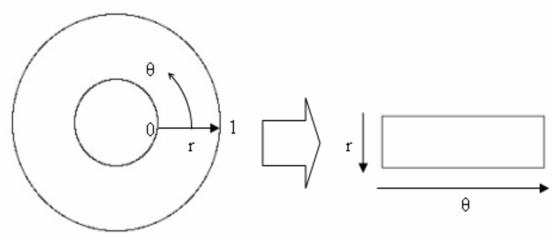


Figure 2: Daugman's Rubber Sheet Model.

The remapping of the iris region from (x, y) Cartesian coordinates to the normalized non-concentric polar representation is modeled as:

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \qquad (3)$$

$$x(r,\theta) = (1-r)x_p(\theta) + rx_l(\theta) \qquad (4)$$

$$y(r,\theta) = (1-r)x_p(\theta) + ry_l(\theta) \qquad (5)$$

Where, I(x, y) is the iris region image, (x, y) are the original Cartesian coordinates, (r, θ) are the corresponding normalized polar coordinates, and are the coordinates of the pupil and iris boundaries along the θ direction.

The rubber sheet model takes into account pupil dilation and size inconsistencies in order to produce a normalized representation with constant dimensions. In this way the iris region is modeled as a flexible rubber sheet anchored at the iris boundary with the pupil centre as the reference point.

Even though the homogenous rubber sheet model accounts for pupil dilation, imaging distance and non-concentric pupil displacement, it does not compensate for rotational inconsistencies. In the Daugman system, rotation is accounted for during matching by shifting the iris templates in the θ direction until two iris templates are aligned.

D. ENCODING

The given iris is encoded into a 256 byte value known as the Iris Code [3]. The randomness of iris patterns and the uniqueness of the iris enable the fact of generating a unique iris code for every individual. The Iris Code for a given iris image is obtained as shown in figure 3.

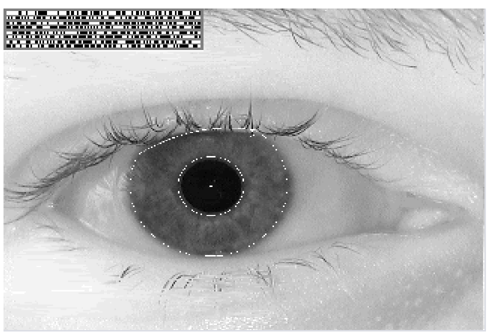


Figure 3: Iris Code

E. MATCHING

The Hamming distance [4] gives a measure of how many bits are the same between two bit patterns. Using the Hamming distance of two bit patterns, a decision can be made 20 as to whether the two patterns were generated from different irises or from the same one. Hamming distance is given by:

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j (XOR) Y_j \qquad (6)$$

In comparing the bit patterns X and Y, the Hamming distance, HD, is defined as the sum of disagreeing bits (sum of the exclusive-OR between X and Y) over N, the total number of bits in the bit pattern.

If two bits patterns are completely independent, such as iris templates generated from different irises, the Hamming distance between the two patterns should equal 0.5. This occurs because independence implies the two bit patterns will be totally random, so there is 0.5 chance of setting any bit to 1, and vice versa. If two patterns are derived from the same iris, the Hamming distance between them will be close to 0.0, since they are highly correlated and the bits should agree between the two iris codes.

III. EXISTING WORKS

John Daugman's [5] frequency approach using Integro Differential operator is the first iris recognition algorithm. Wildes [6] made use of high contrast edges for quality assessment and image intensity gradient and Hough transform for segmentation. Boles and Boashash [7] made use of edge detection for iris segmentation purpose. Avilla and Reillo [8] made use of Intensity based detection for Iris Segmentation. The recent work on iris recognition considers the left and right half of the iris region excluding the eyelashes and eyelids [9]. It makes use of pixel traversal algorithm to find the pupil center. Then by sectoring at different angles the normalization, encoding and matching is performed.

The limitation of the existing system is that it considers the entire left and right region of iris. But it has been studied that iris level degrades as one move away from the pupil. Hence it is time consuming. Also the texture level in the papillary region is very high. Hence the accuracy level can be further increased.

IV. PROPOSED WORK

The proposed system is based on the fact that the Iris detail degrades as one move away from the papillary boundary to the limbus boundary [10]. As per our proposal, after segmenting the iris from the digitized image the inner multi-bands (Regions of Interest) are identified using the following mathematical derivation:

DERIVATION:

- Total diameter of the eye ball = 24 mm
- Diameter of the iris = 11 mm
- Radius of the iris = 5.5 mm
- Diameter of the Pupil = 5mm (under normal conditions)
- Radius of the pupil = 2.5mm
- Radius of the iris (-) Radius of the pupil = 5.5-2.5 = 3 mm
- The ratio between the papillary and the ciliary region is given by,
  Pupillary Region: Ciliary Region=1:3

Hence,

- Pupillary region = (1/4)*3=0.75mm (approx.)
- Ciliary region = 3-0.75= 2.25 mm (approx.)
- REGION OF INTEREST1= 0.75mm (from the pupillary boundary)
- REGION OF INTEREST2= 2.25/2=1.125 mm (from the collarette)

Figure 4: Sectoring

Thus from the above calculations, the thickness of the pupillary region is approximately 0.75mm from the pupil boundary. Collarette is the layer that separates the papillary and ciliary region. The thickness of the Region of Interest 2 is 1.125mm.

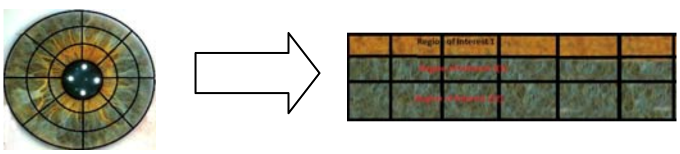


Figure 5: Normalization

After segmenting the iris region and sectoring, it is normalized using Daugman's rubber sheet model. Encoding is done by applying different filters to the two regions of interest.

V. RESULTS AN DISCUSSIONS

The proposed system was tested on Iris database, namely the CASIA. This database consists of iris images enrolled in *JPEG* format and the quality of the iris varies. The proposed system yields a very high level of accuracy.

Table1: Results of Iris Recognition

CASIA DATA BASE	Recognition rate (%)		Rejection rate (%)	
	Existing	Proposed	Existing	Proposed
V1	98.76	99.36	9.85	5.1
V2	98.46	99.50	11.4	7.8

VI. CONCLUSION

Biometric systems are widely used to overcome the traditional methods of authentication. Among the traits, iris is more reliable. The drawbacks in the existing Daugman's algorithm have been overcome by this new methodology using traversing pixel algorithm in localization and sectoring concept in the latter part of normalization. Also considering only the inner multi-bands of iris for recognition purpose saves time and improves the accuracy level. The performance table shows that biometric system performs better than the existing system with accuracy of 99.50%.

ACKNOWLEDGEMENT

This work was supported under the AICTE Research Promotion Scheme Grant No.8023/BOR/RID/RPS-124/2008-09. Main analyses of the results in this paper use CASIA iris image database.

REFERENCES

[1] John Daugman, "How Iris Recognition Works", IEEE Transactions On Circuits And Systems For Video Technology, Vol. 14, No.1, January 2004.
[2] Karen P. Hollingsworth, Kevin W. Bowyer And Patrick J. Flynn, "The Best Bits In An Iris Code", IEEE Transactions On Pattern Analysis And Machine Intelligence, Vol.31, No. 6, June 2009.
[3] Adams W.K.Kong, David Zhang And Mohamed S.Kamel, "An Analysis Of Iriscode", IEEE transactions On Image Processing, Man, And Cybernetics-Part B:Cybernetics, Vol.19, No.2, February 2010.
[4] Nathan D. Kalka, Jinyu Zuo, Natalia A. Schmid And Bojan Cukic, "Estimating And Fusing Quality Factors For Iris Biometric Images", IEEE Transactions On Systems, Man And Cybernetics-Part A; Systems And Humans, Vol.40, No.5, May 2010.
[5] John Daugman, "Biometric Personal Identification System based on Iris Analysis", U.S Patent Number 5 291 560, Mar 1, 1994.
[6] R.P. Wildes, "Iris Recognition : An Emerging Biometric Technology", Proc. IEEE, vol.85, no.9, pp.1348-1363, Sep 1997.
[7] W.W. Boles and B. Boashash, "Human Identification Technique using Images of the Iris and Wavelet Transform", IEEE Trans. And Signal Processing, vol.46, no.4, pp.1185-1188, Apr. 1998.
[8] Avilla and Reillo, "Two different approaches for iris recognition using Gabor filters and Multi-Scale Zero Crossing Representation", IEEE Pattern Recognition, vol.38, no.2, pp.231-240, Feb 2005.
[9] Mayank Vasta, Richa Singh, Afzel Noore, "Improving Iris Recognition Performance Using Segmentation, Quality Enhancement, Match Score Fusion, And Indexing", IEEE Transactions On Systems, Man, And Cybernetics-Part B:Cybernetics, Vol.38, No.4, August 2008.
[10] L. Ma, T.Tan, Y. Wang, D. Zhang ,"Personal Identification Based On Iris Texture Analysis", IEEE Transaction On Pattern Analysis And Machine Intelligence, Vol. 25, N°12, December 2003.