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Robust IRIS Recognition System based on 2D Wavelet Coefficients

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ABSTRACT

A IRIS recognition system provides automatic identification of an individual based on a unique iris feature. Iris recognition is considered as one of the most unique and exact biometric recognition system. In this paper, we implement a new technique for the development of Iris Recognition System, additionally results has been analyzed and compared with other researches work. We use the reverse biorthogonal 2-D wavelet transform in order to extract the most deterministic patterns in a human's iris and forms of a feature vector. the quantized vectors compared using the Hamming Distance, and with the proposed approach we have achieved a recognition rate 99.92% with the equal error rate 0.09% which is highest recognition rate ever being achieved in the era.

Key words: Bilinear Transformation, Biometrics, Canny Operator, Haar Wavelet, Hough Transform, Iris Recognition, Wavelet

INTRODUCTION

Today's world has become technological and with this advancement, the ways of recognition have also been changed. The most advanced way of recognition is not by seeing, listening or feeling but by using Biometrics. Biometrics is a technique of recognition of individuals through their characteristics that can be like finger prints, DNA, face or even eye retina.

Biometrics comes from two words: bio which means life and metrics which means measurement. It is a method to analyze and measure biological and physical characteristics of a body to verify and identify an individual person. This useful technology has made our lives easy in many ways. For example, we do not need a gatekeeper in offices, schools or libraries. People just swipe their fingers to get access. We do not need to browse through numerous record books to find criminal record of a person. We just scan his face or use his finger prints to find out his entire criminal history.

Biometrics Principle

The biometrics device consists of three things:

a) Scanning device: The eye image is captured with the help of this device.
b) Software: The useful information is gathered with the help of software and it is converted into digital form.
c) Database: The codes which are matched are stored in database.

The main modes are:

- Verification Mode: The stored image is compared with the new captured image.
- Enrolment Mode: The images are matched and stored in the database.

Biometrics Types

Biometrics can be classified into Behavioural and Physiological Biometrics.

1. Physiological Biometrics- Physiological biometrics remembers the characteristics of your body. Few examples are Palm veins, face recognition, DNA, palm print, finger print, odour, iris recognition etc.
2. Behavioural Biometrics: These connect and recognize the behaviour of person for example signature, voice.

HUMAN IRIS

Iris is the colored part of human eye which lies between the white sclera and the dark black pupil. Iris is circular in shape, present in front of the eye lens and cornea. Eyelid protects the Iris. Colour of the iris gives the colour to the eye.

Real life Application examples of IRIS Technology throughout the world:

- India has used this technology in preparing Adhar Card for its residents. Along with the identity, all other relevant information is also saved like education, parents' name, profession etc. Hence, only by using IRIS technology, everything about the person can be known.
- Pakistan has also used IRIS technology by name Bio ID to control aid distribution for Afghan refugees.
- The technology has also been used by National Geographic Channel to find out the girl "Sharbat Gula". Photographer Steve McCurry used the technology to find the girl who has grown up.
- UAE land, air and sea ports are also equipped with the same technology.
- US and Canada uses the technology in their airports for allowing the low-risk pre-approved passengers to enter without checking.

LITERATURE REVIEW

In [1], Daughman, explained that how the identity of a person can be verified by the pattern of his/her Iris. It is proposed that by performing a statistical test on the individual's eye image one can identify a person. Integro Differential operator was used to localize the Iris in the eye image. Iris patterns were encoded with the help of the 2-D Gabor Wavelet Coefficients. The matching of the newly taken iris code with the previously stored codes was done by Bernaulli Trail Exclusive-OR formulation. The database used is the database provided by Ophthalmology associates of Connecticut. At a Hamming Distance of 0.32, False Acceptance Rate (FAR) was 1 in 1,51,000 and False Rejection Rate (FRR) was 1 in 1,28,000. At a Hamming Distance of 0.084, FAR was 1 in 1031. It is also mentioned that the length of all the Iris codes should be same. Correct Recognition Rate, Equal Error Rate are not mentioned.

Again in [2], Daughman was first to propose the Iris Recognition algorithm in 1990s and got US patent for his work. His algorithm comprises of four steps – 1) Segmentation or Localization of the Iris, Pupil in the Eye image using Integro – Differential Operator. 2) Normalization by Rubber Sheet Model. 3) Feature Extraction using the 2-D Gabor Filter. 4) Code Matching using the XOR Operation (Hamming Distance calculation). He tested his algorithm on images taken from the database provided by Ophthalmology Associates of Connecticut. At a Hamming Distance of 0.26, chances of imposter acceptance or False Acceptance Rate was 1 in about 2 Billion and False Rejection Rate was 1 in 1,31,000. The Correct Recognition Rate was about 99.96%. The major drawback of his algorithm was that Integro - Differential Operator fails in case of noises like reflections on the iris from the light source etc. Secondly, the time taken by the whole process was very high [2].

Boles and Boashash [3], in their work they gave a different algorithm for Iris Recognition based on the Zero Crossing of the Wavelet. They overcome the shortcomings of the Daugman's algorithm. Their algorithm was capable of handling noisy condition like glares resulting from the reflections etc. It allowed possible variations in the camera to face distance. They used Edge Detection Technique for Segmentation of the Iris in the Eye image. Then Normalization of the Iris image was done to have constant diameter. After the normalization is done, the unique Iris feature was taken from the normalized Iris image by using 1-D Wavelet Transform. The Matching of the code taken and the code stored was done using Zero Crossing representation. But, they have tested their algorithm on only few numbers of images which does not tell its performance properly. The Correct Recognition Rate for their algorithm is very low i.e. 92% and equal error rate was 8.13% which is extremely high. This was the reason this algorithm was a failure.

Lin and Lu [4] proposed an iris recognition method based on the imaginary coefficients of Morlet Wavelet Transform. Firstly, they located the iris by Gray Projection and Center Detection Operator. Secondly, normalization of the iris image is done using Polar Coordinate Transform and rectangular iris image is obtained. Thirdly, for Feature Extraction 1-D Morlet Wavelet Transform is applied to the rectangular iris image row by row and a series of imaginary coefficients of wavelet transform is obtained. Then according to the imaginary coefficients, binary code of the iris image is made and iris codes are obtained. For Matching they used AND operation. They tested there algorithm on 567 images provided by the CASIA Database. The False Acceptance Rate was 0.301% and False Rejection Rate was 0.4115%. They have used Morlet Wavelet Transform and wavelet family has almost got obsolete in today's world.

Jain et al [5] presents a biometric algorithm for iris recognition using Fast Fourier Transform and moments. The images were first converted into the greyscale image then, FFT was applied which converts the image from spatial (image) domain into the frequency domain. It is more efficient to perform operations in the frequency domain than in the spatial. After that, the moments were taken, which identifies the object area, centroid, orientation etc. At last Euclidean distance formula is used for image matching. In their work they have taken the images from CASIA database. Major shortcoming of their algorithm is that they have tested their algorithm on only 10 images for matching and declared 100% Correct Recognition Rate. They have not mentioned the FAR and FRR. ERR for their work was 0.58%. Moreover, they have used Euclidean Distance formula for image matching which can make the computations slow.

In [6], Zhou and Sun gave an iris recognition system in which the iris localization is done with histogram analysis technique by converting the greyscale eye image into its binary form which contains only two values either 0 or 1. Normalization was done using Daugman's Rubber sheet Model. Feature Extraction was done by applying 1-D Log Gabor Wavelet. K- Dimensional tree is used for matching of the unique iris code. Algorithm was tested on the images provided by the CASIA database (version is not mentioned). Recognition Success Rate was 99.64%. Major drawback of his algorithm is that only limited number of iris codes can be loaded in the tree because the search efficiency decreases with increase in the tree size. Moreover, they have not mentioned the FRR, FAR and ERR, which are very important parameters to judge the performance of any algorithm.

Khan et al [8] proposed an Iris Recognition System comprising of three main steps: 1) Segmentation: They took into consideration, the assumption that the Iris colour is very much different from the Sclera. So, pupil and Iris region is detected. The pupil was detected by applying a threshold to the eye image. Then they applied Freeman's Chain code algorithm to extract the pupil. Then the Iris localization was done by applying linear contrast filter to obtain linear contrast image. After that, the average window vector is calculated. 2) Feature Extraction: 1-D Gabor Filter was used by them to extract the unique feature from the Iris. 3) Matching: They used Hamming Distance comparison for matching the iris codes. They tested their algorithm on the images provided by UBIRIS ver.1, CASIA- IRIS TWIN, IIT DELHI databases. For UBIRIS v1, session 1 CCR was 93.445%, FRR was 9.29%, FAR was 3.87%. For UBIRIS v1, session 2 CCR was 83%, FRR was 23%, FAR was 23.15%. For CASIA IRIS TWIN, FAR was 0% FRR was 0.05%.

Implementation of Proposed System

The implementation phase of our proposed work comprises mainly four phases namely

- Iris localization
- Iris normalization and enhancement
- Feature extraction
- Matching

The each phase is briefly described in Fig. 1-3.

Iris Localization

In iris localization we basically locate iris region form an eye image for the localization of iris we have used canny edge detection together with Hough circular transform.

Iris Normalization and Enhancement

For removing the iris size inconsistency we normalize the iris image in rectangular coordinates, for normalization we have used Daugman rubber sheet modal formally we improve the iris image using histogram equalization.

Feature Extraction

For feature extraction we used reverse biorthogonal 2-D wavelet transform with this wavelet we would be able to reduce the feature size of iris template to 13 times more, now further we binarized the iris feature using the assumption that the coefficient which are having size more than one will be consider as one and discarded the negative values of the coefficient so that we would be able to apply hamming distance over the coefficient.

Matching

For the matching of the iris template we used hamming distance, The Hamming distance will be defined as follows:

$$HD = \frac{1}{N}\sum_{j=1}^{N} X_j \oplus Y_j \tag{1}$$

Where X_j and Y_j are the two bit wise template to compare and N is the number of bits represented by each templates. The Hamming distance can be computed using the elementary logical operator XOR (Exclusive-OR) and thus can be completed very quickly.

RESULT AND DISCUSSION

To evaluate the performance of the proposed method, the iris images are collected from the largest available database UBIRIS Almost 1290 images of 258 different persons are taken. The entire testing is done on the MATLAB 7.5 platform and the laptop of 1.85GHz processor and 1GB RAM is used to run our prototype model.

As it is clear from Fig. 3, that the inner class and inter class hamming distances are lying separately and there is no overlapping between both the hamming distances. Which shows the portion of graph responsible for the FAR and the table 1 shows the total outcome of our algorithm.

Table -1 Performance Evolution of Our Work

	HD	FAR	FRR
Proposed Method	0.45	0.1%	0.06%

Where the **False Acceptance Rate** (FAR) and **the False Rejection Rate** (FRR), defined as the accepting of a false person and rejecting of a genuine person for a given value of hamming distance respectively.

The performance evolution of any iris recognition system is done on the basis of Recognition Rate (RR) and Equal Error Rate (EER), defined as the number of the correct recognition and the point where the FAR and FRR both are equal in value respectively. In this case, the value of RR is 99.92% and EER is 0.09%. The table 2 shows the comparison of existing and well-known iris recognition and table 3 shows the speed comparison between existing systems. Both the tables show that the algorithm which has been proposed here has a higher recognition rate as well as higher speed. Although, Daugman system has high recognition rate than the proposed system, but the Daugman system comparatively has low speed. On the other hand the Boles system offers high speed but it has low recognition rate and higher EER. Therefore when both speed and recognition rate are taking into consideration, the proposed algorithm is far better than the existing ones.

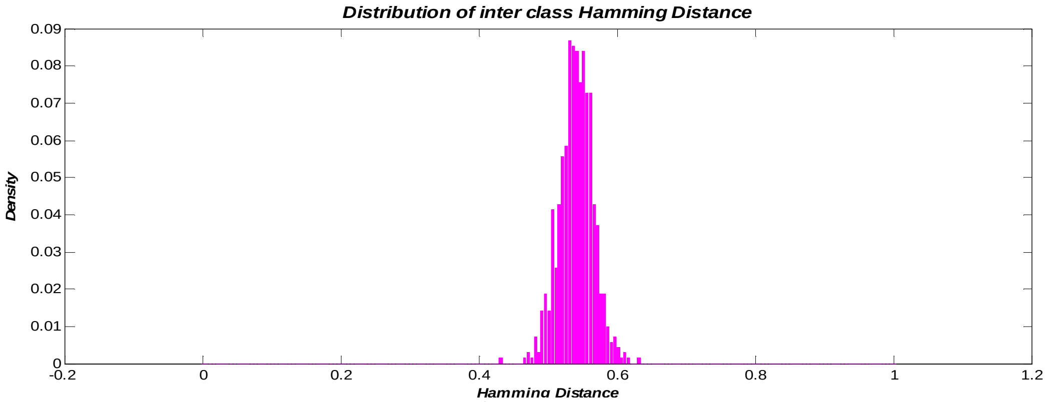

Fig.1 Distribution of inter class hamming distance

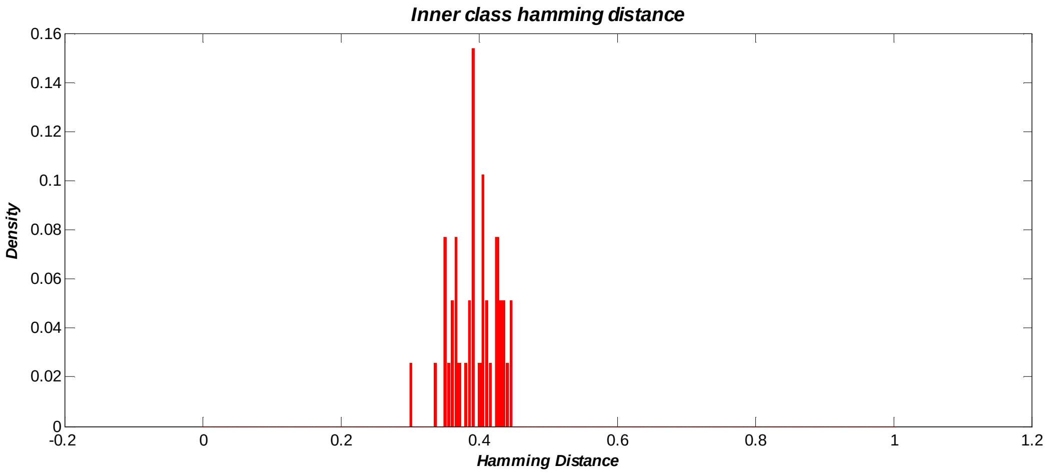

Fig. 2 Distribution of inner class hamming distance

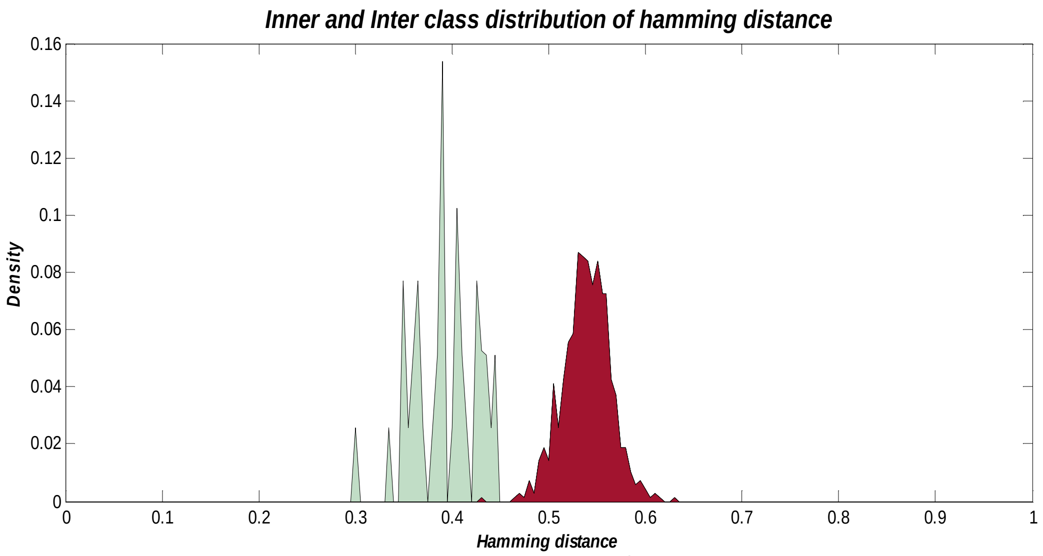

Fig. 3 inner and inter class distribution of hamming distance

Table -2 Comparison between RRs and EERs

Methods	Recognition rates	Equal error rates
Daugman	100%	0.08%
Boles	92.64%	8.13%
Tan	99.19%	0.57%
L.Ma	99.60%	0.29%
Proposed	99.92%	0.09%

Table -3 Speed comparisons between Existing Methods

Methods	Feature Extraction(ms)	Matching (ms)	Total(ms)
Daugman	682.5	4.3	686.8
Boles	170.3	11.0	181.3
Wildes	210.0	401.0	611.0
Tan	426.8	13.1	439.9
L.Ma	260.2	8.7	268.9
proposed	180.687	1.8	178.887

CONCLUSION

This Paper has described an iris recognition system, which has tested over UBIRIS databases of grayscale eye images, and with the proposed approach we build a unique and strong enough system which is far better than the any other system present in the literature not only in terms of recognition rate but also in terms of processing time.

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