IRIS Recognition using Texture Features Extracted from Haarlet Pyramid

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ABSTRACT
Iris recognition has been a fast growing, challenging and interesting area in real-time applications. A large number of iris recognition algorithms have been developed for decades. The paper presents novel Haarlet Pyramid based iris recognition technique. Here iris recognition is done using the image feature set extracted from Haar Wavelets at various levels of decomposition. Analysis was performed of the proposed method, consisting of the False Acceptance Rate and the Genuine Acceptance Rate. The proposed technique is tested on an iris image database having 384 images. The results show that Haarlets level-5 outperforms other Haarlets, because the higher level Haarlets are giving very fine texture features while the lower level Haarlets are representing very coarse texture features which are less useful for discrimination of images in iris recognition.

Keywords
Iris recognition, Haarlet Pyramid, Haarlet Levels**,** False Acceptance Rate, Genuine Acceptance Rate**.**

1. INTRODUCTION
The term iris recognition refers to identifying, by computational algorithms, an unknown iris image. **Iris recognition** is a method of biometric authentication that uses pattern-recognition techniques based on high-resolution images of the irises of an individual's eyes. This operation can be done by means of comparisons between the unknown iris and iris images stored in the database.

In the area of human computer interaction, an ultimate goal is for machine to understand, communicate with and react to humans in natural ways. Although there are many other avenues to person identification – gait, clothing, hair, voice, and height are all useful indication of identity of the person, none are as compelling as iris recognition.

Iris recognition systems have a wide range of applications, especially when dealing with security applications, like computer and physical access control, real-time subject identification and authentication, and criminal screening and surveillance.

Retina scanning, iris recognition uses camera technology, with subtle infrared illumination reducing reflection from the convex cornea, to create images of the detail-rich, intricate structures of the iris. Converted into digital templates, these images provide mathematical representations of the iris that yield unambiguous positive identification of an individual.

Glasses or contact lenses do not interfere with the operation of iris recognition technology. Very few surgical procedures involve altering the iris, in which case re-enrolment in the database would be necessary. Blind people, as long as they have an iris present to scan, can likewise be identified with iris recognition technology.

Iris recognition technology offers the highest accuracy in identifying individuals as compared to any other method available. This is because no two irises are alike - not between identical twins, or even between the left and right eye of the same person. Irises are also stable; unlike other identifying characteristics that can change with age, the pattern of one's iris is fully formed by ten months of age and remains the same for the duration of their lifetime.

A key advantage of iris recognition is its stability, or template longevity, as, barring trauma, a single enrolment can last a lifetime. Because of its speed of comparison, iris recognition is the only biometric technology well-suited for one-to-many identification.

2. HAAR TRANSFORM
This sequence was proposed in 1909 by Alfréd Haar [13]. Haar used these functions to give an example of a countable orthonormal system for the space of square-integral functions on the real line. The study of wavelets, and even the term "wavelet", did not come until much later [14]. The Haar wavelet is also the simplest possible wavelet. The technical disadvantage of the Haar wavelet is that it is not continuous, and therefore not differentiable. This property can, however, be an advantage for the analysis of signals with sudden transitions, such as monitoring of tool failure in machines. The Haar wavelet's mother wavelet function ψ(t) can be described as:

$$\psi(t) = \begin{cases} 1 & ,0 \le t < \frac{1}{2} \\ -1 & ,\frac{1}{2} \le t < 1 \\ 0 & ,\text{otherwise} \end{cases} \quad (1)$$

and its scaling function φ(t) can be described as:

$$\varphi(t) = \begin{cases} 1 & ,0 \le t < 1 \\ 0 & ,\text{otherwise} \end{cases} \quad (2)$$

3. HAARLETS

The procedure of generating Haarlets [2,12] is shown in flowchart given in figure 1 and can be explained as given in following steps.

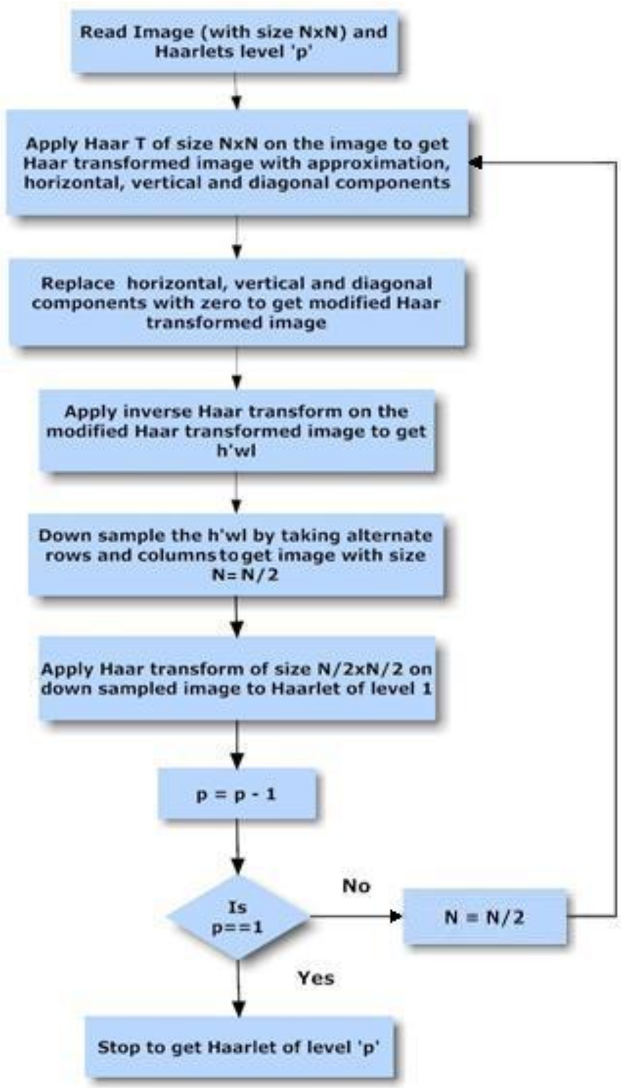

Fig. 1 Flowchart for generating Haarlets of level 'p'

Let I_{NXN} be the image with size NxN of which Haarlets are to be obtained and H_{NxN} be the Haar transform matrix of size NxN.

a) Apply Haar transform of size NxN on the image of size NxN to get Haar transformed image with approximation (hIA), horizontal (hIH), vertical (hIV) and diagonal (hID) components.

$$hI_{NxN} = [hIA, hIH, hIV, hID]$$
$$= [H_{NxN}]\,[I_{NxN}]\,[H'_{NxN}]$$

b) Replace horizontal (hIH), vertical (hIV) and diagonal (hID) components with zero to get modified Haar transformed image 'hwI'.

$$hwI_{NxN}=[hIA, Zero, Zero, Zero] \quad (4)$$

c) Apply inverse Haar transform on the modified Haar transformed image to get h'wI.
$$h'wI_{NxN}=[H'_{NxN}]\,[hwI_{NxN}]\,[H_{NxN}] \quad (5)$$

d) Down-sample the result of step'c' (h'wI) by taking alternate rows and columns to get image with size N/2xN/2.
$$dhI_{N/2xN/2}= \text{down sample}(\,h'wI_{NxN}) \quad (6)$$

e) Apply Haar transform of size N/2xN/2 on down-sampled image ($dwI_{N/2xN/2}$) to get the Haarlet of level1.
$$\text{Haarlet Level I} =[H_{N/2xN/2}]\,[dwI_{N/2xN/2}]\,[H'_{N/2xN/2}] \quad (7)$$

f) Repeat steps b to e 'P-1' times on the level 1Haarlet to get Haarlet of level 'P'.

4. HAARLETS PYRAMID

The Haarlets of a particular image for different levels, when considered together gives Haarlet Pyramid [2]. Here for generating first level of Haarlet pyramid Haar transform is applied on image to get approximation, horizontal, vertical and diagonal components. The approximate components of first level Haarlet are considered to be transformed with Haar T to get second level Haarlet. The Haarlet pyramid of sample images are shown in figure 2 given below. Where the iris image is decomposed into three levels of Haarlet pyramid as Haarlet level-1, Haarlet level-2 and Haarlet level-3.

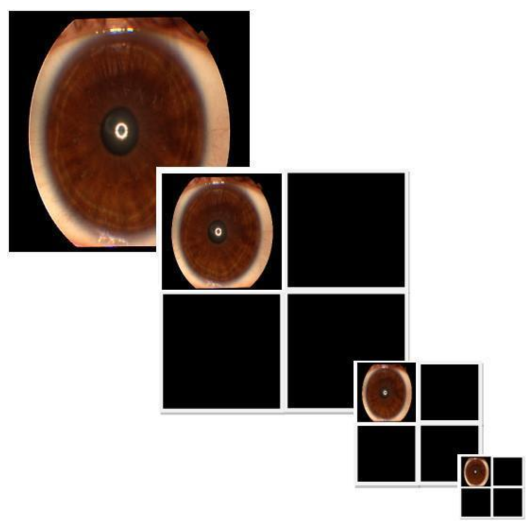

Fig. 2 Different Levels of Haarlet Pyramid

5. EUCLIDEAN DISTANCE [3-9]

We have used Euclidean distance [3-9] on the feature set as the similarity measure. The Direct Euclidian Distance between training image P and test image Q can be given as equation (6), where Vpi and Vqi be the feature vectors of training image P and test image Q respectively of size 'n'.

$$ED = \sqrt{\sum_{i=1}^{n} (Vpi - Vqi)^2} \quad (6)$$

6. PROPOSED TECHNIQUES

6.1 Iris Image Feature Extraction

Here the approximate components of Haarlet level-1, Haarlet level-2,....,Haarlet level-7 are obtained for every image in the database and Haar transforms of respective sizes are applied on them, the results are stored as feature vectors for respective image. At level-1 Haarlet the feature vector size is N/2xN/2. At level-2 Haarlet the feature vector size is N/4xN/4 and so on. Thus the feature vectors for upto level-7 Haarlets are extracted and the feature vector database is generated.

6.2 Iris Recognition

Here the feature set of Haarlet level-p is extracted as a feature set for query image using proposed technique of Haarlet generation. Then these are matched with Haarlet level-p feature vector database using Euclidian distance as similarity measure. As compared to applying complete Haar T on the image, this proposed method takes fewer computations to extract the feature set and gives better precision and recall values.

For image of size NxN complete Haar needs $2N^2\log_2(N)$ additions and for Haarlet of level-p the number of additions needed are $2(N/2^p)^2 \log(N/2^p)$ as the size of feature vector would be $(N/2^p)x(N/2^p)$. This gives tremendous reduction in query execution time using higher Haarlet level.

7. IMPLEMENTATION

7.1 Platform

The experiments were performed on Matlab R2009b, Intel Core 2 Duo T8100 (2.1 Ghz).

7.2 Database

The techniques are tested on Iris Database created at Palacky University[18]. This database has 6x64 (i.e. 3x64 left and 3x64 right) iris images (each with 512 pixels by 512 pixels), corresponding to 64 persons, including both males and females. The irises were scanned by TOPCON TRC50IA optical device connected with SONY DXC- 950P 3CCD camera. The images were taken in a single session. The six images taken per person for three people are shown in Figure 3.

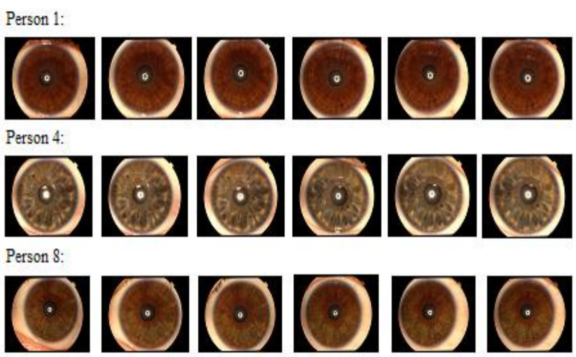

Fig. 3 Sample Images from Iris Database

8. RESULTS & DISCUSSIONS

The false acceptance rate (FAR) [11] is the measure of the likelihood that the biometric security system will incorrectly accept an access attempt by an unauthorized user. A system's FAR typically is stated as the ratio of the number of false acceptances divided by the number of identification attempts.

The genuine acceptance rate (GAR) [10] is the measure of the likelihood that the biometric security system will correctly accept an access attempt by an authorized user. A system's GAR typically is stated as the ratio of the number of correct acceptance divided by the number of identification attempts.

The FAR and GAR values were calculated for the comparison of all the images in the database. Average of the FAR and GAR values of the all the images in each level were taken together, forming the average FAR and GAR for the particular level.
During performance testing a test image was considered and five more images of the same person were compared and displayed, so percentage correct detection is the percentage of relevant images it returned and percentage incorrect detection is the amount irrelevant images it returned.

In all 384 queries were tested on our database for analysing the performance of proposed iris identification techniques. The table (TABLE 1) gives the percentage of FAR and GAR for iris identification using variations in Haarlet based techniques. Here it is observed that Haarlet-level-5 gives the best performance. It outperforms complete Haar transform and because of reduced feature vector size gives faster recognition.

TABLE 1: FAR/GAR for various Haarlet levels

	GAR(in %)	FAR(in %)
COMPLETE	61.45833	38.54167
LEVEL 1	61.45833	38.54167
LEVEL 2	60.76389	39.23611
LEVEL 3	61.80556	38.19444
LEVEL 4	62.5	37.5
LEVEL 5	64.58333	35.41667
LEVEL 6	63.19444	36.80556
LEVEL 7	60.76389	39.23611

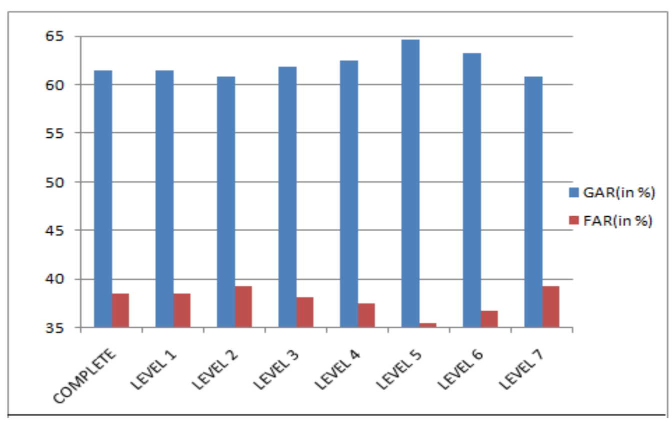

Fig.4 FAR/GAR Using Haarlets on Our database

9. CONCLUSION

Recognition accuracy, robust method and computational costs are topics that must be taken into account when analyzing an iris recognition method. The FAR/GAR values show that Haarlets are outperforming Haar based image retrieval, proving that Haarlets has better discrimination capability. Also Haarlets of level-5 is giving better performance than other Haarlets because higher level Haarlets are giving very coarse texture features while lower level Haarlets are giving too fine texture features losing discrimination capability, which are not really useful in iris recognition and proper texture properties are carved by Haarlets level-5 at greatly reduced query execution time. The proposed method (Haarlets-level-5) is also suitable for real time applications.

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11. AUTHOR BIOGRAPHIES

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