# Iris Recognition using Texture Features Extracted from Walshlet 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 Walshlet Pyramid based iris recognition technique. Here iris recognition is done using the image feature set extracted from Walsh 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 Walshlet at level-5 outperforms other Walshlets, because the higher level Walshlets are giving very fine texture features while the lower level Walshlets are representing very coarse texture features which are less useful for discrimination of images in iris recognition.

## Categories and Subject Descriptors
1.4 Image Processing and Computer Vision
1.4.2 Compression (Coding):- Approximate methods
H.3.3 [Information Search and Retrieval]

## General Terms
Algorithms, Performance

## Keywords
Iris recognition, Walshlet Pyramid, Walshlet 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.

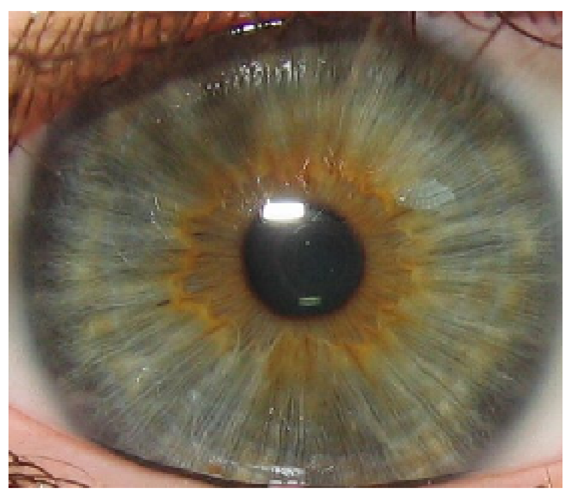

**Fig. 1 Sample Iris Image [18]**

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.

### 1.1 Existing Implementations

There are already existing deployments of iris recognition technology. The quick review of these deployments is taken here. United Arab Emirates IrisGuard's Homeland Security Border Control has been operating an expellee tracking system in the United Arab Emirates (UAE) since 2001, when the UAE launched a national border-crossing security initiative. Today, all of the UAE's land, air and sea ports of entry are equipped with systems. All foreign nationals who possess a visa to enter the UAE are processed through iris cameras installed at all primary and auxiliary immigration inspection points. To date, the system has apprehended over 330,000 persons re-entering the UAE with fraudulent travel documents. One of three biometric identification technologies internationally standardized by ICAO (International Civil Aviation Organization) for use in future passports (the other two are fingerprint and face recognition). Iris recognition technology has been implemented by BioID Technologies SA in Pakistan for UNHCR repatriation project to control aid distribution for Afghan refugees. Refugees are repatriated by UNHCR in cooperation with Government of Pakistan, and they are paid for their travel. To make sure people do not get paid more than once, their irises are scanned, and the system will detect the refugees on next attempt. The database has more than 1.3 million iris code templates and around 4000 registrations per day. The one-to-many iris comparison takes place within 1.5 seconds against 1.3 million iris codes. At Schiphol Airport, Netherlands, iris recognition has permitted passport-free immigration since 2001. A U.S. Marine Corps Sergeant uses an iris scanner to positively identify a member of the Baghdadi city council prior to a meeting with local tribal leaders, sheiks, community leaders and U.S. service members. One of such examples is UK's IRIS — Iris Recognition Immigration System. It has also been used to verify the recognition of the "Afghan Girl" (Sharbat Gula) by National Geographic photographer Steve McCurry [17]. In a number of US and Canadian airports, as part of the NEXUS program that facilitates entry into the US and Canada for pre-approved, low-risk travelers. In several Canadian airports, as part of the CANPASS Air program that facilitates entry into Canada for pre-approved, low-risk air travelers.

## 2. WALSH TRANSFORM [12-15]

Walsh transform matrix [12-15] is defined as a set of N rows, denoted Wj, for j = 0, 1, ... , N - 1, which have the following properties:

- Wj takes on the values +1 and -1.
- Wj[0] = 1 for all j.
- WjxWkT=0, for j k and WjxWkT =N, for j=k.
- Wj has exactly j zero crossings, for j = 0, 1,.., N-1.
- Each row Wj is either even or odd with respect to its midpoint.

Walsh transform matrix is defined using a Hadamard matrix of order N. The Walsh transform matrix row is the row of the Hadamard matrix specified by the Walsh code index, which must be an integer in the range [0, ..., N - 1]. For the Walsh code index equal to an integer j, the respective Hadamard output code has exactly j zero crossings, for j = 0, 1, ... , N - 1.

Full 2-Dimensional Walsh transform applied on an image of size NxN requires only additions and no multiplications. The number of additions required are $2N^2(N-1)$.

# 3. WALSHLETS

The procedure of generating Walshlets [2,13] is shown in flowchart given in figure 2 and can be explained as given in following steps. Let $I_{NXN}$ be the image with size NxN of which Walshlets are to be obtained and $W_{NxN}$ be the Walsh transform matrix of size NxN.

a) Apply Walsh transform of size NxN on the image of size NxN to get Walsh transformed image with approximation (wIA), horizontal (wIH), vertical (wIV) and diagonal (wID) components.

$$wI_{NxN} = [wIA, wIH, wIV, wID] = [W_{NxN}] [I_{NxN}] [W'_{NxN}] \quad (1)$$

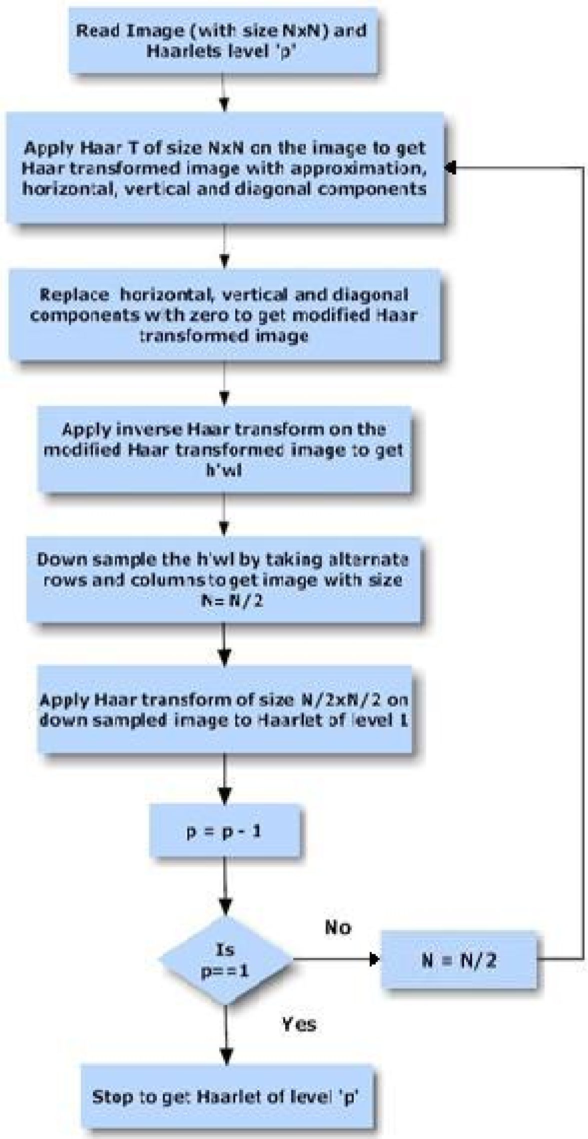


**Fig.2 Flowchart for generating Walshlets of level 'p'**

b) Replace horizontal (wIH), vertical (wIV) and diagonal (wID) components with zero to get modified Walsh transformed image 'mwI'.

$$mwI_{NxN}=[wIA, Zero, Zero, Zero] \quad (2)$$

c) Apply inverse Walsh transform on the modified Walsh transformed image to get m'wI.

$$m'wI_{NxN}=[W'_{NxN}] [mwI_{NxN}] [W_{NxN}] \quad (3)$$

d) Down Down-sample the result of step 'c' (m'wI) by taking alternate rows and columns to get imagewith size N/2xN/2.

$$dwI_{N/2xN/2}= downsample( m'wI_{NxN}) \quad (4)$$

e) Apply Walsh transform of size N/2xN/2 ondown sampled image ( $dwI_{N/2xN/2}$ ) to get theWalshlet of level-1.

Walshlet Level I =

$$[W_{N/2xN/2}] [dwI_{N/2xN/2}] [W'_{N/2xN/2}] \quad (5)$$

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

## 4. WALSHLETS PYRAMID

The Walshlets of a particular image for different levels, when considered together gives Walshlet Pyramid [2,12]. Here for the first level of Walshlet pyramid Walsh transform is applied on image to get approximation, horizontal, vertical and diagonal components. The approximation components of first level Walshlet is considered to be transformed with Walsh to get second level Walshlet. The Walshlet pyramid of sample images is shown in figure 3 given below. The iris image is decomposed into three levels of Walshlets pyramid as Walshlet level-1, Walshlet level-2 and Walshlet level-3.

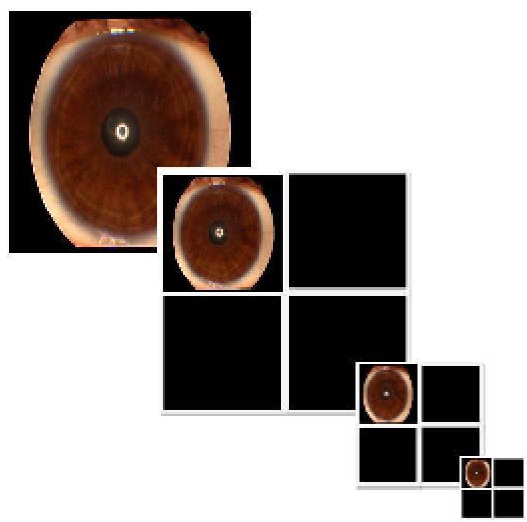

**Fig. 3 Different Levels of Walshlet Pyramid [2]**

## 5. EUCLIDEAN DISTANCE [3-9]

We have used Euclidean distance 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 Walshlets level-1, Walshlets level-2,....,Walshlet level-7 are obtained for every image in the database and Walsh transforms of respective sizes are applied on them, the results are stored as feature vectors for respective image. At level-1 Walshlet the feature vector size is N/2xN/2. At level-2 Walshlet the feature vector size is N/4xN/4 and so on. Thus the feature vectors for Walshlets upto level-7 are extracted and the feature vector database is generated.

## 6.2 Iris Recognition

Here the feature set of Walshlet level-p is extracted as a feature set for query image using proposed technique of Walshlet generation. Then these are matched with Walshlet level-p feature vector database using Euclidian distance as similarity measure. As compared to applying complete Walsh 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 Walsh needs $2N^2(N-1)$ additions and for Walshlet of level-p the number of additions needed are $2(N/2^p)^2$ $[(N/2^p) -1]$ as the size of feature vector would be $(N/2^p)x(N/2^p)$. This gives tremendous reduction in query execution time per higher Walshlets level.

# 7. IMPLEMENTATION

## 7.1 Platform

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

## 7.2 Iris Database

The techniques are tested on Iris Database created at Palacky University [16]. 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 4.

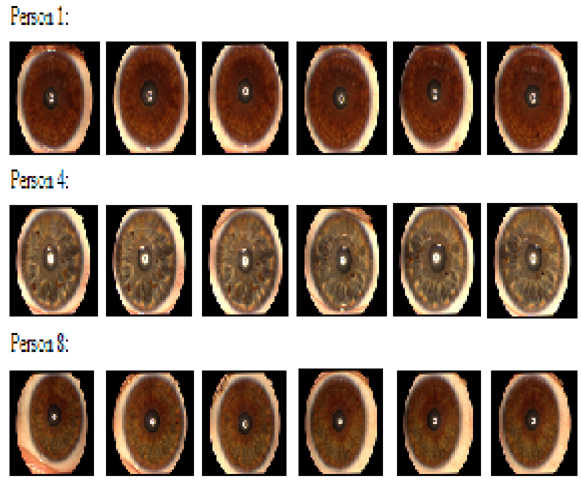


**Fig. 4 Sample Images from Iris Database**

# 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.

**TABLE 1: FAR/GAR for various Walshlet levels**

| | GAR | FAR |
|---|---|---|
| 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 | 61.80556 | 38.19444 |
| LEVEL 5 | 65.27778 | 34.72222 |
| LEVEL 6 | 61.45833 | 38.54167 |
| LEVEL 7 | 60.93056 | 39.06944 |

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 Walshlet based techniques. Here it is observed that Walshlet-level-5 gives the best performance. It outperforms complete Walsh transform and because of reduced feature vector size gives faster recognition as lower number of coefficients are used for comparison.

Figure 5 gives the FAR and GAR values for each level of Walsh Wavelet considered showing Walshlet level 5 giving best performance as indicated by highest genuine acceptance ration and minimum false acceptance ratio.

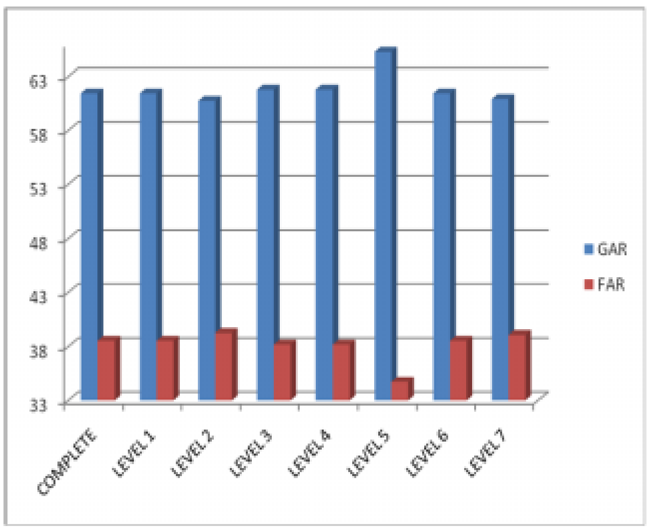


**Fig.5 FAR/GAR Using Walshlets on Our database**

## 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 Walshlets are outperforming Walsh based image retrieval, proving that Walshlets has better discrimination capability. Also Walshlets of level-5 is giving better performance than other Walshlets because higher level Walshlets are giving very coarse texture features while lower level Walshlets are giving too fine texture features losing discrimination capability, which are not really useful in iris recognition and proper texture properties are carved by Walshlets level-5 at greatly reduced query execution time.

The proposed method (Walshlets-level-5) is also suitable for real time applications.

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