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Science

Iris Recognition using Haar Wavelet Transform

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Abstract
Automatic iris recognition system is reliable for automatic personal identification. This research aims to recognize and identify iris among many that were stored in database. It is includes, after entered iris image, image preprocessing, feature extraction based on texture analysis using Haar Wavelet transform to capture both local and global features details in an iris and iris identification (matching process) based on the Euclidean distance between the new input iris and templates stored in the database then choose the minimum distance between them. So the score degree can determine the genuine or imposter person. The database can display information about any processed iris. The study conclusion that Haar wavelet transform was efficient distinguished and noise sensitive under different conditions.

Introduction
Today, biometrics recognition is a common and reliable way to authenticate the identity of a living person based on physiological or behavioral characteristics. Iris, as showed in Fig.(1), is a kind of physiological biometrics feature. It contains unique texture and is complex enough to be used as a biometrics signature [1]. Compared with other biometrics features such as face and fingerprint, iris is a thin membrane on the interior of the eyeball. It is more stable and reliable, imitation is almost impossible [2]. The iris is unique to people and patterns of iris are formed by six months after birth, stable after a year. They remain the same for life. Furthermore, iris recognition systems can be non-invasive to their users [3,4].

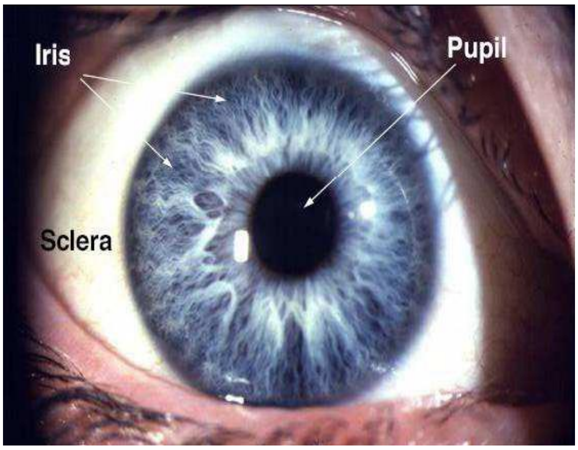

Fig. (1) Iris of human eye.

Background
Numerous algorithms have been proposed for using iris as a biometric. Daugman [5] describes a system that uses Gabor transforms to extract the textural content of an iris image. Wildes [6] employs the Laplacian of a Gaussian (LOG) filter to extract features from the iris image. Noh et al. [7] make use of multi resolution Independent Component Analysis (ICA) to generate discriminating features. Zhang and Salganic off [8] analyzed the sharpness of the pupil/iris boundary for the same purpose. Ma et al. [9] proposed a quality classification scheme to categorize iris images into four classes, namely clear, defocused, blurred and occluded.

In this research propose a novel iris quality measure based on Haar Wavelet Transform applies a pair of low-pass and high-pass filters to regions of the iris texture.

Theoretical Approach
Main Steps of Iris Recognition
There are four steps to iris recognition, iris acquisition, iris localization and normalization, iris feature extraction and matching verification.

Iris Localization and Normalization
The first processing step consists in locating the inner and outer boundaries of the iris, see Fig.(2).

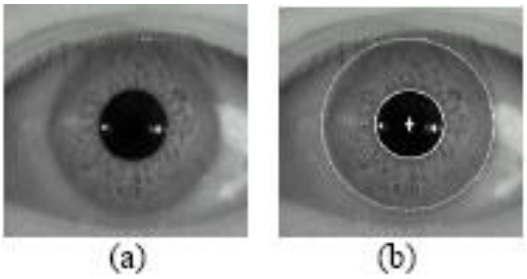

Fig.(2) (a)Iris Image (b) Inner and Outer boundaries of Iris.

In the John Daugman’s system [10], Integro-differential operators are used to detect the center and diameter of the iris and the pupil respectively (see Equation 1). These operators exploit both the circular geometry of the iris and the pupil. Indeed they behave as a circular edge detector since the sclera is always lighter than the iris, and pupil generally darker than iris for healthy eye.

$$\max(r,x_0,y_0)=\left\{\frac{\partial}{\partial r}\int I(r*\cos\theta+x_0,\ r*\sin\theta+y_0)\right\} \quad ....(1)$$

Where (x_0, y_0) denotes the potential center of the searched circular boundary, and r its radius[11].

However it appears that *integro-differantial* operators are sensible to the pectacular spot reflection of the non-diffused artificial light (AlGaAS emitting near infrared diodes, which operate in the 750 to 960 nanometers range) pointing toward the center of the user’s eye can used it in order to eliminate artifacts on the eye image due to environmental light. Whenever this spot takes place in the pupil near from the iris/pupil frontier, the detection of the inner boundary of the iris fails.

Consequently we introduce a detection strategy based on the combination of the i*ntegro-differential* operators with a *Hough* Transform. It consists in using firstly an edge calculation technique to approximate the position of the eye in the global image (center of the pupil), and secondly *integro- differential* operators to search more precisely pupil boundary, iris center and iris boundary. Actually the strategy makes use of gradient decomposed *Hough* Transform [12], which is a crafty variant of the *Hough* Transform applied to circular form detection. From the circle equation $(x-x_o)^2+(y-y_o)^2 = r^2$, r being the radius, we express the center (x_o,y_o) coordinates in function of the two first-order gradient components (Gx along axis x, Gy along axis y) as follows:

$$\left.\begin{aligned} X_o &= x \pm \frac{r}{\sqrt{1+\frac{Gy^2}{Gx^2}}} \\ y_o &= y \pm \frac{r}{\sqrt{1+\frac{Gx^2}{Gy^2}}} \end{aligned}\right\} \quad ....(2)$$

The gradients Gx and Gy are computed both during the unique travel of the eye image. Thus the problem is reduced to increment the number of occurrences for each supposed center through two accumulators (X_o in x, Y_o in y), and to determine the point (x_o,y_o) of the image where it appears a maximum in the accumulators.

$$\left.\begin{aligned} X_o(x_o) &= \sum_x \sum_y \sum_{r=r_{min}}^{r_{max}} nbr.occurence\ x_o \\ y_o(y_o) &= \sum_x \sum_y \sum_{r=r_{min}}^{r_{max}} nbr.occurence\ y_o \end{aligned}\right\} \quad ....(3)$$

Considering only gradient components superior to a minimum threshold (defined experimentally) allows reducing the time computation. Taking the sign of the gradients into account plays also an important role to exclude potential center that have coordinates outside of the eye image.

Haar Wavelet Transform and Iris Feature Extraction

The Haar wavelet, which Alfred Haar discovered in 1910, is both powerful and pedagogically simple. The basic Haar wavelet is a piecewise constant function that is defined as follows [13]:

$$\Psi_{[0,1]}(r) = \begin{cases} 1, & 0 \le r < \frac{1}{2} \\ -1, & \frac{1}{2} \le r < \\ 0, & otherwise \end{cases} \quad \text{……………………………………..(4)}$$

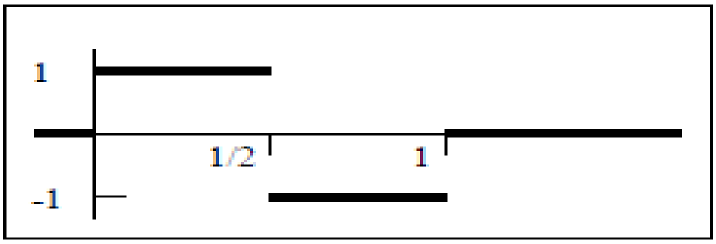

Fig. (3) The standard Haar wavelet.

In the Haar wavelet transformation method, low-pass filtering is conducted by averaging two adjacent pixel values, whereas the difference between two adjacent pixel values is figured out for high-pass filtering.

The Haar wavelet applies a pair of low-pass and high-pass filters to image decomposition first in image columns and then in image rows independently. As a result, it produces four sub-bands as the output of the first level Haar wavelet. The four sub-bands are LL1, HL1, LH1, and HH1. Upto four levels of decomposition are done to get the detail image [14].

The WT separates an image into a lower resolution approximation image (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) detail components. The process can then be repeated to compute multiple scale wavelet decomposition, as in the three scales WT shown in Fig.(4).[15].

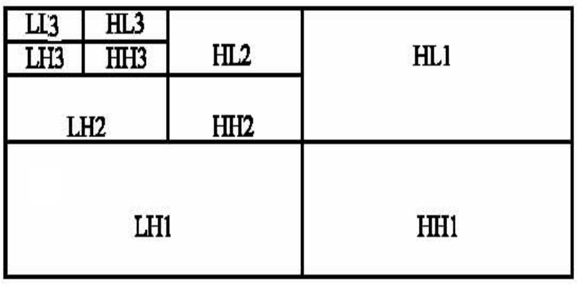

Fig. (4) Structure of Wavelet Decomposition.

The Haar transform is derived from the Haar matrix. An example of a 4*4 Haar transformation matrix is shown below [16] [17].

$$H_4 = \frac{1}{\sqrt{4}} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ \sqrt{2} & -\sqrt{2} & 0 & 0 \\ 0 & 0 & \sqrt{2} & -\sqrt{2} \end{bmatrix}$$

……………………………………(5)

The Haar transform can be thought of as a sampling process in which rows of the transformation matrix act as samples of finer and finer resolution [17].

Compute Average Absolute Deviation

The *A*verage *A*bsolute *D*eviation (AAD) is computed from the mean of filtered images to define the feature vector or the Iris Code for Iris image.

Matching

Among all the image metrics, Euclidean distance is the most commonly used due to its simplicity. Let x, y be vectors from 1 to n value, $x=(x_1,x_2,\dots,x_n)$, $y=(y_1,y_2,\dots,y_n)$, Euclidean distance $d_E(x,y)$ is [18]:

$$d_{E(x,y)} = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2} \quad \text{……………………….(6)}$$

With

x_i :represent iris code features for (x) images

y_i :represent iris code features for (y) images

Iris matching is based on finding the Euclidean distance between the corresponding Iris Codes.

The input Iris Code is matched with templates stored in the database to obtain different matching scores.

In a biometric system operating of verification mode, there are four possible outcomes:

1) genuine acceptance (correct score 0);
2) genuine acceptance (correct when score lower than threshold T);
3) imposter rejection (incorrect);
4) imposter rejection (incorrect when score higher than threshold T).

The first and the second outcomes are correct while the third and the fourth outcomes are Incorrect [20].

Proposed Iris Recognition System

The proposed iris recognition system contains four main steps, iris image acquisition, iris localization and normalization, iris feature extraction, average absolute deviation computing and matching. Fig.(5) illustrates steps of the proposed system.

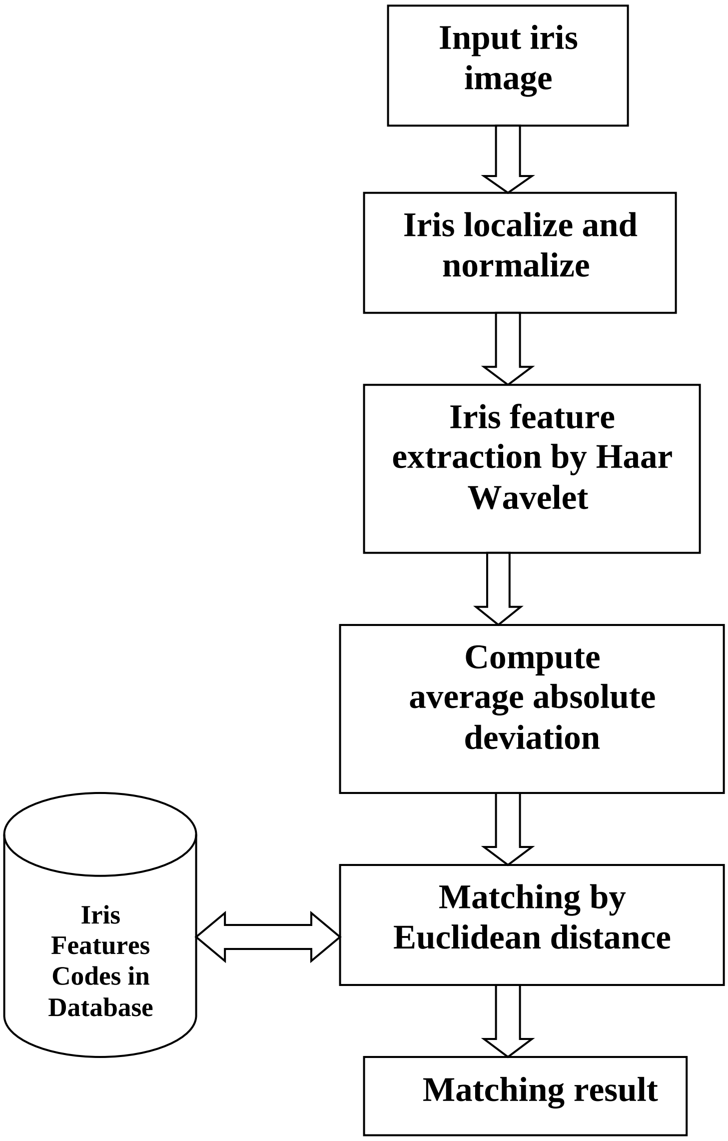

Fig. (5) Proposed iris recognition system.

Database of Research

For the purpose of testing the performance of this proposed algorithm, Program has been written in a Vbasic 6.0 language and constructed an iris image database which contains 50 Iris images given from website [19]. These images are from 15 different volunteers (both male and female) and different location from camera. 15 samples from our iris database are shown in Fig.(6).

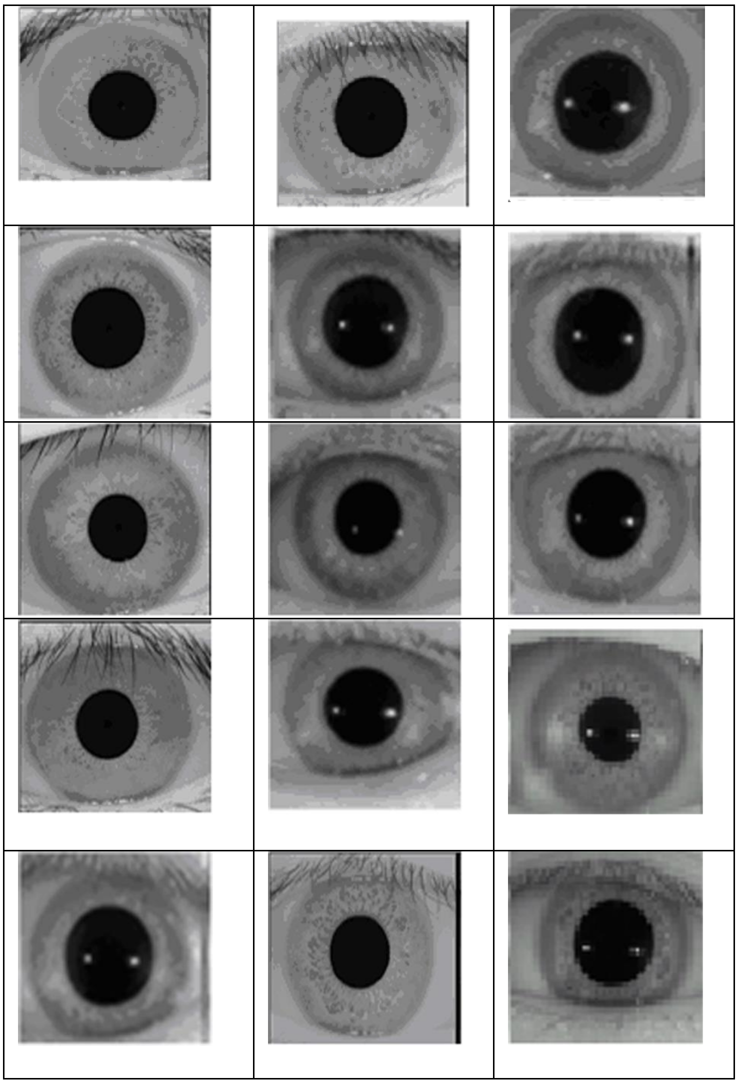

Fig. (6) Iris Samples.

Experiments and Results

The verification accuracy of our iris representation and matching approach, input Iris is matched with each iris images in the database. A matching is labeled correct (Score 0) if the same iris did yield identical Iris Code, (see Table (1)). Also A matching is labeled correct (when score lower than threshold T) because of Iris Code for input iris nearly same any Iris in Database (see Table (2)). A matching is labeled incorrect if the same iris did not yield nearly IrisCode, The value of threshold T empirically about 9.

Table (1)
Examples of genuine Acceptance (Correct Score 0).

No	*Picture Name*	*X,Y coordinates of point When Iris Image Stored*	*X,Y coordinates of point When Input Iris Image*	*Matched Result*	*Picture Name With Matched*	*Score of Match*	*Ratio of Match*
		X,Y click	*X,Y click*				
1	A1	114 , 124	114 , 124	Success	itself	0	%100
2	A2	136 , 110	136 , 110	Success	itself	0	%100
3	A3	65 , 176	66 , 178	Success	itself	0	%100
4	A4	151 , 143	154 , 143	Success	itself	0	%100
5	A5	141 , 147	141 , 146	Success	itself	0	%100

Table (2)
Examples of genuine Acceptance (Correct Score lower than T).

No	*Picture Name*	*X,Y coordinates of point When iris image Stored*	*X,Y coordinates of point When Input iris image*	*Matched Result*	*Picture Name With Matched*	*Score of Match*	*Ratio of Match*
		X,Y click	*X,Y click*				
1	A2	136 , 110	136 , 109	Success	itself	2.83	%97.17
2	A2	136 , 110	141 , 111	Success	itself	4.28	% 95.74
3	A2	136 , 110	133 , 102	Success	itself	8.40	% 91.60
4	A2	136 , 110	144 , 100	Success	itself	7.17	%92.83
5	A2	136 , 110	147 , 112	Success	itself	8.31	%91.69
6	A6	116 , 146	119 , 145	Success	itself	8.62	%91.38
7	A7	72 , 164	75 , 169	Success	itself	1.66	%98.34
8	A2	136 , 110	146 , 108	Success	itself	8.31	%91.69

Conclusions

A proposal algorithm for iris recognition has been presented. Hough transform is useful for segmentation of the iris because of efficient localization. The Haar wavelet transform has a number of Advantages, it is conceptually simple, fast, memory efficient and reversible when compared with other wavelets. A fixed length feature vector is obtained. Experimental results show that proposal algorithm can effectively distinguish different persons by identifying their irises. It is also computationally efficient and insensitive to illumination and noise. Our future work will focus on more robust iris features as well as iris recognition from image sequences.

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الخلاصة

نظام تمييز القزحيه من الانظمة الشائعة والمعتمده لتعريف الاشخاص تلقائياً. يهدف هذا البحث لتمييز وتعريف القزحيه من بين عدة قزحيات مخزونه في قاعدة بيانات Database حيث يتضمن البحث بعد ادخال صورة القزحية يتم اجراء معالجات لتحديد موقع القزحيه ثم أستحصال خصائصها المحلية والعامة باعتماد تحويل هار الموجي عليها ومن ثم اجراء عملية الموائمة باستخدام قياس المسافة الاقليدية بين خصائص القزحية التي تدخل الى النظام والقزحيات المخزونة في قاعدة البيانات بأحتساب اقل مسافة بين تلك الخصائص وبذلك يتم قبول او رفض القزحيه على اساس تلك المسافة وامكانية عرض معلومات الشخص الكاملة من قاعدة البيانات. أستنتجت الدراسة بأن تحويل هار الموجي كان كفوء تمييزي وحساس للتشويش للصور تحت ظروف مختلفة.