IRIS RECOGNITION USING GABOR FILTERS+

Ali Abdul Mun'im Ibrahim*

Abstract

Automatic Iris Recognition System is reliable for automatic personal identification. This research is an attempt to recognize and identify iris among many that were stored in Database. It is composed of iris image acquisition, image preprocessing, feature extraction based on texture analysis using bank of gabor filters to capture both local and global details in an iris, the feature value is the Average Absolute Deviation (AAD) of each filtered image constitutes the components of our feature vector. These features are arranged to form feature vector (IrisCodes). Iris identification (matching process) based on the Euclidean distance the new input IrisCode is matched with templates IrisCode stored in the database to obtain different matching scores. So the Score degree can determine the genuine or imposter person. The Database can display information(person name,Iris image) about any processed iris.

المستخلص:

نظام تمييز القزحيه من الانظمة الشائعة والمعتمده لتعريف الاشخاص تلقائيا". هذا البحث هو محاوله لتمييز وتعريف القزحيه من بين عدة قزحيات مخزونه في قاعدة بيانات Database باستخدام مجموعة مرشحات كابور حيث يتألف البحث من كيفية الحصول على صورة القزحيه ومن ثم اجراء معالجات لتحديد موقع القزحيه بتحديد حافتيها الداخلية والخارجية ثم اجراء تقسيم لتلك المنطقة المراد استحصال خصائصها الى قطاعات Sectors.

ان مجموعة مرشحات كابور لها القابلية للحصول على التفاصيل والخصائص المحلية والعامة في القزحيه وجعلها بأطوال ثابتة بواسطة احتساب المعدل المطلق لانحراف كل قطاع وتخزن على شكل متجه ومن ثم تتم الموائمة عبر المقارنة بين متجه خصائص القزحية التي تدخل الى النظام ومتجه خصائص القزحيات المخزونة في قاعدة البيانات باستخدام احدى الطرق الاحصائية البسيطة(المسافة الاقليدية) وذلك بأحتساب اقل فرق بين متجهات تلك الخصائص وبذلك يتم قبول او رفض القزحيه على اساس ذلك الفرق وامكانية عرض معلومات الشخص (اسم الشخص ، صورة القزحية) المخزنه في سجلات قاعدة البيانات.

1. Introduction

1.1. Overview

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 figure (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

+Received on 17\7\2007 , Accepted on ٢١\٧\٢٠٠٨ .

*Assist. Lecturer\Technical College of Management-Baghdad.

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].

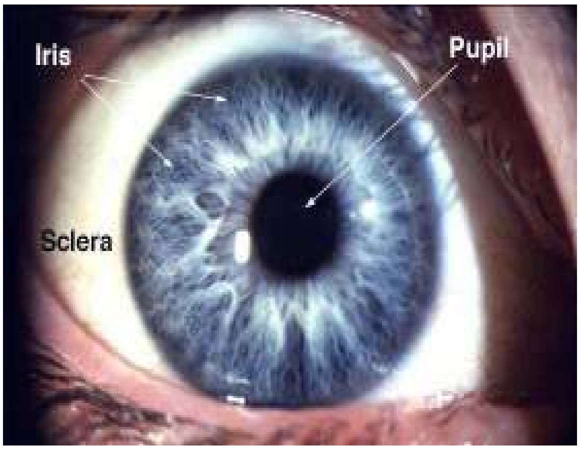


Figure (1)

1.2. Outline

The remaining parts of this research are organized as follows: section(2) explains iris image acquisition. Section (3) denoted to iris localization and normalization. Section (4) explains features representing the patterns are extracted. Section (5) denoted to matching process by Euclidean distance. Finally, section (6) illustrates Experiments Results and conclusions.

1.3.Iris Image Acquisition

Iris is small in size and most dark in color, it is difficult to acquire good images for analysis using the standard CCD camera and ordinary lighting[5]. To capture the rich details of iris pattern, a monochrome CCD camera (480*640) have been used because near-infrared (NIR) illumination wavelengths between approximately 700 and 900 nanometers(nm). See figure (2), [6].

Figure (2)

3. Iris Localization and Normalization

The first processing step consists in locating the inner and outer boundaries of the iris, see figure (3).

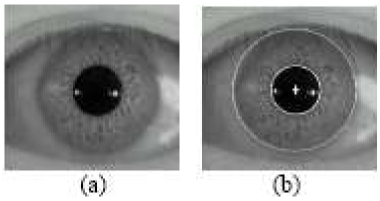


Figure (3)

In John Daugman's system[7], 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 or the pupil. Indeed they behave as a circular edge detector since the sclera is always lighter than then iris, and pupil generally darker than iris for healthy eye.

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

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

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 We 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 integro-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 [8], which is a crafty variant of the Hough Transform applied to circular form detection. From the circle equation $(x-x0)^2+(y-y0)^2 = r^2$, r being the radius, we express the center (x0,y0) coordinates in function of the two first-order gradient components (Gx along axe x, Gy along axe y) as follows:

$$X_0 = x \pm \frac{r}{\sqrt{1+\frac{Gy\ 2}{Gx\ 2}}} \qquad \text{Eq.2}$$

$$y_0 = y \pm \frac{r}{\sqrt{1+\frac{Gx\ 2}{Gy\ 2}}}$$

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 (X0 in x, Y0 in y), and to determine the point (x0,y0) of the image where it appears a maximum in the accumulators.

$$X_0\ (x_0) = \sum_x \sum_y \sum_{r=r_{\min}}^{r_{\max}} nbre.occurence.x_0$$

$$y_0\ (y_0) = \sum_x \sum_y \sum_{r=r_{\min}}^{r_{\max}} nbre.occurence.y_0 \qquad \text{Eq.3[8]}$$

where nbre.occurence is the number of occurrences for x0 and y0 respectively between the radius of pupil(rmin) and the radius of iris(rmax).

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.

4. Iris Feature Extraction Algorithm

The three main steps in our feature extraction algorithm are:

1) tessellating the region of interest around the Pupil
2) filtering the region of interest in eight different directions using a bank of Gabor filters (eight directions are required to completely capture the local ridge characteristics in a Iris while only four directions are required to capture the global configuration);
3) computing the *A*verage *A*bsolute *D*eviation from the mean (AAD) of gray values in individual sectors in filtered images to define the feature vector or the IrisCode.

4.1. Tessellate the region of interest a round Pupil

Let I(x, y) denote the gray level at pixel (x, y) in an M × N Iris image and let (x_c, y_c) denote a point in pupil. The region of interest is defined as the collection of all the sectors S_i, where the i^{th} sector S_i is computed in terms of parameters (r,θ) as follows[9]:

$S_i = \{ (x,y) \mid b(T_{i+1}) \le r \prec b(T_{i+2}),\ \theta_i \le \theta < \theta_{i+1},\ 1 \le x \le N,\ 1 \le y \le M \}$

$T_i = \text{int}\,(i / k)$ …..Eq. 4

$\theta_i = (i \bmod k) \times (2\pi / k)$ Eq. 5

$r = \sqrt{(x-x_c)^2 + (y-y_c)^2}$ Eq. 6

$\theta = \tan^{-1}((y-y_c)/(x-x_c))$ Eq. 7

b is the width of each band, k is the number of sectors considered in each band, and i = 0 • • • (B × k- 1), where B is the number of concentric bands considered around the reference point for feature extraction. These parameters depends upon the image resolution and size of Iris image. In this work, experiment with database (image size = 256 × 256 pixels, scanned at 600 dpi), we considered five concentric bands (B = 7) for feature extraction and segmented into sixteen sectors (k = 20) (Figure 4), we have a total of 20 × 7 = 140 sectors (S0 through S139) and the region of interest is a circle of radius 60 pixels, centered at the reference point. 140 features for each of the eight filtered images provide a total of 140 × 8 =1120 features per Iris image.

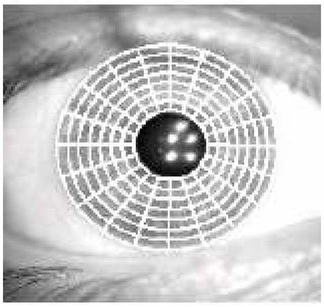


Figure (4)

4.2. Gabor filtering

In recent years, Gabor filter based methods have been widely used in computer vision, especially for texture analysis. Gabor elementary functions are Gaussians modulated by sinusoidal functions. It is shown that the functional form of Gabor filters conforms closely to the receptive profiles of simple cortical cells, and Gabor filtering is an effective scheme for image representation [10]. A two-dimensional (2D) even Gabor filter can be represented by the following equation in the spatial domain:

$$G(x,y;\theta,f)=\exp\left\{-\frac{1}{2}\left[\frac{x'^2}{\delta_{x'}^2}+\frac{y'^2}{\delta_{y'}^2}\right]\right\}\cos(2\pi f x')$$

$$x' = x\cos\theta + y\sin\theta$$

$$y' = y\cos\theta - x\sin\theta$$

Eq.8[11]

Where f is the frequency of the sinusoidal plane wave along the direction θ from the x-axis, δx' and δy' are the space constants of the Gaussian envelope along x' and y' axes respectively. Further details of Gabor filters may be found in [10][11].

Convolution with Gabor filters is still the major contributor f to the overall feature extraction time. We set the filter frequency to the average ridge frequency (1/k), where k is the average inter-ridge distance. The average inter-ridge distance is approximately 6 pixels in a 600 dpi Iris image. If f is too large, spurious ridges are created in the filtered image whereas if f is too small, nearby ridges are merged into one. We have used eight different values for θ (0∘ , 22.5∘ ,45∘ , 67.5∘ ,90∘ , 112.5∘ , 135∘ , and 157.5∘) with respect to the x-axis.

Each subimage is respectively filtered by these Gabor filters. This leads to a total of 1120 (8 for each subimage) output images from which the iris features are extracted.

4.2. Feature vector

Let F $_{i\theta}$ (x,y) be the θ-direction filtered image for sector S_i.

Now, $\forall i \in \{0,1,....139\}$ and

$$\theta \in \{0^\circ, 22.5^\circ, 45^\circ, 67.5^\circ, 90^\circ, 112.5^\circ, 135^\circ, 157.5^\circ\},$$

the feature value, V $_{i\theta}$, is the average absolute deviation from the mean defined as:

$$V_{i\theta} = \frac{1}{n_i}\left(\sum \left|F_{i\theta}(x,y) - P_{i\theta}\right|\right) \quad \text{Eq.9}$$

Where n_i is the number of pixels in Si and $P_{i\theta}$ is the mean of pixel values of $F_{i\theta}(x,y)$ in sector Si . The average absolute deviation of each sector in each of the eight filtered images defines the components of our feature vector. Our empirical results showed that using Average Absolute Deviation AAD features give slightly better performance than variance features as used in features values[12]. The 1120-dimensional feature vectors (Iris Codes) for Iris image.

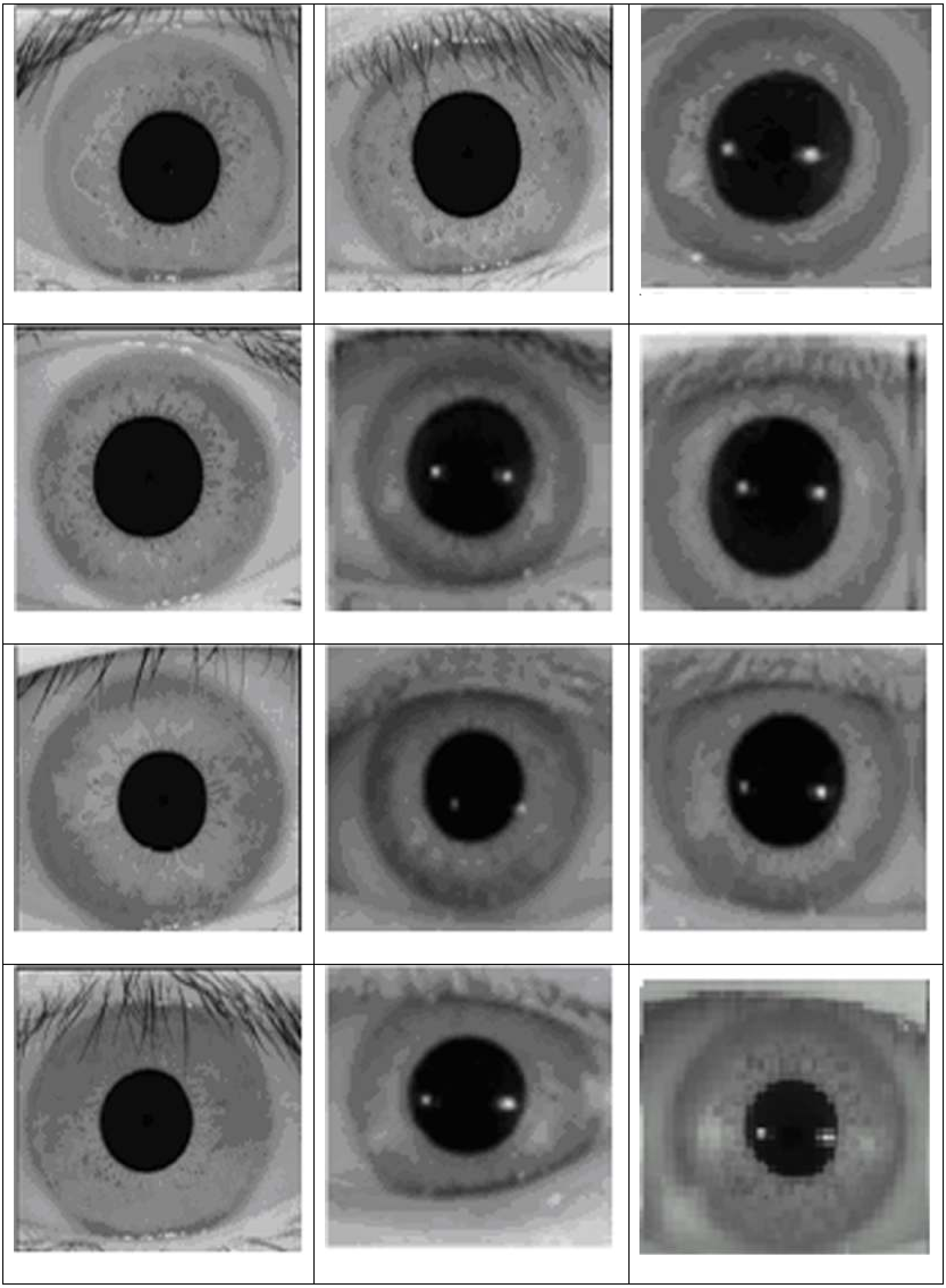
5. Matching

Iris matching is based on finding the Euclidean distance between the corresponding IrisCodes. The input Iris Code is matched with templates stored in the database to obtain different matching scores.

6. Experiments results and Conclusions

6.1. Experiments and results

For the purpose of testing the performance of this proposed algorithm, an iris image database is to be constructed which contains 50 iris images taken from website of iris image(www.sinobiometrics.com). 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 Figure 4.



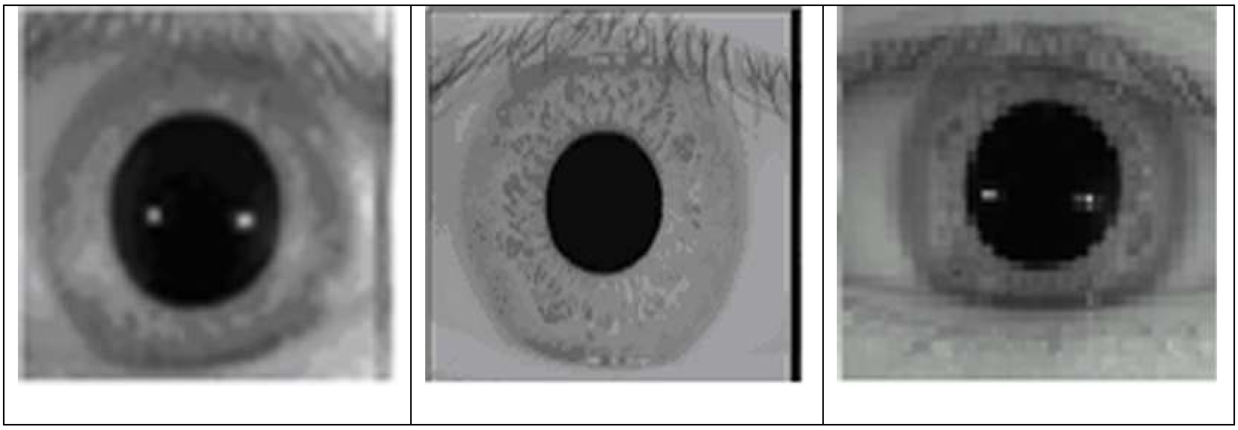


Figure 4. Iris Samples.

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

1) genuine acceptance (correct score 0);

2) genuine acceptance (correct when score lower than threshold T);

2) 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.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 IrisCode, (see table (1)). Also A matching is labeled correct (when score is lower than threshold T) because IrisCode for input iris is approximately the same for any iris in the Dbase (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 Stored Iris**	**X,Y coordinates of point When Input Iris**	**Matched Result**	**Picture Name With Matched**	**Score of Match**
		X,Y click	**X,Y click**			
1	Hay4	114 , 124	114 , 124	Success	itself	0
2	Fa3	136 , 110	136 , 110	Success	itself	0
3	Ali	65 , 176	66 , 178	Success	itself	0
4	Fouad1	151 , 143	154 , 143	Success	itself	0
5	Fouad3	141 , 147	141 , 146	Success	itself	0

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

No	Picture Name	X,Y coordinates of point When Stored iris	X,Y coordinates of point When Input iris	Matched Result	Picture Name With Matched	Score of Match
		X,Y click	X,Y click			
1	Fa3	136 , 110	136 , 109	Success	itself	2.838
2	Fa3	136 , 110	141 , 111	Success	itself	4.285
3	Fa3	136 , 110	133 , 102	Success	itself	8.400
4	Fa3	136 , 110	144 , 100	Success	itself	7.175
5	Fa3	136 , 110	147 , 112	Success	itself	8.316
6	Fouad6	116 , 146	119 , 145	Success	itself	8.621
7	Ali_press	72 , 164	75 , 169	Success	itself	1.669
8	Fa3	136 , 110	146 , 108	Success	itself	8.316

6.2. Comparison with existing methods

In 1991, Johnson reported to actually realize a person identification system based on iris recognition[13]. Wildes described a system for personal verification based on automatic iris recognition in 1996[14]. In 1998, Boles proposed an algorithm for iris feature extraction using zero-crossing representation of 1-D wavelet transform [15]. All these algorithms are based on gray image, and color information was not used in them. The system of Wildes is sensitive to illumination variations. In our method, an iris is localized and unwrapped to form a block of texture which is made up of eight sub images. The texture sub image is locally enhanced and the feature value is the Average Absolute Deviation(AAD) of each image. All these make our method tolerant to illumination variations. Compared with zero-crossing representation of 1D wavelet transform as used by Boles[15] which employed only the information along the circle , our method explores 2-D texture analysis that can process much more useful information.

6.3. Conclusions

A new algorithm for iris recognition has been presented. The proposed algorithm extracts both local and global details of the iris. Each iris image is filtered with Gabor filters and then a fixed length feature vector is obtained. Experimental results show that our algorithm can effectively distinguish different persons by identifying their irises based on the Euclidean distance the new input IrisCode is matched with templates IrisCode stored in the database to obtain different matching scores. It is computationally efficient and insensitive to illumination and noise. Our future work will focus on iris recognition from image sequences.

References

1- *P.W.Hallinan, "Recognizing Human Eyes" , geometric methods computer vision*, vol 1570,pp214-226,1991.

2- *www.findbimetrics.com-Biometrics Iris Recognition Guides and Article*.

3- *J.Daugman," High confidence personal identification by rapid video analysis of iris texture",proc.* Of the IEEE, International Carnahan conf. on security technology, 1992.

4- *R.P.Wildes, J.C. Asmuth, G.L. Green and S.C. Hsu," A system for automated iris recognition"*, IEEE paper, 1994.

5- *Y.Zhu, T.Tan, and Y.Wang," Iris Image Acquisition system", Chinese patent Application*,No 99217063.x,1999.

6- *James L.Cambier,"Iris Image Interchange format", lridian technologies*, Inc.,2002.

7- *A.K.Jain R.M.bolleand S.qankanti.Biometrics:personal Identification in a networked society.* Norwell,MA:kluwer,1999.

8-*D.E.Benn, M.S.Nixon and J.N.Carter, « Robust eye extraction using H.T. »,* AVBPA'99.

9- *D. Maltoni,D. Maio. A.K. Jain, S.Prabhaker, "Handbook of fingerprint recognition"* , Springer, New York, (2003).

10- *T.S. Lee, "Image Representation Using 2D Gabor Wavelets", IEEE Trans. Pattern Analysis and Machine Intelligence,* vol.18, pp.959- 971, Oct. 1996.

11-*T. Tan, "Texture Feature Extraction Via Visual Cortical Channel Modelling",*Proc. of IAPR, Inter. Conf. Pattern Recognition(ICPR'92), vol. III, pp.607-610, 1992.

12- *Ali A. Ibrahim , Fingerprints Recognition Using Gabor Filters*, M.Sc., University of Baghdad , Iraq 2005.

13- *R.G. Johnson, "Can iris patterns be used to identify people"*,chemical and laser sciences division LA-12331-PR, Los Alamos National Laboratory, Los Alamos Calif, 1991.

14- *R.P. Wildes, J.C. Asmuth, etc.,"A Machine-vision System for Iris Recognition"*, Machine Vision and Applications,vol.9,pp1-8,1996.

15- *W.W. Boles ,and B. Boashah, "A Human Identification Technique Using Images of the Iris and Wavelet Transform"*, IEEE Trans. On Signal Processing,vol.46,pp. 1185-1188,April 1998.