Proc. of the Intl. Conf. on Advances In Computing, Communication and Information Technology – CCIT 2014.

Copyright © Institute of Research Engineers and Doctors. All rights reserved.

Using Phase Demodulator for Encoding Iris Features

Abdullah S. Alotaibi , M.A. Hebaishy

abstract
***Abstract*- Today's digital world requires us to access and protect computer information and interact securely with computer systems. Traditional methods for personal authentication such as physical key, ID card, secret password, PIN, …., etc. These methods suffer from various problems. Biometric measurements which mean biological features such as fingerprints, voice, face, hand geometry,…,etc. have a convenient and reliable solution to these problems. Recently, iris authentication has received increasing attention due to its high reliability for high security applications. The phasor demodulator is simply a four quadrant plane that maps the resulting feature matrix, from applying the normalized image to Gabor filter, to binary code. This mapping depends on the sign of both the real and imaginary part of the feature matrix. In this paper we show how to get Iris code with different Sizes using phase demodulator.**

***Keywords*— biometrics, normalized image, iris features, Gabor filter, phase demodulator, iris code.**

I. Introduction

The iris is the only internal organ of the body that is readily visible from the outside. Its purpose is to control the amount of light that enters the eye through the pupil, by using the dilator and sphincter muscles to control the pupil size. It is made up of an elastic fibrous tissue that gives it a very complicated texture pattern. This texture pattern has no links with the genetic structure of an individual and is generated by chaotic processes[1]. The human iris begins to form in the third month of gestation and the structure is complete by the eight month, even though the color and pigmentation continue to build through the first year of birth. After that, the structure of the iris remains stable throughout a person's life, except for direct physical damage or changes caused by eye surgery. The iris hence parallels the fingerprint in uniqueness but enjoys a further advantage that it is an internal organ and less susceptible to damages over a person's lifetime[2][3]. The general structure of the eye and the position of the iris in the eye is shown in Fig.1.
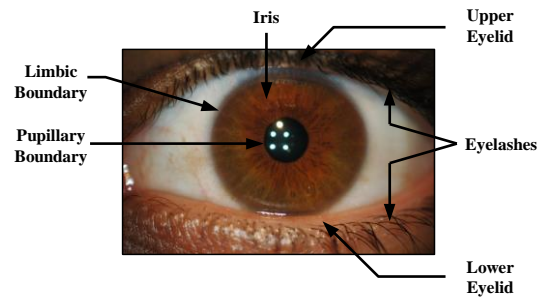

Fig.1. Eye Image

II. Iris Feature Extraction

The iris is an extremely complex structure with many small-scale features detectable by visual means, including image analysis. It contains many collagenous fibers, contraction furrows, coronas, crypts, colors, freckles, rifts, and pits., ciliary processes, rings, as shown in Fig.2. Measuring the patterns of these features and their spatial relationships to each other provides other quantifiable parameters useful to the identification and verification process [4][5].
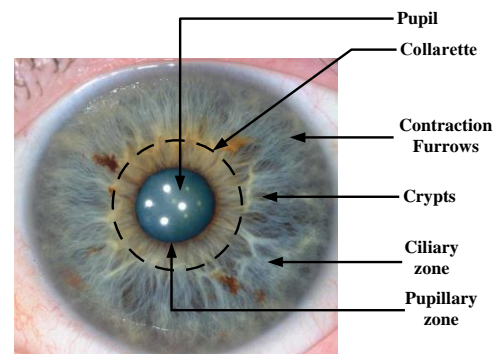

Fig.2. Iris structure

Many distinguishing features can be extracted from the iris, as the iris has an extremely features-rich structure.

SEEK DIGITAL LIBRARY

Early steps in iris recognition systems, intended to use the color of the eye, but it was found that it is an unsuccessful way to distinguish between different eyes, and at later age, work started on features extracted from iris with the concept of big variation in structure of Irises between person and another, and even in the same person there is a difference between his left and right eyes.

We can categorize the structure if Iris into 4 main different categories: Stream Iris structure, Jewel Iris structure, Flower Iris structure, Shaker Iris Structure[6].
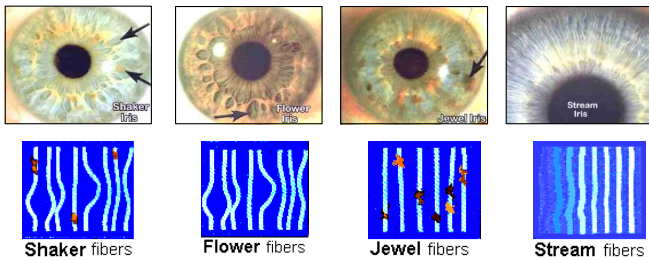

Fig.3. Different structures of Iris

From the viewpoint of texture analysis (structure of iris), local spatial patterns in an iris mainly involve frequency and orientation information, so features could be extracted as the variation of frequencies in each Iris[5].

There are many techniques that used to extract features from iris image, the most famous well-established texture analysis methods to extract features from normalized block shown in Figure(14) of texture image in the resent years are , 2D Gabor filter and Daugman's algorithm(1985,1988,1994) who used 2D Gabor wavelet to extract IrisCode.
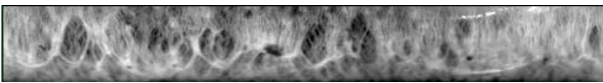

Fig.4. Normalized Texture Image

A. Complex Gabor Filter

Gabor Filter is Gaussians modulated by oriented complex sinusoidal function[6].

$$\psi(x,y,\omega_0,\theta) = \frac{\omega_0}{\sqrt{2\pi}k} e^{-\frac{\omega_0^2}{8k^2}(4(x\cos\theta+y\sin\theta)^2+(-x\sin\theta+y\cos\theta)^2)}$$

$$\left[e^{i(\omega_0 x\cos\theta+\omega_0 y\sin\theta)} - e^{-\frac{k^2}{2}} \right] \quad (1)$$

While ω_0 is the radial frequency in radians per unit length.

θ is the wavelet orientation in radians. k is a constant ,

with $k \approx \pi$ for a frequency bandwidth of one octave and $k \approx 2.5$ for a frequency bandwidth of 1.5 octaves . In our work we used $k = \pi$.

x and y are the size of the filter, and it is preferred to make it the same size of the image to be convolved with; however by decreasing its size, the output of the convolution will be acceptable while processing time is reduced.

We can decrease the filter size x and y to size reaches 64x64 (the normalized image size = 64x512) and this will not differ so much in the output of the filter, and this is because the effective part of the filter is found at its center (and this is very clear in the next tables of figures about the response of Gabor filter)[7].
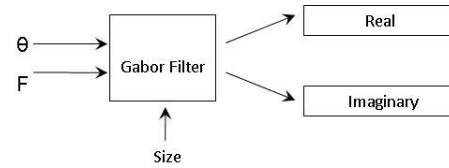

Fig.4. Gabor Filter Generator

The response of the filter with different frequencies and orientations is depicted. In the table(1) we see its response in 2D showing the only the orientation of the filter in respect to the Cartesian coordinates in 2–D space.

We can deduce that as frequency increases the response becomes sharper and the θ changes the orientation of that response.

Table1. Response of Gabor filter for different F and θ in 2D (filter size = 32x32)

B. Convolution:

The normalized image is converted to gray-scale as in our work in extracting features we are concerned with the structure (texture) of the eye only not its color, then this gray-scale normalized image is applied to the filter to get the output of the convolution between image and the filter response shown in Fig.5.[8]
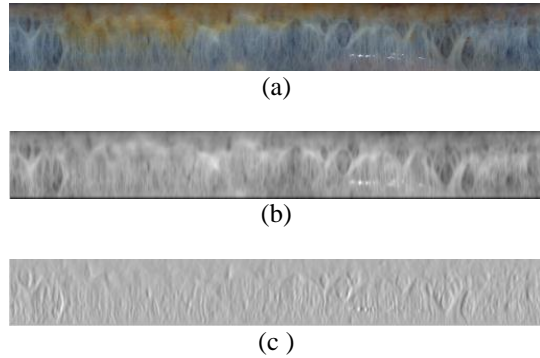
(a)

(b)

(c)

Fig.5. The output of Gabor filter when normalized image is applied to it (the used filter is with frequency = 5 and θ = 0°) (a) Normalized image   (b) Real part of convoluted image with gabor filter (c) Imaginary part of convoluted image with Gabor filter

III.   IRIS ENCODING

After the step of convolution with Gabor filter we get two matrices as the output of it: Real part of convolution and Imaginary part, we now have to find a suitable way to get an effective and efficient code that could be manipulated easily and has the capability of distinguishing between different irises.

Only phase information is used for recognition of irises as amplitude information is not very discriminating, and it depends upon factors such as contrast, illumination, and camera gain. The extraction of phase has the further advantage that phase are assigned regardless of how low the image contrast.

For better performance and higher accuracy, we divide the output of the convolution process into a number of blocks, for each block we find its mean then we apply it to the phase demodulator (in our work dividing the output into 16x32 blocks gives the best performance).

A. Phase Demodulator:

The phase demodulator in Fig.6. is simply a four quadrant plane that maps the resulting feature matrix, from applying the normalized image to Gabor filter, to binary code. This mapping depends on the sign of both the real and imaginary part of the feature matrix.

The horizontal axis represents the real component with the positive to the right. And the vertical axis represents the imaginary component with the positive to up. We have four combinations to map. The mapping for negative-negative, negative-positive, positive-negative and positive-positive is 00, 01, 10 and 11 respectively, where the first sign is for the

real component. Since we demodulate the signal using this QPSK technique then we need 2 bits to represent one complex value. Which means the code will have double the features matrix size.[9][10]
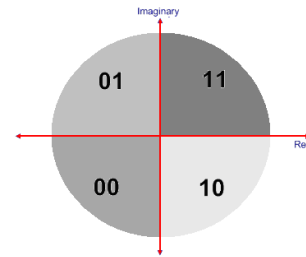

Fig.6. Phase Demodulator

B.   Blocks No. Vs Code Size

1. For whole image size: it means that we get 2 bits code for each pixel in the image and this will lead to a very huge code (64 x 512 x 2 bits), and this is time and space waste with no enhancement in the performance, so this code size isn't efficient at all, and isn't used.

2. For 8 x 16 blocks: it means that we will divide the 64 x 512 output into 8 x 16 blocks, (i.e. the size of each block = 8x32), then for each block we get the mean of it and find the code, so we will have a code of size (8 x 16 x 2 bits), and that size is small but it is suitable for small databases which contain less than one hundred person.

3. For 16 x 32 blocks: it is the most suitable one for normal databases of hundreds or few thousands, and it is very efficient in space and time consuming with good performance. Code size = 16 x 32 x 2 bits = 1024, which can give theoretically 2^{1024} different code which is very sufficient.
    For a normalized image of size 512 x 64, it will have a 16 x 32 x 2 bits code, the 2 bits are because of the phase modulator that uses 2 bits to describe each value, that's a must as we use four quadrants, the representation image of 16 x 32 x 2 code shown in Fig.7.

Fig.7. Image of resulting iris code

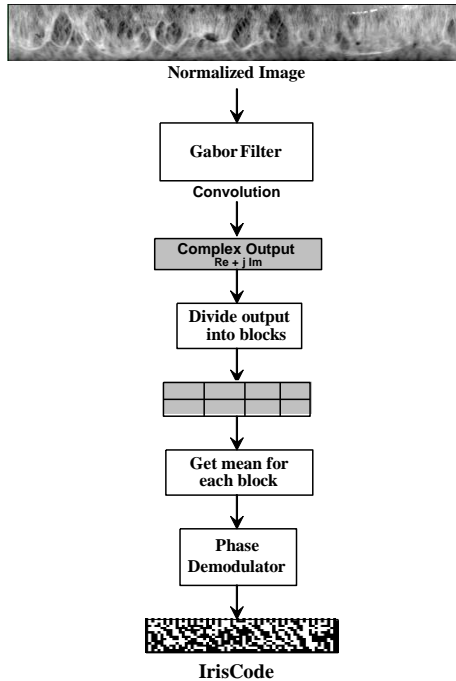The previous analysis is summarized the block diagram shown in Fig.8.

Normalized Image

Gabor Filter

Convolution

Complex Output
Re + j Im

Divide output into blocks

Get mean for each block

Phase Demodulator

IrisCode

Fig.8. Block diagram of iris code extraction

C. Experimental results

Filtered image with Gabor filter at frequency = 2 and corresponding Iriscode, these results can be obtained with different orientations and different frequencies as shown in Fig.9.

θ	Real Part	Imaginary Part	Iris Code
0°			
45°			
90°			
135°			

Fig.9. Sample of experemental iris code results

IV. **Conclusion**

Multi-channel frequencies for Gabor are used to get features from iris image samples. This proved to give more accurate code and better recognition rate by using phase diagram.

Iris code size is obtained according to normalized iris image division as for each block two bits are obtained.

Code size = 16 x 32 x 2 bits = 1024, it is the most suitable one for normal databases and it is very efficient in space and time consuming with good performance.

References

[1] Boles, W. W. and Boashash, B., "A Human Identification Technique Using Images of the Iris and Wavelet Transform," IEEE Trans. on Signal Processing, vol. 46, pp. 1185-8, 1998.

[2] Chinese Academy of Science - Institute of Automation, Database of the Eye Grayscale Images. http://www.sinobiometrics.com

[3] Daugman, J. G., "High Confidence Visual Recognition of Persons by a Test of Statistical Independence," IEEE Trans. Pattern Anal. Machine Intell., vol. 15, pp. 1148-61, 1993.

[4] Daugman, J., "Recognizing Persons by Their Iris Patterns", In: Biometrics: Personal Identification in Networked Society, 1998, Amsterdam: Kluwer, pp. 103-121.

[5] M. Hebaishy and et al. "Human identification based on iris texture analysis Project". Electronics and communications dept. faculty of engineering, Cairo University, 2005.

[6] M. Hebaishy " Optimized Daugman's Algorithm for Iris Localization" scg.zcu.cz/wscg2008/Papers_2008/poster/A11-full.pdf., 2008.

[7] Daugman, J. G., "High Confidence Visual Recognition of Persons by a Test of Statistical Independence," IEEE Trans. Pattern Anal. Machine Intell., vol. 15, pp. 1148-61, Nov. 1993.

[8] Daugman, J. and Cathryn Downing," Effect of Severe Image Compression on Iris Recognition Performance", IEEE Transaction on Information Forensics and Swcurity, Vol. 3, NO. 1, March 2008.

[9] Kazuyuki Miyazawa, Koji Kobayashi and et al. "AN Iris Recognition System Using Phase-Based Image Matching", Tohoku University and Yamatake Corporation Japan.2008.

[10] K. Miyazawa, K. Ito, T. Aoki, K. Kobayashi, and H. Nakajima, "An efficient iris recognition algorithm using phase-based image matching," Proc. Int. Conf. on Image Processing, pp. II–49–II–52, Sept. 2005.

 Abdullah S. Alotaibi /Computer Science Dept.
Faculty of Science and Humanities/Shaqra University
Country : King of Arabia Saudia

M. A. Hebaishy/Computer Science Dept.
Faculty of Science and Humanities/Shaqra University
Country : King of Arabia Saudia
Electronics Research Institute , Egypt.