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Iris Feature Extraction and Encoding

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Abstract**—** *The iris is the colored part of the human eye that controls the amount of light that enters into the eye located behind the corona between the sclera and the pupil. 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. Measuring the patterns of these features and their spatial relationships to each other provides other quantifiable parameters useful to the identification and verification process. The most difficult part of the identification process is Iris localization it defines the inner and outer boundaries of iris area used for feature analysis. The iris feature extraction is the important part in the identification process. To overcome the contrast and illumination iris image we use complex Gabor filter with phase demodulator to encoding iris features. The phase 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 this paper shows how to extract iris code depends on the phase calculations.*

Keywords**—** *Feature extraction, iris features, Gabor filter, phase demodulator, iris code.*

I. INTRODUCTION

The iris contains many collagenous fibers, contraction furrows, coronas, crypts, colors, freckles, rifts, and pits, ciliary processes, rings, as shown in figure 1. Measuring the patterns of these features and their spatial relationships to each other provides other quantifiable parameters useful to the identification and verification process [1], [2].

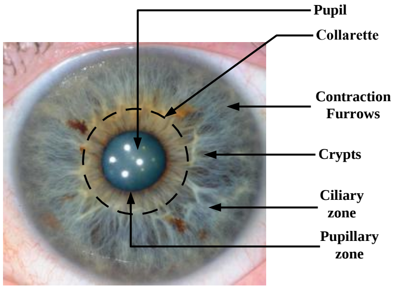


Fig. 1. Iris structure image.

From the structure of iris, local spatial patterns mainly involve frequency and orientation information, so features could be extracted as the variation of frequencies in each part of iris image.

II. IRIS FEATURE EXTRACTION

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 (2) 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 Iris Code.

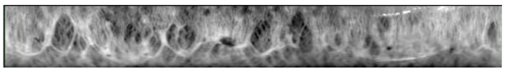


Fig. 2. Normalized texture image.

Complex Gabor Filter: Gabor Filter is Gaussians modulated by oriented complex sinusoidal function [3].

$$\psi(x,y,\omega_0,\theta)=\frac{\omega_0}{\sqrt{2\pi k}}e^{-\frac{\omega_0^2}{8k^2}(4(x\cos\theta+y\sin\theta)^2+(-x\sin\theta+y\cos\theta)^2)}\cdot\left[e^{i(\omega_0 x\cos\theta+\omega_0 y\sin\theta)}-e^{-\frac{k^2}{2}}\right] \quad (1)$$

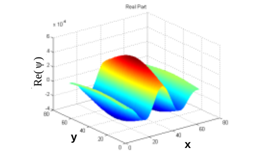
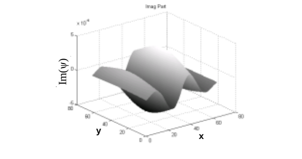
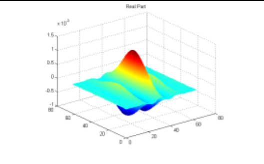
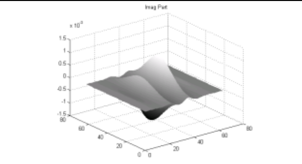
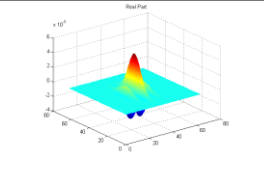
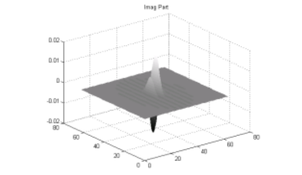
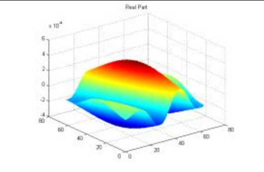
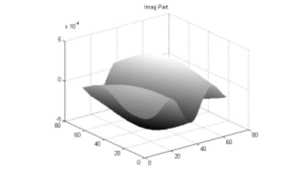
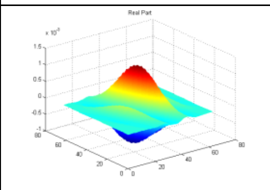
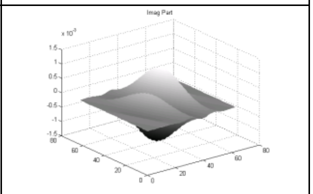
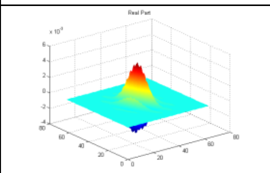
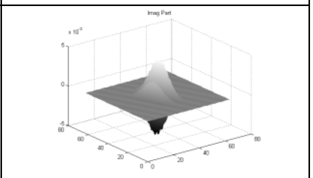
While ω_0 is the radial frequency in radians per unit length. θ is the wavelet orientation in radians. k is a constant, with $k \approx \pi$ for a frequency bandwidth of one octave and $k \approx 2.5$ for a frequency bandwidth of 1.5 octaves. In this paper $k=\pi$ used.

x and y are the size of the filter, and it is better select the filter and the image with the same 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) [4].

The response of the filter with different frequencies and orientations is depicted. In table (I) shown the response in 2D, only the orientation of the filter in respect to the Cartesian coordinates in 2–D space. When the frequency increases, the response becomes sharper and the θ changes the orientation of that response see figure 3.

TABLE I. Response of Gabor filter for different ω_0 and θ in 2D.

$\omega_0=\pi/16$ θ=0		
$\omega_0=\pi/8$ θ=0		
$\omega_0=\pi/4$ θ=0		
$\omega_0=\pi/16$ θ=π/8		
$\omega_0=\pi/8$ θ=π/8		
$\omega_0=\pi/4$ θ=π/8		

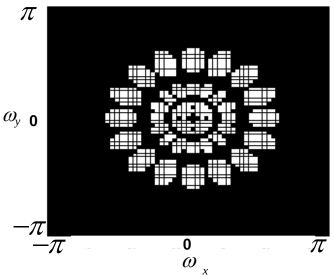
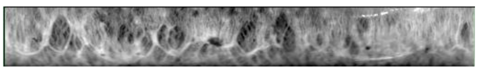


Fig. 3. Bandwidth response of Gabor filters with different frequencies and orientations.

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 figure 4. [5]



Normalized input Image

Output Phase Image of Gabor filter at high frequency

Output Phase Image of Gabor filter at medium frequency

Output Phase Image of Gabor filter at low frequency

Fig. 4. The phase response of output Gabor filter when convoluted with normalized iris image.

III. IRIS ENCODING

After the step of convolution with Gabor filter, output phase image consists of two matrices: Real part and Imaginary part. Now have to find a suitable way to get an effective and efficient code that has the capability of distinguishing between different irises. The only phase information used for recognizing the human irises. The phase extraction of image is not affected by the variation of contract and brightness iris image. For better performance and higher accuracy, the output image of the convolution process is divided into a number of blocks, for each block its pixels mean is calculated apply it to the phase demodulator (for the best performance the output convoluted image is divided into 16x32 blocks).

Phase Demodulator: The phase demodulator in figure 5, 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 phase demodulator represents four combinations: negative-negative, negative-positive, positive-negative and positive-positive is 00, 01, 10 and 11 respectively [6], [7].

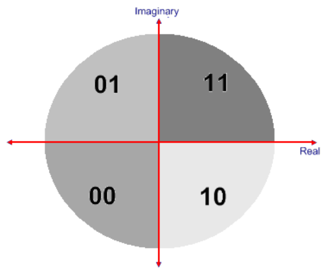


Fig. 5. Phase demodulator.

Blocks No. Vs Code Size

1. For whole image size: it means that 2 bits code for each pixel in the image are obtained 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. If the image divided into 8 x 16 blocks: it means that, the size of each block = 8x32, then the mean value for imaginary and real of each block is calculated to get the corresponding code. so the code size (8 x 16 x 2 bits), is small but it is suitable for small databases which contain less than one hundred person.

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3. If the image divided into 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 21024 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 representation image of 16 x 32 x 2 code shown in figure 6.

Fig. 6. Image of resulting iris code.

The previous analysis is summarized in the block diagram shown in figure 7.

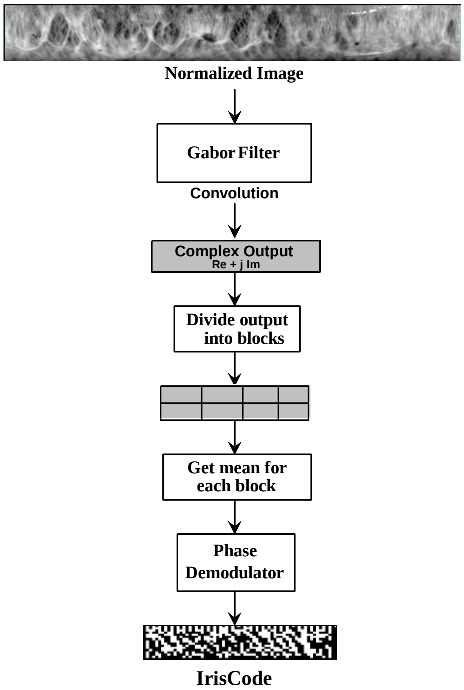

Fig. 7. Block diagram of iris code extraction.

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 demodulator 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.

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