

Iris Texture Analysis with Polar-Based Filtering: Preliminary Results

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ABSTRACT

This paper presents a new iris texture analysis approach. The new approach exploits distribution of iris patterns in which they spread mostly along its radial-angular direction. The analysis is done circularly using Gaussian and Gabor filter. The orientation of Gabor is rotated corresponding to polar location of an interested pixel.

The new approach is called polar-based filtering. We investigate our approach using both of 1-D and 2-D filtering methods. Our approach transforms an iris image onto spatial-frequency domain, resulting in four different iris texture images: approximation, radial-like, angular-like, and sparse edge texture. Our preliminary results demonstrate promising iris patterns.

Keywords: Texture Analysis, Iris Texture Analysis, Polar-based Filtering.

1. INTRODUCTION

1.1 Overview

Since the terrorist event of 11 September, interests in biometric technologies have increased dramatically. Biometrics recognizes a person based on physiological or behavioural characteristics, which include fingerprints, palmprints, signatures, faces, speeches, retinæ, irises, and other unique human characteristics. Among the biometrics, iris pattern claims to be highly accurate [1,2]. The probability of finding identical two irises is very small, even the ones from identical twins. In addition, iris recognition is a noninvasive procedure as an iris scan can be performed from a point several feet away.

Iris is a protected organ located behind the cornea, but in front of the lens. It consists of four layers: anterior border layer, stroma, dilator pupillae muscle and posterior pigment epithelium (see figure 2). The anterior layer is a visible layer containing identifiable features such as pigment frill, collarette, radial and concentric furrows, pigment spots (moles and freckles), and crypt [3]. These physical features are very useful in recognizing an iris. It is easily noticeable that most iris features form in a radial and circular direction.

In this paper, we propose a new iris texture analysis method that is capable to extract the radiating and circular

iris patterns, including its sparse edges. Details of our approach are described in section 2.

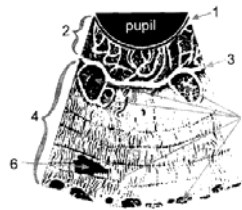


Figure 1. Anterior surface of the human iris:

1-pigment frill, 2-pupillary area, 3-collarette, 4-ciliary area, 5-crypts, 6-pigment spot.

1.2 Related works

Existing iris recognition systems analyze iris features by first remapping an iris region onto a new image plane. Daugman [2] converts Cartesian coordinates of an iris to pseudo-polar coordinates before extracting its features using 2-D frequency-selective Gabor filter. Wildes [3] analyzes the iris features based on an isotropic band-pass decomposition derived from the application of Laplacian and Gaussian filters. This decomposition is done on Cartesian image coordinates. Boles [4] applies a dyadic wavelet transform on a 1-D iris signature. The signature is an image data extracting along circular close contours centered at the centroid of the pupil. Lim et al. and Li Ma [5,6] map an iris region onto a rectangular image patch of fixed size. Haar wavelet and circular symmetric Gabor filters are used to extract iris features in Lim and Li Ma works, respectively. Our approach requires no mapping process.

1.3 Outline

This paper is organized as follows: section 2 explains our iris texture analyzing method. Detailed descriptions of the proposed 1-D and 2-D polar-based filtering are explained in section 3 and 4, respectively. Preliminary results are shown and discussed in section 5. Section 6 is conclusions and future works.

2. THE PROPOSED APPROACH

In this section, we describe the details of our proposed method. The method is composed of two main steps: iris localization and iris texture analysis.

2.1 Iris Localization

Iris localization is to locate the inner and outer boundaries of an iris. The inner boundary can be found by

detecting a pupil area where its perimeter designates the inner boundary of the iris. The iris outer boundary is a circular edge separating the iris from the sclera zone. Both boundaries can be located by utilizing intensity differences among organs (pupil, iris, and sclera) and circular shape of the pupil and iris.

Given an eye image, we first detect the pupil and determine its center. A simple threshold technique is used for pupil detection as its intensity is different from the others. An edge operation is applied to detect a pupil region. By prior knowledge of the pupil shape, a circle is fitted onto the obtained edge information. The iris inner boundary and its center can then be defined by the fitting parameters. The obtained center position is used as a reference point of the following processes.

By exploiting intensity differences between iris and sclera, the outer boundary can be located. The outer boundary is assigned to the first local change of intensity summation of pixels on a virtual arc. The arc is a portion of a virtual circle formed by extending the radius of the inner boundary. Only pixels lie within $\pm 45^\circ$ of the circle are accounted for the intensity summation. This is to reduce effects of noise caused by unwanted features such as eyelid, eyelashes, sclera, etc.

2.2 Iris Texture Analysis

Our analysis approach is set up on the analogy of a conventional wavelet decomposition, in which the approaches aim to decompose an image into different frequency bands. In the conventional approach, an image is considered as a Cartesian image. A set of low-pass and high-pass filters is operated in an x-y direction. Our approach, a polar-based filtering, considers an input image as a polar plane having the origin at the center of the pupil. A set of spatial filters is, therefore, operated in a radial-angular direction.

The polar-based filtering decomposes an input image into four different bands according to the four different textures. These are an image approximation, radial-like texture, angular-like texture, and sparse edges. Figure 2 illustrates our filtering operation.

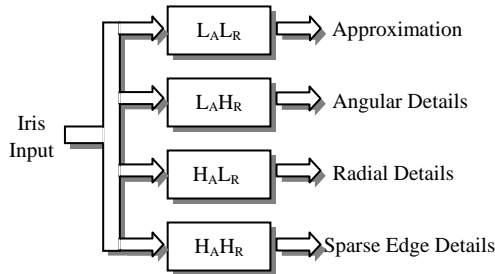


Fig.2: The Filter Bank of the Polar-Based Filtering: Letters L, H denote the low-pass filter and high-pass filter and subscripts A, R denote angular and radial direction, respectively.

Our analysis approach is a multi-directional filtering. The orientation of the filter varies according to an angle of a pixel in the polar coordinate system. Gaussian and

Gabor filter are used as kernel filters of our approach. The next two sections elaborate the implementation details of our approach.

3. THE SEPARABLE 1-D POLAR-BASED FILTERING

In 1-D approach, an image is independently filtered by two 1-D filters. The filtering considers the input image as a polar plane image having its origin at the reference point. The filters convolute the input image in a radial-angular direction as shown in figure 3. A linear interpolation is used to compensate misaligned pixels for both radial and angular convolution.

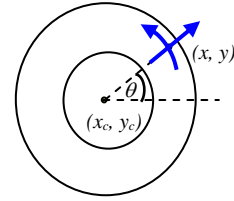


Fig.3: 1D polar-based filtering at arbitrary pixel.

The kernels of our filters are the Gabor function and Gaussian function. The Gabor function denoted by Equation (1) is a Gaussian function modulated by a sinusoidal function. The Gabor function plays a crucial role of high-pass filtering. Whereas, the Gaussian function performs a low-pass filtering and its equation is given by Equation (2).

$$g_H(x; f) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}} \cos(2\pi fx), \quad (1)$$

$$g_L(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}}, \quad (2)$$

where σ is the standard deviation of the Gaussian envelope and f is modulating frequency.

4. THE 2-D POLAR-BASED FILTERING

The 2-D polar-based filtering decomposes the input image using four filters. The four filters are the products of filters denoted by Equation (1) and (2). The product results in one approximation function denoted by equation (3) and three Gabor functions denoted by equation (4)-(6). Its responses are shown in figure 4(a), 4(b), 4(c), and 4(d) in respectively.

$$g_{LL}(x, y) = g_L(x)g_L(y) \quad (3)$$

$$g_{LH}(x, y; f_y) = g_L(x)g_H(y; f_y) \quad (4)$$

$$g_{HL}(x, y; f_x) = g_H(x; f_x)g_L(y) \quad (5)$$

$$g_{HH}(x, y; f_x, f_y) = g_H(x; f_x)g_H(y; f_y) \quad (6)$$

Filtering the original image with the approximation function yields the approximation image. Whereas

filtering the image with the three Gabor function, Equation (4-6) yields the radial-like, angular-like, and sparse edges details, respectively.

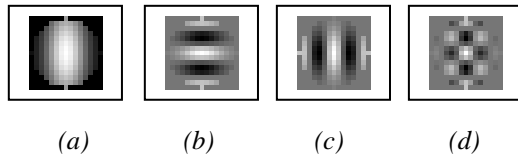


Fig.4: The responses of the 2-D polar-based kernels at $\theta = 0^\circ$.

To analyze iris patterns in radial-angular direction, the three Gabor functions are rotated such that the filters align with the radius and its perpendicular of the virtual circle. The rotation concept is demonstrated in figure 5. Rotating a filter can cause bias around its corners. To account for this bias, each filter is sampled such that it has a circular shape.

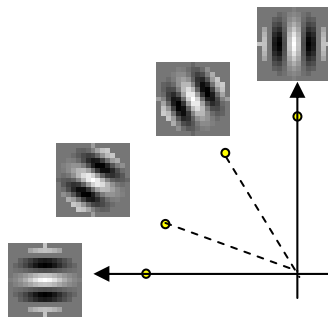


Fig.5: 2D polar-based filtering at arbitrary pixel.

5. EXPERIMENTAL RESULTS

To investigate our approach, we conduct two studies: synthesis image study and a real iris image study. Empirically, the filters are designed to have $\sigma_x = 3$, $\sigma_y = 7$, and $f = 0.13$. In the first study, we synthesize an image as shown in figure 6. The 1-D and 2-D filtering is applied to the synthesis image yielding results shown in figure 8. Both filterings successfully decompose the image into its approximation, radial-like, angular-like, and sparse edge details.

In the second study, images of human iris are acquired using Panasonic NV-VZ1EN camcorder. Figure 7 shows an example of the acquired iris images. The image is decomposed using the same 1-D and 2-D filters as in the first study. Figure 9(a) shows the decomposition of the separable 1-D filter. Figure 9(b) shows the decomposition of the 2-D filter. The obtained results illustrate the effectiveness of both filtering schemes in detecting iris patterns. The decomposed images can be examined further to extract a radiating and circular iris patterns. The obtained sparse edges are useful in detecting iris pigment spots. Comparing the two approaches, the 2-D filtering extracts more feature details than the 1-D approach.

6. CONCLUSION AND FUTURE WORKS

In this paper, we focus on an image analysis technique for analysing iris patterns. To process the iris textures in an efficient and effective way, we filter an iris image in a polar-based style. The iris image is considered as a polar plane image where the center of the pupil is the origin of the plane. The angle value is utilized in the polar-based filtering approach in which the kernel filters are rotated corresponding to the angle value. Two experiments are conducted: separable 1-D and 2-D polar-based filterings. Both filtering approaches show promising results. Our future works are in the direction of developing feature extraction and representation techniques. A complete iris verification system is our ultimate goal.

7. ACKNOWLEDGEMENT

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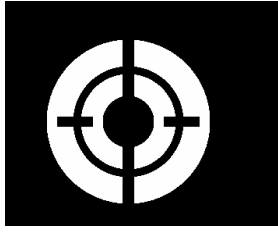
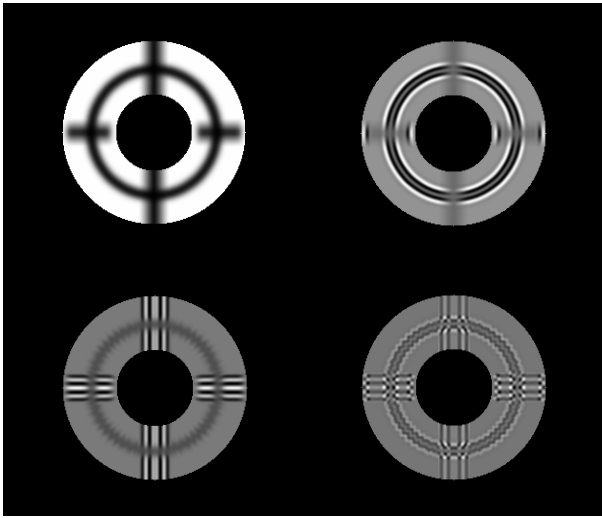


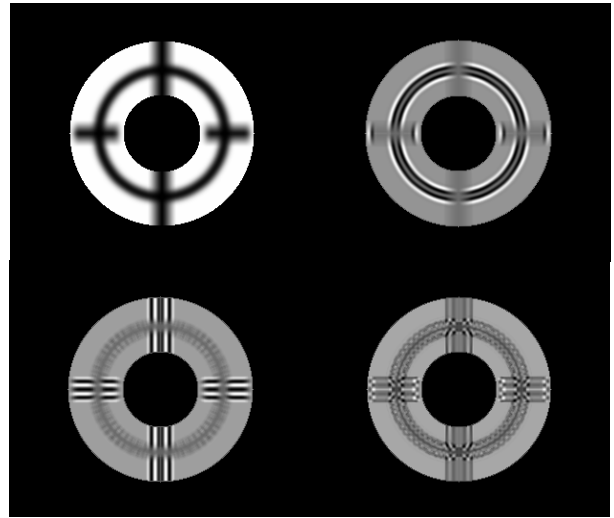
Fig.6: Testing Image



Fig.7: Testing Iris Image

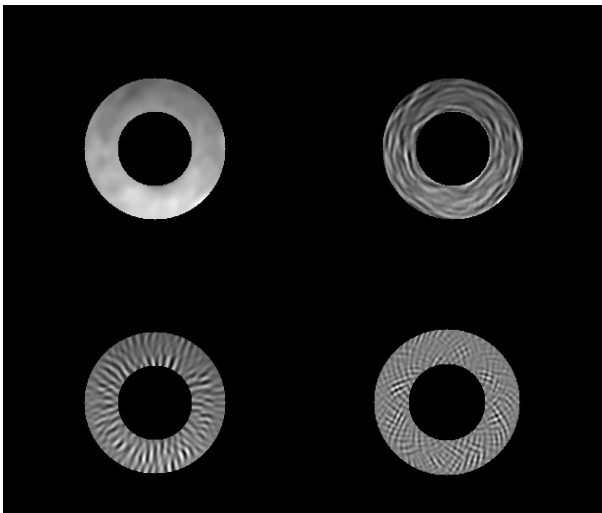


a) Using Separable Polar-Based Filter Bank

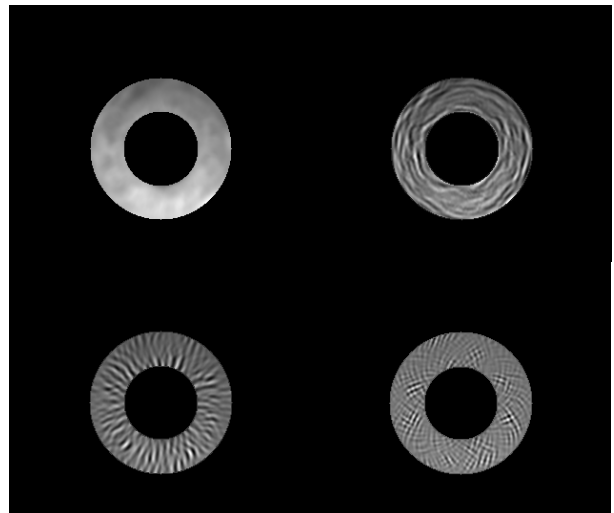


b) Using 2-Dimension Polar-Based Filter Bank

Fig.8: Results of the Polar-Based Filtering of a Testing Image.



a) Using Separable Polar-Based Filter Bank



b) Using 2-Dimension Polar-Based Filter Bank

Fig.9: Results of Polar-Based Filtering of an Iris Image.