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Human Identification Based On Scleral Vasculature

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Abstract

The blood vessel patterns of sclera show rich and unique details. To date, sclera is relatively less studied and little is known regarding its usefulness and performance. Here, sclera recognition for human identification is proposed. It poses a challenge because sclera vessel patterns are often dense and/or saturated and, most importantly, the vessel structure in the sclera is complex and has deformations. A new method for sclera segmentation which uses Daugman's integro-differential operator is proposed. It is followed by Otsu's thresholding method and erosion. A comparative analysis is presented between Gabor filter and Canny edge detection methods. Since, Canny filter has higher noise immunity as compared to Gabor filter it is used to enhance and thin the conjunctival vasculature patterns. A sclera template generation method is proposed that uses Hough transform. The proposed scheme is tested on the images from UBIRIS 3 database which is publicly available. Thus, the use of sclera vasculature pattern as potential biometric is investigated.

Keywords: Biometric, canny, edge detection, sclera recognition, segmentation.

Introduction

Authentication to a system can be provided by passwords or PINs. But, biometric identification is more reliable than these since they are unique. There are many different traits that can be used as biometrics, including fingerprint, face, iris, retina, gait, and voice. Each biometric has its own advantages and disadvantages. Intrinsic biometrics characteristics are preferred as they more difficult to forge, have high user acceptance and reliability [6].

Iris recognition has become popular because it is unique and does not change throughout life. Apart from iris and retina, the human eye has an ocular surface known as the sclera. To date, sclera is relatively less studied and little is known regarding its usefulness and performance. However, to prove this, it is necessary to gain sufficient amount of information from the sclera and the accompanying vessel patterns. This work designs an image processing and pattern recognition module for a biometric system using vasculature on sclera region [1].

The rest of the paper is organized as follows. Section II describes the main steps of segmentation. In section III Canny edge detection and adaptive thresholding is used to remove illumination effects. Finally, Section IV introduces the feature extraction and template generation approach using Hough transform.

Segmentation

Segmentation is the first step in sclera recognition. Many researchers have worked on the segmentation of the pupil and iris boundaries for iris recognition in the NIR wavelengths. However, these approaches are designed for iris segmentation so sclera information is often discarded in iris recognition. these approaches are therefore not verified suitable for sclera recognition.

In this paper, a fully automatic sclera segmentation method for grayscale images is proposed. The block diagram of the segmentation algorithm is shown in Fig. 1, which includes the following steps: the region of interest (ROI) selection step, the Otsu's method-based thresholding step and the sclera area detection step.
An integro-differential operator given by:

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$$\max_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right|$$

(1)

Where,

I(x,y) is the eye image, r is radius of search, $G_\sigma(r)$ is Gaussian smoothing function at scale σ and s is contour of circle.

An integro-differential operator is adopted for iris region localization so that the centre location and radius of circular iris region can be found [2]. The left and right ROIs are selected based on the iris center and boundaries. The height of the ROI is the diameter of the iris, and the length of the ROI is

Fig. 1(a) Original Image . (b) ROI Selection. (c) Left Region. (d) Otsu's Thresholding. (e) Sclera Area

the distance between the limbic boundary and the margin of the image.

Otsu's method is applied to the ROIs to obtain potential sclera areas. This way, we eliminate nonsclera areas [3]. Fig. 1 shows the process for detecting the left sclera area. The same approach is applied to detect the right sclera area.

Sclera Vessel Pattern Enhancement

The segmented sclera area is highly reflective. As a result, the sclera vascular patterns are often blurry and/or have very low contrast. To mitigate the illumination effect to achieve an illumination-invariant process, it is important to enhance the vascular patterns.

A bank of multi-directional Gabor filters can be used for vascular pattern enhancement. These are given by

$$G(x,y,\vartheta,s) = e^{-\Pi\left(\frac{(x-x_0)^2+(y-y_0)^2}{s^2}\right)}$$

(2)

$$\times e^{-2\Pi i(\cos\vartheta(x-x_0)+\sin\vartheta(y-y_0))}$$

where, (x_0, y_0) is the centre frequency of the filter, s is variance and ϑ is angle of sinusoidal modulation. The Gabor filtered image is shown in Figure 2 [1].

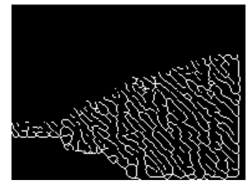

Fig. 2 Gabor Edge Detected Image.

Another method suitable for this purpose is Canny edge detection. Canny edge detection gives good detection results and is efficient but has speed limitation [4].

Canny edge detection consits of:

1. Smoothing:

Gaussian filter is first applied to remove the noise. The mask of Gaussian filter of size 5x5 with a standard deviation of 1.4 is shown below [4].

$$\text{Gaussian Mask} = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 15 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix}$$

2. Finding Gradients:

The Canny algorithm generally finds edges where there is lage intensity change in the image. To find these areas we have to find the gradients of the image. To do this we have to apply Sobel mask (Fig. 3.) [4].

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Fig. 3. Sobel convolution mask for horizontal(x) and vertical(y) edges

In first step we find the x-gradient and y-gradient respectively by applying the above mask. The magnitudes of these gradients can then be determined as a Manhattan distance measure to reduce the computational complexity [4].

$$|G| = |G_x| + |G_y| \quad (3)$$

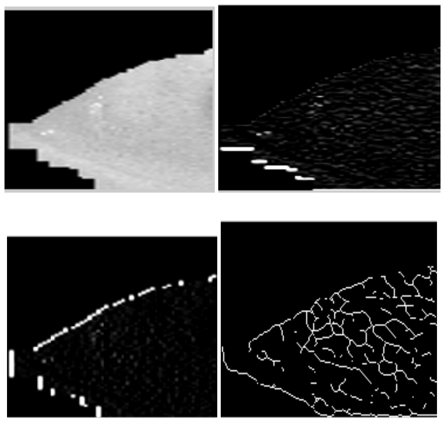

Fig. 4(a) Original Image . (b) Horizontal Edge Detected Image. (c) Vertical Edge Detected Image. (d) Final Edge Detected Image after Thresholding.

3. Thresholding:

The easiest way to differentiate between true edges and noise is using a threshold, so that edges stronger than a certain value would be preserved. Edge pixels stronger than the threshold are marked and the ones weaker than the threshold are suppressed.
The enhanced images are shown in Figure 4.

Feature Extraction

The final edge detected image is recursively parsed into smaller segments. The process is repeated until the line segments are nearly linear with the line's maximum size. For each segment, a line is fit to each segment [1].

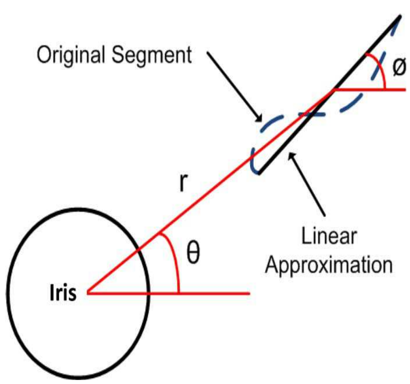

Fig. 5. Sketch of parameters of segment descriptor.

These line segments are then used to create a template for the vessel structure. The segments are described by three quantities—the segment angle to some reference angle at the iris center, the segment distance to the iris center, and the dominant angular orientation of the line segment[5].

Fig.5 shows a visual description of the line descriptor. A descriptor is $S = (\theta\ r\ \emptyset)$. The individual components of the line descriptor are calculated as:

$$\theta = \tan^{-1}\left(\frac{y_l - y_i}{x_l - x_i}\right) \quad \textbf{(3)}$$

$$r = \sqrt{(y_l - y_i)^2 + (x_l - x_i)^2} \quad \textbf{(4)}$$

$$\phi = \tan^{-1}\left(\frac{d}{dx} f_{line}(x)\right) \quad \textbf{(5)}$$

Where, $f_{line}(x)$, is the polynomial approximation of the line segment, (x_l, y_l) is the center point of the line segment, (x_i, y_i) is the center of the detected iris, and S is the line descriptor.

Result And Conclusion

A new biometric: sclera recognition is proposed. An integro-differential operator followed by Otsu's thresholding and erosion is proposed for segmentation. Two methods for enhancement are Gabor filtering and Canny edge detection. As can be seen in figure 3, Gabor filter detects the pattern but is susceptible to noise. Whereas, the pattern detected by Canny filter has relatively less noise. Thus, Canny filter has higher noise immunity than Gabor filter. So, Canny edge detected patterns are further used for feature extraction.

Currently, the proposed system is implemented in MATLAB (R2010a). The processing speed can be dramatically reduced by parallel computing approaches.

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