IRIS COLLARETTE BOUNDARY LOCALIZATION USING 2-D DFT FOR IRIS BASED BIOMETRIC SYSTEM

Kapil Rathor

***Abstract*— There has been a rapid increase in the need of accurate and reliable personal identification infrastructure in recent years, and biometrics has become an important technology for security. Iris recognition is seen as a highly reliable biometric technology. The performance of iris recognition is severely impacted when encountering poor quality images. The selection of the features subset and the classification is an important issue for iris biometrics. The iris recognition system consists of four-process: image acquisition, pre processing, feature extraction and identification or verification. In this paper, the proposed method is for localizing the iris area between the inner boundary and the collarette boundary, to remove unnecessary areas and to increase the rate in recognition. For finding the collarette boundary 2-D DFT is used. After that the image is sharpen using high pass butter worth filter. The Zigzag collarette boundary is located using canny edge detection method. This shows that the iris localization by the proposed methods improves the recognition rate.**

***Index Terms*— Canny edge detection, Histogram equalization, Discrete Fourier transforms (1-DFT, 2-D DFT).**

I. INTRODUCTION

With increase in terrorism and illegal acts, there is a growing demand for more secure and reliable identification in our society that can replace the traditional means of identification. Biometric technologies based on recognition of behavioral or physiological characteristics of humans, promises to be an effective solution. Biometric recognition can be described as automated methods to accurately recognize individuals based on distinguishing physiological and/or behavioral traits. It is a subset of the broader field of the science of human identification. Biometrics offers the means to identify individuals without requiring that they carry ID cards and badges or memorize passwords. Examples of biometric technologies include fingerprint recognition, face recognition, iris recognition and many others. The parts of body and behavior have been used for years as a means of person recognition and authentication. For example, fingerprint has been used for a long time in security and access applications. In comparison to other biometric features such as face, fingerprint, retina, and hand geometry, iris is seen as a highly reliable biometric technology because of its stability, and high degree of variation between individuals. The iris is seen as a highly reliable and accurate biometric technology because each human being is characterized by unique irises that remain relatively stable over the life period. Iris is present in the form of ring around pupil of a human eye in all the human beings. Its complex pattern contains many distinctive features such as arching ligaments, crypts, radial furrows, pigment frill, Pupillary area, ciliary area, rings, corona, freckles and zigzag collarette [1][2] which gives a unique set of feature for each human being, even irises of identical twins are different.

Surface of the iris is composed of two regions, the central pupillary zone and the outer ciliary zone. The collarette is the border between these two regions. The collarette region is less sensitive to the pupil dilation and usually unaffected by the eyelashes and eyelids. [3]

A. Features of the human iris

Now some of the visible features of the human iris will be described, which are important to identify a person, especially pigment related features, features controlling the size of the pupil, visible rare anomalies, pupil, pigment frill and collarette. The crypts, in the figure shown as number 5in Fig. 1, are the areas in which the iris is relatively thin. They have very dark colour due to dark colour of the posterior layer. They appear near the collarette, or on the periphery of the iris. They look like sharply demarcated excavations. The pigment spots, in the fig1 shown as number 6, are random concentrations of pigment cells in the visible surface of the iris and generally appear in the ciliary area. They are known as moles and freckles with nearly black colour. Features controlling the size of the pupil are radial and concentric furrows. They are called contraction furrows and control the size of the pupil. Extending radically in relation to the center of the pupil are radial furrows. The typical radial furrows may begin near the pupil and extend through the collarette. The radial furrows are creased in the

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anterior layer of the iris, from which loose tissue may bulge outward and this is what permits the iris to change the size of the pupil. The concentric furrows are generally circular and concentric with the pupil. They typically appear in the ciliary area, near the periphery of the iris and permit to bulge the loose tissue outward in different direction than the radial furrows.

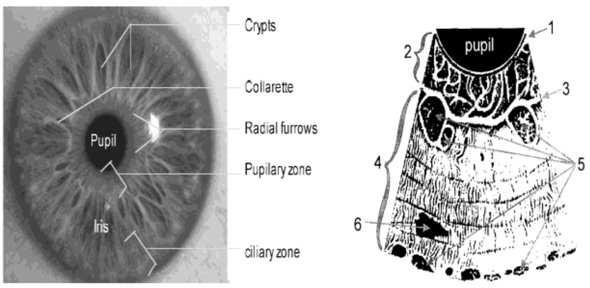

Fig. 1: Features controlling the size of the pupil (1-pigment frill, 2-pupillary area, 3-collarette, 4-ciliary area, 5-crypts, 6-pigment spot) [4]

Collarette is the boundary between the ciliary area and pupillary area. It is a sinuous line shown as number 3 in Fig 1, which forms an elevated ridge running parallel with the margin of the pupil. The collarette is the thickest part of the human iris. The human iris may have some of the rare anomalous visible features. Due to aging or trauma, atrophic areas may appear on the iris, resulting in a "moth-eaten" texture. Tumours may grow on the iris, or congenital filaments may occur connecting the iris to the lens of the eye. [4]

B. Zigzag collarette area localization

Zigzag collarette area is one of the most important part of iris complex patterns since it is usually insensitive to the pupil dilation and less affected by the eyelids and eyelashes unless the iris is partly occluded since it is closed with the pupil size as shown in fig 2. From the empirical study, it is found that the zigzag collarette region is generally concentric with the pupil and the radius of this area is restricted to the certain range. The zigzag collarette area is localized as shown in fig. 2. [5]

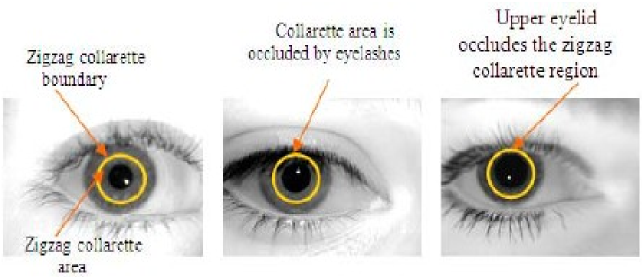

Fig. 2 collarette area is occluded by eyelashes, and (c) upper eyelid occluded the collarette region [5]

II. Iris Localization

To find out the three boundaries for iris localization, first, find the inner boundary between the pupil and the iris. Second, find the outer boundary between the iris and the sclera. For finding these boundaries, an edge detector and some image processing methods are applied to an eye image. Finally, find the collarette boundary in the iris between pupillary zone and the ciliary area using statistical information. [5]

A. Inner Boundary

Though the pupil area has a low gray level and looks dark in the eye image, it can be found by edge detector. In addition, characteristics of the pupil remove some of the unnecessary areas and help to find the inner boundary. To find out the inner boundary, canny edge detector is applied to the eye image after excluding unnecessary areas. [5]

***B.** Exclusion on Unnecessary Areas*

The pupil belongs to the dark side and the noise of the reflection off glasses belongs to the light side in the each image. Therefore, it is possible to remove the light side which has higher gray level. The mean value represents the boundary between the light and dark side, so it can adjust gray levels which have lower than mean value, to the whole gray level [6]. So by determining the median and applying morphological opening and closing operation, the effect of reflection of glasses (specular reflection) can be minimized.

C. Edge image of eye by canny edge detection algorithm

The purpose of edge detection in general is to significantly reduce the amount of data in an image, while preserving the structural properties to be used for further image processing. Before applying edge detection algorithm the image is filtered for removing noise contains from the image after that the canny edge detection algorithm is applied to the image.

1) Smoothing

In order to filter out any noise in the original image before trying to locate and detect any edges Gaussian filter can be used. As the Gaussian filter can be computed using a simple mask, it is used exclusively in the Canny algorithm. Once a suitable mask has been calculated, the Gaussian smoothing can be performed using standard convolution methods. A convolution mask is usually much smaller than the actual image. As a result, the mask is slid over the image, manipulating a square of pixels at a time. The larger the width of the Gaussian mask, the lower is the detector's sensitivity to noise. The localization error in the detected edges also increases slightly as the Gaussian width is increased. [7] The transfer funtion of this gaussian function is given by

$$h(n_1, n_2) = \frac{h_g(n_1,n_2)}{\sum_{n_1}\sum_{n_2} h_g} \quad (1)$$

$$\text{Where} \quad h_g(n_1, n_2) = e^{\frac{-(n_1^2+n_2^2)}{2\sigma^2}}$$

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2) Edge Detection

The Canny algorithm basically finds edges where the gray scale intensity of the image changes the most. These areas are found by determining gradients of the image. Gradients at each pixel in the smoothed image are determined by applying what is known as the Sobel-operator. First step is to approximate the gradient in the x- and y-direction respectively by applying the kernels shown in Equation (2). [8]

$$K_{GX} = \begin{matrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{matrix} \quad \text{And } K_{GY} = \begin{matrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{matrix} \qquad (2)$$

The gradient magnitudes (also known as the edge strengths) can then be determined as an Euclidean distance measure by applying the law of Pythagoras as shown in Equation (3).

$$G = \sqrt{G_x^2 + G_y^2} \qquad (3)$$

where Gx and Gy are the gradients in the x- and y-directions respectively. An image of the gradient magnitudes often indicates the edges quite clearly. However, the edges are typically broad and thus do not indicate exactly where the edges are. To make it possible to determine this, the direction of the edges must be determined and stored as shown in Equation (4).

$$\theta = arc\tan(\frac{G_y}{G_x}) \qquad (4)$$

D. Outer Boundary

It is very difficult to locate the boundary between the iris and the sclera when it is blurred. To find out the outer boundary, canny edge detector is applied to the original eye image again. After that the circular Hough transform is used to find the centre and radius of the iris. Completing the process of Hough transform the Hough accumulator contains the values of number of circle passing to the particular point. So the point from which maximum circles are passing is the centre of the iris and corresponding radius is the radius of the iris. [5]

E. Collarette Boundary

A collarette boundary can be discriminated by adjacent pixels of variety. The Pupillary zone is vastly various and the ciliary area is seldom various as shown in Figure 4. To locate the collarette boundary, the iris area between the inner boundary and the outer boundary is converted from the Cartesian coordinate to the polar coordinate. The coordinate conversion is described in next section. [9]

Histogram equalization is applied to the converted iris image and pixels which are seldom various are removed by a highpass filter with the One-Dimensional Discrete Fourier Transform (1-DDFT). Finally, the collarette boundary is found using statistical information. [5]

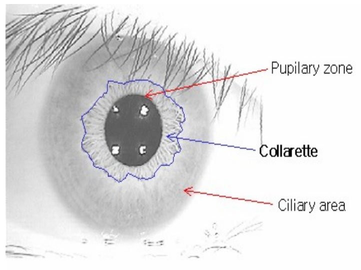

Fig. 3: Image of the papillary zone, ciliary area and collarette [5]

1) Coordinate Conversion

The area between the inner boundary and the outer boundary, called the iris, includes the collarette boundary and these shapes of boundaries are close to a circle. So finding the collarette boundary takes much computation time. To reduce computation time, it needs to convert the Cartesian coordinate into the polar coordinate. Equation for converting coordinates is

$$\theta = \tan^{-1}(\frac{y}{x}) \qquad (5)$$

Where 0< θ < 2π and r is given by the radius of the outer boundary. Figure 5 shows the results of the coordinate conversion. We using 0< θ < 2π excluding portion of eyebrow. [5]

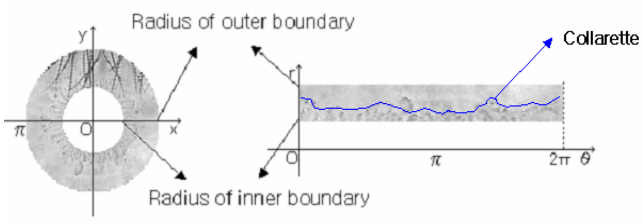

Fig. 4 Result of coordinate conversion [5]

2) Histogram Equalization and 1-D DFT

To locate a collarette boundary histogram equalization and 1-D DFT, are used. In the histogram of the converted image, gray levels are concentrated at the center of gray level from 0 to 255. An eye image, whose pixels tends to occupy the entire range of possible gray levels and, in addition, tends to be distributed uniformly, will have an appearance of high contrast and will exhibit a large variety of gray tones. A characteristic of the Pupillary zone is that there are many differences of gray level at adjacent pixels. To detect differences, the polar coordinate image is converted from the spatial domain into the frequency domain with 1-D DFT. The image, transformed to the frequency domain, represents high frequencies (the gray level varies vastly) at the central part and low frequencies (the gray level seldom varies) at the outside of the centre, so lower frequencies can be removed by a high pass filter. [5] (Report)

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III. Proposed Method

In above method of 1-D DFT we need to convert Cartesian coordinates to polar coordinate system, then only we can apply 1-D DFT. But if we use a different method by using 2-D DFT then we need not to convert any coordinate system. So according to proposed method First of all the eye image is cropped in to the iris image. The histogram Equalization is applied on cropped image. Than the 2-D DFT (By MATLAB function fft2) is applied on the cropped image. After getting the image in frequency domain since the low frequency components will shifted to the corners of the image and high frequency image are at centre of the image. So Low frequency area is shifted to the centre and the high frequency components are out wards from the centre. So this is done by Matlab Function **fftshift.** After that the butter worth high pass image is applied to make image sharpen. Then the inverse fft is calculated using ifft2. At this stage the high frequency and low frequency part are differentiated. So At last the canny edge detection is applied to locate the Zigzag collarette.

So the results of the above steps are as follows:

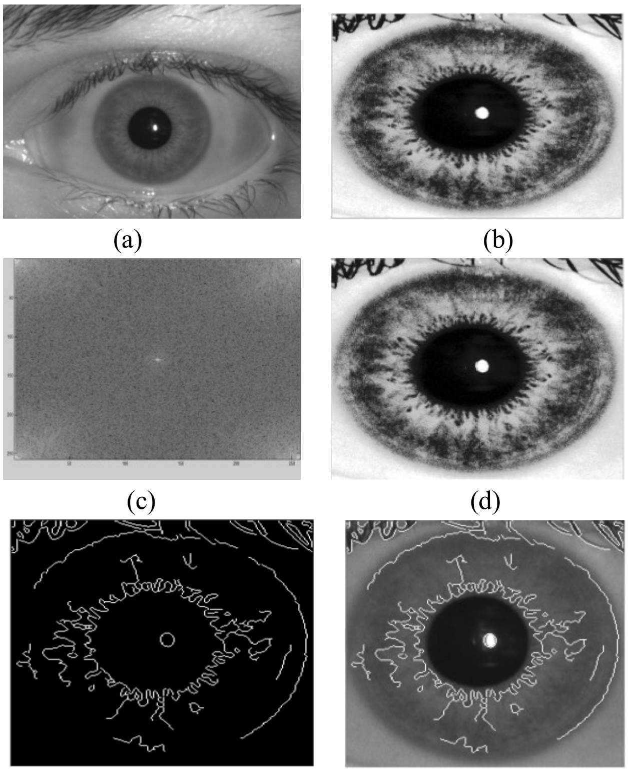
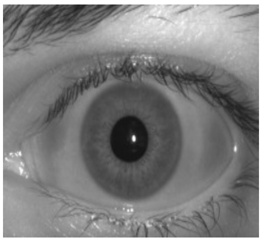
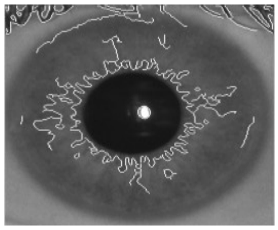
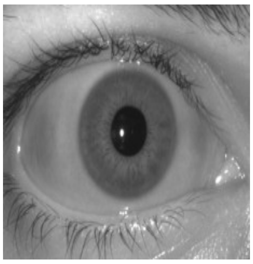
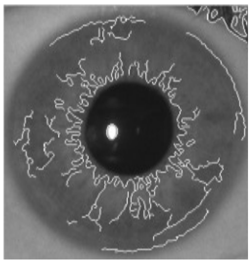
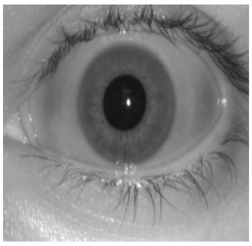
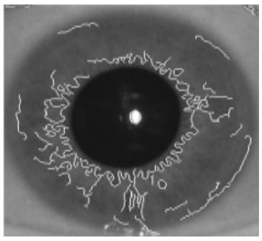
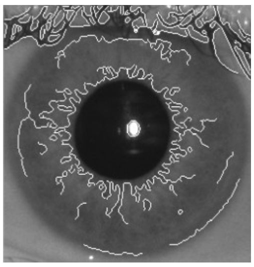
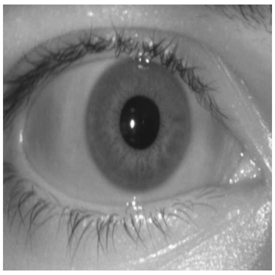
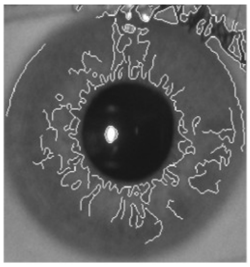


Fig. 5: Different Stage output image in Zigzag collarette boundary localization; (a) Cropped eye image, (b) Image after histogram equalization,(c) Image after 2-D DFT and FFT Shift, (d) Image After inverse FFT,(e) Image after canny edge detection with zigzag collarette detected and located, (f) Collarette boundary is shown in original image.

IV. Zigzag collarette localization Results

Above Process is applied on Proprietary Database and Results are as follows:

Table I. Zigzag Collarette boundary Localization

Sr. no.	**Eye image**	**Cropped eye image with zigzag collarette localized**
1.		
2.		
3.		
4.		
5.		

V. Conclusion

In table zigzag boundary which is highlighted around pupil boundary is nothing but zigzag collarette boundary. In result we can see that besides the boundary some other features are

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also located in the same image at the same time. That features are nothing but crypts. Now as we know that after feature localization the feature are encoded for further process of recognition. So after getting the proper boundary only the area between pupil boundary (inner boundary) and collarette boundary is taken. This will reduce the area for further process (like Normalization, Encoding etc.). As collarette is only the one of the features which is very unique and the least affected by eyelids and eyelashes among all the other features of eye, than this can be encoded very easily and recognition rate will also increase.

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