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Pupil Detection Based on Color Difference and Circular Hough Transform

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ABSTRACT

Human pupil eye detection is a significant stage in iris segmentation which is representing one of the most important steps in iris recognition. In this paper, we present a new method of highly accurate pupil detection. This method is consisting of many steps to detect the boundary of the pupil. First, the read eye image (R, G, B), then determine the work area which is consist of many steps to detect the boundary of the pupil. The determination of the work area contains many circles which are larger than pupil region. The work area is necessary to determine pupil region and neighborhood regions afterward the difference in color and intensity between pupil region and surrounding area is utilized, where the pupil region has color and intensity less than surrounding area. After the process of detecting pupil region many steps on the resulting image is applied in order to concentrate the pupil region and delete the others regions by using many methods such as dilation, erosion, canny filter, circle hough transforms to detect pupil region as well as apply optimization to choose the best circle that represents the pupil area. The proposed method is applied for images from palacky university, it achieves to 100 % accuracy

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1. INTRODUCTION

Iris' eye is one of a most important human biometric that is used for persons identification and authentication. Iris segmentation is an important step in iris recognition, whereas the pupil detection is the key factor of this step. There are many studies interest in this field will be discussed such as: Daugman [1],[2],[3],[4],[5] presented method used an integrodifferential operator to localize both the inner boundary for iris (pupil detection) and outer boundary for iris. They used two arcs to detect the upper and lower eyelids. This method is sensitive to noise and does not eliminate the noise of pupil.

Wilds et al [6],[7],[8] presented a method used edge detection and hough transform to segment the eye image, this method cannot eliminate the noise of pupil and eyelashes and required a high computational cost. Tisse [9] enhanced Daugman's used a method based on reducing the computation time and solving the problem of locating the pupil center outside. With this method, one can use it without eliminating the noise produced due to eyelashes and pupil. Ma et al [10] presented a method by using hough transform after filtering the image and finding the edge points. With the use of this method, the noise of eyelashes is canceled but the pupil noise exists in the segmented area. Zhoghua Lin and Handfei Yu [11] presented a method for detecting pupil, their method consists of three stages depending on OTSU method and Hough transform. The method achieves 100% accuracy.

Imen Khanfir et al [12] presented a method based on histogram thresholding technique in order to extract pupil eye that is followed by a morphological cleaning technique to clear out the pupil binary image by eliminating lashes and reflection points. This method made iris localization faster by a factor of 18. Gomai et al [13] presented a method to detect the boundary of pupil's eye based on the minimum and mean intensity of pupil, this method is able to detect and isolate pupil with high accuracy result and reduce time-consuming. Iman A. Saad et al [14] presented a new method for accurate pupil detection. The method was able to treat the bad acquisition conditions that related to low contrast or unregular brightness, where are caused by many causes, such as, the position of light sources, specular reflection, eyelashes, and eyelids. The accuracy of this method reaches to 100%.

Rubel Biswas et al [15] presented a method for iris detection and recognition, the proposed method consisted of many steps segmentation, normalization, feature encoding, feature extraction, and classification. Hough Transform used for detecting the center of the pupil of an iris, the accuracy of this method reaches to 92%. Vineet Kumar.et al [16] presented a method for iris localization, the proposed algorithm for iris localization divided into two phases which are pupil boundary detection and limbic boundary detection, they used edge map and circural hough transform for pupil boundary detection, the accuracy of this method reach to 99.7% for CASIA-Iris-Thousand (version 4.0) and 99.38% for CASIAIris-Lamp (version 3.0) databases. Teddy et al [17] presented a method for secure smart phone using iris verification, they used wavelet packet and hamming distance for recognition, the accuracy of this method reach to 100% identification rate. In this paper, we present an approach for pupil detection based on many steps. The experimental part was applied on eye image database collected by Palacky University.

2. THE PROPOSED METHOD

In this method, we used a new idea for pupil detection with better accuracy. This idea depending on the differences between the intensity level (low or high level) and (chromatic or near to gray color) in the pupil and iris regions. Figure 1 illustrated the histograms for crop regions of the pupil and the iris. From the histogram of the pupil, one can see the most of the pupil region is gray or tend to gray color. This means the color difference between the (RGB) is small (the data images in the pupil is achromatic Often). The figure shows also the intensity for RGB component is low in the case of neglecting the luminous disc in the center, whereas in the iris region the intensity is high and the color deferent is clear (the data images in this Iris region is chromatic Often).

These color features isolate the iris area partially where the area of the pupil is not completely gray. It contains a slight color and the area may also contain small gray gaps. These difficulties can be overcome by binarization the pupil region, which can be achieved by use dilation and erosion of the pupil to a reach an approximate isolation for the boundary of iris. The pupil region has been fitted to Circular Hough Transform. A preliminary work area with radius $\mathrm{r_w}$ is selected, It is a circular area with radius between $(\mathrm{r_{wmin}}, \mathrm{r_{wmax}})$, through which determines the pupil boundaries as shown in Figure 2. The identification of this region provides a shortcut in time when conducting mathematical operations and computed for the entire image. First, the image is converted to a binary image $\mathrm{I_b}$ taking into account the difference in color and intensity between the pupil and iris region.

$$If\ c(i\ ,j\ ,k,r_w) < t_1 \tag{1}$$

$$c(i\ ,j\ ,k,r_w) = 0 \tag{2}$$

Here i, j being the position Coordinates, $k = 1,2,3$ are the RGB component and t_1 is the greatest approximate value of intensity in a pupil area. Total differences of RGB component is:

$$I_{td} = d_{rg} + d_{rb} + d_{bg} \tag{3}$$

Where:

$$d_{rg} = abs(r - g) \tag{4}$$

$$d_{rb} = abs(r - b) \tag{5}$$

$$d_{bg} = abs(b - g) \tag{6}$$

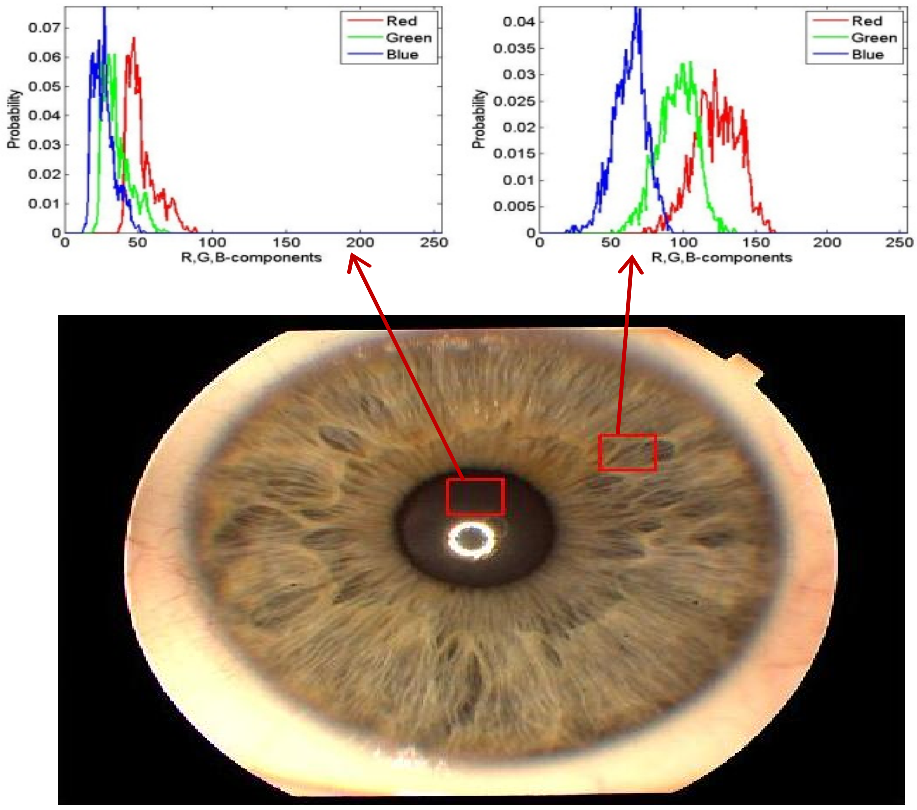

Figure 1. comparing between the histograms for pupil and iris region within certain areas.

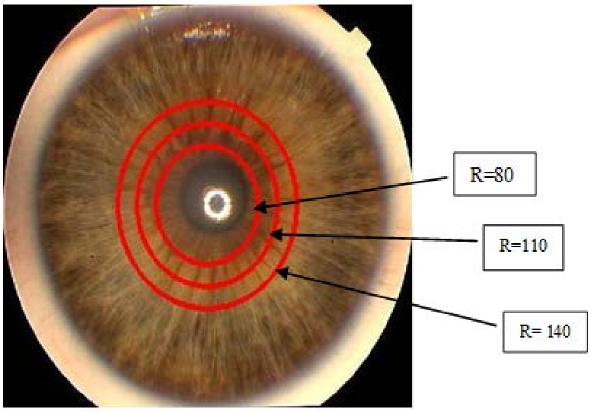

Figure 2. circle work area with different radius.

The result of this step is the region of pupil become white area as shown in Figure 3. Converting the image into a binary image depends on the threshold value t_2 where:

$$t_{2min} \leq t_2 \leq t_{2max} \quad (7)$$

$$\text{If } I_{td} < t_2 \text{ then } I_b(r_w, t_2) = 0 \quad (8)$$

$$\text{else } I_b(r_w, t_2) = 1 \quad (9)$$

For the total RGB component is:

$$T = r + g + b \quad (10)$$

$$\text{If } T < t_3 \text{ then } I_b(r_w, t_2) = 0 \quad (11)$$

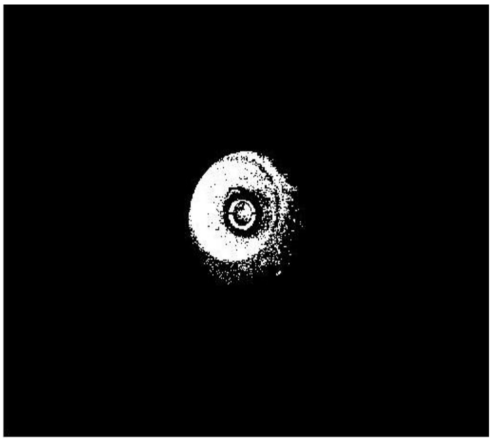

Figure 3. binary result according to color difference.

The second step is to isolate the pupil by dilating of excess areas, filling the gaps and using edge detection techniques. This is done through the following steps:

$$I_{bd}(r_w, t_2) = I_b(r_w, t_2) \oplus se \quad (12)$$

Where

$$se = \begin{vmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{vmatrix} \quad (13)$$

The fact that the iris region is not colored has gray-generated objects, to remove all connected components objects that have fewer area sm from the binary image, for all block region cI_{bd} in the binary image I_{bd} to get I_{bdr} where:

$$\text{If} cI_{bd} < sm \text{ then } cI_{bd} = 0 \quad (14)$$

The area of the pupil is not connected because it is not absolutely gray. This resulting in a gap when converted to a gray image to connecting this area used canny edge detection and seed filling techniques to resulting.

$$I_{bdrcf}(r_w, t_2) \quad (15)$$

The result of this step shown in Figure 4. Figure 4 shows the binary image is not completely circular, thus it was used CHT that is working to complete the circular shape by input approximate radius rc as shown in Figure 5. In this study, several radii were used to get $I_{ch}(r_w, t_2, r_c)$, and then filling the circular region being $I_{chf}(r_w, t_2, r_c)$. We will produce several circles filled with different radii , r_c.

$$r_c = [\min_{r_c}, \max_{r_c}] \quad (16)$$

To find the absolute error between I_{bdrcf} and I_{ch}

$$Er = |I_{ch}(r_w, t_2, r_c) - I_{bdrcf}(r_w, t_2, r_c)| \quad (17)$$

The best value of the parameters r_w, t_2, r_c as shown in Figure 6 getting at:

$$\min_{r_w, t_2, r_c}(Er) = 0 \quad (18)$$

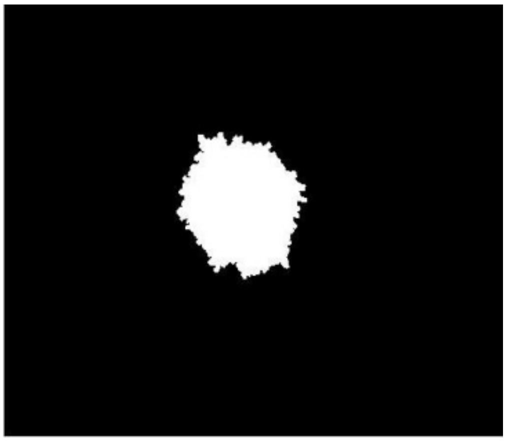

Figure 4. Binary result from removing all connected objects and seed filling the hole region.

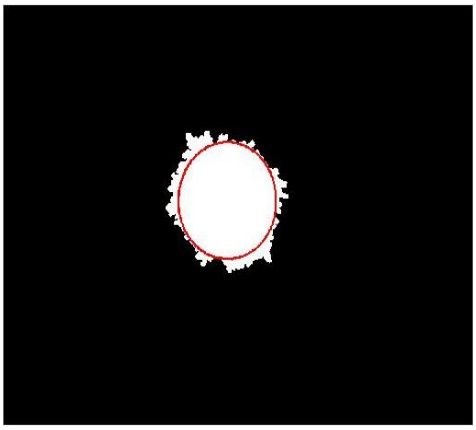

Figure 5. Circle hough transform for fitting circle.

3. EXPERIMENTAL RESULTS

Our method performed by using Matlab (version R2013a) on computer platform has 2.4 GHZ core i5 processor and 4G ram. In this work we used r_w= [90 140] , t_2 = [50 70] , t1= 50 and r_c= [30 to 140], The proposed method was applied to images collected by the Palacky University. The database [18] has 6* 64 iris images (i.e. 3*64 left and 3*64 right), the images properties are 768*576 pixels, and file format is PNG. The table (1) shows the accuracy values of the pupil detection by using algorithms in [19] and [20], first value is 99.86%, second 98.85% and the proposed method reach to 100 % accuracy.

4. CONCLUSION

Pupil detection is the most important step in iris detection. In this work, we present a new method for pupil detection. The method consists of many steps beginning from reading eye image until reach to pupil detection step. The recent is the most important step where it depends on the difference in color and intensity between pupil and surrounding area. This characteristic is very useful to determine the pupil region and extract it, thus the pupil becomes has a little color and intensity than surrounding region. The new method is very successful in pupil detection, the accuracy of the method reach to 100 % compare with other methods.

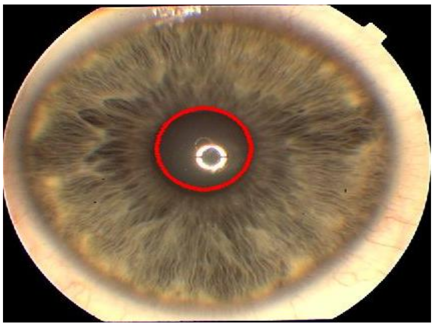

Figure 6. Final pupil detection step.

Table1. Comparsion between our Proposed Method Result and others Method

method	A. Basit et al [19]	Ann A. Jarjes [20]	Our method
Accuracy rate	99.86 %	99.85%	100%

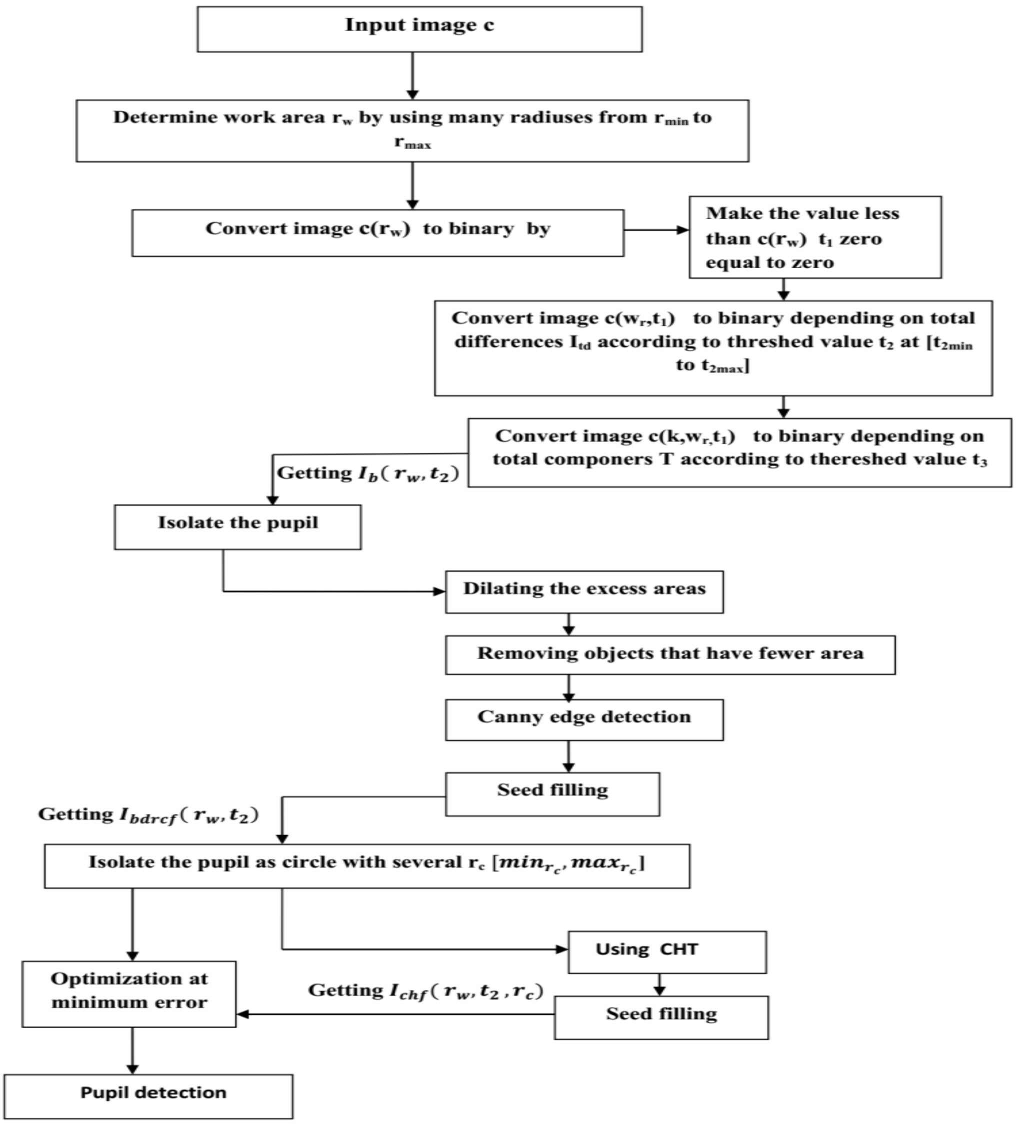

Figure 7. Flow chart of proposed method

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