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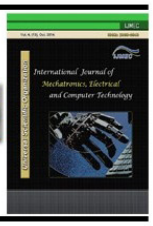

Real time eye detection using edge detection and euclidean distance

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Abstract

Nowadays research in face features detection and recognition is getting more attention among researchers due to its different applications in science. This paper proposed a new method for eye detection using edge detection and Euclidean distance. In the proposed method, skin region is specified using a skin detection technique which employs some formulas in two different color spaces. In the specified skin region, horizontal edges are detected by combining the results of two known masks, Prewitt and Sobel. By using morphology operations such as dilatation and erosion, very small edges are removed and close edges are connected. The face region is divided to three parts: the upper right quarter, the upper left quarter and the lower half. In each part, the biggest binary object is found as the right eye, the left eye and the mouth. In order to verify the previous steps, the distances between left eye center to mouth center and right eye center to mouth center are found. The proposed method is tested on PICS, which is a database containing face images. It shows 93 percentage accuracy in an acceptable time.

Keywords: *eye detection; edge detection; human computer interface*

I. Introduction

Nowadays, research in face features detection and recognition is getting more attention among researchers because of its extended usage in different research areas such as Human Computer Interface (HCI), brain computer interface and etc. One of the interesting topics in this area is developing an eye detection technique named as eye mouse in computer devices (computer, mobile, tablet and etc.) [1]. This technique is used in performing activities such as reading, writing and searching. One of its other applications is monitoring tired drivers eyes while driving [2]. Determining eye place in face images is one of the main works in the image processing applications such as face recognition, face verification, estimate pupil place and human computer interface. Some different methods have been suggested for eye detection such as illumination [3], geometry information [4], edge [5] and color [6]. There are three approaches in eye detection: shape-based, appearance-based and feature-based approaches. The shape-based approach uses previous model of the shape and near structures of the eye [7, 8]. Whereas appearance-based approach uses ready models directly based on appearance of eye region [9, 10]. Feature-based approach uses features such as edges, eye corners or select points based on special filter responses [5, 11]. Eye detection is a very challenging work because of some issues such as eye's occlusion by eyelid, opened/closed eye, changing in both size and reflection effect or different head poses and etc. [12]. Our method is a feature-based approach. In proposed method, edge feature is used to perform eye detection. If the edge detection is applied on face images, most of the edges contain eyes and mouth. This method works only on face images in

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which the eyes are open and also both eyes can be seen in the image. The rest of the paper is organized as follow: Section 2 includes related work; Section 3 contains details of the proposed method; the experimental results are presented in Section 3; and Section 4 contains conclusion of the paper.

II. Related Work

Nasiri et al. presented eye detection method based on illumination, although the method is very strong but it has high computation cost and also it just works on color images [3]. Soylemez and Ergen suggested detection method with using Hough transform, but this method has a high computation cost [4]. Chiang et al. presented color-based method.

This method's speed is high but it doesn't work on images of people who have black skins because in these images the eyes region isn't darker than the skin region [6]. Ying-Li et al. offered a method based on eye-closing and eye-opening states. This method recognizes close state for eyes that is slightly open. In illumination conditions, the eyes with glasses could not be recognized because of the glasses cover over the eyes [7]. Grauman et al. suggested a method based on blinking patterns used as a communication signal in Word software to be able typing without using hands [10].

Other methods are based on hardware that are suggested in [13, 14]. These methods are strong and fast but they have limitations such as need for additional hardware, working on videos and have distance limitation because of pupil reflection.

III. The Proposed Method

In the proposed method skin region is detected using skin detection in YCbCr and RGB color spaces. Afterward the color image containing skin region is separated and converted to gray scale image. The eyes are detected on gray scale image using morphology operation and edge detection technique. The Prewitt and Sobel detection masks are used to detect horizontal edges.

After edge detection operation, the morphology operation such as dilatation, erosion, filling holes and etc. is done to improve blobs that are detected and to remove very small edges. The face image is divided into three parts and in each part the largest connected component is found. To verify the exact location of the eyes, the Euclidean distance is obtained. The flow diagram of the proposed method is shown in Fig. 1.

A. Skin detection

For skin detection, the RGB color space of the image is converted into YCbCr color space based on (2).

$$r = R / 255,\ g = G / 255,\ b = B / 255 \tag{1}$$

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.4810 & 128.5530 & 24.9660 \\ -37.7970 & -74.2030 & 112.0000 \\ 112.0000 & -93.7860 & -18.2140 \end{bmatrix} * \begin{bmatrix} r \\ g \\ b \end{bmatrix} \tag{2}$$

The YCbCr color space has three components Y, Cb and Cr. Kukharev and Nowosielski [15] obtained rules for each component of this color space using 25 sample face images of different races. A pixel is a skin pixel if it satisfies (3).

$$(Y > 80)\ AND\ (85 < Cb < 135)\ AND\ (135 < Cr < 180) \tag{3}$$

The RGB color space includes three components red(R), green (G) and blue (B). Kovac et al. presented some rules for each component. They used YCbCr color space in different skin groups to obtain these rules. A pixel is a skin pixel if it satisfies the (4) [16, 17].

$$(R > 95)\ AND\ (G > 40)\ AND\ (B > 20)\ AND$$
$$(|R-G| > 15)\ AND\ (R > G)\ AND\ (R > B)\ AND$$
$$(Max\{R,G,B\} - Min\{R,G,B\} > 15) \quad (4)$$

B. Horizontal edge detection

A skin color image is obtained using both methods that already have been introduced, after that, the contrast of the image is improved. The image is converted into gray scale image. The difference between maximum light intensity and minimum light intensity in gray scale image is called image contrast.

Our primary image could contain some defects; one of these defects is unsuitable image contrast. Because of unsuitable image contrasts, the edge finding process may lead to a false result.

The Sobel [18] and Prewitt method uses the derivative approximation to find edges. Therefore, it returns edges at those points where the gradient of the considered image is a maximum. The horizontal and vertical gradient matrices whose dimensions are 3×3 for the Sobel method has been generally used in edge detection [19].

Sobel edge detection method is shown in (5) and Fig. 3. Prewitt edge detection method is illustrated in (6) and Fig. 4. The contrast of gray scale image is improved using the Sobel edge detection method applying on horizontal edge detection.

The sharp edge regions are eyes, nose, eyebrow and mouth in the face. By using the Prewitt edge detection method the horizontal edges in a face are detected. After obtaining edges by two methods the results are combined and the edges which are detected in both methods are considered as the true edge. To reach this goal both matrixes are multiplied pixel by pixel.

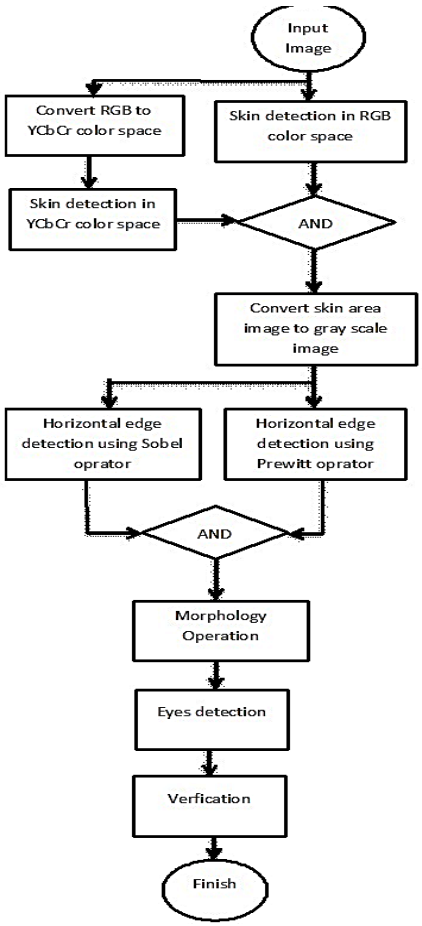

Fig. 1. The flow diagram of the proposed method

$$\nabla f=\left[g_x^2+g_y^2\right]^{\frac{1}{2}}=\{[(z_7+2z_8+z_9)-(z_1+2z_2+z_3)]^2$$
$$+\left[(z_3+2z_6+z_9)-(z_1+2z_4+z_7)\right]^2\}^{\frac{1}{2}} \quad (5)$$

$$\nabla f=\left[g_x^2+g_y^2\right]^{\frac{1}{2}}=\{[(z_7+z_8+z_9)-(z_1+z_2+z_3)]^2$$
$$+\left[(z_3+z_6+z_9)-(z_1+z_4+z_7)\right]^2\}^{\frac{1}{2}} \quad (6)$$

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

Fig.2. Image neighborhood

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

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

Fig. 3. Masks of Sobel operator

-1	0	1
-1	0	1
-1	0	1

-1	-1	-1
0	0	0
1	1	1

Fig. 4. Masks of Prewitt operator

C. Morphology operation

Morphology operation is an extended set of image processing operations based on shapes. Morphology operations include dilatation, erosion, closing and opening operations. These operations cause smoothing the object boundary without causing any change in a given region. Using these operations cause improvement in detection efficiency. Dilatation operation causes adding pixels to an object boundary but erosion operation causes removing pixels from an object boundary. Adding and removing pixels to and from an object is based on size and shape of the element structure. The size and shape of an element is defined based on pixels neighborhood. Closing operation is dilatation after erosion and opening operation is erosion after dilatation on the same structural element.

Dilatation causes binary objects to become big and thick. The degree of this thickness depends on the shape of the structural element. The structural element that has radius 3 disk is used to connect the edges that are close to each other. Erosion causes binary objects to become thin in binary image. The same as dilatation, to specify the thickness property, radius 3 is used. The reason of using radius 3 is that in some faces the eye and the eyebrow are not close to each other, so they don't connect to each other. The holes are filled in binary object. The small objects in binary image are removed to reduce the amount of objects to be investigated and as the result to improve the speed of the

method. As the possibility of being some hair on a face image would result to a false detection of an eye. To prevent such false results the boundary pixels of binary image are removed.

D. Eyes and mouth detection

To detect eyes and mouth on a face each object is investigated based on its correct position part on a face image. To detect the right eye, the upper right quarter in the face image would be examined. To detect the left eye the upper left quarter in the face image would be examined. Also to detect the mouth the lower half part of the face image would be investigated. For the right eye detection the biggest binary object would be found in upper right quarter in the face image because this part contains the most number of edges belonging to the right eye. For the left eye detection the biggest binary object is obtained from upper left quarter in the face image because the most number of edges belonging to the left eye is in this region. For mouth detection the biggest binary object would be discovered in the lower half part of the face image because the most number of edges in this region belongs to the mouth.

E. Verification

As a verification part, to be sure that the have been found objects are really related to the real eyes and mouth, the distance between mouth center and left eye center and also the distance between mouth center and right eye center is obtained based on (7). In order to find the center of the binary object, the surrounding rectangle is obtained and then the center of the rectangle is specified [19]. The difference between these two distances should be less than a threshold. If the difference value is lower than the threshold value, this method has successfully found the eyes and the mouth position. To find the distance between two points, the Euclidean distance is used. If "*D1*" is considered as the distance between the mouth and the right eye and "*D2"* is considered as the distance between the mouth and the left eye, the equations are as below (7). The "*Th*" value specifies the difference that should be below a threshold value for verification.

Center of right eye = (X1,Y1)

Center of left eye = (X2,Y2)

Center of mouth = (X3,Y3)

$$D1=\sqrt{(X3-X1)^2+(Y3-Y1)^2}$$

$$D2=\sqrt{(X3-X2)^2+(Y3-Y2)^2}$$

$$Th = | D2 - D1 | \quad (7)$$

IV. EXPERIMENTAL RESULTS

The proposed method is implemented and tested on PICS image database. Our database contains 100 images including men and women selected from different races and ages randomly. Color images are in different sizes and lighting conditions. Most of these 100 images are from PICS image database. Table I shows that the proposed method has high accuracy than the method based on edge density.

TABLE I. experimental results on PICS image database

Method	Accuracy
Method based on edge density[5]	80%
The proposed method	93 %

Some samples of images from PICS database that are passed though the proposed method processes (eye detection after skin detection) are shown in Fig. 5.

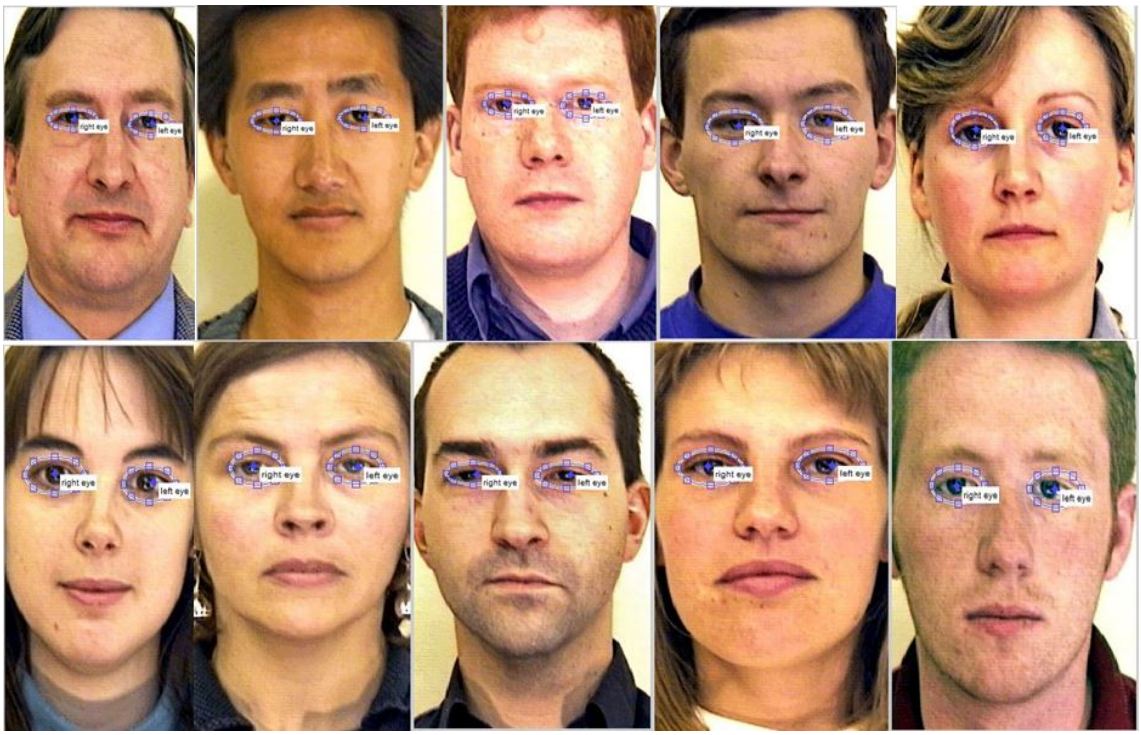

Fig. 4: Sample images showing that the proposed method detected eyes truly after skin detection

CONCLUSION

In this paper, a new method is suggested in eye detection for real time applications. This method is strong and fast on face images of different people from different races and in different lighting conditions. But in the case of images with very bad lighting conditions the proposed method doesn't perform correctly. The reason is that working on grayscale images is very ideal in terms of computation cost. The proposed method uses Sobel and Prewitt methods to find horizontal edge in face image. To improve the method the morphology operation is used. For verification, the Euclidean distance method is used because normally the distance between eyes center and mouth center is equal. Experimental results show that the proposed method has high accuracy. The accuracy of proposed method is 93% that is an ideal accuracy for an eye detection technique.

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