The Eyelids Distance Detection in Gray Scale Images

Abdol Hossein Fathi [*], Fardin Abdali Mohammadi[†]
and Mohammad Taghi Manzuri [‡]
Faculty of Computer Engineering
Sharif University of Technology, Tehran, Iran
*Tel: +98-916-661-5160, E-mail: ahfathi@noavar.com
[†] Tel: +98-912-605-2405, E-mail: Ebdalimo@ce.sharif.edu
[‡] Tel: +98-21-6616-4611, E-mail: manzuri@sharif.edu

***Abstract*— in this paper a new method for finding the distance between eyelids, in order to determine the open or closed state of eye, has been introduced. For this aim, first the gray scale image of eye region is converted into a binary image. Next, a differential variance projection function is applied on the binary image of eye region in horizontally direction to show the uppermost and lowest points on the eyelid edges. Having the distance between these two points, the distance between two eyelids will be obtained. This distance may be used as a criterion in recognizing the open or closed state of eye. We have used numerous and different images to evaluate the efficiency of the presented method, and the obtained results have convinced us that the applied algorithm is efficient.**

Key words: Binary Image, Eyelids Distance, Variance Projection.

I - INTRODUCTION

In many cases we can make use of detecting the eye and its parts, especially when we determine the distance between eyelids to find the state of eye. This method is applicable in different applications, such as human face detection, security systems, and distinguishing awakens from sleep state in people, especially in analyzing the behavior of car-drivers.

The localization of face parts, especially eye and eyelids is a challengeable matter. The organization of the paper is as follows: In section II, we introduce the variance projection function, and describe the way we have used this function for finding the distance between eyelids, and then in the third section, results from experiments related to the application of algorithm on different images, have been shown.

II - FINDING THE DISTANCE BETWEEN EYELIDS

Detecting eye and its parts is too difficult and too complicated because eye has an active pattern consist of two eyelids and a black iris and there is no chance for extracting a static pattern out of it. In these latest years different algorithms on detecting the face [1- 3] and detecting the facial features such as eye [4 – 10] have been presented. Distinction between eye different parts like black iris and eyelids is more difficult than finding out the eye itself.

A common approach to it is applying ways established based on edges. In these ways is by applying an edge detector operator on the eye region tried to found out the circumference of a circle as the black iris. Then the biggest continuous curve of edges above and under the center of this circle is chosen as the upper and lower eyelids [11]. Distance between center of the circle related to eye black iris to the uppermost edge related to the above eyelids will be criterion for open or closed state of eye. Another way is that we point out the eye corners and use the angle between two eyelid edges as a criterion on measuring how much the eye is open [12]. In using edge-based approaches, the image must have a high resolution while most of the time resolution on eye region is low and applying edge-based algorithm is unreliable and error in judgment is drastically high.

In this paper we've enjoyed a more reliable approach in finding out eye's parts and especially in finding the distance between two eyelids and it is, make use of a variance function and applying it on the eye region. Images from eye region because of some characteristics such as black iris, eye whiteness, eyebrows and eyelids have a great alteration in intensity of luminosity. Variance is a function that is able to show clearly the alterations of a random variable. Therefore we apply this variance projection function on eye region to use this characteristic and draw the points with highly alteration such as eyelid edges and iris. For more understanding see the following image (Fig.1) that the variance projection function has been applied on.

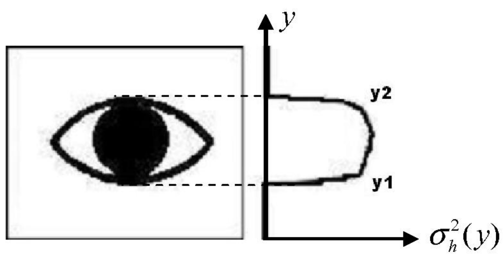

Fig.1. Applying Variance Projection Function on the Eye Image

In fig. 1, suppose X_{eye} for length of eye window and Y_{eye} for height of it. After applying the variance projection function on the eye region, in horizontal direction we have the right hand curve. We have:

$$\sigma_h^2(y) = \frac{1}{X_{eye}} \sum_{x=1}^{X_{eye}} [I(x,y) - M(y)]^2 \qquad (1)$$

In it I(x, y) is the intensity of luminosity in the point (x, y) from the eye region image and M(y) is the mean for intensity of luminosity in y^{th} line from the eye section that is calculable like this:

$$M(y) = \frac{1}{X_{eye}} \sum_{x=1}^{X_{eye}} I(x,y) \qquad (2)$$

Accordingly we calculate variance for all the other lines and process them upwardly. As it is obvious from the fig. 1, at firs variance amount is low; the first point with high variance is related to the lower eyelid edge, after that variance amount would be high and there would be no perceptible alteration until we reach the upper eyelids edge and there we have sever shortage of variance amount. Finding out these two points (lower and upper eyelid edges) that alteration in variance amount is high in them we can apply the resulted differential variance projection function. Of course, to that the other alterations don't misunderstand us in detecting the two points with maximum alterations, after applying the differential variance projection function we omit all the amounts that are less than the half of amount of the biggest resulted differential variance projection.

$$y_i = [y_j \mid (\frac{\partial^2 \sigma_h^2(y_j)}{(\partial y_j)^2} = 0 \;\; and \;\; \sigma_h^2(y_j) \ge \max(\sigma_h^2)/2)] \qquad (3)$$

For j = 1 to Y_{eye} and i = 1, 2.

Here, $\max(\sigma_h^2)$ is the biggest differential variance projection value and $\sigma_h^2(y_j)$ is the j^{th} value of differential variance projection function. Then we will be able to find the two points with maximum alterations with high efficiency and great accuracy. In fig. 2, we observe this function.

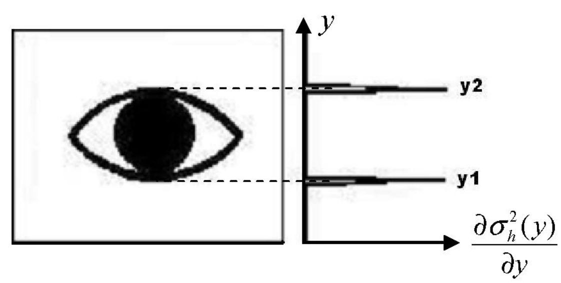

Fig.2. Applying Differential Variance Projection Function on the Eye Image

Distance between these two maximum points ($d=y_2-y_1$) is the real distance between two eyelids and is a criterion in finding how much the eye is open. Since must of the time eye resolution is low and this region have many noises such as eye shade, eyelids shade and wrinkles round the eye, applying differential variance projection function directly on the eye image when finding the upper and especially lower eyelid edges don't have a high efficiency and accuracy. Because of this for increasing the efficiency and accuracy in finding the distance between two eyelids we first convert the eye region image from the gray scale into binary applying a threshold on it (the threshold value is 75), and then to omit noises and other little sections on this image, we apply a dilation operator on this binary image.

After that for finding the lower and upper eyelids edges we apply the differential variance projection function on this image. In fig. 3, we can see these operations.

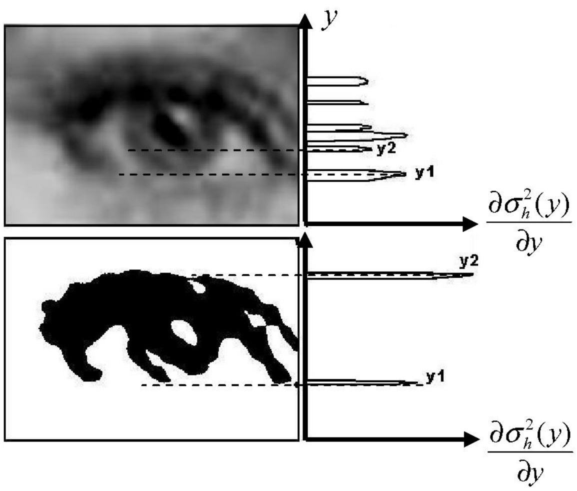

Fig.3. Applying Differential Variance Projection Function Directly on the Eye Image and on the Binary Image of Eye Region

It is clear from fig. 3, that applying differential variance projection function on the binary image of eye region in comparison to applying it directly on the eye region image has a higher efficiency and greater accuracy. We have applied both these two methods on 185 eye region images of different people and in different situations and the obtained results are testimonies to this claim. This result has been presented in Table 1. This approach contrary to other edge-based approaches has no need to high resolution in detecting the distance between two eyelids and is more reliable. Furthermore in cases when eye is closed it can accurately show eye state and the distance between eyelids. Table 2 compares the presented method in this paper to other available approaches and shows its efficiency and preference on them.

III - Experiment Results

We applied algorithm in finding the distance between two eyelids on 185 eye images from different people and in different situation and did this by applying a differential variance projection function both on the eye region and on the resulted_binary image from the eye region that the obtained results have been presented in Table 1. As it is clear from the results extracting a binary image from eye region and applying the algorithm on it make it more efficient and more accurate. We can see some of these images on fig. 4, in image *(e)* because the subject had worn glasses, the algorithms hasn't find the real distance between eyelids and also in image *(f)* because of the direction and situation of eye in that algorithm, distance between two eyelids has been shown less than real distance.

TABLE I
RESULTS RELATED TO THE APPLICATION OF DETECTING ALGORITHM ON FINDING THE DISTANCE BETWEEN EYELIDS

Methods of applying variance projection function on images	Total images	correct recognized images	Images with error in judgment	Success percentage
On binary images	185	180	5	97.29 %
Directly on images	185	158	27	85.40 %

TABLE II
COMPARING PRESENTED METHOD TO AVAILABLE APPROCHES

Methods in finding eye status	Sensitivity to intensity of luminsoity	Ability in finding eye closed state	Sensitivity to eye direction and situation	Sensitivity to person
Talmi and Liu [12]	High	Limited	Mean	No
Sirohey and et. al. [11]	High	No	Low	No
Our method	Low	Yes	Low	No

IV - Conclusion

As it is clear from the results of experiments the detecting algorithm on finding the distance between two eyelids with 97% efficiency in finding out eye status and distance between eyelids is actually workable. We can use this algorithm in application such as sleepiness state of drivers or mutual relation between human and computer and other applications that need finding eye state.

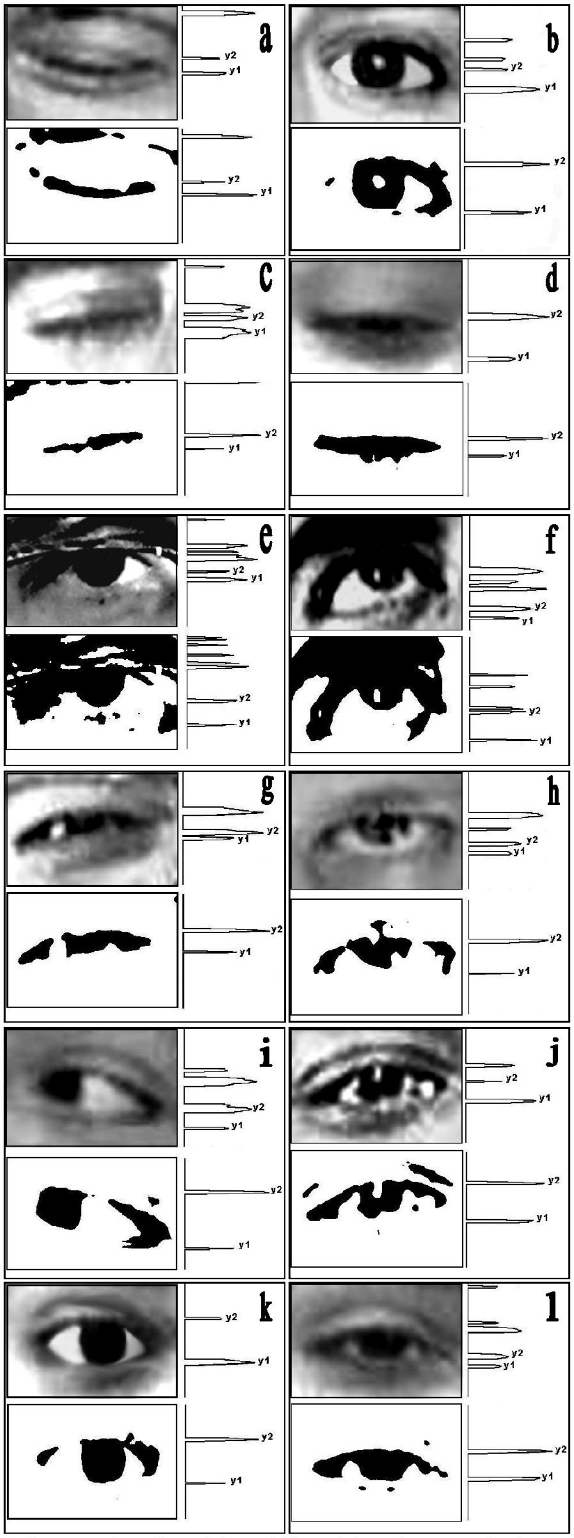

Fig.4.Results of Applying Differential Variance Projection Function on the Several Eye Images

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