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Effects of Different Edge Detection Techniques towards Detection of Closed or Opened Human Eye

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Abstract—*The edges in closed and opened eyes can be observed at eye brows and eye lashes. Proper detection of human eye edges can be helpful to differentiate between closed eyes and opened eyes. The effects of different edge detection techniques towards human eye have been analyzed and summarized in order to obtain proper edge in gray level towards human eye.*

1. INTRODUCTION

The detection of states of human eyes (opened or closed) is very useful in order to find whether the person is in drowsy condition or not. These can be extremely helpful in order to detect drowsiness while driving. A proper error and noise reduction followed by suitable edge detection method should be obtained in order to achieve the difference between opened and closed eyes. The distance between two edges in a gray eye image (edges at eye brows and eye lashes) is the determining factor for this decision. If the distance between the edges is higher than a predetermined threshold value (in terms of row and column numbers) then it can be concluded that the person has closed eyes. On the contrary, if the distance is lesser than predetermined threshold distance, then the conclusion will be opened eyes.

2. EDGE DETECTION IN IMAGE PROCESSING

The sharp edges in gray images are considered to be the spaces where the change in gray level is abruptly sharp. For two or more consecutive space points, if the magnitude and phase of gray level gradients are above some predetermined threshold level, these points can be assumed to be inside edges [7, 8]. Edge can be horizontal, diagonal, and vertical in nature. The magnitude of the gradient determines the abruptness of the variability of gray level in unit space whereas the phase determines the color changing directions of the edges (whether it is approaching to brighter region or darker region). All the points except the spurious noises can constitute an edge. Edges from a noise-reduced image can be obtained from different kernel or mask from different edge detection protocols. Some mostly used edge detection operators are Sobel operator, Canny operator, Roberts operator and Prewitt operator. The qualitative differences among these operators have been analyzed. The gradients can be obtained from individual X-gradient and Y-gradient of gray level from that point. Assuming the X-gradient and Y-gradient of a particular point at co-ordinate (x, y) are D_x and D_y respectively, the magnitude of gradient of a particular pixel point is shown in Equation 1.

$$|D| = \sqrt{[(D_x)^2 + (D_y)^2]} \quad (1)$$

The phase expression of the gradient has been shown in Equation 2.

$$\tan \phi = \frac{Dy}{Dx} \quad (2)$$

The magnitudes and phases of two successive points must lie inside the region of threshold level which is predetermined. If the magnitudes of two consecutive points are $|D_1|$ and $|D_2|$ respectively and the phases of two consecutive pixels are ϕ_1 and ϕ_2 then the following condition must be satisfied in order to consider them inside the edges. These equations are shown in Equation 3 and E1uation 4.

$$|D_1| \sim |D_2| < \text{predetermined gray level threshold} \quad (3)$$

$$\phi_1 \sim \phi_2 < \text{predetermined phase threshold} \quad (4)$$

3. EDGE DETECTION ON HUMAN EYE BY SOBEL OPERATOR

The necessary 3×3 X-kernel and Y-kernel for Sobel operator have been shown in Table 1 and 2 [3, 4].

Table 1: X kernel of Sobel operator.

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

Table 2: Y kernel of Sobel operator.

-1	2	1
0	0	0
-1	2	1

A closed eye image has been acquired through digital camera and it has been converted to grayscale image. The images have been shown in Fig. 1(a) and Fig. 1(b) respectively. The gray image is then passed through pixel wise adaptive Wiener filtering in order to remove the noise. The noise reduced picture is also shown in Fig. 1(c).

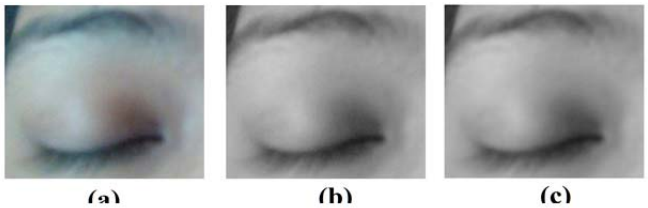

Fig. 1(a). Original colored image of closed eye

(b). Gray image of closed eye

(c). Filtered gray image of closed eye

Similar observations are done for opened eyes. An image of opened eye has been acquired (shown in Fig. 2(a)). The gray image has been shown in Fig. 2(b). The gray image is then filtered by pixel wise adaptive Wiener filter. The final image has been shown in Fig. 2(c).

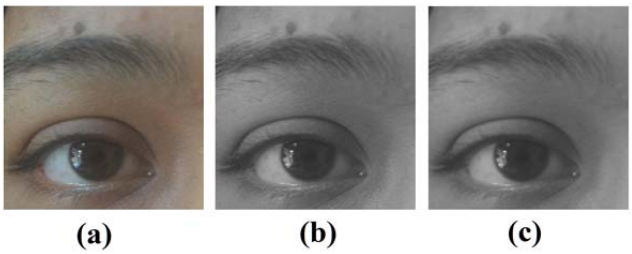

Fig. 2(a). Original colored image of opened eye

(b). Gray image of opened eye

(c). Filtered gray image of opened eye

Wiener filter is a two dimensional adaptive filter. It calculates local mean gray level value for each pixel point and the spurious pixel point with variance due to noise from mean gray level value is removed.

The images of closed eyes without and with filtering both have been applied in Sobel filtering and the results are shown in Fig. 3(a) and 3(b) respectively.

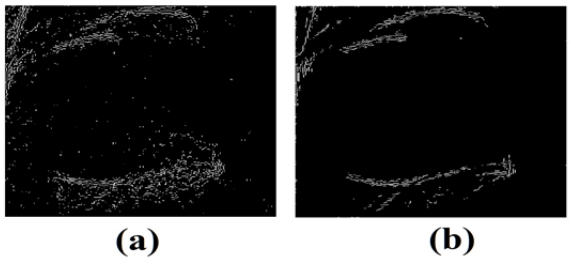

Fig. 3(a). Sobel operator on image of closed eye without filtering, (b). Sobel operator on image of closed eye after filtering

The images of opened eyes are also edge detected by Sobel operator and the results are shown in Fig. 4(a) and 4(b) respectively for noisy image and image after noise reduction.

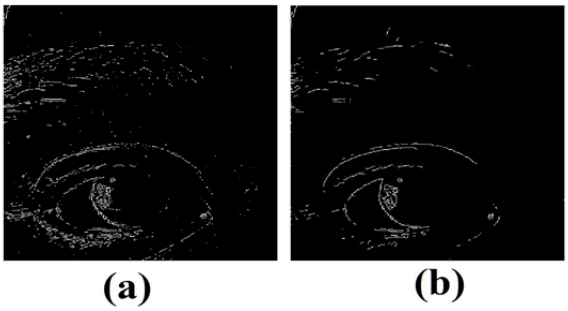

Fig. 4(a). Sobel operator on image of opened eye without filtering, (b). Sobel operator on image of opened eye after filtering

From Fig. 3 and 4, it can be shown the spurious noises have been removed by the filter. The two valleys of gray levels (eye brows and eye lashes) are shown by bright white line after edge detection. The distance between these two valleys are increased when a person close the eyes. This can be a possible approach for drowsiness detection while car driving.

4. EDGE DETECTION ON HUMAN EYE BY PREWITT AND ROBERTS OPERATOR

The 3×3 X-kernel and Y-kernel of Prewitt operator have been shown in Table 3 and Table 4 [2]. The 2×2 X-kernel and Y-kernel of Robert operator have been shown in Table 5 and Table 6 [1]. Robert operator is used with this realization that diagonal differentiation gives better gradient values.

Table 3: X kernel of Prewitt operator.

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

Table 4: Y kernel of Prewitt operator.

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

Table 5. 2×2 X kernel of Roberts operator.

1	0
0	-1

Table 6. 2×2 Y kernel of Roberts operator.

0	1
-1	0

The Prewitt and Roberts operators are applied to the noisy and noise filtered image too see their effects towards edge detection. The effects of Prewitt filtering on closed eyes are shown in Fig. 5. The effects of Prewitt filtering on opened eyes are shown in Fig. 6. The effects of Roberts filtering on closed eyes are shown in Fig. 7. The effects of Prewitt filtering on opened eyes are shown in Fig. 8.

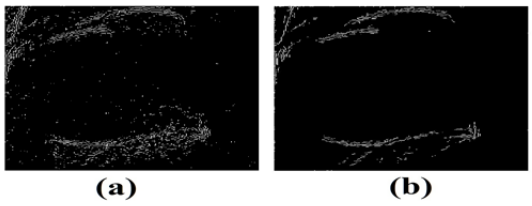

Fig. 5(a). Prewitt operator on image of closed eye without filtering, (b). Prewitt operator on image of closed eye after filtering

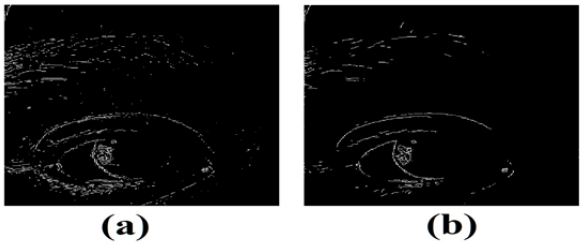

Fig. 6(a). Prewitt operator on image of opened eye without filtering, (b). Prewitt operator on image of opened eye after filtering

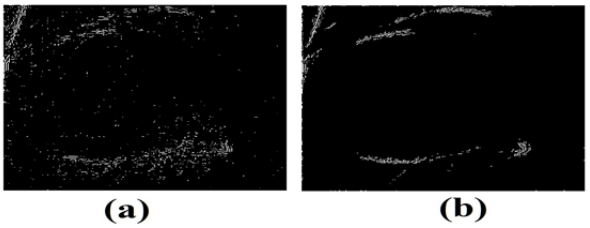

Fig. 7(a). Roberts operator on image of closed eye without filtering, (b). Roberts operator on image of closed eye after filtering

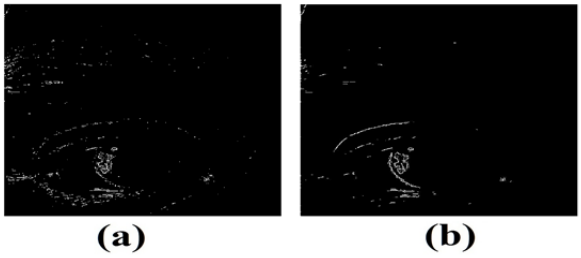

Fig. 8(a). Roberts operator on image of opened eye without filtering, (b). Roberts operator on image of opened eye after filtering

From the above figures, it can be concluded that the real edges (eye brows and eye lashes) are prominently detected after filtering. The effects from Sobel and Prewitt operators are found to be same for our case. While using Robert operator, some edge information become lost near around eye brow for both opened and closed eyes. In this regard, the choice of proper edge detection technique for our case must go for either Sobel or Prewitt operator.

5. EDGE DETECTION ON HUMAN EYE BY MULTI THRESHOLD TECHNIQUE USING CANNY OPERATOR

Canny edge detection technique uses two gray level threshold values for tracing edges [5, 6]. Therefore it can trace both strong edges and weak edges. The proper differentiation between spurious points and weak edges must be required for this operator. This operator automatically joins the edge points for both strong and weak edges. Fig. 9 and 10 have shown the effect of Canny edge operator on closed and opened eye respectively.

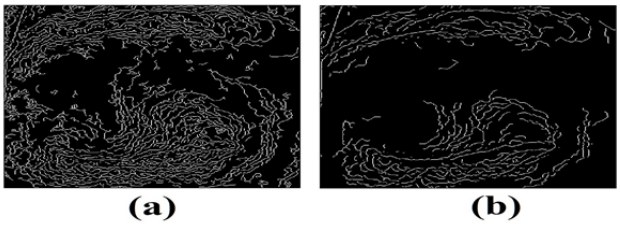

Fig. 9(a). Canny operator on image of closed eye without filtering, (b). Canny operator on image of closed eye after filtering

From the above figures, it can be summarized that for our figures, Canny operator is unable to separate the spurious nose and weak edges. The weak edges and unnecessary points are treated as edges and they are also joined with the strong edges to produce unfaithful edge information both for opened and closed eyes. The distance between two edge segments are underestimated by this operator.

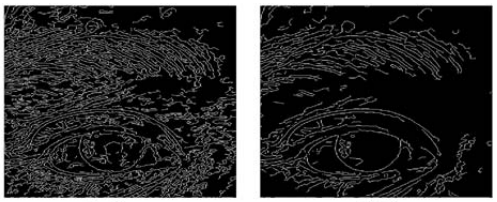

Fig. 10(a). Canny operator on image of opened eye without filtering, (b). Canny operator on image of opened eye after filtering

6. CONCLUSION

From the above inspections from all the edge operators, for our problem, Sobel and Prewitt operators are found to be the most efficient method. The Robert operator shows loss of information at the edges and the Canny operator connects weak unnecessary edges with the eye brows and eye lashes and thus underestimates the distance between eye brows and eye lashes both for closed and opened eyes. With more error and noise correction techniques, in future, more faithful edge detection may be possible.

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