

Detecting driver drowsiness using total pixel algorithm

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Submission date: 20-Jan-2020 01:49PM (UTC+0700)

Submission ID: 1243961780

File name: 2019-Detecting_driver_drowsiness_using_total_pixel_algorithm.pdf (707.99K)

Word count: 2044

Character count: 10300

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To cite this article: K Adi *et al* 2019 *J. Phys.: Conf. Ser.* **1217** 012036

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Detecting driver drowsiness using total pixel algorithm

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Abstract. Advancement in transportation technology certainly comes with numerous positive impacts. Nonetheless, some negative aspects including growing numbers of traffic accidents cannot be taken for granted. Factors that trigger traffic accidents range from human errors, vehicle mishaps, to the environment itself. Human error is somehow the factor that often causes traffic accidents. This research aims to propose a method of detecting drowsiness using the total pixel algorithm for drivers, with the help of video cameras connected to a computer. It was expected that it would help reduce the number of traffic accidents. The method employed in this research is detecting drivers' faces by segmenting RGB images into YCbCr color spectrum, determining the area of the eyes, and classifying eyes condition using total pixel algorithm. The system developed has been able to detect drowsiness in drivers without glasses with 90.5% to 92% accuracy. However, for the detection of objects with glasses ranging from 72.8% to 74.8% accuracy.

1. Introduction

Development in transportation technology does have positive impacts on people's well-being, especially as mobile devices for better and more comfortable everyday life. But somehow, its negative effect, regarding traffic accidents must also be anticipated. Traffic accidents tend to increase in numbers due to factors of human error, vehicle problems, and environmental issues. Out of those three factors, human error is the major cause of traffic accidents. One of the causes of mistakes people makes while driving is because they are sleepy and tired. This results in a lack of awareness and response to road conditions. Figures show that fatigue while driving contributes to more than 25% of the causes of traffic accidents [1, 2].

This research is very important because the results of this research can be used to detect the drowsiness of a driver (pre-sleepiness condition) due to fatigue. The computer vision system is capable of detecting drowsiness by implementing image processing methods. Images of drivers' face can be processed to detection their conditions. Manual visual observation has limitations that result in different perceptions on drowsiness in drivers, that an image processing methods to properly analyze facial images of drivers is required. Analyses of a driver's condition typically include stages of detection or tracking of face and eyes, classification of eye conditions, and alerting drivers.

One of the fundamental techniques for initial image segmentation of a digital image is a face and eye detection [3, 4, 5, 6]. This detection is carried out with the method of complexion (skin color) segmentation. Complexion segmentation is robust enough as skin color has the same characteristics with the YCbCr color spectrum [7, 8]. The RGB image will be converted to YCbCr image with equation [9,10] :



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$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.279 & 0.504 & 0.098 \\ -0.148 & -0.291 & 0.439 \\ 0.439 & -0.368 & -0.071 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

Then the YCbCr channel is segmented based on skin color with thresholding segmentation method using equations [11,12,13]:

$$g(x, y) = \begin{cases} 0 & \text{if } f(x, y) < T \\ 1 & \text{if } f(x, y) \geq T \end{cases} \quad (2)$$

Segmented images will be denoted by $g(x, y)$ from the image $f(x, y)$ associated with the threshold value (T). If $g(x, y) = 1$, then the value is foreground, whereas if $g(x, y) = 0$, then this value represents the background.

Meanwhile, for eye condition classification, total pixel algorithm is used. It uses one single parameter of eye's width. This method uses a simple algorithm that classifies eye conditions into either open or closed. To get the total pixel value, the area of the eye is calculated by the equation [13]:

$$A = \sum_{i=1}^n \sum_{j=1}^m g(i, j) \quad (3)$$

A is the area which is the total pixel that is 1 of the object image $g(i, j)$ which is the result of the thresholding segmentation.

2. Material and Method

The materials used in this research are video images of MP4 extension format. To obtain maximum results, scanned images are then converted into a standard file format for further image processing. The subsequent stages are depicted in Figure 1.

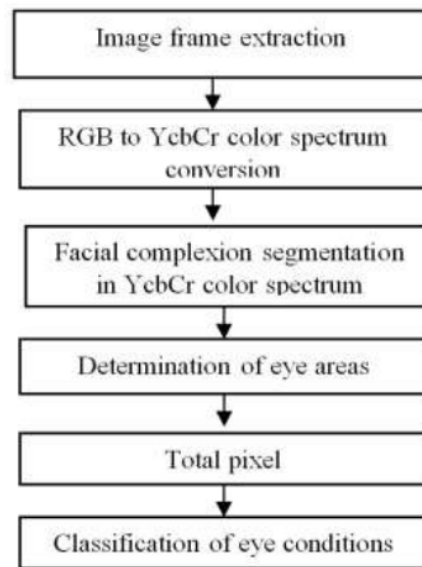


Figure 1. Process diagram for drowsiness detection

The process begins with image frame extraction, followed by conversion from RGB to YCbCr color spectrum. Based on the YCbCr color spectrum, complexion segmentation is then carried out using a threshold. Areas detected as a facial area are marked with a bounding box with a particular ID and coordinate (x, y, w, h). Figure 2 shows methods to drowsiness detection using image processing technique. Figure 2.a shows a visualization of ID assignment. Facial area is assigned ID A, and the other areas in the frame are assigned ID B. The ID A area is given a bounding box. Once segmentation is done, the next process is a determination of the eye area. This area is assigned as the middle three parts of the face. With proper camera placement, an area of the eye cannot be missed. Figure 2.b visualizes eye segmentation on an object. The designated eye area is assigned ID C, while the rest of the areas in this frame are assigned ID D. Then in the ID C area the total black pixels are calculated in the form of a percentage of the total number of pixels in the ID C area. So, when the eyes are open or closed will give different a percentage value of the total black pixels.

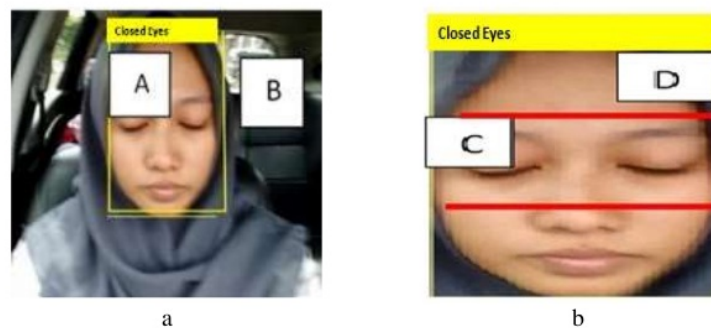


Figure 2. The result of drowsiness detection (a) Visualization for ID assignment and (b) Visualization of the segmented eye area

The following stage is the use of total pixel algorithm. In principle, this algorithm calculates the number of black pixels, with the assumption that eyelid will be white when the eye is closed. When this happens, then the total number of black pixels is reduced. The following is the total pixel algorithm:

1. Calculate the area of the eyes.
2. Convert YCbCr to gray level for that area.
3. Convert this gray level into a binary image using a thresholding segmentation method.
4. Calculate the total black pixel.
5. Calculate the result of total black divided by the total pixels of the eye area (in percentage).
6. Determine whether the eye is closed or open using that threshold total black pixel percentage.

3. Result and Discussion

A total of four data of drivers; two with glasses, and the other without glasses, have been taken. Data 1 and Data 2 is an object without glasses; Data 1 consists of 2880 frames and Data 2 consists of 2204 frames. Then Data 3 and Data 4 is an object with glasses, Data 3 has 2880 frames, and Data 4 object has 250 frames. Each frame must undergo image processing to determine whether the eyes are closed or open. Other than that, each frame must also be observed visually, to confirm whether the eyes are open or closed. These two observations are then compared to one another, with the assumption that visual observation is the correct one. Results of these can be seen in Table 1 for objects without glasses and Table 2 for objects with glasses.

Table 1. Classification results for objects without glasses.

Data	Eye condition	Visual	Proposed Methods	Error
Data 1	Open	2335	2608	9.5%
	Closed	545	272	
Data 2	Open	1313	1138	8.0%
	Closed	891	1066	

It can be seen from Table 1 and Table 2 that the system developed here is capable of detecting open and closed eyes with errors less than 10%. However, for objects (drivers) wearing glasses, these errors may increase to more than 25%. These errors are in general caused by vibration, alteration in incoming light, and the use of glasses. Vibration causes noise in the form of a blur as the objects are not focused. Changes in incoming light intensities result in under-exposed or over-exposed situations that cause imperfect image segmentation. This could be even worse for objects (drivers) wearing glasses as reflections may take place, which the eyes underneath those glasses cannot be detected properly.

Table 2. Classification results for objects with glasses.

Data	Eye condition	Visual	Proposed Methods	Error
Data 3	Open	1509	2293	27.2%
	Closed	1371	587	
Data 4	Open	140	203	25.2%
	Closed	110	47	

Figure 3 depicts different driver conditions; for (a) and (b), drivers are without glasses, and therefore there is no noise. Hence, eyes are properly detected to determine whether they are open or closed; for (c), the driver wears glasses, but without the noise. His eyes are correctly identified; for (d), the driver wears glasses and reflection takes place. In this condition, the eyes behind the glasses cannot be properly detected, that the total black pixels only come from the glasses frame. As is the case for video 4, most closed eyes are identified as open.

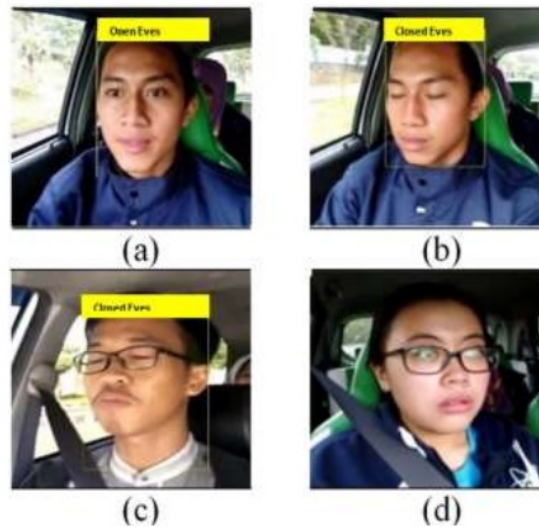


Figure 3. Driver conditions: (a) and (b) without glasses and no noise, (c) with glasses but no noise, and (d) with glasses and with noise (reflected light/not detected)

4. Conclusion

Results in this research show the algorithm proposed is capable of detecting drowsiness, by classifying them into open and closed eyes, based on the thresholding values of the area of the eyes. It is also shown that for objects (drivers) using glasses, identification for eyes condition is obstructed as glasses reflect light.

Acknowledgments

This research was funded by the Development and Implementation Research Scheme, Diponegoro University in 2018

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