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Drowsiness Detection According to the Number of Blinking Eyes Specified From Eye Aspect Ratio Value Modification

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***Abstract*—The current accidents in road increase caused by driver's negligence. There are several reasons, that is fatigue, drowsiness, not concentration, and others. One of the drowsiness detectors is through the blinking of an eye. In normal people the blinking of the eye is 10 per minute, whereas in people who are sleepy eye blinks below 10 per minute. In this research we proposed the modified algorithm to have eye aspect ratio value. Experimental data are taken from video with 30 frames per second. Experiments were performed in the laboratory with driver simulation tools. Data are taken for 105 minutes and given the load test so that the driver will experience fatigue while driving.**

***Keywords*—modified of eye aspect ratio; drowsiness; blinking rate**

I. INTRODUCTION

The research on sleepiness in motorists has been done by many researchers. Several stages of drowsiness detection: the first face detection and eye detection with Viola and Jones algorithm [1], Histogram of oriented gradient (HOG) detector [2] [3], and Convolutional Neural Network (CNN) . The next process is feature extraction using: Landmarks, and Local Binary Pattern (LBP). The features obtained were analyzed using percentage of eye closure (PERCLOS) [4] [5], blink frequency [6] [7], eye aspect ratio (EAR) [6], face position, nodding frequency. The last classified with Support Vector Machines (SVM) [8], KNN, and Hidden Markov Model (HMM) [9] to detect sleepiness of the driver.

II. PREVIOUS STUDIES

A. Histogram of Oriented Gradient (HOG)

By using HOG [2] [3] then the edge of the image or gradient structure can be obtained. In this transformation the difference in translation and rotation can be overcome easily.

There are several stages in the process of face and eye recognition: First, the image is broken down into small blocks by scale and location. The determination of key points is taken by determining the best candidate in the scale space. Scale space, $S(x, y, \sigma)$, is obtained by converting input images, $M(x, y)$, with Gaussian function $F(x, y, \sigma)$ [3] :

$$S(x, y, \sigma) = M(x, y) * F(x, y, \sigma) \quad (1)$$

where the operation convolution is $*$ in x and y. The Gaussian function $F(x, y, \sigma)$ [3]:

$$F(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2+y^2)/2\sigma^2} \quad (2)$$

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The next step is to find the difference between two adjacent scale spaces and to determine the potential interest point named scale-space extreme detection.

The second, process is placement of key point. Key points are determined based on stability measurements. The low contrast or not localized along the edges in this process will be rejected.

The third, orientation is assignment. At each location the key points are marked one or more orientations based on the direction of the local image gradient.

The fourth, determine key point descriptor. On the scale area around each key point is measured local image gradient.

B. Landmarks

Landmark [10] can represent facial geometry with many points. These points are related to face or eye as an object. There are three categories landmarks:

1) anatomical landmarks
2) mathematical landmarks
3) pseudo-landmarks

In this paper we are used six Landmark points show in Fig. 1.

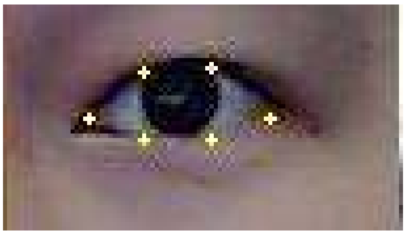

Fig. 1. Open eye with 6 points landmark

C. Eye Aspect Ratio

Everyone must have blinked. The blink function is to flatten the tears throughout the surface of the eyeball, especially the cornea. The goal is to wet, because the part is easily irritated if allowed to dry. Another function of the blink is as a reflex to prevent foreign objects from entering the eye [11]. This function is supported by the hair of the eyes, as a dust barrier that will close following the eyelid movement when blinking.

It is not known exactly how quickly the eyes blink, but it is believed to be no more than 400 milliseconds. So quickly the eyes blink, so the phrase 'just a blink of an eye' is very popular to illustrate the speed of time passes. The blink of the eye is too fast to be realized by the human brain [12] [13]. Although the eye experiences dark conditions for a split second, the brain will ignore it so it will not interfere with vision in general.

After we have landmark points for every video frame, then we can count EAR [6]:

$$EAR = \frac{A+B}{2*C} \tag{3}$$

With A is distance between two landmark points to the left, B is distance two landmark points to the right, C is distance two landmark points from left to the right show in Fig. 2..

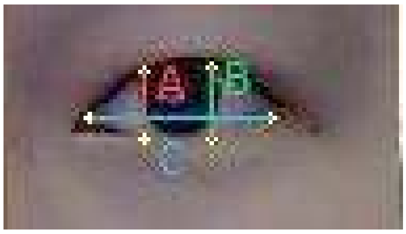

Fig. 2. Open eye

III. Modified Eye Aspect Ratio (M-EAR)

Unfortunately the size of eyes did not same between one person with the other person, so if a person have a big eyes and a person who have the little eyes did not have the same height eyes or A and B value. The person with the little eyes may be having the same height of eyes with the person with the big eyes when he closes the eyes. This will be affected with the experiment data.

In this research we proposed the modified eye aspect ratio (M-EAR) for closed eyes with this equation:

$$EAR_{closed} = \frac{A_{min}+B_{min}}{2(C_{max})} \tag{4}$$

And the open eyes with this equation:

$$EAR_{open} = \frac{A_{max}+B_{max}}{2(C_{min})} \tag{5}$$

From equation (4) and equation (5) we calculate $M - EAR$ with:

$$M - EAR_i = \frac{1}{2}\left(EAR_{open} - EAR_{closed}\right) \tag{6}$$

With $i = 1,2,\ldots,n$ and n is the number of drivers.

IV. Experimental Results

In this research we use driver simulation shows in Fig. 3 and Fig. 4. The camera distance to the driver in this system is 80 to 100 cm.

Fig. 3. Driver simulator

Fig. 4. Equipment driver simulator

In our experimental we observed five driver with five time slots in video. The first data retrieval is taken for 2 minutes, the second, third, fourth and fifth tests for 10 minutes, so we have five video simulations. From each video we collect $A_{max}, A_{min}, B_{max}, B_{min}$, and we calculate EAR_{closed}, EAR_{open}., and $M - EAR$. To detect the driver drowsy or not drowsy we need the smallest value M-EAR from five video. Fig. 5 shows M-EAR threshold from five drivers.

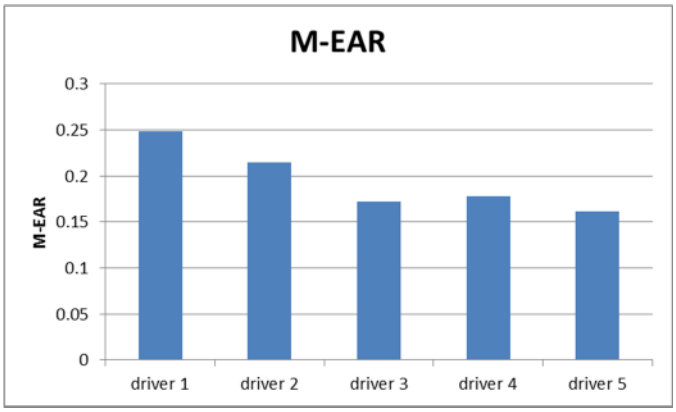

Fig. 5. Graphic M-EAR from five driver

After the M-EAR value is obtained then the next step is to determine the eye condition of each frame in open or closed conditions.

On a one minute video there are 60 x 30 frames or 1800 frames. Each frame has one EAR value. From this M-EAR we observed the blinking eyes. If the EAR value of each frame in the video below the minimum value of M-EAR, then on the frame is set eyes close, otherwise set eyes open. In Fig. 6 shows sample of the process of knowing the eyes are closed or open through the EAR value compared to the MEAR value. Value 1 means eyes are closed and value 0 means eyes are opened. Blinking eyes is calculated from the change of eyes open to closed eyes, in this experiment is calculated the change in the number of open eye conditions to the eyes closed.

Next is calculated how the average blink per minute on each video of the same person. Fig. 7 shows the blinking eyes per minute for every driver.

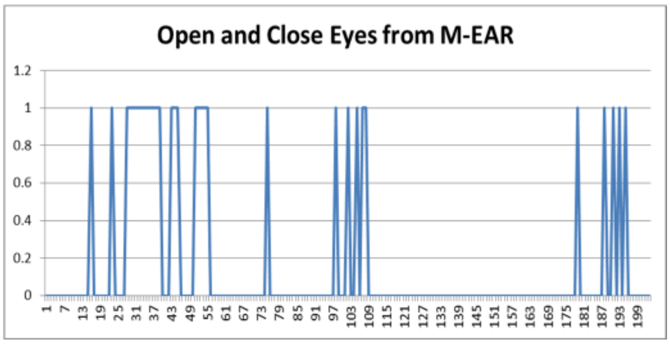

Fig. 6. Graphic M-EAR from five driver

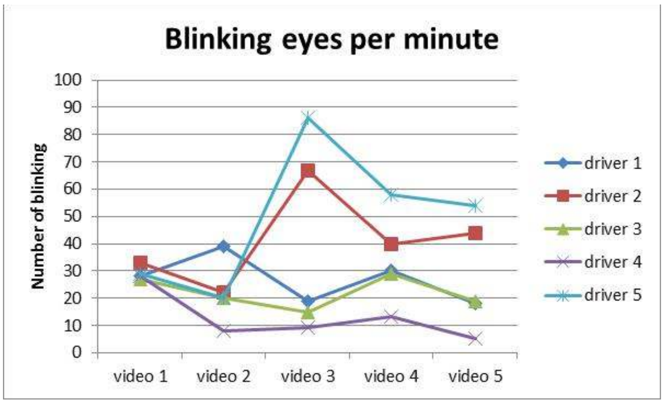

Fig. 7. Graphic blinking eyes with EAR Modification

Drivers are said to be sleepy if eyes are closed more than 45 frames and blinking eyes below 10 per minute. In Fig. 7 it can be concluded that driver 2 and driver 5 are not sleepy because the number of blinking is more than 10 blinking per minute, while drivers 1 and 3 are not sleepy but are tired because the number of blinking between 20 to 40, and driver 4 can be said to be drowsy because the amount of blinking is below 10 per minute.

V. CONCLUSION

The proposed method to calculate M-EAR can determine blinking eyes and know whether the driver is sleepy or not. From the experimental data of five drivers (each of five videos), then based on the reference [9] that the condition is sleepy if the number of blinks below 10 per minute value, it can be determined fourth driver in sleepy condition.

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