Real Time Driver Fatigue Detection Based on SVM Algorithm

Conference Paper · October 2018

DOI: 10.1109/CEIT.2018.8751886

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***Abstract*—Among the causes of the traffic accidents driver drowsiness comes at one of the first places. According to the literature some work has been done in driver fatigue detection. This paper proposes a Real Time Driver Fatigue Detection Based on Support Vector Machine (SVM) Algorithm. Fatigue detection mainly focuses on drivers' face expressions and behaviors. OpenCV and Dlib libraries were utilized to detect the expressions of drivers' faces. The proposed system has five stages: PERCLOS, count of yawn, internal zone of the mouth opening, count of eye blinking and head detection to extract attributes from real time video. Subsequently, facial expressions were trained with SVM. In this study an SVM-based driver fatigue detection is recommended and the tests showed that the accuracy rate of fatigue detection is up to 97.93%.**

Keywords—fatigue detection; SVM; driving safety; video processing

I. INTRODUCTION (*HEADING 1*)

Nowadays, driver safety is important for people. According to the World Health Organization (WHO) statistical data, traffic accidents result in millions of people losing their lives every year. The vast majority of fatal accidents are caused by driver fatigue and carelessness. The 7% of all accidents and 21% of lethal traffic accidents are stated by American Automobile Association to involve sleeping drivers [1].

In order to provide driver safety, many companies as well as researchers have been researching and developing driver fatigue systems as related technologies have advanced. Thus, this proposed system aims to prevent the traffic accidents caused by driver fatigue.

The system developed by Parmar [2] in 2002 detects the eyes of the driver with a monochromatic camera to see if they are open or closed. Yufeng et al [3] compared two images of the drivers while driving to determine the state detection of the theirs'. Horng and his colleagues [4] took eyes of the drivers' into account in 2008, and per second, 30 frames were used to determine in how many frames the eyes were closed. In the system developed by Bajaj and colleagues [5] in 2010, face and mouth conditions are taken as basis, and using the obtained data and fuzzy logic algorithm are used to extract fatigue level. Coetzer et al. [6] compares YSA, SVM and AdaBoost classification algorithms for eye detection, in the study they performed in 2011. Anumas and colleagues [7] focused on the causes of driver fatigue and driving impairment in their 2012 work. Zhang and his colleagues [8] used the convulational neural network (CoNN)* algorithm in their work to try to detect the flex in the drivers. Zhang et al. [9] attempted to detect insomnia by looking at the observations made in 2017, and used CoNN method to detect the condition of the eyes. In a study by Mandal and colleagues [10], they used bus drivers to detect driver fatigue. Savaş et al [11] attemted to detect driver fatigue by using principal component analysis and adaboost algorithm. In this study, eye detection and PERCLOS were used. Yuen and his colleagues [12] compare face analysis methodologies in their 2017 work. Thus, the frame for face detection is recommended.

In this study, facial behaviors of drivers were analyzed in general. Facial analysis comprises eye detection, blinking time, blink count, PERCLOS, mouth detection, yawn detection, mouth opening ratio during yawn, yawn counts, and head position detection.

The rest of this paper is organized as follows: Section 2 mentions methods used and sofware, section 3 decribes the proposed system and section 4 presents the conclusion and future works.

II. METHODS USED AND SOFTWARE

A. Dlib Library

Dlib is a C++ toolkit which includes machine learning algorithms and uses real time applications. A pre-trained facial landmark detector from Dlib library is used to predict the location of 68 x-y coordinates that map facial landmarks on the face zone [13].

Detecting facial landmarks is a critical subject in terms of facial zone shapes estimation. In this study, the dlib library was used to detect and track the faces of the drivers in real-

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* Convulational Neural Network has been abbreviated as CoNN, not CNN, CNN has been used as the abbreviation of Celluar Neural Network in the leterature as a long time.

time videos. Therefore, important facial structures were detected on the face zone using shape estimation methods.

B. Open Computer Vision(OpenCV)

OpenCV, developed by Intel, is widely used in computer vision. It is also open source library and it has C/ C ++, Java and Python interfaces written in C that can run on many platforms (such as Windows, Linux…etc). The intent is to be able to process meaningful information contained within a picture or video [14]. On OpenCV platform, many applications such as motion detection, camera calibration, face detection and recognition, can be performed by using computer vision and image processing algorithms.

III. PROPOSED SYSTEM

In this study, SVM based driver fatigue prediction system is proposed to increase driver safety. The proposed system has five stages: PERCLOS, count of yawn, internal zone of the mouth opening, count of eye blinking and head detection to extract attributes from video recordings. The classification stage is done with Support Vector Machine (SVM). While the YawDD dataset is used during the training phase of the classification, real-time video recordings are used during the test phase.

A. Feature Extraction

Driver's face features must be extracted to calculate Perclos, eye blinking, and detect yawning, internal zone of the mouth opening, head position.

As the first part, we detected the eye and mouth position and these areas were extracted. Secondly, we calculated Perclos and eye blinking for eye areas. Next, we detected yawning and internal zone of the mouth opening for mouth area. Finally, we marked the position of the driver's head. Facial landmark is shown in "Fig. 1".

Fig. 1. Facial landmark

1) PERCLOS: PERCLOS is the ratio, shown in percentages, of frames with the eyes closed to total frames at a given time period. In other words, PERCLOS can be defined as a method of fatigue analysis that reveals the ratio of eyes closed based on the number of open and closed eyes [15]. This value can be calculated as in(1);

$$f_{PERCLOS}=n_{close}/N_{CloseandOpen}\text{x}100\% \quad (1)$$

$N_{CloseandOpen}$ represents the total number of open and closed eyed frames at a given time, and n_{close} represents the number of closed eyed frames at a particular time. The results of 80 percent overtaking in driver fatigue are considered to be sleeping hazards for PERCLOS [16].

2) Count of eye blinking: Eye Aspect Ratio (EAR) is shown in "Fig. 2" by Facial landmarks.

Fig. 2. (a)Right EAR, (b)Left EAR

The horizontal and vertical distance of the eye is calculated as in (2);

$$EAR= (38-42) +(39-41)/(2*(40-37)) \quad (2)$$

37 - 42 represents 2D right eye facial landmark locations and 43 - 48 represents 2D left eye facial landmark locations. EAR function is calculated separately for each eye (EAR_{Right_Eye} and EAR_{Left_Eye}). Then the blinking is detected with the data obtained as in (3);

$$Eye_{Blink\_Detect}= (EAR_{Left\_Eye} +EAR_{Right\_Eye})/2 \quad (3)$$

According to literature [17], the number of blinks are between 15-30 per minute, 0.25 ~ 0.3 seconds every time when driver is awake. However, in this study it was calculated as 0,24 seconds each time. This frequency gives the optimum result for the system.

If Eye_{Blink_Detect} <0,24 eye closed

else eye opened

3) Count of yawn: Mouth Aspect Ratio (MAR) is shown in "Fig. 3" by facial landmarks.

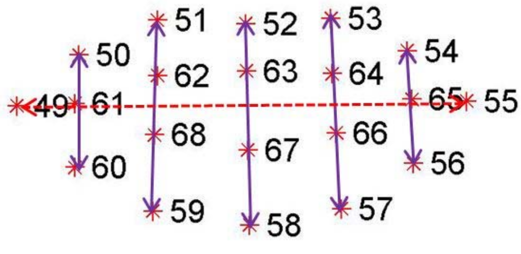

Fig. 3. Mouth aspect ratio (MAR)

The horizontal and vertical distance of the mouth is calculated as in (4);

$$MAR=(50-60)+(51-59)+(52-58)+(53-57)+(54-56)/(2*(49-55)) \quad (4)$$

49- 68 represents 2D facial landmark locations. By means of these numbers, with the result of mouth state, we can calculate the count of yawn over a period of time.

4) Internal zone of the mouth opening: It is a major problem whether the mouth's being open is the result of speaking or fatigue. For this reason, internal zone of the mouth opening of the driver is examined in this study. This makes it possible to distinguish if the mouth expression is speech or yawn.

5) Head detection: In this study, the system is alerted when the driver's face can not be detected by the camera for 5 seconds (the driver's head falls down - the driver does not look at the road). Head falls down is shown "Fig. 4".

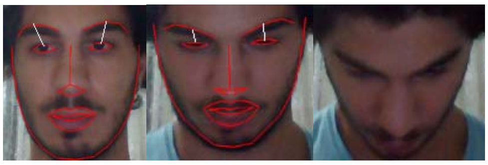

Fig. 4. Head falls down detection

B. Support Vector Machine (SVM)

SVM is a classification algorithm separating data items. This algorithm proposed by Vladimir N. Vapnik based on statistical learning theory [18]. SVM, one of the machine learning methods, is widely used in the field of pattern recognition. The main purpose of the SVM is to find the best hyperplane to distinguish the data given as two-class or multi-class. The study was carried out in two classes. Whereas label 0 means that the driver is tired, label 1 means the driver is non-tired. Thus, it is aimed to distinguish tired drivers (driver fatigue) from non-tired drivers.

In an SVM algorithm that can be linearly separated, the inequality in finding the optimal hyperplane is given by the formula x. It is calculated as in (5) (6).

$$wx_i + b \leq +1 \text{ each } y = +1 \qquad (5)$$

$$wx_i + b \geq +1 \text{ each } y = -1 \qquad (6)$$

x is data space, y is the label value, w is the weight vector and b is the slip ratio.

IV. RESULTS AND DISCUSSION

In training driving simulation experiments, we had 10 volunteers (5 men and 5 women) whose ages were between 18-30. All the trainings and testing steps were real time. The experiment was carried out under the laboratory conditions.

All the volunteers drove training simulation during the experiments. Attributions obtained in real time during the driving when fatigue detection system was working are indicated in "Fig. 5" and real time example of detection is shown in "Fig. 6".

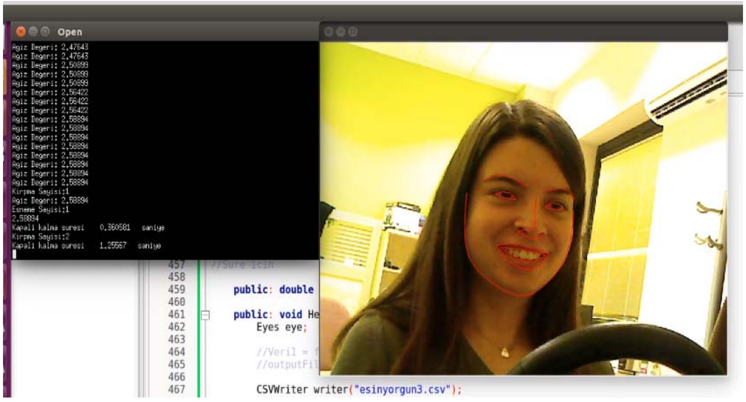

Fig. 5. Attribution obtained in real time

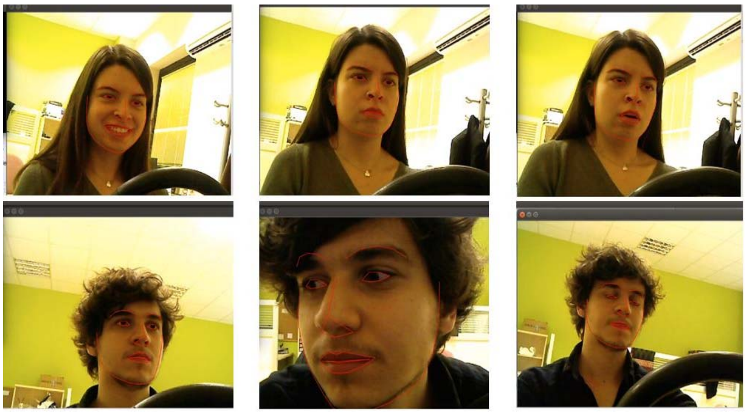

Fig. 6. Real time example of detection

The results of driver fatigue detection were classified using SVM classification algorithm. The total 713 datas line each of which has five stage features were sampled from 10 volunteers. All the data in the study are divided into two groups: 80% training data set (568 data set) and 20% test data set (145 data set). In the study, cross validation was selected as 10.

Our measurements are as follows:

- TP means that a real fatigue is detected;
- TN means that a non-fatigue situation is correctly detected as non-fatigue by the system;
- FP means that a non-fatigue situation is incorrectly detected as real fatigue;
- FN means that a real fatigue situation is incorrectly detected as non-fatigue.

The accuracy of driver fatigue calculated as (7)

$$\text{Accuracy} = (TP+TN)/(TP+TN+FP+FN) \qquad (7)$$

V. CONCLUSION

As a result of the study, a system was designed to investigate the effects of fatigue and insomnia on drivers' physical transient behaviors, and to simulate drowsy drivers as a result of research. In this system, behavioral detection model is used for detecting fatigue drivers. The proposed system has five stages: PERCLOS, count of yawn, internal zone of the mouth opening, count of eye blinking and head detection to extract attributes from video recordings. As a result, the system is classified as SVM in two classes (not fatigue / fatigue).

In this study a Real Time Driver Fatigue Detection SVM Based on SVM Algorithm is presented whose test results showed that the accuracy rate of fatigue detection is up to 97.93%.

VI. ACKNOWLEDGMENT

This research is supported by Kocaeli University, Scientific Research Project Department (A-2-2 Doctoral Thesis Support Projects, , Project no:2017/087). The authors would like to thank to all volunteer drivers who kindly participated in this study and to Kocaeli University.

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