Drowsiness Detection Based on Eye Closure and Yawning Detection

B. Mohana, C. M. Sheela Rani

Abstract: The number of major road accidents that occur per day is on a rise and most of them are attributed to being the driver's fault. According to the survey done in 2015, drivers are held responsible for approximately 78% of the accidents. To minimize the occurrence of these incidents a monitoring system that alerts the driver when he succumbs to sleep is proposed. This algorithm processes live video feed focused on the driver's face and tracks his eye and mouth movements to detect eye closure and yawning rates. An alarm sounds if the driver is drowsy or already asleep. Haar-cascade classifiers run parallelly on the extracted facial features to detect eye closure and yawning.

Keywords: Drowsiness detection, eye closure detection, Haar-based classifier, yawn detection.

I. INTRODUCTION

One of the most predominant reasons that causes untimely deaths are road accidents. In the former case, the co-passenger would alert the driver of his/her lapse of attention and the driver would take measures to return to the required state of alertness. We witness many incidents in the news that report deaths and severe injuries caused by road accidents, mostly in the early morning period. A car hit another or careened in to the road blocks/boundaries. But what if the driver is alone or is driving in the night where there is a chance that the fellow passengers are asleep. Driving under the influence of drowsiness is the root cause for over 100,000 road accidents every year [1]. This amounts to 2.2% death rate worldwide [2].

Micro sleep [3] is a temporary lapse in consciousness that may last up to 30 seconds. This period results in a vulnerable driver as they are not able to respond to sensory input in a prompt manner. This may also significantly increase the reaction time. In terms of behaviour, this phenomenon can be observed in the form of eye lid closure, droopy eyes. This is extremely dangerous in situations that demand constant vigilance. It is cited as a major factor in many road accidents [4]. Driving a vehicle is one such activity. As the person under the influence is unaware of his/her lapse, it must be monitored by an outside observer. This lapse does not stop the car from continuing in its high speed. The danger is not only to the driver but also to the unsuspecting people on the roads.Owing to the prevalence of this issue, a lot of effort has been put into the research to solve this issue. These are broadly categorized depending on either the nature of the techniques used or the types of inputs used. Most of the existing methods to detect drowsiness are using machine learning techniques like classification, regression, clustering and filtering techniques. Currency evaluation and recognition [5], licence plate recognition [6] are some of the practical applications of these algorithms. The nature of the implemented algorithms leads to the techniques being either in the neural network category (i.e., deep learning) or computer vision-based classifier category.

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A. Physiological features-based method

This method is performed by analysing physiological signals like skin electric potential, heart and pulse rates, brain waves. Monitoring physiological reactions involves connecting the subject to devices by the means of wires. This can also be considered invasive to the person. A support vector machine based on genetic algorithm is used as a classifier on electrocardiogram signals in [7]. Driver's stress level is analysed to monitor driving performance using the ECG and convolutional neural networks in [8].

B. Visual features–based method

PERCLOS [9], short for percentage of eye closure is the measure of the area covered by the eye lids over time. It reflects slow eye closure rather than blinks. In [10] Viola Jones is used for eye detection and yawning detection which is followed by a binary support vector machine and correlation coefficient matching performs the tracking of eyes and yawning detection. In [11] an infrared camera is used to improve detection rates along with Haar- based classifiers and HoG to convert the support vector machine images to vector data. In [12] OpenFace and a 3D CNN are used for facial feature detection. This CNN is used to extract the facial expression features. In [13] AlexNet is used for face detection. Head pose is also considered in this algorithm which is analysed selected rigid landmarks. In [14] face detection is performed accomplished using MCT Adaboost classifier and an LBF regressor is used to improve accuracy in embedded systems.

C. Driving behaviour–based method

This method detects driver's drowsiness by analysing parameters like vehicle speed, brake speed, lateral displacement, acceleration, steering angle. The use of intelligent algorithms in cars has increased in the recent years. These systems monitor both the car and its driver to control steering, brake, transmission, engine speed to improve the quality of driving and safety. These are implemented in the industrial scale by many car companies. The Driver Alert Control, developed by Volvo, warns drowsy drivers by connecting a using a vehicle-mounted camera to the car's lane departure warning system (LDWS). Similar to this, Mercedes-Benz introduced an Attention

Assist System which collects data from driver patterns and correlates with the steering movement. Bosch's driver drowsiness detection system operates on making decision from the data given by sensors monitoring driving velocity, lane assist camera, turn signal use.The proposed algorithm analyses visual based features, specifically eyes and mouth to detect drowsiness. This choice is made due to the practicality of implementing a non-intrusive system unlike monitoring physiological reactions. As the individual task of monitoring sleep only leads to alerting the driver after the event has occurred, yawn detection is incorporated into our algorithm. Yawn detection provides preventive measures and can help in heading off the problem while we are still ahead. The proposed system involves raising two kinds of alarms. One in the case of sleeping and another in the case of debilitating drowsiness. The former state is characterized by a moment of shut eyes and the latter is identified by a prolonged state of yawning.

II. PROPOSED ALGORITHM

The proposed algorithm works in seven stages as described by Fig. 1. The video feed used in testing this technique is obtained from laptop webcam.

A. Pre-processing

The video is obtained from a camera focused on the driver's face. The processing rate of the acquired video is 25 frames per second. These frames are then flipped and converted to grayscale.

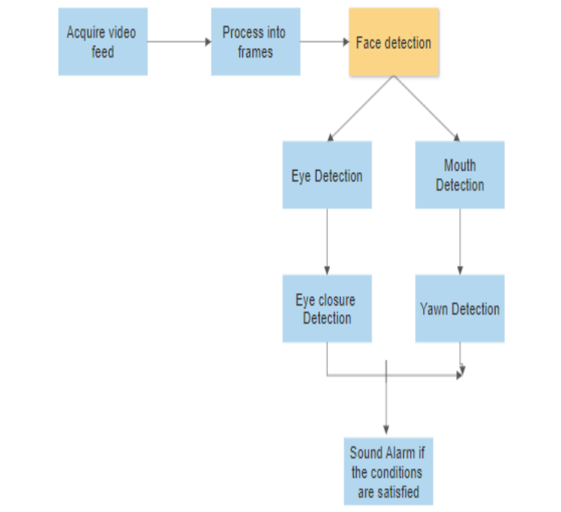

Fig. 1. Process flow of the proposed algorithm.

B. Face detection

The Haar-based classifier [15], [16] contains several features such as heights, weights, face features, the threshold of face colours. It is constructed by using a lot of positive and negative samples. Based on the positive sizes, some of the features will be extracted. Based on the Haar detection, edge detectors are applied. Output from the edge detector is stored in an array. The cascade consists both positive and negative samples.Eyes and mouth features are extracted and parallel processing is preceded by successful driver's face detection. The pixels of the upper area of face are only considered as eyes are present there. The eyes are positioned just a few pixels below the top edge of the face.Edge detection is applied to the region marked in the previous step. Out of the detected objects, the object with the highest surface area and the second highest are obtained. These are the first and second positive samples given that they are twenty pixels apart and not the same. These are the eyes of our driver.

C. Facial mapping using Dlib

The algorithm is implemented using Dlib [17] python library that contains a landmark's facial detector with pre trained models. It estimates and maps a person's face in the form of facial points with 68 cartesian co-ordinates as shown in Fig.2. The 68-point iBUG 300 dataset was used to train the dlib facial landmark predictor and is the source of these markings.

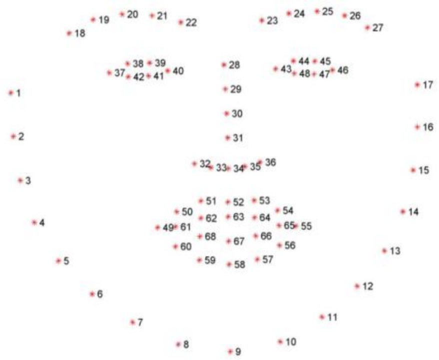

Fig. 2. Landmarks as depicted by dlib facial predictor.

D. Eye closure detection

Eye aspect ratio (EAR) [18],[19] is a parameter that determines eye state used to figure out if it is open or closed. It can be calculated using facial landmarks plotted by the 68 facial landmark point plot provided by python's dlib library. It uses the points in the region of interest to compute.

$$EAR = \frac{\|l_2 - l_6\| + \|l_3 - l_4\|}{2\|l_1 - l_5\|} \qquad (1)$$

Equation (1) is used to calculate EAR value and l1, l2, l3, l4, l5, l6 are the boundary landmarks from the region marked to contain the eyes. A blink is detected when the calculated value is below 0.3. The threshold value set in this algorithm is 0.3. If this continues consecutively for 50 frames, eye closure is confirmed.

E. Yawn detection

Yawning is characterized by a widely opened mouth. Like the eye closure detection, the facial landmarks are used to detect an open mouth [20]. The flowchart depicted in Fig. 3. describes the process of detecting the event of yawning from the instance a face is detected. Lip distance is the parameter used to determine if the subject's mouth is open. If the lip distance calculated from the frame is above lip distance threshold, the subject is determined to be yawning. An alarm is raised if the subject has yawned more than the set boundary value (10) consecutively. Small openings that in reality are construed as a result of talking, eating are ignored.

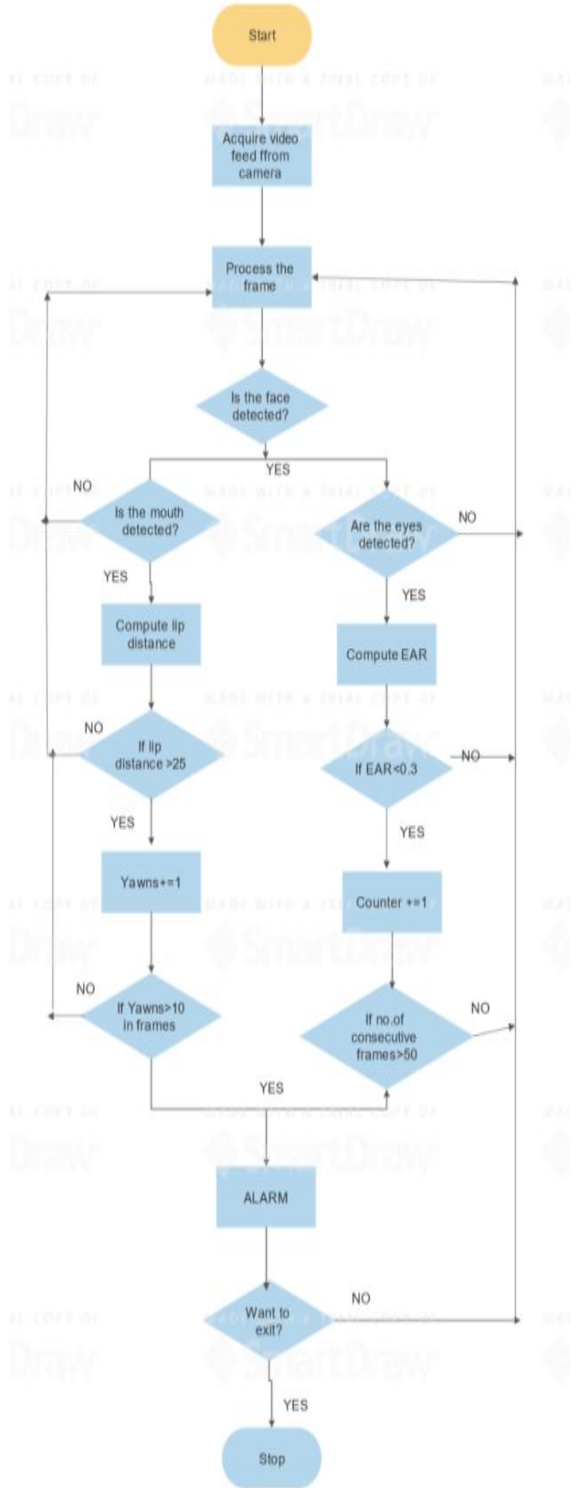

Fig. 3. Flow chart describing the algorithm.

III. EXPERIMENTAL RESULTS

The subject is placed in front of the camera so that the face is in focus. The window displays the plotted landmarks, yawn count and a message of the subject's state. An alarm is sounded when the yawn count exceeds the set boundary parameter. Alarm is also sounded if the eyes are found to be closed. The testing of this technique is carried out on 20 subjects. In all cases except for 3, the facial features are accurately detected. The accuracy of the testing is calculated using (2).

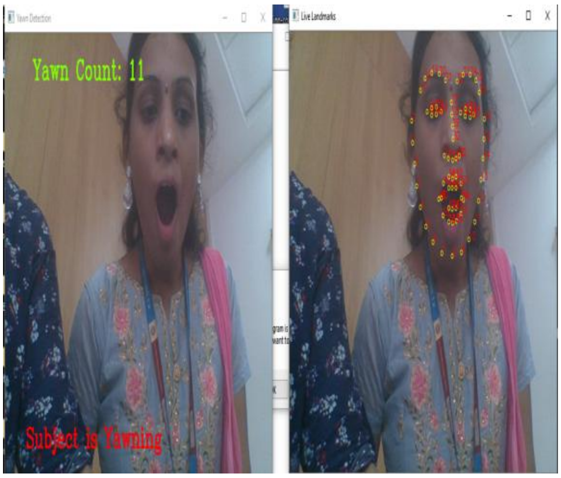

Fig. 4 Yawn detection.

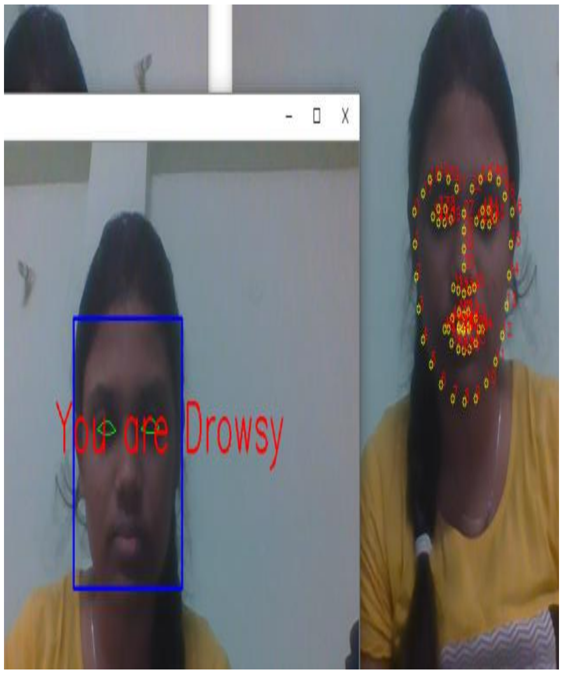

Fig. 5. Eye closure detection.

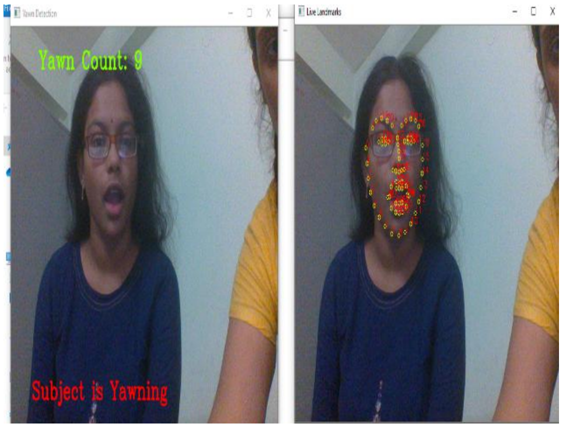

Fig. 6. Yawn detection with facial landmarks.

$$Accuracy\ rate = \frac{Number\ of\ samples\ with\ positive\ detection}{Total\ number\ of\ samples\ tested} x\ 100 \qquad (2)$$

When the subject is detected to have closed eyes as shown in the Fig. 5. and Fig 6., the message "You are drowsy is displayed" along with an alarm being activated. Fig. 4. depicts a subject yawning. The detection is acknowledged by messages "Subject is Yawning" and Yawn count value. In the case of Fig. 4., as the yawn count exceeds 10, an alerting alarm sound is also activated. Fig. 6. also depicts the successful detection of eyes where the subject is wearing spectacles.

IV. CONCLUSION

The proposed algorithm detects drowsiness in a driver using eye closure and yawning as markers. The system is tested on a variety of subjects with limited number of testcases. It accurately detects faces and the required facial features in 85 % of the cases. It is observed that accuracy of detection increases under better illumination conditions. In all the cases of positive feature detection, drowsiness is promptly detected. Occlusions such as spectacles are no hindrance in eye closure detection. This could be extended to eliminate the difficulties posed by bad lighting conditions.

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