Software Centric Driver Fatigue Discernment System Using Computer Vision

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***Abstract*— In recent times, there has been a massive multiplication in the number of vehicles seen on the road. With this increase, there has, unfortunately, also been a significant rise in the daily recorded cases of road accidents. One of the topmost causes of road mishaps is tiredness of the driver driving the automobile. Distraction caused due to tiredness can be shunned by recognizing the moment when the driver is getting drowsy and alerting her/him. We aim to contribute to creating a system which determines the state of drowsiness and sends an alert to the driver so accidents can be prevented.**

We set up a real time face detection using a pre-trained facial landmark detector which marks different parts of the face by coordinates. Out of all the features detected, the eyes and mouth are fixated upon. We calculate the opening and shutting of eyes and the mouth as a descriptor of tiredness using different metrics. Then these metrics are measured against a threshold value for determination of fatigue. At last, if the detector labels the person as drowsy, an alarm goes off alerting the driver and deferring a mishap.

Keywords—facial landmark, drowsiness, yawn, detection, alarm.

I. INTRODUCTION

Feeling sleepy or fatigued, or being unable to keep your eyes open, is referred to as the state of drowsiness. Excess sleepiness, which is another term for drowsiness, is characterized by tiredness, inertness, and a slow cognitive deftness. Drowsiness has an expensive impact on the public in terms of health and safety. Most people do not get enough sleep demanded by their body in this fast paced, 24/7 society where our work has become our identity. [1] Regardless of what the fatigue is caused by, be it long hours of demanding work, uncanny work shifts due to globalization, traveling at odd hours to avoid traffic, trying to maintain a social life after work, transportation workers trying to keep up the demands of the goods, becoming a new parent causing sleep restriction, or taking road trips on the weekends, the negative consequences can be impaired cognition and performance, health issues, and motor vehicle accidents. Drowsy driving can be fatal, but it is avoidable.

Some warning signs of drowsy driving are missing exits, drifting from our current lane, unable to recall familiar routes and frequent yawning and blinking.

II. EXISTING METHODS

There are various existing techniques for determining some of the signs of drowsy driving. Biomedical signals can be used to determine fatigue by monitoring cerebral, muscular, and cardiovascular activity and physiological characteristics such as heart rate, pulse rate, etc. The detection of these requires physical sensors to be put on the driver's body which can lead to driver being irritated. Another method which is used is monitoring the movement of the steering wheel, brake patterns or accelerator, lateral acceleration and displacement and vehicle speed for determining vehicular behavior and driver's operation. This technique's response time is not sufficient. At last, there are non-intrusive ways of determining using computer vision whereby capturing images of the driver for determining behaviors like frequent blinking, yawning, drooping of head, etc. This method is easier to incorporate into automobiles. [18]

We are using computer vision for facial landmarks determination and focusing on the eyes and mouth specifically. After their extraction, various metrics were used as parameters for determining drowsiness. [2] These were based on width distance decrease in case of eyes for determining blinking and vertical width increase in the case of mouth for determining a yawn. Threshold values for determining the level of width increase or decrease are used for characterizing the person as drowsy or normal.

III. MOTIVATION

Fatigue, like other psychophysical disorders that affect individuals, causes attention problems. It has a big influence on people's responsiveness since a physically weary person reacts unsteadily compared to someone who is well-rested. The advent of the first signs of exhaustion can be exceedingly dangerous, particularly for drivers, whose occupation necessitates tremendous concentration.

According to the National Sleep Foundation's 2005 Sleep in America Poll, 60% of adults admitted to driving when fatigued in the previous year. According to the CDC, one out of every 25 Americans fell asleep while behind wheel in the previous month.[35] Because it's almost impossible to identify

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whether tired driving resulted in an accident, especially after fatal incidents, this data certainly underestimates the harm of drowsy driving. The non-intrusive way of detecting drowsiness by taking photos detecting bodily indicators of weariness is more feasible and can avert driver displeasure. Since there is no requirement for physical equipment such as wires or sensors, it is the method used here.

Drowsy driving accidents typically include a single driving operator with no other companions speeding off the road with no indication of applying brakes, and they typically appear on remote roads and highways, necessitating instant processing for sending alerts on the right time. [10] Since this is a real time drowsiness detection, this method seems fit and viable.

The creation of a sleepiness detector makes the economy of a country save money by reducing road destruction and other expenses incurred as a result of traffic crashes. It contributes to car safety technology and competence by preventing drowsiness at an embryonic stage through a notification system. The system's primary significance stems from the fact that it aids in the preservation of priceless lives. This system can be implemented in vehicles to make them smarter.

IV. *ABOUT DATASET*

The videos which were used for detection of the thresholds were from University of Texas at Arlington Real-Life Drowsiness Dataset (UTA-RLDD). This data set was gathered, created, and produced in order to recognize a range of drowsiness, not only the most extreme examples. It captured even the tiniest variations in facial movements when a subject transitioned from awake to tired and vice versa. UTA-RLDD dataset consists of videos of around 60 participants.

Out of all the subjects, 51 were men and 9 were women. Videos in the dataset were captured from contrasting angles in contrasting real-life backgrounds and surroundings. Approximately every video is 10 mins in length and is categorized as either 'alert' (recorded as 0), 'low vigilant' (recorded as 5) or 'drowsy' (recorded as 10) in which the participants provided the labels themselves based on the state they felt they were in.

A csv file was created using the video frames and then subjected to standardization. The feature measurements and their normalized values, as well as the participant number and label, were then chosen as model parameters. Only alert and drowsy labelled values were used, dropping the low vigilance tagged data.

V. *ALGORITHMS AND TECHNIQUES USED*

In this project, Dlib library is used for facial landmarks detection. It uses 68 points to show the multiple facial landmarks which are numbered in a systematic manner to give us proper bifurcation between facial features like eyes, nose, mouth etc. [8] As the entire facial landmarks are systematically divided, it becomes easy for programmers to give certain parts of the result as a parameter or an attribute to a function due to continuing numbers. Using these, different features have been used for calculating drowsiness. Dlib is used because it can give predictions in real-time, unlike a CNN model.

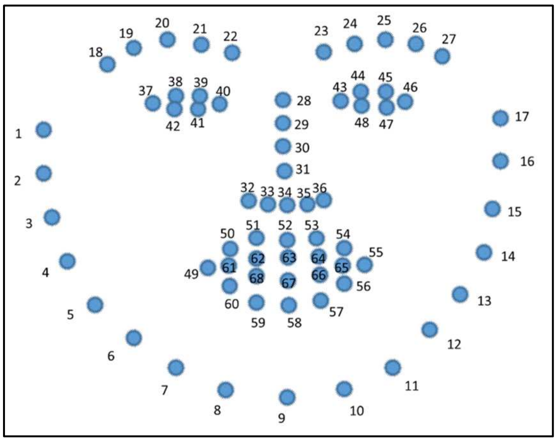

Fig. 1: Dlib Facial Landmarks

From the above figure it can be very much differentiated that all the numbers or facial landmark points from the number 1 to number 17 make the below structure of the face whereas the upper structure of the face is given by point number 18 to point no. 27. Rest all the points from 28 to 68 decide the remaining internal structure of the face i.e., eyes, mouth, and nose. More techniques and values used are mentioned below.

i. *EAR (EYE ASPECT RATIO)*

The structure here in the following figure represented by the red box refers to the eyes of the detected object and is thus decided by the facial landmark points from 37 to 48. [28]

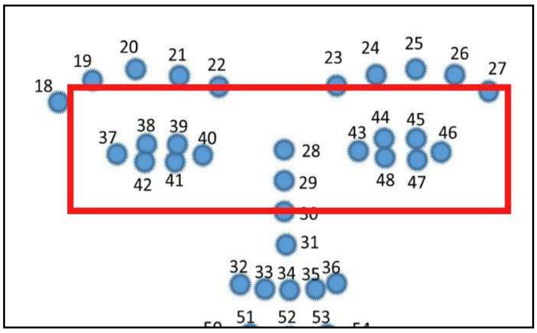

Fig. 2: Eye Aspect Ratio

$$EAR = \frac{|x| + |y|}{2 * |z|} ---- \rightarrow (i)$$

where, x and y are verticle distances and z is the horizontal distance of the eye

Fig. 3: Eye Aspect Ratio Formula

The above figure signifies the exact code model for calculating the formula for EAR (eye aspect ratio). Here we are calculating the value of EAR in numbers by first calculating the vertical distances of the eyes and then the horizontal distance. After which we are adding both the vertical distances and dividing them with twice the value of the horizontal distance.

ii. MAR (MOUTH ASPECT RATIO)

The structure here in the following figure represented by the red box refers to the mouth of the detected object and is thus decided by the facial landmark points from 49 to 68. [7]

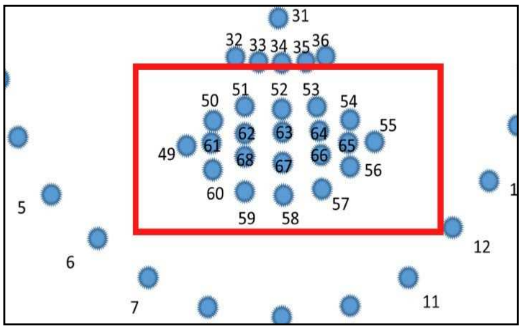

Fig. 4: Mouth Aspect Ratio

$$MAR = \frac{|X_1 + X_2 + X_3|}{3} ---- \rightarrow (ii)$$

where, Xn are the distinct verticle distances of the mouth

Fig. 5: Mouth Aspect Ratio Formula

The above figure signifies the exact code model of calculating the formula for MAR (mouth aspect ratio). Here we are calculating the value of MAR in numbers by first calculating the vertical distances of the mouth and then the center horizontal distance.

After which we are adding all the vertical distances and dividing them with three in the denominator.

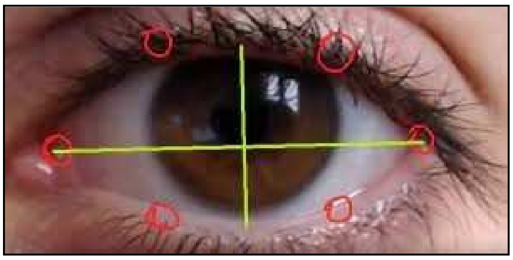

Fig. 6: Pupil Circularity

iii. CIRCULARITY

A lower circularity is being calculated for all those candidates who have their respective eyes nearly shut or semi-open than all those candidates who have significantly open eyes because of the squaring nature of the formula.

$$Circularity = \frac{4 * \pi * Area}{Perimeter^2} ---- \rightarrow (iii)$$

where, Area and Perimeter represent the said values of the eyes.

Fig. 7: Pupil Circularity Formula

The above figure signifies the exact code model of calculating the formula for circularity. Here we are calculating the value of circularity in numbers by first checking all the distances of the points present in the eyes area and then putting up all this in the formula which just needs the area and perimeter.

iv. MOE (MOUTH OVER EYE)

The MOE is referred to as the correlation between the MAR over the EAR.

$$MOE = \frac{Mouth\ aspect\ ration}{Eye\ aspect\ ration} ---- \rightarrow (iv)$$

where, the numerator and denominator represent MAR and EAR.

Fig. 8: Mouth Over Eyes Ratio Formula

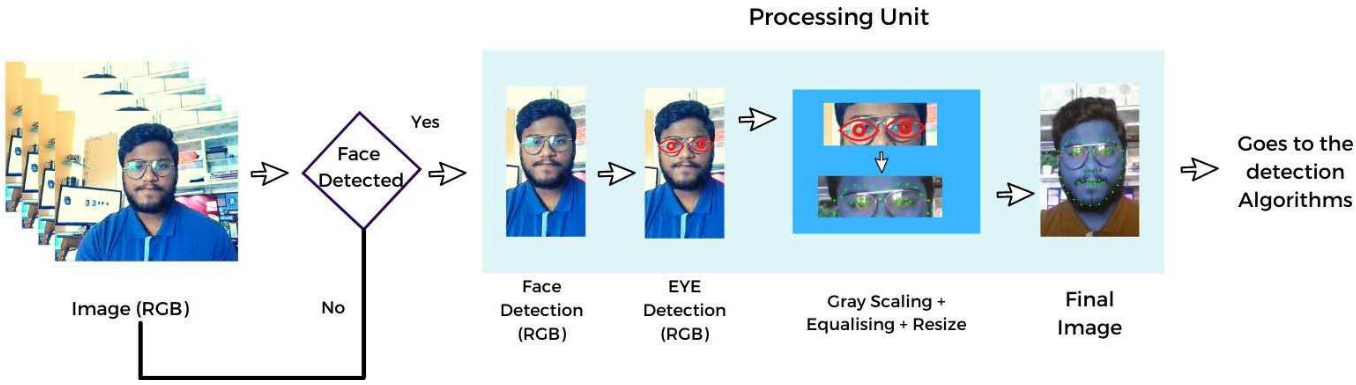

Fig. 9: Processing Unit Diagram

VI. METHODOLOGY

Below mentioned flow chart signifies the entire workaround of the code and the research. The processes have multiple branches and intersection which can be very conveniently covered by this.

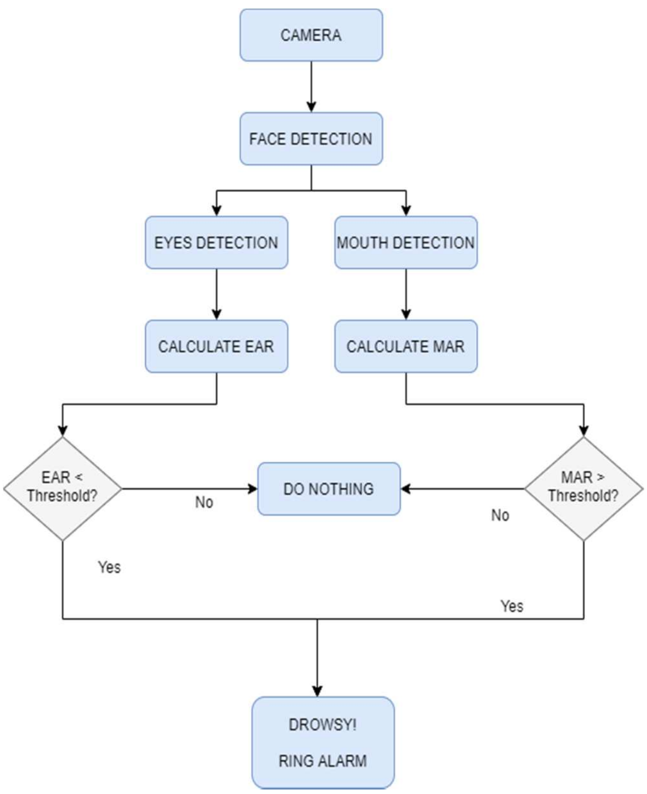

Fig. 10: Flow Chart

Here the entire flow of the research starts from the pressing the camera button where it captures a series of images / frames for further computation. Next as soon as the frames are received by the algorithm,

we proceed towards face detection i.e., where we only keep the frames where faces are clearly visible. Moving on, with the help of Dlib library we are able to extract the eye from the entire facial landmark and parallelly working towards bifurcating the mouth facial landmark too.

We now call the functions which we have previously created for this very sole purpose of calculation of the eye aspect ratio and the mouth aspect ratio. With the respective values of EAR and MAR achieved we compare these values with their designated threshold values which we have previously calculated.

The threshold value of EAR = 0.249 is calculated by taking into account the midpoint of the mean of multiple EAR values in "normal case" and the mean of multiple EAR values in "drowsy case". And similarly, we will be calculating the threshold for MAR which we got as 13.98.

As the comparison is done, we receive the final verdict as Drowsy or Normal and if drowsy, we are ringing the alarm. The multiple frames we calculated are being monitored through the entire algorithmic process which is here defined by these graphs.

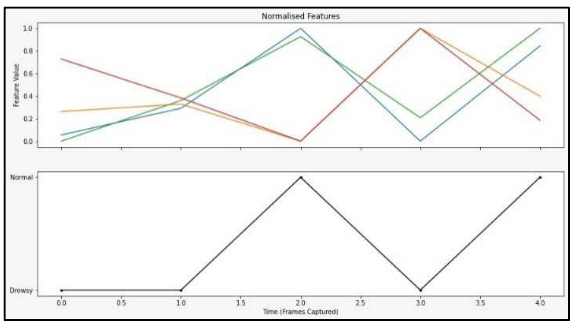

Fig. 11: Real Time Frame Chart

VII. CONCLUSION AND RESULT

Our methodology of detecting drowsiness is based upon EAR and MAR values which we get from facial landmarks values derived from the Dlib model which itself has an accuracy of 99.83%. The real time capturing of images was successfully able to detect the correct classification between normal and drowsy states in male and female candidates. The physical changes considered were opened eyes, closed eyes with both specs and without and yawning.

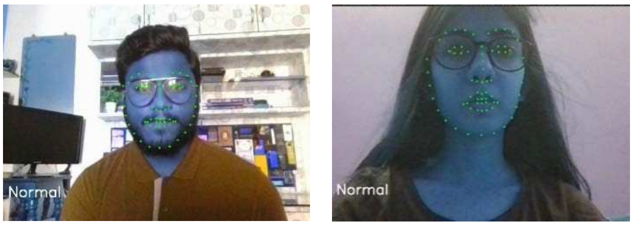

Fig. 12: Normal with specs

Fig. 13: Drowsy with specs

Fig. 14: Drowsy while yawning

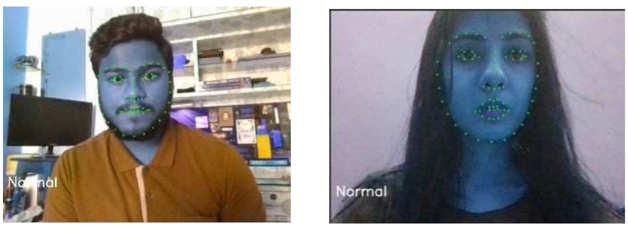

Fig. 15: Normal without specs

Fig. 16: Drowsy without specs

VIII. FURTHER APPLICATION AND SCOPE

Because this system's algorithm does not require datasets, it can be simply deployed as a mobile application, lowering hardware costs. With better quality cameras, pupil circulation can be incorporated as a metrics in calculating drowsiness effectively. In smart cars, automatic speed control can also be implemented if the driver is detected to be drowsy.

It can also be used as an add-on to existing road travel aiding apps such as maps or security providing services, etc. Alcohol state detection can be integrated to make the prevention system more credible. A feedback system with possible advice for driver's fatigue management can be assimilated. Furthermore, this system can be used in airplanes and other air traveling vehicles to avoid airway accidents.

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