Multifunctional HUD with Drowsy Detection and Fog Elimination Mechanism

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Abstract

People are conscious of the risk of drinking and driving but don't realize the danger of drowsiness. Prior state of art reveals very little work on designing the automated system that measures the driver drowsiness. Our research lodge a system for the drivers and travelers who drive various means of transportation and alerts them when a driver is in a drowsy state. We have amalgamated the HUD (Head-up Display) facilities, drowsy detection system, and fog elimination system altogether to help the driver reach the destination safely by providing navigation, visual indication and many useful applications of mobile phones on HUD. Experimental results reveal that our proposed system is superior to existing HUDs and provide more features for the benefit of drivers.

Keywords: Head-Up Display, Fog Elimination, Drowsy detection, Facial landmark detection

1. Introduction

The recent study reveals that on an average 3,287 road accidents occurs daily and out of this approximately 23 % of accidents occurs due to fog and approximately 3% due to drowsiness of driver(CDC)(Jon Erdman, 2015)(Fuletra, J. D., & Bosamiya, D., 2013). Most of the car accidents at night happens because of the driver's drowsiness. Factors causing drowsiness are alcohol consumption, use of certain medications, sleep loss etc.

Fatigued driver significantly affects the driving and increases the chances of a crash. 51% of youngsters feel drowsy while they are driving and even 17% are actually fallen asleep according to National Sleep Foundation (NSF) (National Sleep Foundation) (Fairclough, S. H., & Graham, R., 1999). More than 30% road accidents are due to driver's sleepiness or fatigue. There are two main causes of driver fatigue:

i. Quality and quantity of the sleep are not good
ii. Untreated or unrecognized sleep disorders, such as sleep apnea.

The only way to recompense this is by sleeping. Else it might result in having a higher problem of occurrence of fatigue-related accident. Another reason for road accidents is Fog, which leads to almost zero visibility.

We all are aware that every year most of the car accidents happened in Delhi during December and January is due to dense fog. According to a survey, Delhi witnessed around 7,375 road accidents in 2017 due to heavy fog (Deepak Dash, 2018). Similar conditions are witnessed at many other cities during winter. Sixteen Indians die in road accidents every hour (NDTV Road Safety, 2018). According to the Global Road Safety Report 2015, total 141,526 persons were killed and approximately five lakh people injured in India because of road crashes (Kumari, B. M. K., & Kumar, P. R., 2017). However, this number is estimation because all accidents are not reported to the police.

Several types of research are ongoing in this domain to alert the drivers during long distance driving. Driver awareness programs are being organized that make drivers aware of the precautions for drowsy driving, to avoid scheduling conflicts and make them aware of the disadvantages of distracted driving. These programs also provide them local statistics on road accidents, their causes and consequences.

Head-Up Display (HUD) technology is being introduced for the ease of drivers. The HUD can be mounted on the dashboard of the cars. HUD is a transparent display that displays the data without requiring users to change or look away from their usual viewpoints. In the effort to make driver alert and active during driving, we have come up with a system, named "Multi-Functional HUD (MFH)". MFH has taken the above two problems into consideration i.e. Drowsy detection and Fog elimination. MFH also has major functionalities of HUD such as display of speedometer, displaying real-time navigation, using different available applications while driving or using it for multimedia purposes.

In section 1, we have discussed the need for Drowsy detection mechanism and Fog elimination mechanism in vehicles. The rest of the paper is organized as follows: Section 2 describes prior state of art. In section 3, we describe the proposed system followed by experimental results in section 4. We conclude our work in section 5.

2. Literature Survey

Prior state of art reveals that the Drowsiness Detection Techniques are primarily based on Image Processing (Assari, M. A., & Rahmati, M., 2011) (Parmar, S. H., Jajal, M., &Brijbhan, Y. P. , 2014), Electroencephalograph (EEG) (Mardi, Z., Ashtiani, S. N. M., &Mikaili, M., 2011)(Choudhary, P., Sharma, R., Singh, G., & Das, S., 2016), Artificial Neural Networks and Vehicular measures(Choudhary, P., Sharma, R., Singh, G., & Das, S., 2016). EEG Technique involves the use of Electrode cap to measure the electrical potential (John Brown and Joseph Carr, 2001). This may not be practically feasible for real-life scenario since the driver would not wear the EEG Electrode helmet while driving which is an essential requirement.

In the case of Yawning based technique, the camera captures the driver image and based on the number of learning algorithms and images compares the training image set with the live video images, which are insensitive to the changes in lighting conditions, skin types, and geometrical facial features. It will detect the person while he is yawning by matching the image with an image stored in the database. The robustness of the implemented technique is due to the fact that several verification criteria are used to avoid false detections (Abtahi, S., Hariri, B.,&Shirmohammadi, S., 2011, May),(Parmar,N., 2002)(Ueno, H., Kaneda, M., &Tsukino, M., 1994, August). However, technique fails if the driver keeps the hand in front of his mouth while yawning.

Image processing based drowsy detection involves several techniques like Template matching, Eye Blink Check and Yawning based detection technique. Based on prior state of art, it can be stated that the Eye blink Technique based on the Image Processing is the most efficient way of using Drowsy Detection System. We now briefly discuss each of these techniques.

2.1 Eye Blink Detection Technique:

In this technique, the eye blinking rate and eye closure duration of the driver is measured to detect the drowsiness. Whenever a driver is in a drowsy state his eye blinking rate increases and he closes his eyes frequently. The technique proposed by Sharma.et.al.used an algorithm that sets a time interval which should not be exceeded by the eye closure time (Adrian Rosebrock, 2017)(Park, S., Pan, F., Kang, S., &Yoo, C. D., 2016). If at any instance of time, eye closure time exceeds the predefined threshold time, the system triggers an alarm to alert the driver. For example, if threshold frequency of eye closure is set as 10 seconds and the system detects eye closure duration more than that, then, the alarm will be triggered immediately and it will continue till the system detects that the driver's eyes are open and he is not in a drowsy state.

2.2 Yawning Based Technique:

Yawning is one of the symptoms of fatigue or drowsiness. One can assume that a person is feeling drowsy while seeing a person yawning. Using face tracking and then mouth tracking one can detect yawn. Such techniques detect the opening rate of mouth. Instead of using just one technique to detect drowsiness of driver, some researchers have combined various vision based image processing techniques to have better performance (Abtahi, S., Hariri, B., &Shirmohammadi, S., 2011). But there is one disadvantage in this technique that if the driver keeps the hand in front of the mouth, the system may not detect the person yawning. Since majority of people have the habit of keeping the hand in front of their mouth while yawning, so the system may fail to detect properly. Thus this technique may not give accurate results in real life scenarios.

2.3 Electroencephalograph (EEG):

In this method, the EEG electrodes are used which transforms iconic current from cerebral tissue into electrical current used in EEG preamplifier. EEG recording modes are mainly of three types: - (a) Unipolar (b) Average and (c) Bipolar. An averaging technique is the best because it is accurate and has higher noise immunity so the best result can be obtained (Otani, S., & Fushimi, Y.

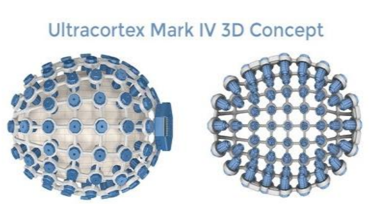


Fig. 1- The EEG Cap (OpenBCI: Biosensing for Everybody (2015))

(2018))(Jaakko Malmivuo, 1995)(Liu, C. C., Hosking, S. G.,&Lenné, M. G., 2009)(Mr. Rash Dubey, Mr. A. Pathak, 2010).

Figure 1 shows that it is an EEG cap which is to be wear by the driver. Through this device, the electrical activities of the brain are been recorded by the recorder in the form of the waves. The frequency bands are classified into five categories.[Otani, S., & Fushimi, Y., 2018]

(i) Delta (0.5-4Hz), (ii) Theta (4-8Hz), (iii) Alpha (8-13Hz), (iv) Beta (13-22Hz), (v) Gamma (22-30Hz and higher)

Sleep is not a random process; instead, it is a very organized one. Sleep has five stages: stage 1-4 (non-REM sleep) followed by Rapid Eye Movement (REM) sleep. This process is cyclical. Once REM sleep is achieved, the cycle reverses itself and goes back through stages IV, III, II and again to III, IV and REM. Through these frequency bands the processor will process the data and according to the recorded EEG patterns, it will alert the user if a driver is in Drowsiness state.Fig.2 shows that, the recorded patterns of the different states of the sleep from the human brain.

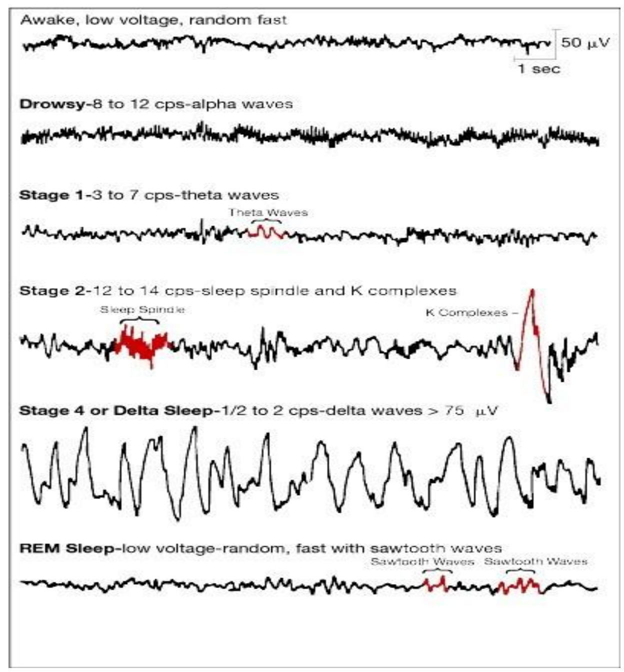


Fig.2-EEG activity is dependent on level of consciousness (Jaakko Malmivuo , 1995)

Due to the bulky size of a device, the users are uncomfortable to wear it. Moreover, signal processing to capture signals from a mind and predict drowsiness based on the signals, proper equipment's are needed and the overall cost will be more.

Due to above-mentioned lacunae, we propose a technique that implements a remote Night vision Infrared (IR) camera attached to the Head-Up Display, which will work as a smart camera using Machine Learning algorithm named Facial Landmark detection algorithm and uses OpenCV library to code in Python. Our technique is grounded on the eye blinking mechanism to detect drowsiness. Using this technique the drowsiness will be detected and it is one of the most efficient ways to detect the drowsiness of a driver. Further, we enhance our system by adding fog elimination mechanism to it. These features will make driving safe and comfortable.

3. The Proposed System

The proposed system comprises of HUD with DDS and FDS. Fig.4 depicts various components of our proposed system. We now explain each of these components in subsequent subsections.

3.1 Drowsy Detection System (DDS)

In drowsy detection mechanism, when the driver is in the drowsy state an alarm sound will be generated and an alert will be displayed on the HUD which will alert the drowsy driver. The camera on the HUD will continuously capture the face of the driver. Using the face detection technique it detects the Eyes from the Face landmarks (Adrian Rosebrock. Edition : 1.1.0)(Joshi, A., Dhanawade, A., Kashid, M., &Palve, S, 2012). And then using the aspect ratio function it will detect if the eyes are open or closed. If the eyes are closed more than 5 seconds, an alert will be displayed on the HUD and alarm will be generated. We now elucidate the steps to detect the drowsy state of a driver.

- Our process for Drowsy Detection starts with capturing the live monitoring using a Night vision Infrared (IR) camera. Live monitoring will be done through the Night vision Infrared (IR) camera.
- Firstly, the face will be detected in live monitoring, using facial landmark detection technique of computer vision, the process of localizing facial structures on face including eyes, nose, eyebrows, mouth, and jaw line is done. After the face is detected our main focus is on eye detection.
- Secondly, the eyes will be detected from the facial landmarks. Each eye has 6 (x, y)-coordinates as shown in Fig.3 and using the facial detection algorithm we can detect that. Then the function Eye Aspect Ratio (EAR) is used to detect whether the eyes are open or closed. EAR remains constant when the eyes are open and fall to zero when the eyes are closed. EAR is calculated using equation 1.

$$EAR = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|} \qquad (1)$$

Where, p1, p2, p3, p4, p5, p6 are facial landmark locations.

i. The numerator of the equation is used to compute the distance between vertical eye landmarks and denominator computes the distance between the horizontal landmarks.
ii. We have set a time trigger of 5 seconds that means if the EAR is zero for 5 or more than 5 seconds it is assumed the driver is in a drowsy state and the alarm is triggered.
iii. Simultaneously like alarm, HUD will also display alert messages. So, the travelers who are travelling with the driver will be alerted by displaying the alert message.
iv. If the drowsy state is not detected then it will repeat the same process until the drowsy state is not detected.

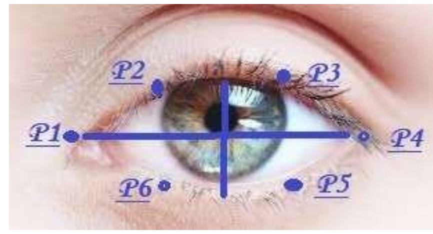


Fig. 3- The 6 facial landmarks associated with eye.

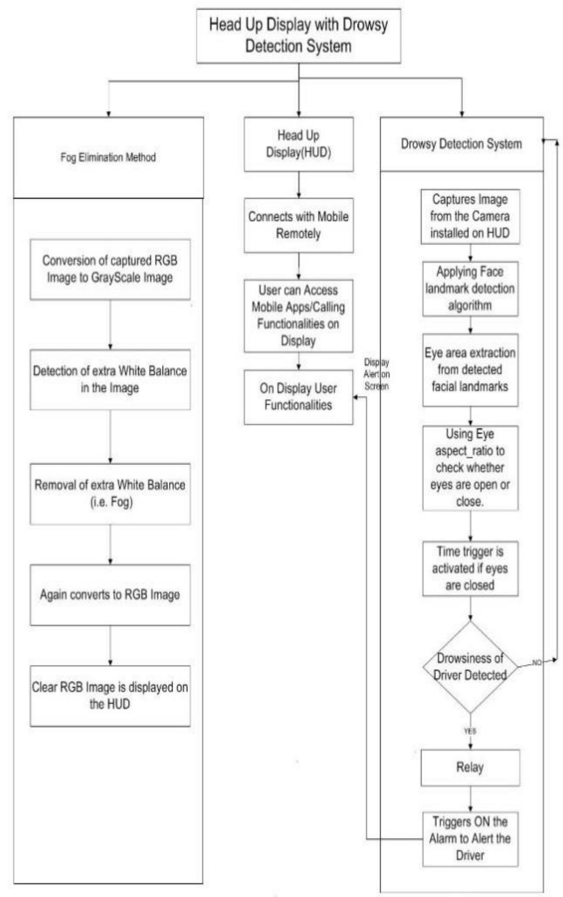


Fig.4- Flowchart of the proposed technique

3.2 Fog Elimination System (FES)

If a driver is driving in rainy or freeze climate/environment and there is fog on the road and the road is ambiguous to the Driver then FES will help to display the video of live road with the elimination of Fog so that the Driver can get a clear vision of the road on the Display of HUD.

A Night vision Infrared (IR) camera is mounted on the other side of the HUD similar to the one used for a drowsy detection system which will be used for Fog Elimination. The Fog Elimination method will be done on live video recording and the resulted image will be displayed on the HUD. Our research on FEM is grounded on the work proposed by Jian Sun et.al (Kaiming He, Jian Sun, &Xiaoou Tang., 2011)(He, K., Sun, J., & Tang, X.,2011)(Narasimhan, S. G., &Nayar, S. K., 2003) Fog Elimination works as:

Firstly the camera will capture the video and will detect the foggy part in the video which contains dust, smoke, fog, etc. Then the RGB colours from the image will be eliminated. And the remaining colours will be white and black including the fog with white colour in the picture So now the resulted image in the video will be processed for eliminating the extra white balance/colour that is fog. So we will get a black and white image (video) excluding the fog part through this filtering process that is "Dark Chanel Prior (DCP)".

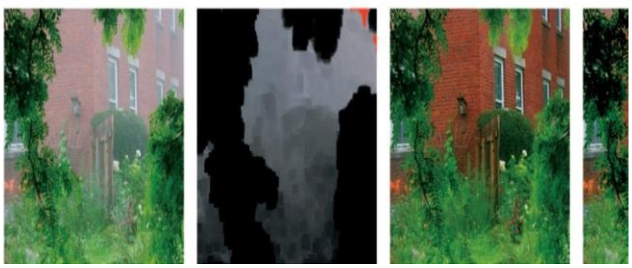


Fig.5-Step by step resultsof Fog Elimination Method (Kaiming He, Jian Sun, &Xiaoou Tang., 2011)

Fig.5 shows the steps of how the process of fog elimination works. Fig.5 (a) represents fogy image, Fig. 5(b) shows the grayscale image to eliminate extra white balance, Fig. 5(c) shows image after adjusting white balance and finally, Fig.5 (d) represents fog eliminated image. Following steps are performed after the separation of RGB from the image and getting a Grey Scale image:

I. The computation of the dark channel: The computation of the dark channel: Calculating the minimum of the three color component that is RGB for each pixel in the image.
II. Estimation of the transmission map: It is done with the help of the haze equation and through the assumption of the atmospheric brightness.
III. Recovering the scene radian: - Using the haze model equation we have to apply the dot channel value under the transmission map and the remaining one variable is scene radians that can be easily equated.
IV. Haze free image: -The analysis or measurement of CNR (Carrier-to-noise ratio) which will give the visibility of the foggy image.

4. EXPERIMENTAL ANALYSIS

We have performed the experiments to test the working of DDS and FES. Devices requires are: Night vision Infrared (IR) camera, and Head Up Display. The system was implemented in Python with Processor of Intel core i5-7200 CPU, 8GB (DDR4) RAM, Nvidia 920M (2GB VRAM DDR4) Graphic card, 64-bit operating system, x64-based processor and Windows 10 Operating System. Table 1 shows the list of Tools and libraries used for implementation of the proposed system. When the program is executed it detects the eyes of a human captured by the camera and if the system detects the eyes are closed for more than 5sec the alarm will be triggered and the alert will be displayed on the HUD. The scanning process is done in real time and detects in the time interval of approximately 0.25 seconds.

Table 1 -List of Tools and Libraries

S.No	Tools and Libraries	Remarks
1	Pycharm	Pycharm is an IDE(Integrated Development Environment) used by the programmers for computer programming, specifically for the Python language.
2	OpenCV	OpenCV is an open source library used for programming functions aimed at real time vision.
3	SciPy	SciPy is an open source library in python which is mainly used for scientific and technical computing.
4	Numpy	NumPy is a library in Python which adds support for N-dimensional array calculations and also high-level mathematical function used operate these arrays.
5	Python	Python is a multi-paradigm language which fully supports object-oriented and structured programming.
6	MATLAB	MATLAB is a multi-paradigm programming language and an environment used for numerical computing.

Ourcode does the face detection, it detects whether the eyes of the driver is opened or closed. This code includes many libraries namely NumPy, threading, cv2 etc. All these libraries are imported in order to make the coding work less complicated. It comprises of the following functions:

Start sound: It will initialize the sound when a driver is detected in a drowsy state. It uses a pygame library to initialize, load and play the buzzer or sound.

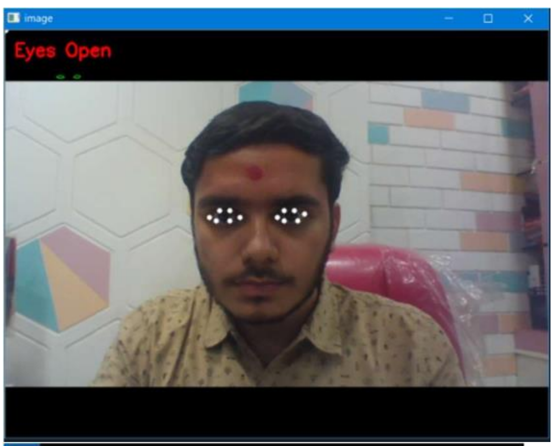
Resize and shape to np: As the image can be captured from any angle, length or height we need to resize the image. In order to resize the image, we use this function so that in the end we get all the image dimensions of the same size. The cords specified in the shape_to_np indicates the coordinate of the image. The coordinate of the top left corner is always (0, 0).

Eye aspect ratio: The aspect ratio is nothing but an image projection attribute that describes the relationship between the width and height of the image. Its value depends on the image. As in some image if we ignore the aspect ratio then image we get may appear a little crunched and if we maintain the aspect ratio of the image then we may get a proper image but it will be a cropped version of the original one. Our code uses the Euclidean method to calculate the distance between the eye's horizontal landmarks. The formula applied to calculate the distance is:

$$\square(\square,\square)=\sqrt{\sum_{\square\square\square}^{\square}(\square_{\square}-\square_{\square})^{\square}} \quad (2)$$

Where, d(p, q) represents the distance between the two coordinates, pi & qi are two different coordinates of facial landmarks.

In our code many variables are used to capture the image at a real-time, to get the shape and aspect ratio of the eye and after calculating all this if the eye of the driver is closed for more than 5 seconds the alarm variable's value will be changed to TRUE, "ALERT!!! PLEASE WAKE UP" will be printed on the HUD and the sound is generated using a start sound function. Fig.6 shows the results of testing done for the DDS. In Fig. 6(a), the eyes of the driver is open, so the system runs normally and after approximately every 0.25 seconds, an image of the driver is again captured and check for drowsiness. The execution of the system is shown in Fig. 6(b). Fig.6(c) shows the captured image of a driver with closed eyes, as a result of eye-blink detection. Thus, a message is displayed with an Alarm sound "ALERT!!! PLEASE WAKE UP" as shown in fig. 6(d). In Fig.7 (a) EAR value with 1 is the absolute value, that is if the EAR is less than 1 and if it reaches to zero the eyes are closed. In the graph when the EAR is zero it shows the eyes are close and if it remains 0 for a fixed interval the alert is triggered. Fig.7 (b) shows the graph using threshold values of EAR which is the result of code as shown in Fig.6



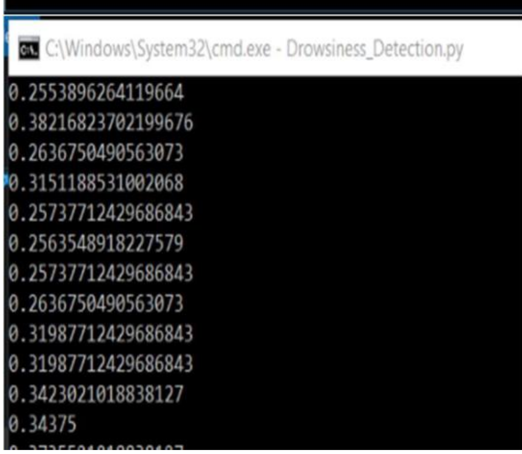
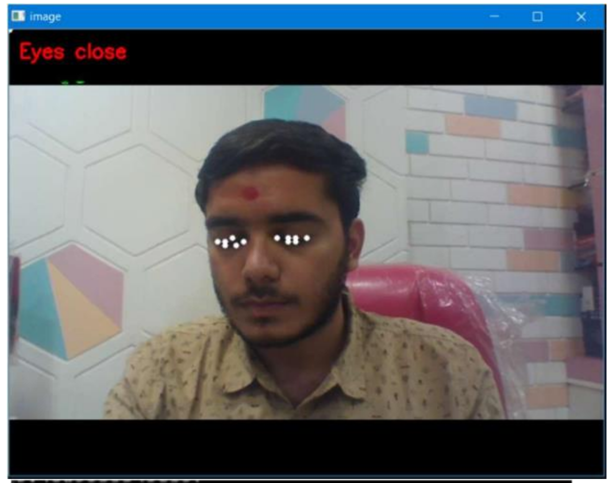


Fig.6-.(a) Real-time detection using a camera for Eye-blink detection with open eyes. (b) Results for Eye-blink detection when eyes are open and the driver is not in a drowsy state.



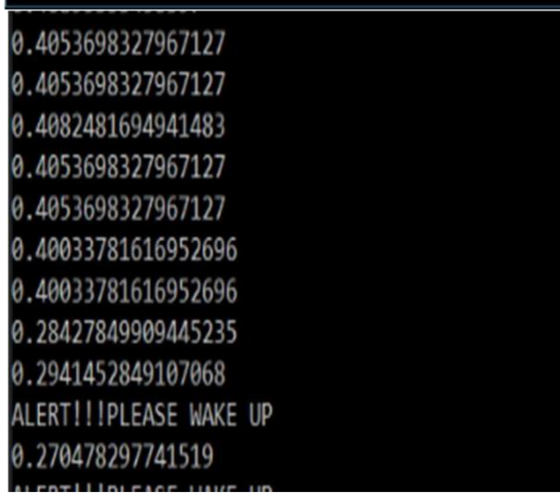


Fig.6-.(c) Real-time detection using a camera for Eye-blink detection with closed eyes. (d) Results for Eye-blink detection when eyes are closed.

Resultant graphs

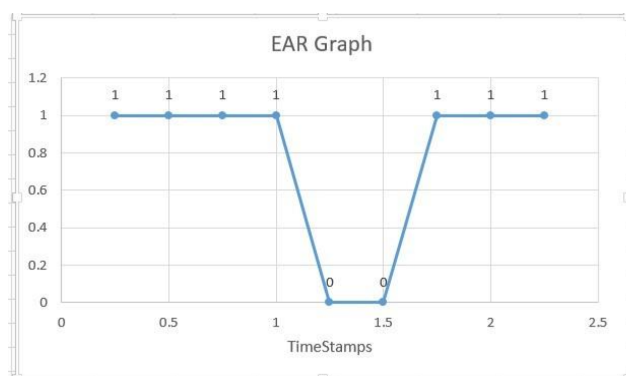


Fig.7-(a) Resultant outcome by applying EAR equation in python when eyes are open then resultant outcome will be 1 and when the eyes are closed then resultant outcome will be 0.

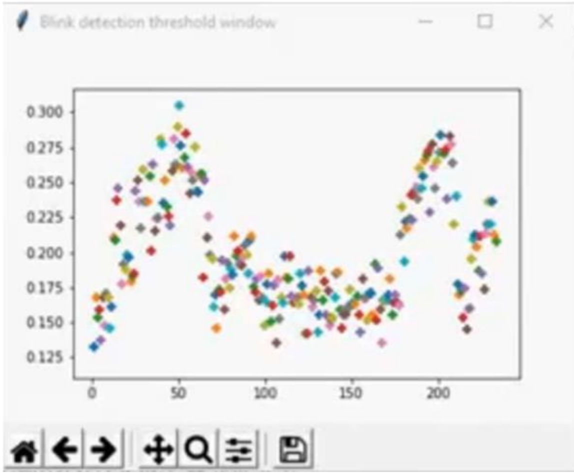


Fig.7-(b) Graph plotted according to the values obtained from fig.6 (b) and fig 6(c) (Tereza Soukupova and Jan ´ Cech ˇ,2016)

5. Comparison with prior work

The prior state of art reveals that HUD was designed with functionalities like navigation, displaying speed, using different multimedia applications . Their work does not support the Drowsy detection mechanism and fog elimination mechanism. However, the proposed system enables HUD with DDS and FES. Table 2 summarizes the comparison between them.

Table 2: Comparison with Existing Work

S.No	Existing Work	Our Proposed work
1	HUD with basic functionalities like Navigation, Speed display, etc.	HUD with basic functionalities like Navigation, Speed display, etc.
2	Single camera HUD	Dual Night vision Infrared (IR) camera at both front and rear side
3	Does not provide DDS.	Support HUD with DDS
4	Does not provide FES.	Support HUD with FES

6. Conclusion

Compact size multifunctional HUD is innovated for betterment and lifesaver for the humans. This HUD is different from the other normal HUD's since it provides different functionalities such as Fog Elimination through the front HDR Night vision Infrared (IR) camera which will display a clear image removing haziness from the image. And the other similar camera will be attached to its opposite end which will detect the drowsiness of the driver through OpenCV which will continuously detect the movement of the eye. If the eyes of the driver will remain closed for more than 10 seconds then it will generate an alarm. The other advantage of the HUD will be it will navigate the driver, calling purpose, and many more functionalities which can be customized by the user through the application. So, this innovation is 'Compactly versatile'. The proposed technique may be improvised by implementing the concept of Neural networks for the DDS. For real-time faster haze removal, Artificial Intelligence can be used.

REFERENCES:

CDC-Drowsy Driving: Asleep at the Wheel (https://www.cdc.gov/features/dsdrowsydriving/index.html Last Visited : 16 Oct 2018 07:30:10 GMT)

Jon Erdman (2015)Fog: Deadlier Driving Danger Than You Thinkhttps://weather.com/news/news/fog-driving-travel-danger-20121127 Last visited :11 Oct 2018 13:54:25 GMT.

Fuletra, J. D., &Bosamiya, D. (2013). A survey on driver's drowsiness detection techniques. International Journal on Recent and Innovation Trends in Computing and Communication, 1(11), 816-819.

National Sleep Foundation-THE PROBLEM WITH DROWSY DRIVING https://www.sleepfoundation.org/sleep-news/the-problem-drowsy-driving Last visited :16 Oct 2018

Fairclough, S. H., & Graham, R. (1999). Impairment of driving performance caused by sleep deprivation or alcohol: a comparative study. Human factors, 41(1), 118-128.

Deepak Dash(2018) Fog-related crashes getting deadlier https://timesofindia.indiatimes.com/india/fog-related-crashes-getting-deadlier/articleshow/62407961.cms Last visited :16 Oct 2018 14:58:08 GMT

NDTV Road Safety(2018)-ROAD ACCIDENT STATISTICS IN INDIAhttps://sites.ndtv.com/roadsafety/important-feature-to-you-in-your-car-5/ last visited : 15 Oct, 2018.

Kumari, B. M. K., & Kumar, P. R. (2017). A survey on drowsy driver detection system. 2017 International Conference on Big Data Analytics and Computational Intelligence (ICBDAC).

Assari, M. A., & Rahmati, M. (2011). Driver drowsiness detection using face expression recognition. 2011 IEEE International Conference on Signal and Image Processing Applications (ICSIPA).

Parmar, S. H., Jajal, M., &Brijbhan, Y. P. (2014). Drowsy Driver Warning System Using Image Processing 1.

Mardi, Z., Ashtiani, S. N. M., &Mikaili, M. (2011). EEG-based drowsiness detection for safe driving using chaotic features and statistical tests. Journal of medical signals and sensors, 1(2), 130.

Choudhary, P., Sharma, R., Singh, G., & Das, S. (2016). A Survey Paper On Drowsiness Detection & Alarm System for Drivers. International Research Journal of Engineering and Technology (IRJET).

Choudhary, P., Sharma, R., Singh, G., & Das, S. (2016). A Survey Paper On Drowsiness Detection & Alarm System for Drivers. International Research Journal of Engineering and Technology (IRJET).

Introduction to biomedical equipment technology by John Brown and Joseph Carr (2001)

Abtahi, S., Hariri, B., &Shirmohammadi, S. (2011, May). Driver drowsiness monitoring based on yawning detection. In Instrumentation and Measurement Technology Conference (I2MTC), 2011 IEEE (pp. 14).IEEE.

Parmar,N.(2002). Drowsy driver detection system. Engineering Design Project Thesis, Ryerson University.

Ueno, H., Kaneda, M., &Tsukino, M. (1994, August). Development of drowsiness detection system. In Vehicle Navigation and Information Systems Conference, 1994. Proceedings., 1994 (pp. 15-20). IEEE

Adrian Rosebrock (2017) Drowsiness detection with OpenCV https://www.pyimagesearch.com/2017/05/08/drowsiness-detection-opencv/Last visited: date :15 Oct 2018

Park, S., Pan, F., Kang, S., &Yoo, C. D. (2016, November). Driver drowsiness detection system based on feature representation learning using various deep networks. In Asian Conference on Computer Vision (pp. 154-164). Springer, Cham.

Otani, S., & Fushimi, Y. (2018). U.S. Patent Application No. 15/630,218.

Jaakko Malmivuo (1995) Bioelectromagnetism http://www.bem.fi/book/13/13.htm Last visited: date :16 Oct 2018 12:02:45 GMT.

Liu, C. C., Hosking, S. G., &Lenné, M. G. (2009). Predicting driver drowsiness using vehicle measures: Recent insights and future challenges. Journal of safety research, 40(4), 239-245.

OpenBCI: Biosensing for Everybody(2015) https://www.kickstarter.com/projects/openbci/openbci-biosensing-for-everybodyLast visited: date :16 Oct 2018 12:02:45 GMT.

Mr. Rash Dubey, Mr. A. Pathak(2010) Digital Analysis of EEG Brain Signal.

Deep Learning for Computer Vision with Python by Adrian Rosebrock. Edition : 1.1.0

Joshi, A., Dhanawade, A., Kashid, M., &Palve, S. (2012) Drowsy Driver Detection System.

Kaiming He, Jian Sun, &Xiaoou Tang. (2011). Single Image Haze Removal Using Dark Channel Prior. IEEE Transactions on Pattern Analysis and Machine Intelligence, 33(12), 2341–2353. doi:10.1109/tpami.2010.168

He, K., Sun, J., & Tang, X. (2011). Single image haze removal using dark channel prior. IEEE transactions on pattern analysis and machine intelligence, 33(12), 2341-2353.

Narasimhan, S. G., &Nayar, S. K. (2003, October). Interactive (de) weathering of an image using physical models. In IEEE Workshop on color and photometric Methods in computer Vision (Vol. 6, No. 6.4, p. 1). France.

Tereza Soukupova and Jan ´ Cech ˇ(2016)-Real-Time Eye Blink Detection using Facial Landmarks