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IMAGE AND BRAIN SIGNAL PROCESSING BASED DROWSINESS DETECTING AND ALARMING SYSTEM

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Abstract

Accidents due to drowsiness are considered as silent killers. In India, accident rates are more than 20% and it is increasing year by year. Loss of consciousness causes changes in human body which leads to drowsiness. Detecting drowsiness of drivers while driving is a big challenge but at the same time serious road accidents are mostly due to micro sleep and fatigue. Drowsiness detection of drivers uses modern technology that helps the drivers to prevent accidents due to drowsiness. A system that automatically detects drowsiness of the driver in real time using computer vision is proposed. This multi-model technique makes use of Signal and Image processing for effectively detecting drowsiness. The face is detected by using a camera and the facial landmarks were captured for analysis and the eye region is being extracted for calculating EAR (Eye Aspect Ratio)

which would help in understanding the open and close movement of eyes. Added to that the Electro Encephalography (EEG) signals of the brain are captured using non-invasive method and the processed signals are used to check the alertness of driver. This multi-model drowsiness detection system detects the difference between blinking and drowsiness easily. The value which is being fetched from both the proposed techniques is fused and given as input to the alert system for providing a caution to the drivers. The number of road accidents could be avoided on successful implementation of this system as accuracy of detection is expected to increase in decent scale compared to the existing systems.

Keywords

Accident, Drowsiness, EEG Signals, EAR Algorithm, Signal Processing and Image Processing

1. Introduction

An autonomous driving car uses modern algorithms of Artificial Intelligenceto travel without using human intervention using a combination of sensors, cameras and radar.To be an autonomous certified vehicle, it must travel through predetermined destination over roads without human help. Some faulty mechanics can be cited as the cause for certain accidents making autonomous carsmore dangerous things to hit the open road. Vehicles driven by human are the reality that is present now in practice and statistics proves that human error is the reason for majority of car crashes. Computer software (algorithms) can able to solve few of these problems. The main motive of this paper is to decrease the accident rates of vehicles by improving or increasing the safety measures around the vehicles.

Driver sleepiness detection could be a safety technology that helps to stop accidents caused by the motive force obtaining drowsy. Our goal is to find the initial signs of fatigue before a critical situation arise. The proposed system is a computer vision system which will mechanically discover driver somnolence in a time period video stream then display an alert message if the person seems to be drowsy.

The principle of the proposed system using OpenCV library that relies on the $64000 time facial pictures analysis for warning the person of his/her somnolence or in attention to stop traffic accidents. The facial expressions of the driver is taken by a camera that is being installed in front of the driver. An EAR algorithm is proposed to find the level of fatigue by measuring the eyelid blinking duration and face detection algorithm is used to track the eyes, and ultimately warn the driver. If the eyes are found to be closed for 20 consecutive frames, the proposed detection system

arrives to the conclusion that the person is falling asleep and prompts an alert message. The system is additionally ready to discover once the eyes cannot be found. At the same time, the EEG signals of the brain are captured using non-invasive device (mind wave neurosky) and the processed signals are used to check the alertness of the driver. This multi-model drowsiness detection system detects the difference between blinking and drowsiness easily. The proposed system may be evaluated for the effect of drowsiness warning through an alert message under various operation conditions.

2. Literature Review

Recent survey is that annually 200 deaths and 76,000 injuries are due to fatigue connected crashes. The development of technologies for sleuthing or preventing somnolence at the wheel may be a major challenge within the field of accident prevention systems. To avoid the heavy loss to life and property due to mild inattentiveness of driver due to drowsiness, technical methods can be developed to support the drivers to control their involuntary action.

Drowsiness of the drivers was the main cause of accidents in Sri Lanka. The best way to avoid accidents caused by driver's temporary state was proposed to notice temporary state of that driver and warn him before he sleeps. In their paper, the driver's temporary state was detected using a sleepiness detection methodology-a hybrid approach of eye membrane detection and pulse pattern detection. (Chandrasena H.M & D.M.J. Wickramasinghe, 2017).

(Puja Seemar & Anurag Chandna, 2017) focuses on a driver sleepiness detection system in intelligent transportation system, where Raspberry pi is used to understand the unusual state of the driver. In their work blink pattern and eye movements were observed and transformed a 2D to 3D image using wavelet analysis for making efficient edge detection which gives better result during image processing than stereo photogrammetry. (Nagajyothi & Geethu Mohan,2014) in their paper proposed drowsy driver detection system that uses eye OPEN or CLOSE state in a facial image to detect drowsiness by using Matlab coding given to Matlab driver .Then the signals are given to the relay that control the speed of car and ringing the alarm when eye get closed. Binarization and Eye detection, Drowsiness Detection Function were two important processes involved and prototype was development in this paper.

A close study during which key physiological parameters that relate to sleepiness are described and analyzed. With known key physiological parameters like EEG, ECG, EOG, ST, GSR, EMG were used to indicate the onset of drowsiness and he attempted to spotlight their

benefits and limitations from a sensible perspective.(Chowdhury. A et al., 2018) Many completely different detection strategies together in the aspect of being robust to sign loss. A simulation such as a real driving environment is created and a driver like simulator was employed to collect real data and artificial neural networks was used to analyze the real time data. Although the impact of the projected system on the advance of the detection accuracy wasn't outstanding in accuracy but results shows the reliability of the system had been increased exponentially. (Samiee. S et al, 2014)

Along with detecting drowsiness, the level at which drowsiness would be reached was also predicted in the proposed system. The proposed system was implemented and subjects were asked to drive in an induced drowsiness diving simulated environment. Two models using artificial neural networks were used where one is used to detect the degree of drowsiness per minute and the other ANN is used to predict the time required to reach a particular drowsiness level per minute (Charlotte Jacobé de Nauroiset al., 2019). A unique approach towards time temporary state detection that makes use of a deep learning methodology was proposed that was enforced on humanoid applications with high accuracy. The main contribution of their work is the compression of serious baseline model to a light-weight model. Moreover based on facial landmark key point detection a minimal network structure is designed to check the drowsiness level of the driver and they achieved an accuracy greater than 80%.(Jabbar, R et al., 2018)

A system that is capable to detect the drowsiness level through involuntary motion of driver provoked by the respiration captured by means of cameras. Kinect is a non-invasive image-based system used to measure breathing rate. Driving simulator is used to carry out the experiments and the data acquired from the video recorded is being processed to extract significant breathing patterns of both sleep and awake state.(Jose Solaz et al,2016).A system that makes use of EEG signals to detect the drowsiness along with the eye blink of the driver using ADS1299 is proposed which is a low power consumption model that is cost effective.(MuruganEzhumalai,Venkat Subramanian & Venkatraman Pitchaikannu,2015).A survey on all the existing drowsiness detection system and classified them as image processing, EEG based detection and Artificial neural network and their main focus on computer vision.(VrushaliB.Ghule&S.S.Katariya, 2015)

A prototype of drowsiness detection system using Haar algorithm and Viola jones algorithm. Camera that points directly towards the driver’s face and monitors the driver’s eyes in order to detect fatigue or drowsiness by self-developed image processing algorithm which gave information regarding drowsiness of drivers (Twinkal Parmar, Jaymin Bhalani & Dishant Shah, 2016).The drawbacks of using image processing such as low accurate system for drowsiness

detection were discussed and Electroencephalography (EEG) signals application can be implemented to find out whether the driver is drowsy in more proper and accurate way. The working of the project is that the brain sensor catches the brain signal of different frequency and these signals would be transferred to the computer with the help of the Wi-Fi connection to check the alertness level. Level splitter section (LSS) is used to analyze the level and gives the Drowsy driving alert and keeps the vehicle to be in self-controlled function until awakening state.(M. Murali, Varun Pathak & Manish Sen,2018)

An EEG based system where signals were recorded from 10 volunteers. After extracting some chaotic features like Higuchi's fractal dimension and Petrosian's fractal dimension ,the two-tailed t-test was done and evaluated by ANN and classification accuracy was about 83.3%.(Zahra Mardi, Seyedeh Naghmeh Miri Ashtiani & Mohammad Mikaili, 2011).A model with functional near-infrared spectroscopy (fNIRS) to differentiate the alert and drowsy states for a passive brain-computer interface (BCI). The prefrontal and dorsolateral prefrontal cortex were the regions from which the signal is extracted. Linear discriminant analysis (LDA) is employed for training and testing and best performance in classification is achieved using mean oxyhemoglobin, the signal peak, and the sum of peaks as features. (Jawad Khan. M & Keum-Shik Hong, 2015).

3. Existing System

There are few existing systems that are in use in the present world but they have their own practical limitations.

- PERCLOS Systems: The percentage of time the pupils of the eyes are 80% or more occluded over a specified time interval is measured.
- Head position metrics: Lot of innovations based Systems have been designed to detect the driver’s head position and when there is a change of head from its headrest position to a certain angle the system alerts the driver.
- Mean power frequency is the algorithm which uses EEG, ECG as parameters with least accuracy.
- Kalman filtering tracking is the algorithm which uses camera, Eyelid movement, gaze movement, head movement, head movement and facial expression with YAWN-82%, PERCLOS-86%, and AECS-95%.
- Thresholding, Mean Algorithm uses IR camera to filter visible light if the driver wears sunglasses.

- Fuzzy reasoning algorithm measures facial features of eyes, mouth and head as parameters. It only focused on detection rate for facial tracking and face tracking rate.
- Principal Component Analysis is the algorithm uses EEG as parameters and found training set-92.6% and testing test-74.6%.
- Dynamic Bayesian network uses EEG and ECG as parameters along with First-order Hidden Markov Model.
- Support Vector Machine is the algorithm which uses Eye movement, driving performance data and found Distraction detection of 81.1%.

All the above mentioned system suffers severe limitations like Installation of more number of sensors; Cost of implementing the environment is much costlier and inefficient use of speed of the processors for video streaming.

4. Proposed System

The main focus of this work is to develop an effective drowsiness detection system where the camera has to be positioned in such a way that it will accurately monitor the state of the driver's eyes in real-time along with their brain waves. It is believed that frequent closing of eyes is the first sign of drowsiness. It is believed that by monitoring the eyes one can detect drowsiness at an early stage to avoid accidents. Sequence of facial pictures observing eye movements and blink patters are used to detect fatigue. The neurosky kit which is being mounted on drivers head helps to capture the EEG signals of brain helping to estimate the alertness of the driver.The proposed system not only depends on the live streaming video noting every eye movement of the driver, it also employs processing of brain signals directly to check the alertness of the driver.

The proposed system as in Figure 1, works by determining how long a given person's eyes are closed. If their eyes are closed for an exact amount of some time, assume that they are obtaining all the way down to doze off associated alarm is played to wake them up and grab their attention. In the proposed system, the camera is placed such that it may be simple to sight a face and apply facial landmark localization algorithm (EAR algorithm) to locate the eyes correctly. EAR algorithm used to work with the ratio of distances between the vertical eye landmarks and additionally the distances between the horizontal eye landmarks and the formula is as follow

$$EAR = \frac{||p2-p6||+||p3-p5||}{2||p1-p4||} \quad (1)$$

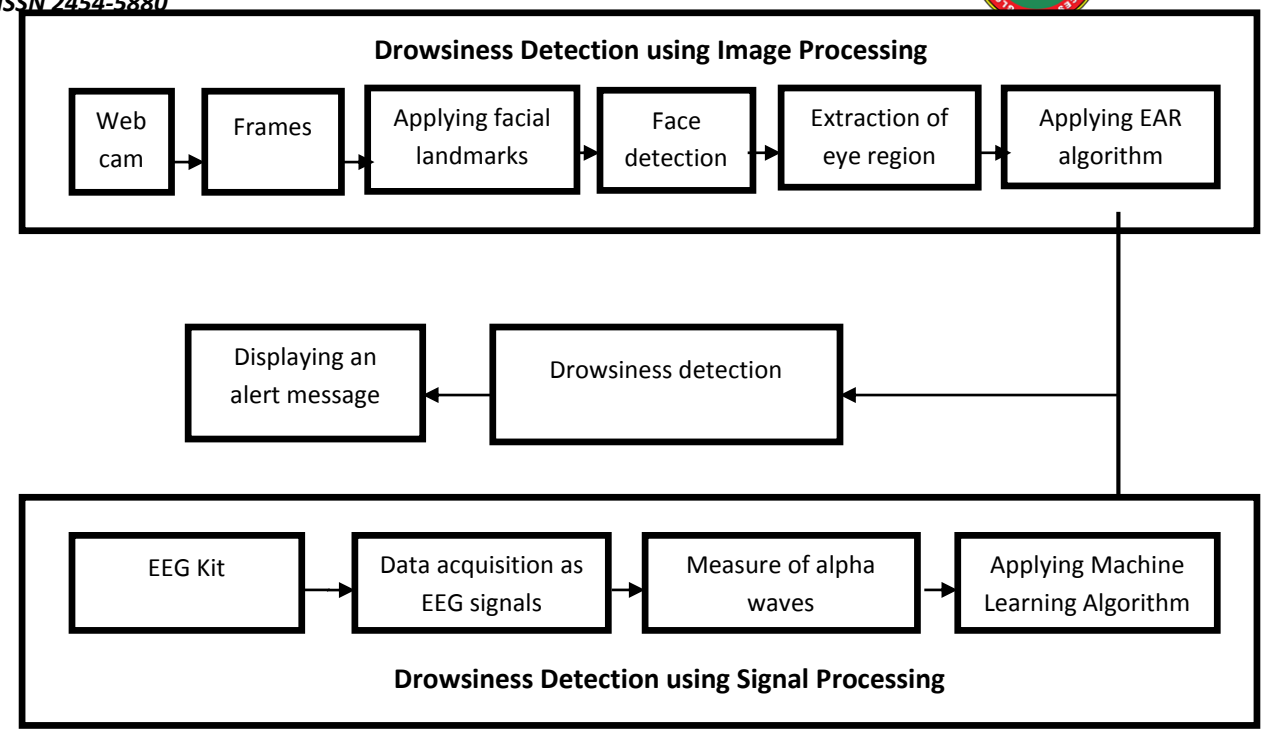

Figure 1: *Modular Diagram of Drowsiness Detection System*

The design consists of algorithm for drowsiness detection and the safe zone identification at the same time brain signal processing to check the mental alertness. In drowsiness detection, the eye co-ordinates are extracted from the face of the human using OPENCV module. Then the Eye Aspect Ratio (EAR) is calculated by using the vertical and horizontal distance of the eye edges. (Euclidean distance).Later the drowsiness of the person is found out by using the threshold level of the eye.

At times there are situations where the concentration of the driver reduces irrespective of their eye state which may lead to road accidents. Our image processing algorithm that uses eye movement as key parameter fails to address the scenario of loss of concentration. To handle that Brain Signal Processing is employed where the alert or relaxed state can be easily calculated based on the alpha and beta waves of the EEG signal. The non-invasive EEG signal capturing devices such as neurosky or emotive were used to record the brain signals in real time. These signals are processed and appropriate classification algorithm is applied to classify whether the driver is in alert state or relax state.

The step by step implementation of the proposed drowsiness detector algorithm works as follows:

4.1 Image Processing Module

- Fix the camera at right position to monitor the face of the driver as real time streaming.
- After detecting the face, facial landmark detection algorithm is applied and the attention regions are extracted.
- Calculate the eye ratio those value is used to identify whether the eyes are closed for a sufficiently long enough quantity of your time.
- The return value of the eye ratio are regarded constant when the eye is open.
- The value reduces to zero when there is a blink.
- If the eye is closed, the eye magnitude relation will yet again keep regarding constant, but are long smaller than the magnitude relation once the eye is open.
- In Figure 2, on the top-left is the image of the Eye facial landmarks plotting of a fully opened eye while the top-right gives the image of an eye that is closed. The bottom figure gives the plotting of the attention ratio over time.
- The eye ratio is constant (indicating the eye is open), then quickly drops to zero, then will increase once more, indicating a blink has taken place.

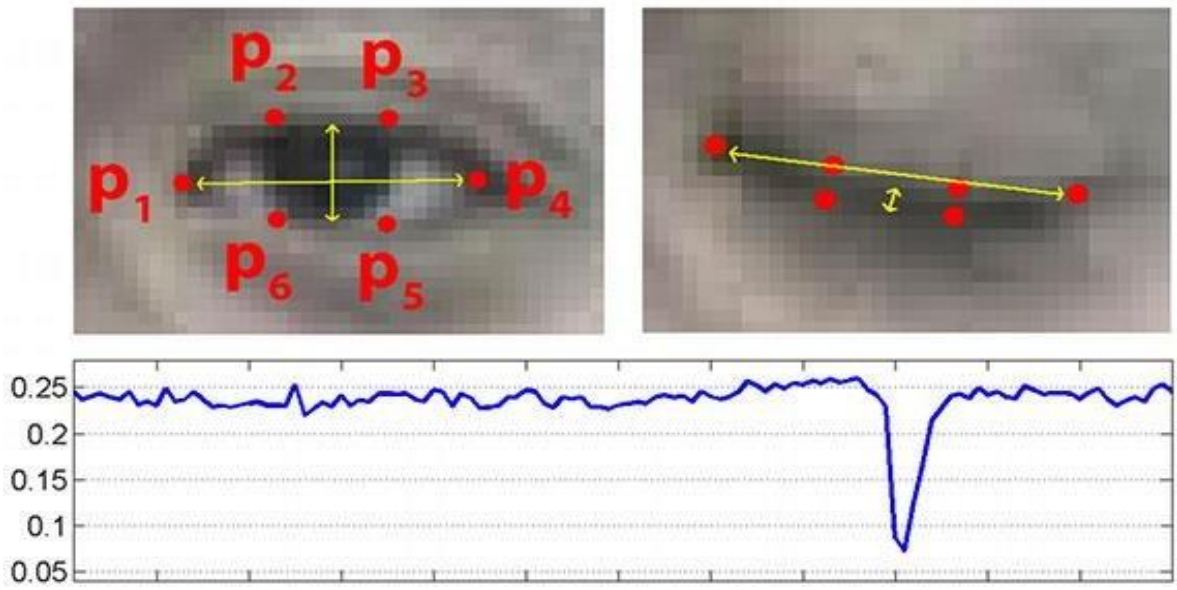

Figure 2: *Threshold Value Changes*

- The proposed drowsiness detector system will continuously monitor the eye aspect ratio to check whether the value falls and no increase for a threshold period of time. The sleepiness detector works and faithfully alerts using the sleepiness detector victimization module in python on every occasion once a driver is drowsy.

4.2 Signal Processing Module

- Fix the portable neurosky kit on drivers head while driving
- The data is collecting real time and EEGLAB module of MATLAB is used to preprocess the signals from the channels.
- An efficient random forest classification algorithm is applied on the preprocessed data and the alertness of the driver is calculated.

5. Implementation Results

Predictor is a generalized predefined dataset having all types of shapes (like objects such as apple, pen, facial landmarks etc.,). Facial landmark detection is a subset of this shape predictor superset. The dataset contains a series of numbers which represents the training values. These values are extracted and are written in xml sheet for training and testing of the machine, where each record gives a particular alignment of face and each field gives the position of part in 68 point landmark scheme.

The first series of number contains the image captured (in jpg format). First record contains the position of the face (top, left, right, bottom) located. In xml sheet, second record starts with the values having its first field as part name (eye brows, eyes, nose, mouth, jaw line etc.) starting with 00. Second field gives co-ordinates of the part (x, y) point). Third record contains the first field as part name with value 01 and second and third field as co-ordinates. Similarly 67 records are defines a particular alignment of the image. After 67 records a new record with different alignment of the face begins with different positional values (top, left, right, bottom). Next continuous 68 records define the parts and its position. This is done for 300 faces with different alignment. A specific case of object detection is Face recognition. In object-class detection, the task is to find the locations and sizes of all objects in an image that belong to a given class.

Our system is implemented successfully and it is trained well such that eyes is being detected in both light and darkness as in Figure 3 and Figure 4.

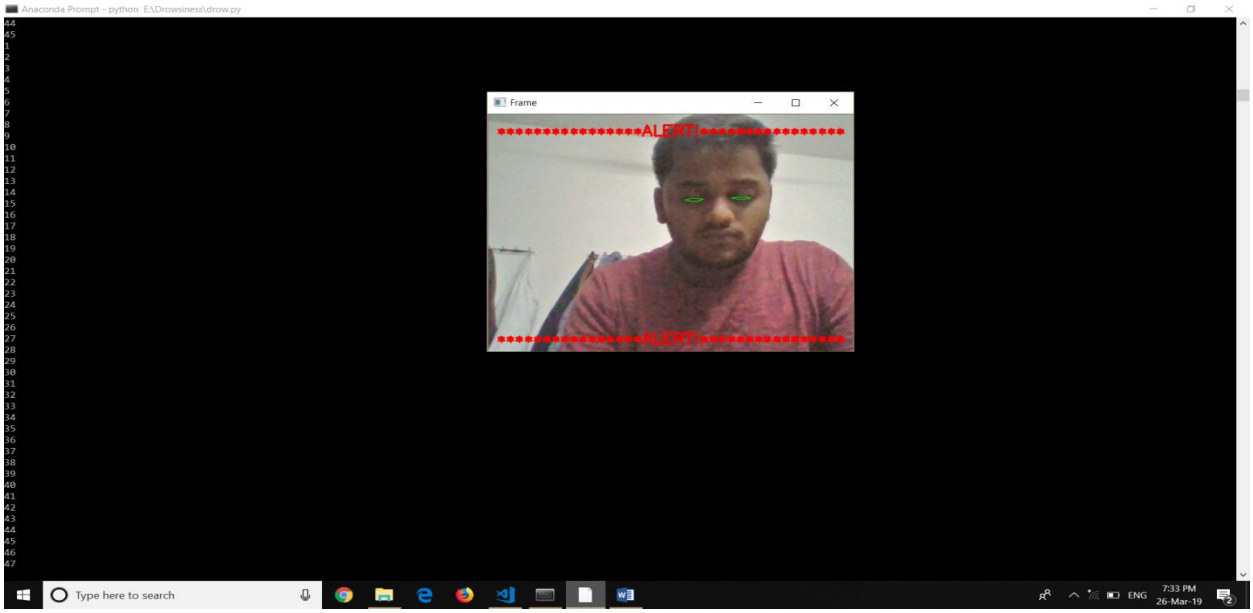

Figure 3: *Drowsiness Detected*

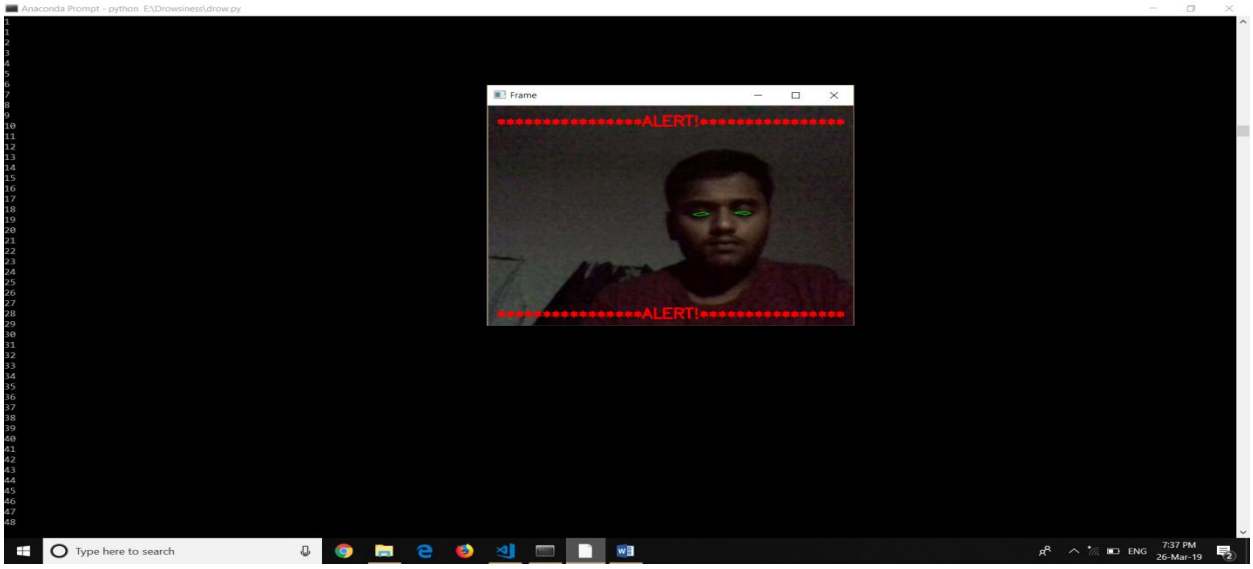

Figure 4: *Drowsiness Identified in Dark*

6. Conclusion

Drowsiness image processing detection module has two necessary vision techniques - Facial landmark detection and Eye ratio. Facial landmark prediction is that the strategy of localizing key facial structures on a face, along the eyes, eyebrows, nose, mouth, and jaw line. Eye ratio is employed to see whether or not the eyes are closed or not. If the eyes are closed for a sufficiently long enough amount of the time, the motive force is in danger of falling asleep and

Drowsiness signal processing detection module collects the EEG signals in real time and evaluates the alertness of the driver using the active alpha level of EEG waves. If the attention level in the alpha drops below the threshold level, then possibility of driver sleeping is more. Fusion of the result from both the module helps to accurately determine the drowsiness of driver, thus associating an alert message to grab the attention of driver. The proposed system is used to avoid various road accidents caused by drowsy driving and jointly this method used for security purpose of a driver. This system has a limitation of purchasing a non-invasive BCI kit and also wearing it throughout driving. In future, an affordable and handy EEG signal capturing device could be designed and used for detecting drivers drowsiness.

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