IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Vol. 12, Issue 3, March 2023

DOI: 10.17148/IJARCCE.2023.12337

Driver Drowsiness Detection Methods: A Comparative Study

Ms. Sayali Alex Dive[1], Mr. Gaurav Prashant Pande[2], Mr. Soumitra Yatin Sathe[3], Mr. Satyajit Sirsat[4]

B.E Student, Computer Engineering, Nutan Maharashtra Institute of Engineering & Technology, Pune, India[1-3]

Professor, Computer Engineering, Nutan Maharashtra Institute of Engineering & Technology, Pune, India[4]

Abstract: Driver drowsiness is a major concern in road safety, leading to numerous accidents and fatalities worldwide. Consequently, the development of accurate and reliable drowsiness detection systems is critical to enhance road safety. Recently, various machine learning (ML) algorithms have shown great potential in detecting drowsiness using various physiological and behavioral signals. Several fatal and non fatal injuries can be prevented if the drowsy drivers are warned in time. According to many recent surveys, around 21% of road accidents take place due to the driver's drowsiness.

Many of these collisions lead to loss of life, property or infrastructure; endangering not only the driver but also other individuals. The transport businesses that employ overnight driving have been seen to be at the highest risk. Driving during the night can lead to severe fatigue and drowsiness even when the driver is well-rested. As a result, many automobile industries have begun to take steps to implement driver drowsiness detection systems. Existing systems implemented by top car brands consist of the ECG machines holstered within the sides of the driver's seat. However, these have proved to be uncomfortable. Various Machine learning and deep learning models can be used to detect fatigue and drowsiness and potentially reduce the dependency on physical devices used in ECG.

Keywords: Drowsiness detection, Classification, Machine Learning, Deep Learning.

I. INTRODUCTION

In a world with growing technology it becomes incumbent to apply it whenever we can to prevent the loss of life and property. The automobile industry has been steadily growing in the past decades; the usage of automobiles is at the peak right now in an innovation obsessed world. As a result, road traffic and driving has also increased in scale. Thus, it becomes important to ensure proper driving etiquette to ensure safety of individuals.

Many recent surveys have concluded that one of the major reasons for gruesome road accidents is due to driver fatigue. Driver fatigue, in layman's terms, is defined as the state of tiredness of the driver while they are handling the driving process of the vehicle. Around 21% [1] of the accidents happen because the driver is in an unfit state of physical fitness while driving the vehicle.

The damage is even higher when HMV (Heavy Motor Vehicles) are involved. This case arises in respect to the trucking industry where goods are transported using trucks especially overnight. The night time causes even higher levels of fatigue among the driver, reports say. As a result, this is one of the areas where a driver drowsiness detection system is extremely important.

Below figure 1 depicts behavioral states with respect to drowsiness. Behavioral states with respect to drowsiness refer to observable changes in behavior and performance as a result of increasing levels of sleepiness or fatigue (i.e, intensity). These changes can include slower reaction times, decreased attention, decreased vigilance, and increased errors or accidents.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Vol. 12, Issue 3, March 2023

DOI: 10.17148/IJARCCE.2023.12337

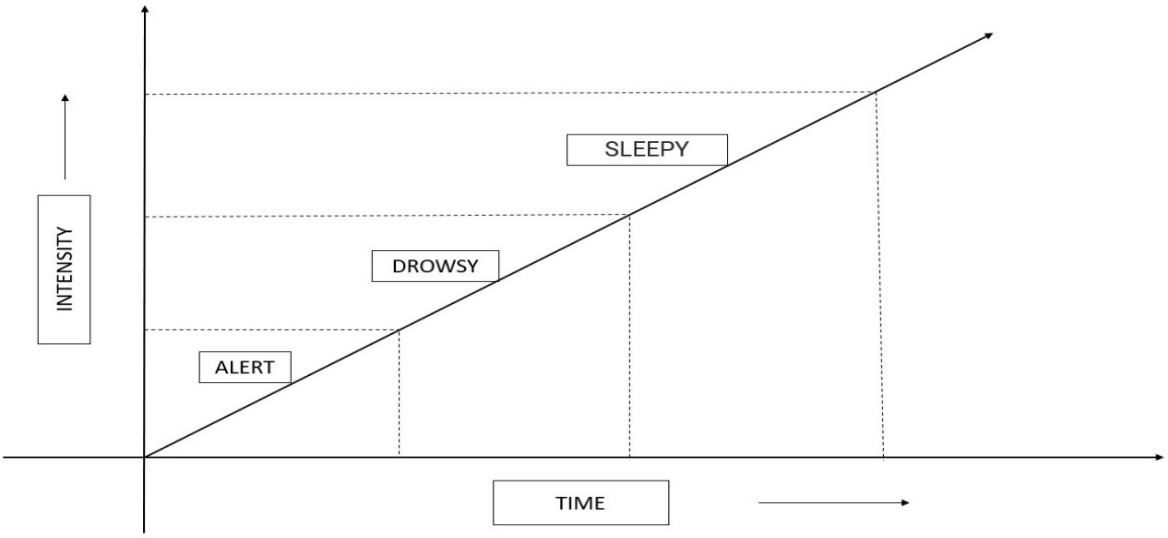

Fig. 1. Drowsiness level against time

The motivation thus lies in the prevention of the road accidents due to an evidently avoidable circumstance - driver fatigue. Thus, the proposed system endeavours to prevent such a loss by alerting the driver and creating an analysis report to help them determine when there is a requirement of a break from the tedious job of driving.

According to many reviews, a person is unable to drive for more than three hours without experiencing fatigue. Fatigue can refer to many problems including but not limited to Back pain, Muscle stretching, Cramps, Dead nerves and other physical pain that can arise due to sitting in the driver's seat for extended periods of time. The Driver is also supposed to hydrate from time to time which is neglected for long times too. There are other aspects such as psychological stress that can arise due to long period of driving.

The driver can also feel mentally drowned out due to long distance driving. They can feel distraction, headaches or other problems.

There have been many such motivated attempts to create a system which can prevent the gruesome road accidents usually happening through drowsy driving. The system has been designed similar to how we have breath analyser tests in order to prevent people from driving when they are drunk. In fact, in almost all countries it is a crime to drive while in a state of inebriation.

Drowsy driving has been called just as dangerous as drunk driving but it is not treated with the same jurisdiction. As a result, it becomes a person's moral duty to avoid driving in a state of total physical exhaustion. However, we must also take into account the drivers who have been hired for their services such as truck drivers. These workers are usually assigned to night driving which is twice as dangerous. Even for a well rested driver it is dangerous to drive at night,
This is because due to some physiological aspects of the human body we want to feel sleepy at night due to our body's biological clock. Thus a person feels even more sleepier at night.

We must therefore, implement similar systems in-order to protect ourselves from such inevitable conditions and circumstances.

II. DEFINING DROWSINESS

The term “drowsy” can be defined as a state of sleepiness wherein the subject begins to dose off due to fatigue or other factors. Often times a person can be classified as “asleep” when they are drowsy. “Sleep” is usually bifurcated into two stages: Rapid Eye Movement (REM) and Non-Rapid Eye Movement (NREM). [2] Drowsiness is mainly relegated to the NREM stage of sleep with its own types such as mild, moderate and severe fatigue. Other ways of defining the amount of drowsiness or sleepiness are standard scales such as Karolina Sleepiness Scale (KSS) [3] or the Epworth Sleepiness Scale. [4]

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Vol. 12, Issue 3, March 2023

DOI: 10.17148/IJARCCE.2023.12337

III. COMPARATIVE ANALYSIS

The detection of driver drowsiness or fatigue is incumbent to ensure road safety. In this section, we shall evaluate the effectiveness of each of the mentioned research methods. The methods are namely vehicle based, behavioural based and physiological based.

Vehicle based methods include Steering Wheel Movement (SWM) and Standard Deviation of Lane Position (SDLP) to detect the drowsiness of the driver [6]. Recent trends and the advancement of AI and ML technologies have resulted in the behavioural based methods being the most popular methods of driver fatigue detection. The methods decidedly give better overall accuracy as compared to the physiological methods.

Behavioral methods include the analysis of facial features by implementing various Machine Learning and Deep Learning based models. There is difference in the feature selection process of these methods as well. The features can include, but are not restricted to, the drivers eye, mouth and head posture. From here on, we can take combinations of any one or multiple features and various different ML and DL based models.

There are multiple concepts applied in this case such PERCLOS (Percentage of eye closure), FOM (Frequency of Mouth closure), EAR (Eye Aspect ratio), MAR (Mouth Aspect Ratio), ECR (Eye closure rate), MOR (Mouth Opening Rate), HNPR (Head non-positive face rate).

Table 1 Comparison between various approaches based on behavioral analysis [7]–[11]

Sr.No.	Feature selected	Classification model	Accuracy
1	PERCLOS, FOM	Artificial Neural Network (ANN), Support Vector Machine (SVM)	98.1
2	Head Posture	reLU-BiLSTM	97.3
3	ECR, MOR,HNPR	Multi-task cascaded convolutional neural network (MTCNN)	96.5
4	PERCLOS	multi block local binary patterns (MB- LBP) and Adaboost classifier	96
5	Eye Patterns	Random Forest, Support Vector Machine	94.4

Physiological methods include the analysis based on the observed Electromyography (EMG) and Electrocardiography (ECG), obtained in real-time. One study implemented the combination of ECG and Deep Learning methods to generate a 90% accuracy in detecting driver fatigue [12], while another implemented an amalgamation of ECG and EMG to generate a around 91% accuracy score [13].

We can evaluate that Behavioral methods have higher scores of accuracy as opposed to the physiological methods. However, the studies have possibly used isolated datasets.

Physiological methods include the analysis based on the observed Electromyography (EMG) and Electrocardiography (ECG), obtained in real-time. One study implemented the combination of ECG and Deep Learning methods to generate a 90% accuracy in detecting driver fatigue [12], while another implemented an amalgamation of ECG and EMG to generate a around 91% accuracy score [13].

We can evaluate that Behavioral methods have higher scores of accuracy as opposed to the physiological methods. However, the studies have possibly used isolated datasets

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Vol. 12, Issue 3, March 2023

DOI: 10.17148/IJARCCE.2023.12337

IV. RESEARCH METHODS

The main purpose of this comparative study paper is to recognize various techniques used to detect the driver drowsiness. This helps to know the key concepts in the concerned domain.

There are various methods to detect drowsiness:

1) Vehicle based method
2) Behavioral based method
3) Physiological based method

A. Vehicle based method

In this method, few sensors are mounted over the vehicle control system like steering wheel, brake and accelerator pedal as well as driver seat.

It use various sensors, such as pressure sensors, a capacitive sensors and more, to measure the driver movements as well as the behavior. The sensor for the steering wheel detects the grip of driver on it and change in lane of the vehicle, and the pedal sensors will detect the force applied by the foot of the driver on the pedals. The sensor in the driver's seat detects his/her posture and movements, such as slouching.

They collect data and send data to a control unit, which determine the level of drowsiness in driver. This system is a non-intrusive way to monitor the driver's behavior and detect drowsiness. However, this method is not useful when vehicle is out of control and become obsolete.

B. Behavioral based method

This is a innovative method to detect the drowsiness level of driver. This method uses combination of camera (to get the facial characteristics), sensors and machine learning algorithms to analyze the driver's behaviour.

The main characteristics of a drowsy human is frequent yawing, undulating tilting of head posture and eyelid closure of extended time period.

Head posture based systems are able to predict whether a person is dozing off during the head posture starts becoming crooked as the driver begins to fall asleep. So, in order to alert the driver the system first need too determine whether or not he is dozing off.

Facial based systems use facial characteristics, which are eye and mouth to analyze drowsiness. PERCLOS, i.e, percentage of eye closer is used to calculate the eye aspect ratio that determine eye lid closure

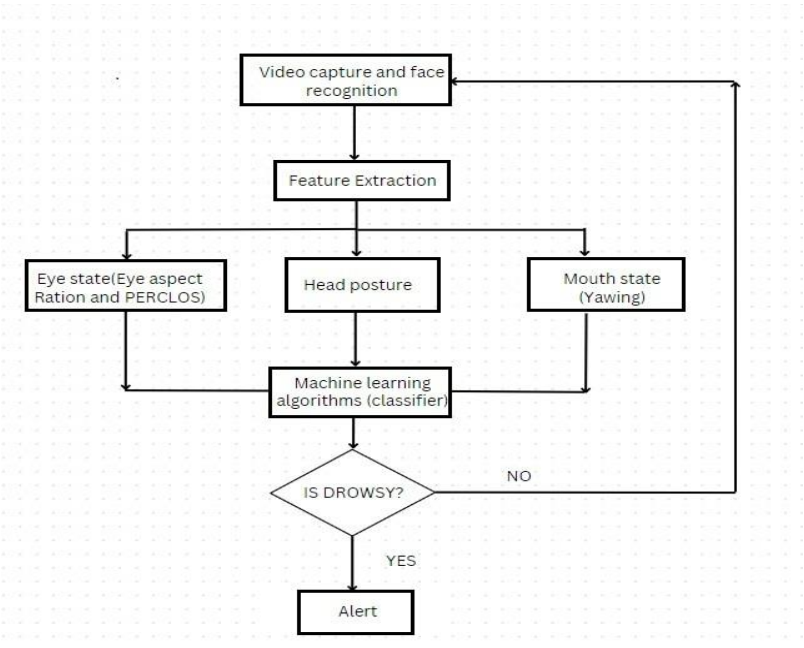

Fig. 2. Flowchart for drowsiness detection using behavioural methods

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Vol. 12, Issue 3, March 2023
DOI: 10.17148/IJARCCE.2023.12337

The above figure show an elaborate workflow to detect drowsiness by behavioral characteristics. These are:

Video capturing and face recognition: The face is captured in this step using a camera mounted in appropriate place. Frames are captured from the video at the required seconds. Face can be detected by haar cascade or library like Dlib. Feature extraction: The facial characteristics like mouth and eyes as well as head posture are captured in this step from the frames. Various machine learning algorithms like SVM, LBP, CNN are used to extract features from face.

These features are passed to a classifier (trained machine learning models) to detect drowsiness and give an alert. If driver is drowsy, it will give an alert and when no drowsiness is present it will start again from Video capturing and face recognition.

However, this method can be applied in ideal environments like enough lighting and no sunglasses which can block eye detection.

C. Physiological based method

Physiological methods for measuring drowsiness are another approach to detecting a drowsy driver. It uses sensors to measure various physiological signals, such as brain activity, heart rate, and skin conductance, to determine the driver level of drowsiness.

Most used physiological method used for measuring drowsiness is electroencephalography (EEG). EEG sensors are placed on the scalp to measure brain activity. It then provides insight into the driver's level of alertness. Another method is Electrocardiography (ECG) and measures the electrical activity of the heart and can detect changes in heart rate that can indicate fatigue. [5]

Skin conductance sensors are also used to detect changes in sweat gland activity, which can indicate drowsiness. Main disadvantage is, this method is complex to implement in real life due to involvement of various sensors

V. CONCLUSIONS

In conclusion, different drowsiness detection methods such as vehicle-based, behavioral-based, and physiological-based methods are discussed. Each method has its own advantages and limitations. Vehicle based methods are largely used in the automobile industry and can detect drowsiness based on vehicle operational data, but they might be not accurate enough to detect drowsiness due to dependency on road surface, type of vehicle and driving skills. Behavioral based methods depend upon the driving environment but are non intrusive and can be highly used with current technologies. Physiological based methods measure physical indicators such as brain activity and provide more accurate and objective data, but may be more intrusive due to the requirement of specialized equipment.

The method of drowsiness detection used depends on the individual research goals as well as practical factors like cost and equipment accessibility. Mixing various approaches could result in outcomes that are more thorough and precise. Further research is required to assess the efficacy of various approaches in diverse contexts and demographics as well as to create more dependable and useful drowsiness detection systems for practical use in the real world.

REFERENCES

[1] Du-Hou Li, Qun Liu, Wei Yuan, and Hao-Xue Liu. Relationship between fatigue driving and traffic accident. Journal of traffic and transportation engineering (Xi'an, Shaanxi), 10(2):104–109, 2010.
[2] David W Carley and Sarah S Farabi. Physiology of sleep. Diabetes spectrum: a publication of the American Diabetes Association, 29(1):5,2016.
[3] Azmeh Shahid, Kate Wilkinson, Shai Marcu, and Colin M Shapiro.Karolinska sleepiness scale (kss). STOP, THAT and one hundred other sleep scales, pages 209–210, 2012.
[4] Murray W Johns. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. sleep, 14(6):540–545, 1991.
[5] Rongrong Fu and Hong Wang. Detection of driving fatigue by using noncontact emg and ecg signals measurement system. International journal of neural systems, 24(03):1450006, 2014.
[6] Arun Sahayadhas, Kenneth Sundaraj, and Murugappan Murugappan. Detecting driver drowsiness based on sensors: a review. Sensors, 12(12):16937–16953, 2012.
[7] Burcu Kir Savas¸ and Yas¸ar Becerikli. Real time driver fatigue detection system based on multi-task connn. Ieee Access, 8:12491–12498, 2020.

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified ⁜ Impact Factor 8.102 ⁜ Vol. 12, Issue 3, March 2023
DOI: 10.17148/IJARCCE.2023.12337

[8] Shahzeb Ansari, Fazel Naghdy, Haiping Du, and Yasmeen Naz Pahnwar. Driver mental fatigue detection based on head posture using new mod-ified relu-bilstm deep neural network. IEEE Transactions on Intelligent Transportation Systems, 23(8):10957–10969, 2021.

[9] Huijie Jia, Zhongjun Xiao, and Peng Ji. Fatigue driving detection based on deep learning and multi-index fusion. IEEE Access, 9:147054–147062, 2021.

[10] Zhongmin Liu, Yuxi Peng, and Wenjin Hu. Driver fatigue detection based on deeply-learned facial expression representation. Journal of Visual Communication and Image Representation, 71:102723, 2020.

[11] Caio Bezerra Souto Maior, M´arcio Jos´e das Chagas Moura, Jo˜ao Mateus Marques Santana, and Isis Didier Lins. Real-time classification for autonomous drowsiness detection using eye aspect ratio. Expert Systems with Applications, 158:113505, 2020.

[12] Rahul Bhardwaj, Priya Natrajan, and Venkatesh Balasubramanian. Study to determine the effectiveness of deep learning classifiers for ecg based driver fatigue classification. In 2018 IEEE 13th international conference on industrial and information systems (ICIIS), pages 98–102. IEEE, 2018.

[13] Lin Wang, Hong Wang, and Xin Jiang. A new method to detect driver fatigue based on emg and ecg collected by portable non-contact sensors. Promet-Traffic&Transportation, 29(5):479–488, 2017.