**A**

**Project Synopsis Report**

**on**

# Real-Time Driver Drowsiness Monitoring System

Submitted

in Partial Fulfillment of the Requirements for

The Degree of

Bachelor of Technology

in

Computer Science and Engineering

Submitted by


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INSTITUTE OF TECHNOLOGY AND MANAGEMENT

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AKTU College Code-054


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# CERTIFICATE

This is to certify that the project entitled “Real-Time Driver Drowsiness Monitoring System” submitted by “Pradeep Kumar” (2000540100110) , “Raj Chaudhary” (2000540100120) , “Rajat Gupta” (2000540100123) , “Rajan Tiwari” (2000540100122) to Babu Banarasi Das Institute of Technology & Management, Lucknow, in partial fulfillment for the award of the degree of B. Tech in Computer Science and Engineering is a bonafide record of project work carried out by him/her under my/our supervision. The contents of this report, in full or in parts, have not been submitted to any other Institution or University for the award of any degree.

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# DECLARATION

We declare that this project report titled **Real-Time Driver Drowsiness System** submitted in partial fulfillment of the degree of **B. Tech in Computer Science and Engineering** is a record of original work carried out by me under the supervision of **Mr. Gyanendra Dixit** and has not formed the basis for the award of any other degree or diploma, in this or any other Institution or University. In keeping with the ethical practice in reporting scientific information, due acknowledgements have been made wherever the findings of others have been cited.

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# ABSTRACT

Nowadays, accidents occur during drowsy road trips and increase day by day; It is a known fact that many accidents occur due to driver fatigue and sometimes inattention, this research is primarily devoted to maximizing efforts to identify drowsiness. State of the driver under real driving conditions. The aim of driver drowsiness detection systems is to try to reduce these traffic accidents. The secondary data collected focuses on previous research on systems for detecting drowsiness and several methods have been used to detect drowsiness or inattentive driving. Our goal is to provide an interface where the program can automatically detect the driver's drowsiness and detect it in the event of an accident by using the image of a person captured by the webcam and examining how this information can be used to improve driving safety can be used. A vehicle safety project that helps prevent accidents caused by the driver's sleep. Basically, you're collecting a human image from the webcam and exploring how that information could be used to improve driving safety. Collect images from the live webcam stream and apply machine learning algorithm to the image and recognize the drowsy driver or not. When the driver is sleepy, it plays the buzzer alarm and increases the buzzer sound. If the driver doesn't wake up, they'll send a text message and email to their family members about their situation.

# 1.INTRODUCTION

*"Accidents happen, but it's how we respond and learn from them that truly matters*."

Many road accidents which lead to death are because of drowsiness while driving. Drivers who drive long hours like truck drivers, bus drivers are likely to experience this problem. It is highly risky to drive with lack of sleep and driving for long hours will be more tiresome. Due to the drowsiness of the driver causes very dangerous consequences, it is estimated that 70,000 to 80,000 injures & crashes happen worldwide in a year. Even deaths have reached 1000-2000 every year. There are many unofficial deaths which are not confirmed by drivers that it was due to their drowsiness. This takes lives of many innocent people. It is a nightmare for a lot of people who travel across world. It is very important to identify the driver drowsiness and alert the driver to prevent crash.

The goal of this project is the detection of the indication of this fatigue of the driver. The acquisition system, processing system and warning system are the three blocks that are present in the detection system. The video of the driver's front face is captured by the acquisition system and it is transferred to the next stage i.e., processing block. The detection is processed online and if drowsiness of driver is detected, then the warning system gives a warning or alarm.

The methods to detect the drowsiness of the drive may be done using intrusive or nonintrusive method i.e. without the use of sensors connected to the driver. Addition of more parameters can increase the accuracy of the system to some extent. The motivation for the development of cost effective, and real-time driver drowsiness system with acceptable accuracy are the motivational factors of this work. Hence, the proposed system detects the fatigue of the driver from the facial images, and image processing technology and machine learning method are used to achieve a cost effective and portable system.

For this work, our premise is the following: a camera mounted on a vehicle will record frontal images of the driver, which will be analyzed by using artificial intelligence (AI) techniques, such as deep learning, to detect whether the driver is drowsy or not. By using that information, the system will be able to alert the driver and prevent accidents. Given that the

ADAS (Advanced Driver Assistance Systems) will have different functionalities integrated, one of the restrictions imposed to the module presented in this work will be to avoid the activation of false alarms that may distract the driver and cause him or her to turn off the ADAS.

Thus, the main novelty of this work is the use of a non-intrusive system that is capable of detecting fatigue from sequences of images, which at the moment is an open problem. In most of the available works, the experimental methodology consists of extracting and classifying individual frames from each video and verifying whether the classification is correct or not, but that approach does not consider the intrinsic relationship between consecutive images, and their measures of false positives are less reliable. Currently, there are few works that test the systems on complete videos and count the number of alarms emitted during each video (which is necessary when evaluating the number of false alarms raised during a period of time). Therefore, the proposals presented in this paper can be considered a starting point for the design of such systems.

Deep learning algorithms are characterized by the use of neural networks whose models are built of massive amounts of layers, and they have the ability to automatize the feature extraction process. Among deep learning algorithms, there is a specific type of deep neural networks (DNNs) called convolutional neural networks (CNNs), which have great performance on computer vision because they are able to find patterns and recognize characteristics among images.

**Keywords**: Driver Drowsiness Monitoring  System, Machine Learning, CNN and AI.

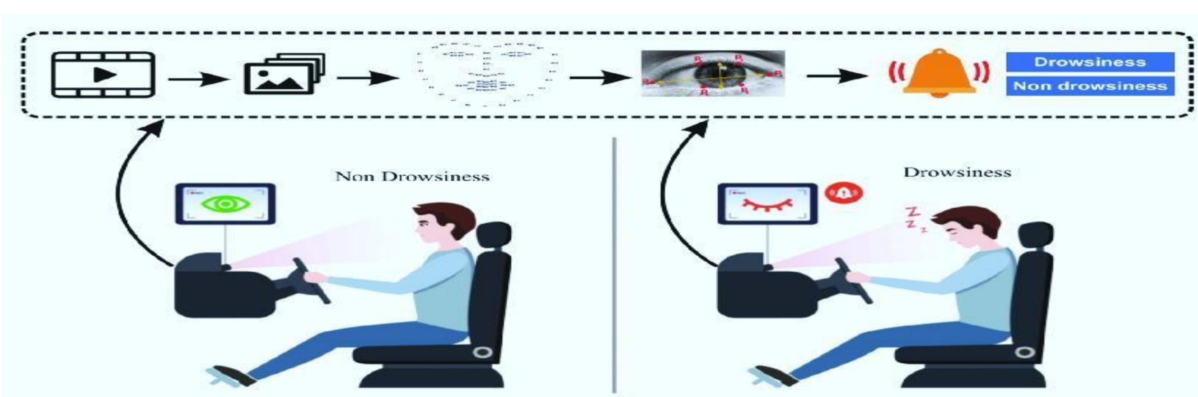


Fig 1.1. General Model of Driver Drowsiness Monitoring System

# 2.LITERATURE REVIEW

**Knapik and Cyganek(2022)** presented a novel approach for driver fatigue detection, based on yawning detection, using long-range infrared thermal imaging . A special dataset was created for this research . The system works as follows. First, images are acquired from a thermal video. Then, three cascaded detection modules are applied for the face area, eye corners, and yawn. Since the mouth area is sometimes hard to detect in thermal images, due to the temperature difference in that area, information about other face regions' relative temperatures is used to detect the yawn reflex. Thus, the authors used the eye corners as an indicator for yawning. Cold and hot thermal voxel sum methods were used to detect yawning . Finally, based on the proposed algorithm's results and assumed constraints, an alarm is initiated when fatigue is detected. The system showed accuracies of 71% for cold voxels detection and 87% for hot voxels detection.

**Kiashari et al.(2022)** introduced a non-intrusive system that detects drowsiness using facial thermal imaging to analyse the driver's respiration signal. Thirty subjects participated in their study, which was conducted in a car simulator. A thermal camera was used to capture the driver's thermal images. From the obtained thermal signals, the standard deviation and mean of both the respiration rate and inspiration-to-expiration time ratio were calculated and used as input features, in order to train two machine learning classifiers, namely, support vector machine (SVM) and k-nearest neighbour (KNN). Both classifiers were able to detect drowsiness. However, SVM outperformed the KNN, with 90% accuracy, 85% specificity, 92% sensitivity, and 91% precision.

**Khan et al.(2022)** proposed a real-time DDD system based on eyelid closure. The system was implemented on hardware that used surveillance videos to detect whether the drivers' eyes were open or closed. The system started by detecting the face of the driver. Then, using an extended Sobel operator, the eyes were localized and filtered to detect the eyelids' curvature. After that, the curvature's concavity was measured. Based on the measured concavity value, the eyelid was classified as open (concave up) or closed (concave down). If the eyes were deemed closed for a certain period, a sound alarm is initiated. The system used three datasets. The authors generated two of them, and the third was acquired from. The first dataset, which contained simple images, with a homogenous background, showed an accuracy of 95%. The second set, which included a complex benchmark image dataset, achieved an accuracy of 70%; the third one, which used two real-time surveillance videos, showed an accuracy that exceeded 95%.

**Maior et al.(2022)** developed a drowsiness detection method based on eye patterns monitored by video streams using a simple web camera. The method tracks the blinking duration using the EAR metric. The proportion between the eye's height and width is calculated to evaluate the EAR value. A high EAR value indicates that the eye is open, while a low value indicates that it is closed. The proposed method consists of three main parts: eye detection, EAR calculation and blink classification, and real-time drowsiness detection. An experiment was conducted to generate a training database. After obtaining the images from the web camera, the EAR values were calculated and stored for each frame. Then, a specific number of consecutive values were used as input for the machine learning algorithms. Drowsiness is detected if the blink duration is longer, compared to a standard blink. Three classification methods were employed: multilayer perceptron, random forest (RF), and SVM. Overall, SVM showed the best performance, with an average test accuracy of 94.9%.

**Hashemi et al.(2021)** proposed a real-time DDD system based on the area of eye closure and use of the convolutional neural network (CNN) . Three networks were introduced for eye closure classification: fully designed neural network (FD-NN), transfer learning in VGG16 (TL-VGG16), and transfer learning in VGG19 (TL-VGG19), with extra designed layers. The authors used the ZJU gallery dataset, in addition to 4157 new images. The experiment resulted in the following network accuracies: 98.15%, 95.45%, and 95%, respectively.

**Zandi et al. (2021)** proposed a non-intrusive drowsiness detection ML system based on eye-tracking data. The experiments were conducted in a simulated driving environment, with 53 participants. The authors collected data for eye-tracking signals and multichannel electroencephalography signals. The electroencephalography signal was only used as a reliable baseline for comparison and to label the eye-tracking signals epochs as drowsy or alert. The proposed ML system extracted 34 eye-tracking signals' features, obtained from overlapping eye signals' epochs with different lengths. The system performance, subject to various combinations of different features and epoch lengths, was also studied. Two binary classifiers were used: the RF classifier with 200 trees and non-linear SVM with a Gaussian kernel classifier. The experiment results revealed that the RF classifiers resulted in an accuracy range of 88.37% to 91.18% across all epochs, as well as a sensitivity–specificity of 88.1% to 88.8% for a 10-s epoch. In contrast, the non-linear SVM classifier showed an accuracy range of 77.12% to 82.62%. Additionally, it resulted in a sensitivity–specificity of 79.1% to 80.8% for a 10-s epoch. Using eye-tracking data and a proper classification framework, such results confirmed that drowsiness could be reliably detected with high accuracy, specificity, and sensitivity.

**Celecia et al. (2021)** proposed a low-cost, portable, robust, and accurate DDD device that used an infrared illuminator and camera to record images. The device's processing model, which was performed over a Raspberry Pi 3 Model B, combines features obtained from the eyes and mouths of the subjects under consideration. The features include PERCLOS, eye closing duration, and average mouth opening time. The 300-W dataset was used in the training process. The authors determined the state of each feature through a cascade of regression tree algorithms. A Mamdani fuzzy inference system then estimated the driver state by combing the three features' states as an input. The device generates a final output that represents the drowsiness level by giving a label of either "Low-Normal", "Medium-Drowsy", or "High-Severe state." According to Celecia et al., using various drowsiness measures overcomes the issues of partly losing some of them in the image. Thus, the study resulted in a DDD device, robust to different ambient lighting conditions, with 95.5% accuracy.

**Alioua et al.(2021)** proposed a non-intrusive and robust system that detects drowsiness in real-time to reduce traffic accidents. The system detects drowsiness based on a closed-eyes and open-mouth detection algorithm. In this work, a group of images was collected using a webcam. According to the authors, the system starts with an SVM face detector to extract the face region from the video frames. Then, the eye and mouth regions localization within the face is performed. Finally, the circular Hough transform is applied to the extracted eye to find the iris, a colored muscular curtain close to the front of the eye, as an indication of eye openness. Additionally, it is used over the mouth region to determine the degree of mouth openness. Based on the fusion of the state of the eye and the mouth, the system decides whether the driver is drowsy or not. The results showed that this system is robust, with 94% accuracy and 86% kappa statistic value.

**Khunpisuth et al.(2019)** conducted a study with ten volunteers. During the study, the frequency of eyes blinking and head tilting was monitored and related to the drivers' drowsiness state. The authors built an embedded device for drowsiness detection that used a Raspberry Pi Camera and Raspberry Pi 3 Model B to collect image data, detect the drowsiness level, and alert the driver. Initially, the proposed device applied the Haar cascade classifier to detect an upright face, head level, and eye blinking. Moreover, if the head position is not upright, geometric rotation is used to calculate the angle and rotate the image to an upright position, in order to detect accurately. Secondly, template matching is used to detect whether the eyes are open or closed. Thirdly, the drowsiness level is calculated via the frequency of head tilting and eye blinking. The system uses a scale of 0–100 to describe the severity of the drowsiness. If the drowsiness level reaches 100, the system triggers a loud, audible warning to alert the driver. Finally, the accuracy system gave an accuracy of 99.59%. However, this system had some limitations, as it is affected by the subject's skin tone and background light.

**Deng and Wu.(2019)** proposed DriCare, a real-time DDD system. This system detects the drowsiness status using images from video streams. The authors introduced an enhanced in-video face-tracking algorithm, called multiple CNNs-kernelized correlation filters. Further, they used 68 key points in the driver's face to locate key regions, including the eyes and mouth. The authors then calculated the number of closed-eye frames to the total number of frames, continuous-time of eye closure, blinking frequency, and number of yawns in a minute to detect the driver's drowsiness. Finally, the DriCare system alerts the driver, using some warning, if found drowsy. The system was tested on CelebA , YawDD datasets, and other videos obtained by the authors. Overall, the system showed an accuracy of around 92%.

## 2.2 Comparative study( Of Different Papers by using Table)-

| S. No. | Title | Author | Publication | Methodology | Year |
|---|---|---|---|---|---|
| 1. | Deep-Learning Method to Predicting Traffic Accidents Due to Drowse | Shivam Singh, Shreya Bansal, Anjum Parvez | 2022 International Conference on Cyber Resilience (ICCR), | • Data Preprocessing<br>• Feature Engineering<br>• Hyperparameter Tuning | 2022 |
| 2. | Prevention from Road Accidents by Detecting Driver Drowsiness | S Priyadarshini | Recent Trends in Information Technology and its Application 5 (2), | • Perform data cleaning to remove noise, outliers, and artifacts.<br>• Annotation and Labeling<br>• Continuous Monitoring and Feedback | 2022 |
| 3. | Development of a Driver Safety Monitoring Device with Ignition Interlock. | Joseph Kayode, Kevin J Agim, Omolayo M Ikumapayi, Adeyinka OM Adeoye | International Journal of Safety & Security Engineering 12 (6), | • Requirements Analysis<br>• Build prototypes for field testing | 2022 |
| 4. | Arduino based real time drowsiness and fatigue detection for bikers using helmet | M Oviyaa, P Renvitha, R Swathika, I Joe Louis Paul, S Sasirekha | 2nd International Conference on Innovative Mechanisms for Industry Applications (ICIMIA) | • Choose appropriate sensors (e.g., cameras, alcohol sensors)<br>• Monitoring and Maintenance | 2022 |

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|---|---|---|---|---|---|
| 5. | Real time ‘driver drowsiness’& monitoring & detection techniques | Divyanshu Tyagi, Drishti Sharma, Rishabh Singh, Kaushal Kishor | International journal of Innovative Technology And Exploring Engineering | • Real Time Data Processing<br>• Alert Mechanism<br>• Integration and Vehicle System | 2022 |
| 6. | Mobile Application on Drowsiness Detection When Driving Car | Akshat Singhal, Sunil Kumar | VLSI, Microwave and Wireless Technologies: Select Proceedings of ICVMWT | • Identify the target audience and their specific needs<br>• Drowsiness Detection Algorithm Development | 2022 |
| 7. | Driver drowsiness detection and tracking based on YOLO with Haar cascades and ERNN | Belmekki Ghizlene Amira, Mekkakia Maaza Zoulikha, Pomares Hector | International Journal of Safety and Security Engineering | • Train a YOLO model on the dataset to detect objects.<br>• Design an alert system that can notify the driver in case of detected drowsiness. | 2021 |
| 8. | Driver drowsiness monitoring system using visual behavior and machine learning | M.Aishwarya, Sampuram Salini, P.Deepthi, V. Anantha Krishna | International journal of creative research thoughts | • Legal and Ethical Considerations<br>• Testing and Validation in Real-World Scenarios | 2021 |
| 9. | Research on a real-time driver fatigue detection algorithm based on facial video sequences | Tianjun Zhu, Chuang Zhang, Tunglung Wu, Zhuang Ouyang, Houzhi Li, Xiaoxiang Na, Jianguo Liang, Weihao Li | International journal of Applied Science | • Model Training and Validation<br>• Comparison with Existing Methods | 2021 |

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|---|---|---|---|---|---|
| 10. | IoT-based smart alert system for drowsy driver detection | Anil Kumar Biswal, Debabrata Singh,Pattanayak, Debabrata Samanta, Ming-Hour Yang | Wireless communications and mobile computing | • Testing in Controlled Environments<br>• Legal and Ethical Considerations | 2021 |
| 11 | Drowsy driver detection using eye-tracking through machine learning | S Akshay, MB Abhishe D Sudhanshu, C Anuvaishnav | Second International Conference on Electronics and Sustainable Communication Systems (ICESC), | • Peer Review and Publication<br>• Testing and Validation in Controlled Environments | 2021 |
| 12 | Smart driver monitoring system. | Shubhi Shaily, Srikaran Krishnan, Saisriram Natarajan, Sasikumar Periyasamy | Multimedia Tools and Applications. | • Selecting Sensors and Hardware<br>• Implement a system for remote monitoring and reporting | 2021 |
| 13 | Application of IoT and Machine Learning for Real-time Driver Monitoring and Assisting Device | Pranay Sharma, Naveksha Sood | 11th International Conference on Computing, Communication and Networking Technologies (ICCCNT) | • Integrate sensors into the vehicle's interior<br>• Extract relevant features from the collected data | 2020 |
| 14 | Deep Learning based Drowsiness Detection and Monitoring using Behavioral Approach | P William, Mohd Shamim, Ajay Reddy Yeruva, Durgaprasad Gangodkar, Swati Vashisht, Amarendranath Choudhury | 2nd International Conference on Technological Advancements in Computational Sciences (ICTACS) | • Split the dataset into training, validation, and test sets<br>• Document the research methodology, algorithm design, experiments, and results. | 2022 |

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|---|---|---|---|---|---|
| 15. | Low-cost real-time driver drowsiness detection based on convergence of images and signals | Kwang-Ju Kim, Kil-Taek Lim, Jang woon Baek, Miyoung Shin | international conference on artificial intelligence in information and communication (ICAIIC), | • Gather data from the integrated sensors in real-time.<br>• Ensure compliance with legal and privacy regulations. | 2021 |
| 16 | Real Time Eye Monitoring System Using CNN for Drowsiness and Attentiveness System | Rahul Pai, Avinash Dubey, Nikhita Mangaonkar | Asian Conference on Innovation in Technology (ASIANCON), | • Design and implement the CNN model for analyzing the eye images<br>• working with sensitive data like eye images. | 2021 |
| 17 | Deep learning based approach for real-time driver drowsiness detection | Amit Raha Niloy, Nusrat Sharmin | 5th International Conference on Electrical Engineering and Information Communication Technology (ICEEICT), | • Split the dataset into training, validation, and test sets<br>• Implement a mechanism to process incoming facial data in real-time. | 2021 |
| 18 | Real-time detection for drowsy driving via acoustic sensing on smartphones | Yadong Xie, Fan Li, Yue Wu, Song Yang, Yu Wang | IEEE Transactions on Mobile Computing | • Lean and preprocess the audio data to remove noise. | 2020 |
| 19 | Drowsy driver detection using eye-tracking through machine learning | S Akshay, MB Abhishek, D Sudhanshu, C Anuvaishnav | Second International Conference on Electronics and Sustainable Communication Systems | • Split the dataset into training, validation, and test sets<br>• Comparison with Existing Methods | 2021 |
| 20 | Real-time detection for drowsy driving via acoustic sensing on smartphones | Yadong Xie, Fan Li, Yue Wu, Song Yang, Yu Wang | IEEE Transactions on Mobile Computing | • Implement a mechanism to process incoming audio data in real-time.<br>• Consider ethical implications, including privacy and data protection | 2020 |

# 3.Research Gap

Significant research gap in the realm of real-time driver drowsiness monitoring systems using deep learning and Convolutional Neural Networks (CNN) is the scarcity of comprehensive studies that combine the power of deep learning techniques with CNN specifically tailored for detecting drowsiness under various driving conditions and environments. While existing research has made progress in this area, there is still a lack of robust and adaptable models that can consistently and accurately identify drowsiness in real-time, especially in scenarios with challenging lighting conditions, diverse driver demographics, and the integration of novel sensors and data sources. Furthermore, these systems often lack real-world validation, and there is a need for more studies that rigorously assess their performance in practical driving scenarios to ensure their reliability and effectiveness in enhancing road safety. Addressing this research gap is crucial to advancing the development of more effective and reliable driver drowsiness monitoring systems that can mitigate the risks associated with fatigued or drowsy driving.

Furthermore, research should explore the development of user interfaces and feedback mechanisms that not only detect drowsiness but also effectively communicate alerts to drivers without causing distraction or alarm. Balancing effective drowsiness detection with driver comfort and trust in the technology is a challenge that has not yet been comprehensively addressed. Thus, an interdisciplinary approach is needed to bridge these research gaps, incorporating fields like computer science, ethics, law, and human-computer interaction to create holistic, effective, and ethically sound real-time driver drowsiness monitoring systems that can make meaningful contributions to road safety.

# 4.PROPOSED WORK

## 4.1 Problem Statement

In recent years, the prevalence of road accidents attributed to driver drowsiness has become a critical concern for public safety. Drowsy driving significantly impairs a driver's cognitive abilities and reaction time, increasing the risk of accidents, injuries, and fatalities on the road. Existing methods for detecting drowsy driving often lack real-time capabilities or rely on intrusive measures.

Hence, there is a pressing need for the development of an efficient and non- intrusive real-time driver drowsiness monitoring system. This system should employ advanced technologies, such as computer vision, machine learning, and sensor fusion, to accurately assess a driver's level of alertness. It should be capable of detecting subtle signs of drowsiness, including eye closure duration, head nods,and other behavioral indicators.

The proposed system must operate in real-time, continuously analyzing data streams from multiple sources, including video feeds, physiological sensors, and audio cues. It should be able to provide timely alerts to the driver, ensuring immediate corrective action is taken to prevent accidents.

Overall, the objective of this project is to design and implement a robust real-time driver drowsiness monitoring system that significantly reduces the risk of accidents caused by drowsy driving, thereby enhancing road safety and saving lives.

## 4.2 Proposed Approach

The proposed approach for the real-time driver drowsiness monitoring system encompasses a multi-modal framework that integrates computer vision, machine learning, and sensor fusion techniques. This system will leverage a front-facing camera for facial analysis, an infra-red camera for eye-tracking in low light conditions, and an accelerometer to detect subtle head movements. Through careful data preprocessing, including noise reduction and image stabilization, we aim to enhance the quality of the acquired data. Advanced computer vision algorithms will be deployed to accurately detect facial landmarks and track eye movements, enabling measurements of key indicators like eye closure duration, blink frequency, and gaze direction. The amalgamation of these features will form the basis for training a machine learning model, potentially a combination of convolutional neural networks (CNNs) and recurrent neural networks (RNNs), to analyze and recognize drowsiness patterns in real-time. An alert system will be designed to promptly notify the driver upon detection of drowsiness, using a combination of visual alerts on the dashboard, auditory signals, and haptic feedback. To further enhance system adaptability, adaptive thresholds will be implemented based on factors like time of day, driving conditions, and individual driver characteristics. Rigorous real-world testing and validation, including controlled and uncontrolled driving scenarios, will be conducted to ensure the system's accuracy and responsiveness

Components:

**4.2.1Machine learning**:

Machine learning is the kind of programming which gives computers the capability to automatically learn from data without being explicitly programmed. This means in other words that these programs change their behaviour by learning from data.

Python is clearly one of the best languages for machine learning. Python does contain special libraries for machine learning namely SciPy, pandas and NumPy which great for linear algebra and getting to know kernel methods of machine learning. The language is great to use when working with machine learning algorithms and has easy syntax relatively.

Machine learning categories are:-

### 4.2.2 Supervised learning:

The machine learning program is both given the input data and the corresponding labelling. This means that the learn data has to be labelled by a human being beforehand.

### 4.2.3 Unsupervised learning

No labels are provided to the learning algorithm. The algorithm has to figure out a clustering of the input data.

### 4.2.4 OpenCV:

OpenCV stands for Open Source Computer Vision. It's an Open Source BSD licensed library that includes hundreds of advanced Computer Vision algorithms that are optimized to use hardware acceleration. OpenCV is commonly used for machine learning, image processing, image manipulation, and much more. OpenCV has a modular structure. There are shared and static libraries and a CV Namespace.

In short, OpenCV is used in our application to easily load bitmap files that contain landscaping pictures and perform a blend operation between two pictures so that one picture can be seen in the background of another picture. This image manipulation is easily performed in a few lines of code using OpenCV versus other methods. OpenCV.org is a must if you want to explore and dive deeper into image processing and machine learning in general.

### 4.2.5 TensorFlow:

TensorFlow is an open-source machine learning framework developed by the Google Brain team. It provides a comprehensive set of tools and libraries for building and training various machine learning models, particularly deep learning models. TensorFlow is designed to allow for efficient computation and execution of complex mathematical operations, making it particularly well-suited for tasks like training neural networks.

TensorFlow is widely used in both research and industry for a variety of machine learning tasks, including image and speech recognition, natural language processing, reinforcement learning, and more. It has played a significant role in advancing the field of deep learning and has been instrumental in the development of many state-of-the-art models and applications.

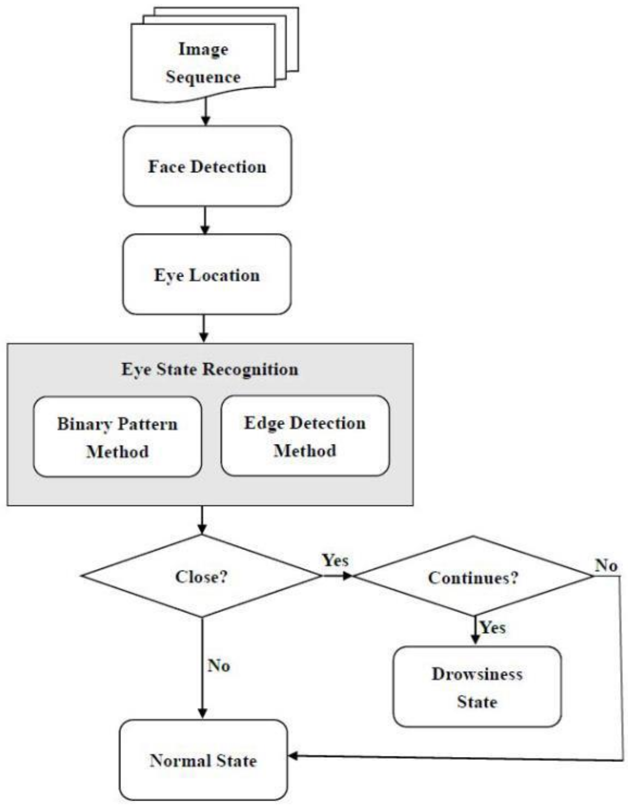



Fig.4.2 Data Flow Diagram for Driver Drowsiness Monitoring System

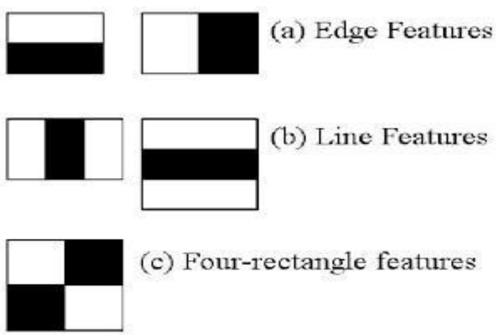
**Algorithm:**

1. Image sequence input to camera.
2. Face detection
3. Locating eyes
4. Eye state recognition using Binary pattern method and Edge detection method.
5. If eyes are closed and continues to be closed for predefine threshold, Drowsiness state is detected
6. Else normal state
7. Repeat the process

### 4.2.6 Face Detection:

Object Detection using Haar feature-based cascade classifiers is an effective object detection method proposed by Paul Viola and Michael Jones in their paper, "Rapid Object Detection using a Boosted Cascade of Simple Features" in 2001. It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. It is then used to detect objects in other images.

Here we will work with face detection. Initially, the algorithm needs a lot of positive images (images of faces) and negative images (images without faces) to train the classifier. Then we need to extract features from it. For this, Haar features shown in the below image are used. They are just like our convolutional kernel. Each feature is a single value obtained by subtracting sum of pixels under the white rectangle from sum of pixels under the black rectangle.




The characteristic feature of the eye is extracted to recognize the eye's state. In general, the state of left eye is equal to right one at the same time. Therefore, we only consider one eye's state in one frame. This consideration is also useful to the reduction of computational complexity. In this step, two schemes are adopted: (1) binary pattern and (2) the Canny's edge detection

The eye image is converted to binary pattern based on the threshold value

T. $T = \{\Sigma \text{ Xi } n \ i=1 \ \}/n$

When the conversion of eye image is completed, the height of the eyelids is utilized to determine the eye's state.

Binary pattern : (a)-(b) open eye and (c)-(d) closed eye


### 4.2.7 Distance Calculation:

Distance is a mathematical description of how far objects are from each other. As next step, we find distance of the midpoint from the point at lower eyelid. In analytic geometry, distance between two or more points is calculated by using the distance formula given by the Pythagorean Theorem. The distance between two points (X1, Y1) and (X2, Y2) is given as:

$$d = \sqrt{(\Delta x)^2 + (\Delta y)^2} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}.$$

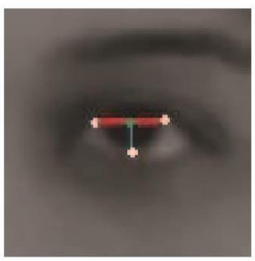


Fig.4.3 Line segment that joins mid point to the point at the lower eyelid

### 4.2.8 Eye State Determination:

Finally, the decision for the eye state is made on the basis of distance ’d’ calculated in the previous step. If the distance is zero or is close to zero, the eye state is classified as “closed” otherwise the eye state is identified as “open”.

### 4.2.9 Drowsiness Detection:

The last step of the algorithm is to determine the person’s condition on the basis of a pre-set condition for drowsiness. The average blink duration of a person is 100-400 milliseconds. This is 0.1-0.4 of a second. Hence if a person is drowsy his eye closure must be beyond this interval. We set a time frame of 5 seconds. If the eyes remain closed for five or more seconds, drowsiness is detected and alert pop regarding this is triggered.

# 5. CONCLUSION & FUTURE WORK

## 5.1 Conclusion

Over the past decade, the drowsiness detection field has experienced significant enhancements, due to technological advancements in IoT, sensor miniaturization, and artificial intelligence. This paper has presented a detailed and up-to-date review of the driver drowsiness detection systems that have been implemented in the last ten years. It has described the four main approaches followed in designing DDD systems and categorized them based on the type of drowsiness indicative parameters employed. These four categories are image-, biological-, vehicle-, and hybrid-based systems. The paper has provided a detailed description of all the presented systems, in terms of the used features, implemented AI algorithms, and datasets used, as well as the resulting system accuracy, sensitivity, and precision.

We expect 5G networks to play a prominent role in enhancing DDD systems. With 5G connectivity, future DDD systems will be based on real driving scenarios. The data will be obtained from various drivers in actual vehicles, where factors such as ambient light, road surface vibrations, and individual differences among drivers are considered. The use of 5G connectivity will also enable the use of multi-access edge computing power for deep learning, resulting in highly accurate real-time decisions. Vehicles are expected to operate as members of Internet of vehicle networks, enabling the network to warn the drowsy driver, take control of the car (if needed), and contact neighboring vehicles in the network to alert them about the weary driver. These technologies will lead to safer roads and pave the way towards realizing smart cities.

We conclude by emphasizing that DDD technology has enormous market potential. Many car manufacturers, such as Toyota and Nissan, have recently installed or upgraded driver assistance devices in their products. The artificial intelligence and deep learning fields are developing tremendously. Soon, the DDD systems will most likely evolve, enabling the formation of smart cities.

## 5.2 Future Work

Mobile phones have been introduced in literature as an inexpensive alternative to collect driving data. Nowadays, mobile phones are equipped with at least two cameras and multiple sensors. Additionally, they can connect with a wide range of sensors through Bluetooth or other wireless technologies. When attached to the driver's dashboard, a mobile phone's front camera can collect various visual parameters, including eye features, mouth features, and head movements. Furthermore, the rear camera is capable of detecting vehicle-based features, such as lane departure and change in orientation, among others. Most mobile phones are also equipped with GPS sensors, an accelerometer, a gyroscope, and a magnetometer, which also could describe the car's direction and orientation, leading to a better understanding of the driving experience. The phone's microphone can also be used to collect data about the driver.

DDD systems not only assure the safety of the driver and companions but also other passengers on the road. When the DDD system detects that the driver is drowsy, it signals an alarm (such as a flickering light) to other vehicles on the road, warning them that the driver is drowsy and to take precaution. The car could also be a member of an Internet of vehicle network, an IoT network involving vehicles. In such a setting, vehicles send live data that includes the driver's vital signals over a wireless medium, such as 5G . The data are collected and analyzed in a traffic management platform, which, in the case of detected drowsiness, sends an alert signal to the driver to reduce the speed or park the car. It could also run an autopilot to take over the vehicle and park it safely. On the other hand, the platform can also contact neighboring vehicles in the networks to warn them about the drowsy driver.

A significant limitation in most proposed DDD systems is their dependence on limited datasets that were produced in simulated environments. The accuracy of these systems could be increased by obtaining more data from various drivers in actual vehicles, where factors such as the ambient light, road surface vibrations, and individual differences among drivers are considered. This requires the use of deep learning, which can be done locally by equipping the vehicles with AI-enabled processors and GPUs.

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