Chapter 12

Book Chapter

Smart Road Safety: An IoT Approach to Driver Drowsiness Detection and Prevention

Sheela S Maharajpet [*1], Nagaraj C Talwar [†2], and Gautam A. Dematti [‡3]

[1]Assistant Professor, Department Of MCA, Acharya Institute of Technology, Bangalore
[2]Student, Department Of MCA, Acharya Institute of Technology, Bangalore
[3] Angadi Institute of Technology & Management, Belagavi

Abstract

The main cause of fatalities and injuries among humans is traffic accidents. The World Health Organisation estimates that injuries sustained in automobile accidents claim the lives of one million people worldwide. When a driver is sleep deprived, worn out, or both, they are more prone to nod off at the wheel and hurt not only themselves but also other people. Sleepiness when driving is a major contributing cause to major traffic accidents, according to studies on the topic. These days, research indicates that the main factor contributing to drowsiness while driving is weariness. The main cause of the increase in traffic accidents these days is tiredness. This develops into a major issue for the world that requires immediate attention. Enhancing real-time sleepiness detection performance is the main objective of all devices. Numerous tools were created to identify drowsiness, and these tools rely on various artificial intelligence algorithms. Thus, another area of our research is driver drowsiness detection, which uses facial recognition and eye tracking to determine a driver's level of tiredness. The

*Email: sheelamaharajpet4@gmail.com Corresponding Author
†Email: nagarajc.22.mcav@acharya.ac.in
‡Email: gautam.dematti@aitmbgm.ac.in

system compares the extracted eye image with the dataset. The system used the dataset to identify that it could alert the driver with an alarm if the driver's eyes were closed for a predetermined amount of time, and it could resume monitoring if the driver's eyes were open following the alert.

Keywords: Video Input/Output. Facial Recognition. Extracting Eye Image. Face Detection. Driver's Eye, Alert.

1 Introduction

Drowsiness is the term used to describe feeling unusually weary or drowsy during the day. Other symptoms like forgetting or falling asleep at strange times can result from being too sleepy. This is an innate human physiological phenomena that deters drivers and has an impact on their quality of life. (Phan, Trieu, & Phan, 2023). Although the feeling of tiredness may only last for a few minutes, the effects could be severe. Exhaustion is usually the primary cause of sleepiness because it lowers alertness and attention. However, additional factors that may contribute to sleepiness include drugs, shift work, insufficient concentration, sleep disorders, and alcohol consumption. They have no way of knowing when they will fall asleep. Even while it's risky to fall asleep while driving, being fatigued makes it challenging to drive safely even when you're awake. It is estimated that one in twenty drivers have dozed off while operating a vehicle. Drivers who operate trucks and buses on 10- to 12-hour trips are more susceptible to driving when fatigued. These people put other drivers in danger more than they do themselves. Drowsiness and Fatigue of drivers are major causes of road accidents. (Alshaqaqi et al., 2013). You may feel drowsy from driving when you need to sleep or from driving a long distance when you are sleep deprived. In these situations, the driver's growing tiredness is the cause of any accidents that occur on the road.

According to the National Highway Traffic Safety Administration, driver weariness is a factor in over 100,000 auto accidents and 1,500 fatalities each year. Police and hospital reports serve as the foundation for these figures. Sleep-related driving is thought to be responsible for 1,550 deaths, 71,000 injuries, and $12.5 billion in monetary damages.Sleepy driving was a factor in 697 fatalities in 2019. The National Transportation Safety Administration (NTSA) admits that it is difficult in order to assess the exact quantity of collisions or fatalities brought on by sleepy driving and that the numbers provided are underestimates.(Albadawi, Takruri, & Awad, 2022). Approximately 1.3 million people have been killed each year due to car accidents. (Titare, Chinchghare, & Hande, 2021).

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The public sector services (including transportation) delivered must make use of technological advancements and digital capabilities to reduce these obstacles. (Mittal et al., 2023). The machine learning algorithms and tools in Artificial intelligence identifies patterns drawing inferences and making efficient predictions. (Anusha, Vasumathi, & Mittal, 2023). Thus due to such algorithms and technologies, it is now feasible to identify driver fatigue and alert them prior to an accident. There are several signs that a driver is sleepy, including frequent yawning, prolonged eye closure, and random changes in lanes. Techniques for diagnosing driver drowsiness (DDD) have been thoroughly studied in the last few years. Researchers have proposed a number of strategies to detect fatigue as soon as practical in order to avoid accidents. The first step in our attempt to identify tiredness is to identify a face, which is followed by the location and blink pattern of an eye. A facial analysis tool called "Shape predictor including 68 landmarks" is employed. We estimate the position of the driver's eye by using a camera, most likely a webcam pointed in the direction of the driver's face. This allows us to recognize the driver's face and facial landmarks. It needs to do this by analyzing each face and pair of eyes using in-house image processing. (Abtahi, Hariri, & Shirmohammadi, 2011).

New approaches like Sparse Matrix can help to optimize the transshipment models. (Garg & Mittal, 2021).The blinking rate—the speed at which the eyes open and close—and the position of the eyeballs can be detected by the system after it has established their location. After a set period with the eyes closed, the alarm will ring to alert the driver. Initially, the eye is assigned a score of zero. If the eye is closed, the score will increase, and if it is open, the score will decrease. The alarm will sound to notify the driver if the score rises above a certain point.

2 Literature Survey

The driver sleepiness detection system is a safety element of cars that keeps careless drivers from hurting other people. It is essential to identify and alert the driver as quickly as possible in order to prevent any inadvertent mishappening that can cause fatalities.(Gupta et al., 2023). Studies used an eye-blink pattern analysis method for drowsiness detection called eye-blinking-based.(Safarov et al., 2023). The suggested framework computes and quantifies the Eye Aspect Ratio, or The extent of the driver's eye, using an image processing technique. (Jagbeer Singh et al., 2023). The Eye Aspect Ratio data must be gathered To be able to determine the threshold value that indicates when a driver feels drowsy. Because it reduces the number of injuries brought on by drunk driving, which in turn reduces the overall number of automobiles, an alarm-equipped alert system is crucial.(Dewi et al., 2022).As of right now, there is very little restriction on the detecting system's ability to identify the equal driving force's drowsiness. Additionally, the alarm is functioning correctly and may sound a legitimate alarm to notify the motorist.

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However, because each person has a unique Eye Aspect Ratio (EAR), the threshold frames needed to sound the warning may differ. (Biswal et al., 2021). There are various suggestions made for additional research in this field. First, after multiple tests, the system ought to be able to recognize when an individual is feeling drowsiness and automatically establish the eye aspect ratio threshold without having to configure it for each individual individually. (Al Redhaei et al., 2022). This is because some people tend to have higher precautions and awareness towards road safety thus wanting a more sensitive and frequent alarm alert system.

A sleepiness detection system based on multilayer perceptron classifiers is proposed in the research by Jabbar et al.'s (2018) . It is made especially for embedded systems, such smartphone Android. The system's job is to identify facial landmarks in photos and send the collected information to the trained model so it can determine the driver's condition. The method's objective is to minimize the model's size in light of the fact that existing applications are incompatible with embedded devices because of their constrained computational and storage capabilities. The experimental results show that the model in use has an accuracy rate of 81% and a modest size. As a result, it can be included into mobile applications, the Driver sleepiness detection system, and sophisticated driver support systems. There is still room for performance enhancement, though. Subsequent research will concentrate on identifying the driver's yawning and distraction.

Shaik's (2023) studied has looked at the various methods that can be used to gauge a driver's degree of sleepiness. Among the many methods used to diagnose drowsiness are behavioral, physiological, driving-based, subjective, and driving assessments. These instruments were also carefully studied, and a list of their advantages and disadvantages was provided for each tool. Participant-based driver sleepiness investigations are time- and resource-consuming, and efforts to quantify drowsiness in on-road investigations are currently ongoing. The development of legitimate, discrete real-world surveillance technologies will make it easier to conduct realistic driving studies. There are various ways to identify drowsiness; these include the classification strategy, sleepiness measures, dataset, participants, accuracy, and a list of important components. Finally, this section also includes improvements and suggestions for possible new study directions.

The model proposed by Jain, Bhagerathi, and C N's (2021) can identify signs of sleepiness by keeping a watch on the mouth and eyes. significant facial characteristics are identified through the application of shape prediction techniques. These techniques take in face landmarks as inputs, which are derived from facial landmark detection. The EAR function, which calculates the ratio of distances between the horizontal and vertical eye landmarks, is the subject of this module. Additionally, a text-to-speech synthesizer module called e-Speak is employed to notify drivers with suitable vocal cues when they exhibit signs of fatigue or yawning.

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The entire initiative is intended to lower the accident rate and advance technology in an effort to reduce the number of people killed in traffic accidents. This paper's future research can concentrate on utilizing external cues to gauge drowsiness and exhaustion. The external elements could include the mechanical data, weather, vehicle condition, and sleeping time. One of the biggest risks to road safety is drowsy driving, and commercial motor vehicle operators face an especially serious issue with this. Twenty-four-hour services, erratic environmental conditions, large yearly mileage, and a growth in demanding work schedules are the reasons that contribute to this major safety hazard.(Elbaz et al., 2020). Monitoring the driver's level of tiredness and providing them with information about it so they may take the appropriate action is a crucial step in the preventive steps that are required to address this issue. As of right now, neither the zoom nor the camera's direction may be changed while the system is in use. Further efforts can be made in the future to automatically zoom in on the eyes once they have been located.

In the study Khairosfaizal and Nor'aini's (2009) and Söylemez and Ergen's (2013) proposed and developed a vision-based solution to mitigate driver fatigue. detection, which uses visual cues to inform the driver, should he be experiencing sleepiness. In both daytime and nighttime conditions, this device uses a camera that uses infrared to detect the driver's state. The foundation for implementing face and eye detection is symmetry. Circles are transformed using the Hough Transform to ascertain the states of the eyes. Although the results are promising, face detection could yet be improved by implementing more symmetry-calculation techniques.

The two suggested implementations of a driver drowsiness detection system in Magán et al.'s (2022) paper both heavily rely on deep learning. These systems use the driver's image to detect signs of exhaustion; however, instead of predicting this information based on a single image, this work considers the driver's last minute of sleep to determine whether or not the driver is fatigued. The first proposed method uses a deep learning model to predict the driver's level of fatigue by combining a CNN and a recurrent neural network. applying artificial intelligence and deep learning techniques, the second way preprocesses the input before applying the fuzzy inference system to quantify fatigue through fuzzy logic. But the second option, which mixes fuzzy logic and deep learning, showed encouraging outcomes. In the 60 videos of alert drivers, there was only one video in which the system raised an alarm incorrectly (raising an unnecessary alarm in only 7% of the cases where the driver was actually alert). This means that the system can operate continuously without bothering the driver when they are not sleepy. In this sense, achieving a minimal false positive rate is regarded as successful. The issues and constraints of other earlier proposed initiatives of a similar nature have been addressed by this real-time sleepiness detection system for cars.(Arunasalam et al., 2020). The advancement of this technology will make it possible to implement rudimentary, affordable road safety measures against drunk drivers.

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The project has the following features: the ability to detect driver fatigue, an alert system that sounds an alarm, the capacity to restrict speed if a certain level of fatigue is reached, and the capability to send messages that contain the driver's exact location. When this initiative is actually implemented, it may indirectly lower the number of accidents caused by drivers who are too tired or drowsy.

Driving force tiredness can be accurately detected with the device that is being recommended for this examination. The driving force sleepiness detection device's layout and assessment are covered. The suggested device is intended to prevent many traffic accidents caused by intoxicated drivers. It can also help drivers stay awake while operating a vehicle by alerting when they are the driving intoxicated. The notion behind the drowsiness detection device is that it recognizes and provides information on behavioral, physiological, and vehicle parameters based entirely on it. It appears that drivers are yawning less, not more, often in the moments before going to sleep. Although the accuracy cost of employing physiological measurements to determine drowsiness is considerable and those are rather intrusive, this emphasizes the need of presenting examples of exhaustion and drowsy scenarios in which subjects unquestionably fall asleep.(Awais, Badruddin, & Drieberg, 2017). However, the invasive character of this can be addressed by using contactless electrode implantation techniques. Consequently, it would be highly beneficial to combine physiological measures with Dlib with behavioral and car-based measures in order to create a green drowsiness detection system.(Titare, Chinchghare, & Hande, 2021).

Drowsiness-related accidents can be prevented by using driver drowsiness detection systems, which are intended to assist drivers in maintaining awakeness while operating a vehicle. (Verma et al., 2023). A study by Mbatha, Booysen, and Theart's (2024) the degree of skin blackness and fluctuating lighting circumstances may have an impact on our system's functionality. Therefore, more research is required to assess our system's efficacy in varying skin tones and lighting situations. Salem and Waleed's (2024) study shows that driver sleepiness monitoring systems have the potential to increase road safety, despite these drawbacks. These devices have the potential to be a vital aid in preventing driver fatigue-related accidents with additional research and development. The model's high precision, recall value, and F1-score indicate that it can correctly identify driver drowsiness, according to the results. On both the training and test datasets, the CNN model produced classification accuracy of over 98%. Additionally, the CNN model correctly detected the sleepy drivers and warned them by both visual and audible cues.

Globally, one of the main causes of accidents is driver drowsiness. One crucial technique for determining a driver's level of weariness is to detect sleepiness. A.Milan et al.'s (2021) created a working prototype of a sleepiness detection system that tracks the driver's eyes and sounds an alert when it senses drowsiness. The technology that has been designed is a discreet, real-time monitoring solution that aims to improve driver safety without drawing

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attention to itself. When a driver's eyelids stay closed for an extended amount of time, the system interprets it as drowsiness and sounds an alarm. To solve these problems, the project suggests and puts into practice an infrared light-based hardware solution. Following the face detection phase, the system tracks and extracts important facial features from video sequence frames that are particularly useful for detecting tiredness. The system has undergone real-world testing and implementation.

The mechanism of detection distinguishes between tiredness and a typical eye blink. An inconspicuous system has been discussed by Kumari B.M et al.'s (2018).Adding different kinds of sensors will allow the system to be enhanced further. Using a non-invasive technology, it was feasible to detect the eyes and track fatigue. The positional information about the eyes is obtained using an algorithm for image processing that the author created. Whether the eyes are open or closed throughout the monitoring procedure is detectable by the technology. When the eyes are closed for a long time, a warning is issued. Moreover, the system is able to detect any inaccuracies in eye localization that may have occurred during its monitoring instantly. In the event of this kind of error, the system can recover and localise the eyes accurately. (Perez et al., 2001).

In a paper, Ahmed et al.'s (2023) accurately classified driver drowsiness split up into four categories: yawn, no yawn, closed, and open. Deep learning will be explored within this research to achieve this goal. This study used and trained the sleepiness dataset, which has 2900 photos, inorder to get accurate results. This work of categorizing the numerous sleepiness categories are splitted into four classes is successfully completed by the CNN approach. Improved detection performance was made possible by the CNN model structure comprising the Conv2D, MaxPooling2D, Flatten, and Dropout layers. Consequently, with a 97% accuracy rate, 99% precision rate, 99% recall rate, and 99% F1 score, the CNN modelling approach outperformed all other benchmark research. Mehta et al.'s (2019) work proposes a real-time system that tracks and identifies drivers' distractions. By identifying facial landmarks, the driver's face is recognized, and a warning is sent to prevent crashes in real time.

In order to keep the driver from getting distracted by the sensors on his body, non-intrusive techniques have been chosen over intrusive techniques. The proposed technique detects driver fatigue in real time by utilising adaptive thresholding in combination with the Eye Aspect Ratio and the Eye Closure Ratio. This is useful in situations where the drivers are used to long drives and heavy workloads. The proposed system makes use of the collected data sets in multiple scenarios. After storing the facial landmarks it finds, machine learning techniques are applied to categorise the data. The system indicates that the random forest classifier produces an 84% best case accuracy.

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3 Proposed Design

- Overview Design
  To accomplish these goals, the required hardware and software components need to be acquired. The basic concept behind driver sleepiness detection is to use data processing to obtain an approximate driver condition from an image taken with a camera. In this project, cameras are combined with load cell sensors, an Arduino board, and Python machine learning. For facial and eye detection, OpenCV libraries are used in conjunction with CNN and OpenCV algorithms.
- Face Detection
  For DriverDrowsiness Detection, hardware and software components are required. These parts include a camera to recognise faces and eyes and track the speed at which eyes blink, additionally sensors to detect hand pressure and send data to an Arduino board. This research employs a number of methodologies, which are discussed in this publication.
- Histogram Oriented Gradient
  For this project, the picture preprocessing steps—image scaling and colour normalization—are executed utilising the HOG method. The driver's exact location in the collected image is provided, as well as useful attributes for eye identification and HOG feature extraction from the image patterns.
- Eyes Detection
  The procedure of estimating a driver's level of tiredness based on blinking eye blinking rate comes after taking a picture of the driver and preprocessing it. The threshold value is used to verify changes in the blink rate, and values are computed for each frame. The CNN algorithm is utilized to accurately determine the rate at which eyes blink, and it is also beneficial for facial recognition.(see figure 1).
- Hardware
  This project makes use of the open-source, user-friendly Arduino microcontroller, which is depicted in Figure 1.1 The eye blink ratio from the camera and software program, which is connected to Arduino via a system cable, is an additional input to the Arduino platform.(see figure 2).

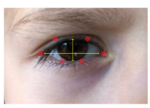

Figure 1. Eye Detection

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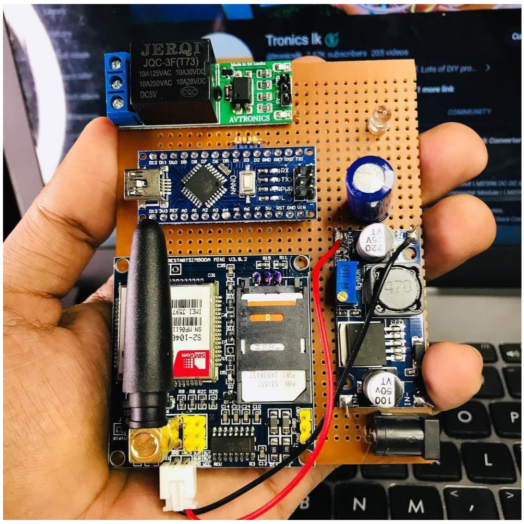

Figure 2. Arduino Board

4 Flow Chart

The flowchart has been demonstrated in the below image:(see figure 3)

1. Video input/Camera: The system captures video using a camera as its input source.
2. Extracting frames: The system then extracts individual frames from the continuous video stream for further processing.
3. Face Detection: Within each extracted frame, the system identifies any faces present using face detection algorithms.
4. Eye Detection: After detecting faces, the system locates the eyes within those faces to analyze for signs of sleepiness.
5. Is sleepy: The system then makes an assessment based on the eye data to ascertain if the person is sleepy or not.
6. Alert: Finally, the system determines if the person is alert or not predicated on the sleepy assessment.
7. Yes: This shows that the system is indeed performing these processes to assess sleepiness and alertness

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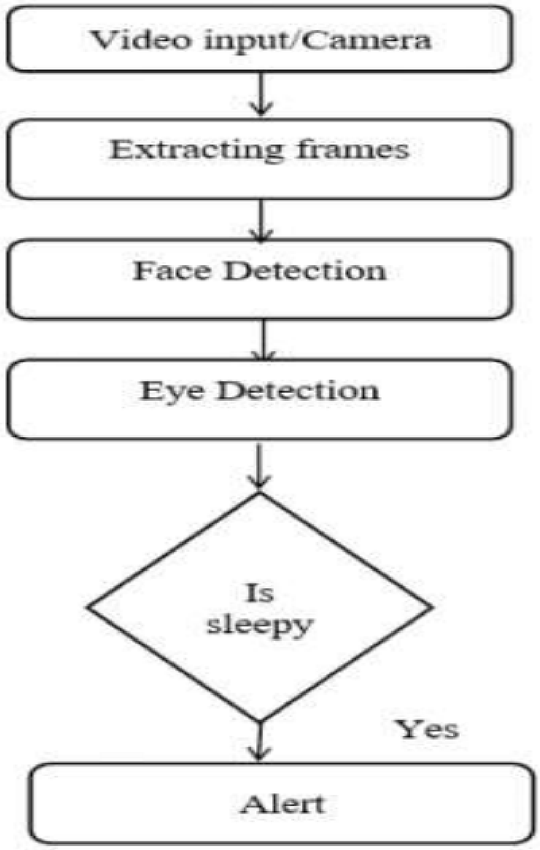

Figure 3. Working Flow of Drowsy Driving Prevention

5 Results

The Driver Drowsiness Detection Prevention successfully identified drowsiness in real-time, utilizing high precision Eye Aspect Ratio (EAR) metrics. (see figure 4). Timely alerts were effectively delivered through a vibrating motor, significantly enhancing driver safety and reducing the risk of drowsy driving incidents.(see figure 5)

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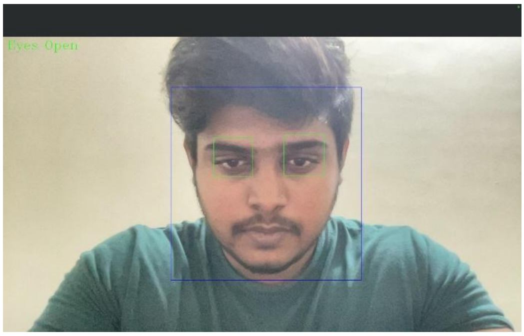

Figure 4. The Eyes are Open and Drowsiness will not Detected .

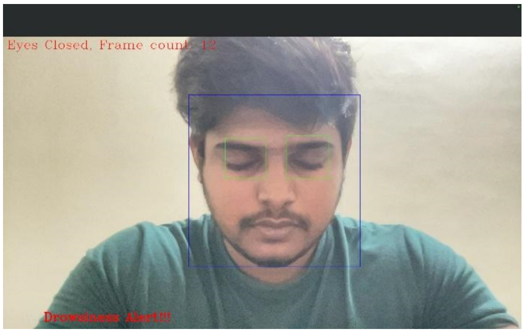

Figure 5. Eyes closed hence drowsiness detected and Alert will Ring and driver gets vibration by the device

6 Conclusion

In conclusion, the driver drowsiness detecting system is a safety feature of cars that keeps drunk drivers from hurting other people. It is imperative to promptly identify and alert the driver in order to avert inadvertent collisions that may cause fatalities. The proposed system is able to determine the level of driver drowsiness by using an image processing approach called the Eye Aspect Ratio, which measures the size of the driver's eye. The Eye Aspect Ratio data must be gathered in order to determine the threshold value that indicates when a driver feels drowsy. Because it reduces the amount of injuries brought on by intoxicated driving, an alarm-based alert system is crucial because it lowers the overall number of car crashes that occur each year. As of right present, the detecting algorithm has very little trouble repeatedly identifying the equal driving force's tiredness.

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Additionally, the alarm is functioning correctly and may sound a legitimate alarm to notify the motorist. However, because each person has a unique Eye Aspect Ratio (EAR), the threshold frames that set off the alarm may change.

Future research in this field is advised to follow a number of these guidelines. First, after multiple tests, the system ought to be able to recognize when an individual is feeling sleepy and automatically decide the eye aspect ratio threshold without having to configure it for each individual. This is a result of the fact that some people desire a more frequent and sensitive alarm alert system due to their heightened knowledge of road safety and tendency to take greater measures.

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