Driver Drowsiness Detection System by Measuring EAR and MAR

Alfiya Sheikh[1], Bhavika Makode[2], Vanshika Makode[3] , Zoya Khan[4], Dr. Vanita Buradkar[5]

[1]Student , Department of Computer Science and Engineering [2]Student , Department of Computer Science and Engineering [3]Student , Department of Computer Science and Engineering [4]Student , Department of Computer Science and Engineering
[5]Assistant professor, Department of Computer Science and Engineering

(DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE)
Rajiv Gandhi College of Engineering Research and Technology, Chandrapur, Maharashtra, India
alfiyasheikhas12@gamil.com, bhavikamakode12@gmail.com, vanshikamakode11@gmail.com, zoyakhan88578857@gmail.com

Abstract: - Driver drowsiness is one of the major causes of road accidents, leading to severe injuries and fatalities worldwide. In this paper, we propose a real-time Driver Drowsiness Detection System using Python, OpenCV, and Dlib to monitor driver alertness and provide timely alerts to prevent accidents. The system uses a webcam to continuously capture facial images and applies computer vision techniques to detect facial landmarks, particularly focusing on the eyes. By calculating the Eye Aspect Ratio (EAR) over a sequence of frames, the system determines if the driver's eyes remain closed for an extended period, indicating drowsiness. Once drowsiness is detected, an alarm sound is played using the Pygame library to immediately alert the driver. The implementation aims to improve road safety by providing a low-cost, easily deployable solution using widely available hardware and open-source tools. This system can be integrated into various vehicles, offering an additional layer of safety for long-distance drivers, truck drivers, and night-time travellers.

Keywords: Driver Drowsiness Detection, Python, OpenCV, Dlib, Computer Vision, Eye Aspect Ratio, Real-Time Alert System, Road Safety, Facial Landmark Detection, Pygame Alarm

INTRODUCTION

The road transportation plays a crucial role in the movement of goods and people across cities and countries. However, oneof the leading causes of road accidents is driver drowsiness, which severely affects a driver's alertness and reaction time[1]. According to global traffic safety reports, a

significant proportion of highway accidents are caused by drivers falling asleep at the wheel, especially during long-distance journeys or night-time driving. Taxi drivers, truck drivers, and bus operators often work extended hours with minimal rest, making them especially vulnerable to fatigue and drowsiness-related incidents. This pressing issue calls for the development of innovative solutions to monitor driver alertness in real time and provide timely warnings before an accident occurs.

This research focuses on designing and implementing a Driver Drowsiness Detection System using Python, OpenCV, and Dlib, combining the power of computer vision and machine learning techniques. The main objective is to detect the early signs of drowsiness by analysing the driver's facial landmarks, particularly focusing on eye closure duration and yawning patterns. By continuously monitoring the Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR) through a webcam, the system can determine if the driver's eyes have been closed for a prolonged period or if the driver is frequently yawning — both strong indicators of fatigue. Once drowsiness is detected, the system immediately triggers an audible alarm to alert the driver, reducing the risk of potential accidents.

The proposed system is built on widely accessible and open-source technologies, ensuring that it can be implemented in real- time and without requiring expensive hardware. Python serves as the primary programming language, leveraging libraries like OpenCV for image processing, Dlib for facial landmark detection, and SciPy for computing geometric distances between facial points. Additionally, Pygame is used to play warning sounds when drowsiness is detected. This system is designed to be efficient, lightweight, and easy to deploy on various platforms, making it suitable notonly for individual drivers but also for fleet management systems seeking to enhance road safety.

By integrating computer vision with real- time monitoring, the Driver Drowsiness Detection System aims to serve as a vital safety technology to prevent accidents, safeguard lives, and promote responsible driving habits.

Application

The development and implementation of a real-time Driver Drowsiness Detection System using Python, OpenCV, and Dlib. Road accidents caused by driver fatigue are a major concern globally, particularly among taxi drivers, truck drivers, bus drivers, and individuals covering long distances. Lack of sleep and prolonged driving sessions lead to drowsiness, significantly increasing the risk of road accidents. To address this safety issue, we propose a system that continuously monitors the driver's facial features, particularly focusing on eye closure and yawning patterns, to detect signs of drowsiness and provide timely alerts.

The core objective of the system is to detect if a driver's eyes remain closed beyond a safe duration or if they show signs of frequent yawning, both of which are strong indicators of fatigue. We achieve this by using a webcam to capture real-time video, which is processed using OpenCV for face and eye detection[2]. Dlib is employed to identify 68 facial landmarks, and the Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR) are calculated using the scipy library[3]. These metrics help determine the state of the eyes (open or closed) and detect excessive mouth opening due to yawning. If the EAR drops below a predefined threshold for consecutive frames, or if the MAR exceeds its threshold, an alert is triggered. The system uses the pygame library to play an audible alarm to wake or alert the driver.

The application of this system is highly valuable in both commercial and personal transportation sectors. It can be integrated into vehicles to enhance road safety by minimizing the chances of drowsiness- related accidents. Fleet operators, logistics companies, and long-distance transport services can particularly benefit from this system to ensure driver attentiveness. Furthermore, with advancements, this technology can be combined with other in-vehicle monitoring systems such as steering behavior analysis or heart rate sensors to build comprehensive driver assistance systems.

The proposed Driver Drowsiness Detection System is a cost-effective, efficient, and scalable solution to address the critical problem of driver fatigue. Its implementation using Python and widely available computer vision libraries makes it accessible for further research, improvement, and real-world deployment to help save lives on the road.

LITERATURE REIVEW

Drowsiness detection in drivers has become a crucial area of research due to the alarming number of road accidents caused by fatigue. According to the World Health Organization (WHO), driver fatigue is one of the leading causes of traffic accidents globally, especially among long-distance drivers such as truck, bus, and taxi operators. Various studies highlight that a driver's alertness decreases significantly when they experience prolonged wakefulness, leading to slower reaction times and reduced attention. To address this problem, computer vision and machine learning techniques have been widely explored, providing real-time monitoring solutions that can alert drivers before an accident occurs.

In recent years, OpenCV and Dlib have emerged as popular tools in building real- time drowsiness detection systems. These libraries provide powerful facial landmark detection capabilities, making it possible to monitor eye and mouth movements effectively. The Eye Aspect Ratio (EAR), as proposed in several studies, is a key metric used to detect when eyes remain closed for a specific number of consecutive frames, indicating possible drowsiness[4]. Additionally, the Mouth Aspect Ratio (MAR) helps detect yawning behavior, which is another early indicator of fatigue[5].

Existing literature includes works like Patel et al. (2019), who used facial landmarks to detect micro-sleeps and yawning, achieving promising accuracy using classical machine learning approaches[6]. Similarly, researchers such as Singh and Kaur (2020) proposed real-time driver monitoring systems using convolutional neural networks (CNNs), improving detection accuracy even under low-light conditions[7]. Moreover, studies by Abtahi et al. (2014) focused on integrating head pose estimation with eye tracking, demonstrating that combining multiple behavioral cues improves the reliability of drowsiness detection.

Our proposed system builds upon this foundation by using Python with OpenCV, Dlib, Imutils, and Scipy libraries, along with Pygame for alert mechanisms. It continuously monitors the driver's face through a webcam, calculating EAR and MAR values to determine signs of drowsiness or yawning. When these thresholds are crossed, an alarm sound is played to alert the driver, potentially preventing accidents. This lightweight, cost-effective system does not require specialized hardware, making it accessible for real-world applications.

OBJECTIVE

1. A large number of accidents on highways are caused by driver drowsiness and lack of attention
2. The system uses computer vision techniques to detect the driver's face and facial landmarks in real-time.

3. Dlib's pre-trained shape predictor identifies 68 facial landmarks, focusing on the eyes and mouth.

4. Eye Aspect Ratio (EAR) is computed to detect prolonged eye closure, indicating possible drowsiness. Mouth Aspect Ratio (MAR) is computed to detect excessive yawning, another sign of fatigue.

5. The System uses audio alerts (alarm sounds) to wake up or warn the driver when drowsiness or yawning is detected.

6. The implementation is done in Python 3.6, using libraries including OpenCV, Imutils, Scipy, Dlib, and Pygame[8].

7. The Goal is to enhance road safety by providing a proactive alert system that helps prevent accidents due to driver fatigue.

METHODOLOGY

1 Data Collection

Data collection is performed using a live webcam feed that captures real-time video of the driver's face. This visual data provides continuous frames that serve as the input for further analysis. The system does not rely on pre-stored datasets but rather collects data dynamically, ensuring the adaptability of the model to different individuals and lighting conditions[9].

2 Processing

Once the raw video frames are captured, preprocessing is essential to prepare the data for analysis. Each frame is resized for consistent input dimensions and converted from color (BGR) to grayscale to simplify computation without losing critical facial detail. Grayscale conversion reduces thecomplexity of the data and increases the processing speed, which is crucial for real- time applications. Face detection is performed on these grayscale images to localize the face, after which facial landmarks are extracted for further processing.

3 Feature Extraction

Feature extraction focuses on calculating meaningful metrics from the detected facial landmarks. Specifically, two key ratios are computed: the Eye Aspect Ratio (EAR) and the Mouth Aspect Ratio (MAR). EAR is determined by measuring the distances between the horizontal and vertical eye landmarks, capturing the degree of eye openness. MAR, on the other hand, is calculated using vertical and horizontal mouth landmarks to detect yawning behavior. These ratios provide quantitative measures to monitor drowsiness-related signs such as prolonged eye closure or frequent yawning.

4 Model Training

In this project, we adopt a rule-based approach rather than a machine-learning model. Thresholds are set based on established research and empirical tuning: the EAR threshold (0.25) identifies closed eyes, and the MAR threshold (0.7) detects yawns. To minimize false positives, an additional parameter the number of consecutive frames with an EAR below threshold is used, ensuring that brief blinks are not mistaken for drowsiness. Although no deep learning model is trained here, the system relies on robust statistical measures drawn from facial dynamics.

5 Driver Drowsiness Detection System

The core of the system involves continuous monitoring of the EAR and MAR across video frames. When the system detects that the EAR remains below the set threshold for a sustained number of frames (e.g., 20 consecutive frames), it flags the driver as drowsy. Similarly, when the MAR exceeds the yawning threshold, the system recognizes it as a sign of fatigue. The system displays visual alerts on the video window, warning the driver in real time.

6 Alert System

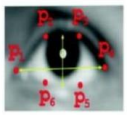
An effective alert mechanism is essential to ensure the driver is warned promptly. The system integrates an audio alert using the pygame mixer module, which plays a loud warning sound whenever drowsiness or yawning is detected. This dual alert system visual on-screen messages and audible alarms maximizes the chances of re- engaging the driver's attention and preventing an accident.

7 Deployment

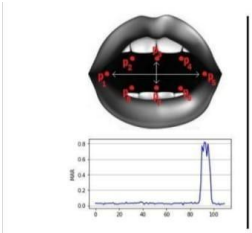
For deployment, the system runs on any standard computer with a webcam, making it easily accessible without specialized hardware. The Python-based solution, built using OpenCV, Dlib, Scipy, Imutils, and Pygame, ensures cross-platform compatibility and allows integration into various vehicle systems. Once installed and activated, the system starts monitoring as soon as the webcam is turned on, providing a real-time driver monitoring solution ready for

practical use.

EAR formulae:



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



$$MAR = \frac{\|p_2 - p_8\| + \|p_3 - p_7\| + \|p_4 - p_6\|}{2\|p_1 - p_5\|}$$

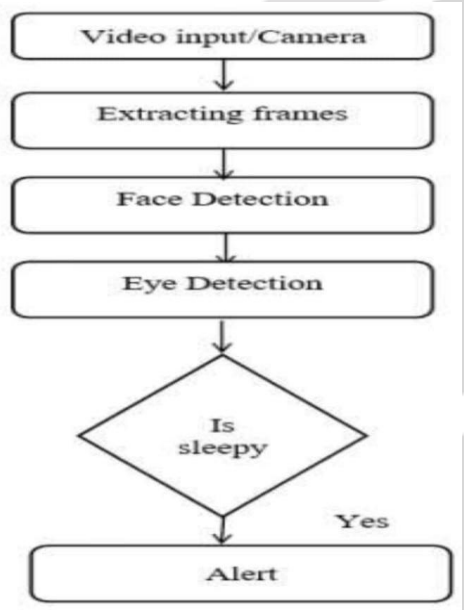


Fig 1. Architecture of the model.

ADVANTAGES

1. Real-time Monitoring:
The system operates in real time, processing video frames on the spot without any significant delay. This ensures immediate detection and prompt alerts when the driver begins to show signs of drowsiness, providing them with the opportunity to take corrective actions like pulling over or resting before continuing to drive. Real-time operation is critical because even a few seconds of delayed response could be the difference between safety and a serious accident.

2. Non-Intrusive Design:
Unlike some other drowsiness detection systems that require wearable devices or contact-based sensors, this system relies purely on a camera feed, making it non- intrusive and user-friendly. The driver does not need to wear any additional equipment or attach sensors, which improves comfort and acceptance. This camera-based approach also eliminates the need for physical calibration, allowing easy integration into vehicles without altering the driving experience.

3. Cost-Effective Implementation:
The system uses open-source Python libraries and requires only a standard webcam for input, making it an affordable solution. There is no need for expensive hardware like infrared cameras, headrest sensors, or embedded vehicle

systems. This cost efficiency makes it an attractive option for mass deployment in commercial fleets, public transportation, and even private vehicles, especially in developing regions where budget constraints are a major consideration.

4. Easy Integration and Scalability:
The software-based nature of the system means it can be easily integrated into various vehicle types and platforms. It can run on lightweight systems such as Raspberry Pi or be embedded into larger in- vehicle entertainment or monitoring systems. Moreover, with minor adaptations, the system can scale up to incorporate additional features such as distraction detection, facial recognition, or health monitoring, making it a flexible and future- proof solution.

5. Customizable Thresholds:
The system allows developers or manufacturers to adjust detection thresholds such as EAR, MAR, and the number of consecutive frames required to trigger an alert. This customization ensures the system can be fine-tuned for different user profiles, driving conditions, and use cases, thereby improving accuracy and reducing false alarms. For example, thresholds can be adjusted for nighttimedriving, long-haul trucking, or urban commuting scenarios.

6. Enhancement with Machine Learning: Although the current system is primarily rule-based, it can be easily enhanced by integrating machine learning models to improve detection accuracy. Using data- driven approaches, the system can learn from patterns in driver behavior, adapting over time to improve personalized detection.

OUTPUT

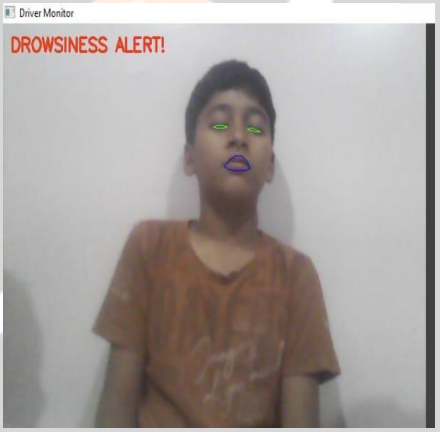


Fig 2. Drowsiness Alert

Fig 3. Yawning Alert

CONCLUSION

The Driver Drowsiness Detection System, utilizing Python, OpenCV, and Dlib, offers a practical and efficient solution to combat driver fatigue—a significant contributor to road accidents. By monitoring facial landmarks, particularly the eyes and mouth, the system calculates the Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR) to identify signs of drowsiness, such as prolonged eye closure or frequent yawning. When such indicators are detected, an audible alarm is triggered using the Pygame library, alerting the driver to regain alertness.One of the system's notable advantages is its simplicity and accessibility. Requiring only a standard webcam and a device capable of running Python, it eliminates the need for specialized hardware or intrusive sensors. This non-invasive approach ensures driver comfort while maintaining safety. Moreover, the system's design allows for real-time performance, making it suitable for various driving conditions.

The integration of multiple detection cues—monitoring both eye closure and yawning—enhances the system's reliability and reduces the likelihood of false alarms. Adjustable thresholds for EAR and MAR enable customization to accommodate individual behaviors and specific driving environments. Future enhancements could include incorporating vibration alerts or integrating notifications with connected devices to further improve responsiveness.

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