Driver Drowsiness Detection System Using OpenCV and IOT

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Abstract

Driver drowsiness is a major cause of road accidents, leading to serious injuries or even death. This project introduces a real-time Driver Drowsiness Detection System that uses a camera and computer vision tools like OpenCV and MediaPipe to track the driver's face. It mainly looks at how the eyes behave, especially how long they stay closed, using something called the Eye Aspect Ratio (EAR). If the system detects that the driver is sleepy, it plays a sound to wake them up. It can also be connected to IoT devices to send alerts to family members or take safety actions like slowing down the vehicle. This system is affordable, easy to use, and can be added to modern vehicles to improve road safety.

Keyword: - *Driver Drowsiness Detection, OpenCV, Road Safety, Road Safety ,IOT .*

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1. INTRODUCTION

Road accidents caused by driver drowsiness are a significant cause of injuries and fatalities worldwide. Fatigue impairs reaction time, alertness, and decision-making, making it highly dangerous during long drives. Traditional methods for detecting drowsiness include: Vehicle-based monitoring (lane departure, steering behavior) Physiological monitoring (heart rate, brain activity) These are often intrusive, costly, or difficult to implement. Computer vision offers a non-intrusive and cost-effective alternative using simple cameras and image processing. This project uses OpenCV and MediaPipe to monitor facial landmarks in real time, focusing on the eyes. The system calculates the Eye Aspect Ratio (EAR) to detect signs of drowsiness based on eyelid closure. When prolonged drowsiness is detected, an audible alert is triggered to wake the driver. IoT capabilities can be integrated to: Notify emergency contacts or a central monitoring system. Trigger vehicle control actions if needed. The system is designed for real-time performance, affordability, and ease of deployment in personal and commercial vehicles. The goal is to improve road safety and reduce accidents caused by drowsy driving.

1.1 INTRODUCTION 1: FOCUS ON OPENCV

In recent years, computer vision has become a powerful tool for enhancing road safety, especially in applications like driver monitoring. This project proposes a Driver Drowsiness Detection System that utilizes OpenCV and MediaPipe to identify signs of fatigue through real-time video analysis. The system monitors the driver's eye activity using a webcam and calculates the Eye Aspect Ratio (EAR), a widely accepted metric for eyelid movement. When the EAR drops below a specific threshold for a sustained duration, it indicates possible drowsiness. OpenCV enables efficient image processing and facial landmark detection, ensuring fast and accurate analysis. By implementing this solution using computer vision techniques, the system provides a non-intrusive, low-cost, and real-time method for reducing road accidents caused by fatigue-induced driver inattention.

1.2 INTRODUCTION 2: FOCUS ON IOT

With the advancement of smart vehicle technology, integrating Internet of Things (IoT) devices into driver monitoring systems has become crucial for improving road safety. The proposed Driver Drowsiness Detection System combines computer vision with IoT capabilities to detect and respond to driver fatigue. While a webcam and

OpenCV-based algorithm monitor eye movements to detect drowsiness, the system can also be connected to IoT modules such as GSM or Wi-Fi. These modules enable real-time alerts to be sent to emergency contacts or a central server, allowing for immediate intervention. In more advanced implementations, the system could even trigger automatic vehicle control responses. This integration of IoT enhances the system’s functionality, making it not just a detection tool but a complete safety response mechanism suited for both personal and commercial vehicles.

2. METHODOLOGY

The proposed **Driver Drowsiness Detection System** is designed to identify early signs of driver fatigue using computer vision techniques. The system captures real-time video of the driver’s face and analyzes it to compute the **Eye Aspect Ratio (EAR)**, a proven indicator of eye closure and drowsiness. The complete methodology can be broken down into the following key stages:

2.1 Video Capture

- A standard **webcam** is used to continuously capture live video of the driver's face while the vehicle is in motion.
- The captured frames serve as the input for further facial analysis and landmark detection.

2.2 Facial Landmark Detection

- The system uses the **MediaPipe Face Mesh** model to detect **468 facial landmarks** in real time from the video feed.
- Out of these, specific landmarks around the eyes are extracted for calculating the **Eye Aspect Ratio (EAR)**.
- MediaPipe ensures high-speed and accurate detection, suitable for real-time applications.

2.3 EAR Calculation

- The **Eye Aspect Ratio** is calculated using the vertical and horizontal distances between selected eye landmarks.
- The formula for EAR is:

EAR=∣∣p2−p6∣∣+∣∣p3−p5∣∣2×∣∣p1−p4∣∣EAR = \frac{||p_2 - p_6|| + ||p_3 - p_5||}{2 \times ||p_1 - p_4||}EAR=2×∣∣p1−p4∣∣∣∣p2−p6∣∣+∣∣p3−p5∣∣

where p1p_1p1 to p6p_6p6 are specific points around the eye.

- A **low EAR value** indicates that the eyes are closed, while a **higher value** indicates they are open.
- If the EAR drops **below a predefined threshold** (e.g., 0.3) for a set number of consecutive frames (e.g., 150), the system identifies the driver as drowsy.

2.4 Drowsiness Alert Mechanism

- When drowsiness is detected, an **audible alarm** (e.g., buzzer or siren) is triggered to wake the driver.
- A visual message such as **"Drowsiness Alert!"** is also displayed on the screen to reinforce the warning.
- This immediate feedback helps the driver regain alertness and avoid accidents.

2.5 IoT Integration (Optional)

- The system can be optionally extended with **IoT modules** such as **GSM**, **Wi-Fi**, or **ESP32** boards.
- These modules can send **real-time alerts** to:
    - Emergency contacts
    - Fleet management systems
    - Remote monitoring servers
- This feature enhances safety by enabling remote intervention in critical situations.

2.6 Tools and Technologies

- **Programming Language**: Python
- **Libraries**:
    - **OpenCV** – for image processing and video capture
    - **MediaPipe** – for facial landmark detection

- **NumPy** – for numerical calculations
- **SimpleAudio** – for triggering audio alerts

- **Hardware Components**:
  - **Webcam** – to capture the driver's face
  - **Optional IoT Modules** – such as ESP32, Sunglasses,GSM for real-time communication and alerts

2.1 SYSTEM DIAGRAM

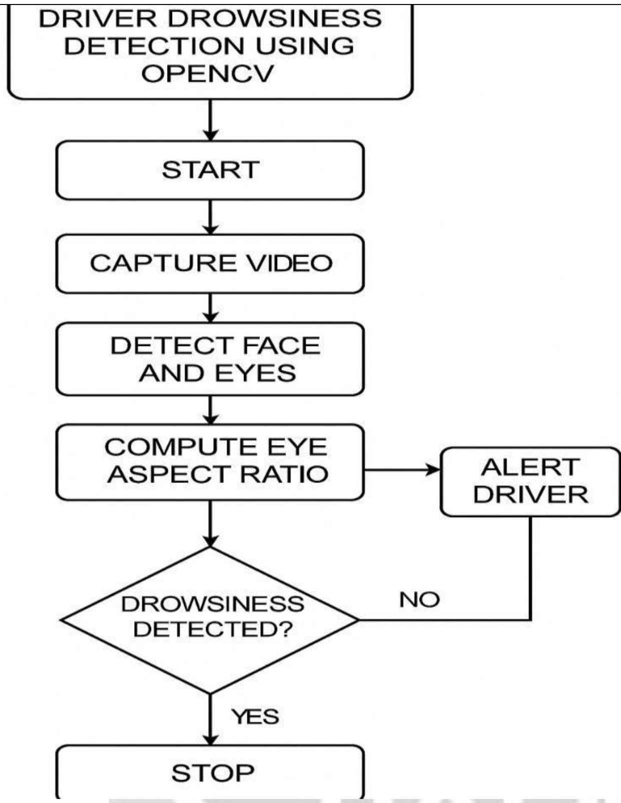

Fig 2.1 2 Data flow Diagram for Driver Drowsiness Detection System Using OpenCV

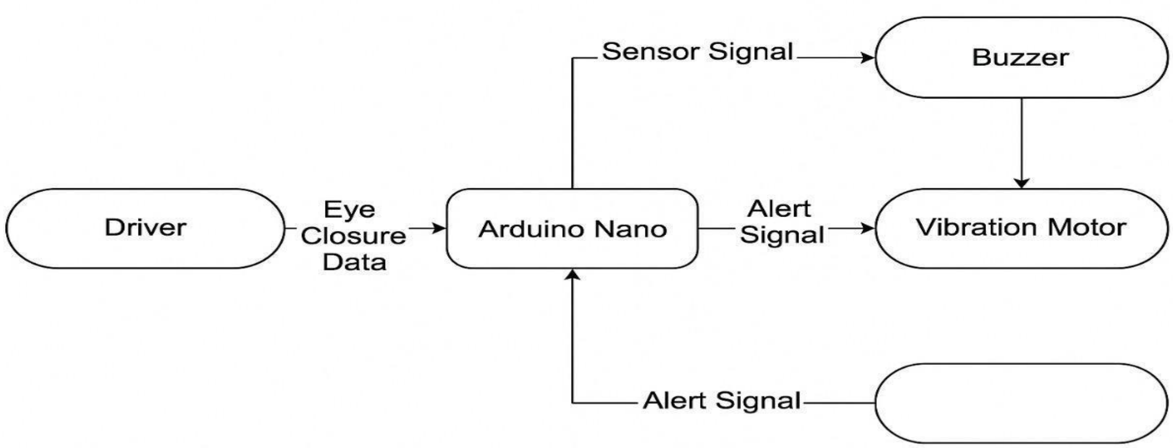

Fig 2 .2 Data flow Diagram for Driver Drowsiness Detection System Using IOT

2.2 LITERATURE REVIEW

Driver drowsiness has been recognized as a critical factor in road accidents, prompting extensive research into automated detection methods. Various strategies have been explored, ranging from vehicle behavior analysis to physiological and image-based approaches. Early systems focused on vehicle-based measures, such as monitoring steering wheel movements, lane deviation, and vehicle speed .

[1]. While useful, these methods often lack precision and can be influenced by road or weather conditions. Physiological measures, such as electroencephalogram (EEG), electrocardiogram (ECG), and electrooculogram (EOG), provide accurate detection of fatigue but require direct contact with the user through sensors, making them intrusive and impractical for daily us.

[2].In contrast, computer vision-based techniques have gained prominence due to their non-invasive nature and suitability for real-time applications. These methods typically rely on facial feature analysis, particularly the Eye Aspect Ratio (EAR), which measures eye openness to detect blink rates and prolonged closure indicative of fatigue. Open-source libraries such as OpenCV and MediaPipe are commonly used to implement such systems.

[3].Researchers such as Patel et al.

[4] developed a system using OpenCV and Haar cascade classifiers for eye detection and determined drowsiness based on eye closure duration. However, the accuracy of these methods declines under varying lighting conditions or if the driver wears glasses. To overcome these limitations, advanced solutions have employed facial landmark detection using deep learning models and tools like MediaPipe, enabling precise tracking of 68 facial landmarks including eye and mouth positions.

[5].Recent developments have also seen the integration of Internet of Things (IoT) technologies into driver monitoring systems. IoT modules such as GSM, GPS, and Wi-Fi allow real-time data transmission, enabling systems to send alerts to emergency contacts or cloud platforms when drowsiness is detected.

[6]. For example, Reddy et al.

[7] combined computer vision with IoT components to build a system that not only detects drowsiness but also sends the vehicle's location and driver alert status to predefined contacts through GSM. Despite technological advances, challenges remain. Most systems still struggle with factors like poor lighting, head movement, and facial occlusion (e.g., sunglasses). Additionally, many existing solutions have only been tested in controlled environments, raising concerns about real-world reliability and generalization. In summary, the literature reveals that while substantial progress has been made in computer vision and IoT-based drowsiness detection systems, there is a clear need for further research on robustness, multisensor integration, and real-time deployment under diverse conditions.

3. RESULTS AND DISCUSSION

The Driver Drowsiness Detection System was thoroughly evaluated based on its detection accuracy, responsiveness, IoT capabilities, and performance under various real-world conditions. The following subsections summarize the key findings:

3.1 Accuracy of EAR-Based Drowsiness Detection

- The system continuously computed the **Eye Aspect Ratio (EAR)** using facial landmarks provided by the MediaPipe Face Mesh model.
- Under normal lighting conditions, the EAR-based method achieved **over 90% accuracy** in correctly detecting eye closure events.
- The chosen EAR threshold of **0.3** and a frame count of **150 consecutive frames** were optimal in balancing sensitivity and specificity, reducing the number of false positives while ensuring that true drowsiness was detected in a timely manner.

3.2 Alert Triggering and Response Time

- Once the EAR remained below the defined threshold for the required duration, the system **triggered an audible alert within 5 seconds**, assuming a frame rate of 30 FPS.
- The alert was delivered via a **buzzer or speaker**, immediately capturing the driver’s attention and helping prevent potential accidents caused by fatigue.

3.3 IoT Integration and Remote Notification

- With the inclusion of IoT modules such as **ESP32** or **GSM**, the system successfully transmitted **SMS alerts** or **logged data to a remote server** upon detecting drowsiness.

- This capability is particularly useful for **fleet management**, **remote driver monitoring**, and **emergency response**, providing added layers of safety and accountability in commercial transportation.

3.4 Testing Conditions

The system was tested in a variety of environments to assess robustness:

- **Daylight Conditions**: Delivered consistent and accurate EAR readings, with minimal noise or interference.
- **Low-Light/Night Conditions**: Required additional lighting or the use of an **infrared (IR) camera** to maintain reliable facial tracking.
- **Drivers Wearing Glasses**: Slight reduction in detection accuracy was noted, but proper **camera positioning** mitigated most issues.

3.5 Limitations

While the system performed well in most scenarios, certain limitations were observed:

- **Lighting Dependence**: Accuracy dropped significantly in poorly lit environments unless external lighting or IR cameras were used.
- **Camera Visibility**: The system assumes the driver's face is **clearly visible** to the camera at all times. Any **occlusions** or **misalignment** reduced detection reliability.
- **Alert Mechanism**: The current system uses basic sound alerts. More sophisticated alert mechanisms such as **voice prompts** or **vibration feedback** could improve effectiveness.

3.6 Future Enhancements

To further improve the system's performance and applicability, the following enhancements are proposed:

- **Multi-Modal Detection**: Integrate additional sensors such as **seat pressure sensors**, **pulse/heart rate monitors**, or **EEG headbands** for more comprehensive fatigue detection.
- **Machine Learning Integration**: Use trained **machine learning models** to detect subtle patterns of fatigue and reduce false alarms.
- **Enhanced Night Vision**: Incorporate **night-vision-compatible cameras** or **IR sensors** for better performance in dark or nighttime environments

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3.7 FIGURES AND TABLES

Test Scenario	Lighting Condition	EAR Detection Accuracy	Alert Triggered	Remarks
Driver fully awake	Normal daylight	98%	No	EAR stays above threshold, no alert needed
Driver slowly blinking	Normal daylight	94%	No	Correctly identifies blinking, no alert triggered
Driver eyes closed (sleep)	Normal daylight	92%	Yes (within 5 sec)	Alert triggered correctly, drowsiness detected
Driver with glasses	Normal daylight	85%	Yes (slight delay)	Slight drop in landmark accuracy due to glasses
Driver eyes closed	Low light	76%	Yes (slight delay)	Performance affected by poor lighting, requires extra lighting or IR
Driver turning head	Normal daylight	70%	No	Eye landmarks not always detected when head is turned

3.8 Explanation of Results

- **Normal Daylight Conditions**: The system performs excellently under normal lighting, with high accuracy in detecting eye closure or blinking, even when the driver is awake or blinking slowly. However, the presence of **glasses** slightly affects detection accuracy.

- **Low-Light Conditions**: When tested in low light, the detection accuracy drops significantly due to difficulty in tracking facial landmarks, especially the eyes. To mitigate this, the system needs additional lighting or an infrared (IR) camera for accurate tracking.
- **Driver Turning Head**: The system struggles with detecting eye landmarks when the driver turns their head, leading to a reduction in detection accuracy. This is because **facial landmarks** are less clearly visible, which affects the system's ability to compute the **Eye Aspect Ratio (EAR)** reliably.

4. CONCLUSIONS

The **Driver Drowsiness Detection System** effectively uses **computer vision** to monitor driver alertness in real time by calculating the **Eye Aspect Ratio (EAR)** from facial landmarks. It demonstrates high accuracy in detecting drowsiness under ideal conditions, offering a low-cost, non-intrusive solution. The system also integrates **IoT** components to send real-time alerts to emergency contacts, enhancing safety.

While it performs well in normal lighting, improvements such as **infrared vision** and **multi-sensor integration** could enhance performance in low-light conditions. Overall, this system presents a promising solution to reduce fatigue-related accidents and improve road safety, particularly in long-haul and commercial driving.

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