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SleepyWheels+: A Multi-Stage Driver Drowsiness Detection and Automated Safety Intervention System

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KEYWORDS

Driver Drowsiness Detection, Automated Safety System, Facial Landmark Identification, Speed Reduction Mechanism, Automatic Door Interlocking, Real-Time Alerting, , Twilio API, Mobile Deployment, Neural Network, Accident Prevention, Highway Safety, Driver Monitoring.

ABSTRACT

Around 40% of highway accidents in India are caused by drivers falling asleep behind the wheel. While several research efforts have been made to detect driver drowsiness, many suffer from high complexity and cost. In this paper, we propose SleepyWheels+, an advanced multi-stage system that enhances driver safety through real-time drowsiness detection and automated intervention mechanisms. SleepyWheels+ integrates a lightweight neural network with facial landmark identification to monitor driver fatigue efficiently. Our approach not only detects drowsiness but also incorporates automatic door interlocking, speed reduction mechanisms, and real-time alerting to enhance safety. When signs of drowsiness are detected, the system initiates multiple automated responses, including reducing vehicle speed, locking/unlocking doors as needed, and sending emergency alerts via WhatsApp using Twilio credentials. A Twilio sandbox account is used to connect with registered receiver numbers, ensuring timely notifications to emergency contacts. SleepyWheels+ utilizes EfficientNetV2 and a facial landmark detector for drowsiness detection. The model is trained on a specialized driver sleepiness dataset and achieves 97% accuracy. Due to its lightweight nature, it can be deployed as a mobile application across multiple platforms, making it a cost-effective and scalable solution for real-time driver monitoring and accident prevention. By integrating automated interventions and real- time communication, SleepyWheels+ significantly reduces the risks associated with driver fatigue, making highways safer.

1. INTRODUCTION

Driver fatigue is a major cause of highway accidents, with studies indicating that nearly 40% of such incidents in India occur due to drivers falling asleep behind the wheel. Existing drowsiness detection systems face challenges related to complexity, cost, and real-time

deployment. To address this, we propose SleepyWheels+, a multi-stage, automated system that not only detects drowsiness but also takes proactive safety measures to prevent accidents. SleepyWheels+ integrates facial landmark detection to monitor driver fatigue accurately. Unlike traditional methods, our system goes beyond detection by implementing automated interventions such as vehicle speed reduction, automatic door interlocking, and real time alert notifications. A key feature is the use of Twilio's API to send WhatsApp alerts to emergency contacts,ensuring immediate assistance. The system is lightweight, achieving 97% accuracy, and can be deployed as a mobile application, making it highly scalable and cost-effective. By combining real-time monitoring, automation, and communication, SleepyWheels+ offers a comprehensive solution to mitigate drowsiness-related accidents and enhance road safety.

1.1 Objectives

The primary objective is to create an efficient, low- cost solution to:

- Detect drowsiness in drivers through facial landmark analysis
- Alert the driver with an audio signal to regain attention.
- Reduce the risk of accidents caused by fatigue.

Driver Drowsiness Detection

Driver drowsiness detection refers to the process of identifying signs of fatigue in drivers to prevent accidents. This is done by monitoring facial expressions, eye movements, and head positions using computer vision and deep learning techniques. SleepyWheels+ employs and facial landmark detection to assess fatigue levels in real time.

Facial Landmark Identification

This technique involves detecting facial features such as eyes, mouth, and head orientation to analyze signs of drowsiness. If the system identifies closed eyes for an periodof time or yawning, it sends warning.

Speed Reduction Mechanism

When drowsiness is detected, the system gradually reduces the vehicle's speed to prevent sudden accidents. This is achieved by sending signals to the vehicle's control unit and reduces speed .

Automatic Door Interlocking System

To enhance safety, the system locks or unlocks vehicle doors based on drowsiness detection. This prevents the driver from exiting the vehicle in unsafe conditions.

Real-Time Alerting System

The system notifies emergency contacts or relevant authorities when drowsiness is detected. Alerts can be sent via WhatsApp, SMS, or other messaging platforms, allowing for quick response and assistance.

WhatsApp Notification via Twilio API

Twilio is a cloud-based communication platform that enables automated messaging. SleepyWheels+ uses Twilio's sandbox account to send WhatsApp alerts to predefined emergency contacts. This ensures thatfamily members or emergency responders are notified instantly in case of drowsiness detection.

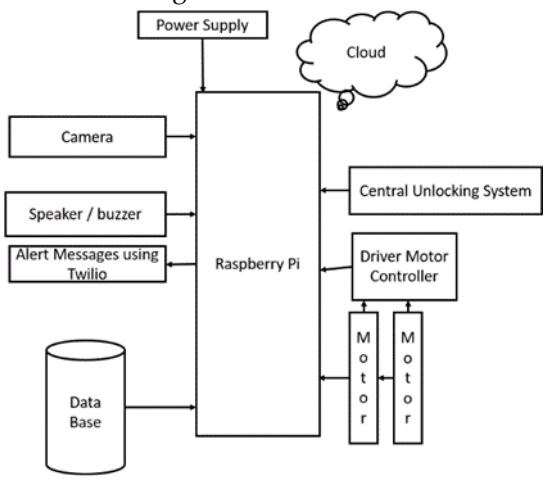
Neural Network-Based Detection

A neural network is used to process and classify driver states (alert or drowsy) based on facial input. The model is trained on a custom dataset specific to driver sleepiness, ensuring high accuracy in real- world scenarios. Accident Prevention and Highway Safety By integrating drowsiness detection with automated interventions and real-time alerts, SleepyWheels+ significantly reduces the risk of highway accidents, enhancing overall road safety.

EXISTED SYSTEM: SleepyWheels is a novel approach toward drowsiness detection using a lightweight convolutional network in parallel with facial landmark detection, to achieve real-time driver drowsiness detection. It achieves an accuracy of 97% on the custom-made SleepyWheels dataset. It has proved to be effective in a variety of test cases, such as absence of facial features while covering eye or mouth, varying skin complexion of drivers, varied positions of the camera and varying angles of observation.

Proposed Model: In Proposed Model,if the Drowsiness is Detected the alarm will be sended by the Processing unit and Speed will be decreased and Automatic break system comes into action amd sends message through TWILIO API.

1.2 Block Diagram



2. EXPERIMENTAL METHODOLOGY

The SleepyWheels+ system is designed to detect driver drowsiness and take automated actions to prevent accidents. The methodology involves multiple stages, from identifying signs of fatigue to executing real-time safety mechanisms like speed reduction, door interlocking, and emergency alerts. Below is a detailed breakdown of each step in the systems.

2.1. Data Collection and Model Trainin Collecting

Driver Fatigue Data To ensure accurate drowsiness detection, the system is trained using a specialized dataset that contains images and videos of drivers in both alert and drowsy states. The dataset includes: Different facial expressions (eyes open, eyes closed, yawning, head tilting).Varying environmental conditions (different lighting, skin tones, and camera angles). Multiple camera placements (dash- mounted, rearview mirror, smartphone). Training the Deep Learning Model The model is trained using , a lightweight and powerful deep learning framework .The training process ensures that the system can accurately classify drowsy and alert states with 97% accuracy.The model is optimized to run efficiently on mobile and embedded systems.

2.2 Real-Time Facial Landmark Detection and Drowsiness Analysis Capturing the Driver's Face

A camera (dashboard, in-car, or smartphone) continuously records the driver's face.The system analyzes facial expressions and movements in real time.

2.2.1Detecting Drowsiness Using Facial Features

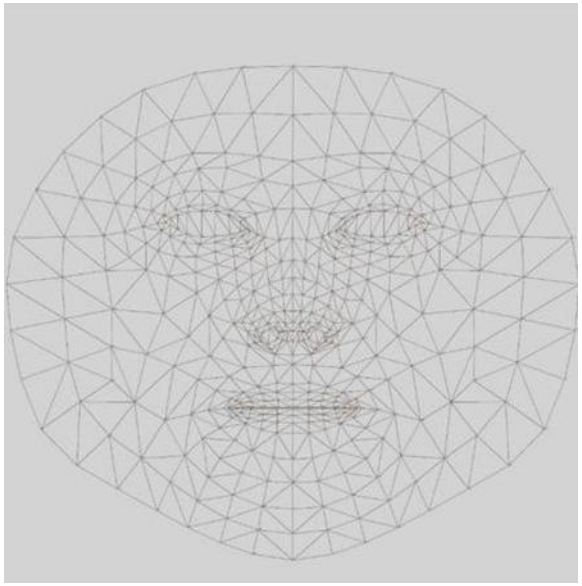


Figure 2.1 landmarks returned by MediaPipe's Face Mesh

The landmarks 30, 29, 28, 243, 22, 24, 463, 258, 259, 359, 254 and 252 are used to calculate EAR (Eye Aspect Ratio) and the landmarks 61, 39, 0, 269, 287, 405, 17, 181 are used to calculate MAR (Mouth Aspect Ratio). Equation 2 calculates the EAR values. Table 2 gives the computed values of the EAR for the left and right landmark and Figure 2 showcases

$$EAR = \frac{||p2-p6|| + ||p3-p5||}{2*||p1-p4||}$$

The system monitors key facial landmarks such as:

• Eyes → Detects whether they are open or closed for a prolonged time (Blink Detection).

Variable	Left Eye Landmark	Right Eye Landmark
p1	30	463
p2	29	258
p3	28	259
p4	243	359
p5	22	254
p6	24	252

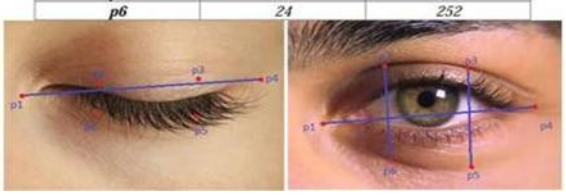


Fig 2.2 Measurement of eye aspect ratio (EAR) when closed (left) and when open (right)

• Mouth → Identifies yawning, which is a strong indicator of fatigue.

Variable	Mouth Landmark
p1	61
p2	39
p3	0
p4	269
p5	287
p6	405
p7	17
p8	181

• Head Movement → Detects head nodding or tilting, a sign of micro-sleeps.

2.2.2Drowsiness Classification

• If the system detects signs of fatigue for a certain period (e.g., 2-3 seconds), it classifies the driver as drowsy. • If no signs of fatigue are found, the system continues monitoring.

2.3 Warning System Activation

When drowsiness is detected, SleepyWheels+ triggers an alert to wake up the driver using the following methods:

2.3.1Audio and Visual Warnings

• A loud alarm sound plays through the car speakers or mobile phone.

• The screen displays a visual warning message like "Wake Up! You are feeling drowsy!"

2.3.2Vibration Alert

• If connected to a smart steering wheel or driver's seat, the system activates vibration motors to alert the driver.

If the driver fails to respond to these warnings, the system moves to the next stage of automated intervention

2.4. Automated Safety Measures

If the driver remains unresponsive, SleepyWheels+ takes control by triggering various safety mechanisms:

2.4.1Speed Reduction Mechanism.

• The system gradually slows down the vehicle by sending commands to the vehicle's Electronic Control Unit (ECU).

• This ensures the vehicle is brought to a safe speed without sudden braking to avoid accidents.

2.4.2Automatic Door Interlocking

• The system locks the doors if drowsiness is detected, preventing the driver from exiting the vehicle in an unsafe manner.

• In case of a critical emergency (e.g., vehicle stopped safely), the doors can be unlocked remotely by emergency contacts.

2.5 Emergency Alert System Using Twilio and WhatsApp

If the driver remains in a drowsy state, the system notifies emergency contacts through WhatsApp messages using Twilio API.

2.5.1Connecting to Twilio's API

• Twilio's sandbox account is used to connect with pre-registered phone numbers of family members, fleet operators, or emergency services.

2.5.2Sending Automated WhatsApp Alerts The system automatically generates a message containing:

• Driver's status (Drowsy/Unresponsive)

. • Vehicle location (GPS coordinates) for immediate tracking.

• Emergency contact information for quick response.

"ALERT! The driver of vehicle XYZ is feeling drowsy and has not responded to alerts. Location: [Google Maps link]. Please take immediate action!" Thisensures that emergency responders or family members can intervene quickly to prevent accident.

2.6. Mobile Application Deployment

2.6.1Lightweight and Portable System

• The SleepyWheels+ model is optimized to run on mobile devices (Android/iOS), making it accessible to drivers worldwide.

• It does not require expensive hardware, allowing easy adoption by individuals and fleet operators. 2.6.2 Compatibility with Different Vehicles.

• Can be used in personal cars, taxis, trucks, and commercial vehicles.

• Works with dash cameras, smartphones, or built-in vehicle cameras.

3. LITERATURE SURVEY

Several methods have been developed to detect driver drowsiness. One of the earliest approaches relies on analyzing driving patterns by monitoring steering wheel movements and vehicle trajectory. Researchers like Krajewski et al. found an 86% accuracy in detecting drowsiness using this method. However, this approach is not always reliable since it depends on road conditions, vehicle type, and driver skill. A more recent and widely used technique is based on computer vision,

which uses a camera to monitor facial expressions and detect drowsiness indicators like frequent blinking, yawning, and head movements. Researchers such as Danisman et al. and Dua et al. developed systems that analyze eye closure and yawning patterns to determine sleepiness. More advanced deep learning models, such as CNNs, have been used to improve accuracy, but they often require high memory and processing power, making them difficult to deploy on mobile or embedded devices. However, models are now bridging the gap between high accuracy and lightweight computing, making them a promising alternative. Many automobile companies, including Volkswagen, Renault, Nissan, BMW, and Jaguar Land Rover, offer built in drowsiness detection systems. However, most of these systems rely mainly on driving behavior (pedal and steering interactions) rather than facial recognition. The goal of SleepyWheels is to demonstrate theeffectiveness of a simple and efficient computer vision- based model over traditional methods used in commercial vehicles, making drowsiness detection more accessible and reliable.

4. RESULTS AND CONCLUSION:

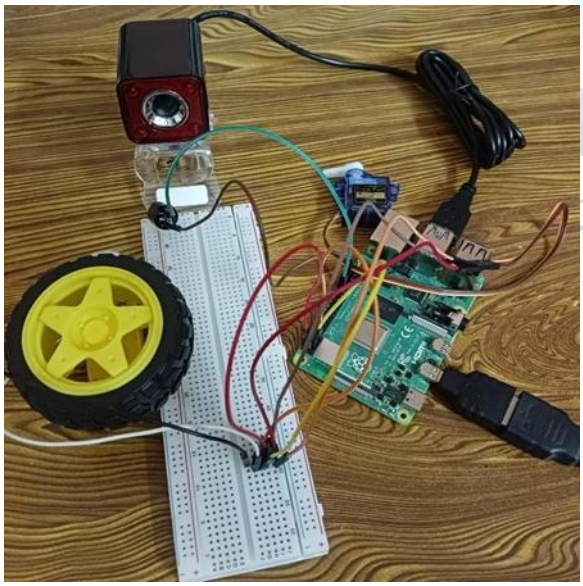


Fig4.1:PROTOTYPE

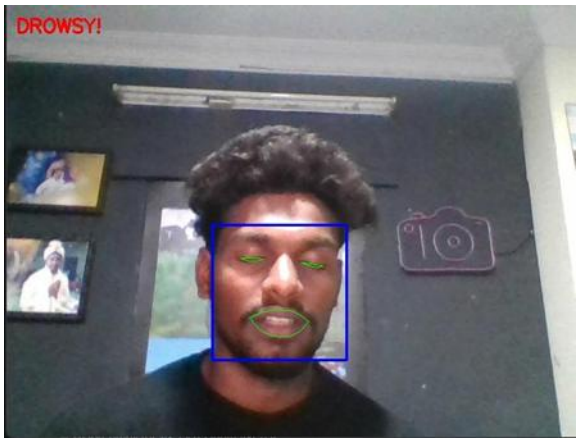


Fig 4.2 Drowsiness Detected.

When a Driver Closes eyes for a Period of time.The Droesiness is Detected and Sends Alert Message or Alarm.In the above figure Drowsiness is Detected.

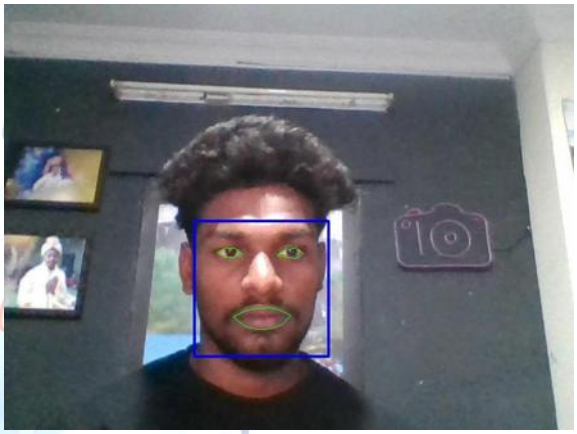


Fig 4.3 Driver Alert After Drowsiness is Detected

After Detection of Drowsiness the Driver is Alerted.If there is no alertness in Driver the System will Automatically Reduces the Speed and Automatic Breaking system will be activated and sends whatsapp Alert message to the Emergency contacts through TWILIO API. The system locks or unlocks vehicle doors based on drowsiness detection. This prevents the driver from exiting the vehicle in unsafe conditions.

6.Future Work

Outline specific plans for future work based on the ongoing findings and areas requiring further investigation or refinement. This may include adjustments to experimental parameters, additional data collection, or validation studies.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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