iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: VI Month of publication: June 2025

DOI: https://doi.org/10.22214/ijraset.2025.72725

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VI June 2025- Available at www.ijraset.com

Road Safety by Detecting Drowsiness while Driving using Machine Learning

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Abstract: Driver drowsiness is one of the major causes of road accidents, leading to countless injuries, fatalities, and property damage every year. In this paper, we introduce a real-time drowsiness detection system that uses computer vision to monitor the driver's alertness. The system works with a regular webcam and tracks facial landmarks to analyze eye aspect ratio and blinking behavior. If the driver shows signs of drowsiness, such as slow blinking or prolonged eye closure, the system immediately triggers an audible alarm to wake them up and avoid a possible accident. We've built the system using Python along with OpenCV, dlib, and pygame libraries, which makes it affordable and easy to implement. Our experiments show that it performs well in normal lighting conditions, offering a practical and non-intrusive way to improve road safety.

I. INTRODUCTION

Road safety continues to be a major concern around the world, with millions of accidents reported each year. One of the key contributors to these incidents is driver fatigue or drowsiness, especially during long-distance travel or highway driving. When a driver is drowsy, their reaction time, focus, and decision-making ability are significantly impaired, which can lead to serious or even fatal accidents. While traditional methods like awareness campaigns and rest-stop recommendations have helped to some extent, they haven't been completely effective in tackling this issue. Thanks to rapid advancements in technology—especially in embedded systems and computer vision—there's now potential to build smart systems that monitor a driver's alertness in real time.

These systems can issue warnings when signs of drowsiness are detected, helping prevent accidents before they happen. This thesis focuses on the design and implementation of a driver drowsiness detection system using facial landmark tracking and head pose estimation. The goal is to create a solution that is efficient, non-intrusive, and suitable for integration into today's vehicles, ultimately promoting safer driving and supporting intelligent driver assistance systems.

II. TOOLS & REQUIREMENTS

- Webcam or Camera Module.
- Dual-core processor.
- 4 GB RAM.
- Intel i3/i5 or equivalent.
- 8 GB RAM.
- Speaker or Buzzer.
- Embedded Computing Borad.
- Raspberry Pi (Model 4 or Higher)
- NVIDIA Jetson Nano.
- Xavier NX.
- Operating System.
- Programming Language (Python 3x)
- OpenCV.
- Dlib.
- Imutils.
- Pygame.
- Numpy.
- IDE/Text Editor.
- Package Manager.

III. ADVANTAGES

- Real-Time Monitoring: Continuously tracks facial features and triggers alerts withminimal delay.
- Non-Intrusive: Does not require wearables or physical contact, ensuring driver comfort.
- Cost-Effective: Built with affordable hardware (webcams) and open-source libraries.
- Early Warning Capability: Detects drowsiness indicators before critical alertness dropsoccur.
- Scalable and Extensible: Can be deployed in various vehicle types and upgraded withadditional sensors.
- User-Friendly: Provides intuitive audio and visual feedback that is easy to interpret.

IV. DISADVANTAGES

- Lighting issues: Poor lighting reduces detection accuracy.
- Sunglasses/headgear: Block face/eye visibility, causing false negatives.
- Privacy concerns: Continuous monitoring may raise ethical questions.
- Head position changes: Fast or extreme head turns may disrupt facial landmark detection.

V. APPLICATIONS

1) *Personal Vehicles*

- Monitoring the driver's eye movement and face continuously.
- Triggering real-time alerts (like sound, vibration, or voice prompts) when signs of sleepiness are detected.
- Reducing the risk of accidents by keeping the driver alert or advising them to stop and rest.

2) *Public Transport*

- A drowsiness detection system can alert drivers before they fall asleep.
- It enhances passenger safety, reduces accident risks, and ensures better service reliability.
- Could be mandated by transportation authorities as part of safety regulations.

3) *Fleet and Logistics Companies*

- Driver fatigue, especially in overnight or long-haul journeys.
- Liability for accidents caused by sleepy drivers.

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4) *Car Manufacturing*

- Built into the vehicle using in-dash cameras or steering sensors.
- Combined with other safety features like lane-keeping, emergency braking, or adaptive cruise control.
- Used to pause self-drivingmode or switch back to manual mode if the driver is drowsy in semi-autonomous cars.

VI. FUTURE SCOPE

1) *IoT & Cloud Monitoring:*

IoT (Internet of Things) allows devices (like your drowsiness detection system) to connect to the internet and share data in real-time.

When drowsiness is detected, the system can transmit alerts and data to:

- Fleet managers who manage delivery or transportation drivers.
- Family members for private vehicles, so they're informed of the driver's condition.

2) *Multimodal Inputs:*

Relying on only one input (e.g., eyes) can lead to false positives or missed detections.

Multimodal systems use multiple inputs such as:

Eye tracking: For blinking and gaze direction.

Heart rate sensors (e.g., smartwatch): Sudden drop or irregularity couldindicate fatigue.

Steering behaviour: Jittery or slow corrections may reflect drowsiness.
Voice recognition: Slurred or delayed speech from the driver could be another symptom.

3) Autonomous Vehicles:
Semi-autonomous vehicles (like Tesla Autopilot or Level 2 ADAS) still require the driver to be alert and ready to take control.
If the driver is drowsy or unresponsive, they may fail to take over the vehicle in an emergency.

4) Deep Learning:
Deep learning, especially CNNs, excels at image recognition tasks.
Instead of using simple EAR formulas, CNNs can:

- Automatically learn to detect subtle facial changes
- Recognize micro-expressions and fatigue patterns (e.g., droopy eyelids, facial tension)
- Work better across different skin tones, face shapes, and lighting conditions

VII. CONCLUSIONS

In this project, we developed a real-time driver drowsiness detection system using computer vision techniques. By leveraging facial landmark detection, eye aspect ratio analysis, blink frequency monitoring, and head pose estimation, the system effectively identifies signs of driver fatigue, excessive blinking, and head nodding. The implementation provides immediate audio and visual alerts, offering a practical and non-intrusive solution to enhance road safety and reduce the risk of accidents caused by drowsiness. Experimental results demonstrate that the system performs reliably under typical conditions and can be integrated into modern vehicles as an intelligent driver assistance feature.

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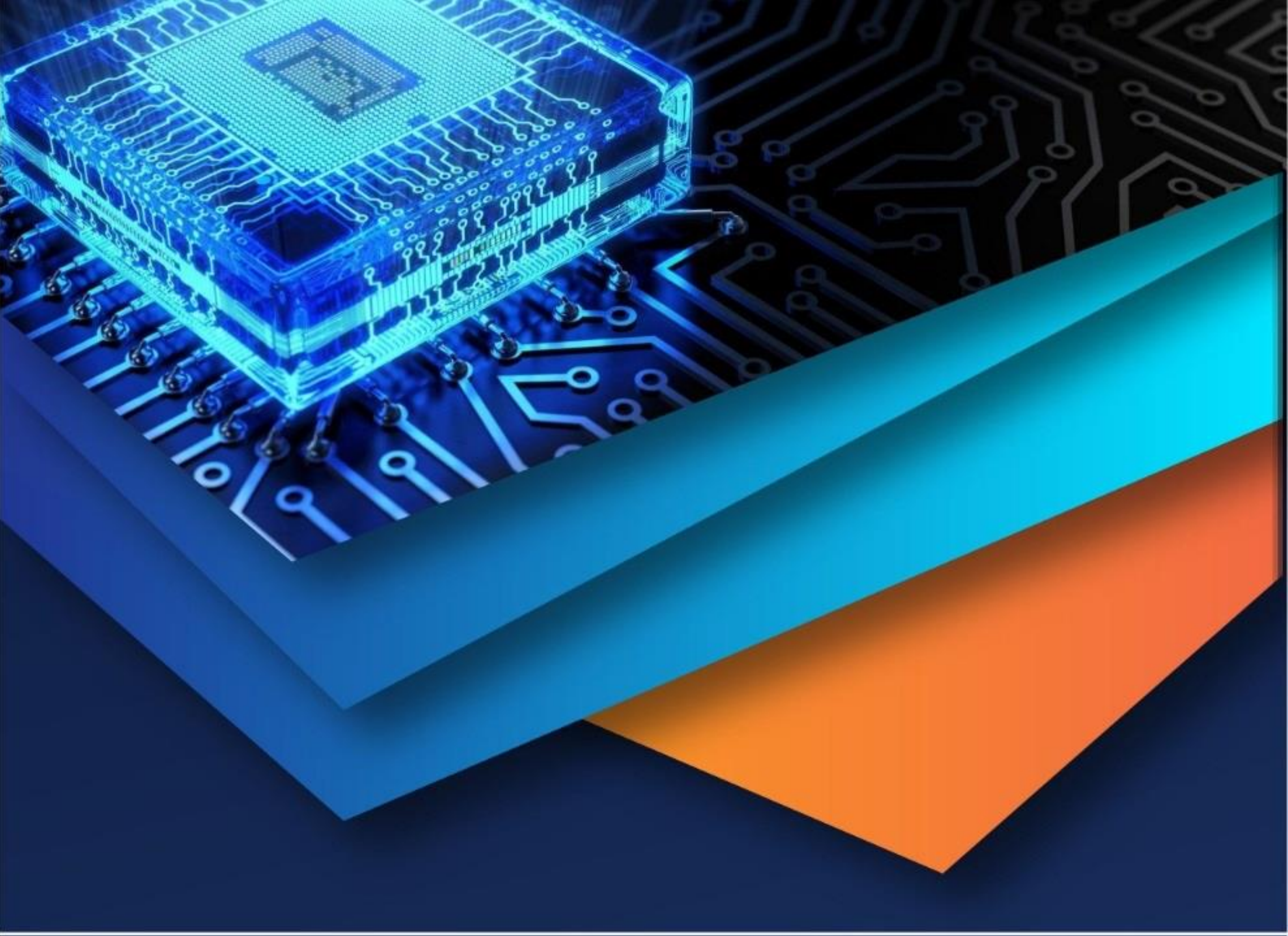

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