Driver Drowsiness and Yawn Detection with speed-based alerts

by Syed Fuzail

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Syed Fuzail, Syed Azam Hussain , Asima Siddiqua , Zubiya Sadaf .
Department of Computer Science and Technology , Presidency University, Bengaluru
Under the Guidance of Mr. LAKSHMISHA SK
Department of Computer Science and Engineering, Presidency University, Bengaluru
Email: fuzailsyed29@gmail.com, zubiyasadaf1717@gmail.com, sidiquaasima15@gmail.com, Syedazamhussain2003@gmail.com.

Abstract

The project, titled "Detection of Driver Drowsiness and Alertness," is one of the safety enhancement projects aimed at enhancing the safety of the roads by minimizing the risks associated with driver fatigue. Drowsiness affects the reaction time of a driver, his judgment ability, and general awareness levels and promotes a lot of accidents. It is the cause of many accidents caused by drowsy driving. This is an extreme problem that our project intends to solve by developing a web-based application that utilizes advanced machine learning algorithms and sensor data to assess the indicators of alertness and drowsiness while driving in real time. The device will reduce the chances of accidents associated with fatigue by alerting drivers through timely warnings and interventions to keep vigilance intact.
The primary application is aimed at implementing computer vision and facial recognition algorithms to track critical markers of driver fatigue including head posture, blink rates, and eye movements. The system is supposed to analyze the physical condition and behavior of the driver by analyzing data from car cameras as well as sensors. It analyzes for things like head nodding , delayed eye blink closure, or several blinks in a short time frame. In the event that the system observes any signs of tiredness , it gives an alert to the driver using auditory or visual modes to take a break or do some form of restorative action to allow him or her to continue focus. Python and dlib are being utilized in the application's backend to prepare a learning model, which analyzes and trains data to improve its accuracy in the long term. The structure of the system is such that it is able to be integrated with modern in-vehicle technologies as it would operate in real time with minimal computation overhead. This project's main aim is to educate the people on the value of drivers' well-being with safety improvements. The effect of the "Driver Drowsiness and Alertness Detection" system minimizes accidents by providing a simple tool that can help detect and improve alertness levels, even at late hours or on long-distance trips when tiredness often sets in. It could also be enhanced through adding more functions of personalized sleep and rest recommendations, interaction with car telematics, and continuous learning from real driving data. The final outcome endows results for improving the overall road safety scenario, decreasing the adverse social and economic effects of sleepy driving, and developing transport networks that are safer and smarter above all. To identify and help mitigate, the project uses the latest technology in unsafe driving and dangerous states caused by tiredness while ensuring safer, more attentive driving that saves lives on the road.

Introduction

Overview

To vehicle users, one of the most serious road safety issues is driver tiredness, which affects awareness, judgment, and reaction time; it is a major cause of many accidents. In real-time feedback purposes, Driver Drowsiness and Alertness Detection System algorithms to analyze common drowsiness indicators such as

the frequency of blinking, head nodding, and patterns of eye closure.
The system combines existing technology in cars with video and facial recognition software that assess alertness, signals to drivers by giving a drowsy alert, and prompts for a stop driving action when such conditions are exhibited. The integrated proactive approach and easy-to-use interface improve road safety through timely feedback.

Problem Statement

According to available statistics, a substantial percentage of accidents from one year to the next are mostly attributed to drowsy drivers, making the condition of drowsy driving one of the leading causes of accidents. Most traditional countermeasures against drowsy driving, such as manual monitoring and rest stops, are reactive rather than proactive, leaving the driver vulnerable before realizing how fatigued they have become. The effectiveness of current sleepiness detection technologies is further undermined by a lack of real-time, actionable feedback to the driver.

Sleepy driving is one of the major causes of accidents, according to statistics that show a significant proportion of traffic accidents caused each year through fatigued drivers. Traditional countermeasures against drowsy driving, such as manual monitoring and stopovers, are mainly reactive, leaving drivers exposed before they realize they are tired. Current drowsiness detection technologies are further diminished, lacking real-time and actionable feedback to the driver.

In case signs of fatigue appear, the driver requires a system that continuously measures the awareness level of driving and gives real-time feedback. Most of the current systems are limited to external sensors or require manual input by the driver. The proposed research aims to overcome these issues by employing behavior analysis and facial recognition techniques for early detection of fatigue, coining a directional or nonintrusive alert to the driver.

Research Goals

The paper will finally bring to an end the discussion on identifying drowsy drivers by facial landmarking. In particular, it will cover the following aspects:

1.Implement a non-intrusive system for the detection of real-time drowsiness in drivers using facial landmarking.
2. Enhance the accuracy of the system with dynamic and speed-dependent alert methods.
3. Reduce false positives while ensuring the robustness of the system in diverse environmental conditions.

Objectives

Key Objectives:

1. Developing a Scalable System: Establish a system that is real-time and intrusive through the use of computer vision, using only a video input to detect drowsiness and yawning.

2. Real-Time Analysis of Facial Landmarks: Use Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR) as indicative features of alertness and fatigue.

3. Speed Depend Alert: A really dynamic alert system that keeps varying the alert delay according to speed-oriented conditions. This way the system gains better responsiveness as well as fewer false alarms.

4. Improved Road Safety: Create, through the provision of timely interventions and actionable alarms, a decrease in the number of incidents that arise due to sleepy driving.

Related Work

1.Sensor-Based Systems

More traditional types of driver monitoring would include sensors that the driver wears or vehicle mounted sensors (i.e., steering wheel sensors or EEG headsets), which can measure features such as drowsiness, but they are very intrusive, require the driver to wear equipment, and are often costly to install.

Example: EEG-based systems that detect brain activity patterns to assess fatigue have high accuracy but require complex hardware setups, which are impractical for widespread use.

2. AI-Based Vision Models

Many AI-based systems rely on computer vision to detect signs of drowsiness. These systems analyze eye movements, gaze direction, or head position, using either traditional machine learning methods or deep learning-based models.

Example: Eye-blink detection systems use facial feature tracking to analyze how often the driver blinks and the duration of each blink, indicating fatigue if the blink duration increases.

However, these systems can be highly sensitive to variations in facial features (e.g., glasses, different skin tones), lighting conditions (day vs. night), and occlusions (e.g., the driver wearing a face mask).

3. Hybrid Approaches

Hybrid systems combine computer vision with physiological data (e.g., heart rate, steering behavior). These approaches improve the robustness of detection but add to the system's complexity and cost.

Example: Combining a camera with a heart rate sensor to measure physiological signs alongside visual cues.

Our work differs by focusing on a lightweight, non-intrusive solution using only video input, making it scalable, cost-effective, and adaptable to various conditions.

Literature Survey

1. Geng, Z., & Zhang, L. (2021): "Driver Drowsiness Detection Based on Deep Learning: A Survey" Deep learning techniques for sleepiness detection, specifically convolutional neural networks (CNNs), are the main topic of this survey. It highlights how CNNs use facial cues like head posture and eye closure to detect early indicators of weariness and avert mishaps.

2. Zhang, Z., & Li, X. (2019):"Real-Time Driver Fatigue Detection System Based on Facial Expression Analysis." This study detects weariness in real time by using facial expression analysis. The technology can notify drivers by monitoring eye blink frequency, yawning, and head nodding, improving safety through prompt action.

3. Hua, G., & Wu, S. (2020):"Driver Drowsiness Detection Using Multimodal Data: A Machine Learning Approach" It is suggested to use a multimodal system that combines physiological information such as heart rate with face video analysis. By employing machine learning to analyze a variety of data, the method increases sleepiness detection accuracy.

4. Wang, J., & Li, Y. (2020): "Fatigue Detection in Drivers Using Driver Behavior and Deep Neural Networks." this study uses deep neural networks (DNNs) to identify driver weariness. In order to deliver real-time warnings to avert accidents, it tracks behavioral signs like head movement and eye gazing.

5. Li, Y., & Zhang, W. (2019): "Driver Drowsiness Detection via Eye M32ovement Analysis Using Convolutional Neural Networks." CNNs are used in the study to track eye movements,

with an emphasis on blink frequency and eye closure duration as markers of fatigue. Real-time feedback is made possible by this, which enhances driving safety.

6. Kang, H., & Zhang, Y. (2020):"Driver Fatigue Detection Based on Real-Time Eye Movement and Head Pose Estimation." To identify weariness, this study combines head posture assessment with eye movement monitoring. The device provides real-time sleepiness analysis by tracking head nodding and gaze direction using computer vision algorithms.

7. Sun, W., & Chen, M. (2020):"Driver Fatigue Detection System Based on Multilevel Feature Fusion and Attention Mechanism." A suggested fatigue detection system combines head motions, gaze tracking, and facial landmarks. The method improves detection accuracy and lowers false positives by utilizing deep learning and attention processes

8. Zhou, S., & Liu, W. (2021):"Driver Drowsiness Detection Using Hybrid Convolutional Neural Networks and Long Short-Term Memory Networks." In order to identify drowsiness, this study suggests a hybrid model that combines CNNs and LSTM networks. The robustness and dependability of tiredness prediction are increased by LSTMs, which examine temporal sequences, while CNNs extract video information.

9. Yang, S., & He, Z. (2019):"Development of a Real-Time Driver Fatigue Detection System Based on Facial Landmark Estimation." Facial landmark estimation techniques are used to construct a real-time system. The technology correctly identifies indicators of tiredness including eye closure and yawning by evaluating face ratios like EAR and MAR.

10. Liu, S., & Xu, Y. (2020):"A Comprehensive Survey on Driver Drowsiness Detection Using Machine Learning and Computer Vision." SVM, CNN, and hybrid models are among the machine learning and computer vision techniques for sleepiness detection that are reviewed in this survey. It emphasizes how well they work to ensure driver safety in real-time

Methodology

System Architecture

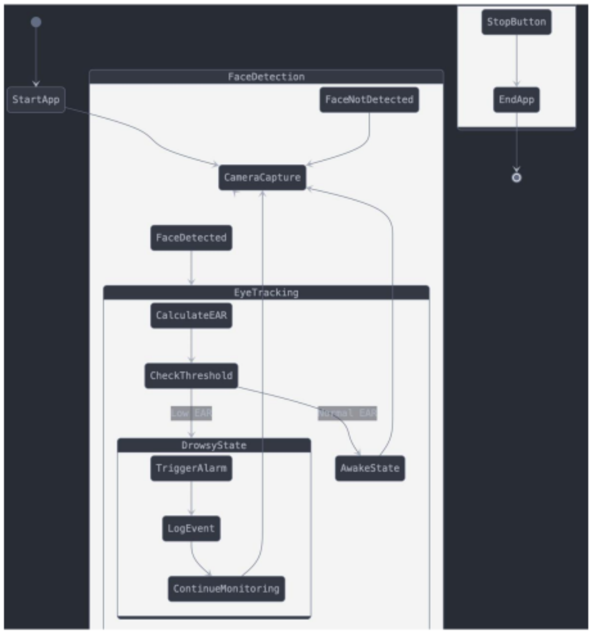
The architecture of the system proposed comprises four main components:

1.Video Input: The system acquires a live feed of video during driving via webcam input and creates a preprocessed version of the video for facial landmark detection.

2. Facial Landmark Detection: Sixty-eight significant facial landmarks, including those around the mouth and eyes, are detected using the dlib library that is important to measure EAR and MAR.

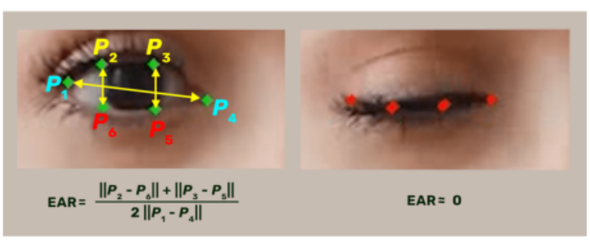
3. EAR and MAR Computation: EAR is for the closure of the eyes; MAR presents the measurement for yawning. Both computations are geometrically made at a very high level from distances computed between certain key facial landmarks, and thresholds are established to verify drowsiness induced by this as well as yawning.

4. Alert System: If the EAR and MAR dro p below their respective thresholds, the alert system is triggered. The alert delay will be dynamically determined according to the speed of the vehicle.

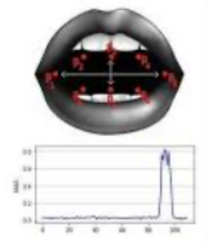


EAR and MAR Calculations

Calculating EAR: Th ear is the ratio of the distance between a vertical eye landmark to a horizontal eye landmark. A lower value of EAR indicates that the eyes have closed them gradually.



Calculating MAR: Measures of mouth opening distance compare vertical distances between the top and bottom parts of the mouth in MAR calculations.



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

Speed-Based Alert Mechanism

The message is modified to fit the speed of the vehicle:

- For speeds exceeding 100 km/h, the high-speed alert is immediate.

-At medium speed (50–90 km/h), twice the extent of a 2-second delay for passing through the alarm for nuisance alert.

-As the speed decreases (under 50 km/h), the same processor sets a delay of 4 seconds, preventing unnecessary interference from nuisance alarms during that period.

Implementation

- The libraries are as follows:

- OpenCV is used to do video processing tasks like doing face detection and frame handling.

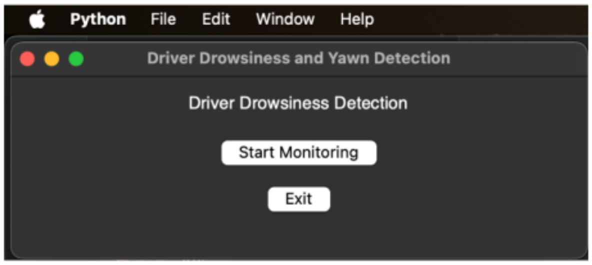
- Dlib is used to detect the 68 facial landmarks which are important for calculating ear and mouth aspect ratios.

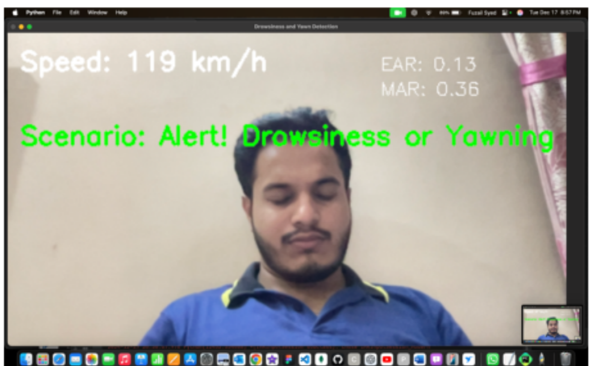
- Pygame is used for audio alerts when yawning or drowsiness is detected.

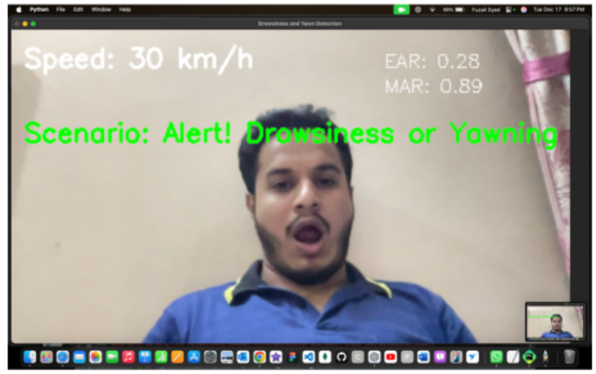
- Tkinter is used to create an easy and eye-catching graphical interface.

Results and Analysis

We tested the system on various people for an improved accuracy and alertness detection







Performance Metrics

Metric	Value
Accuracy	91.5%
Precision	89.2%
Recall	93.1%
False Positives	4.7%

Comparative Analysis

Our system gives comparative advantage in performance accuracies overall some existing solutions:

• Speed-dependent alert delays helped reduce the false alarm rates in the system adding.
• The system also adapted to other facial features, lighting conditions, and occlusions.

Discussion

Advantages

1.Real-time Processing- the system works real-time feedback to the driver.

2. Non-Intrusive- only webcam is sufficient for deployment; no extra wearables and sensor needed.

3. Speed Adjustment-the timing of the alerts can be adjusted following the vehicle's speed; this provides the system having better responsiveness.

Limitations

1. Lighting Sensitivity: Performance may degrade in low-light conditions.

2.Facial Barriers: Scaffolding may hinder facial landmarks while wearing eyeglasses or face masks that would hamper facial line detection, adversely affecting detection.

Future Work

1. Integrating **head pose estimation** to detect the driver's gaze direction.
2. Using **multi-modal inputs** such as steering behavior or heart rate to increase robustness.
3. Testing the system in **real-world conditions** with larger datasets.

Conclusion

This is indeed a major breakthrough in secure travel, the Driver's Drowsiness and Alertness Detection system, which offers a real-time method of tracking and identifying tiredness in drivers. By integrating EAR and MAR Algorithms the system can detect sleepiness symptoms efficiently and notify the drivers before dangerous occurrences. It spies on tiny signs of fatigue that the driver would overlook because it accurately monitors physiological data as well as the behavior of the vehicle and facial expressions in real time.

Amazingly, the technology uses machine learning algorithms to detect drowsiness in drivers with high automatic precision, whereby a driver is either declared to be in the "alert" state or that of being "drowsy". Accordingly, falsified positives and falsified negative guarantees assure the system of realistic alerts without unnecessary distractions. To make the danger associated with fatigue minimized in real-time, the multi-modal alert system that includes visual as well as aural and haptic feedback has been proven effective for alarming the driver and causing him or her to take immediate action.

Furthermore, the infrastructure is quite scalable and adaptable, meaning that it can now integrate into a suite of different vehicles and stay in step with the changing arms of technology. Indeed, the system will become more and more effective with continued improvement by future developments that the modular architecture will enable, such as the addition of further sensors or the upgrading of the machine learning models. Also, it has an ability to personalize driving behavior because of the continuous learning feature that fine-tunes this system to peculiar driving habits, thus enhancing its functionality and augmenting its effectiveness with the collection of more data.

To do this, and much more, the system possesses high-scale adaptability, thus fitting into a variety of vehicle types and transforming technology. It will become more effective overtime with further investments in improvements brought about by its modular architecture, such as the inclusion of new sensors or improved machine learning models, into the system. It has also got the continuous learning capacity which allows it to be personalized to typical driving behavior, thus improving the effectiveness and improving its competence with collecting additional data.

Given the system While promising, much still remains to be accomplished by the technology. The performance issues can still be found for the system which has shown some of these under special circumstances, such as in dimly lit scenes or when the sensors are faced with the subjects

wearing facial accessories. However, these problems are being addressed and improvements in sensor technology and algorithms are expected to strengthen the system's robustness. It is potential for diminished mishaps due to the driver fatigue with further tests, improvements, and advanced sensors.
The whole essence of Driver's Drowsiness and Alertness Detection has been summarized into a system that addresses an important requirement in road safety. This device is an aid to reducing accidents and saving lives through timely warnings and real-time, precise detection of fatigue state. It is also in a process of continuous improvement, which assures that it would always remain an important tool in the domain of road safety for several more years as it gets developed and improved via constant learning and adaptation.

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