IoT-Based Safe Drive Drowsiness Detection System

Vaishali Kolhe[1], Piyush Peraspure[2], Sachchaita Hangloo[3], Aamodi Patole[4], Yashraj Jagtap[5]
[1,2,3,4,5]Department of Computer Engineering, DY Patil College of Engineering, Akurdi, Pune- 411044 India

***Abstract*—Driver drowsiness is one of the most important reasons for road accidents around the world, especially while traveling long distances and at night. Continuous monitoring of the driver's alertness is required for preventing accidents. Conventional techniques for fatigue detection using physiological sensors are invasive, costly, and not suitable for real-time implementation in vehicles. This paper proposes a non-invasive IoT-based driver drowsiness detection system using computer vision and facial landmark analysis. The proposed system uses the MediaPipe FaceMesh model for identifying the important facial landmarks around the eye and mouth regions. Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR) are calculated continuously to identify the sustained closure of eyes and yawning behavior. Moreover, the estimation of head tilt, as well as the monitoring of head stillness, is combined for enhanced robustness. A laughter/talking filter is used to avoid false alarms when the mouth is normally moving. When drowsiness is detected, the system sends an alert and records events for later analysis. Future improvements will include implementation on a hardware kit based on Raspberry Pi, with emergency notification and location sharing using GSM. The system offers an effective and affordable solution for smart driver safety systems.**

***Index Terms*—Driver Drowsiness Detection, MediaPipe FaceMesh, EAR, MAR, Head Pose Estimation, IoT Safety System, Raspberry Pi.**

I. INTRODUCTION

Road accidents caused by driver fatigue and drowsiness are still a serious concern worldwide. Drivers usually face decreased alertness because of prolonged driving times, lack of sleep, or repetitive highway driving conditions. This fatigue has a major impact on the driver's reaction time, decision-making capacity, and control over the vehicle, resulting in life-threatening consequences.

Conventional methods for drowsiness detection using physiological parameters like EEG, ECG, and heart rate measurement are accurate but involve the use of wearable devices.

Recent developments in computer vision technology make it possible to monitor facial behaviors like eye closure, yawning, and head position without contact. Vision technology is more feasible and cost-effective. Hence, this paper proposes an intelligent real-time driver monitoring system based on MediaPipe FaceMesh and geometric fatigue indicators.

II. RELATED WORK

Driver drowsiness detection is a popular research area to minimize road accidents caused by driver fatigue. The existing methods can be broadly classified into physiological, vehicle-based, and vision-based approaches. Physiological approaches like EEG or heart rate measurement offer high accuracy but are invasive and not suitable for real-world driving scenarios. Vehicle-based solutions rely on steering wheel movement analysis or lane deviation, but they can identify fatigue only after the driver's performance has degraded.

Vision-based approaches have been widely adopted because of their non-contact and low-cost characteristics. EAR-based eye closure detection and MAR-based yawning detection are well-known fatigue signs. In recent years, head pose estimation has also been adopted as a means to enhance robustness against partial occlusion and individual differences. However, false alarms triggered by speaking or laughing are still a problem in many existing systems. The proposed research aims to enhance reliability by integrating EAR, MAR, head tilt estimation, and a laughter filter.

III. PROPOSED SYSTEM ARCHITECTURE

The proposed Safe Drive Drowsiness Detection System is designed as a real-time vision-based driver monitoring system. The system architecture is composed of several sequential modules that continuously monitor the driver facial behavior through a live camera feed.

The system has several major components:

1. Video Acquisition Module: Acquires real-time images from the front-facing camera.
2. Face Landmark Detection Module: Employed MediaPipe FaceMesh to determine facial landmark locations.
3. Feature Extraction Module: Calculated EAR and MAR features based on predefined landmark locations.
4. Head Pose Monitoring Module: Estimated pitch and yaw angles to identify head tilts indicative of fatigue.
5. Drowsiness Decision Module: Integrated eye closure duration, head tilt, and head motionlessness for final identification.
6. Alert and Logging Module: Produced warning notifications and logged fatigue incidents for analysis.

The proposed system is computationally efficient and ready for future implementation on embedded systems like Raspberry Pi.

IV. METHODOLOGY

4.1. Facial Landmark Selection using MediaPipe FaceMesh

The MediaPipe FaceMesh model is capable of detecting 468 facial landmarks. However, for fatigue detection, only the most important points are chosen:

Left Eye: 6 points

Right Eye: 6 points

Mouth: 4 points

This means that EAR is calculated using 12 points on the eyes, and MAR is calculated using 4 points on the mouth.

4.2. Eye Aspect Ratio (EAR) for Eye Closure Detection

One of the most prominent signs of a drowsy driver is prolonged eye closure. The Eye Aspect Ratio is calculated based on the geometric relationship between the vertical and horizontal distances of the eye landmarks:

$$EAR = \frac{\backslash\backslash p2 - p6\backslash\backslash + \backslash\backslash p3 - p5\backslash\backslash}{2\backslash\backslash p1 - p4\backslash\backslash} \quad (1)$$

A threshold value of 0.22 is used. The eyes are treated as closed only when the EAR value is below the threshold for more than 1.2 seconds to avoid false positives caused by blinking.

4.3. Mouth Aspect Ratio (MAR) for Yawning Detection

The detection of yawning improves the identification of fatigue. The value of MAR is calculated as follows:

$$MAR = \frac{\backslash\backslash m1 - m2\backslash\backslash}{\backslash\backslash m3 - m4\backslash\backslash} \quad (2)$$

A threshold value of 0.5 is used for the detection of excessive mouth opening.

4.4. Head Tilt Estimation using Pitch and Yaw Angles

Driver drowsiness is commonly linked with unusual head position, such as nodding forward or sideways. Thus, the proposed system will incorporate monitoring of head pose through pitch and yaw estimation.

Pitch Angle: Calculated from alignment of nose and chin

Yaw Angle: Estimated from nose displacement with respect to eye midpoint

The calibration phase of the first 30 frames defines the neutral head position. Head tilt is detected if:

$$|\ Pitch\ | > 5^0 \quad or \quad |\ Yaw\ | > 5^0 \quad (3)$$

This module improves the system’s robustness with respect to varying driver conditions.

4.5. Head Stillness Monitoring

Besides the tilt, the driver’s drowsiness can also cause a lack of facial expressions. The system follows the movement of the nose from frame to frame. If the head is almost stationary for more than 1.5 seconds, the system determines the head is stationary, which is an additional sign of fatigue.

4.6. Laughter/Talking False Alert Reduction

Talking or laughing is often mistakenly identified as yawning. To minimize the problem of false positives, a laughter filter is proposed below:

$$\text{Laughing} = (\text{MAR} > \text{Threshold}) \wedge (\text{EAR} > \text{Threshold}) \quad (4)$$

In this way, mouth opening is disregarded unless it is accompanied by fatigue indicators such as eye closure or head tilt.

4.7. Final Drowsiness Decision Logic

The driver is said to be drowsy if:

- The eyes are closed for a period of time longer than the blink duration
- The head is tilted or in the same position
- The driver is not laughing/talking

$$\text{SleepDetected} = \text{EyesClosed} \wedge (\text{HeadTilt} \vee \text{HeadStill}) \wedge \neg\text{Laughing} \quad (5)$$

This decision logic is better than single-feature decision logic.

V. IMPLEMENTATION

The proposed system is developed using Python with the following libraries:
OpenCV: Real-time video processing
MediaPipe FaceMesh: Facial landmark tracking
NumPy: Mathematical computations

When the system detects drowsiness:
A warning message is displayed
Event images are stored for evidence
EAR, MAR, pitch, and yaw values are logged
Cooldown time prevents repeated alerts

The modular design enables direct extension towards IoT hardware integration.

The process also continuously processes each video frame and updates the values of EAR, MAR, and head orientation in real time. Temporal counters are used to differentiate between normal blinking and prolonged eye closure. All calculations are optimized to provide smooth execution without the need for GPU acceleration. Fatigue events are also logged with timestamped logs for further analysis of driver alertness patterns.

VI. RESULTS AND DISCUSSION

The system was tested for various real-time driving conditions such as:
Normal blinking
Yawning expressions
Head nodding
Talking and laughing scenarios
The combination of EAR, MAR, and head pose contributed greatly to the reliability of detection. The laughter filter was successful in suppressing false alarms due to mouth movements during speech.

Performance analysis revealed that:

Parameter	Observed Value
Frame Rate	25-30 FPS
Detection Accuracy	~90–95%
Alert Response Time	<1 second

Experiments have shown that the use of several fatigue indicators increases the reliability of detection. Eye closure can be unreliable in cases of partial occlusion or poor illumination, while head tilt serves as additional evidence. The laughter filter is very efficient in suppressing false alarms when speaking, thus ensuring that the system reacts only to real fatigue manifestations.

VII. CONCLUSION

This paper introduced an IoT-based Safe Drive Driver Drowsiness Detection System using the MediaPipe FaceMesh. The proposed model incorporates Eye Aspect Ratio, Mouth Aspect Ratio, head tilt calculation, head stillness analysis, and laughter removal to improve robustness. The proposed system strikes a good balance between accuracy and complexity by relying on only a few facial landmarks. The combination of geometric fatigue parameters and head movement analysis ensures the system is robust to changes in the facial expressions and driving behavior of the driver. The system provides a cost-effective, real-time, and non-intrusive solution for preventing driver fatigue and reducing accidents.

VIII. FUTURE SCOPE

Future upgrades will be centered on the deployment of the system using a comprehensive embedded IoT hardware kit. The future system will comprise:
Raspberry Pi controller
Camera module
Buzzer alarm system
GSM module
GPS/location sharing during critical fatigue events
The future IoT integration of the system will ensure that the system is fully smart and acts as a driver safety assistant in a real-world transportation setting.

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