Heart Rate Monitoring and Drowsiness Detection System

Ayush Bajgai **Leo Jose**

May 28, 2025

1 Abstract

This project introduces a real-time Drowsiness and Heart Rate Monitoring System aimed at improving road safety through the continuous evaluation of driver alertness and health condition. The system utilizes facial landmark evaluation, Eye Aspect Ratio (EAR) computations, and simulated heart rate data to identify early indicators of exhaustion and atypical physiological states. The technology triggers instant warnings to lower the likelihood of accidents brought on by drowsy or poorly drivers by means of heart rate monitoring and examination of real-time video feeds for extended eye closures. Unlike conventional methods depending on wearable sensors, this system runs without specific hardware, using effective computer vision algorithms for precise, real-time performance. A web-based dashboard also offers real-time driver status updates to help quick intervention when required. This approach provides a versatile, reasonably priced, scalable method for proactive driver monitoring, therefore enabling a useful tool for enhancing road safety in many driving conditions.

2 Introduction

Accident risk is greatly increased by driver fatigue stress, and health issues. According the safety reports says that sleepy driving by alone causes hundreds of accidents every year[1]. Although traditional driver assistance systems like Advanced Driver Assistance System (ADAS) tend to emphasize vehicle control and road safety, they sometimes neglect important elements of driver well-being. This paper offers a thorough Driver Health Monitoring and Drowsiness Detection System using facial landmark analysis, Eye Aspect Ratio (EAR) computations, and simulated heart rate data to continually evaluate driver alertness and health condition, hence closing this gap.

The proposed system based on real-time for prolonged eye closures and combining simulated heart rate data to imitate physiological conditions. The suggested system is meant to proactively spot early indicators of exhaustion and possible poor health. Relying instead on efficient computer vision algorithms and simulated data for flexible testing and fast prototyping, this method does away with the requirement for actual sensors. The technology intends to lower accident risk, improve road safety, and support driver well-being by means of real-time insights into driver state including both alertness and simulated heart condition.

3 Objective

This project aims to provide a thorough Driver Health Monitoring and Drowsiness Detection System capable of real-time alertness assessment using facial landmark analysis, Eye Aspect Ratio (EAR) processing, and simulated heart rate data. While incorporating simulated heart rate data to evaluate any health concerns without depending on physical sensors, the system intends to constantly monitor driver attentiveness and identify early indicators of restlessness by means of real-time video analysis. The device also aims to offer automated alerts for quick intervention upon detection of extended eye closure or unusual heart rate patterns. It also has a centralized, web-based dashboard for real-time visualisation of driver status, hence improving the decision-making process for management. By proactively monitoring driver health and awareness, the overarching aim is to create a scalable, hardware-independent solution that lowers the likelihood of accidents and enhances road safety. It also includes:

- Use of the user heartbeat data to constantly track heart rate.
- Use eye aspect ratio (EAR) analysis to spot indications of driver tiredness.
- Notify system administrators when thresholds are crossed.
- Use of facial landmarks for detecting drowsiness.

4 Literature Review

The domain of driver drowsiness monitoring and detection has been extensively investigated, thereby focusing on both computer vision and physiological clues in an effort to enhance road safety. Kazemi and Sullivan [2] started drowsiness detection using facial landmarks and Eye Aspect Ratio (EAR), one of the earliest methodologies. Their technique is appropriate for real-time use since it aligns facial features in milliseconds using an ensemble of regression trees.

Apart from face evaluation, wearable technology has also been tried for driver monitoring. Melnicuk et al. [3] showed, as a proof, that heart rate variability could fairly well reflect cognitive load and stress, direct indicators for drowsiness. Dummy heart rate data are employed in this study to mimic driver attentiveness, hence eliminating real-time physiological sensors.

Using photoplethysmography (PPG) and eye tracking, Lee and Chung [4] built a real-time monitoring system combining visual and physiological data to identify fatigue symptoms. Their study underlined the need of combining several sensor modalities to improve detection accuracy. Similarly, from several physiological data like heart rate and body temperature, Akshara, Deepak et al. [4] suggested an IoT-based sleepiness monitoring system to detect tiredness. This method was evaluated for actual driving conditions and revealed the benefit of multi-sensor fusion in the identification of tiredness. The paper [5] suggests a multi-sensor driver monitoring system for professional drivers' health. It efficiently finds pseudo headache and tiredness by means of pseudo-symptom data and outlier identification, hence lowering false positives and adjusting to particular drivers via online updating.

Following on studies have underlined the rise in precision of drowsiness detection with deep learning and machine learning. For instance, Pandey and Prabha [6] proposed a smart health monitoring system based on machine learning and IoT stressing the importance of data processing in real time and edge computing for application in critical health monitoring.

Although such studies have greatly improved the sector, the current work aims at a more basic method employing face landmarks for EAR analysis and heart rate data to reduce hardware dependencies and enhance scalability.

5 Methodology

The approach of this study emphasizes drowsiness detection by Eye Aspect Ratio (EAR) analysis and dummy heart rate data simulating driver alertness utilizing facial landmarks. The method is meant to detect early indicators of tiredness based on facial feature analysis without depending on real-time physiological sensors. The method is broken down into three key parts:

5.1 Facial Landmark Detection and EAR Calculation

Specifically on the eyes, the system uses the dlib package in Python for facial landmark detection. Based on the work of Kazemi and Sullivan [2], this method makes use of an ensemble of regression trees for real-time face alignment. So, six important facial landmarks surrounding the eyes help to compute the Eye Aspect Ratio (EAR):

where P1, P2, P3, ... P6 are the particular eye area coordinates. The system marks the driver as tired should the EAR persistently falls below a pre-defined

$$\text{EAR} = \frac{||p_2 - p_6|| + ||p_3 - p_5||}{2||p_1 - p_4||}$$

Figure 1: Eye Aspect Ratio Calculation

threshold (e.g., 0.25) over 20 consecutive frames.

5.2 Hear Rate Simulation

This initiative simulates driver awareness using dummy heart rate data rather than actual real-time physiological data. Generated to reflect normal and drowsy conditions, the heart rate readings let the system evaluate threshold-based notifications without requiring worn sensors. This method preserves a realistic simulation of health monitoring even as it streamlines the testing environment.

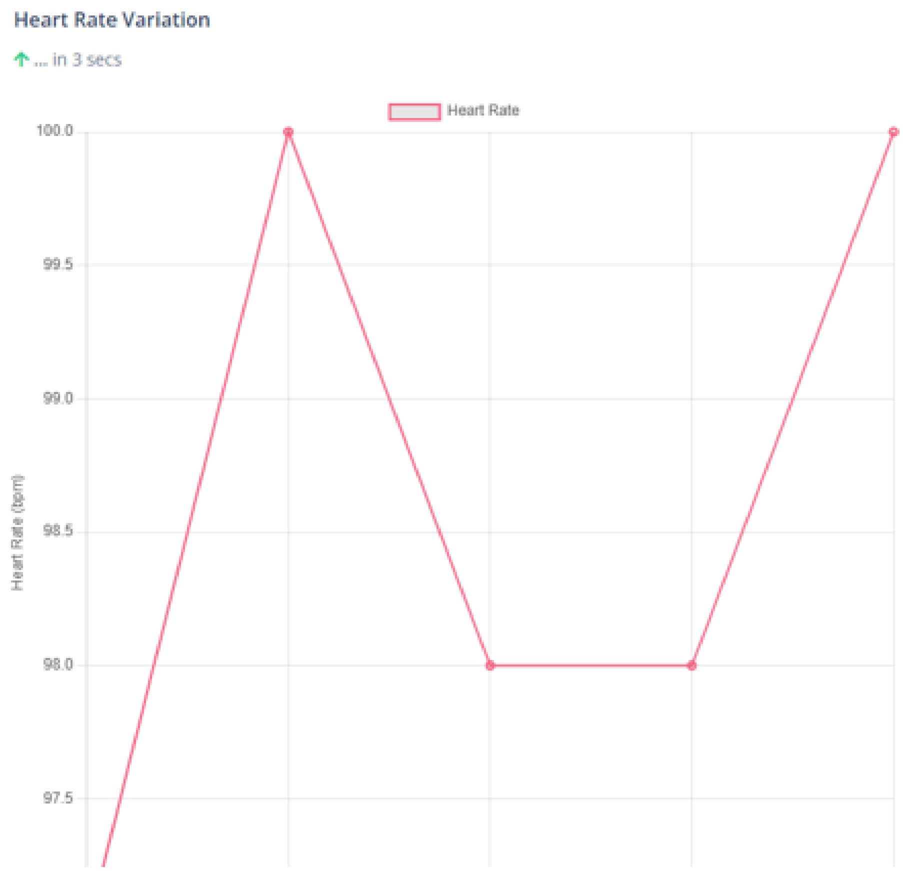

Figure 2: Real time heart rate monitoring

5.3 Alert System

The technology activates a warning on the monitoring dashboard once drowsiness is found. If the driver not react within a specified time (e.g., 8 seconds), the system notifies emergency services, giving the driver's position and simulated health status. By informing emergency services with vital information including the vehicle's position, driver health data, and the type of warning for safety concerns; the system escalates the situation.

5.4 System workflow

The system workflow is designed to track driver attentiveness via facial landmark identification and simulated heart rate data. A major sign of drowsiness the Eye Aspect Ratio (EAR), is computed using real-time facial expression recording. The system alerts if the EAR keeps falling below a certain level.

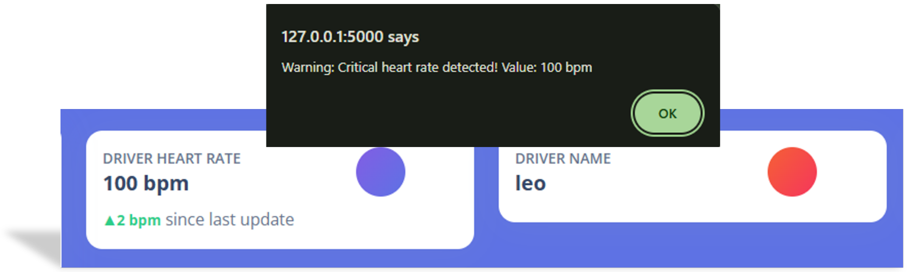

Figure 3: Alert System

Apart from facial analysis, dummy heart rate data is used to mimic driver alertness, enabling the system to detect possible drowsiness without depending on real-time physiological sensors. Displayed on a centralized dashboard, this data is analyzed allowing managers to track driver status, react to alarms, and raise emergency messages as required. Focusing instead on streamlined, scalable, and real-time data analysis, this integrated strategy guarantees efficient driver monitoring without the need for advanced wearable technologies.

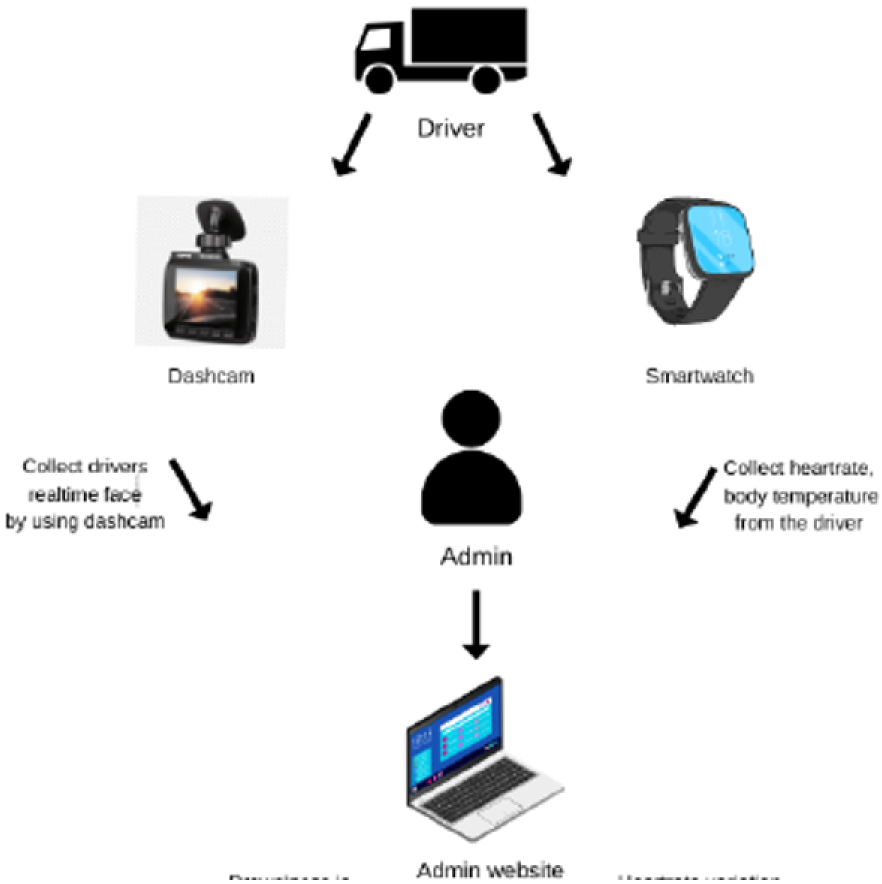

Figure 4: System Workflow

6 Performance and Evaluation Summary

Focusing mostly on facial landmark identification and simulated heart rate data, the implemented system shows efficient real-time monitoring of driver focus by means of continuous data analysis. To find early indicators of drowsiness, the system computes the Eye Aspect Ratio (EAR) from successive video frames. The system activates a real-time warning if the EAR regularly falls below a predefined threshold (e.g. 0.25) for 20 frames. Furthermore, if the driver does not react within a specified time (e.g. 8 seconds), the system raises the warning to inform administrators of the possible safety concern. The centralized dashboard provides a complete picture of driver state, which supports real-time decision making and allows fast reaction to identified drowsiness.

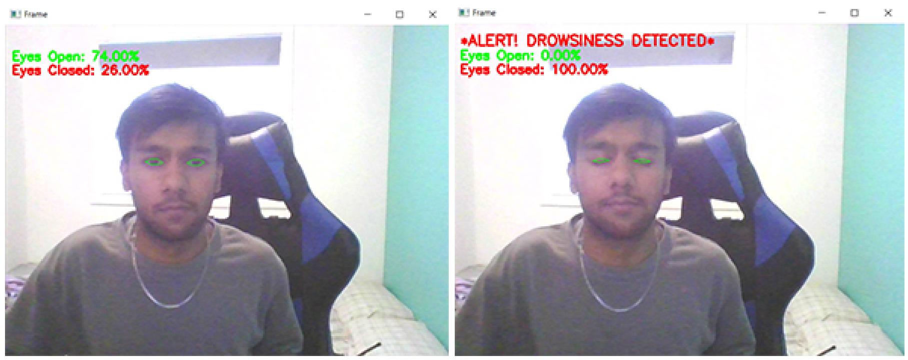

Figure 5: Dashboard showing Drowsy before and after with percentage

6.1 Open and Closed Eye Percentage Metrics

The system activates a visual alert, as seen in the (Figure 5), once it finds a continuous decline in EAR. Prominently shown on the screen, the alert phrase ("ALERT! DROWSINESS DETECTED") quickly catches the driver's attention. Reducing the possibility of false positives, this signal is triggered by a combination of closed eye percentages and frame analysis done consecutively. On real-time the camera feed, the percentages provide a clear picture of the driver's alertness level.

- Eye Open Percentage: Reflects the percentage of recent frames with an EAR over the threshold, suggesting typical alertness.
- Eye Closed Percentage: Shows the percentage of recent frames with an EAR below the threshold, suggesting possible drowsiness.

6.2 Performance Indicators

The effectiveness of the installed drowsiness detection system is mostly evaluated on its capacity to precisely recognize and react to initial signs of driver fatigue. Among the key performance metrics are system stability, alert responsiveness, detection accuracy, false positive rate, and true positive rate (sensitivity). Based on the Eye Aspect Ratio (EAR) threshold, detection accuracy indicates the system's ability to accurately detect frames as either open or closed. Along with quick intervention, alert responsiveness tracks the pace at which the system displays warnings upon detection of extended eye closures.

On the other hand, the False Positive Rate is the percentage of times the system misclassified a non-drowsy condition as drowsy. Hence causing possibly unnecessary disruptions. True Positive Rate reflects the percentage of real drowsy times accurately marked by the system, hence showing its sensitivity to true sleepiness events. Ultimately, system stability is the similarity of EAR calculations over several head positions and illumination conditions. Thus, guaranteeing accurate results under varied real-world situations. These signs taken together give a thorough evaluation of how well the system keeps driver attention and lowers accidents caused by fatigue.

7 Conclusion and Future Work

This study introduces a driver drowsiness detection system that effectively identifies early signs of exhaustion through facial landmarks and simulated heart rate data. By concentrating on Eye Aspect Ratio (EAR) analysis, the system effectively detects indicators of tiredness without requiring complex wearable sensors, rendering it a cost-efficient and scalable option for real-world scenarios.

Although the system offers good drowsiness tracking along with regular real-time notifications, there are certain areas for possible improvement. Future research may focus on including machine learning techniques to increase the accuracy of drowsiness detection by learning from different driving circumstances and facial expressions. Expanding the system to incorporate more complete biometric data, including head pose estimate or pupil dilation analysis, would also help to improve its accuracy even more. Adaptive threshold settings depending on driving history and environmental conditions could help to lower false positives and enhance general system dependability as well.

Moreover, the system might gain from including predictive analytics for predicting driver tiredness before crucial thresholds are crossed, maybe using actual driving data for ongoing model improvement. This strategy would improve the proactive characteristics of the system, hence enabling it to be more efficient in avoiding incidents connected to tiredness. All things considered, this initiative lays a solid foundation for future studies in the area of driver safety and intelligent transportation systems.

This system's data flow is simplified for maximum efficiency. Each frame is evaluated for EAR values; facial landmark identification runs frame-by-frame. To guarantee ongoing health monitoring, dummy heart rate data is processed concurrently. Web-application is used to track driver status and handle emergency escalations via the integrated system's via real-time dashboard.

At concluison, this paper aims to lower hardware dependencies, increase scalability, and guarantee strong performance in real-world situations. Thus, it's a simplified method focusing on facial analysis and simulated health data.

8 Reference

[1] National Highway Traffic Safety Administration, “Drowsy Driving,” [Online]. Available: https://www.nhtsa.gov/risky-driving/drowsy-driving. [Accessed Date: May 3, 2025]

[2] V. Kazemi and J. Sullivan, ”One Millisecond Face Alignment with an Ensemble of Regression Trees,” in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2014, pp. 1867–1874. [Accessed Date: May 4, 2025]

[3] V. Melnicuk et al., ”Employing Wearable Technology in Non-Intrusive Driver State Monitoring,” IEEE IV, 2016. [Accessed Date: May 4, 2025]

[4] A. M. C. Akshara, H. T. S. Harshitha, N. Deepak, P. B. Priyanka, and S. H. A. Sharath, ”IoT Based Driver Drowsiness Detection and Smart Alerting System,” International Journal for Research in Applied Science and Engineering Technology (IJRASET), vol. 10, no. 6, pp. 1234–1238, 2022. [Accessed Date: May 5, 2025]

[5] H. Hayashi, M. Kamezaki, and S. Sugano, ”Toward Health–Related Accident Prevention: Symptom Detection and Intervention Based on Driver Monitoring and Verbal Interaction,” IEEE Open Journal of Intelligent Transportation Systems, vol. 2, pp. 240-253, 2021.

[6] H. Pandey and S. Prabha, ”Smart Health Monitoring System Using IoT and Machine Learning Techniques,” in Proceedings of the 2020 Sixth International Conference on Bio Signals, Images, and Instrumentation (ICBSII), Chennai, India, 2020, pp. 1–4.

Link to view report:

https://www.overleaf.com/read/ghhppnckrwsw#6c4581