INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)
(Int Peer Reviewed Journal)
Vol. 05, Issue 10, October 2025, pp : 1239-1242
www.ijprems.com
editor@ijprems.com
e-ISSN : 2583-1062
Impact Factor : 7.001

DRIVER SAFETY ENHANCEMENT APPLICATION USING REAL-TIME MONITORING

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DOI: https://www.doi.org/10.58257/IJPREMS44347

ABSTRACT

The increasing number of road accidents due to human errors such as not wearing seatbelts and driver drowsiness has highlighted the urgent need for intelligent driver monitoring systems. In this context, the integration of computer vision technologies offers a promising solution for enhancing road safety. This project proposes the development of a real-time driver safety system usingcomputer vision techniques, focusing on three primary objectives: seatbelt detection, drowsiness detection, and SOS alerts in case the driver falls asleep. The seatbelt detection module ensures compliance with safety regulations by identifying whether the driver is wearing a seatbelt. This is achieved through real-time video stream analysis using object detection models trained to recognize seatbelt patterns . The second module, drowsiness detection, monitors the driver’s eye movement and blink rate to predict fatigue or sleep onset. The final component involves an SOS alert mechanism that activates if the system detects prolonged eye closure, indicating the driver has fallen asleep. This alert can notify emergency contacts or systems to prevent potential accidents. The proposed system will utilize pre-trained convolutional neural networks (CNNs), OpenCV for image processing, and Python-based frameworks for real-time implementation . The innovation lies in integrating these modules into a single unified system that functions seamlessly in real-time environments. Through the successful deployment of this system, we aim to reduce road accident rates and improve driver safety, particularly in high-risk and long-distance transportation scenarios.

Keywords: Driver Safety, Seatbelt Detection, Drowsiness Detection, Flask, YOLOv8, Mediapipe.

1. INTRODUCTION

Road safety has become a major global concern due to increasing vehicular traffic and urbanization, with driver negligence, fatigue, and failure to follow basic safety practices like wearing seatbelts contributing to millions of preventable deaths each year. Technological advancements in computer vision and machine learning now provide the ability to monitor driver behavior in real time, offering proactive solutions to reduce accidents. This project focuses on developing a comprehensive driver monitoring system that can detect seatbelt usage, identify signs of drowsiness, and send SOS alerts in case of sleep detection. Designed for real-time implementation in vehicles, either as a standalone unit or integrated with existing dashboards, the system leverages advanced image recognition and video processing techniques to ensure speed, accuracy, and reliability, aiming to enhance preventive safety measures and minimize the risk of road accidents.

2. LITERATURE SURVEY

Reddy and Gopal (2021), in their study Real-Time Drowsiness Detection using Computer Vision published in the International Journal of Computer Applications, explore an approach to monitor driver alertness through visual cues. Their work primarily focuses on the use of the Eye Aspect Ratio (EAR) method to detect drowsiness in real time. By analyzing changes in eye openness captured through a camera, the system calculates EAR values to determine whether a person is becoming drowsy. This research forms the basis for EAR-based drowsiness detection systems and is referenced in this context as [2].

Zhang, Wang, and Yang (2020), in their paper A Deep Learning Framework for Seatbelt Detection published in the IEEE Transactions on Intelligent Vehicles, present a robust approach to automatically detect seatbelt usage using deep learning techniques. Their framework leverages convolutional neural networks (CNNs) to accurately identify whether a seatbelt is worn by

analyzing in-vehicle images. The proposed method demonstrates high precision and reliability, making it suitable for real-time vehicle safety monitoring systems. This work supports the implementation of deep learning-based seatbelt detection and is referenced in this context as [3].

Redmon and Farhadi (2018), in their technical report YOLOv3: An Incremental Improvement available on arXiv, introduce enhancements to the YOLO (You Only Look Once) object detection framework, resulting in improved accuracy and speed for real-time applications. YOLOv3 employs a multi-scale prediction mechanism and deeper architecture, allowing it to detect objects of various sizes more effectively while maintaining fast inference times. This model serves as a widely adopted framework for real-time object detection tasks due to its balance of performance and efficiency. In this context, it is referenced as [5].

The OpenCV Developers Team (2023), through the comprehensive OpenCV Documentation available at https://docs.opencv.org, provides essential tools and libraries for implementing realtime computer vision applications. OpenCV (Open Source Computer Vision Library) supports a wide range of functionalities including image processing, object detection, and facial recognition, making it a cornerstone in the development of computer vision systems. Its extensive documentation facilitates rapid development and integration of vision-based features in real-time systems. In this context, OpenCV is utilized for various computer vision tasks and is referenced as [4].

Awais, Badruddin, and Drieberg (2017), in their article A Hybrid Approach to Detect Driver Drowsiness Utilizing Physiological Signals to Improve System Performance and Wearability published in Sensors, present an advanced method for detecting driver drowsiness by combining physiological signals with traditional detection techniques. Their hybrid approach aims to enhance both the accuracy and wearability of drowsiness detection systems, addressing the limitations of solely vision-based methods. By integrating signals such as EEG and ECG, the study contributes to the development of more reliable and user-friendly systems. This work highlights the potential of advanced drowsiness detection methods and is referenced accordingly.

Abtahi, Omidyeganeh, Shirmohammadi, and Hariri (2014), in their work YawDD: A Multi-Modal Dataset for Driver Drowsiness Detection presented at the ACM Multimedia Systems Conference, introduce a comprehensive dataset designed to support the development and evaluation of drowsiness detection systems. YawDD includes various modalities such as facial features and

head movements, enabling researchers to train and validate models with realistic and diverse data. This dataset serves as a valuable resource for advancing the accuracy and robustness of drowsiness detection technologies and is referenced as a key dataset in this context.

Tawari and Trivedi (2014), in their paper Driver Gaze Region Estimation Without Use of Eye Movement published in the IEEE Transactions on Intelligent Transportation Systems, propose a non-invasive method for estimating a driver’s gaze region without relying on direct eye movement tracking. Their approach utilizes head pose and contextual visual cues to determine the driver’s focus area, enabling effective visual attention monitoring while maintaining system simplicity and user comfort. This work supports the development of non-intrusive driver monitoring systems and is referenced for its contribution to visual attention estimation techniques.

Viola and Jones (2001), in their seminal work Rapid Object Detection using a Boosted Cascade of Simple Features presented at the IEEE CVPR Conference, introduced a groundbreaking approach for real-time face and object detection. Their method utilizes Haar-like features combined with a cascade of classifiers trained through AdaBoost, enabling fast and efficient detection even on low-power devices. This technique laid the foundation for many modern computer vision systems. It remains widely used for applications such as face detection in surveillance and driver monitoring systems. The method is especially valued for its speed and simplicity.

Satapathy and Panda (2021), in their paper Real-Time Drowsiness Alert System Using CNN and Eye Aspect Ratio published in the International Journal of Engineering Research & Technology, present a hybrid approach that combines Convolutional Neural Networks (CNN) with Eye Aspect Ratio (EAR) for effective drowsiness detection. Their system monitors facial features and eye movements in real time to identify signs of fatigue. The CNN enhances feature extraction

3. OBJECTIVIES

1. Develop a seatbelt detection system using real-time image processing with CNN models like YOLOv3 or MobileNet.

2. Implement a drowsiness detection system by monitoring eye aspect ratio (EAR) and blink frequency to trigger alerts.

3. Activate an SOS alert system that notifies pre-defined contacts or onboard systems when prolonged eye closure or absence of face is detected.

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4. METHODOLOGY

1. Data Collection and Preprocessing:

Data is collected for both **seatbelt detection** and **drowsiness detection**.

Seatbelt Detection: Labeled images or video frames of drivers with and without seatbelts are gathered from public or custom datasets.

Drowsiness Detection: Facial images showing open and closed eyes are used to train the EAR-based model.

Preprocessing: All images are resized, normalized, and converted to grayscale. Data augmentation (rotation, brightness adjustment, flipping) enhances model robustness under varying lighting and angles.

2. Model Training:

Seatbelt Detection (YOLOv3/MobileNet): YOLOv3 is used for real-time seatbelt detection, while MobileNet offers a lightweight alternative for embedded systems. The model classifies whether a seatbelt is worn or not.

Drowsiness Detection (EAR using dlib): The dlib library extracts 68 facial landmarks. The Eye Aspect Ratio (EAR) is computed to monitor eye closure, detecting drowsiness when EAR remains below a set threshold for consecutive frames.

3. Integration and Testing:

Both detection modules are integrated into a single **Python application** using **OpenCV** for real-time video capture. The system processes webcam or vehicle camera input to display results such as "Seatbelt Worn" or "Driver Drowsy" on-screen.

4. SOS Alert System:

If unsafe conditions are detected (e.g., prolonged eye closure, no seatbelt, or no face detected), the system automatically triggers an **SOS alert**. Alerts can be sent via **email, SMS**, or **IoT-based devices** like NodeMCU or GSM modules to notify emergency contacts.

5. Evaluation Metrics:

System performance is evaluated using:

Accuracy – overall correctness of detection.

Precision and Recall – reliability of positive detections.

Latency – time taken to detect and trigger alerts.

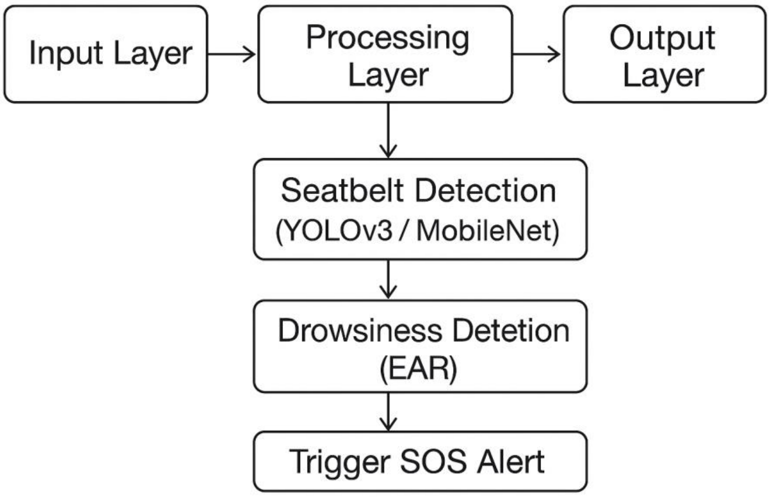

Figure 1: System Architecture.

5. RESULTS AND DISCUSSION

The driver safety system was tested with real-time video data for seatbelt detection, drowsiness monitoring, and SOS alerts. The YOLOv3-based seatbelt module accurately identified seatbelt usage under different conditions with minimal false positives. The drowsiness module, using EAR and blink analysis, effectively detected fatigue and triggered timely alerts, showing robust precision and recall. The SOS alert system successfully notified pre-defined contacts during prolonged eye closure or absence of the driver's face, enhancing safety for long-distance and commercial driving. Overall, the integrated system demonstrates real-time effectiveness in preventing accidents and promoting compliance with safety practices, with potential for further enhancements through telematics and cloud integration.

6. CONCLUSION

This project presents a unified driver safety system that integrates computer vision for seatbelt detection, drowsiness monitoring, and SOS alerts, addressing major causes of road accidents. The drowsiness detection module uses Eye Aspect Ratio (EAR) and CNNs to monitor eye movements, identifying early signs of fatigue and triggering timely alerts to keep the driver attentive. The seatbelt detection module employs YOLOv3 and OpenCV for real-time monitoring, ensuring compliance with essential safety practices. Additionally, the SOS alert system can automatically send location-based emergency messages during critical situations, enhancing rapid response. By combining these features into a single, real-time platform, the system offers a proactive, efficient, and non-invasive solution to improve overall driver safety in both private and commercial vehicles.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Dr. P.G. Halakatti Post Graduate Centre, Rani Channamma University, Vijayapur, for providing me with the opportunity to undertake this project. I am deeply thankful to my guide for their continuous support, guidance, and valuable suggestions throughout the project. I also extend my thanks to all the faculty members and peers who provided encouragement and assistance whenever needed. Finally, I would like to acknowledge my family and friends for their constant motivation and support, which helped me successfully complete this research work.

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