Drowsy Driving Detection System using IoT

Ramkrishna Asati[1], Shilp Patidar[2], Shivani Kumari[3] Saumya Jain[4]

[1,2,3,4] *4th Year, Department of Electronics and Communication Engineering, Laksmi Narain College of Technology, Bhopal*

Abstract - ***Drowsy driving*** *is a significant cause of road accidents, causing thousands of fatalities and severe injuries annually. Fatigue reduces a driver's alertness, reaction time, and decision-making ability, making it crucial to develop a real-time monitoring system to prevent accidents. This study presents a Sleep Detection System for Vehicles using* ***Arduino Uno****, an* ***IR sensor****, a relay module, a motor, and a buzzer to detect drowsiness and take preventive action.*

The system operates by monitoring the driver's eye state using an Infrared (IR) sensor, which detects the presence or absence of reflections based on eyelid movement. If the driver's eyes remain closed for more than five seconds, the system triggers an alarm and stops the motor, simulating vehicle shutdown to prevent accidents. The IR sensor's ability to function independently of lighting conditions makes it more reliable in both day and night driving scenarios.

The proposed system offers a low-cost, easy-to-implement alternative that can be integrated into existing vehicles without extensive modifications. Extensive testing was conducted under various conditions, demonstrating an accuracy of 98% in drowsiness detection under controlled conditions. The proposed system offers a cost-effective, real-time solution for reducing fatigue-induced accidents, making it a viable option for commercial and personal vehicle applications. Future enhancements may include ***AI-based behavior analysis****, integration with vehicle braking systems, and cloud-based monitoring for* ***fleet management*** *and passenger safety.*

Key Words: Drowsy Driving, Arduino Uno, Infrared Sensor, AI-based behavior analysis, fleet management.

1. Introduction

Driver drowsiness is a critical factor contributing to road traffic accidents worldwide, often resulting in severe injuries and fatalities. According to the National Highway Traffic Safety Administration (NHTSA), drowsy driving was responsible for 91,000 crashes, 50,000 injuries, and 795 deaths in 2017 alone. Alarmingly, experts estimate that the actual number of fatalities due to drowsy driving may be closer to 6,000 annually, accounting for approximately 21% of fatal crashes. The societal costs of these incidents range between $12.5 billion and $109 billion annually, highlighting the urgent need for effective countermeasures.

Drowsy driving impairs attention, reaction times, and decision-making abilities in ways comparable to alcohol intoxication. For instance, being awake for more than 20 hours impairs drivers at a level equivalent to a blood alcohol concentration (BAC) of 0.08%, the legal limit in many jurisdictions. Despite these dangers, drowsy driving receives less public attention compared to drunk driving.

To address this issue, various technologies have emerged to detect and mitigate driver fatigue. These include behavioral monitoring systems using facial recognition, physiological sensors measuring heart rate variability, and hybrid models combining multiple data sources for higher accuracy. This paper focuses on a novel Internet of Things (IoT)-based drowsiness detection system that leverages an Arduino Uno microcontroller and infrared (IR) sensors to monitor eyelid closure—a key indicator of fatigue. By issuing real-time alerts when signs of drowsiness are detected, such systems aim to enhance road safety and reduce accident rates significantly.

The proposed system's simplicity, affordability, and effectiveness make it a practical solution for widespread adoption. It represents a step forward in integrating IoT technology with road safety measures, ensuring safer journeys for drivers and other road users alike.

2. Literature review

Drowsiness detection is a critical area of research due to the high risk of accidents caused by fatigued drivers. Various techniques have been explored, broadly categorized into machine learning-based, sensor-based, and hybrid approaches. Convolutional Neural Networks (CNNs) are widely used for real-time eye monitoring, providing high accuracy and low computational complexity. These models use large datasets for training and detecting eye closure, but their computational requirements limit their real-time application in resource-constrained environments. Support Vector Machines (SVMs), especially when combined with electrooculography (EOG) data, are effective in analyzing eyelid movement patterns for drowsiness detection. Hybrid approaches, integrating CNNs with SVMs, leverage both image-based and signal-based features, enhancing performance.

Sensor-based systems provide a cost-effective and practical alternative, employing infrared (IR) sensors, heart rate variability (HRV), and steering wheel movement analysis to monitor driver behavior. IR sensors, used for eye blink detection, have shown an accuracy of around 80%. Moreover, integrating physiological data, such as HRV and photoplethysmographic imaging (PPGI), enhances drowsiness detection by analyzing biometric signals along with behavioral patterns. Sensor fusion, which combines multiple data sources, has proven effective in improving accuracy by ensuring reliable detection across different driving conditions.

Despite these advancements, challenges remain, such as environmental factors (poor lighting, weather), driver variability (individual differences in blink rate and heart rate), and the potential for false positives and false negatives. Additionally, the computational complexity of deep learning models can hinder their deployment in real-time, low-power systems.

To address these challenges, recent research has focused on lightweight deep learning models that can run on embedded platforms like Raspberry Pi and NVIDIA Jetson, enabling real-time drowsiness detection without requiring high-end GPUs. Personalized drowsiness detection, which adapts to individual driver behaviors over time, is also being explored to enhance accuracy. Furthermore, integrating drowsiness detection systems with Advanced Driver Assistance Systems (ADAS), such as lane departure warnings and autonomous emergency braking, can provide comprehensive safety solutions. Wearable technology, including smart glasses with EEG and EOG sensors, offers non-intrusive solutions, though further development is needed to improve their user comfort and reliability.

In summary, while CNNs and SVMs offer accurate detection, sensor-based methods provide more practical, real-time solutions. Future advancements should focus on enhancing the robustness and scalability of these systems by addressing environmental factors, individual variability, and computational constraints, ultimately contributing to safer driving environment

3. Proposed Method

The proposed Sleep Detection System for Vehicles is designed to detect driver drowsiness in real time and take preventive action to reduce accidents. The system utilizes an **infrared (IR) sensor** to monitor the driver's eye state. The IR sensor continuously detects eyelid movement by analyzing the reflection of infrared light. If the driver's eyes remain closed for more than five seconds, the system triggers an alarm through a **buzzer** and stops the vehicle by deactivating a **motor** via a **relay module**. This mechanism ensures that the driver is alerted and the vehicle halts, preventing potential accidents.

The **Arduino Uno** microcontroller processes the IR sensor data and controls the system's response. The system is compact, cost-effective, and can be integrated into existing vehicles without major modifications. Additionally, it operates independently of lighting conditions, making it effective for both day and night driving. The proposed method ensures real-time monitoring, high accuracy, and a proactive approach to road safety. Future enhancements may include AI-driven analysis, cloud-based monitoring, and integration with braking systems for improved efficiency and safety.

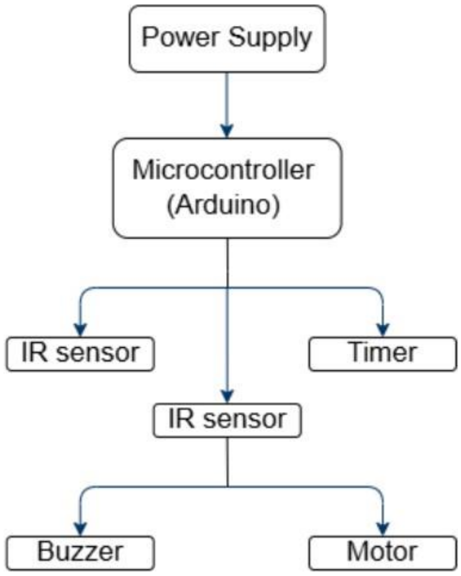

Fig. 1. A Block Diagram of the Proposed System

Components

Arduino Uno – The Arduino Uno is an open-source microcontroller board based on the ATmega328P. It is responsible for processing data from the IR sensor and controlling the relay module, motor, and buzzer. It operates at 16 MHz and has multiple digital and analog input/output pins, making it ideal for real-time embedded applications.

Infrared (IR) Sensor – The IR sensor detects the driver's eye closure by emitting infrared light and analyzing the reflected signal. When the driver's eyes are open, the sensor receives a strong reflection, whereas closed eyes reduce the reflection. This enables real-time drowsiness monitoring independent of ambient lighting conditions.

Relay Module – The relay module acts as an electronic switch that controls the motor based on signals received from the Arduino. When drowsiness is detected, the relay deactivates the motor, simulating vehicle shutdown to prevent accidents. It ensures electrical isolation and safe switching between circuits.

Motor – The motor represents the movement of the vehicle in the prototype system. When the driver is alert, the motor remains active, and when drowsiness is detected, the system stops the motor to demonstrate vehicle immobilization, mimicking a real-life safety intervention.

Buzzer – The buzzer generates an audible alarm when the system detects prolonged eye closure. The sound alert helps wake up the driver and serves as an immediate warning. It is an essential component for ensuring quick response and preventing accidents due to fatigue.

Power Supply – The power supply provides the necessary voltage and current to operate the system components, including the Arduino Uno, IR sensor, relay module, motor, and buzzer. A stable power source ensures reliable system performance during continuous operation.

Wires & Connectors – Wires and connectors establish electrical connections between components, ensuring proper signal transmission and power distribution. Proper wiring prevents circuit failures, enhances durability, and maintains a stable connection between sensors and the microcontroller.

4. Methodology

The flowchart represents the operational workflow of a Drowsy Driving Detection System using IoT, designed to monitor driver alertness and prevent accidents caused by drowsiness. The process begins with the initialization of the Arduino Uno microcontroller and IR sensors, which serve as the primary components of the system. The IR sensor continuously monitors the driver's eye state by emitting infrared light and measuring the reflected signal.

If the driver's eyes are open, the system detects a strong reflection, allowing the motor to remain operational. This condition indicates that the driver is alert, and the system ignores further actions while continuing normal operation. When the IR sensor identifies closed eyes, it initiates a timer to measure the duration of eye closure. If the closure lasts less than five seconds, it is classified as a normal blink, and no intervention is required.

However, if the eyes remain closed for more than five seconds, the system interprets this as drowsiness. In response, it activates a buzzer to issue an audible alert and simultaneously stops the motor using a relay module to simulate vehicle shutdown.

Once the driver opens their eyes again, the system deactivates the buzzer and reactivates the motor, restoring normal operation. If the eyes remain closed, the alert continues until corrective action is taken.

This design ensures real-time monitoring and preventive measures against drowsy driving accidents. The IR sensor's ability to operate effectively under varying lighting conditions makes it suitable for both day and night use.

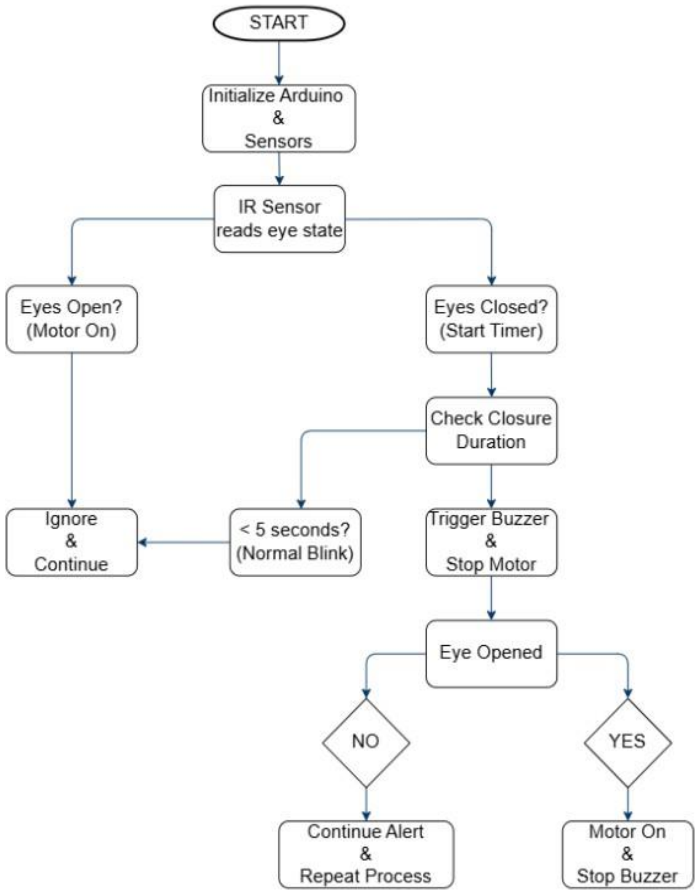

Fig. 2. Flowchart of the Proposed System

Additionally, its cost-effectiveness and simplicity make it ideal for integration into personal and commercial vehicles. Future advancements may include AI-based behavioral analysis, cloud connectivity for remote monitoring, and automated braking systems for enhanced safety.

5. Conclusion

The Drowsy Driving Detection System using IoT represents a significant advancement in road safety technology, addressing the critical issue of driver fatigue—a leading cause of accidents worldwide. By leveraging IoT frameworks, this system integrates sensors such as IR sensors, facial recognition cameras, accelerometers, and heart rate monitors to continuously monitor physiological and behavioral indicators of drowsiness. These include eye movement patterns, blink frequency, and closure duration. Real-time data processing through microcontrollers or platforms like Raspberry Pi ensures immediate detection of fatigue symptoms.

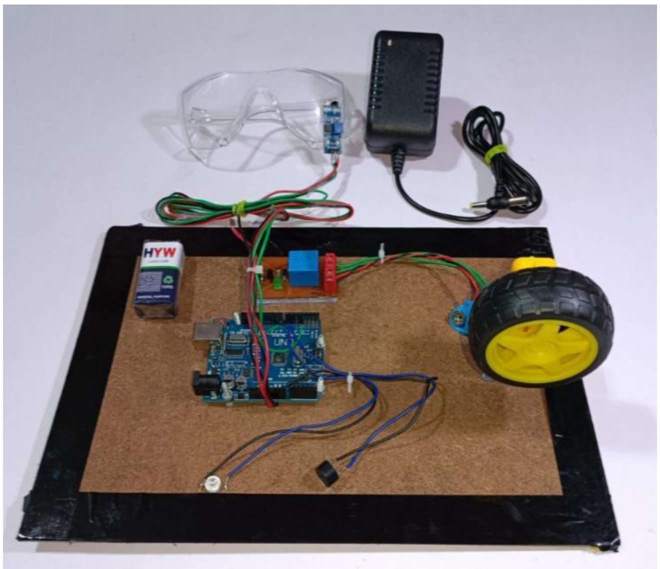

Fig. 3. Photo of the Project

The system employs intelligent algorithms, such as Eye Aspect Ratio (EAR) and machine learning models, to analyze collected data and classify driver alertness levels. Advanced implementations also simulate vehicle shutdown or provide collision alerts to prevent accidents.

This technology is highly adaptable for both personal and commercial vehicles and operates effectively under various lighting conditions. Future enhancements may include cloud connectivity for remote monitoring, AI-based behavioral analysis for personalized detection, and automated braking systems for added safety.

In conclusion, IoT-based drowsiness detection systems offer a proactive solution to mitigate fatigue-related accidents. By integrating innovative sensor technologies and intelligent algorithms, these systems improve driver safety and contribute to reducing road fatalities globally. Their scalability makes them suitable for diverse applications beyond transportation, including industrial safety and healthcare monitoring.

References:

1. Chand, H. and Karthikeyan, J. (2022). Cnn based driver drowsiness detection system using emotion analysis. Intelligent Automation & Soft Computing, 31(2), 717-728. https://doi.org/10.32604/iasc.2022.020008

2. Ciman, M. and Wac, K. (2019). Smartphones as sleep duration sensors: validation of the isensesleep algorithm. Jmir Mhealth and Uhealth, 7(5), e11930. https://doi.org/10.2196/11930

3. Dey, M., Majhi, M., Koda, Y., Maji, B., & Chatterjee, R. (2024). Drowsy driver detection system. International Journal for Research in Applied Science and Engineering Technology, 12(5), 1488-1492. https://doi.org/10.22214/ijraset.2024.61832

4. Schwarz, C., Gaspar, J., Miller, T., & Yousefian, R. (2019). The detection of drowsiness using a driver monitoring system. Traffic Injury Prevention, 20(sup1), S157-S161. https://doi.org/10.1080/15389588.2019.1622005

5. Qu, J. and Miwa, S. (2023). Towards a scalable resource-driven pedestrian detection for low-cost IR sensors. https://doi.org/10.1117/12.2663441

6. Debasis Parida. Arduino based Driver Drowsiness Detection & Alerting System. https://circuitdigest.com/microcontroller-projects/arduino-based-driver-drowsiness-detection-and- alert-system