

Design and Implementation of an IoT-Enabled Safety System for Electric Vehicles

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Abstract—Safety is one of the most critical aspects in the operation of electric vehicles, especially in low-speed environments such as campus transportation, industrial mobility, and short-distance travel systems. Accidents in such systems are often caused due to driver inattentiveness and lack of proper obstacle detection mechanisms. To address these challenges, this paper presents the design and implementation of an IoT-based driver safety and obstacle detection system using the ESP8266 microcontroller.

The proposed system integrates Force Sensitive Resistors (FSR) for monitoring driver engagement and an ultrasonic sensor (HC-SR04) for detecting nearby obstacles. The FSR sensors are mounted on the steering wheel to detect the presence of the driver's hands by measuring applied pressure, ensuring that the driver is actively controlling the vehicle. The ultrasonic sensor continuously measures the distance between the vehicle and surrounding objects using echo-based distance calculation. These sensors provide real-time data to the ESP8266, which acts as the central processing unit. The ESP8266 processes the sensor inputs using predefined logic and identifies unsafe conditions such as the absence of driver interaction or the presence of obstacles within a critical distance. Upon detection of such conditions, a buzzer alert system is activated to provide immediate audio feedback to the driver, enabling quick corrective action. The system operates continuously in real time, ensuring minimal delay in response and reliable performance.

Additionally, the ESP8266 offers built-in Wi-Fi capability, enabling future enhancements such as cloud connectivity, remote monitoring, and data analysis. The system is designed to be cost-effective, compact, and easy to implement, making it suitable for integration into small-scale electric vehicles and smart mobility solutions.

The results demonstrate that the proposed system provides accurate detection, fast response, and reliable operation under various conditions. Overall, the developed system enhances vehicle safety, reduces the risk of accidents, and contributes to the advancement of intelligent and connected transportation systems.

Index Terms—IoT, Electric Vehicle, ESP8266, Ultrasonic Sensor, FSR Sensor, Driver Safety, Obstacle Detection

I. INTRODUCTION

The transportation sector has undergone significant advancements in recent years, with electric vehicles emerging as a sustainable and eco-friendly alternative to conventional fuel-based vehicles. Electric vehicles offer numerous benefits such as reduced emissions, lower operating costs, and improved energy efficiency. However, ensuring safety in such vehicles remains a critical challenge, particularly in low-speed applications such as campus mobility, industrial transport, and short-distance commuting.

One of the major concerns in electric vehicle operation is driver inattentiveness. In many cases, drivers may lose focus or remove their hands from the steering wheel, leading to unsafe driving conditions. Another important issue is obstacle detection, especially in environments where vehicles operate in close proximity to pedestrians or other objects. Failure to detect obstacles in time can result in collisions and damage. To overcome these challenges, intelligent safety systems integrated with embedded and IoT technologies are required. These systems can monitor driver behavior and environmental conditions in real time, providing alerts when unsafe situations are detected.

In this work, an IoT-based driver safety and obstacle detection system is proposed using the ESP8266 microcontroller. The system combines driver monitoring using FSR sensors and obstacle detection using an ultrasonic sensor. The ESP8266 processes the sensor inputs and activates a buzzer to alert the driver when necessary. This approach ensures continuous monitoring, quick response, and improved safety. The proposed system is designed to be simple, cost-effective, and easily implementable, making it suitable for integration into small electric vehicles and smart mobility solutions.

II. LITERATURE SURVEY

Electric vehicles (EVs) have emerged as an important solution for sustainable transportation due to increasing environmental concerns, pollution, and depletion of fossil fuels. Conventional vehicles contribute significantly to greenhouse gas emissions, which has led to the development of energy-efficient and eco-friendly alternatives. EVs offer advantages such as reduced emissions, improved efficiency, and support for sustainable development [1], [2].

The integration of smart technologies, particularly the Internet of Things (IoT), has enhanced vehicle functionality and safety. IoT enables real-time monitoring, data collection, and communication between devices. In automotive systems, IoT is widely used for monitoring driver behavior and environmental conditions, thereby improving safety and reducing accident risks [3], [4].

Embedded systems play a key role in implementing IoT-based applications. Microcontrollers such as Arduino and ESP8266 are commonly used for processing sensor data and controlling system operations. The ESP8266 is especially

popular due to its low cost, compact size, and built-in Wi-Fi capability, enabling real-time communication and future cloud integration [5], [6], [7].

Sensor technology is essential for vehicle safety systems. Ultrasonic sensors are widely used for obstacle detection as they measure distance using echo-based signals. Their simplicity, reliability, and low cost make them suitable for collision avoidance applications [8], [11].

Driver monitoring is another critical aspect of safety. Force Sensitive Resistors (FSR) are used to detect pressure and ensure that the driver is actively holding the steering wheel. These sensors provide an effective and simple method for detecting driver engagement and preventing inattentive driving [9], [12].

III. PROPOSED METHODOLOGY

The proposed system aims to enhance the safety of electric vehicles by integrating driver monitoring and obstacle detection using an IoT-based approach. The methodology focuses on real-time data acquisition, processing, and alert generation using embedded systems. The overall system is designed to be simple, cost-effective, and efficient for implementation in small-scale electric vehicles. The system is built around the ESP8266 microcontroller, which acts as the central processing unit. It continuously collects data from sensors, analyzes the inputs, and makes decisions based on predefined conditions. The methodology is divided into several stages, including sensor data acquisition, data processing, decision-making, and output response.

A. Sensor Data Acquisition

In this stage, input data is collected from the sensors used in the system. Two Force Sensitive Resistors (FSR) are placed on the steering wheel to detect the presence of the driver's hands. These sensors generate analog signals based on the pressure applied. When the driver holds the steering wheel, sufficient pressure is detected, and corresponding signals are sent to the microcontroller. Simultaneously, an ultrasonic sensor is used to measure the distance between the vehicle and nearby obstacles. The sensor transmits ultrasonic waves and calculates the distance based on the time taken for the echo signal to return. This allows continuous monitoring of the surroundings in real time.

B. Data Processing

The ESP8266 processes the data received from both sensors. The analog signals from the FSR sensors are converted into digital values and compared with predefined threshold levels to determine whether the driver is holding the steering wheel. Similarly, the distance measured by the ultrasonic sensor is evaluated against a predefined safety threshold. If the measured distance is less than the safe limit, it indicates the presence of a nearby obstacle.



Fig. 1. Proposed working solution

C. Decision-Making Mechanism

Based on the processed data, the system makes decisions using conditional logic programmed in the microcontroller. The system checks for two main conditions:

- 1) Whether the driver is holding the steering wheel
- 2) Whether an obstacle is present within a critical distance

If either of these conditions indicates an unsafe situation, the system classifies it as a potential hazard. The decision-making process ensures that safety is continuously monitored without any delay.

D. Output Response (Alert System)

Once an unsafe condition is detected, the ESP8266 activates the buzzer to alert the driver. The buzzer provides an immediate audible warning, ensuring that the driver can take corrective action quickly. The alert system is designed to respond in real time, minimizing the chances of accidents. Unlike visual indicators, audio alerts are more effective in grabbing attention, especially during critical situations.

E. Continuous Monitoring and IoT Capability

The entire process operates continuously in a loop, enabling real-time monitoring of both driver activity and environmental conditions. The ESP8266's built-in Wi-Fi capability allows

future integration with IoT platforms for remote monitoring, data logging, and analysis. This feature can be extended to send alerts to mobile devices or cloud systems, enabling advanced safety features such as predictive analysis and remote supervision.

IV. BLOCK DIAGRAM

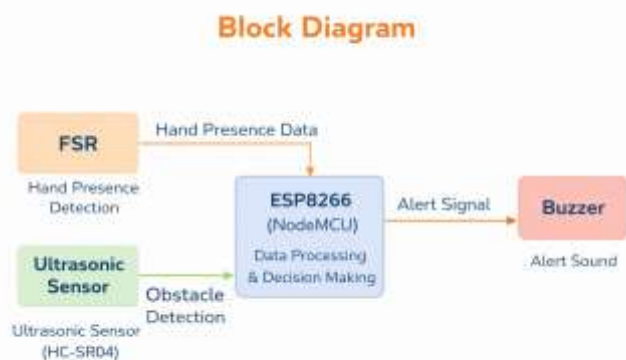


Fig. 2. Block diagram on IOT working

A. Overview

The proposed system is an IoT-based driver safety and obstacle detection system using ESP8266. It monitors driver activity and detects nearby obstacles in real time to improve vehicle safety. FSR sensors are used to check whether the driver is holding the steering wheel, while an ultrasonic sensor detects obstacles.

The ESP8266 processes the sensor data and identifies unsafe conditions. If the driver is inattentive or an obstacle is too close, a buzzer alert is triggered. The system is simple, cost-effective, and suitable for small electric vehicles.

B. Description of Block Diagram

The block diagram represents the overall working of the IoT-based driver safety and obstacle detection system. It consists of input sensors, a processing unit, and an output alert system.

The FSR sensor is used to detect whether the driver is holding the steering wheel by sensing pressure. The ultrasonic sensor (HC-SR04) is used to measure the distance between the vehicle and nearby obstacles.

Both sensor inputs are sent to the ESP8266 microcontroller, which acts as the central processing unit. It processes the data, compares it with predefined conditions, and determines whether the situation is safe or unsafe.

If an unsafe condition is detected, such as absence of driver control or a nearby obstacle, the buzzer is activated to provide an audible alert. This helps the driver take immediate action and ensures safe operation of the vehicle.

C. Data Flow Explanation

- 1) FSR sensor detects the presence of the driver's hand on the steering wheel
- 2) Ultrasonic sensor measures the distance to nearby obstacles
- 3) Sensor data is sent to the ESP8266 microcontroller
- 4) ESP8266 processes the inputs and compares with threshold values
- 5) Unsafe conditions (no driver / obstacle too close) are identified
- 6) Buzzer is activated to alert the driver

D. Functional Modules

The system can be divided into the following modules:

- 1) Driver Monitoring Module : Uses FSR sensor to detect driver hand presence on steering
- 2) Obstacle Detection Module : Uses ultrasonic sensor to measure distance and detect obstacles
- 3) Processing Module : ESP8266 processes sensor data and makes decisions
- 4) Alert Module : Buzzer provides audio alert during unsafe conditions
- 5) Power Supply Module : Provides regulated power to all components



Fig. 3. Modules functionality in the system

E. Working Principle

The system works by continuously monitoring driver activity and obstacle distance. The FSR sensor detects whether the driver is holding the steering wheel, while the ultrasonic sensor measures the distance to nearby objects. Both inputs are processed by the ESP8266 microcontroller. If the driver is not holding the steering or an obstacle is too close, the system identifies it as unsafe and activates a buzzer alert to warn the driver.

V. EXPERIMENTAL RESULTS

The system works by continuously monitoring driver activity and obstacle distance. The FSR sensor detects whether the driver is holding the steering wheel, while the ultrasonic sensor measures the distance to nearby objects. Both inputs

are processed by the ESP8266 microcontroller. If the driver is not holding the steering or an obstacle is too close, the system identifies it as unsafe and activates a buzzer alert to warn the driver.

A. Driver Monitoring

The FSR sensor effectively detected the presence of the driver's hand on the steering wheel. It accurately identified both hand presence and absence conditions. The response was quick and consistent, ensuring reliable driver monitoring.

B. Obstacle Detection

The ultrasonic sensor measured distances accurately within its operating range. It successfully detected nearby obstacles and provided consistent readings. The sensor performed well under normal conditions without major errors.

C. System Response

The ESP8266 processed the sensor data efficiently and executed the programmed logic without delay. The buzzer was activated immediately when unsafe conditions were detected, ensuring timely alerts to the driver.

D. Overall Performance

The system showed stable and reliable performance during testing. It operated continuously without interruption and effectively achieved the objective of improving vehicle safety.

VI. CONCLUSION

The proposed IoT-based driver safety and obstacle detection system using the ESP8266 microcontroller has been successfully designed and implemented. The system effectively integrates driver monitoring and obstacle detection to enhance the safety of electric vehicles, particularly in low-speed and short-distance applications such as campus mobility and industrial transportation.

The use of Force Sensitive Resistors (FSR) enables accurate detection of driver engagement by monitoring the presence of hands on the steering wheel. At the same time, the ultrasonic sensor provides reliable measurement of distance to nearby obstacles, ensuring timely detection of potential collisions. The ESP8266 microcontroller efficiently processes the sensor data and generates immediate alerts through a buzzer whenever unsafe conditions are identified.

The system demonstrates real-time performance with minimal delay, ensuring quick response to critical situations. Its simple design, low cost, and ease of implementation make it suitable for integration into small electric vehicles and other smart mobility solutions. The modular architecture also allows flexibility for future enhancements and scalability.

Overall, the developed system successfully meets the objective of improving vehicle safety by providing continuous monitoring and instant alert mechanisms. It serves as a practical and efficient solution for reducing accidents caused by driver inattentiveness and obstacle proximity.

The project highlights the importance of integrating embedded systems and IoT technologies in modern transportation to achieve safer and smarter mobility systems.

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REFERENCES

- [1] A. Bahga and V. Madiseti, *Internet of Things: A Hands-On Approach*, Universities Press, 2015.
- [2] O. Vermesan and P. Friess, *Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems*, River Publishers, 2013.
- [3] K. Ashton, "That 'Internet of Things' Thing," *RFID Journal*, 2009.
- [4] D. Evans, "The Internet of Things: How the Next Evolution of the Internet Is Changing Everything," *Cisco White Paper*, 2011.
- [5] S. Monk, *Programming Arduino: Getting Started with Sketches*, McGraw-Hill Education, 2016.
- [6] M. Margolis, *Arduino Cookbook*, O'Reilly Media, 2011.
- [7] Espressif Systems, "ESP8266EX Datasheet," 2020.
- [8] HCSR04 Ultrasonic Sensor Datasheet, "Distance Measurement Module," 2019.
- [9] Interlink Electronics, "Force Sensitive Resistor (FSR) Integration Guide and Evaluation Parts Catalog," 2018.
- [10] S. Saha et al., "Design and Implementation of Smart Vehicle Safety System Using IoT," *IEEE Conference Proceedings*, 2019.
- [11] R. Rajesh and M. Kumar, "Obstacle Detection and Avoidance System Using Ultrasonic Sensors," *International Journal of Engineering Research and Technology (IJERT)*, 2018.



Fig. 4. The final output after IOT integration in real EV



- [12] P. Goel and S. Gupta, "IoT-Based Smart Driver Monitoring System for Vehicle Safety," International Journal of Advanced Research in Computer Engineering and Technology (IJARCET), 2020.