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Smart Vehicle Safety System

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Abstract: *The Smart Vehicle Safety System is an advanced IoT-based safety solution designed to improve road safety, reduce accidents, and protect electric vehicle components from electrical faults. The system helps drivers by detecting road potholes in advance and providing alerts before the vehicle reaches damaged road areas, thereby reducing vehicle damage and accident risks. In case of an unfortunate accident, the system uses a QR code attached to the vehicle through which nearby people or emergency responders can quickly access important details of the injured person for immediate assistance. The project also focuses on short-circuit protection for the motor and battery systems in electric vehicles, where advanced protection mechanisms are used to detect abnormal current flow and disconnect the system during fault conditions, preventing overheating, battery damage, and fire hazards. The proposed system is cost-effective, reliable, and suitable for modern smart transportation systems, enhancing both vehicle safety and electrical protection efficiency.*

Keywords: : IoT, Smart Vehicle Safety, Pothole Detection, QR Code Emergency System, Short Circuit Protection, Electric Vehicle Safety.

I. INTRODUCTION

Road accidents and electrical failures in vehicles are major concerns in modern transportation systems, leading to loss of life, vehicle damage, and delayed emergency assistance [1], [11]. Poor road conditions such as potholes, lack of timely accident support, and short-circuit faults in electric vehicles are common causes of vehicle-related hazards [2], [5]. To overcome these problems, a reliable and intelligent safety system is required that can improve driver awareness, enhance emergency response, and protect vehicle components from electrical damage [13], [21].

The Smart Vehicle Safety System is an IoT-based solution developed to increase vehicle safety and reliability [7], [13], [21]. The system detects road potholes in advance and alerts the driver before the vehicle reaches damaged road areas, helping to reduce accidents and vehicle damage [2], [15], [24]. In case of an accident, a QR code attached to the vehicle allows nearby people or emergency responders to quickly access important details of the injured person, enabling faster medical assistance [10]. Wireless communication and sensor network technologies are utilized to improve system performance and monitoring efficiency [19], [25], [26]. The project also focuses on short-circuit protection for electric vehicle motor and battery systems [5], [8], [9][25-185].

II. LITERATURE REVIEW

IoT-based vehicle monitoring and accident prevention systems provide real-time alerts and improve driver awareness. Such systems have shown significant potential in reducing road accidents and improving transportation safety [1], [11], [15].

1) Literature Review 2: Pothole Detection Systems

Research on pothole detection using sensors and smart monitoring techniques has demonstrated effective identification of damaged road surfaces and timely driver alerts [2], [15], [24].

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2) Literature Review 3: Emergency Information and Response Systems

Emergency response systems play a vital role in providing quick medical assistance after accidents. QR-code-based emergency information systems enable rapid access to victim information and improve rescue operations [10], [12].

3) Literature Review 4: Electric Vehicle Protection Systems

Battery management systems, circuit protection devices, and electric vehicle safety mechanisms are widely used to prevent electrical faults and improve vehicle reliability [3], [4], [5], [8], [9], [14].

4) Literature Review 5: IoT and Wireless Sensor Network Technologies

IoT and wireless sensor network technologies have been successfully implemented in monitoring and safety applications. These technologies support real-time communication, intelligent monitoring, and efficient data processing [7], [13], [19], [21], [25].

5) Literature Review 6: Intelligent Detection and Communication Systems

Recent developments in intelligent detection, recognition techniques, and communication protocols have improved the accuracy and reliability of safety systems [16], [17], [18], [22], [23], [26], [27].

6) Literature Review 7: Safety Monitoring and Alert Systems

Advanced monitoring systems with automatic alert generation and fault detection mechanisms significantly enhance user safety and system reliability [24], [28].

Summary of Literature Review

The literature survey indicates that IoT technologies, wireless sensor networks, pothole detection systems, emergency response mechanisms, and electric vehicle protection systems can significantly improve transportation safety [1], [2], [5], [7], [11], [14]. Furthermore, recent research in intelligent monitoring, communication protocols, and safety alert systems demonstrates the feasibility of developing an integrated Smart Vehicle Safety System [19], [21], [24], [25], [26], [28].

III. PROBLEM STATEMENT

Current vehicle safety systems often lack integrated mechanisms for road hazard detection, emergency response, and electrical fault protection. Delayed accident assistance, poor road condition awareness, and electrical failures in electric vehicles can result in severe consequences. Therefore, there is a need for a smart, low-cost, and reliable vehicle safety system that combines IoT-based monitoring, pothole detection, QR-code emergency support, and electrical protection technologies into a single platform [2], [5], [10], [15], [21], [25].

IV. OBJECTIVES OF THE PROJECT

The main objective of the proposed Smart Vehicle Safety System is to develop a smart and efficient vehicle safety solution that helps in accident prevention, emergency support, and protection of electric vehicle components. The project focuses on improving road safety using IoT technology, AI-based pothole detection, QR code emergency assistance, and electrical protection systems.

The specific objectives of the project are as follows:

1. To identify potholes and damaged road surfaces before the vehicle reaches them.
2. To To provide warning alerts to the driver for safer driving and accident prevention.
3. To use ESP32-CAM and AI technology for smart road monitoring and pothole detection.
4. To establish wireless communication using ESP8266 and WiFi technology.
5. To develop a QR code-based emergency system for accident situations.

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6. To provide quick access to important details such as the driver's name and contact number during emergencies.
7. To implement short circuit protection for electric vehicle motor and battery systems.
8. To prevent overheating, battery failure, and fire hazards using relays, motor drivers, and protection circuits.
9. To design a low-cost, reliable, and easy-to-use smart vehicle safety system.
10. To improve road safety and emergency response efficiency through smart IoT-based vehicle monitoring and safety features.

V. PURPOSE OF THE SYSTEM

The primary purpose of the proposed Smart Vehicle Safety System is to enhance vehicle and passenger safety by integrating accident prevention and EV protection features. The system provides alerts for unsafe road conditions and includes a short circuit protection circuit for the EV motor and battery to prevent damage caused by electrical faults. It also uses a QR code-based emergency support system that provides important information such as the driver's name and contact number during accidents. The proposed system aims to improve road safety, protect EV components, and provide faster emergency assistance through a simple, reliable, and cost-effective solution.

VI. SYSTEM ARCHITECTURE

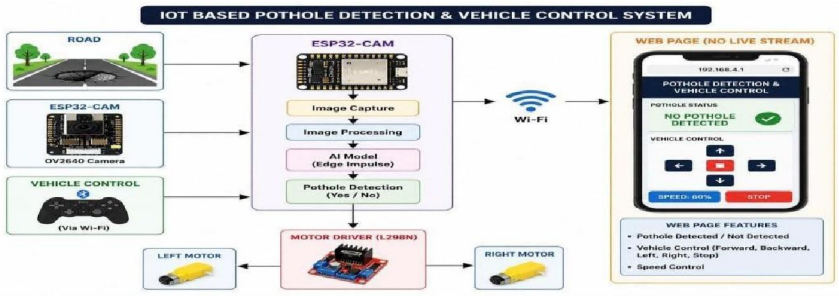

Figure: System Architecture

VII. HARDWARE REQUIREMENTS

The following hardware components are used in the proposed system:

1. ESP32-CAM – Used for image capturing and smart monitoring applications.
2. FTDI Programmer – Used for programming and uploading code to the ESP32-CAM module.
3. ESP8266 – Provides Wi-Fi communication and IoT connectivity.
4. Motor Driver (L293D) – Controls the movement and direction of BO motors.
5. BO Motors – Used for vehicle movement and control.
6. Wheels – Connected to BO motors for vehicle motion.
7. Chassis – Provides structural support for all hardware components.
8. LM2596 Voltage Regulator – Used for voltage regulation and stable power supply.
9. PCB (Printed Circuit Board) – Used for proper circuit connections and compact design.
10. Jumper Wires – Used for electrical connections between components.
11. Cells/Battery – Provides power supply to the complete system

VIII. SOFTWARE REQUIREMENTS

The following software tools are required for implementation:

1. Arduino IDE – Used for coding, compiling, and uploading programs to ESP modules.

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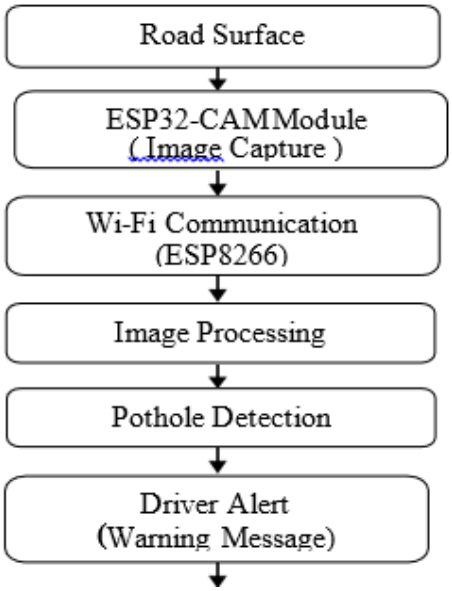
2. Edge Impulse – Used for AI model training and pothole detection applications.
3. ESP32 Board Package – Required for programming ESP32-based modules in Arduino IDE.
4. Edge Impulse Arduino Library – Used for integrating trained AI models into the system.
5. Web Browser (Google Chrome) – Used for monitoring, configuration, and accessing web-based applications.

IX. WORKING PRINCIPLE

The Smart Vehicle Safety System works by using IoT technology to improve vehicle safety and reduce accidents. The ESP32CAM monitors the road and detects potholes ahead of the vehicle, providing an alert to the driver to avoid damage and accidents. The system uses ESP8266 for wireless communication and monitoring. In case of an accident, a QR code attached to the vehicle can be scanned to access important details such as the driver's name and contact number for quick emergency assistance. The system also includes short circuit protection for the motor and battery, which automatically disconnects the power supply during fault conditions to prevent overheating, battery damage, and fire hazards. Thus, the system enhances road safety, emergency response, and vehicle protection.

X. METHODOLOGY

Methodology of the Proposed Smart Vehicle Safety System .



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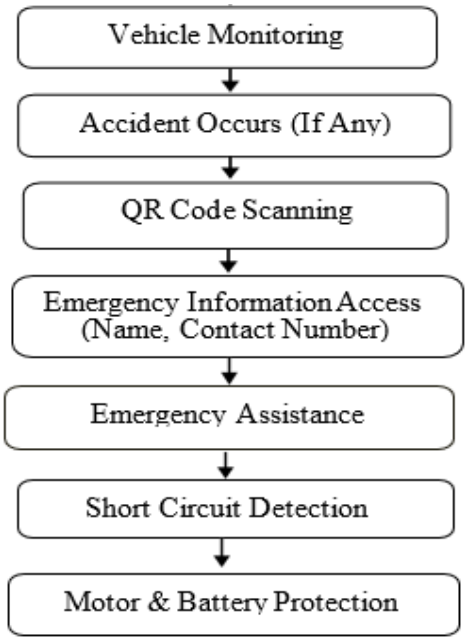

Figure: Flow Diagram

The proposed Smart Vehicle Safety System uses ESP32-CAM and IoT technology to monitor road conditions and detect potholes before the vehicle reaches them, providing alerts to the driver for safer driving. In case of an accident, a QR code attached to the vehicle helps emergency responders quickly access important information such as the driver's name and contact number. The system also includes short circuit protection for the motor and battery, ensuring safe operation by preventing overheating and electrical damage.

XI. APPLICATIONS

The proposed system can be applied in the following areas:

1. Highway and urban road safety applications to reduce accidents caused by poor road conditions
2. Provides quick access to driver information through QR code scanning during accidents
3. IoT-based smart transportation and vehicle monitoring systems.
4. Electric vehicles for motor and battery short circuit protection.

XII. FUTURE ENHANCEMENT

The proposed system can be improved in the future by adding automatic accident alert features, mobile application support, and cloud-based data storage. Additional safety features such as collision detection and voice alerts can also be included to improve vehicle safety and emergency response.

XIII. RESULTS AND DISCUSSION

The proposed Smart Vehicle Safety System was successfully implemented and tested. The system detected potholes and provided alerts to the driver. The QR code successfully displayed important details such as the driver's name and contact number during emergency situations. The short circuit protection system effectively protected the motor and battery from electrical faults. The results show that the system improves road safety, emergency response, and vehicle protection.

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XIV. CONCLUSION

The Smart Vehicle Safety System is an effective solution for enhancing road safety using IoT technology. The system successfully detects potholes on the road and provides alerts to the driver, reducing the risk of accidents and vehicle damage. The QR code-based emergency assistance feature helps provide important information quickly during emergency situations. The inclusion of motor and battery short circuit protection further improves vehicle safety and reliability. Overall, the proposed system is affordable, user-friendly, and suitable for smart vehicle applications, making transportation safer and more efficient.

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