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Deduction of Road Condition Defects Using Multiple Sensor and IoT Technology

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ABSTRACT: Road infrastructure plays a vital role in ensuring safe and efficient transportation systems. However, poor road conditions such as potholes, cracks, bumps, and uneven surfaces are common problems in many urban and rural areas. These defects can cause vehicle damage, increase fuel consumption, create traffic congestion, and even lead to serious road accidents. Traditional road inspection methods mainly rely on manual surveys and periodic inspections carried out by maintenance personnel. These methods are often time-consuming, expensive, and inefficient in detecting road damages promptly. Therefore, there is a need for an automated and real-time road monitoring system that can continuously detect and report road defects.

This project proposes a Smart Road Condition Monitoring System using IoT technology to automatically detect road surface irregularities and transmit the collected data to a remote monitoring platform. The system is designed using an Arduino Uno microcontroller, which serves as the central processing unit for collecting and analyzing data from multiple sensors. The sensing unit consists of an ultrasonic sensor, an accelerometer sensor, and a vibration sensor, each responsible for detecting different types of road anomalies.

The ultrasonic sensor is used to measure the distance between the sensor and the road surface. This helps in identifying potholes and depressions by detecting sudden changes in surface depth.

KEYWORDS: road defect detection, Internet of things (IoT), real time data monitoring, Multiple sensors, Embedded, system

I. INTRODUCTION

- Road infrastructure is one of the most important components of modern transportation systems. Roads enable the movement of people, goods, and services, which supports economic development and social connectivity. Well-maintained road networks contribute to safe and efficient transportation, reduce travel time, and improve fuel efficiency. However, maintaining road infrastructure is a major challenge for municipal authorities and government agencies, especially in rapidly growing urban areas.
- The Internet of Things (IoT) has emerged as a revolutionary technology that connects physical devices to the internet, allowing them to collect and exchange data. IoT systems typically consist of sensors, microcontrollers, communication modules, and cloud-based data platforms.
- In transportation systems, IoT technology plays a crucial role in enabling smart infrastructure management. IoT devices can collect real-time information about traffic conditions, vehicle performance, environmental parameters, and infrastructure health

II. PROBLEM STATEMENT

- Poor road conditions such as potholes, cracks, bumps, and uneven surfaces are common problems in many regions. These defects can cause road accidents, vehicle damage, traffic congestion, and increased maintenance costs. Traditional road inspection methods are mostly manual, time-consuming, expensive, and often fail to detect defects in real time.

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- There is a need for an automated and efficient system that can continuously monitor road conditions and quickly detect defects. By using multiple sensors (such as vibration, ultrasonic, and GPS sensors) integrated with IoT technology, road surface defects can be detected, recorded, and transmitted to a central monitoring system in real time.
- This project aims to develop an IoT-based road condition monitoring system that uses sensor data to identify road defects and send alerts or updates to authorities for faster maintenance and improved road safety.

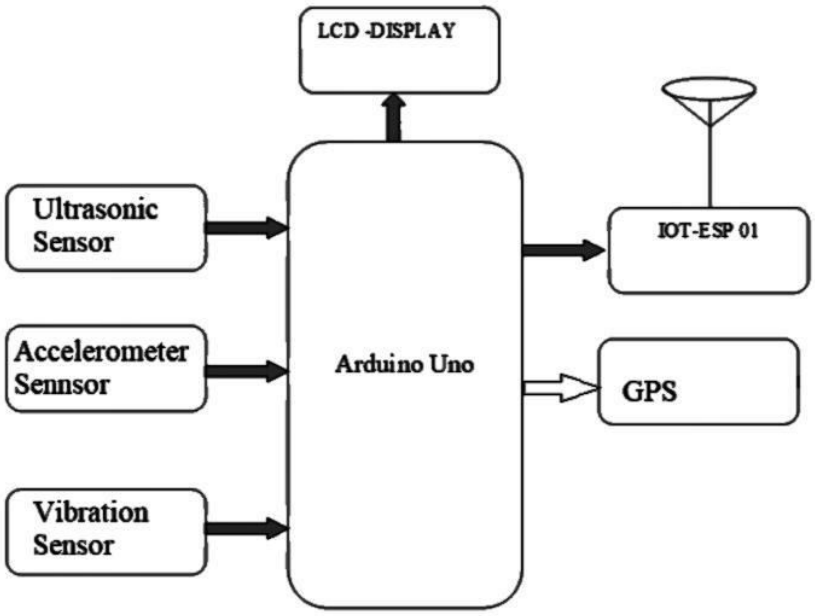
III. EXISTING SYSTEM

- In current electric vehicles, battery safety is mainly maintained using conventional Battery Management Systems (BMS) and basic thermal protection mechanisms.
- Most existing EV safety systems depend on internal battery monitoring circuits that periodically measure parameters like surface temperature and terminal voltage.
- To overcome the limitations of existing safety systems, this project proposes an IoT-Based Fire Accident Avoidance System for Electric Vehicles.
- In this system, sensors are installed near the electric vehicle battery to measure important parameters such as temperature, battery voltage, and smoke or gas presence.

IV. PROPOSED SYSTEM

- To overcome the limitations of existing safety systems, this project proposes an IoT-Based Fire Accident Avoidance System for Electric Vehicles. The proposed system integrates multiple sensors, a microcontroller, and IoT communication technology to continuously monitor battery conditions and detect potential fire hazards.
- In this system, sensors are installed near the electric vehicle battery to measure important parameters such as temperature, battery voltage, and smoke or gas presence.
- Generates an alert notification to the vehicle owner through an IoT platform using a wireless communication module such as Wi-Fi (ESP module).
- Activates a safety mechanism, such as disconnecting the battery power through a relay circuit to prevent further heat generation and reduce the risk of fire.
- The collected sensor data is transmitted to an IoT cloud platform, where it can be monitored in real time through mobile applications or web dashboards. This allows vehicle owners or maintenance teams to observe battery conditions remotely and take immediate action if abnormal conditions occur.

V. BLOCK DIAGRAM



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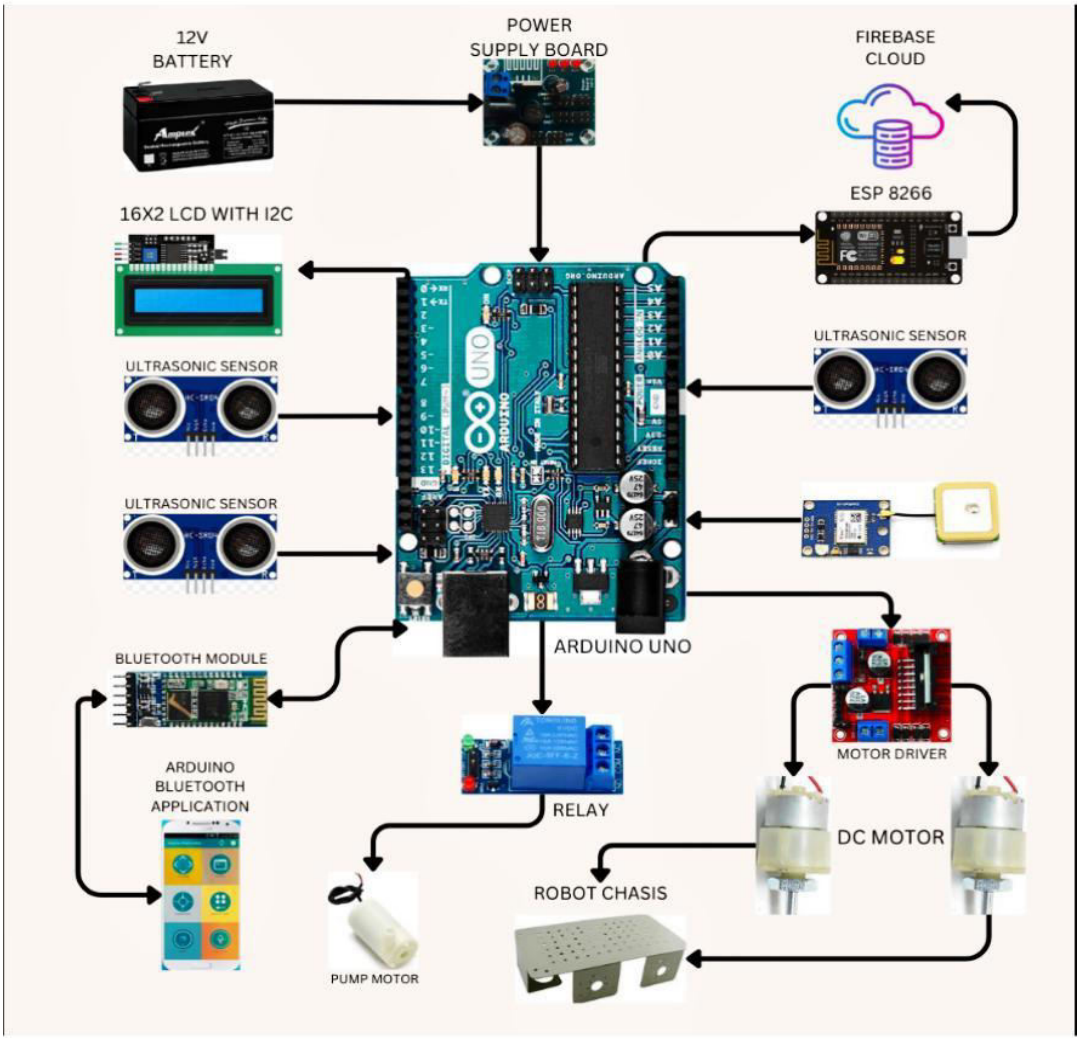

VI. DESIGN AND SELECTION OF COMPONENTS

A. Arduino Uno (ATmega328)

Arduino Uno is the main controller used in the project and is based on the ATmega328 microcontroller. It acts as the brain of the system by controlling all input and output operations. It consists of digital and analog pins, which are used to interface with various sensors and modules. The Arduino Uno processes the data received from components such as sensors and RF modules and performs the required operations accordingly.

B. GPS Module

The GPS module is used to determine the real-time location of the system. It receives signals from satellites and provides information such as latitude and longitude coordinates. This data can be used for tracking and monitoring purposes in the project.

C. Ultrasonic Sensor

The ultrasonic sensor is used to measure distance by emitting ultrasonic waves and calculating the time taken for the echo to return. It is mainly used for obstacle detection and distance measurement in the system.

D. Accelerometer sensor

An accelerometer is an electromechanical sensor that measures proper acceleration—the rate of change of velocity (motion, vibration, or shock) relative to freefall. It converts mechanical force into electrical signals, often using MEMS (Micro-Electro-Mechanical Systems) technology to detect changes in capacitance. These sensors are essential for orientation detection, motion sensing, and vibration monitoring.

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E. Vibration sensor

A vibration sensor is a device that measures the frequency, magnitude, and acceleration of mechanical oscillations in machinery and structures. By converting mechanical motion into electrical signals, these sensors detect imbalances, looseness, or bearing wear, enabling predictive maintenance to prevent equipment failure.

F. LCD display

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers to display information.

VII. SOFTWARE INSTALLATION

Arduino IDE and embedded c program are used as software tools.

A. ARDUINO IDE

A program for Arduino hardware can be written in any programming language supported by compilers capable of producing binary machine code for the target processor. Atmel offers a development environment for their 8-bit AVR and 32-bit ARM Cortex-M based microcontrollers, such as AVR Studio (older) and Atmel Studio (newer). Overall, the Arduino IDE provides a comprehensive development environment for programming Arduino boards, enabling users to quickly prototype and develop projects for various applications. The IDE includes a code editor with features such as syntax highlighting, automatic indentation, and code completion, making it easier to write and navigate code. Arduino IDE comes with a set of built-in libraries that provide functions for interfacing with various sensors, actuators, and other hardware components.

These libraries simplify the process of programming by abstracting complex functionality into simple function calls. The IDE allows users to compile their code with just a click of a button. The message area and console display error messages,
compilation results, and debugging information. One of the major advantages of Arduino IDE is the availability of a large collection of libraries. These libraries simplify programming by providing ready-made functions for sensors, communication modules, displays, and other hardware devices. By using these libraries, developers can easily integrate different components into their projects without writing complex code.

B. Embedded C

Embedded C is a programming language used for developing software in embedded systems. It is an extension of the C programming language and is specifically designed for programming microcontrollers and hardware-based devices. Embedded C provides direct access to hardware components such as input/output ports, timers, communication modules, and memory registers. This allows programmers to control sensors, actuators, and other electronic devices efficiently. In embedded system development, the program must interact closely with the hardware. Embedded C allows the programmer to read data from sensors, perform logical operations, and control output devices such as LEDs, motors, buzzers, and displays.

A typical Embedded C program contains several sections, including header files, variable declarations, initialization routines, and the main program loop. In Arduino-based systems, the program structure mainly consists of two functions: setup() and loop(). The setup() function is executed once when the microcontroller starts running. It is used to initialize input and output pins, configure communication modules, and prepare sensors for operation.

VIII. RESULT AND ANALYSIS

The developed IoT-based Smart Road Condition Monitoring System was tested to evaluate its ability to detect different types of road surface defects and transmit the collected data to an IoT platform for real-time monitoring. The system integrates an ultrasonic sensor, accelerometer sensor, and vibration sensor connected to an Arduino microcontroller, while an ESP-01 Wi-Fi module is used to transmit the processed data to the internet. Experimental testing was performed under different road conditions such as smooth roads, rough surfaces, bumps, and potholes to analyze the performance of the system.

IX. CONCLUSION

Road infrastructure plays a vital role in ensuring safe and efficient transportation systems. However, road defects such as potholes, cracks, and uneven surfaces are common problems that can cause vehicle damage, traffic congestion, and

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road accidents. Traditional road inspection methods rely mainly on manual surveys and periodic maintenance checks, which are often time-consuming and may fail to detect road damage in a timely manner. Therefore, the development of an automated and intelligent monitoring system is necessary to improve road safety and maintenance efficiency.

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