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Safety Features in Electric Vehicle

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ABSTRACT: This project presents the development and implementation of an integrated fire safety and battery monitoring system for electric vehicles (EVs) using Arduino microcontroller technology. The system employs a combination of sensors, including a flame sensor, a DHT11 temperature and humidity sensor, a voltage sensor, and a gas sensor, to continuously monitor potential fire hazards and battery conditions within the vehicle.Upon detection of abnormal conditions indicative of a fire, such as the presence of flames, excessive temperature, or gas leakage, the system activates a relay-controlled fire extinguisher and an alert buzzer to mitigate the risk. Additionally, the voltage sensor monitors the battery for overvoltage conditions, ensuring early detection of electrical anomalies that could lead to fire hazards.The system incorporates an I2C LCD display for real-time local monitoring of sensor readings and a NodeMCU (ESP8266) module to transmit data to the ThingSpeak IoT platform. This allows for remote monitoring and logging of environmental conditions and battery status within the EV. Furthermore, the Virtuino mobile application is used to provide a user-friendly interface for real-time visualization of data, enhancing the system's accessibility and usability.The implementation of this fire safety and battery monitoring system aims to enhance the safety of electric vehicles by providing an automated, real-time response mechanism to fire hazards and battery issues, ensuring prompt intervention and minimizing potential damage. This project demonstrates the feasibility and effectiveness of integrating IoT technologies with traditional safety measures to create a comprehensive safety solution for modern electric vehicles.

I.INTRODUCTION

Electric vehicles (EVs) are rapidly transforming the transportation sector by providing a sustainable and environmentally friendly alternative to traditional internal combustion engine vehicles. With advancements in battery technology and electric propulsion systems, EVs offer significant reductions in greenhouse gas emissions and lower operating costs. However, these benefits come with unique safety challenges that need to be addressed to ensure the safe operation and widespread adoption of EVs. One of the primary safety concerns is the risk of fire hazards, which can arise from several factors, including battery overvoltage, short circuits, overheating, and gas leaks. High-voltage electrical systems and large battery packs, integral components of EVs, require robust monitoring and safety mechanisms to prevent and mitigate potential fire risks.

In response to these challenges, this project aims to develop a comprehensive fire safety and battery monitoring system for electric vehicles using Arduino microcontroller technology. The system integrates multiple sensors to continuously monitor the vehicle's environment and electrical systems. A flame sensor detects the presence of flames, while a DHT11 sensor monitors temperature and humidity levels to identify conditions conducive to fire hazards. A voltage sensor ensures the battery operates within safe limits by detecting overvoltage conditions, and a gas sensor identifies any leaks of flammable gases, which could pose additional risks.

Upon detecting any abnormal conditions, such as the presence of flames, elevated temperatures, gas leaks, or battery overvoltage, the system activates a relay-controlled fire extinguisher and an alert buzzer to promptly address the hazard. The system also features an I2C LCD display for real-time local monitoring of sensor readings. To enhance accessibility and remote monitoring capabilities, the system uses a NodeMCU (ESP8266) module to transmit data to the ThingSpeak IoT platform. This data can then be visualized using the Virtuino mobile application, providing users with a user-friendly interface for real-time monitoring and logging of environmental conditions and battery status.

The primary objectives of this project are to ensure early detection and intervention in case of fire hazards, monitor battery health to prevent electrical issues, detect gas leaks to maintain a safe environment, and provide a user-friendly interface for real-time data visualization and remote monitoring. By achieving these objectives, the project aims to significantly enhance the safety and reliability of electric vehicles, promoting their wider adoption while ensuring the protection of vehicle occupants and surrounding environments. This integrated approach leverages IoT technologies to create a robust safety solution that addresses the unique challenges posed by electric vehicles.

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II. LITERATURE REVIEW

Anij Joseph John, et al. [01] has done an experimental study on "Automatic Fire Extinguishing Robotic Vehicle". This robot is defined as a mechanical design that is capable of performing human tasks or behaving in a human like manner. Building a robot requires expertise and complex programming. It's about building system and putting together motors, sensors, wires among other important components. A fire fighter robot is one that has a small fire extinguisher added to it. By attaching a small fire extinguisher to the robot, the automation put out the fire by human controlling. Fire fighters face risky situations when extinguishing fires and rescuing victims, it is an inevitable part of being a fire fighter. In contrast, a robot can function by itself or be controlled from a distance, which means that fire fighting and rescue activity could be executed without putting fire fighters at risk by using robot technology instead.

Choton Kanti Das, et al. [02] has done a research on Design and Implementation of an "Automatic Fire Extinguishing System Based on Fault Secure Multi-Detectors". The main objective of this paper was to provide an automatic fire-extinguishing system which eliminates the disadvantages of the prior arts, and to enable easy installation or removal of the system in or from a region wherein automatic fire-extinguishing should be effected and to allow a flexible arrangement of gas jetting nozzles according to the size and shape of the region. However, since such conventional automatic fire-extinguishing systems require a complicated system of gas pipes from a gas bomb to the gas jetting nozzles, the cost and installation of the pipes is expensive.

Andrzej Łebkowski [03] has done experimental studies on "Electric Vehicle Fire Extinguishing System". The presented fire extinguishing system for an electric vehicle, basing on data from temperature sensors, flame sensors and impact sensors, can alert the vehicle's driver about a fire in the vehicle and proceed with immediate preventive action. The fire system has an advantage over the other solutions, which are limited to disconnecting the battery, that it can react further, by actively trying to extinguish the present fire. The fire extinguishing system for an electric vehicle can interact with other diagnostic and monitoring systems including remote notification of emergency services, and remote electric vehicles diagnostics.

B. Swetha Sampath [04] has done a research on Hardware based "Automatic Fire Extinguisher Robot". The Robot in this paper detects the temperature of about 300°C from the furnace, using a thermocouple. IC 741 has been used both as a comparator and an amplifier. The amplified DC voltage has been converted into AC using a DC to AC convertor. The AC voltage thus generated supplies power to the water pump. Generally water or other substitutes like foam and carbon dioxide can also be used to extinguish the fire. Obstacle avoider and motion sensor have been used to avoid the obstacles and move in all directions as per the fire intensity. The robot is shielded with calcium silicate boards to withstand very high temperatures.

Rafat Shams, et al. [05] has developed a model of "Automated Fire Extinguishing System with GSM Alarm". This paper demonstrates the requirements, specifications, design problems and solutions for the fire extinguishing system project fulfilling the requirements. Fire fighting is an important and hazardous job. A fire fighter can be able to extinguish fire quickly, averting the damages and reduce losses. Technology has joined the gap between fire fighting and machines using some effective method. The purpose of this thesis was to establish a system that can detect fire and extinguish it in the shortest time subject to a few effective factors. In this case, the system aims to put out the fire before it spreads increasing the security of home, laboratory, office, factory and building that is important to human life

III. METHODOLOGY OF PROPOSED SURVEY

The development of the integrated fire safety and battery monitoring system for electric vehicles involves a comprehensive and systematic approach, combining hardware assembly, software development, and rigorous testing to ensure a robust and reliable solution. The first step in the methodology is the design and selection of hardware components. The Arduino microcontroller is chosen as the central processing unit due to its versatility and ease of integration with various sensors and modules. Essential sensors include a flame sensor for early fire detection, a DHT11 sensor for monitoring temperature and humidity, a voltage sensor to track battery voltage levels, and a gas sensor, such as the MQ series, to detect flammable gases. These sensors provide critical data on the vehicle's environmental and electrical conditions. A relay module is incorporated to control the activation of the fire extinguisher system, ensuring a rapid response to detected hazards. An I2C LCD display is used for real-time local monitoring, while the NodeMCU (ESP8266) module enables WiFi connectivity for remote data transmission to the ThingSpeak IoT platform. An alert buzzer is also included to provide audible warnings of any detected hazards.

Following the selection and integration of hardware components, the next step involves detailed hardware assembly.

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Each sensor is connected to the Arduino's input pins, with careful attention to power supply and grounding to ensure reliable operation. The relay module is connected to the Arduino's digital output pin, configured to control the fire extinguisher activation circuit. The I2C LCD display and buzzer are integrated for real-time data display and alert notifications, respectively. The NodeMCU is connected to the Arduino to facilitate WiFi communication and data transmission to the ThingSpeak platform.

Software development is a critical phase of the project, involving the writing and uploading of code to the Arduino and NodeMCU using the Arduino IDE. The code is designed to read data from the sensors, process the signals, and identify abnormal conditions that indicate potential hazards. Upon detecting such conditions, the system activates the relay to trigger the fire extinguisher and sounds the buzzer to alert vehicle occupants. The NodeMCU code is developed to transmit sensor data to the ThingSpeak platform, enabling remote monitoring and data logging. The Virtuino mobile application is configured to retrieve and display this data, providing a user-friendly interface for real-time monitoring.

Extensive testing and validation are conducted to ensure the system's functionality, reliability, and safety. Each sensor is individually tested to verify accurate readings and proper integration with the Arduino. Various hazard scenarios, such as the presence of flames, high temperatures, overvoltage conditions, and gas leaks, are simulated to test the system's response. The entire system is tested as a whole to ensure seamless communication between all components, including the Arduino, NodeMCU, ThingSpeak, and Virtuino. Prolonged testing is performed to assess the system's stability under continuous operation, and fail-safe mechanisms are implemented and tested to ensure the system operates safely under all conditions.

Finally, the system is deployed in a prototype electric vehicle or a controlled testing environment to monitor real-world performance and gather feedback for further improvements. Comprehensive documentation is prepared, including hardware setup, wiring diagrams, software code, and a detailed user manual and troubleshooting guide. This thorough methodology ensures the creation of a reliable and effective integrated fire safety and battery monitoring system for electric vehicles, significantly enhancing their safety and reliability.

Development

Tools

Hardware –

1. Arduino UNO
2. Node MCU
3. Flame Sensor
4. Gas Sensor
5. DHT11
6. Buzzer
7. Relay

Software – Arduino IDE, Proteus

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IV. BLOCK DIAGRAM AND CIRCUIT DIAGRAM

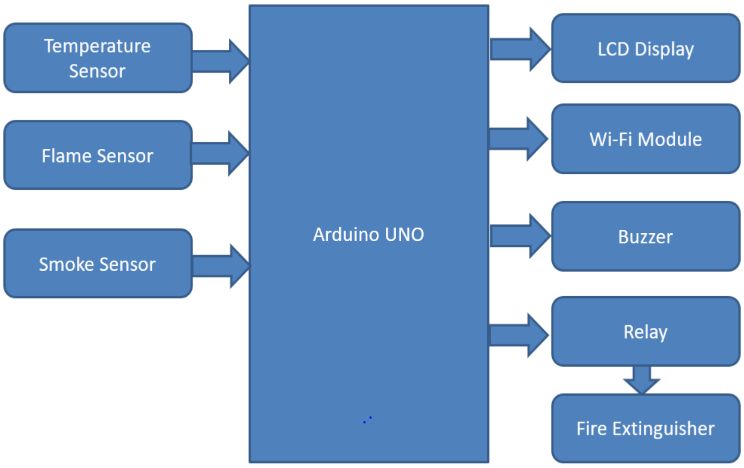

Figure 1. Block Diagram

The major elements of block diagram are:

- Arduino UNO
- Node MCU
- Flame Sensor
- Gas Sensor
- DHT 11

ARDUINO UNO

The Uno R3 is a open source microcontroller board based on the ATmega328 chip. This Board has 14 digital input/output pins, 6 analog input pins, Onboard 16 MHz ceramic resonator, Port for USB connection, Onboard DC power jack, An ICSP header and a microcontroller reset button. It contains everything needed to support the microcontroller. Using the board is also very easy, simply connect it to a computer with a USB cable or power it with DC adapter or battery to get started.The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2Atmega8U2 up to version R2) programmed as a USB-to-serial converter. While the UNO can be powered via the USB connection or with an external power supply, the power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Also leads from a battery can be inserted in the Gnd and Vin pin headers of the Power connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 5v to 12v for Uno.

Node MCU

The NodeMCU with cp2102 Wifi Board is an all-in-one microcontroller + WiFi platform that is very easy to use to create projects with WiFi and IoT (Internet of Things) applications. The board is based on the highly popular ESP8266 WiFi Module chip with the ESP-12 SMD footprint. This WiFi development board already embeds in its board all the necessary components for the ESP8266 (ESP-12E) to program and uploade code. It has a built-in USB to serial chip upload codes, 3.3V regulator and logic level converter circuit so you can immediately upload codes and connect your circuits. This board contains the ESP-12E chip with a 4MB! flash memory so no worries for your long project codes!

The ESP8266 NodeMCU with cp2102 development board - a true plug-and-play solution for inexpensive projects using

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WiFi. The module arrives pre-flashed with NodeMCU firmware so just install your USB driver. The NodeMCU is an open-source project and you can find all the design files and so on from their github page.This microcontroller board can easily be programmed using the Arduino IDE programming software.

Flame Sensor

The flame sensor is a crucial component of the integrated fire safety and battery monitoring system for electric vehicles. Its primary function is to detect the presence of flames, providing early warning of fire hazards. The sensor is specifically designed to sense infrared (IR) light emitted by flames, allowing for quick and accurate detection.

Flame sensors operate based on the detection of infrared radiation, which is characteristic of burning flames. Most flame sensors are equipped with a photodiode or phototransistor that is sensitive to the IR spectrum, typically around 760 nm to 1100 nm. When a flame is present, it emits IR radiation, which the sensor detects. The sensor then outputs a signal indicating the presence of a flame.

DHT11

The DHT11 is a low-cost digital temperature and humidity sensor, widely used in environmental monitoring applications. It operates on a voltage range of 3.3V to 5.5V and can measure temperatures from 0°C to 50°C with an accuracy of ±2°C, and humidity from 20% to 90% RH with an accuracy of ±5% RH. The sensor provides a digital output and is simple to interface with microcontrollers like Arduino and Raspberry Pi, often using libraries that facilitate easy data retrieval. Despite its limited accuracy and range, the DHT11 is valued for its affordability and ease of use in basic sensing projects. The DHT11 is a commonly used Temperature and humidity sensor that comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data.

Smoke Sensor

MQ135 Gas Sensor module for Air Quality having Digital as well as Analog output. Sensitive material of MQ135 gas sensor is SnO_2, which with lower conductivity in clean air. When the target combustible gas exist, The sensors conductivity is more higher along with the gas concentration rising. MQ135 gas sensor has high sensitivity to Ammonia, Sulphide and Benze steam, also sensitive to smoke and other harmful gases. It is with low cost and suitable for different application. Used for family, surrounding environment noxious gas detection device, Apply to ammonia, aromatics, sulfur, benzene vapor, and other harmful gases/smoke, gas detection, tested concentration range: 10 to 1000 ppm

Relay

5 Volts 1-Channel relay module is an interface board that is compatible with Arduino, AVR, PIC, ARM, etc. This module can work in a high current like AC250V 10A or DC30V 10A. It controls larger loads and devices like DC motors, AC motors, and other AC and DC devices with the digital outputs from controllers and processors. It is a 1-channel relay module, so it can control any 1 device. Each relay or channel of 1 channel relay module needs 15-20mA driver current and 5 Volts supply.

V. ADVANTAGES AND APPLICATIONS

Advantages

- Cost-Effective Solution
- Enhanced Safety
- Simple Integration

Application

- In EV vehicle
- In industry for fire Safety
- In school for fire safety

VI. RESULTS

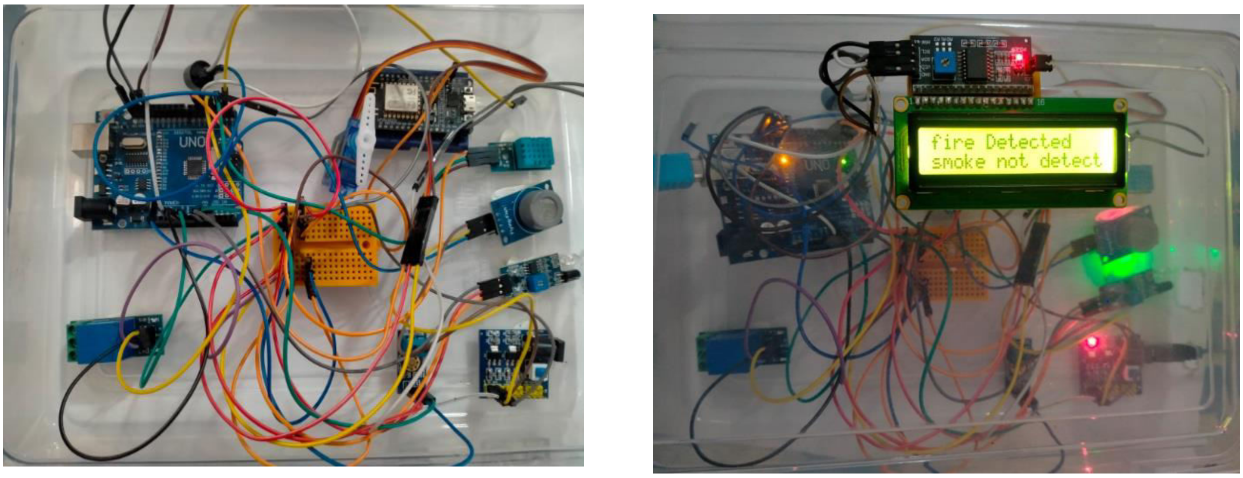

Figure 2. Result

VII. CONCLUSION

Flame sensors play a crucial role in enhancing the fire safety of electric vehicles by providing early detection of potential hazards. However, they are not without their limitations. Despite their rapid detection capabilities, their effectiveness can be hindered by factors such as limited detection range, susceptibility to false alarms, and dependency on power sources. Additionally, their focus on detecting flames alone may overlook other fire indicators, necessitating the integration of complementary sensors for comprehensive fire detection. Environmental factors and installation challenges further contribute to the complexity of utilizing flame sensors effectively. Despite these challenges, addressing these limitations through careful system design, regular maintenance, and strategic sensor placement can significantly enhance their reliability and overall contribution to vehicle safety. Therefore, while flame sensors are valuable tools in electric vehicle fire safety systems, a holistic approach that considers their advantages and disadvantages is essential to ensure optimal performance and safety standards in electric vehicle applications.

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