Hazard Detection and Response Robot for Real Time Monitoring

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Abstract. Abstract- The project aims to design and develop a robot to detect hazards and give response using various sensors and an automated alert system. The robot is equipped with an ESP32-CAM module to capture live video, an MQ2 gas sensor to detect harmful gases, and a DHT11 sensor to monitor temperature and humidity levels. When the robot senses a dangerous situation, it activates both sound alarms using a buzzer to warn of the threat. The robot's movement is driven by 60 RPM motors, managed by an L293D motor driver, enabling it to move independently and respond to hazards. ESP32 camera module ensures continuous remote monitoring, offering users essential visual information about the robot's surroundings. Additionally, a storage compartment is included for safely handling or collecting small hazardous items when needed. This all-in-one system improves safety across industrial, commercial, and residential settings by combining real-time hazard detection, alert systems, and easy monitoring capabilities.

Keywords: DHT11 Sensor, MQ2 Gas Sensor, ESP 32 CAM, Arduino UNO,L293D Motor Driver, DC Motor.

1 Introduction

Robotics has become a crucial aspect of modern technology, offering innovative solutions across a wide range of industries. One of its key applications is in safety and hazard detection, where robots are used to autonomously monitor and address environmental risks. This project focuses on creating a hazard detection and response robot capable of identifying and reacting to hazardous conditions like temperature, humidity, and gas levels in real time. By integrating sensors, mobility systems, and wireless control, the robot can navigate different environments autonomously, providing instant alerts to potential hazards. Combining advanced technologies such as sensor integration, wireless communication, this project seeks to improve the safety and operational efficiency in hazardous settings. The proposed system uses these technologies to create an autonomous robot for real-time hazard detection and

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response, offering a practical solution for safety in dynamic and potentially dangerous environments. Its modular design allows for flexibility in various applications, including industrial safety and surveillance. These robots are designed to improve safety by constantly monitoring for environmental risks and they help to automate tasks, making work safer, more efficient, and of higher quality.

This project is designed to be flexible, making it useful for many purposes. It can help with industrial safety by checking for dangerous conditions and preventing accidents. It's also great for surveillance, keeping secure areas safe. The design can be adjusted for other uses too, like managing disasters, monitoring the environment, or helping in search and rescue missions, making it helpful in everyday work and emergencies.

2 Literature Survey

Paper [1] introduces a robot for safe remote surveillance in war zones and borders. It uses an Arduino Uno board, an L293D motor driver for movement, and an HC-05 Bluetooth module for wireless control via an Android device. A night vision camera provides real-time visuals with a range of 100 meters, ensuring effective monitoring in risky areas. The authors in [2] developed a versatile surveillance and rescue robot. Powered by an Arduino Uno, it includes a PIR sensor for motion detection, an ultrasonic module for obstacle avoidance, and a DHT11 sensor for temperature and humidity. It also uses an MQ-135 sensor for hazardous gas detection and features an accelerometer, gyroscope, and magnetometer for stability. A GPS module aids tracking, while Bluetooth and Wi-Fi enable remote control via an Android phone. The robot has a robotic arm with a gripper for rescue tasks and a solar panel for ecofriendly, self-charging in remote areas.Cheng, Ye, and Zhang in 2021[3] demonstrated a smart car controlled using Bluetooth was proposed. It is powered by a microcontroller and uses an HC-05 Bluetooth module to connect with a smartphone. The car has sensors to detect and avoid obstacles, allowing it to be controlled manually or move on its own [1-3]. Authors in [4] highlighted in their paper that surveillance systems play a crucial role in areas like security, monitoring, and automation. The introduction of compact and cost-effective modules such as the ESP32-CAM has paved the way for innovative advancements in the design and functionality of surveillance robots. This review focuses on examining current research and progress in the development of surveillance robots that incorporate the ESP32-CAM module [4].Akilan et al. in 2020 [5] stated that robots used for surveillance are made to keep an eye on dangerous situations that could endanger human safety, like places with high radiation levels, harmful chemicals, or unstable terrain.These robots can lessen the need for human involvement in hazardous areas and give real-time data.Robots may provide real-time data to distant operators thanks to Internet of Things (IoT) technology.The robot's sensors gather information about motion, temperature, and gas levels [4-5]. Paper [6] presented that the robotic-system is outfitted with cameras to relay live video for identifying environmental conditions or barriers, such as infrared or ultrasonic sensors. Using a smartphone app, remote control and monitoring is possible [1-6].

3 System Design

The design of the hazard detection and response robot combines several key components for effective sensing, movement, and alerting. It includes a DHT11 sensor to monitor temperature and humidity, along with an MQ2 sensor for detecting gases, ensuring real-time hazard detection. The robot also features an ESP32-CAM module for continuous video capture, allowing for ongoing visual monitoring. Powered by an Arduino Uno, the robot uses an L293D motor driver to navigate precisely with 60 RPM motors. The alert system consists of an LED and buzzer, providing immediate warnings when hazards are detected. Additionally, the robot has a storage compartment for handling non-hazardous objects. Together, these components create a reliable and adaptable system designed to enhance safety in various environments.

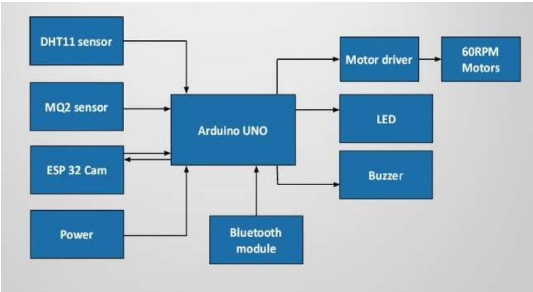

Fig. 1.: Block Diagram of Hazard Detection and Response Robot For real time monitoring.

4 System Requirement Specification

DHT11 Sensor: DHT11 is a digital humidity and temperature sensor. It is widely used in various electronics projects due to its simplicity and low cost.

MQ2 Gas Sensor: MQ2 sensor issued to sense multiple gas concentration in the air likepropane, LPG,hydrogen, methane, alcohol.Gases detection is triggeredwhen there is a change in resistance value.It is capable of detecting the gases which are in the range of 200-10,000 ppm in concentration and operates at 5V DC.

LED: When power flows through a semiconductor device called a light-emitting diode (LED),the light emits. LEDs are energy-efficient, compact, and long-lasting. They are used in a wide variety of applications, such as electrical device indications and extensive lighting systems.
Buzzer: A buzzer is commonly used as an output device in electronic systems. It converts electrical energy into sound, providing audible feedback to the user in response to certain events or conditions. As an output device, it is often used in applications like alarms, notifications, and status indicators

ESP32 Camera: The ESP32-CAM microcontroller is cheap and small. It has a builtin camera that allows you to take higher quality photos without crashing the ESP32, and is used to buffer images from the camera in the video stream.

60 RPM Motor: 60 RPM motor typically refers to a low-voltage, compact motor with a speed of 60 rotations per minute, often used in lightweight applications or small robotics projects. These motors are generally smaller in size compared to standard DC motors, making them suitable for projects with limited space.

Bluetooth Module: A popular Bluetooth module for Arduino and other microcontroller-based applications, the HC-05 allows wireless communication between devices. It is adaptable for a variety of wireless applications, including data transfer and wireless sensor networks, because it runs on Bluetooth 2.0+EDR (Enhanced Data Rate) and supports both master and slave setups.

Software Design: Programs are designed and manufactured using the Arduino IDE application. The Arduino IDE is a piece of software used to program the Arduino.

5 Methodology

The methodology is focused on creating a reliable workflow that effectively integrates sensing, movement, and alert systems, following a clear process of design, construction, and testing. The project started by identifying the key environmental factors needed for hazard detection and choosing the right sensors to measure them accurately. A modular approach was used for both hardware and software, allowing each component to be tested separately. Algorithms were created to process sensor data in real time and trigger actions like activating alerts or recording video. The mobility system was programmed to ensure smooth movement across different terrains, while video recording was synchronized with the robot's operation. Ongoing testing was performed to fine-tune detection levels and response times, ensuring the system worked reliably under different conditions. This step-by-step process ensured effective hazard detection and quick responses, meeting the project's functional goals.

6 Implementation and Results

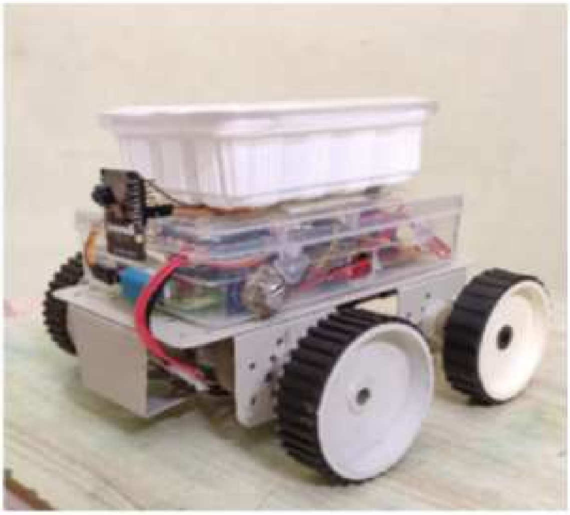

Fig. 2. Implementation of hazard detection and response system

The development of the hazard detection and response robot began with assembling the necessary hardware components. The DHT11 and MQ2 sensors were connected to the Arduino Uno to monitor temperature, humidity, and gas levels in the environment. The ESP32-CAM module was integrated to provide real-time video capture, which starts as soon as the robot begins its operation. The mobility system, consisting of 60 RPM motors controlled by an L293D motor driver, was programmed to ensure precise movement and navigation. The robot's alert system, which includes a buzzer, was set up to emit audible warnings when hazardous conditions are detected. Software was created to process sensor data in real time, and based on preset thresholds, the robot activates the buzzer when hazards are detected. The final system allows the robot to autonomously detect hazards, alert users, and capture video while navigating its environment.
The final results include activating the buzzer when threshold value of the DHT11 is reached or gas sensor is activated. In programming, we considered 35 as a threshold value for temperature and 70 for humidity. Additional results for live streaming with the help of ESP32 camera can be observed in the webpage.

The following are the results produced in the serial monitor of Arduino IDE.

```
15:03:31.091 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:31.279 -> Humidity = 55.00%
15:03:31.279 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:31.503 -> Humidity = 55.00%
15:03:31.503 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:31.784 -> Humidity = 55.00%
15:03:31.784 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:32.011 -> Humidity = 55.00%
15:03:32.011 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:32.191 -> Humidity = 55.00%
15:03:32.191 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:32.426 -> Humidity = 55.00%
15:03:32.426 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:32.660 -> Humidity = 55.00%
15:03:32.660 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:32.900 -> Humidity = 55.00%
15:03:32.900 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:33.118 -> Humidity = 55.00%
15:03:33.118 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:33.305 -> Humidity = 55.00%
15:03:33.305 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:33.540 -> Humidity = 55.00%
15:03:33.540 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:33.821 -> Humidity = 55.00%
15:03:33.821 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:34.009 -> Humidity = 55.00%
15:03:34.009 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:34.243 -> Humidity = 55.00%
15:03:34.243 -> SMOKE DETECTED!BELOW THRESHOLD Temperature = 27.10°C | 80.78°F
15:03:34.477 -> Humidity = 55.00%
```

Fig . 3.: Normal condition

```
15:07:13.651 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:13.886 -> Humidity = 98.00%
15:07:13.886 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:14.120 -> Humidity = 98.00%
15:07:14.120 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:14.354 -> Humidity = 98.00%
15:07:14.354 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:14.589 -> Humidity = 98.00%
15:07:14.589 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:14.823 -> Humidity = 98.00%
15:07:14.823 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:15.058 -> Humidity = 98.00%
15:07:15.058 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:15.292 -> Humidity = 98.00%
15:07:15.292 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:15.479 -> Humidity = 98.00%
15:07:15.479 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:15.714 -> Humidity = 98.00%
15:07:15.714 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:15.948 -> Humidity = 98.00%
15:07:15.948 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:16.182 -> Humidity = 98.00%
15:07:16.182 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:16.417 -> Humidity = 98.00%
15:07:16.417 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:16.604 -> Humidity = 98.00%
15:07:16.604 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:16.839 -> Humidity = 98.00%
15:07:16.839 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:17.120 -> Humidity = 98.00%
15:07:17.120 -> SMOKE DETECTED!THRESHOLD EXCEEDEDTemperature = 33.30°C | 91.94°F
15:07:17.307 -> Humidity = 98.00%
```

Fig. 4.:Hazard condition

7 Conclusion

This project successfully demonstrated the integration of various technologies to develop a robust hazard detection and response robot. The Bluetooth control system provided seamless wireless communication, enabling real-time operation via the Arduino Bluetooth Control app. The integration of the DHT11 and MQ2 sensors ensured accurate environmental monitoring for hazard detection, while the ESP32-CAM module facilitated continuous video capture, enhancing the robot's monitoring capabilities. The robot's mobility system, driven by 60 RPM motors and an L293D motor driver, ensured smooth navigation across diverse environments. The buzzer alert system provided immediate feedback upon detecting hazards, ensuring quick responses. With effective hazard detection, prompt alerting, and reliable navigation, this project demonstrates the potential of combining sensing, robotics, and wireless control to address safety concerns in various applications. The success of this robot highlights its potential for use in safety, surveillance, and automation tasks.

Disclosure of Interests. The authors declare that there is no conflict of interests related to the publication of this paper

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