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IoT BASED FIRE FIGHTING ROBOT WITH SMOKE DETECTION

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Abstract: This paper presents the design and implementation of an IoT-enabled fire-fighting robot with integrated smoke detection for application in hazardous and fire-prone environments. The proposed system is intended to operate autonomously, enabling early identification and suppression of fire while minimizing human involvement. It incorporates flame and smoke sensors interfaced with a microcontroller to continuously monitor environmental conditions and detect fire-related anomalies with improved accuracy.Upon detection of fire or smoke, the robot navigates toward the affected region and activates an onboard extinguishing mechanism, such as a water-based spray system, to control and suppress the flames. The integration of IoT technology through Wi-Fi communication facilitates real-time data transmission . Users can access system parameters, including temperature, smoke concentration, and operational status, via a connected interface.The developed system enhances safety by reducing human exposure to hazardous conditions and improving response time during fire emergencies. It demonstrates the effective integration of IoT, and robotics in developing reliable and intelligent solutions for fire detection and control applications.

Keywords: **:** IoT, Fire Fighting Robot, Smoke Detection, Arduino, Flame Sensor, Temperature Sensor,Wireless Control.

I.INTRODUCTION

Recent advancements in Internet of Things (IoT) technology have enabled significant improvements in safety and automation systems, particularly in fire hazard management. Traditional fire detection methods often depend on manual intervention, which can be unsafe and slow in emergency situations. To overcome these limitations, an IoT-enabled fire-fighting robot with smoke detection is proposed as an intelligent solution. The system integrates environmental sensors with a microcontroller to continuously monitor smoke and temperature levels and identify potential fire incidents at an early stage. Once a threat is detected, the robot autonomously moves toward the source and activates a fire suppression mechanism to control the situation. IoT connectivity allows real-time data transmission and remote monitoring through wireless networks, improving response efficiency. This approach enhances operational safety by reducing human exposure to dangerous environments and provides a reliable, cost-effective method for fire detection and control in modern smart systems.

II. LITERATURE SURVEY

A. Role of IoT in Fire Safety Applications

Recent developments in IoT-based systems have enabled better monitoring and control of firefighting robots. A 2024 study on IoT-integrated firefighting robots with mobile application support highlights how wireless communication can be used to monitor environmental parameters and control operations remotely. This approach improves system accessibility and real-time responsiveness.

B. Autonomous Fire Detection and Response Systems

Li (2023) proposed an indoor robotic system capable of performing both inspection and firefighting tasks automatically. The system utilizes advanced sensing methods, including visual and thermal analysis, to detect fire hazards and respond without external control. This research demonstrates the advantages of combining sensing technologies with autonomous decision-making.

C. Design Improvements in Firefighting Robots

Zhao et al. (2022) introduced a firefighting robot equipped with an articulated tracked mechanism designed to handle complex terrains. Their work focuses on enhancing the robot's ability to navigate obstacles and maintain stability under

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challenging conditions. The study highlights the role of mechanical structure and mobility in improving operational effectiveness.

D. Progress in Firefighting Robotic Technologies

In recent years, there has been increasing interest in the application of robotic systems for fire management. The work of Roldán-Gómez et al. (2021) provides an extensive analysis of robots used in firefighting, particularly in large-scale environments such as forests. The study emphasizes how robotic solutions can perform critical tasks like fire detection and suppression while minimizing risks to human firefighters.

III. EXISTING SYSTEM

Current fire detection and suppression systems are primarily based on stationary devices such as smoke detectors, heat sensors, and automatic sprinkler systems. These systems are effective in identifying fire hazards at an early stage; however, they are limited to fixed locations and cannot actively respond to dynamic fire conditions. In most cases, once a fire is detected, human intervention is required to control and extinguish it, which can be dangerous in environments with high temperatures, smoke, or toxic gases.Several robotic systems have been introduced to assist in firefighting operations. These systems typically rely on remote control using wired or short-range wireless communication. While they reduce direct human involvement, their functionality is often limited by restricted mobility, lack of autonomous decision-making, and dependence on continuous operator control.Existing IoT-based solutions mainly focus on monitoring environmental conditions and sending alerts through connected devices. Although these systems provide real-time notifications, they do not integrate autonomous navigation or active fire suppression mechanisms. As a result, their ability to respond effectively to fire emergencies is limited.These drawbacks highlight the need for an advanced system that combines real-time monitoring, autonomous operation, and efficient fire suppression in a single integrated platform.

IV. PROPOSED SYSTEM

The proposed system presents an IoT-based fire-fighting robot integrated with smoke detection to enable early fire identification and rapid response in hazardous environments. The system is designed to operate autonomously by combining sensing, processing, and actuation mechanisms within a single platform.The robot is equipped with smoke and flame sensors that continuously monitor environmental conditions. These sensors are interfaced with a microcontroller, which processes the incoming data and identifies abnormal variations indicating the presence of fire. Once a fire event is detected, the control unit initiates the movement of the robot toward the source using motor drivers and a navigation mechanism.An onboard extinguishing unit, such as a water pump or is activated to control and eliminate the fire. The robot is also integrated with a Bluetooth-enabled IoT module, which allows real-time transmission of data t mobile interface. The proposed system improves operational efficiency by combining autonomous navigation, real-time monitoring, and effective fire suppression. It offers a reliable and cost-effective solution for minimizing human risk and enhancing safety in fire-prone environments.

Technologies and Tools	Purpose
Arduino	Sensor Data Collection And Transmission.
Arudino IDE	Coding and uploading microcontroller.
Motor driver module	Converts control signal into motor movement for robot navigation.
DC motors	For robot movement
Relay module	Switches high power components safely
Solenoid valve	Controls water detection

A. PROPOSED SYSTEM BLOCK DIAGRAM

Power Supply:
Provides electrical power to the entire system so all components can work.

Temperature sensor:
The temperature sensor is used to continuously monitor the surrounding heat levels and detect abnormal rises may indicate the presence of fire.

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Fig 1: Temperature Sensor

Motor driver module:
The motor driver module acts as an interface between the microcontroller and the motors, enabling controlled movement of the robot in different directions.

Fig 2: Motor driver module

Aurdino UNO:
Arduino serves as the central control unit of the system, processing input data from sensors and coordinating the overall operation of the robot

Fig 3:Aurdino UNO

HC-05 Bluetooth:
The HC-05 Bluetooth module enables wireless communication between the robot and external devices such as smartphones or computers for remote control.

Fig 4: HC-05Bluetooth

Block diagram explanation

[1]. **Input Section**

- **Power Supply:** Provides the necessary electrical energy to operate all components of the system.
- **Smoke Sensor (MQ-2):** Detects the presence of smoke or harmful gases to identify potential fire conditions.
- **Temperature Sensor (DHT11):** Measures ambient temperature to detect abnormal heat variations.
- **Ultrasonic Sensor:** Determines the distance to obstacles for safe navigation of the robot.
- **Motor Driver:** Controls the movement of motors based on signals received from the microcontroller.

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- **Water Pump:** Dispenses water to extinguish fire when activated by the system.

[2].Processing Unit

Arduino / ESP32 Microcontroller: **Acts as the central unit that processes sensor data and controls all system operations.**

[3].Processing / Analysis
- **Sensor Data Processing:** Analyzes input from sensors to determine the presence of fire conditions.

[4].Output Section
- **Fire Detection Result:** Indicates whether a fire is detected based on processed sensor data.
- **Autonomous Robot Control:** Enables the robot to move automatically toward the fire source and take action.
- **Bluetooth:** Allows wireless communication for remote monitoring and manual control of the robot.

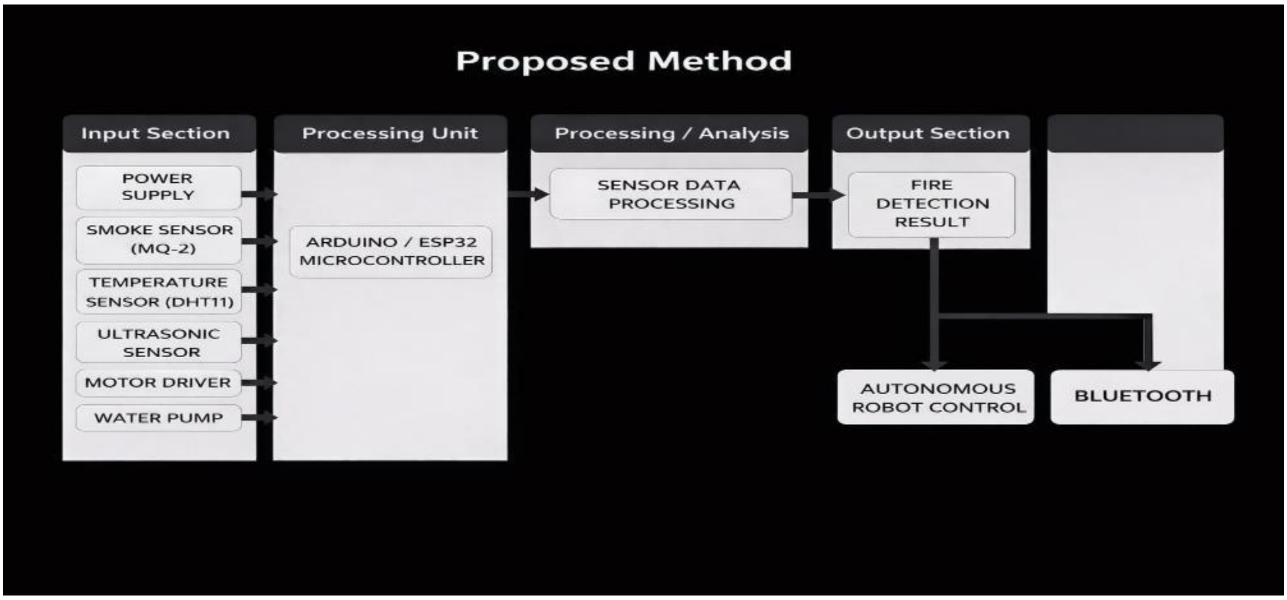

Figure 4.: Proposed System Block Diagram

V. IMPLEMENTATION DETAILS

1. System Design Approach
The proposed system is developed using a modular architecture that integrates sensing, processing, and actuation units to achieve efficient fire detection and suppression.

2. Hardware Setup
The hardware components include an Arduino/ESP32 microcontroller, smoke sensor (MQ-2), temperature sensor (DHT11), ultrasonic sensor, motor driver, and a water pump. These components are interconnected to form a compact robotic platform capable of performing detection and firefighting tasks.

3. Data Acquisition
Environmental parameters such as smoke concentration and temperature are continuously monitored using sensors. The collected data is transmitted to the microcontroller for further processing and analysis.

4. Data Processing and Decision Making
The microcontroller evaluates the sensor data and compares it with predefined threshold values to determine the presence of fire. Based on the analysis, appropriate control signals are generated for system operation.

5. Robot Navigation and Control
The motor driver controls the movement of the robot based on instructions from the microcontroller. The ultrasonic sensor assists in obstacle detection, allowing the robot to navigate safely toward the fire source.

6. Fire Suppression Mechanism
When a fire is detected, the water pump is activated to release water or fire-extinguishing agents, helping to control and suppress the flames effectively.

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7. Communication and Monitoring

The system incorporates a Bluetooth module for wireless communication, enabling remote monitoring and manual control through a smartphone or other devices.

8. System Integration

All hardware and software components are integrated to ensure coordinated operation, resulting in a reliable and efficient fire-fighting robotic system.

VI. EXPERIMENTAL RESULTS

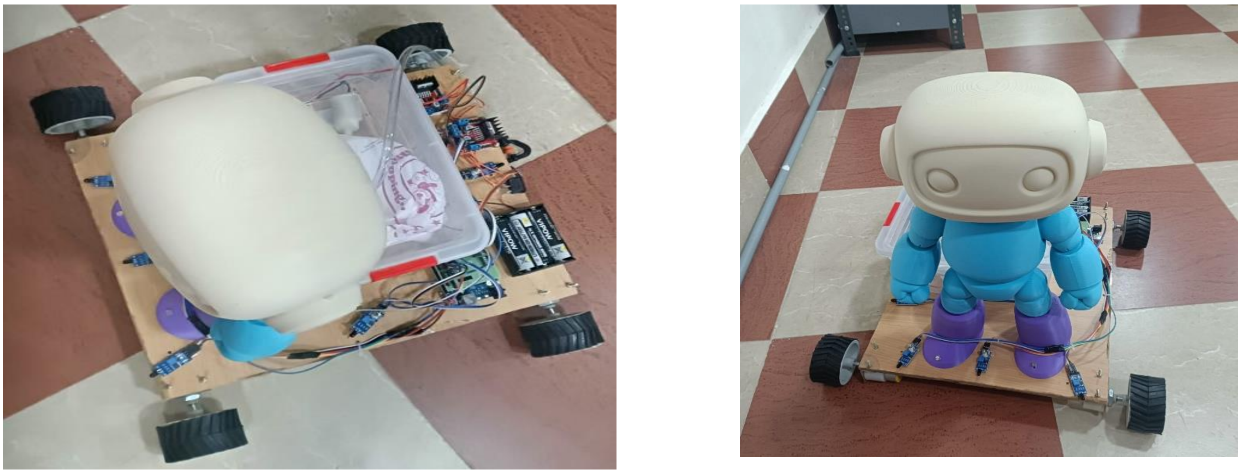

Fig5: Output Kit

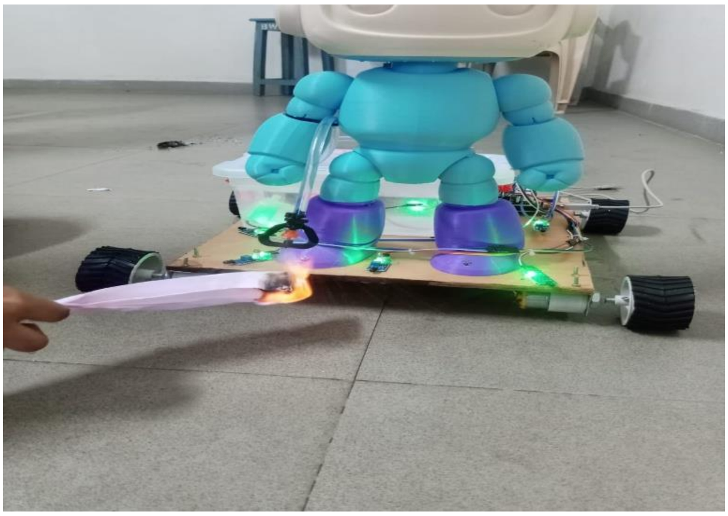

Fig 6: output

VII.CONCLUSION

The proposed IoT-based fire-fighting robot with smoke detection provides an effective solution for early fire identification and rapid response in hazardous environments. The system improves safety by minimizing human involvement and enabling autonomous fire suppression with real-time monitoring. Overall, it demonstrates a reliable and cost-efficient approach for enhancing modern fire safety systems.

VIII. FUTURE SCOPE

1.The system can be enhanced by integrating artificial intelligence for improved decision-making and accurate fire detection.

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2.Advanced navigation techniques such as GPS and path-planning algorithms can be added for better movement in large-scale environments.

3.The use of cameras and image processing can enable visual fire detection and real-time surveillance.

4.IoT integration can be extended to cloud platforms for data storage, analysis, and remote accessibility from any location.

5.The robot can be upgraded with more powerful extinguishing mechanisms to handle large or complex fire scenarios.

6.Implementation of multiple robots working collaboratively can improve coverage and response efficiency.

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