Fire Detection and Fire Fighter

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Abstract- ***This project features a smart fire-fighting robot built with IoT technology, using an ESP32 microcontroller. It includes flame sensors, a water pump, a relay, an ESP32 CAM, and the Blynk IoT platform.***

The robot works on its own to find and put out fires, offering a dependable way to handle fire risks. Flame sensors detect nearby flames, triggering the water pump through the relay to put out the fire. The ESP32 microcontroller takes care of all tasks, such as reading sensor info and controlling the pumps and motors.

The ESP32 CAM provides live video, so users can watch what's happening remotely. Blynk connects the robot to the internet, allowing control and updates from mobile devices. With the Blynk app, users can see live video feeds, check sensor readings, and move or operate the robot from a safe distance. This project shows how IoT and robotics can work together to create an easy-to-use fire detection and fighting tool. It helps improve safety and reduces damage by responding quickly to fire emergencies.

I. INTRODUCTION

Fire is an ancient element that has played a key role on Earth long before written history. It offers many good things like heat, energy, and cleaning power. But it can be dangerous if not kept in check. Luckily, brave people have devoted their lives to protecting others from fires that can start for many reasons, anywhere and anytime. Firefighters are human and can get injured or die in the line of duty.

Fire spreads fast if it isn't managed. A gas leak can even cause an explosion. This firefighting robot runs on an Arduino Uno board. It has a HC-SR04 ultrasonic sensor on a servo motor to detect obstacles and find clear paths. It also includes a fire flame sensor to sense and approach flames. To put out fires, it uses a water tank and spray system. The water nozzle is mounted on a servo motor to cover a large area. Water is pumped from the tank to the nozzle using a 12V pump.

These systems are often built using GSM and GPRS technology for communication, along with public service modules. A notable example is a fire or gas fighting robot created to protect homes, factories, and offices from fires or harmful gases.

This robot can move into areas filled with smoke or gas when nobody is present. It detects fire using infrared and gas sensors like LM35 and MQ6. Once it finds a fire, it uses fans to fight the flames and sends alerts to a server via IoT signals.

These robots are useful in places where humans cannot easily go. Wireless networks now cover broad areas, making everything more connected.

It is important to control these systems without harming the environment. The fire and gas fighting robot is remotely operated using a GSM module embedded in an Arduino UNO. Using embedded systems for communication has led to many useful and safe applications. This project focuses on building a fire and gas robot controlled by SMS.

It can replace traditional fire-fighting tools. When it detects a fire, the robot sends a message to the homeowner. The device uses a SIM card to send alerts directly to the user's phone, keeping them informed during emergencies.

II. PROPOSED SYSTEM

The system being proposed is a fire-fighting robot that works on its own and can be controlled from a distance. It uses Internet of Things (IoT) technology to detect, watch, and put out fires in places that are hard or unsafe for people to reach. The main part of the system is an ESP32 microcontroller, which works with different sensors and modules to collect data in real time, allow remote operation, and fight fires actively.

Its essential parts include:

- Flame and gas sensors, such as MQ2, for recognizing fires and smoke.
- ESP32 CAM module that streams live video, so users can see the environment from a distance.
- Blynk IoT platform, which connects the system to a smartphone app for viewing sensor data and controlling the robot.
- Relay modules and a water pump that turn on automatically to fight the fire once detected.

- DC motors and an L293D motor driver that help the robot move on its own or follow remote commands.
- LEDs and a buzzer that give quick visual and sound alerts if there is a fire or gas leak.
- The robot has a fire detection system that makes it move towards the fire source. Once close enough, the system activates the water pump to put out the flames. At the same time, it sends alerts to the user via email or mobile notifications through the Blynk app. Users can control the robot to move forward, backward, or turn left or right using the Blynk interface.
- This helps in positioning the robot better for fighting fires. The goal of this system is to improve safety by keeping humans away from dangerous fire areas. It helps watch for fires in real time and alerts users quickly. It also aims to reduce damage to property by catching fires early and putting them out. The system is easy to scale up and offers a low-cost way to handle fire emergencies in homes, factories, or offices. Combining sensors, automation, wireless links, and control, this system provides a strong, effective, and smart way to detect and fight fires in risky places.

III. IMPLEMENTATION DESIGN

Creating the Fire Detection and Fire Fighter Robot involves several key steps. These include assembling hardware, connecting sensors, writing embedded software, setting up the Internet of Things (IoT), and testing the entire system. Each step is vital for ensuring that the robot can work on its own and be controlled remotely.

The hardware setup includes a chassis, motors that run on direct current (DC), a water pump, and various sensors. The primary parts are an ESP32 microcontroller for main control, an ESP32-CAM module for live video, and motors controlled by an L293D driver for movement. A water pump and relay switch are used to put out fires. The robot also has sensors like an infrared flame sensor and an MQ2 sensor to detect fire and smoke. It is powered by a 12-volt battery. LEDs and a buzzer provide alerts. All components are fixed securely on the chassis and wired following the circuit diagram. The motors get power from the driver, which the ESP32 controls with GPIO pins.

Sensors are connected to the ESP32 to provide data readings. The flame sensor detects infrared light from fire, while the MQ2 sensor finds gases like LPG, smoke, or methane. These sensors are tested and calibrated to set the right levels for alert triggers.

A relay circuit controls the water pump. When the system detects a fire, the ESP32 sends a signal to open the relay, turning on the pump. Water is then sprayed through a nozzle aimed at the fire.

The robot moves in four directions: forward, backward, left, and right. These movements are controlled through the L293D driver. The settings are sent from the Blynk app via virtual pins V0 to V3. The ESP32 uses HIGH or LOW signals to control the motors.

The ESP32-CAM module captures live video. It streams this video to a web page or the Blynk platform. This allows users to watch the environment remotely, helping with navigation and fire verification.

The Blynk platform connects the robot to the internet. It provides real-time updates on sensor readings and live video. Users can also control the robot remotely with virtual buttons. Blynk sends notifications by email and push alerts when fire or smoke is detected. Virtual pins V0 to V3 control the robot's directions. Pins V4 and V5 show sensor data, and V6 toggles the water pump.

The system is programmed using the Arduino IDE. The code reads analog signals from the flame and gas sensors, sends data to Blynk, and handles commands from the app. It also triggers alarms such as emails, buzzer sounds, and LED lights when needed. The pump turns on automatically if smoke or fire levels go beyond set limits.

Power comes from a 12-volt rechargeable battery. A voltage regulator ensures the ESP32 and sensors get a steady 5V supply. The motors have separate power lines to prevent voltage drops that could disrupt operation.

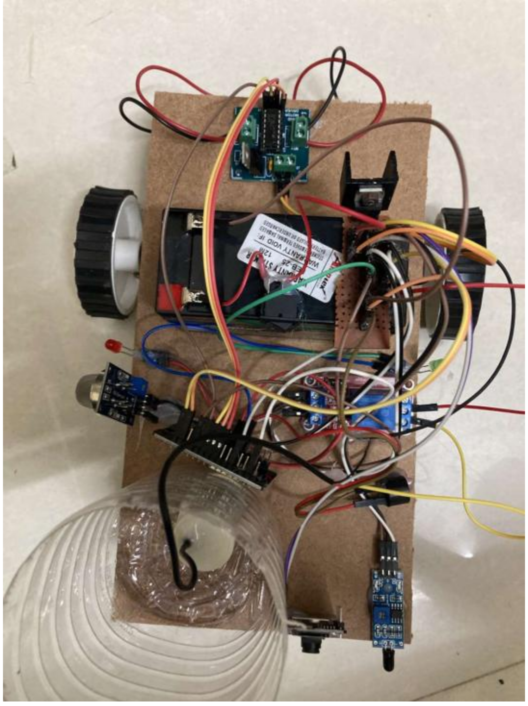
If a fire is detected and its intensity exceeds a set level, a red LED and buzzer turn on. Blynk logs the event and sends an email alert to the user. The system also keeps an eye on gas levels and issues warnings if necessary.

Each part of the system is tested separately, including motors, sensors, relays, and the pump. Sensitivity levels are adjusted using test fires like candles. The robot is tested in real conditions to confirm it detects fires accurately and can extinguish them effectively.

If WiFi gets disconnected, the robot switches to a default mode based on sensor data alone. Future updates may add features like temperature sensors, obstacle detection using ultrasonic sensors, and artificial intelligence to recognize different flame patterns.

IV. RESULTS AND DISCUSSION

The robot detects fire and can move on its own. Arduino controls the motor through a motor driver circuit. To turn left or right, one motor stays off while the other moves, causing the robot to rotate. When the Arduino flame sensor detects a fire, the robot slowly moves forward toward the flame.
The control algorithm makes the robot approach the fire gently. Once the fire is detected, the robot should stop at a set distance and not run over the flames. The flame sensor detects heat, and if its output exceeds a certain level, the robot pauses and backs up slightly. This gives space to use the extinguisher. The centrifugal pump then sprays water to put out the fire. A fire extinguisher is also available for quick response.



V. FUTURE SCOPE

The project aims to create a system that can detect fires and respond without needing human help. Advances in sensor networks and robotics make it possible to use mobile robots for tasks that involve a lot of physical work. This opens the chance to replace humans with robots in jobs that are dangerous, like fighting fires.
Using robots to fight fires is a clear example of automation. Fires cause many deaths each year, so a system like this could save lives. Our experience shows that building a fire-fighting system with sensors and robots is feasible with current technology. We also believe the techniques we develop could be used in other areas where sensing and quick reactions are needed, especially to replace humans with automated mobile robots.
This project is just the beginning. It is mainly a proof-of-concept, showing what is possible. A real, working fire-fighting robot system would need many more features. It should have several robots working together, communicating, and sharing information. It would also need the ability to navigate around obstacles and through fire, and to receive new instructions during a rescue. These things were not covered in this project.
However, there has been research on these topics in other fields. For example, studies on how robots coordinate, avoid obstacles, and communicate with humans on the move. Combining all these ideas into a working fire-fighting system will be a challenge, but it also offers many opportunities to improve safety and help people in danger.

VI. CONCLUSION

This paper offers a clear view of the key ideas used in this field. Its goal is to encourage innovation in technology to get reliable and effective results from different tools. Using a shared digital platform, these new tools will allow easier control, operation, and growth. They will also include smart features, making the tools stronger and more adaptable. This will help improve services for customers, making them more dependable and convenient. In the nineties, there were big improvements in interface design, making it easier for people to use machines. Mechatronics made it simpler to use computers by offering more user-friendly features. Now that the method has been proven, the next step is to upgrade the hardware. Instead of bulky modules that gather user data, smaller and less invasive units will be better. Soon, this technology will likely be used in homes, making life even easier and possibly lazier.

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