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IoT based Fire Extinguisher Robot with Bluetooth Controller

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Abstract: *In hazardous environments such as chemical plants, gas stations, and industrial zones, firefighting operations pose significant risks to human life. To address this challenge, we developed an IoT-based Fire Extinguisher Robot capable of detecting flames, gas leaks, and human presence using integrated sensors like flame, LPG, gas, and PIR sensors. The system incorporates a Bluetooth controller for local manual operation in addition to Wi-Fi-based remote control, enhancing its flexibility in various scenarios. A live video feed from the ESP32-CAM allows real-time monitoring,Sensor readings are continuously uploaded to the cloud through IoT technology for real-time monitoring and analysis. The robot is built using an Arduino Nano, ESP8266, and L298N driver to ensure responsive control and reliable communication. This multifunctional robotic platform not only improves operational safety but also minimizes human intervention in fire-prone environments.*

Keywords: Arduino, WiFi Cam, IoT, PIR Sensor, Flame Sensor. Bluetooth module

I. INTRODUCTION

Fire accidents in industrial areas such as oil refineries, gas plants, and chemical factories pose significant threats to human life and property. As technology advances, robotics is increasingly being used to reduce human involvement in hazardous situations. This project introduces an intelligent **IoT-enabled Fire Extinguisher Robot** designed to detect fire, gas leaks, and human presence through integrated sensors, including flame, gas, LPG, and PIR sensors.

To improve control flexibility, the robot supports **dual operation modes**: **Bluetooth-based manual control** for close-range use and **Wi-Fi-based remote monitoring**. The Bluetooth module allows users to navigate the robot directly without relying on internet access, which is particularly useful in emergency or offline conditions. The robot features real-time video transmission via the **ESP32-CAM**, and sensor data is uploaded to a cloud platform using the **ESP8266 NodeMCU**. Controlled by an **Arduino Nano** and **L298N motor driver**, the system combines automation, wireless control, and environmental monitoring to support safer and more effective firefighting operations.

This system can be utilized as follows:

Industrial Safety Operations

The robot can be deployed in high-risk industrial zones such as oil refineries, chemical plants, and gas storage facilities to detect and suppress fires without putting human lives at risk.

Rescue in Hazardous Environments

Equipped with a PIR sensor, the robot can identify human movement in smoke-filled or low-visibilit areas, helping locate stranded individuals during fire emergencies.

Flexible Control Options

With both Bluetoothand Wi-Fi connectivity, the robot offers local manual control when internet access is limited and remote operation when a wider control range is required.

II. PROPOSED METHODOLOGY

The firefighting robot is developed to identify and address fire hazards in hazardous zones, minimizing the risk to human personnel. The system uses a microcontroller (**Arduino Nano**) as the central processing unit, which coordinates sensor readings and control actions.

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For communication and control, the robot uses a **Bluetooth module** to receive commands from a mobile application, allowing users to manually control the robot's movement within close range. The **L298N motor driver** is used to operate the DC motors that drive the robot in forward, backward, left, and right directions.In addition to local control, the robot features a **GSM module** that sends **SMS alerts** to a predefined phone number when any critical event is detected, such as a fire or gas leak.

The robot also includes a **submersible water pump** to extinguish small fires, which can be activated via Bluetooth commands. This dual-control system—Bluetooth for manual control and GSM for alerting—makes the robot suitable for emergency use in industrial and domestic environments.

To ensure flexible and reliable control, the system employs a **Bluetooth module** that allows users to manually navigate the robot using a mobile application. This includes movement commands such as forward, backward, left, right, stop, and the activation of the water pump. This makes it easy to guide the robot through indoor or outdoor environments to reach the source of the fire

The robot is powered by a **dual-motor setup** controlled by the **L298N motor driver**, which ensures smooth and precise movements. The **submersible water pump** mounted on the robot is controlled through the same interface and can be turned on to extinguish fires as soon as flames are detected.

By combining **Bluetooth for local control** and **GSM for remote alerts**, the system ensures a robust solution for early fire detection and response, especially in areas that are difficult or dangerous for humans to access. This makes the robot a practical tool for applications in homes, factories, warehouses, and other fire-prone environments.

III. ARCHITECTURE OF THE MODEL

The block diagram of the proposed model is shown below:

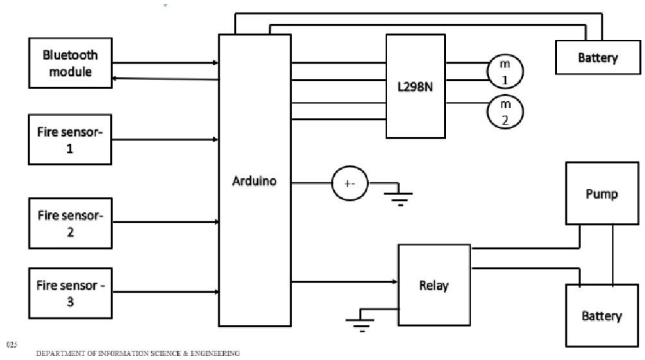

Figure1–Block Diagram

Components:

The following are the components used in this model:

- ArduinoUNO
- Flame Sensor
- Buzzer
- Water Pump
- Motors
- L298NDriver
- Bluetooth module
- Relay
- Battery
- Rubber wheels
- Connecting wires

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Design:

This system architecture illustrates a comprehensive and intelligent fire-fighting robotic system that integrates sensing, mobility, communication, and extinguishing capabilities in a coordinated manner. At the heart of this system lies the **Arduino microcontroller**, which functions as the central processing unit. The Arduino is programmed to receive input signals from multiple **fire sensors** (Fire Sensor-1, Fire Sensor-2, and Fire Sensor-3), each placed at different locations on the robot to allow it to detect the direction and intensity of the fire. These sensors are typically infrared (IR) or flame sensors that detect changes in heat or flame radiation. Once the fire is detected, the Arduino processes the sensor data to determine the fire's relative location and decides the course of action. This enables the robot to respond quickly and accurately in dynamic environments where fire might emerge in different directions.

To enable the robot to move toward the detected fire, the Arduino sends control signals to the **L298N motor driver module**, which acts as an interface between the Arduino and the two DC motors (m1 and m2). These motors are responsible for the robot's movement and are powered by a dedicated battery source to ensure uninterrupted operation. The L298N module allows bidirectional control of the motors, giving the robot the capability to move forward, backward, or rotate as needed to align with the fire source. The robot is mobile and can navigate within indoor or controlled outdoor spaces, making it suitable for applications such as warehouses, factories, or laboratories where fire hazards exist.

In addition to autonomous operation, the robot includes a **Bluetooth module**, which allows wireless communication between the Arduino and a mobile device or computer. Through this module, users can manually control the robot, monitor its status, or override its autonomous behavior in case of emergencies or system failure. This dual-mode (autonomous/manual) operation increases the reliability and versatility of the robot, making it a practical solution for real-world fire response scenarios.

Upon reaching the fire location, the Arduino activates a **buzzer** to alert nearby personnel and simultaneously triggers a **relay module**. The relay acts as an electronic switch and is used to control the operation of a **water pump**, which is connected to a separate high-power battery. The separation of power supplies for the motors and the pump is a critical design choice, ensuring that high current drawn by the pump does not interfere with the robot's mobility or control circuits. When the relay is activated, the water pump sprays water through a nozzle directed toward the fire, thereby extinguishing it. This automated extinguishing process minimizes human risk and ensures timely response to fire outbreaks.

This integrated system offers a compact, cost-effective, and scalable solution for fire detection and suppression. It can be deployed in various environments, including homes, commercial buildings, and industrial sites, especially in areas that are difficult or dangerous for humans to access during a fire. Furthermore, the system can be enhanced with additional features like obstacle avoidance sensors, real-time video streaming, or GSM modules for sending alerts to emergency services. The combination of sensor data processing, real-time decision-making, autonomous navigation, remote control, and active fire suppression makes this robotic system a modern and innovative approach to fire safety and disaster management

Software Implemented:

The software implementation of the fire-fighting robot is developed using the Arduino IDE, where the core program is written in C/C++ tailored for embedded systems. The Arduino microcontroller serves as the brain of the robot, interpreting sensor data, making decisions, and issuing commands to various hardware components. The code is designed to function in both autonomous and manual modes, offering flexibility and safety in critical environments. Through a combination of sensor data processing, motor control logic, and wireless communication handling, the software ensures the robot operates effectively in real-time.

The robot is equipped with three fire sensors that continuously monitor their surroundings. In the Arduino code, each sensor is assigned to a specific digital or analog pin. The software reads the values from these sensors in a loop and compares them against a predefined threshold to determine the presence of a fire. If any sensor detects a fire, a flag is set, and the location of the fire is determined based on which sensor is triggered. This information is then used to

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calculate the direction of movement for the robot. The code ensures that false positives are minimized by incorporating short delays and filtering techniques to stabilize sensor readings.

Once the location of the fire is determined, the Arduino sends digital signals to the L298N motor driver to activate the motors and direct the robot accordingly. The motor control logic includes commands to move forward, backward, and turn left or right based on the fire's position relative to the robot. In manual mode, these commands are instead received via Bluetooth. Pulse-width modulation (PWM) is used to control motor speed, offering smooth and adjustable movement. Safety mechanisms such as timed stops or obstacle detection can be integrated into the movement functions for added reliability.

The robot can be manually controlled using a smartphone through the **Arduino Bluetooth Controller App**. This app connects to the robot via an HC-05 or HC-06 Bluetooth module. Within the Arduino code, the Serial. Read() function listens for specific characters or strings sent from the app. Each command from the app corresponds to a movement function (e.g., 'F' for forward, 'B' for backward, 'L' for left). This communication allows the user to control the robot's navigation remotely and override autonomous operation when needed. It is especially useful for testing or when the robot is deployed in complex environments.

IV. OPERATION

The operation of the fire-fighting robot begins with the continuous monitoring of its environment through three onboard fire sensors. The sensors are strategically positioned on the robot to detect flames or heat sources from various angles, enabling it to pinpoint the general location of a fire. When one or more sensors detect a fire, they send input signals to the Arduino microcontroller, which processes the information to determine the direction from which the fire originates. The Arduino then executes movement commands to guide the robot toward the fire, using a motor driver module (L298N) to control the motion of two DC motors. These motors allow the robot to move forward, backward, and turn, enabling it to navigate accurately toward the fire source.

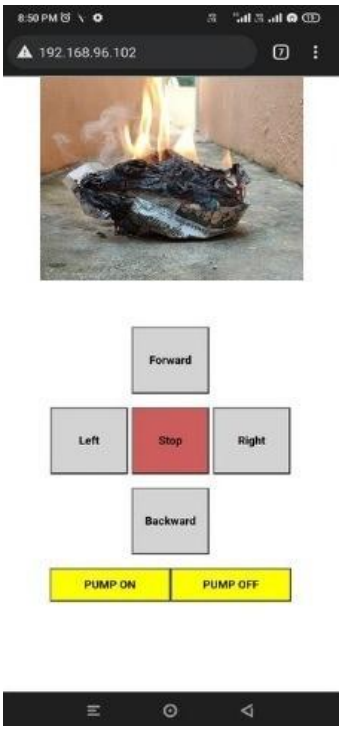

Figure2–Control Interface with live camera feed

Once the robot approaches the fire, it activates an alert through a buzzer to indicate the presence of danger. At the same time, the Arduino sends a control signal to a relay module that is connected to a water pump. The relay acts as a switch, allowing current to flow from a dedicated battery to power the pump. The pump then sprays water in the direction of

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the fire, aiming to extinguish it. After spraying water for a set period, the Arduino turns off the pump by deactivating the relay, preventing unnecessary power consumption and avoiding potential damage to the hardware.

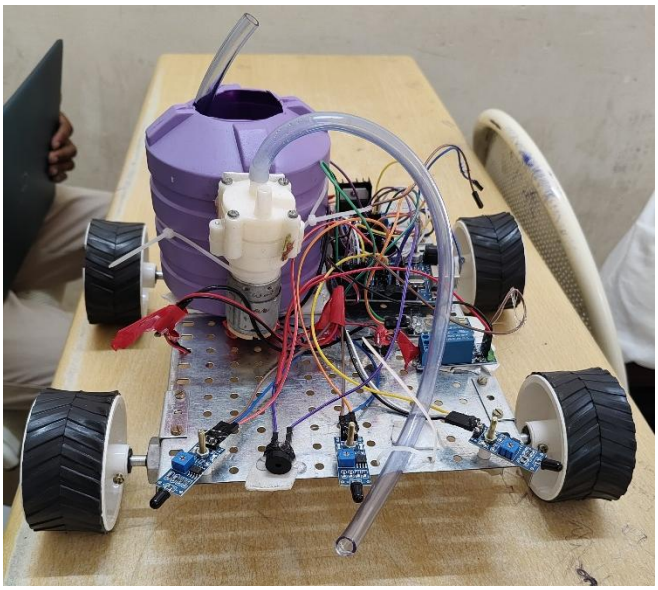
The end user can choose from the following choices on the control interface:

- Forward - Selecting this option instructs the driver to send analog high pulses to both motors (M1 and M2), causing them to revolve clockwise.
- Left and Right - Selecting this option causes the driver to generate alternate pulses, causing the motor M1 to revolve clockwise while the motor M2 rotates counterclockwise, and vice versa.
- Backward-Selecting this option instructs the driver to send low pulses to both motors, causing them to revolve in the opposite direction.
- Stop - This option is used to bring the vehicle to a complete stop.
- Pump On and Pump Off – This option allows the user to switch on and off the water pump in order to put out the fire

The robot also includes a Bluetooth communication module that allows it to be manually operated using a smartphone. Through the **Arduino Bluetooth Controller App**, a user can send directional commands to the robot in real timeThis capability is especially beneficial for testing or when the robot requires help navigating challenging paths. The Bluetooth interface enables commands such as forward, backward, left, right, and stop, which are processed by the Arduino via its serial communication port. The combination of autonomous and manual operation modes provides versatility, ensuring the robot can adapt and perform efficiently in different situations.

Power management plays a vital role in the system's performance. Dedicated batteries are utilized for powering the motors and operating the water pump, preventing the high current required by the pump from affecting the movement and control circuits. The Arduino board is powered either by one of these batteries or via a regulated voltage source, ensuring stable performance throughout the process. The seamless coordination of sensors, movement, communication, and water discharge is managed entirely by the software running on the Arduino, allowing all components to work together efficiently during emergency situations.

In general, the functionality of this system relies on real-time detection, precise navigation, wireless communication, and automated fire extinguishing. It is engineered to respond quickly upon detecting a fire, thereby reducing response time and minimizing human exposure to dangerous environments. The system’s simplicity, reliability, and affordability make it suitable for small-scale industrial use, laboratories, or smart home applications. The combination of basic electronics, sensor technology, and automation provides a practical solution for addressing minor fire hazards efficiently.



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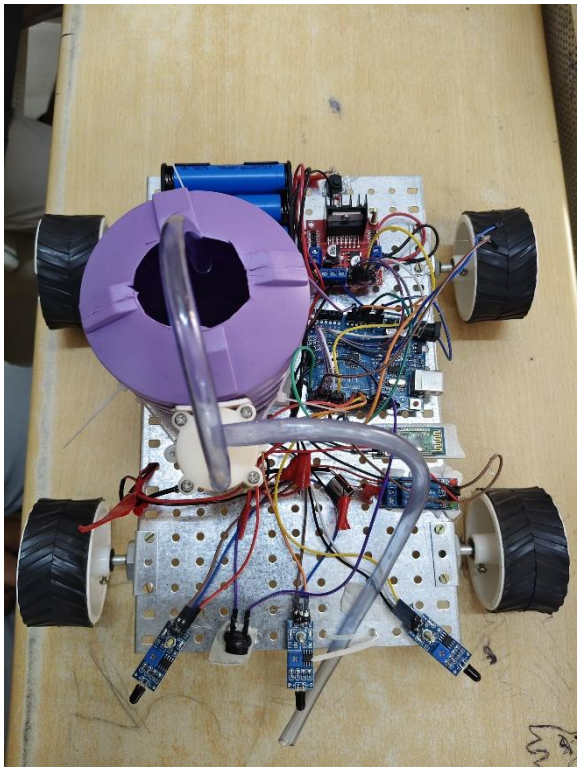

Figure5–Prototype of the model

V. RESULTS

Findings from thefire-fighting robot project demonstrate successful real-time fire detection, accurate movement towards the fire source, and effective extinguishing of the flame using a water pump mechanism. During testing, the robot was able to identify fire in multiple directions using its onboard sensors and navigate autonomously using motor controls governed by the Arduino microcontroller. The integration of the Bluetooth module allowed seamless manual control through the Arduino Bluetooth Controller App, confirming reliable wireless communication. Once the fire was approached, the relay successfully activated the water pump, and the flame was extinguished within seconds. The buzzer provided clear audio alerts during detection, enhancing safety awareness. Overall, the robot performed consistently across various test scenarios, validating its capability as a functional and cost-effective fire response solution.

VI. FUTURE SCOPE

- **Advanced Sensing Capabilities**: Integration of gas sensors, thermal cameras, and smoke detectors to enhance early fire detection and improve accuracy.
- **AI and Machine Learning**: Implementing machine learning algorithms to enable smart decision-making based on sensor patterns and environmental data.
- **Real-time Video Surveillance**: Adding a camera module for live video streaming to allow remote monitoring of fire incidents and robot movement.
- **GPS and Navigation**: Incorporating GPS for precise location tracking and enabling the robot to operate in outdoor or large-scale environments like forests or farms
- **Obstacle Avoidance System**: Using ultrasonic or infrared sensors for intelligent path planning and obstacle detection to improve autonomous navigation.
- **Solar Power Integration**: Exploring solar energy options to reduce dependency on batteries and enhance energy efficiency.

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- **Multi-Robot Coordination**: Developing a network of robots can work together in large or complex fire zones for faster and more effective fire suppression.

VII. CONCLUSION

The creation ofthe Arduino-based fire-fighting robot has proven to be a practical and efficient solution for detecting and responding to small-scale fires in real time. By integrating fire sensors, a Bluetooth communication system, a water pump, and motorized movement controlled by the Arduino microcontroller, the robot is capable of identifying fire sources, navigating toward them, and extinguishing flames autonomously or under manual control. The system offers a low-cost, adaptable, and scalable approach to fire prevention, particularly in hazardous or inaccessible areas. The inclusion of the Arduino Bluetooth Controller App enhances user interaction and flexibility during operation. With consistent performance during testing and a reliable hardware-software interface, this project demonstrates strong potential for real-world applications. Future improvements such as advanced sensing, AI integration,Additionally, incorporating remote monitoring enhances its functionality, turning it into a more powerful asset for emergency response and fire prevention.

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