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Automatic Fire Extinguisher Robot: A Novel Approach to Fire Safety

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ABSTRACT: This details the design, development, and implementation of an Autonomous Fire Extinguisher Robot. The primary objective of this project is to create a compact and mobile robot capable of detecting and extinguishing small-scale fires, thereby reducing risk to human life.

The robot utilizes an Arduino-Uno as its main control unit, which processes data from a flame sensor to detect a fire. Upon detection, the system automatically activates a water pump to spray water on the flames.

For enhanced monitoring and manual override, the robot is equipped with an ESP32-CAM module for live video feed and can be controlled remotely via a custom Bluetooth application.

This project demonstrates a successful integration of sensing, actuation, and wireless communication to create a functional prototype for automated fire suppression.

I. INTRODUCTION

Fire represents one of the most destructive and unpredictable forces, posing a constant threat to life, property, and the environment.

While professional fire fighting services are indispensable, they can be hindered by extreme hazards, confined spaces, or the critical need for rapid initial response to contain a small fire before it escalates.

The integration of robotics into emergency response offers a transformative solution to this challenges, allowing for intervention in scenarios too dangerous for human entry.

This project focuses on the development of an Autonomous Fire Extinguisher Robot, a compact and mobile prototype designed to augment traditional fire fighting efforts. The core objective is to create a system that can automatically detect and suppress small-scale fires, thereby mitigating risk to human life and minimizing potential damage.

The robot is built around an Arduino-Uno microcontroller, which serves as the central brain for processing inputs and coordinating actions. It employs specialized flame sensors to reliably detect the presence of fire by sensing its characteristics. .

II. SYSTEM DESIGN

A. Hardware Components:

1. Arduino Uno microcontroller
2. ESP32-CAM module
3. HC-05 Bluetooth module
4. IR flame sensors
5. L298N motor driver
6. DC geared motors (2 units)
7. Submersible water pump
8. Relay module

9. Robot chassis with wheels
10. 12V battery pack
11. Water tank and tubing
12. Jumper wires and breadboard

B. Software Components:

1. Arduino IDE
2. ESP32 board package for Arduino IDE
3. Bluetooth terminal application

COMPONENT DESCRIPTION:**1. Fire Detection**

- The IR flame sensors detect the presence of fire and send an analog signal to the Arduino Uno microcontroller.
- The Arduino Uno processes the signal and determines if the fire is present based on a pre-set threshold value.

2. Autonomous Mode

- If fire is detected, the Arduino Uno sends a signal to the L298N motor driver to stop the DC geared motors, halting the robot's movement.
- The Arduino Uno then sends a signal to the relay module to activate the submersible water pump.

3. Manual Mode

- The user sends commands to the robot via the HC-05 Bluetooth module using a Bluetooth application.
- The Arduino Uno receives the commands and controls the DC geared motors, navigating the robot to the desired location.
- The user can also trigger the water pump remotely to extinguish the fire.

4. Live Video Feed

- The ESP32-CAM module streams live video feed over Wi-Fi, providing real-time visual data to the operator.
- The operator can view the live video feed and make informed decisions about navigating the robot and extinguishing the fire.

5. Power Supply

- The 12V battery pack powers the entire system, including the Arduino Uno, ESP32-CAM module, HC-05 Bluetooth module, L298N motor driver, DC geared motors, and submersible water pump.

III. WORKING PRINCIPLE

In terms of working, the robot functions as a cohesive unit. In its primary autonomous mode, the Arduino continuously polls data from the flame sensors. When the received analog value exceeds a pre-set threshold indicating fire detection. The microcontroller halts the robot's movement and energizes the relay, which powers the water pump to extinguish the fire. Simultaneously, in manual mode, a user can take control via a Bluetooth application, sending directional commands to navigate the robot and a separate command to trigger the water pump on demand.

Throughout both modes, the ESP32-CAM streams a live video feed over Wi-Fi to a web interface, providing the operator with real-time visual data from the robot's perspective, enabling informed decision-making and precise remote navigation.

IV. FLOWCHART

1. Start
2. Autonomous Mode
 - Arduino polls data from flame sensors
 - If fire detected (analog value > threshold)
 - Activate water pump & Extinguish fire

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3. Manual Mode
 - Navigate robot (forward, backward, left, right)
 - Trigger water pump (on/off)
4. ESP32-CAM
 - Stream live video feed over Wi-Fi
5. Operator Input
 - Sends commands via Bluetooth application (if in manual mode)
6. End

V. RESULTS AND DISCUSSION

The results demonstrate the effectiveness of the Automatic Fire Extinguisher Robot in detecting and extinguishing fires in both autonomous and manual modes. The robot's performance was consistent across various scenarios, with high success rates in fire detection, extinguishing, and navigation. The autonomous mode testing showed that the robot can reliably detect fires and navigate to the fire location, with a high success rate in extinguishing fires. The manual mode testing demonstrated the robot's responsiveness to remote control commands and its ability to extinguish fires with precision.

The live video feed provided clear and stable visuals, allowing the operator to make informed decisions and navigate the robot with ease. The robot's performance was affected by factors such as battery life, water tank capacity, and environmental conditions, which are discussed in the limitations section.

Overall, the results indicate that the Automatic Fire Extinguisher Robot is a reliable and efficient solution for fire safety, offering flexibility and precision in fire extinguishing operations.

VI. CONCLUSION

The Fire Extinguisher Robot project successfully demonstrates the practical implementation of an autonomous system for fire detection and suppression. By integrating Arduino-Uno with flame sensors, motor drivers, wireless communication modules, and an extinguishing mechanism, the project achieves its core objective of creating a functional prototype that can automatically detect and respond to fire hazards.

The inclusion of Bluetooth remote control and live video streaming through ESP32-CAM enhances the system's versatility, allowing for both autonomous operation and human supervision. While the current prototype has limitations in terms of scale and operational duration, it serves as a proof-of-concept for more advanced robotic fire fighting systems.

The project not only provides a foundation for future developments in automated emergency response but also offers valuable insights into the integration of multiple electronic systems, wireless communication, and real-time control algorithms.

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