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Automatic Fire-Fighting Robot Using Arduino

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Abstract:

The "Automatic Fire-Fighting Robot" utilizing the Arduino Uno is an innovative safety automation project designed to detect and extinguish small-scale fires autonomously. This system focuses on rapid fire detection, accurate navigation, and effective fire suppression using simple, cost-effective, and scalable technology. The robot is built on the Arduino Uno microcontroller and integrates components such as flame sensors, ultrasonic sensors, servo motors, water/sprinkler pumps, and motor driver modules. Upon detecting a fire, the robot automatically moves toward the flame and activates its extinguishing mechanism. This project is aimed at reducing fire-related risks, particularly in domestic, laboratory, and industrial settings. Future developments may include thermal imaging, remote monitoring, and enhanced fire suppression techniques.

Index Terms: Fire detection, Arduino robot, flame sensor, autonomous fire-fighting, ultrasonic navigation, firefighting robot, fire suppression system, robotic safety, obstacle avoidance, smart automation.

I. INTRODUCTION

Fires pose serious threats to life and property, and rapid response is crucial. The "Automatic Fire-Fighting Robot" is a safety-focused innovation designed to detect flames and extinguish fires before they spread. Traditional methods rely on human presence and delayed response times. This project leverages robotics and automation to address these challenges by offering a smart, Arduino-controlled robot capable of navigating toward and extinguishing small fires autonomously.

The core of the system is the Arduino Uno, which interprets input from flame and ultrasonic sensors and issues commands to control motors and the extinguishing mechanism. The robot operates independently, moving in an environment while scanning for flames. Upon detection, it alters its path and deploys its fire suppression system, typically a water or CO_2 spray. This system is highly beneficial in laboratories, server rooms, and other sensitive areas where human intervention may be delayed or dangerous.

II. IMPORTANCE

This project serves as a crucial safety enhancement tool for environments prone to fire hazards. The Fire-Fighting Robot is a cost-effective, portable, and user-friendly alternative to traditional fire alert systems. It minimizes human risk, provides faster response, and can be deployed in unmanned areas.

Traditional fire safety mechanisms often require manual operation or are limited to detection without suppression. This robot combines both detection and extinguishing capabilities, enhancing reliability. It can be customized with additional

sensors or wireless communication modules, making it suitable for varied applications ranging from home safety to

industrial automation.

III. METHODOLOGY

ObjectiveDefinition:
The objective is to build a robot capable of detecting fire, navigating toward it while avoiding obstacles, and extinguishing it autonomously.

LiteratureReview:
Prior work in robotic fire suppression, Arduino-controlled navigation, and sensor integration was reviewed to inform the design.

Hardware Assembly:

- **Flame sensor** detects fire direction.

- **Ultrasonic sensors** :aid in obstacle avoidance.

- l controller.

- **Motor driver module (L298N):** controls the DC motors.
- **Servo pump** or **DC pump** :controls water or extinguisher spray.
- **Chassis and wheels :** support mobility.
- **Relay module** may be used to activate higher-powered extinguishing devices.

Programming:

Arduino IDE is used to code fire detection, movement logic, and extinguishing actions. Obstacle-avoidance algorithms ensure the robot doesn't collide while navigating.

Testing and Troubleshooting:
The robot is tested in simulated fire environments (e.g., using candles or alcohol flames). Sensor sensitivity, navigation precision, and extinguishing accuracy are calibrated.

Performance Analysis:
System evaluated based on flame detection range, reaction time, obstacle avoidance efficiency, and extinguishing success rate.

Components:

- **Arduino Uno** – Central microcontroller.
- **Flame Sensors** – Detect the presence of fire.
- **Ultrasonic Sensors** – Help avoid obstacles during navigation.
- **DC Motors with Driver Module (L298N)** – Movement control.
- **Water or CO_2 Pump System** – Fire extinguishing mechanism.
- **Relay Module** – Controls high-power components safely.
- **Chassis and Wheels** – Mechanical framework.
- **Bluetooth Module (Optional)** – Enables remote control via smartphone.

IV. IMPLEMENTATION

The robot uses ultrasonic sensors to detect surroundings and a flame sensor to locate fires. On flame detection, the robot adjusts its path toward the flame. Once close, it activates its extinguishing mechanism (water spray or fan-based flame dispersal). A Bluetooth module can optionally be used for remote operation.

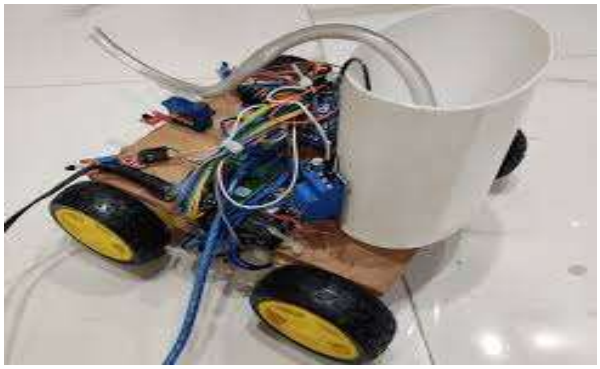
Power is supplied via a rechargeable 12V battery for motors and sensors. The fire detection algorithm prioritizes direction and proximity, enabling a direct approach toward the flame. After extinguishing the fire, the robot can either reset to standby or return to a designated home base.

V. RESULTS AND DISCUSSION The fire-fighting robot demonstrated successful detection of flame sources and autonomous movement toward the fire. It avoided obstacles efficiently and activated the extinguishing system upon close proximity to the flame.The system proved reliable in indoor environments with minimal airflow. Flame sensors showed good response within a 60–80 cm range. Testing showed successful extinguishing of small alcohol flames and candles.

OUTPUT

VI. CONCLUSION

The automatic fire-fighting robot is a compact, effective solution for early-stage fire suppression. With Arduino as its brain, the robot successfully integrates sensors, motors, and pumps to deliver a practical, low-cost safety automation system. It responds rapidly to fire incidents, significantly reducing the risks of escalation in controlled environments.



VII. FUTURE SCOPE

- **Thermal Imaging Cameras:** For better heat detection.
- **AI Integration:** For smarter flame differentiation and decision-making.
- **Remote Surveillance:** Integration with IoT and camera modules.
- **Advanced Navigation:** SLAM (Simultaneous Localization and Mapping) for complex environments.
- **Auto Docking:** Charging stations for longer operation.
- **Larger-Scale Versions:** For use in warehouses or chemical plants.