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Arduino-Based Autonomous Fire Fighting Robot

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Abstract **- Fire accidents are one of the major threats in residential and industrial areas. In many situations, firefighters face dangerous conditions while controlling fire, which may lead to severe injuries and loss of life. To reduce such risks, an autonomous fire-fighting robot has been developed using Arduino Uno. The robot can identify fire automatically and spray water to extinguish it without direct human control.**

The system uses flame sensors to detect the presence of fire and determine its direction. After detection, the robot moves toward the flame with the help of DC motors. A servo motor adjusts the direction of the water nozzle, while a water pump sprays water on the fire source. The complete operation is controlled by the Arduino microcontroller.

The robot is designed as a low-cost and efficient safety system suitable for homes, laboratories, workshops, and educational institutions. The project mainly focuses on automation, reliability, and ease of implementation. Experimental testing proved that the robot can detect and extinguish fire within a short period of time with satisfactory accuracy. This project also creates opportunities for future development in the field of smart safety and robotic automation.

I. INTRODUCTION

Technology plays an important role in improving safety and reducing human effort in risky situations. Fire accidents can occur unexpectedly in homes, industries, laboratories, and public places. In many cases, it becomes difficult for firefighters to reach hazardous areas safely. Robotic systems provide a practical solution for such environments because they can operate without exposing humans to danger.

The Arduino-based fire-fighting robot is designed to detect and extinguish small fires automatically. The robot uses flame sensors to monitor nearby surroundings continuously. Once a fire source is identified, the robot moves toward the flame and activates the water spraying mechanism.

Arduino Uno acts as the central controller of the system. It processes the input signals from sensors and controls the motors, relay module, servo motor, and water pump accordingly.

The robot works completely on programmed instructions and does not require Wi-Fi or remote control for operation.

The project combines embedded systems, robotics, and automation into a compact and economical model. Due to its simple structure and affordable components, the robot can be easily developed for educational demonstrations and practical applications.

II. OBJECTIVES OF THE PROJECT

The main objectives of this project are:

- To develop an autonomous robot capable of detecting fire.
- To extinguish fire automatically using a water pump system.
- To minimize human involvement in dangerous situations.
- To design a low-cost and efficient robotic safety system.
- To improve response time during small fire incidents.
- To study the application of embedded systems in robotics.
- To create a foundation for future intelligent fire-fighting systems.

III. COMPONENTS USED

Arduino Uno

Arduino Uno is the main control unit of the robot. It receives data from flame sensors and controls the movement of motors, servo motor, and water pump. The ATmega328P microcontroller inside the Arduino provides reliable performance for embedded applications.

Flame Sensors

Flame sensors are used to detect infrared radiation produced by fire. Two sensors are connected to the Arduino to improve fire detection accuracy and direction sensing.

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BO Motors

BO motors are used for the movement of the robot. These motors allow forward, backward, left, and right motion.

Servo Motor

The SG90 servo motor controls the angle of the water pipe so that water can be directed accurately toward the flame.

Water Pump

The water pump sprays water to extinguish the detected fire.

Relay Module

The relay module acts as an electronic switch between the Arduino and water pump.

Chassis

The iron chassis supports all components and provides structural stability to the robot.

Power Supply

A rechargeable Li-ion battery is used to power the complete robotic system.

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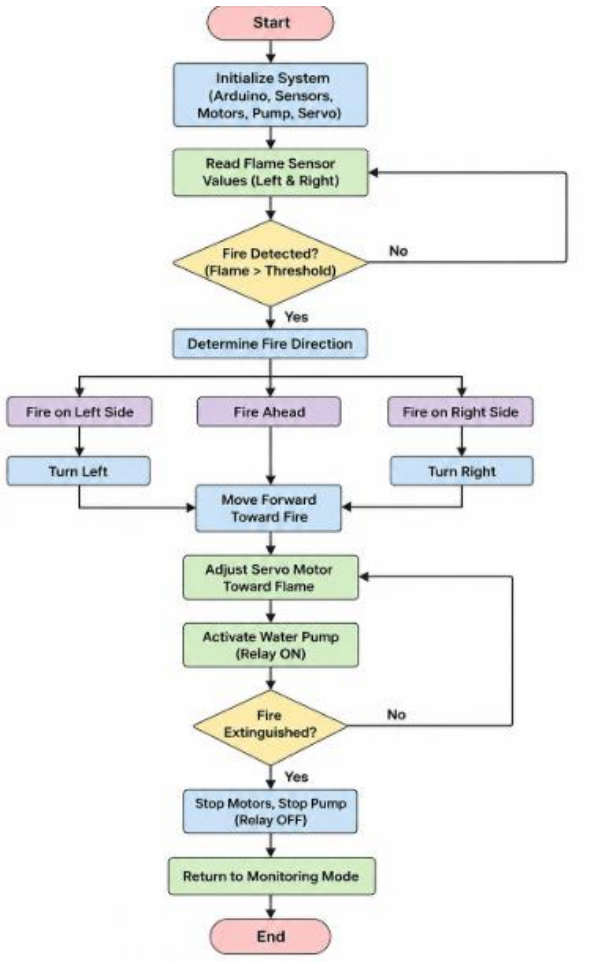
IV. Working Principle

The working process of the robot begins with flame detection. Flame sensors continuously check for infrared signals generated by fire. When the flame intensity crosses a predefined limit, the Arduino identifies the presence of fire.

The robot then moves toward the flame using DC motors. Depending on the sensor readings, the robot changes direction until it reaches the target location. Once the robot reaches an appropriate distance, the servo motor adjusts the water nozzle toward the fire source.

After alignment, the relay activates the water pump and water is sprayed to extinguish the flame. Once the fire is removed, the pump stops automatically and the robot returns to monitoring mode.



V. Circuit Design

The circuit design includes Arduino Uno, flame sensors, motor driver module, servo motor, relay module, water pump, and battery supply. Flame sensors are connected to the analog pins of Arduino. The motor driver controls the DC motors for movement.

The servo motor receives PWM signals from Arduino for nozzle positioning. The relay module controls the water pump operation safely.

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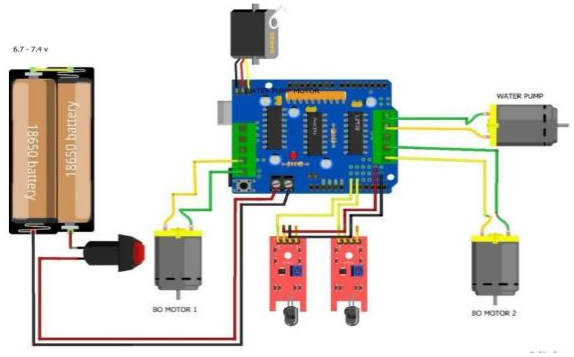
Voltage regulators and capacitors are used for stable power supply and noise reduction. Proper grounding ensures reliable system performance.

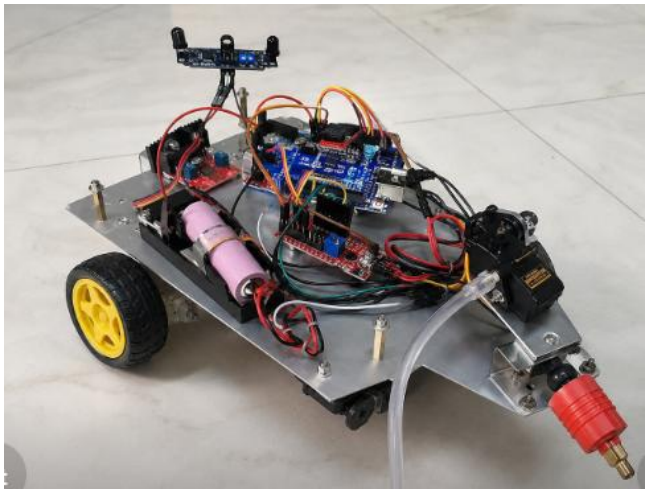


The robot is programmed using Arduino IDE with Embedded C language. The software continuously reads sensor values and checks whether fire is present.

The program performs the following tasks:

- Reading flame sensor values
- Detecting fire direction
- Controlling robot movement
- Rotating servo motor
- Activating water pump
- Managing timing and delays

Conditional statements and control logic are used to automate the complete firefighting process.



VI. Results and Discussion

The robot successfully detected flames and extinguished them during experimental testing. The flame sensors responded quickly, and the robot was able to move toward the fire source with good accuracy.

The servo motor effectively directed the water nozzle, and the water pump extinguished small flames within a few seconds. The system showed stable performance during multiple test runs.

The project demonstrated that a simple and affordable robotic system can perform automatic firefighting tasks efficiently.

VII. Future Scope

Several improvements can be added in the future, including:

- Obstacle avoidance sensors
- Thermal imaging cameras
- Artificial intelligence algorithms
- Wireless monitoring systems
- GPS tracking
- IoT-based fire alerts
- Smoke and gas sensors

These features can increase the efficiency and intelligence of the robot for real-world applications.

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