International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 01 | Jan - 2026 SJIF Rating: 8.586 ISSN: 2582-3930

Fire Fitting Robotic Arm System

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Abstract -Fire accidents pose significant risks to human life and property, particularly in hazardous or inaccessible environments. To reduce the danger faced by firefighters, this project presents the design and development of a fire-fighting robotic arm system capable of detecting and suppressing fires with minimal human intervention. The system integrates a mobile robotic platform equipped with flame and temperature sensors for early fire detection, a robotic arm for precise nozzle positioning, and a water or fire-retardant spraying mechanism. An onboard microcontroller coordinates sensor data processing, arm movement, and fire suppression actions, while wireless communication enables remote monitoring and control. The robotic arm provides enhanced flexibility and accuracy in directing the extinguishing agent toward the fire source. Experimental results demonstrate that the proposed system effectively detects fire, navigates toward the affected area, and suppresses flames in a controlled manner. This system offers a reliable and cost-effective solution for fire management in industrial, residential, and disaster-prone environments, improving safety and reducing human risk.

Key Words: Fire detection, Robotic Arm, Flame sensor, Smoke sensor, Light sensor, DC motor control, RF remote system, Automation, Fire safety, Water pump mechanism.

1. INTRODUCTION

Fire accidents are a major cause of loss of life and property in residential, industrial, and commercial environments. In many situations, fires occur in locations that are dangerous or difficult for humans to access, such as chemical plants, storage warehouses, and disaster-affected areas. Traditional fire-fighting methods often require firefighters to enter these hazardous zones, exposing them to extreme heat, toxic gases, and the risk of structural collapse. To overcome these challenges, the use of robotic systems in fire-fighting applications has gained significant attention.

2. Body of Paper

Mechanical structure

Mechanical structure of the robot is done using appropriate height torque DC motor, wheel and Basement using metal sheet and wooden portion. Required washer, nut bolts are used tighten the assembly.

Advantages
1. Capable of down-shifts in less than ½ to1 min, depending upon motor RPM.
2. The machine has very low error.
3. The size of project made by is more suitable for pick & place system.
3. The cost of machine is less.
4. It is easy to make.
5. It has low maintenance.
6. The system has low energy consumption.
7. Size of machine is small therefore it is easy to transport.

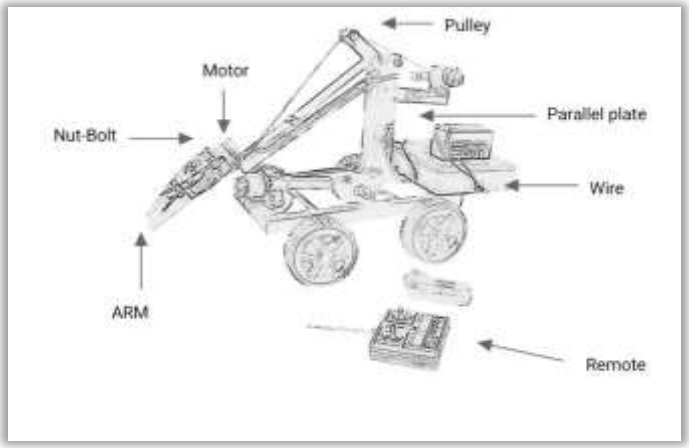

Fig 1:Fire Fitter base ARM System

Advantages

1. Capable of down-shifts in less than 1/2 to1 min, depending upon motor RPM.
2. The machine has very low error.
3The size of project made by is more suitable for pick & place system.
4. The cost of machine is less.
5. It is easy to make.
6. It has low maintenance.
7. The system has low energy consumption.
8. Size of machine is small therefore it is easy to transport.
9. Weight of machine is low.

Disadvantages

1. Being semiautomatic we cannot neglect at least one operator.
2. Battery power is required to operate the machine motor.

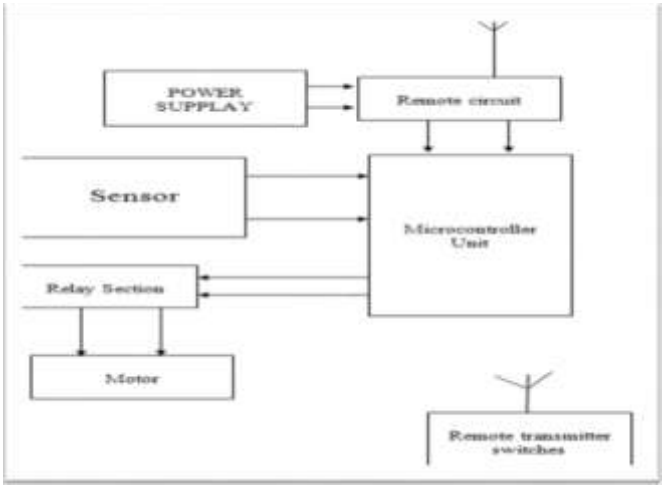

Fig 2: Block diagram of the project

The heart of the working of the robots is formed by Arduino Uno, the microcontroller chip that acts as the robot's brain. The robot can see the fire through a flame sensor. The sensor is responsive to light in the range of wavelengths 760 to 1100 nm band and can detect fires sometimes as far as 100 cm away.

Following the detection of fire, the robot moves toward it. The robot is controlled in motion by motors which are driven through 1.298 motor driver modules. High-power driver modules L298 may be used for driving both DC and stepper motors. Whenever the robot comes near a fire, the water pump is activated and splashes water on the flames. All control of this is handled by the motor driver L293D to drive the pump. The motor driver IC L293D has the potential to drive two DC motors at the same time in both directions.

A servo motor controlled the spray of water by moving the nozzle sideways. They also demonstrate how robotics Jogically intervenes in safety and disaster management. The water sprays are the main firefighting robots where effective safety systems of control might improve fire response while reducing risks through automation, fast communication, and adapted customization. It is a nice demonstration of the role played by robotics to enhance the productivity of machinery while keeping safety under risk conditions.

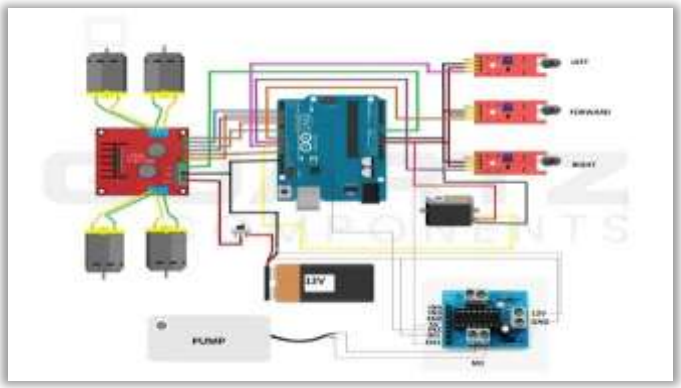

Fig 3: Circuit Diagram

```
#include <Servo.h>

// Define pin numbers for sensors, motors, and pump
#define LEFT_FLAME_SENSOR_PIN A0
#define FRONT_FLAME_SENSOR_PIN A1 #define
RIGHT_FLAME_SENSOR_PIN A2
#define WATER_PUMP_RELAY_PIN 10
// … other motor driver pins (IN1, IN2, EN for L298N)

Servo fire Extinguisher;

Void setup () {
  // Initialize serial communication for debugging
  Serial.begin(9600);
  // Set pin modes for sensors (INPUT) and motors/pump
(OUTPUT)
  // Attach the servo motor to its pin
  fireExtinguisherServo.attach(9);
}

Void loop() {
  // Read sensor values
  Int leftSensor =
analogRead(LEFT_FLAME_SENSOR_PIN);
  Int frontSensor =
analogRead(FRONT_FLAME_SENSOR_PIN);
  Int rightSensor =
analogRead(RIGHT_FLAME_SENSOR_PIN);

  // Define a threshold for flame detection
  Int flameThreshold = 500; // Adjust based on sensor
testing

  If (frontSensor > flameThreshold) {
    // Fire is straight ahead, move forward and activate
pump
    moveForward();
    activateWaterPump();
  } else if (leftSensor > flameThreshold) {
    // Fire is to the left, turn left
    turnLeft();
    deactivateWaterPump(); // Stop spraying while turning
  } else if (rightSensor > flameThreshold) {
    // Fire is to the right, turn right
    turnRight();
    deactivateWaterPump(); // Stop spraying while turning
  } else {
    // No fire detected, stop and search (or move
autonomously/via remote control)
    stopRobot();
    deactivateWaterPump();
    // Add obstacle avoidance logic here
  }
}

// Functions to control robot movement and pump
Void moveForward() {
```

```
  // Code to run DC motors forward
}

Void turnLeft() {
  // Code to turn robot left
}

Void turnRight() {
  // Code to turn robot right
}

Void stopRobot() {
  // Code to stop all motors
}

Void activateWaterPump() {
  // Turn on relay for pump and sweep servo
  digitalWrite(WATER_PUMP_RELAY_PIN, HIGH);
  for (int angle = 0; angle <= 180; angle += 30) {
  fireExtinguisherServo.write(angle);
    delay(100);
  }
}

Void deactivateWaterPump() {
  // Turn off pump and return servo to center
  digitalWrite(WATER_PUMP_RELAY_PIN, LOW);
  fire Extinguisher Servo.write(90);
}
```

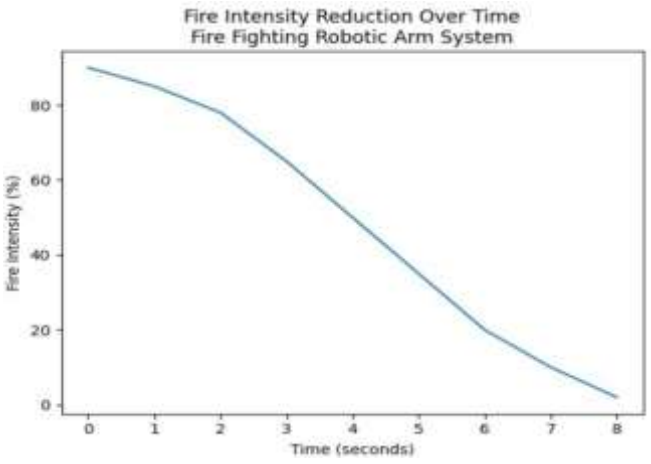

Fig 4: Fire Fitting Robotic Arm System

3. CONCLUSIONS

The fire-fighting robotic arm system successfully demonstrates the effective integration of robotics, sensors, and control mechanisms to enhance safety and efficiency in fire emergency situations. The system is capable of detecting fire, maneuvering the robotic arm with precision, and performing fire-suppression tasks while minimizing direct human involvement in hazardous environments. By automating critical operations, the project reduces the risk to firefighters and allows faster response in areas that are difficult or dangerous for humans to access.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my project guide and faculty members for their constant guidance, encouragement, and valuable suggestions throughout the development of the Fire Fighting Robotic Arm System. Their support helped me understand the concepts of robotics, automation, and sensor integration more deeply.

I am also thankful to my department and institution for providing the necessary facilities, resources, and technical support required to complete this project successfully. Finally, I express my appreciation to my friends and classmates for their cooperation and constructive feedback during the testing and implementation stages.

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