Autonomous Fire-Fighting Robot: Auto Fire Chaser and Extinguisher

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***Abstract*—Fire accidents pose a severe risk to life and property, and manual fire-fighting exposes humans to hazardous environments. This paper presents an autonomous fire-fighting robot capable of detecting small fires using infrared flame sensors and extinguishing them automatically using a water-pump mechanism. The system uses Arduino-based embedded control, motor drivers, flame sensing, and servo-based nozzle aiming to perform autonomous detection, navigation, and extinguishing. The project demonstrates a low-cost prototype suitable for academic and safety-training environments.**

***Index Terms*—Fire-fighting robot, flame detection, autonomous robotics, Arduino, embedded systems, IR sensors.**

I. Introduction

Fires can spread rapidly and cause substantial damage if not controlled in their early stages. Human intervention during fire accidents often involves significant risk. Robotics-based automation offers a safer alternative by enabling early detection and suppression without exposing human personnel.

This project aims to design an autonomous robot that can detect a fire, navigate toward it, and extinguish it using an onboard water pump. Using IR flame sensors, Arduino microcontroller logic, and motor control mechanisms, the robot performs autonomous fire tracking and extinguishing.

II. Problem Statement

Small fires often escalate due to delayed detection or lack of immediate response. Manual engagement puts firefighters at risk and may lead to injury or loss of life. The objective is to build a prototype robot capable of:

- Detecting flame presence and direction.
- Navigating toward the flame safely.
- Activating a water pump for extinguishing.
- Reducing the need for human intervention in hazardous zones.

III. System Overview

The proposed robot integrates IR flame sensors, a servo-based nozzle, BO motors with dual L293D drivers, and a mini water pump controlled via a TIP122 transistor. The Arduino processes sensor data to determine flame direction and triggers appropriate actuation.

The robot patrols forward continuously. When flames are detected, it stops, aligns the servo nozzle, and activates water spraying until the flame is extinguished.

IV. Goals

- Automatic fire detection using infrared flame sensors.
- Motor-controlled navigation toward the fire source.
- Servo-controlled nozzle aiming for accurate water spraying.
- Low-cost implementation suitable for academic and lab demonstrations.

V. System Specifications

Components used:

- Arduino Uno
- Three IR flame sensors
- L293D dual motor drivers
- BO motors
- Mini water pump (TIP122 transistor control)
- Servo motor for nozzle aiming
- 5–9V power supply

VI. System Operation

1) Flame sensors continuously scan for fire.
2) If a flame is detected, the robot halts.
3) Servo aligns the water nozzle forward.
4) Water pump activates.
5) After extinguishing, robot resumes patrol.

VII. Hardware Implementation

All hardware components were assembled on a stable chassis with proper power distribution. Connections ensured secure interfacing between Arduino, sensors, motor drivers, pump, and servo.

VIII. Software Implementation

Arduino code performs:

- Analog sensor reading
- Motor direction control
- Servo positioning
- Water pump activation

IX. Circuit Diagram

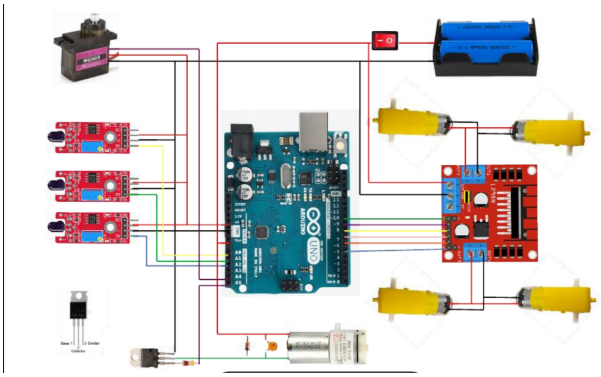

Fig. 1. Circuit design of the autonomous fire-fighting robot.

X. Arduino Code

```
// ----------- PIN DEFINITIONS -------------
#define leftSensor A0
#define rightSensor A1
#define pumpPin A2
#define servoPin A3

// L293D #1
#define IN1 5
#define IN2 6
#define IN3 9
#define IN4 10
#define ENA 3
#define ENB 11

// L293D #2
#define IN5 2
#define IN6 4
#define IN7 7
#define IN8 8
#define ENA2 12
#define ENB2 13

int threshold = 400;

void setup() {
  Serial.begin(9600);
  pinMode(leftSensor, INPUT);
  pinMode(rightSensor, INPUT);

  pinMode(IN1, OUTPUT); pinMode(IN2, OUTPUT);
  pinMode(IN3, OUTPUT); pinMode(IN4, OUTPUT);
  pinMode(ENA, OUTPUT); pinMode(ENB, OUTPUT);

  pinMode(IN5, OUTPUT); pinMode(IN6, OUTPUT);
  pinMode(IN7, OUTPUT); pinMode(IN8, OUTPUT);
  pinMode(ENA2, OUTPUT); pinMode(ENB2, OUTPUT);

  pinMode(pumpPin, OUTPUT);
  digitalWrite(pumpPin, LOW);

  servoPulse(servoPin, 90);
  delay(500);
}

void loop() {
  int left = analogRead(leftSensor);
  int right = analogRead(rightSensor);

  if(left > threshold && right > threshold){
    digitalWrite(pumpPin, LOW);
    servoPulse(servoPin, 90);
    moveForward();
  } else {
    stopMotors();
    servoPulse(servoPin, 90);
    digitalWrite(pumpPin, HIGH);
  }
  delay(50);
}

void servoPulse(int pin, int angle){
  int pwm = (angle * 11) + 500;
  digitalWrite(pin, HIGH);
  delayMicroseconds(pwm);
  digitalWrite(pin, LOW);
  delay(18);
}

void moveForward(){
  digitalWrite(IN1, HIGH); digitalWrite(IN2, LOW);
  digitalWrite(IN3, HIGH); digitalWrite(IN4, LOW);
  digitalWrite(IN5, HIGH); digitalWrite(IN6, LOW);
  digitalWrite(IN7, HIGH); digitalWrite(IN8, LOW);

  analogWrite(ENA,200);
  analogWrite(ENB,200);
  analogWrite(ENA2,200);
  analogWrite(ENB2,200);
}

void stopMotors(){
  digitalWrite(IN1, LOW); digitalWrite(IN2, LOW);
  digitalWrite(IN3, LOW); digitalWrite(IN4, LOW);
  digitalWrite(IN5, LOW); digitalWrite(IN6, LOW);
  digitalWrite(IN7, LOW); digitalWrite(IN8, LOW);
}
```

XI. Conclusion

The autonomous fire-fighting robot successfully detects and suppresses small flames using low-cost electronics and embedded control. This prototype demonstrates the usefulness of robotics in hazardous environments, enabling faster and safer fire response.

References

References

[1] M. Robot, "Autonomous Fire Detection Systems," IEEE Robotics Journal, 2020.

[2] A. Kumar, "Embedded Fire Safety Automation," Int. Conf. on Embedded Systems, 2021.