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Design and Implimenation of a Robot for Extinguishing Fire using the Internet of Things

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Abstract
Robots are becoming more and more important in the rapidly evolving field of technology, particularly in high-risk situations. Our goal is to create an autonomous firefighting robot that can locate and put out house fires on its own with water. This project directly addresses the risks that come with battling fires, putting the safety of people's lives first and improving the effectiveness of rescue efforts. While some fire departments now use robots, there are ongoing issues with size, weight, cost, and performance that call for a comprehensive solution. Our strategy is based on a thorough analysis that identifies five essential components that are necessary for the creation of a useful and reasonably priced firefighting robot. It is critical to address these limitations if we are to overcome the enduring flaws seen in current robotic systems. The intended robot, resulting from this all-encompassing approach, seeks to not only lessen these challenges but also to enhance the capabilities of fire departments significantly. The ultimate objective is to save lives while also making a positive impact on the general effectiveness of rescue efforts during emergencies. The emphasis of this research project is on the revolutionary potential of robotics in guaranteeing emergency responders' and those they are committed to defending's safety. Our goal is to completely transform emergency response by pushing the limits of existing technology and setting the standards for firefighting robots. Our research aims to be a good change agent by using this novel technique, creating a future where autonomous firefighting robots are dependable allies in protecting people and property.

1 Background

Traditional fire detection and extinguishing techniques have been completely transformed by the application of Internet of Things (IoT) technology in firefighting. Real-time monitoring and remote-control capabilities offered by IoT-based devices improve the efficacy and efficiency of firefighting operations. This paper focuses on the creation and deployment of an Internet of Things (IoT)-enabled robot that detects and puts out fires using proximity, heat, and gas sensors. In the modern world, fire occurrences are a serious problem that need to be handled promptly to prevent the loss of life and property. When the temperature under observation rises above 50 degrees Celsius, a fire is declared. Personnel in essential locations, such banks, hospitals, and schools, have fifteen minutes or less to arrive in case of a fire.There is a growing trend in many parts of the world to require automatic fire sprinklers to be installed in new home construction. Although there is no denying that fire sprinkler systems can save lives, multiple studies have found that their effectiveness is between 70 and 93 percent. An impressive number, but there's definitely need for growth when compared to other life-saving devices, like airbags, which have a 99.9 percent effectiveness rate. Sprinklers, however, have very low success rates in homes, failing 1 in 10 times, mostly due to their widespread disregard and inconspicuous design. The system being turned off accounts for 64% of failures, with neglect being the other significant culprit.

2 Objectives

The primary objective of this project is to design and deploy an autonomous robot capable of detecting fires promptly and extinguishing them effectively. Specifically, the robot will utilize proximity sensors to navigate through the environment, heat sensors to detect fire outbreaks, and gas sensors to assess the presence of smoke and hazardous gases. Early Detection and Response: Utilizing IoT sensors to detect the presence of fire or smoke in real-time, allowing for immediate activation of the fire extinguisher motor without human intervention. This early detection can help prevent the spread of fire and minimize property damage. Remote Monitoring and Control: Enabling remote monitoring of the fire extinguisher system's status and performance through IoT connectivity. This allows for continuous monitoring of critical parameters such as pressure levels, temperature, and system health from anywhere, facilitating proactive maintenance and troubleshooting. Automatic Deployment: Integrating IoT technology with the fire extinguisher motor to automate the deployment process in response to fire incidents. This can include automatically activating the motor when sensors detect fire or receiving commands remotely from authorized personnel or fire detection systems.
Data Logging and Analysis: Collecting and analyzing data from IoT sensors and actuators to gain insights into fire incidents, system performance, and user behavior. This data can be used for optimizing system design, improving response times, and implementing predictive maintenance strategies. Integration with Building Management Systems:

Integrating IoT-based fire extinguisher motors with building management systems (BMS) or smart home platforms for centralized monitoring and control of fire safety devices. This allows for seamless integration with other building automation systems and enhances overall safety and security.
Overall, the objective of an IoT-based fire extinguisher motor is to leverage connectivity, automation, and to enhance fire safety measures, improve response times, and minimize the impact of fire incidents. There is a growing trend in many parts of the world to require automatic fire sprinklers to be installed in new home construction. Although there is no denying that fire sprinkler systems can save lives, multiple studies have found that their effectiveness is between 70 and 93 percent. An impressive number, but there's definitely need for growth when compared to other life-saving devices, like airbags, which have a 99.9 percent effectiveness rate. Sprinklers, however, have very low success rates in homes, failing 1 in 10 times, mostly due to their widespread disregard and inconspicuous design. The system being turned off accounts for 64% of failures, with neglect being the other significant culprit.

3 Hardware Components

The fire detection and extinguishing robot will be equipped with various sensors and actuators to perform its functions. These include proximity sensors to detect obstacles and navigate autonomously, heat sensors to detect temperature changes indicative of a fire, and gas sensors to detect harmful gases emitted during combustion. Additionally, the robot will be equipped with an extinguishing mechanism such as water sprayers or foam dispensers.
The main intent of this project is to design and bring about a robot prototype by utilizing the following hardware components. There is a growing trend in many parts of the world to require automatic fire sprinklers to be installed in new home construction. Although there is no denying that fire sprinkler systems can save lives, multiple studies have found that their effectiveness is between 70 and 93 percent. An impressive number, but there's definitely need for growth when compared to the life-saving devices, like airbags, which have a 99.9 percent effectiveness rate. Sprinklers, however, have very low success rates in homes, failing 1 in 10 times, mostly due to their widespread disregard and inconspicuous design. The system being turned off accounts for 64% of failures, with neglect being the other significant culprit.

Servo: A servo is a type of motor that is capable of precise control of angular or linear position, velocity, and acceleration. Servos are commonly used in robotics to control the movement of mechanical components such as arms, grippers, or Sensors. In the context of a fire detection and extinguishing robot, servos may be used to adjust the orientation of sensors or the direction of the water spray.

L2981 Motor Driver: The L2981 is a type of motor driver integrated circuit (IC) commonly used to control the speed and direction of DC motors. It provides the necessary circuitry to interface between the microcontroller or control system and the motors. In a fire detection and extinguishing robot, the L2981 motor driver may be used to control the movement of wheels or tracks.

Batteries: Batteries are electrical energy storage devices used to power electronic devices and systems. In the context of a fire detection and extinguishing robot, batteries provide the necessary power to operate the motors, sensors, and other electronic components. They are typically rechargeable to allow for extended operation without the need for external power sources.

IRF520 MOS Relay Module: The IRF520 MOS relay module is a type of electronic switching device used to control high-power loads such as motors or pumps. It utilizes Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) technology to provide efficient and reliable switching capabilities. In a fire detection and extinguishing robot, the IRF520 MOS relay module may be used to control the activation of the water pump or other high-power components.

4. Circuit Diagram Analysis

Our IoT-based fire extinguisher system integrates cutting-edge technology to enhance fire safety measures. Below is an overview of the circuit diagram detailing the key components and their functionalities:

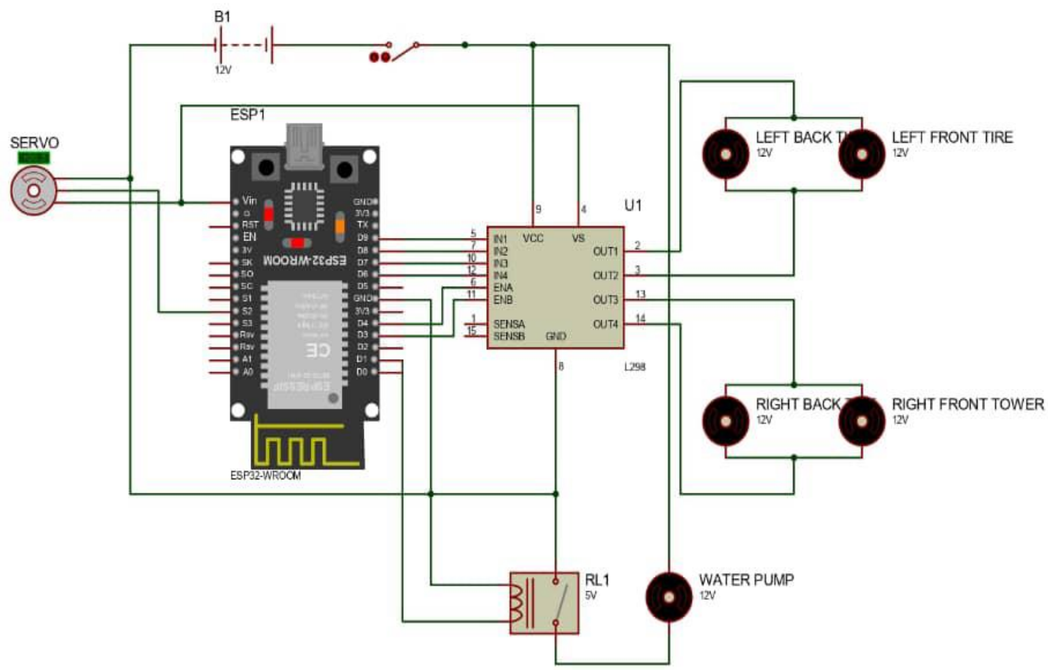

Figure 1: Circuit Diagram of an IOT Based Fire Extinguisher

- IoT Microcontroller: At the heart of the system lies an IoT microcontroller, serving as the central processing unit. This microcontroller facilitates connectivity with the internet and controls the operation of various system components.
- Relay Module: The relay module acts as an interface between the microcontroller and the fire extinguisher motor. When activated by the microcontroller, the relay module switches the power supply to the fire extinguisher motor, initiating the extinguishing process.
- Wi-Fi Module: A Wi-Fi module enables wireless communication between the IoT microcontroller and external devices, such as smartphones or computers. This connectivity allows for remote monitoring and control of the fire extinguisher system, enhancing flexibility and accessibility.
- Power Supply: A stable power supply is essential for the reliable operation of the entire system. Depending on the application, power can be sourced from mains electricity or battery backup to ensure uninterrupted functionality.
- User Interface: We incorporated a user interface component, which was an LED indicator, to provide real-time status updates and alerts to users. This interface enhances user interaction and facilitates quick response to fire incidents.
- IoT Platform Integration: The IoT microcontroller is connected to an IoT platform or cloud service, allowing for data logging, analytics, and remote management of the fire extinguisher system. Integration with IoT platforms enables advanced functionalities such as predictive maintenance and automated reporting.

By leveraging IoT technology, our fire extinguisher system offers advanced capabilities for fire suppression, and remote management. The circuit diagram illustrates the seamless integration of various components to create a robust and intelligent fire safety solution, ensuring prompt and effective response to fire incidents.

5 Flowchart Analysis
The Flow Chart of the Experimentation setup is shown in below:
Step 1: Hardware
Gather the necessary hardware components: ESP32 microcontroller, DC motors, motor driver, water pump, servo motor, and Blynk app.
Design and build the robot chassis.
Mount the hardware components on the chassis.
Wire the components together according to a schematic diagram.
Step 2: Software
Install the Arduino IDE software on your computer.
Write the Arduino code to control the robot's sensors, motors, and water pump. Create a Blynk app to control the robot.
Step 3: Testing
Test the robot's motors to ensure they are moving in the correct direction. Test the robot's water pump to ensure it is working properly.
Test the Blynk app to ensure it can control the robot.
Step 4: Deployment
Deploy the robot in a safe environment. Monitor the robot's performance.
Make any necessary adjustments to the robot's design or software.

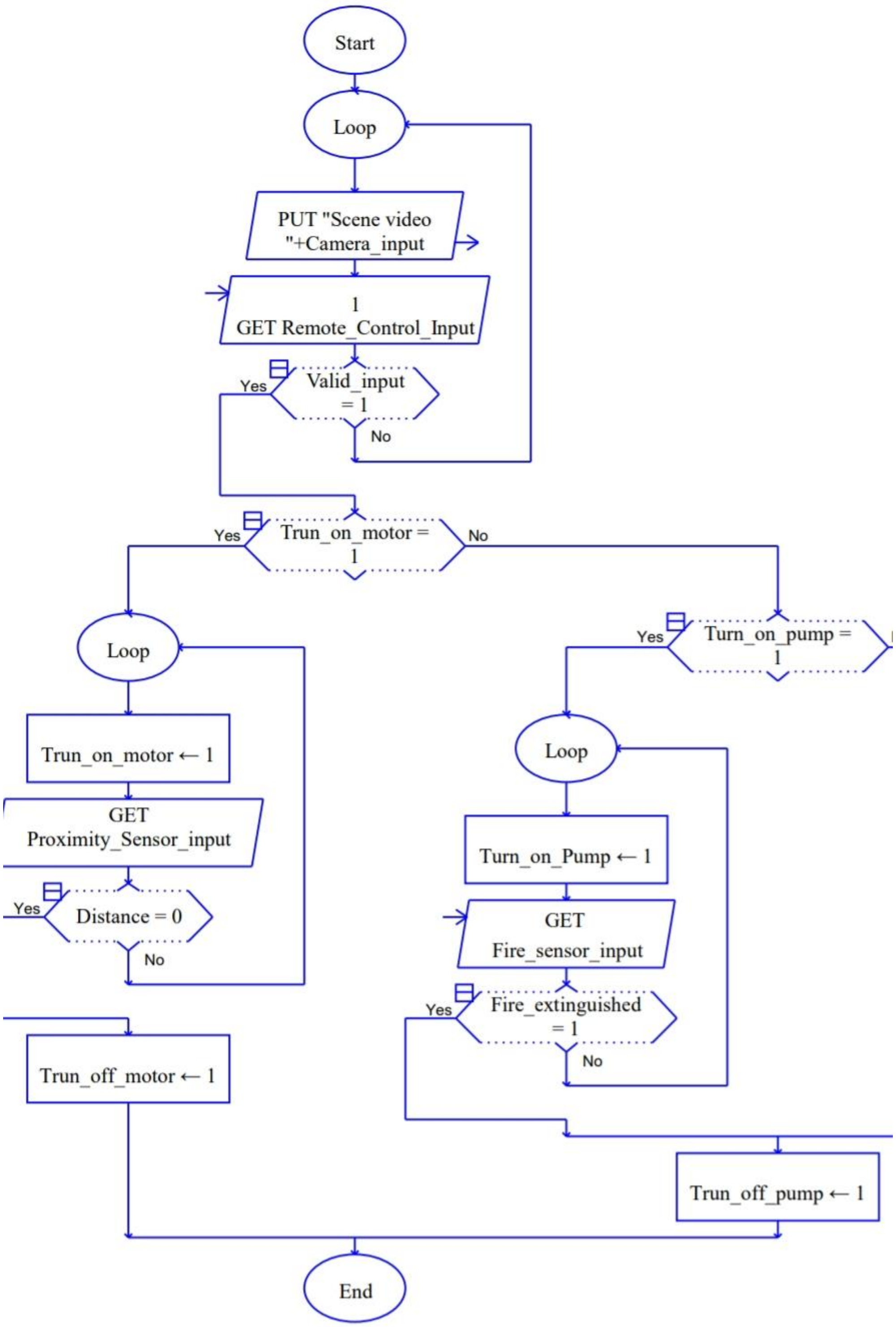

Figure 2: The Flowchart of an IoT-Based Fire Extinguisher.

6 Software Architecture

The software architecture of the robot will consist of modules for sensor data processing, decision making, and actuation. Sensor data will be collected in real-time and analyzed to determine the presence and severity of a fire. Based on this analysis, the robot will execute appropriate actions such as navigating to the fire location and activating the extinguishing mechanism.

7 Implementation of Design

Motor Integration

In the realm of fire safety technology, the integration of motors into IoT-based fire extinguisher systems represents a significant leap forward in mitigating the risks posed by fire incidents. Here's an in-depth exploration of how motors are seamlessly integrated into these systems to bolster their effectiveness:

- Automated Deployment: Motors serve as the powerhouse behind the automated deployment of fire extinguishing agents in response to fire incidents. When triggered by IoT sensors detecting smoke or elevated temperatures, the motors spring into action, swiftly activating the extinguisher mechanism without the need for human intervention. This rapid response capability is critical in containing and suppressing fires before they escalate.
- Precision Control: Integration with IoT technology enables precise control over motor operation, allowing for tailored deployment strategies based on the severity and location of the fire. Through the IoT microcontroller, users can adjust parameters such as discharge duration, spray pattern, and extinguishing agent volume to optimize firefighting efforts and minimize collateral damage.
- Remote Monitoring and Management: Motors in IoT-based fire extinguisher systems are equipped with wireless connectivity capabilities, facilitating remote monitoring and management. Utilizing smartphones, computers, or other connected devices, users can remotely monitor the status of motors, receive real-time alerts during fire incidents, and initiate deployment actions as needed. This remote accessibility enhances situational awareness and enables prompt response to emerging fire threats, even from a distance.
- Redundancy and Fail-Safe Mechanisms: To ensure reliability and resilience, IoT-based fire extinguisher systems incorporate redundancy and fail-safe mechanisms into motor integration. Redundant motor configurations, backup power supplies, and built-in diagnostic systems are employed to mitigate the risk of motor failure and ensure continuous operability in challenging conditions. Additionally, fail-safe protocols are implemented to automatically activate secondary motors or trigger manual overrides in the event of primary motor malfunctions, ensuring uninterrupted fire suppression capabilities.
- Data Insights and Optimization: Motors integrated into IoT-based fire extinguisher systems generate valuable data insights that can be leveraged to optimize system performance and enhance fire safety strategies. By collecting and analyzing motor operation data, such as deployment frequency, duration, and efficiency, stakeholders can identify trends, fine-tune deployment algorithms, and implement predictive maintenance protocols to maximize system reliability and effectiveness over time.

Control System Development

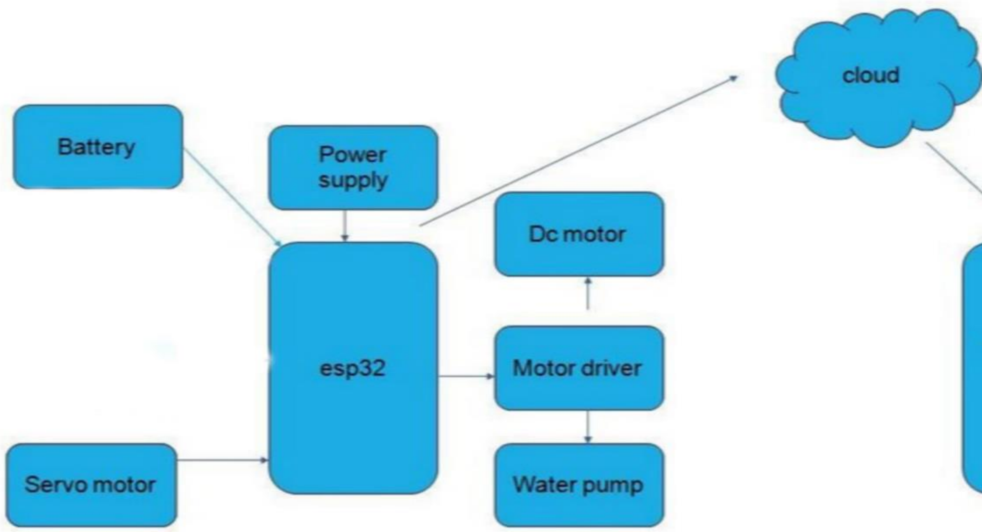

Figure 3: The Block Diagram of an IoT-Based Fire Extinguisher.

A control system will be developed to manage the operation of the robot and coordinate its actions in response to fire incidents. The control system will receive sensor data, process it, and generate commands to control the robot's movements and extinguishing mechanism.

7 Pseudocode

```
// Iot-based remotely controlled fire extinguisher robotic car
// the code using esp 8266 Wi-Fi microcontroller in Arduino ide

#include <ESP8266WiFi.h>
#include <WiFi Client.h>
#include <ESP8266WebServer.h>
#include <Servo.h>

//Defining SSID and PASSWORD to my Robot
const char* ssid = "Robot Wi-Fi";
const char* password = "87654321";
#define ENA   4    // Enable/speed motors Right   GPIO4(D2)
#define IN_1  0    // L298N in1 motors Right      GPIO0(D3)
#define IN_2  2    // L298N in2 motors Right      GPIO2(D4)
#define IN_3  12   // L298N in3 motors Left       GPIO12(D6)
#define IN_4  13   // L298N in4 motors Left       GPIO13(D7)
#define ENB   15   // Enable/speed motors Left    GPIO15(D8)
#define Light  16 // Light  GPIO16(D0)
#define Pump 5 // pump GPIO05(D1)
// Servo motor configuration
Servo myServo;
int servoPin = 14; // pump GPIO05(D5)
String command;
 //String to store app command state.
int speedCar = 150; // 0 to 255
int speed_low = 60;
```

```
// Variables to store servo angle and increment value
int servoAngle = 0;
int servoIncrement = 5; // Adjusting servo angle
ESP8266WebServer server(80);
void setup() {
  Serial.begin(115200);
  myServo.attach(servoPin);
 pinMode(ENA, OUTPUT);
 pinMode(IN_1, OUTPUT);
 pinMode(IN_2, OUTPUT);
 pinMode(IN_3, OUTPUT);
 pinMode(IN_4, OUTPUT);
 pinMode(ENB, OUTPUT);
 pinMode(Light, OUTPUT);
 pinMode(Pump, OUTPUT);
// Connecting WiFi
  WiFi.mode(WIFI_AP);          //Only Access point
  WiFi.softAP(ssid, password);  //Start HOTspot removing password will disable security
  IPAddress myIP = WiFi.softAPIP();
  Serial.print("AP IP address: ");
  Serial.println(myIP);
 // Starting WEB-server
     server.on ( "/", HTTP_handleRoot );
     server.onNotFound ( HTTP_handleRoot );
     server.begin();
}
void loop() {
  server.handleClient();
      command = server.arg("State");
      if (command == "F") goForword();
      else if (command == "B") goBack();
      else if (command == "L") goLeft();
      else if (command == "R") goRight();
      else if (command == "J") digitalWrite(Pump, HIGH); // Pump is on
      else if (command == "H") digitalWrite(Pump, LOW); //  Pump is off
      else if (command == "W") digitalWrite(Light, HIGH); // light is on
      else if (command == "w") digitalWrite(Light, LOW);  // light is off
      else if (command == "0") speedCar = 100;
      else if (command == "1") speedCar = 120;
      else if (command == "2") speedCar = 140;
      else if (command == "3") speedCar = 160;
      else if (command == "4") speedCar = 180;
      else if (command == "5") speedCar = 200;
      else if (command == "6") speedCar = 215;
      else if (command == "7") speedCar = 230;
      else if (command == "8") speedCar = 240;
      else if (command == "9") speedCar = 255;
      else if (command == "S") stopRobot();
      else if (command == "ServoLeft") incrementServoAngle();
      else if (command == "ServoRight") decrementServoAngle();
}
// Function to move the servo to a specified angle
void moveServo(int angle) {
  myServo.write(90 + angle);  // servo's center position
  delay(30);  // servo's speed and requirements
// Function to increment the servo angle
```

```
void incrementServoAngle() {
  servoAngle = min(servoAngle + servoIncrement, 100);  // Limit the angle to prevent overshooting
  moveServo(servoAngle);
// Function to decrement the servo angle
void decrementServoAngle() {
  servoAngle = max(servoAngle - servoIncrement, -100);  // Limit the angle to prevent overshooting
  moveServo(servoAngle);
void HTTP_handleRoot(void) {
if( server.hasArg("State") ){
      Serial.println(server.arg("State"));
  server.send ( 200, "text/html", "" );
  delay(1);
void goForword(){
      digitalWrite(IN_1, HIGH);
      digitalWrite(IN_2, LOW);
      analogWrite(ENA, speedCar);
      digitalWrite(IN_3, LOW);
      digitalWrite(IN_4, HIGH);
      analogWrite(ENB, speedCar);
  }
void goBack(){
      digitalWrite(IN_1, LOW);
      digitalWrite(IN_2, HIGH);
      analogWrite(ENA, speedCar);
      digitalWrite(IN_3, HIGH);
      digitalWrite(IN_4, LOW);
      analogWrite(ENB, speedCar);
  }
void goRight(){
      digitalWrite(IN_1, HIGH);
      digitalWrite(IN_2, LOW);
      analogWrite(ENA, speedCar);
      digitalWrite(IN_3, HIGH);
      digitalWrite(IN_4, LOW);
      analogWrite(ENB, speedCar);
}
void goLeft(){
      digitalWrite(IN_1, LOW);
      digitalWrite(IN_2, HIGH);
      analogWrite(ENA, speedCar);
      digitalWrite(IN_3, LOW);
      digitalWrite(IN_4, HIGH);
      analogWrite(ENB, speedCar);
}
void stopRobot(){
      digitalWrite(IN_1, LOW);
      digitalWrite(IN_2, LOW);
      analogWrite(ENA, speedCar);
      digitalWrite(IN_3, LOW);
      digitalWrite(IN_4, LOW);
      analogWrite(ENB, speedCar);
```

8 Simulation Testing

The functionality and performance of the fire detection and extinguishing robot will be evaluated through simulation testing. Simulated fire scenarios will be created, and the robot's response will be assessed to ensure its effectiveness in detecting and extinguishing fires. Simulation testing of an IoT-based fire extinguisher systems is a critical step in ensuring their effectiveness, reliability, and safety in real-world firefighting scenarios. By thoroughly evaluating system components, algorithms, and performance under simulated conditions, engineers and researchers can develop and deploy fire safety solutions that save lives and protect property effectively.

9 Field Testing

Field testing will be conducted in real-world environments to validate the robot's performance under actual firefighting conditions. The robot's ability to navigate through obstacles, detect fires accurately, and extinguish them effectively will be evaluated, and any necessary adjustments or optimizations will be made based on the test results.

10 Conclusions

In conclusion, the development of an IoT-based fire detection and extinguishing robot represents a significant advancement in firefighting technology. By leveraging IoT capabilities, this robot offers improved efficiency, effectiveness, and safety in combating fires and protecting lives and property. Continued research and development in this field will further enhance the capabilities of IoT-enabled firefighting systems, making them indispensable tools for emergency response teams worldwide.

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