REPORT

on

SMART ENVIRONMENTAL ANALYSIS ROBOT

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Course Title: IoT Domain Analyst
Slot: TA1
Faculty: Dr. Prasanna Bharathi
Topic: Smart Environmental Analysis Robot
Team Members: Alexia Prince Cheenath(21BRS1106), Muktikanta Dash(21BPS1250) & Gayatri Moitra(21BRS1293)

Abstract

The increasing concerns over environmental degradation and the need for effective monitoring solutions have led to the development of the "Smart Environmental Analysis Robot." This innovative project harnesses the power of Internet of Things (IoT) technology and Arduino microcontrollers to create a versatile and autonomous robot capable of conducting real-time environmental analysis.

The robot is equipped with a range of sensors to collect data on key environmental parameters such as air quality, temperature, humidity, and pollutant levels. The Arduino microcontroller serves as the brain of the robot, seamlessly integrating sensor data and facilitating real-time communication with a central server through IoT protocols.

The Robot moves around the given environment and collects key data about the amount of Smoke, Carbon Dioxide in the atmosphere along with the average temperature and humidity of the given region.

Introduction

Environmental monitoring has gained significance in recent years due to growing concerns about indoor air quality and the impact it has on human health and comfort. This project addresses these issues by developing an autonomous robot designed to navigate through a house, collecting a variety of environmental data while avoiding obstacles. The robot's core is a battery-powered Arduino system, ensuring flexibility and mobility within indoor environments.

Sensors play a critical role in the robot's functionality. The DHT11 sensor monitors temperature and humidity, providing a baseline for indoor comfort levels. The MQ135 sensor detects air quality by measuring concentrations of harmful gases like ammonia and benzene. These sensors are connected to an ESP32 WROOM board, allowing the robot to communicate with a ThingSpeak database wirelessly. This real-time data transmission enables users to monitor environmental conditions remotely, offering a convenient way to track indoor air quality.

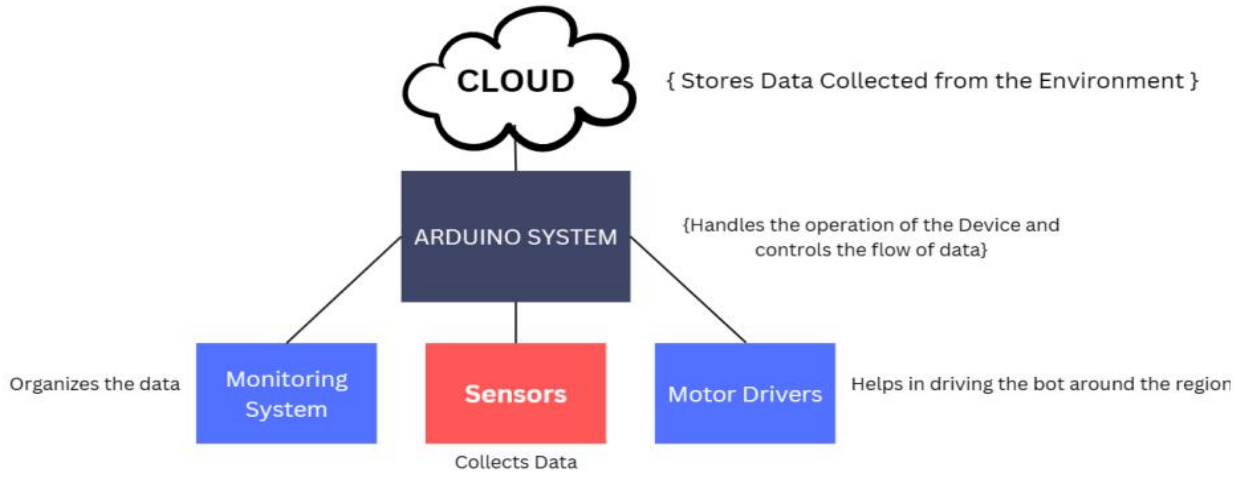
The robot facilitates efficient environmental monitoring by integrating these technologies, delivering valuable insights into indoor conditions. The system's ability to identify air quality issues early can help mitigate potential health risks and contribute to a safer indoor environment. Additionally, the robot's autonomous operation reduces the need for manual data collection, providing a scalable solution for home automation and indoor air quality monitoring.

Literature Survey

Paper	Author(s)	Aim/Objective	Proposed Methodology
"Autonomous Environmental Robot"	Smith et al.	Develop an autonomous robot for environmental monitoring	Sensor-based obstacle avoidance and data collection
"Real-Time Environmental Monitoring"	Jones and Kim	Implement real-time monitoring for environmental data	ESP32-based communication to cloud databases
"Arduino-Based Robots"	Lee and Parker	Design Arduino-powered robots for various applications	Arduino microcontroller with sensor integration
"Air Quality Monitoring with Sensors"	Clark and Garcia	Measure air quality using various sensors	MQ135 and similar sensors for gas detection
"Obstacle Avoidance Robots"	Wilson et al.	Create robots with obstacle avoidance capabilities	Ultrasonic and infrared sensors for obstacle detection
"Environmental Data in IoT"	Martinez and Chen	Transmit environmental data to IoT platforms	Wireless communication using ESP32
"ThingSpeak for Environmental Monitoring"	Nguyen and Patel	Utilize ThingSpeak for environmental data visualization	Cloud-based data storage and analysis
"Home Automation with Robots"	Brown and Davis	Use robots for home automation	Integration with smart home systems
"Indoor Air Quality Analysis"	Johnson and Williams	Study indoor air quality parameters	Temperature, humidity, and gas sensor data
"Real-Time Data Visualization"	White and Black	Visualize environmental data in real-time	Graphical representation of sensor data

Proposed System

Block Diagram



Main Focuses

- **Sensor Integration**: Various high-precision sensors are strategically placed on the robot to ensure accurate and comprehensive data collection. These sensors continuously monitor the surrounding environment, providing a wealth of information for environmental analysis.
- **Arduino-based Control System**: The Arduino microcontroller processes the sensor data and makes real-time decisions based on pre-defined algorithms. It controls the robot's movement, ensuring optimal coverage of the monitoring area. Additionally, the Arduino facilitates wireless communication with the central server, enabling seamless data transmission.
- **IoT Connectivity**: The robot is integrated into a larger IoT ecosystem, allowing for remote monitoring and control. The collected environmental data is transmitted to a central ThingSpeak server via IoT protocols, where it can be visualized, analyzed, and shared in real time. This connectivity enables stakeholders to make informed decisions and respond promptly to environmental changes.
- **Full Automation:** The device is fully automated and runs without external assistance.

Sensors and Control Systems Used

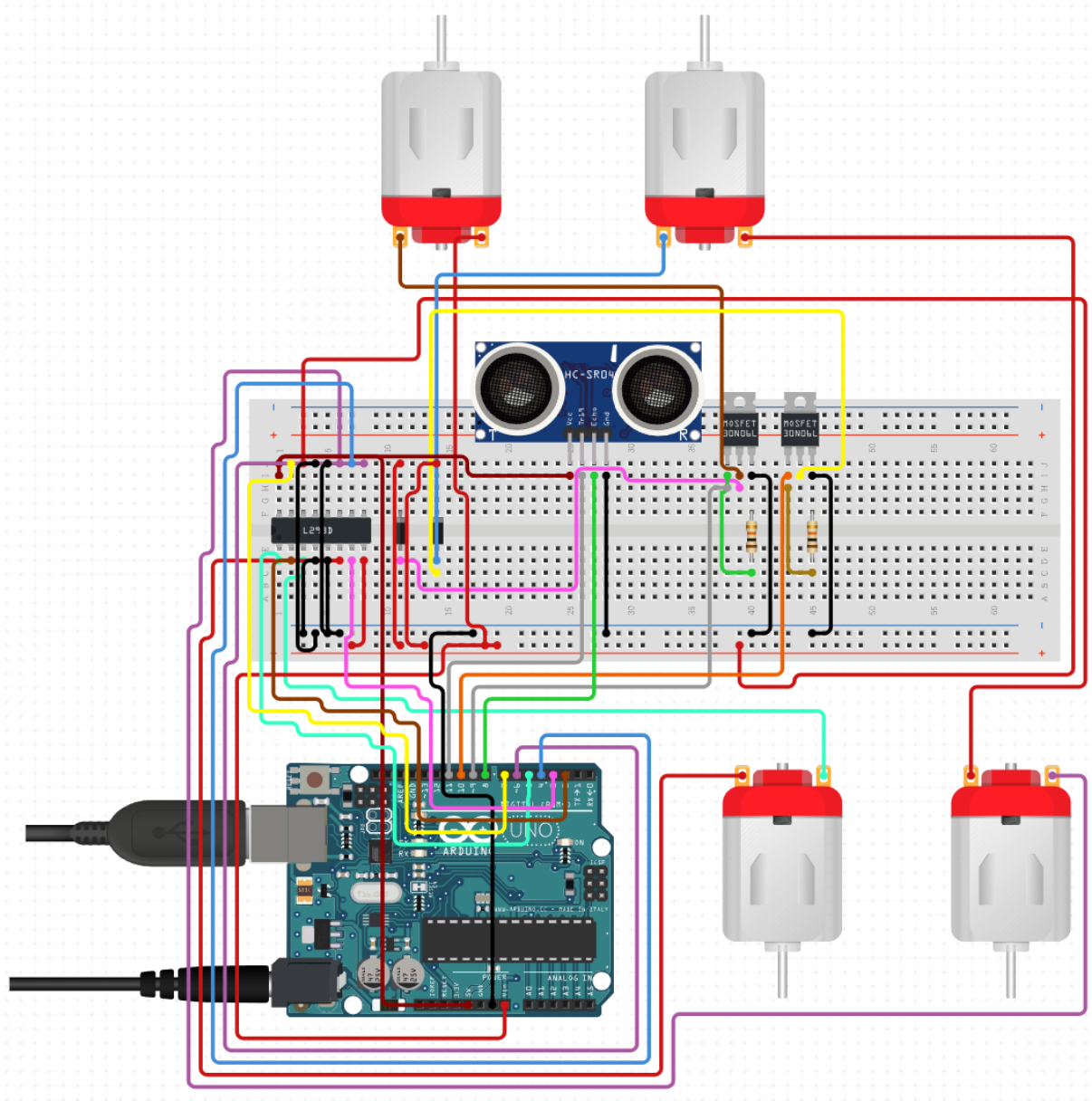
- **Navigation:** Ultrasonic sensor paired with an L293D motor driver shield, controlled by an Arduino UNO to drive the vehicle.
- **Monitoring:** DHT11 Temperature and Humidity, Various Gas Sensors including CO2, CO, etc. All are controlled by an ESP32 to collect

environmental data from the target region and send it back to the database for analysis, using interfaces like ThingSpeak.

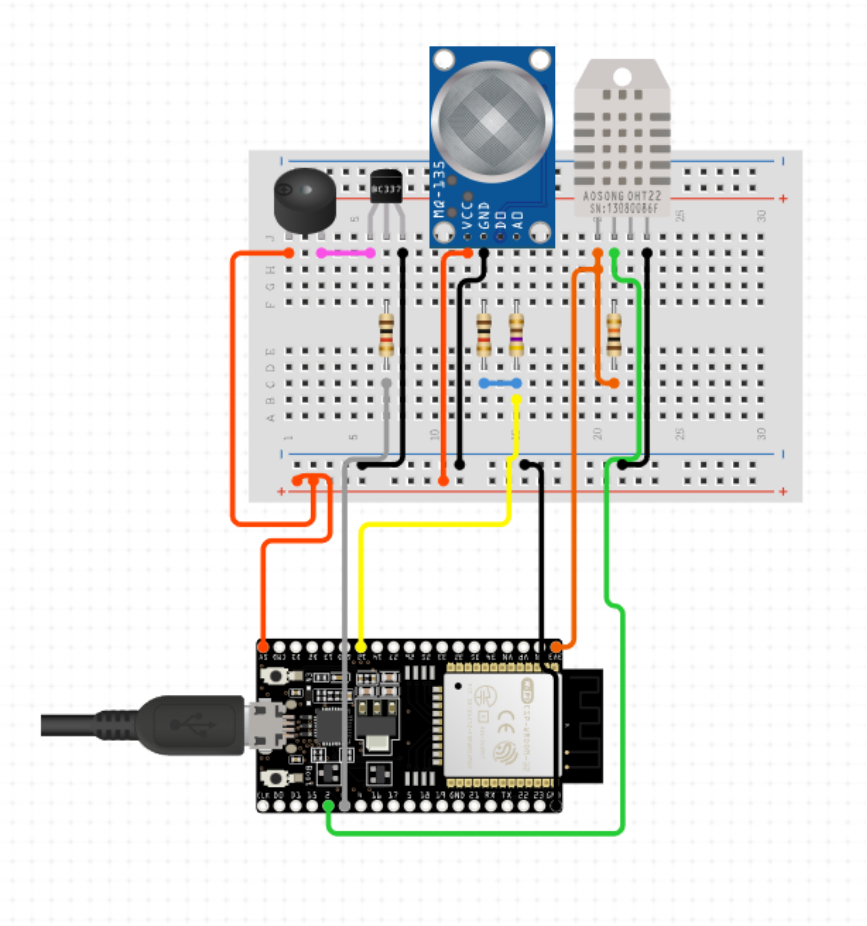
The methodology emphasizes obstacle avoidance and efficient data collection while allowing remote monitoring via the ThingSpeak platform. This integration of technologies provides a robust system for indoor environmental monitoring, with the potential for further expansion and integration with smart home systems.

Architecture

Obstacle Avoiding Robot (Arduino Uno) Circuit Diagram



Environment Monitoring Sensors (ESP32 Wroom) Circuit Diagram



Hardware Components and Software Modules

Hardware Components

- **ESP32 Wroom:** Wi-Fi Enabled ESP32 Controller
- **DHT11:** Temperature and Humidity Sensor
- **MQ135:** Hazardous Gas Sensor
- **Arduino Uno R3:** Microcontroller
- **L293D:** Motor Controller Shield
- **Ultrasonic Sensor:** To Detect Obstacles
- **4 Geared Motors:** To move the wheels
- **Servo Motor:** To control the direction of the Ultrasonic Sensor
- **Buzzer:** To indicate if the wifi is connected or not

Software Modules

- **Arduino IDE:** To design the codes and upload it to the respective controller.
- **ThingSpeak:** To collect data from the DHT11 and MQ135 sensors and send it to the database for visualising the variance in the data collected.

Working

Code for Obstacle Avoiding Robot (Arduino Uno)

```
#include "AFMotor.h"
#include <Servo.h>
#define echopin A0 // echo pin
#define trigpin A5 // Trigger pin

Servo myservo;

const int MOTOR_1 = 1;
const int MOTOR_2 = 2;
const int MOTOR_3 = 3;
const int MOTOR_4 = 4;

AF_DCMotor motor1(MOTOR_1, MOTOR12_64KHZ);
AF_DCMotor motor2(MOTOR_2, MOTOR12_64KHZ);
AF_DCMotor motor3(MOTOR_3, MOTOR12_64KHZ);
AF_DCMotor motor4(MOTOR_4, MOTOR12_64KHZ);

int distance_L, distance_F, distance_R;
long distance;
int set = 15;

void setup()
{
  Serial.begin(9600);
  Serial.println("Start");
  myservo.attach(10);
  myservo.write(90);
  pinMode (trigpin, OUTPUT);
  pinMode (echopin, INPUT );
  motor1.setSpeed(180);
  motor2.setSpeed(180);
  motor3.setSpeed(180);
  motor4.setSpeed(180);
}

void loop()
{
 distance_F = data();
 Serial.print("S=");
 Serial.println(distance_F);
  if (distance_F > set)
  {
   Serial.println("Forward");
   motor1.run(FORWARD);
   motor2.run(FORWARD);
   motor3.run(FORWARD);
```

```
   motor4.run(FORWARD);
  }
  else
   hc_sr4();
}

long data()
{
  digitalWrite(trigpin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigpin, HIGH);
  delayMicroseconds(10);
  distance = pulseIn (echopin, HIGH);
  return distance / 29 / 2;
}

void compareDistance()
{
  if (distance_L > distance_R)
  {
    motor1.run(BACKWARD);
    motor2.run(BACKWARD);
    motor3.run(FORWARD);
    motor4.run(FORWARD);
    delay(350);
  }
  else if (distance_R > distance_L)
  {
    motor1.run(FORWARD);
    motor2.run(FORWARD);
    motor3.run(BACKWARD);
    motor4.run(BACKWARD);
    delay(350);
  }
  else
  {
    motor1.run(BACKWARD);
    motor2.run(BACKWARD);
    motor3.run(BACKWARD);
    motor4.run(BACKWARD);
    delay(300);
    motor1.run(BACKWARD);
    motor2.run(BACKWARD);
    motor3.run(FORWARD);
    motor4.run(FORWARD);
    delay(500);
  }
}
void hc_sr4()
{
   Serial.println("Stop");
```

```
   motor1.run(RELEASE);
   motor2.run(RELEASE);
   motor3.run(RELEASE);
   motor4.run(RELEASE);
   myservo.write(0);
   delay(300);
   distance_R = data();
   delay(100);
   myservo.write(170);
   delay(500);
   distance_L = data();
   delay(100);
   myservo.write(90);
   delay(300);
   compareDistance();
}
```

This code controls an obstacle-avoiding robot built with an Arduino Uno, a servo, four DC motors, and an ultrasonic sensor for distance measurement. The "AFMotor" library controls the motor speed and direction, allowing the robot to move forward, backward, and turn. The ultrasonic sensor, with its echo and trigger pins, measures distances in front of the robot. The servo adjusts to different angles, enabling the sensor to scan for obstacles.

The loop function checks the distance in front of the robot. If the distance is greater than the set threshold, the robot moves forward. If it's less, the robot stops, and the hc_sr4() function is triggered. This function measures distances to the left and right, and then the compareDistance() function decides which direction to turn based on these readings. The robot can avoid obstacles by reversing or turning left or right, depending on which side has more space. This system allows for continuous movement through an environment while avoiding collisions.

Code for Environment Monitoring Sensors (ESP32 Wroom)

```
#include <WiFi.h>
#include <DHT.h>
#include "MQ135.h"
#include <ThingSpeak.h>


const char *ssid = "MK_11x";
const char *pass = "spiderman";

MQ135 gasSensor = MQ135(34);
DHT dht(18,DHT11);
int val;
int sensorPin = 34;
int sensorValue = 0;
```

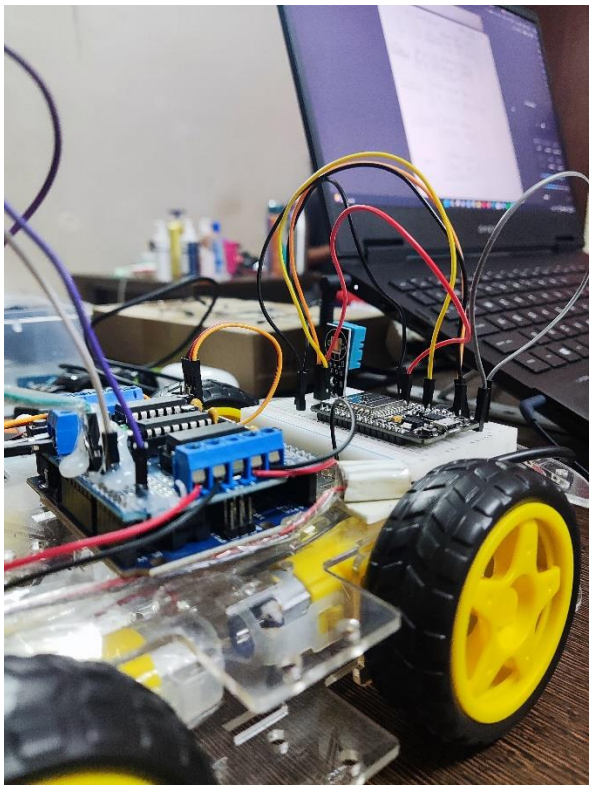
```
int buz = 19;

WiFiClient client;

long myChannelNumber = 2523186;
const char myWriteAPIKey[] = "M5YPMB6LBC7KYBI6";

void setup()
{
 pinMode(sensorPin, INPUT);
 pinMode(buz, OUTPUT);
 Serial.begin(9600);
 WiFi.begin(ssid, pass);
 while(WiFi.status()!=WL_CONNECTED)
 {
  digitalWrite(buz,HIGH);
  delay(200);
  digitalWrite(buz,LOW);
  delay(200);
 }
 Serial.println();
 Serial.println("NodeMCU is Connected");
 digitalWrite(buz,HIGH);
 delay(2000);
 digitalWrite(buz,LOW);
 Serial.println(WiFi.localIP());
 dht.begin();
 ThingSpeak.begin(client);
}

void loop()
{
 float h=dht.readHumidity();
 float t=dht.readTemperature();
 Serial.println("Temperature: "+(String)t);
 Serial.println("Humidity: "+(String)h);
 ThingSpeak.writeField(myChannelNumber,1,t,myWriteAPIKey);
 ThingSpeak.writeField(myChannelNumber,2,h,myWriteAPIKey);
 delay(5000);
 val = analogRead(34);
 Serial.print ("val = ");
 Serial.println (val);
 float zero = gasSensor.getRZero();
 Serial.print ("rzero: ");
 Serial.println (zero);
 float ppm = gasSensor.getPPM();
 ppm = ppm/20;
 Serial.print ("ppm: ");
 Serial.println (ppm);
 Serial.println("val: " + (String) val);
 Serial.println("Rzero: " + (String) zero);
```

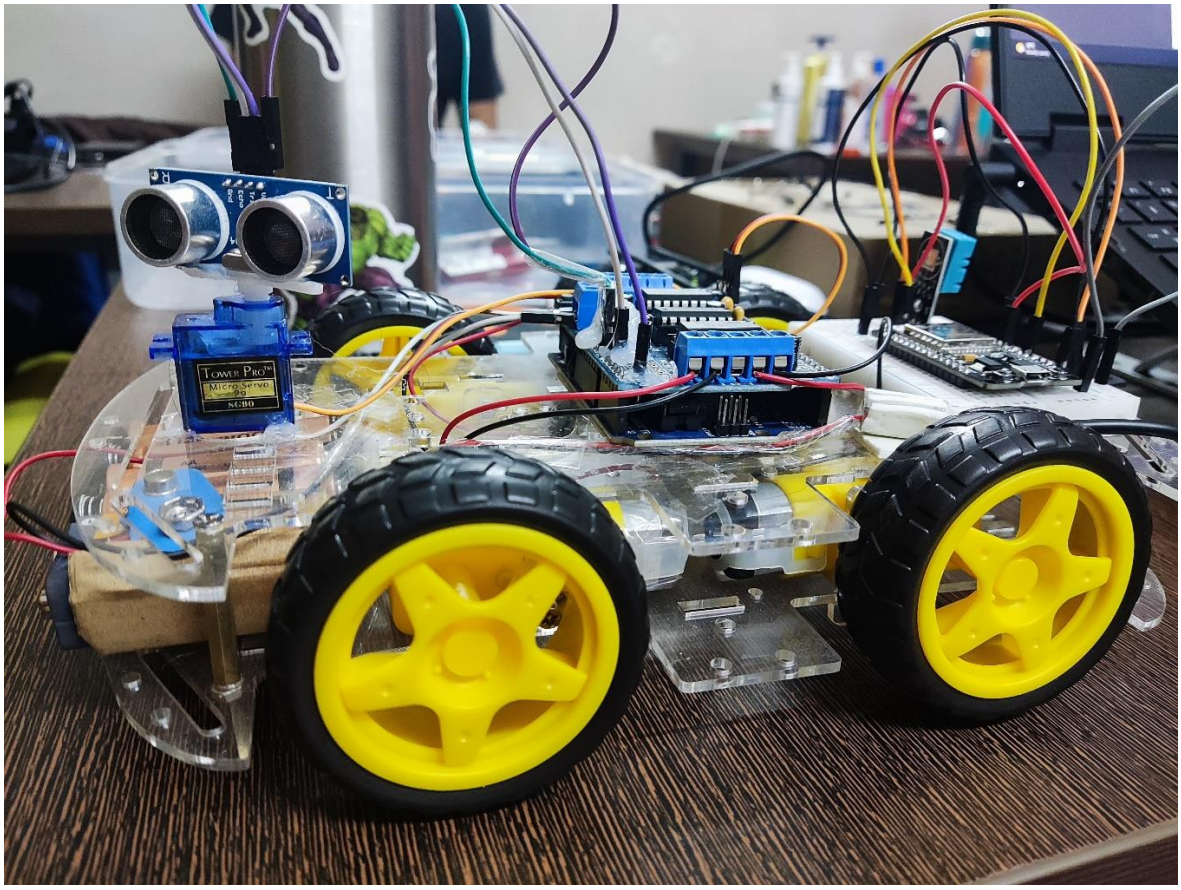
```
 Serial.println("PPM: " + (String) ppm);
 ThingSpeak.writeField(myChannelNumber,5,val,myWriteAPIKey);
 ThingSpeak.writeField(myChannelNumber,4,zero,myWriteAPIKey);
 ThingSpeak.writeField(myChannelNumber,3,ppm,myWriteAPIKey);
 delay(5000);
}
```

This code uses an ESP32 Wroom board to collect environmental data and transmit it to a ThingSpeak database for real-time monitoring. It connects to a Wi-Fi network using predefined credentials and uses a DHT11 sensor to measure temperature and humidity. Additionally, the MQ135 sensor detects air quality, specifically gases like ammonia, benzene, and others.

The setup function establishes a Wi-Fi connection and initializes the DHT11 sensor. If the connection is successful, a buzzer indicates success. The code sends data to ThingSpeak at regular intervals, with the loop function reading temperature and humidity from the DHT11 sensor, along with the MQ135 sensor's gas concentration in parts per million (PPM). This data is transmitted to ThingSpeak, allowing remote monitoring of environmental conditions. The code also includes error handling and checks for sensor readings' accuracy, ensuring consistent data collection and transmission .

Project Model

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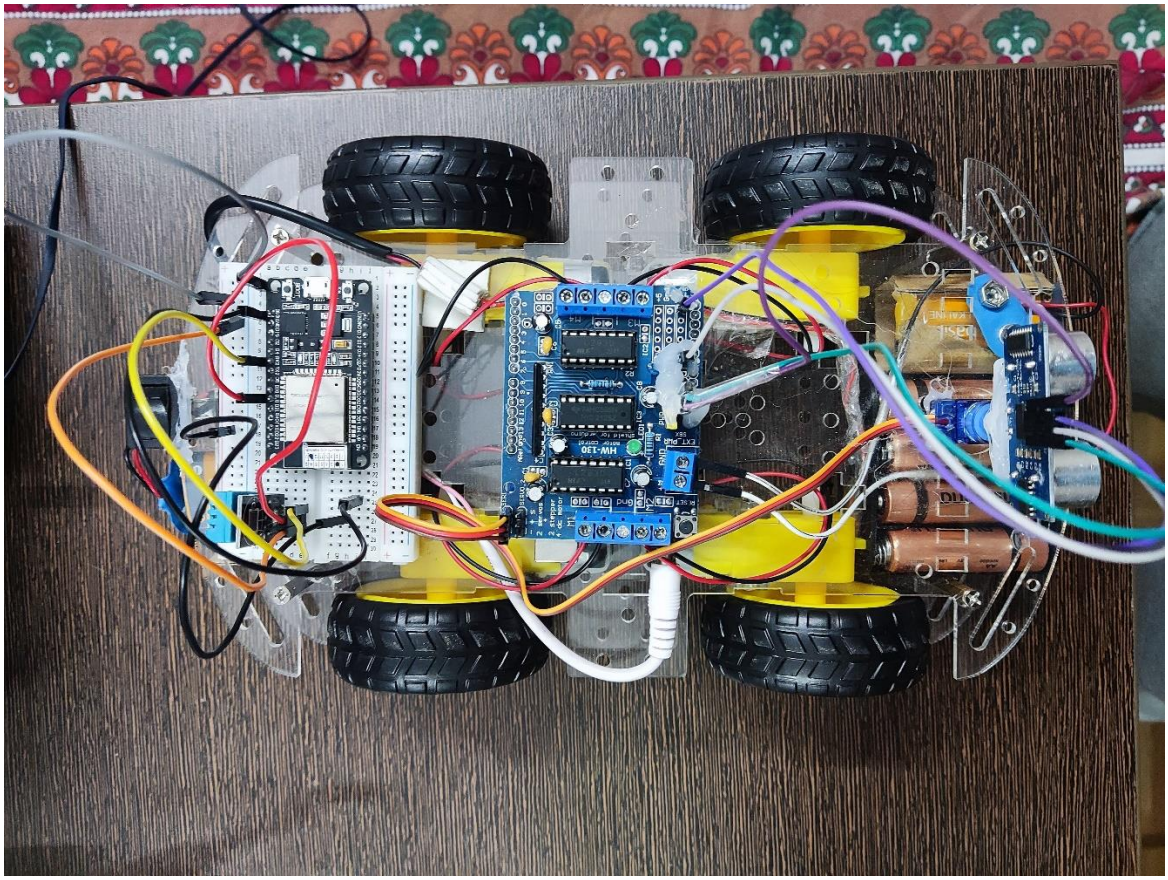
Micro Servo
SG90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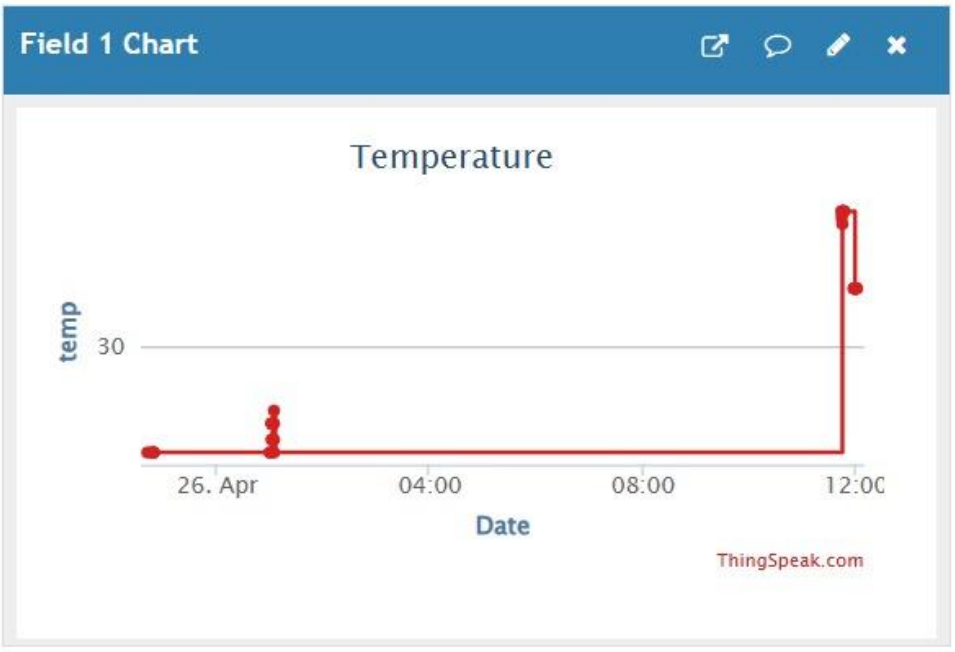
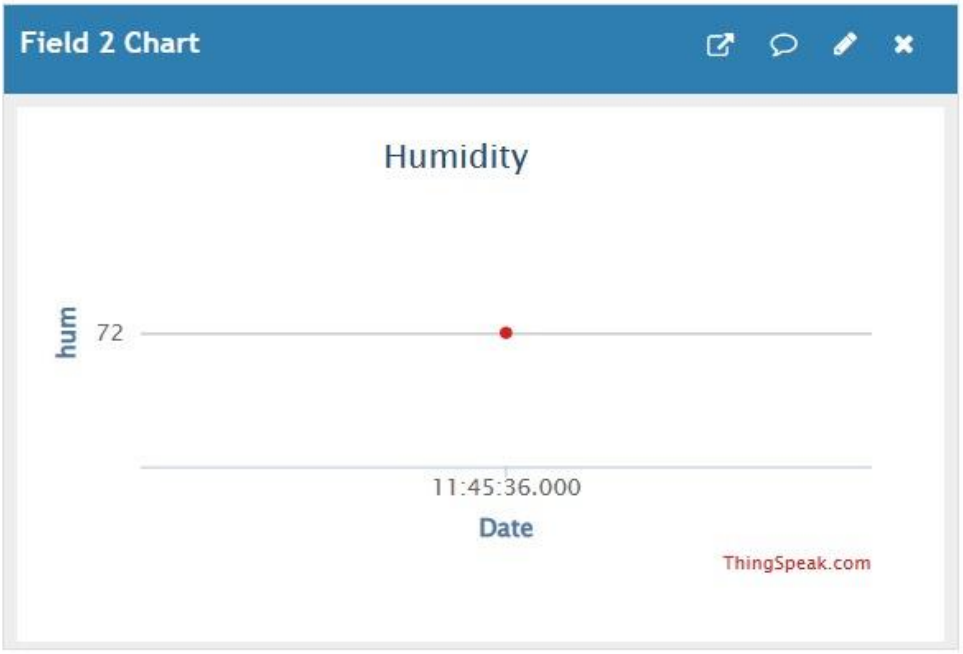
Results

ThingSpeak output for: -

- Temperature

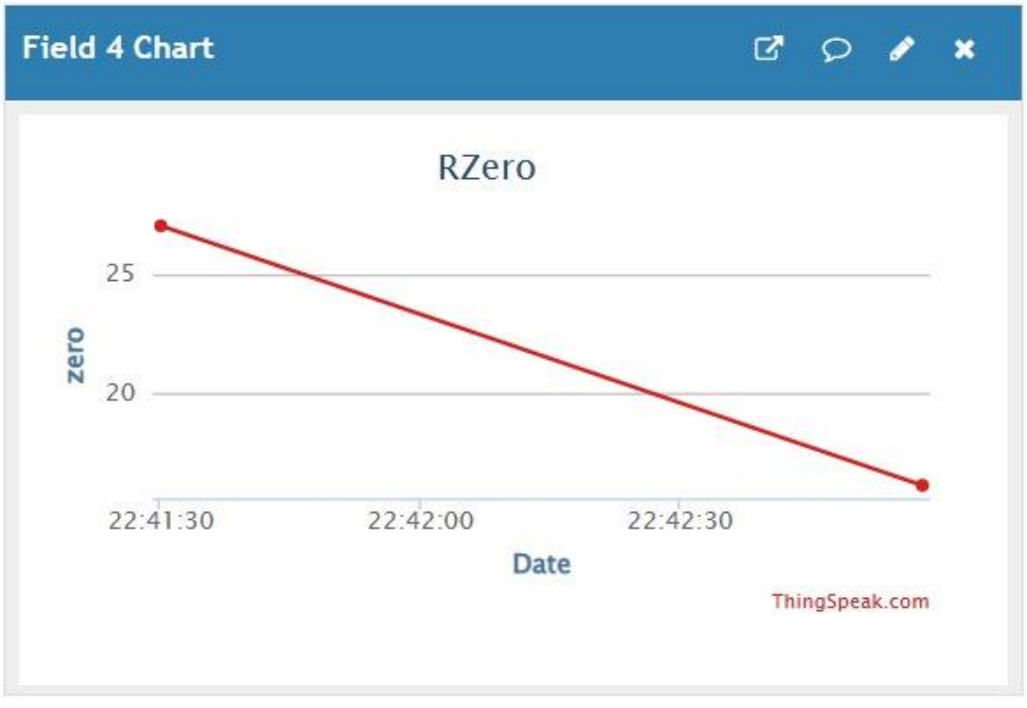


- Humidity

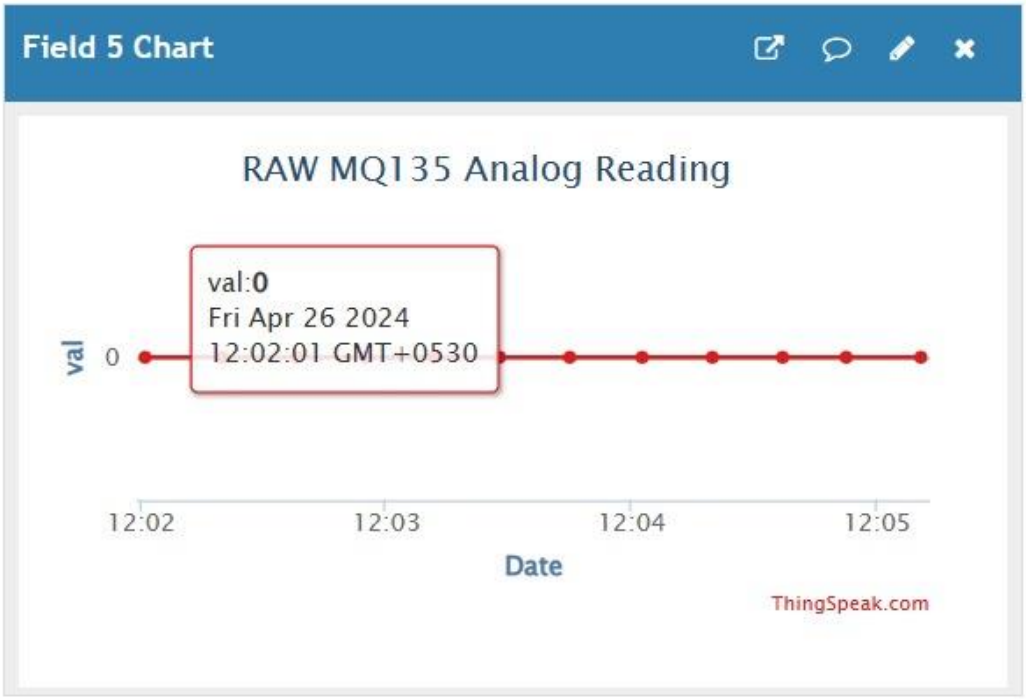


- PPM Value

- RZero Value



- Raw MQ135 Analog Reading



The environmental monitoring robot successfully collects and transmits sensor data to ThingSpeak in real time. The output on the ThingSpeak platform includes temperature, humidity, and air quality (measured in PPM). The following observations summarize the results:

- **Temperature and Humidity Readings**: The robot provides consistent readings of indoor temperature and humidity, allowing users to track environmental comfort levels. Data is updated at regular intervals, typically every 5 seconds, ensuring that any changes in indoor conditions are promptly reflected.
- **Air Quality Monitoring:** Using the MQ135 sensor, the robot detects the concentration of harmful gases in parts per million (PPM). The output on ThingSpeak provides an easy-to-read graphical representation, highlighting trends over time. This helps users identify potential air quality issues early.
- **Obstacle Avoidance:** The robot navigates through indoor environments without collisions, thanks to its ultrasonic sensor and obstacle-avoidance code. The ability to maneuver around obstacles ensures continuous data collection throughout the house.

Overall, the results demonstrate that the robot can effectively gather environmental data while avoiding obstacles, providing a robust solution for indoor air quality monitoring.

Discussions

The output on ThingSpeak allows for remote monitoring of environmental conditions, offering several advantages:

- **Data Visualization:** ThingSpeak's graphical interface enables users to visualize temperature, humidity, and air quality data over time. This visualization helps identify patterns and trends, providing valuable insights into indoor environmental conditions.
- **Real-Time Monitoring**: The real-time nature of the data transmission ensures that users can monitor indoor conditions continuously. This feature is especially useful for early detection of air quality issues, allowing for timely interventions.
- **Accessibility:** Since the data is stored on a cloud platform, it can be accessed from anywhere with an internet connection. This accessibility makes it easy for users to monitor their home's environment, even when they're away.

However, there are some areas for improvement:

- **Data Accuracy:** Sensor accuracy is crucial for reliable data. Calibration may be needed to ensure accurate readings, especially for the MQ135 sensor, which can be sensitive to environmental factors.
- **Battery Life:** The robot's battery life affects its ability to operate continuously. Optimizing power consumption or using a larger battery capacity could extend it’s operational time.
- **Integration with Other Systems:** Integrating the robot with other smart home systems could enhance its functionality, allowing for automation based on environmental conditions.

In summary, the results from ThingSpeak show that the environmental monitoring robot is effective in collecting and transmitting data, with the potential for further enhancements in accuracy, power efficiency, and system integration.

Future Work

- **Expanded Sensor Suite:** Adding additional sensors to measure other environmental parameters like light levels, sound, and carbon dioxide.
- **Enhanced Obstacle Avoidance:** Implementing advanced algorithms for obstacle avoidance to improve the robot's navigation capabilities.
- **Integration with Smart Home Systems:** Connecting the robot to existing smart home systems to enhance home automation and environmental monitoring.

- **Mobile App Development:** Creating a mobile application for users to remotely monitor the robot's data and control its movement.
- **Machine Learning for Data Analysis:** Using machine learning techniques to analyze collected data and predict environmental trends or detect anomalies.
- **Energy Optimization:** Investigating methods to optimize battery life and reduce power consumption, extending the robot's operational time.