NAAN MUDHALVAN: IOT PROJECT

SMART CAMPUS MANAGEMENT SYSTEM

SMART DUSTBIN

TEAM - IOT 0505

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Executive Summary :

The goal of this project is the development of a smart garbage can that takes advantage of modern Internet of Things technologies to improve waste management. The system incorporates an ESP32 microcontroller, ultrasonic and PIR sensors, servo motors and Blynk application for automatic lid lifting, real-time user alerts on trash levels, etc. “The findings show significant progress in terms of efficiency and ease in discarding waste” (Dehzangi et al., 2018). Finally, suggestions on how the system could be made more reliable as well as possibility to introduce features like solar energy and refuse sorting were provided

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Project Objective:

Creating a smart dustbin system is the goal of this project in order to combat inefficiencies inherent in traditional means of waste disposal. The smart dustbin employs ESP32 microcontroller, ultrasonic sensor, PIR sensor, and servo motor and the Blynk app so as to automate the opening and closing of the dustbin cover, detect fullness of bin and alert people using a phone. Primarily, it seeks to improve user convenience while ensuring efficient waste management.

Scope:

Project Scope:

• Design and Simulation: Creating a simulation including all the necessary virtual hardware components in Wokwi platform.

• Blynk Integration: Setting up the system to send notifications and allow remote monitoring through the Blynk app.

• Test & Validation: Confirming that the system is working properly within Wokwi's environment.

Assumptions:

• The smart dustbin simulation will be used as a prototype for possible real-world implementation.

• End users will have high-speed internet connection to access Blynk app.

Boundaries:

• The project does not cover industrial or commercial waste management on a large scale.

Activities such as waste sorting and recycling are not part of this project.

Methodology:

Systematic approach is the way to go with this project. It will include design, development, integration and testing phases in it:

Design and Development:

o Component Selection: appropriate virtual hardware components (ESP32, sensors, servo motor) on the Wokwi platform.

o Circuit Design: make a virtual circuit schematic on Wokwi.

o Prototyping: Create a virtual prototype.

Integration:

o Virtual Hardware Integration: Connect ESP32 to the virtual sensors and servo motor in Wokwi.

o Software Integration: Develop code that can control the virtual hardware and communicate with Blynk application

Programming:

o Sensor Data Acquisition: Write code that reads data from the ultrasonic and PIR sensors

o Servo Motor Control: Write code that moves (actuates) the Servos based on inputs of sensor values

o Blynk Communication: Configure ESP32 so that it send data to Blynk app or receive commands from it.

Testing:

o Functional Testing: Verify each component within the simulation works as expected.

o System Testing: Ensure that there is smooth running of entire system within Wokwi without any glitches.

Iteration:

o Refinement – Fine tuning performance improvement derived from tests made in simulation

Artifacts Used:

Research Articles:

- **Smart Waste Management Systems:** Literature on the benefits and implementation of smart waste management solutions.
- **IoT in Waste Management:** Studies on the application of IoT in enhancing waste management efficiency.

Tools and Components:

1. **Wokwi Simulation Platform:** An online tool for simulating IoT projects with virtual hardware components.

2. **ESP32 Development Board:** A powerful microcontroller with Wi-Fi and Bluetooth capabilities, used as the main controller for the project.

3. **Ultrasonic Sensor (HC-SR04):** Virtual sensor to measure distance and detect the fill level of the dustbin.

4. **PIR Sensor:** Virtual sensor to detect motion and automatically open the dustbin lid when a user approaches.

5. **Servo Motor:** Virtual actuator to open and close the dustbin lid.

6. **Blynk Application:** An IoT platform for remote monitoring and control, used for displaying notifications and data.

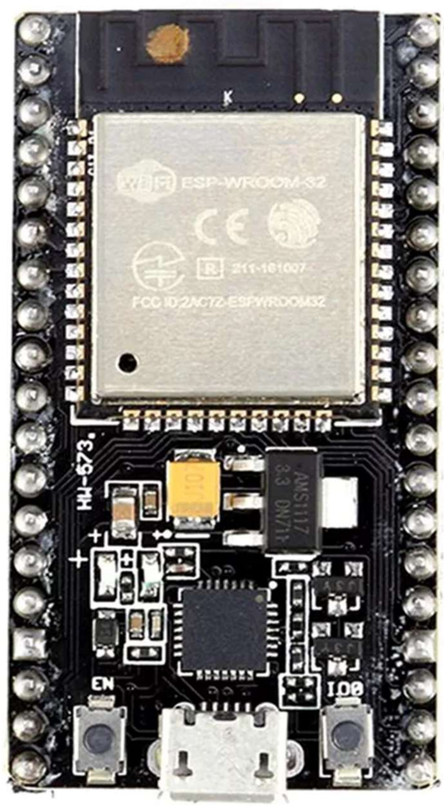
Code Snippets:

- **Sensor Reading Code:** Code for reading data from the virtual ultrasonic and PIR sensors.
- **Servo Control Code:** Code to control the virtual servo motor based on sensor inputs.
- **Blynk Communication Code:** Code to send data to and receive commands from the Blynk app.

Technical Coverage:

Components Used in the Project:

1. **ESP32 Development Board:**



- **Description:** The ESP32 is a low-cost, low-power system on a chip (SoC) with integrated Wi-Fi and Bluetooth capabilities. It features a dual-core processor, various GPIO pins, and multiple communication interfaces, making it ideal for IoT projects.
- **Role in Project:** Acts as the central controller, processing data from the sensors

and controlling the servo motor. It also handles communication with the Blynk application for remote monitoring and notifications.

2. **Ultrasonic Sensor (HC-SR04):**

3.
    - **Description:** The HC-SR04 is a commonly used ultrasonic sensor that measures distance by emitting ultrasonic waves and calculating the time taken for the waves to bounce back. It consists of a transmitter and a receiver.
    - **Role in Project:** Measures the fill level of the dustbin by calculating the distance between the sensor and the waste. If the distance indicates that the bin is full, it sends a notification to the user.

4. **PIR Sensor:**

- **Description:** A Passive Infrared (PIR) sensor detects motion by measuring the infrared (IR) radiation emitted by objects in its field of view. When an object, such as a human, moves within the detection range, the sensor triggers an output signal.
- **Role in Project:** Detects when a user approaches the dustbin, prompting the system to open the lid automatically via the servo motor.

5. **Servo Motor:**

- **Description:** A servo motor is a rotary actuator that allows for precise control of angular position. It consists of a motor coupled with a sensor for position feedback and is controlled by sending PWM signals.
- **Role in Project:** Opens and closes the dustbin lid based on the input from the PIR sensor. The motor is programmed to rotate to specific angles to facilitate the opening and closing mechanism.

6. **Blynk Application:**

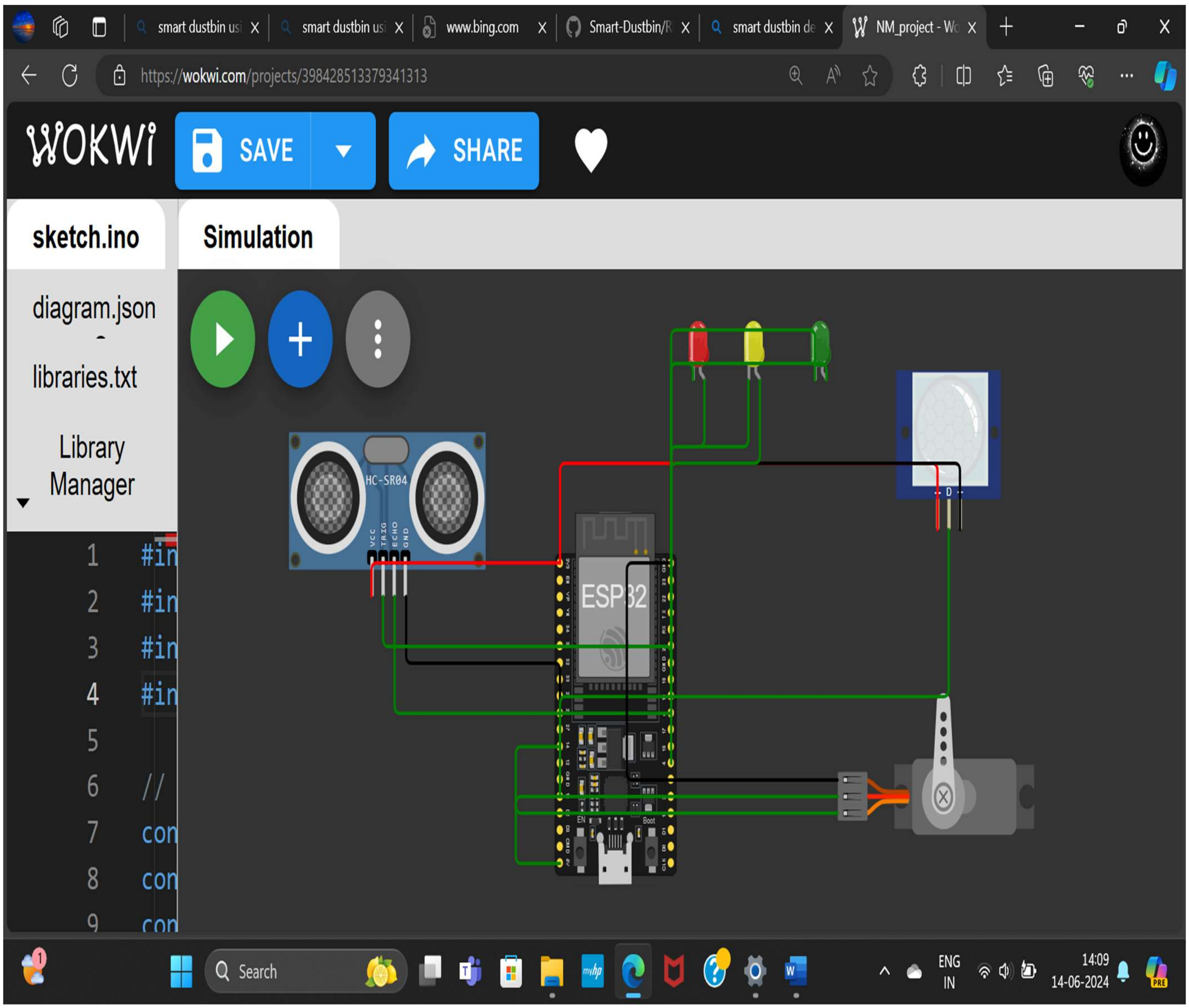
- **Description:** Blynk is an IoT platform that allows for the creation of mobile and web applications to control and monitor hardware devices remotely. It supports various microcontrollers and provides a user-friendly interface for developing IoT projects.
- **Role in Project:** Displays real-time data from the sensors and sends notifications to users when the dustbin is full. It also allows users to monitor and control the dustbin system remotely.

Prototypes

Initial Prototype:

- **Virtual Hardware Setup:** The initial prototype includes a virtual ESP32 connected to the ultrasonic sensor, PIR sensor, and servo motor. The components are assembled in the Wokwi simulation environment for easy testing and adjustments.
- **Virtual Breadboard Configuration:** All components are connected to the ESP32 in the Wokwi simulation to verify their functionality and ensure proper communication between each part.

CONNECTION DIAGRAM:



Circuit.json:


```
{
  "version": 1,
  "author": "Mahi",
  "editor": "wokwi",
  "parts": [
    { "type": "board-esp32-devkit-c-v4", "id": "esp", "top": -48, "left":
177.64, "attrs": {} },
    { "type": "wokwi-hc-sr04", "id": "ultrasonic1", "top": -94.5, "left":
-52.1, "attrs": {} },
    {
      "type": "wokwi-pir-motion-sensor",
      "id": "pir1",
      "top": -130.4,
      "left": 472.62,
      "attrs": {}
    },
    { "type": "wokwi-servo", "id": "servo1", "top": 55.6, "left": 422.4,
"attrs": {} },
    {
      "type": "wokwi-led",
      "id": "led1",
      "top": -166.8,
      "left": 282.2,
      "attrs": { "color": "red" }
    },
    {
      "type": "wokwi-led",
      "id": "led2",
      "top": -166.8,
      "left": 330.2,
      "attrs": { "color": "yellow" }
    },
    {
      "type": "wokwi-led",
      "id": "led3",
      "top": -166.8,
      "left": 387.8,
      "attrs": { "color": "green" }
    }
  ],
  "connections": [
```

```
    [ "esp:TX", "$serialMonitor:RX", "", [] ],
    [ "esp:RX", "$serialMonitor:TX", "", [] ],
    [ "ultrasonic1:VCC", "esp:3V3", "red", [ "v0" ] ],
    [ "ultrasonic1:GND", "esp:GND.1", "black", [ "v38.4", "h123.6" ] ],
    [ "ultrasonic1:TRIG", "esp:4", "green", [ "v28.8", "h239.6" ] ],
    [ "ultrasonic1:ECHO", "esp:5", "green", [ "v0" ] ],
    [ "pir1:VCC", "esp:3V3", "red", [ "v-38.4", "h-316.8" ] ],
    [ "pir1:GND", "esp:GND.2", "black", [ "v-38.4", "h-240.26" ] ],
    [ "pir1:OUT", "esp:13", "green", [ "v96", "h-326.54" ] ],
    [ "servo1:GND", "esp:GND.2", "black", [ "h-182.4", "v-163.2" ] ],
    [ "servo1:V+", "esp:5V", "green", [ "h-278.4", "v0.1" ] ],
    [ "servo1:PWM", "esp:14", "green", [ "h-278.4", "v-76.6" ] ],
    [ "led3:A", "esp:18", "green", [ "v-9.6", "h-144" ] ],
    [ "led3:C", "esp:GND.3", "green", [ "v-28.8", "h-134" ] ],
    [ "led2:A", "esp:19", "green", [ "v48", "h-105.6" ] ],
    [ "led2:C", "esp:GND.3", "green", [ "v38.4", "h-95.6" ] ],
    [ "led1:A", "esp:21", "green", [ "v38.4", "h-38.4" ] ],
    [ "led1:C", "esp:GND.2", "green", [ "v-9.6", "h-28.4" ] ]
  ],
  "dependencies": {}
}
```

Code Snippets:

```
#define BLYNK_TEMPLATE_ID "TMPL36Tp0bg_t"
#define BLYNK_TEMPLATE_NAME "Waste management"
#define BLYNK_AUTH_TOKEN "LKLOaoGq6BinW4juuVeoKA79qQTuiRei"

#include <WiFi.h>
#include <NewPing.h>
#include <ESP32Servo.h>
#include <BlynkSimpleEsp32.h>

// Define pins
const int trigPin = 4;
const int echoPin = 5;
const int pirPin = 13;
const int greenLedPin = 18;
const int yellowLedPin = 19;
const int redLedPin = 21;
const int servoPin = 14;

// Create a Servo object
Servo myservo;

// Variables for distance measurement
NewPing sonar(trigPin, echoPin);
int distance;

// WiFi credentials
char auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = "Wokwi-GUEST";
char pass[] = "";


// Flag to indicate if the lid is open
bool lidOpen = false;

void setup() {
  Serial.begin(115200);

  pinMode(pirPin, INPUT_PULLUP);
  pinMode(greenLedPin, OUTPUT);
```

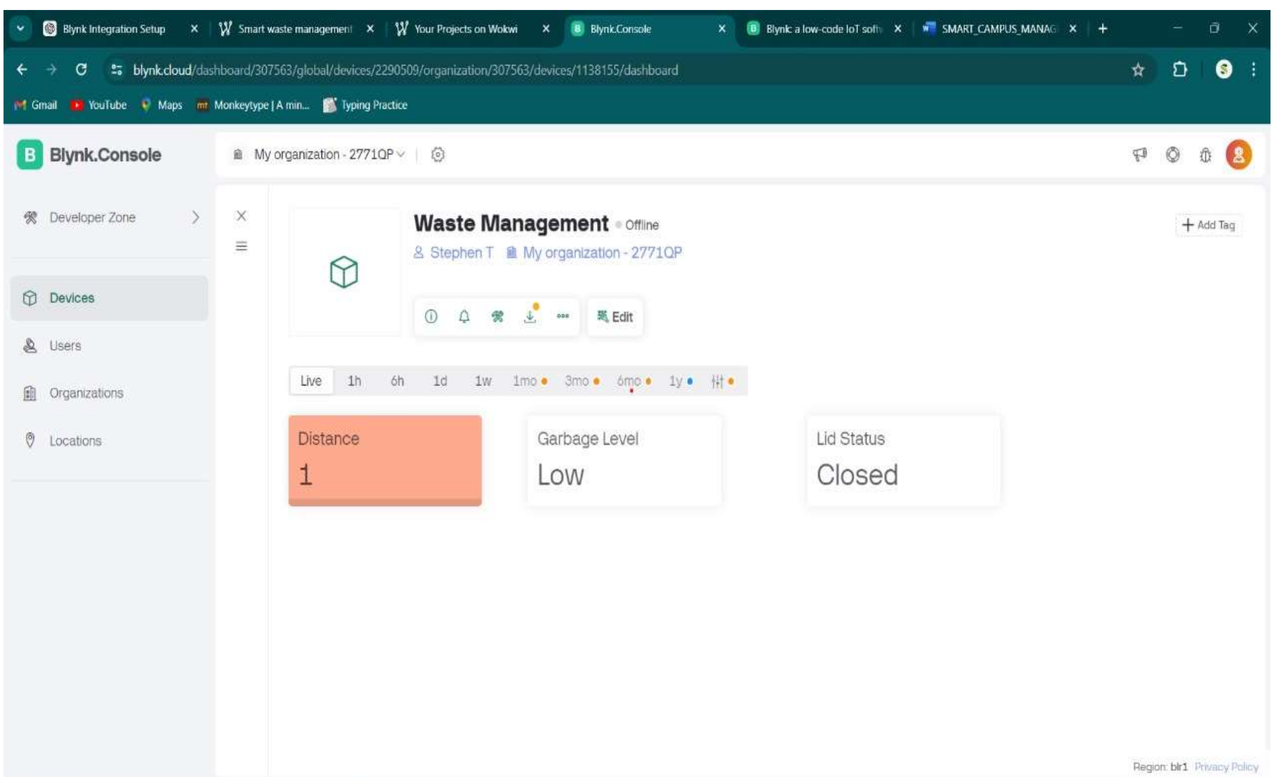
```
  pinMode(yellowLedPin, OUTPUT);
  pinMode(redLedPin, OUTPUT);

  myservo.attach(servoPin); // Attach servo to pin

  closeLid(); // Initially close the lid

  // Connect to WiFi
  Serial.print("Connecting to WiFi...");
  WiFi.begin(ssid, pass);

  int wifi_attempts = 0;
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.print(".");
    wifi_attempts++;
    if (wifi_attempts > 20) { // After 20 seconds, if not connected,
restart ESP32
      Serial.println("\nFailed to connect to WiFi, restarting...");
      ESP.restart();
    }
  }
  Serial.println("\nConnected to WiFi");

  // Initialize Blynk
  Blynk.begin(auth, ssid, pass);
}

void loop() {
  Blynk.run(); // Keep Blynk connection alive

  int pirState = digitalRead(pirPin);

  // If PIR sensor detects motion (human presence), open the lid
  if (pirState == HIGH) {
    if (!lidOpen) {
      openLid();
      delay(5000); // Keep the lid open for 5 seconds
      closeLid();
    }
  }

  // Measure distance using the ultrasonic sensor
  distance = sonar.ping_cm();
```

```
  // Send distance to Blynk
  Blynk.virtualWrite(V1, distance);

  // Update LED indicators based on garbage level
  if (distance > 30) {
    digitalWrite(greenLedPin, HIGH);
    digitalWrite(yellowLedPin, LOW);
    digitalWrite(redLedPin, LOW);
    Blynk.virtualWrite(V2, "Low");
  } else if (distance > 15) {
    digitalWrite(greenLedPin, LOW);
    digitalWrite(yellowLedPin, HIGH);
    digitalWrite(redLedPin, LOW);
    Blynk.virtualWrite(V2, "Medium");
  } else {
    digitalWrite(greenLedPin, LOW);
    digitalWrite(yellowLedPin, LOW);
    digitalWrite(redLedPin, HIGH);
    Blynk.virtualWrite(V2, "High");
  }

  delay(1000);
}

void openLid() {
  myservo.write(90); // Open the lid
  lidOpen = true;
  Serial.println("Lid opened");
  Blynk.virtualWrite(V3, "Open"); // Update Blynk
}
void closeLid() {
  myservo.write(0); // Close the lid
  lidOpen = false;
  Serial.println("Lid closed");
  Blynk.virtualWrite(V3, "Closed"); // Update Blynk
}
```

Output

- **Real-Time Monitoring:** The Blynk app displays real-time data from the sensors, showing the distance measured by the ultrasonic sensor and the status of the PIR sensor.
- **Notifications:** Users receive push notifications via the Blynk app when the bin is full, based on the distance data from the ultrasonic sensor.

BLYNK SETUP:



Testing Concepts:

- **Functional Testing:** Each virtual component (ultrasonic sensor, PIR sensor, servo motor) is tested individually within the Wokwi simulation to ensure they function as intended.
- **System Testing:** The entire system is tested within the Wokwi simulation to ensure all components work together seamlessly and the system operates reliably.
- **Network Testing:** The stability and reliability of data transmission between the virtual ESP32 and the Blynk app are tested under various network conditions to ensure consistent connectivity and real-time updates.

Results:

The smart garbage system did well in achieving the project objectives on Wokwi simulation environment and this clearly showed higher efficiency of managing waste as well as user friendliness. Main findings are:

• Authentic Motion Sensing: The PIR sensor detected users who were going towards that dustbin.

• Distinct Distance Measure: Ultrasonic sensor measured the contents fill level of the dustbin to a great extent.

• Dependable Lid Functionality: Based on inputs from sensors, servo motor operated the lid smoothly.

• Successful Notifications: Real-time notifications about fullness of the bin were sent by Blynk app.

Challenges and Resolutions:

Challenges:

Sensor Interference:

o Issue: From the initial test, Ultrasonic and PIR sensors have been found to interfere with each other.

o Resolution: The virtual sensor position in Wokwi environment was adjusted to reduce interference and ensure that readings are correct.

Network Issues:

o Issue: Network instability led to inconsistent data transmission into Blynk App.

o Resolution: To maintain consistent connection, network optimization techniques were put in place, as well as the system being connected to a Wi-Fi network that is stable.

Lessons Learned:

• Correct placement of virtual sensors is important for avoiding interferences and ensuring accurate readings.

• In fact, even in a simulated environment, reliable internet connection is necessary for IoT systems to properly function

Conclusion:

The smart dustbin project demonstrates the potential of IoT technology in enhancing waste management practices, even within a simulation environment like Wokwi. By automating lid operation and providing real-time notifications, the system improves user convenience and ensures timely waste disposal. The successful implementation of this project within the Wokwi simulation suggests potential for further simulations and eventual real-world testing to enhance system reliability and expand its functionalities.

Project Applications and Feature Scope:

Smart Cities	Enhanced Waste Management	Environmental Sustainability
Rural Areas	Community Engagement	Improved Sanitation
Commercial Spaces	Efficient Waste Disposal	Cost Optimization

Limitations:

Initial Setup Costs

Implementing the smart dustbin may involve initial set up costs, causing a financial challenge for some communities.

Technical Expertise

Ensuring proper maintenance and troubleshooting of IoT-enabled systems requires technical expertise , which may be lacking in certain areas.

Data Privacy Concerns

The collection and transmission of data raise privacy concerns, necessitating robust data protection measures and legal compliance.

References:

1. "Smart Waste Management System Using IoT" – Journal of Environmental Management.
2. Blynk Documentation and Tutorials.
3. ESP32 Development Board Datasheets.
4. HC-SR04 Ultrasonic Sensor Technical Specifications.
5. PIR Sensor Integration Guides.
6. Wokwi Simulation Platform Documentation.