Project Title: IoT-Based Smart Waste Management System for Smart University

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Abstract

The IoT-Based Smart Waste Management System for Smart University is a pioneering project aimed at addressing the growing challenges of waste management within educational institutions. With the proliferation of Internet of Things (IoT) technology, there has been a significant opportunity to innovate in this domain, leading to more efficient, cost-effective, and sustainable waste management practices. This project aims to alleviate the common issues faced by universities in waste management, such as inefficient utilization of resources, environmental concerns, and lack of real-time monitoring. By leveraging IoT technology, our system offers a comprehensive solution that optimizes waste collection processes, minimizes overflow incidents, and promotes environmental sustainability.

Central to our system is the integration of ultrasonic sensors, servo motors, LCD displays, a buzzer, and the Blynk platform within a smart waste bin. Upon detection of an object in proximity, the ultrasonic sensor triggers the servo motor to open the bin lid, facilitating seamless waste disposal. Simultaneously, another ultrasonic sensor measures the distance, providing real-time feedback on the garbage level, which is displayed both locally on an LCD display and remotely via the Blynk application. This enables users to conveniently monitor the fill level of the bin from anywhere, at any time, promoting proactive waste management practices.

Through this report, we delve into the details of our methodology, including the design and implementation of the system components. Additionally, we discuss the results obtained from testing the prototype in a simulated environment, highlighting its effectiveness in waste monitoring and management. Ultimately, this project sets the stage for further advancements in smart waste management systems, fostering cleaner and more sustainable environments within educational institutions and beyond.

Chapter 1

Introduction

The management of waste presents an enduring challenge, particularly in densely populated environments such as university campuses. Traditional approaches to waste disposal, reliant on manual intervention and periodic emptying of bins, often prove inadequate in addressing the evolving needs of modern educational institutions. The consequences of ineffective waste management are manifold, ranging from unsanitary conditions and environmental degradation to public health concerns and aesthetic degradation.

In response to these challenges, the IoT-Based Smart Waste Management System for Smart University emerges as a beacon of innovation and sustainability. This project represents a convergence of cutting-edge technologies, including the Internet of Things (IoT), sensor networks, and automation, to revolutionize waste management practices within university settings.

At its core, the system integrates a suite of sensors, actuators, and communication modules to create an intelligent and responsive waste disposal infrastructure. Ultrasonic sensors detect the presence of objects and measure garbage levels in real-time, while servo motors facilitate automated lid opening for seamless waste deposition. Concurrently, the Blynk platform enables remote monitoring and management of garbage levels, empowering users with actionable insights and control over waste disposal processes.

By transcending the limitations of conventional waste management approaches, our system addresses the multifaceted challenges posed by waste accumulation in university environments. It not only enhances operational efficiency and resource

Fig 1.1: Conventional Waste System

utilization but also promotes sustainability and environmental stewardship. Through the implementation of IoT-enabled smart bins, universities can mitigate the risks associated with overflowing waste, minimize environmental impact, and create cleaner, healthier campus environments.

This report provides a comprehensive overview of the IoT-Based Smart Waste Management System, detailing its design, implementation, and functionality. Furthermore, it presents the results of experimental testing and validation, showcasing the system's efficacy in real-world scenarios. By elucidating the methodology, findings, and implications of this project, we aim to inspire further innovation in waste management practices and contribute to the advancement of sustainable technologies in educational institutions and beyond.

Chapter 2

Problem Statement

The conventional approach to waste management, often observed in everyday life, relies on manual intervention and lacks the sophistication of modern technologies. Typically, individuals dispose of their garbage in dustbins, which are then emptied and reused. However, in high-traffic areas such as universities, this traditional method becomes inadequate due to the substantial volume of waste generated.

In university settings, the accumulation of waste in conventional bins poses several challenges. As bins fill up, people continue to deposit trash, leading to overflow and unsanitary conditions. The presence of excessive waste not only attracts pests like flies and mosquitoes but also contributes to the spread of diseases, posing a health risk to the university community.

Moreover, the absence of timely emptying exacerbates these issues, creating an environment ripe for the proliferation of harmful pathogens. Inadequate waste management practices not only compromise hygiene but also impact the surrounding ecosystem. Overflowing bins, coupled with missing lids, result in waste spillover, contaminating the environment and disrupting ecological balance.

Furthermore, the presence of pests near overflowing bins not only poses health risks but also creates discomfort and nuisance for students, faculty, and visitors. The unsightly appearance and foul odor associated with unmanaged waste detract from the aesthetic appeal of the university campus, negatively impacting the overall experience of its inhabitants.

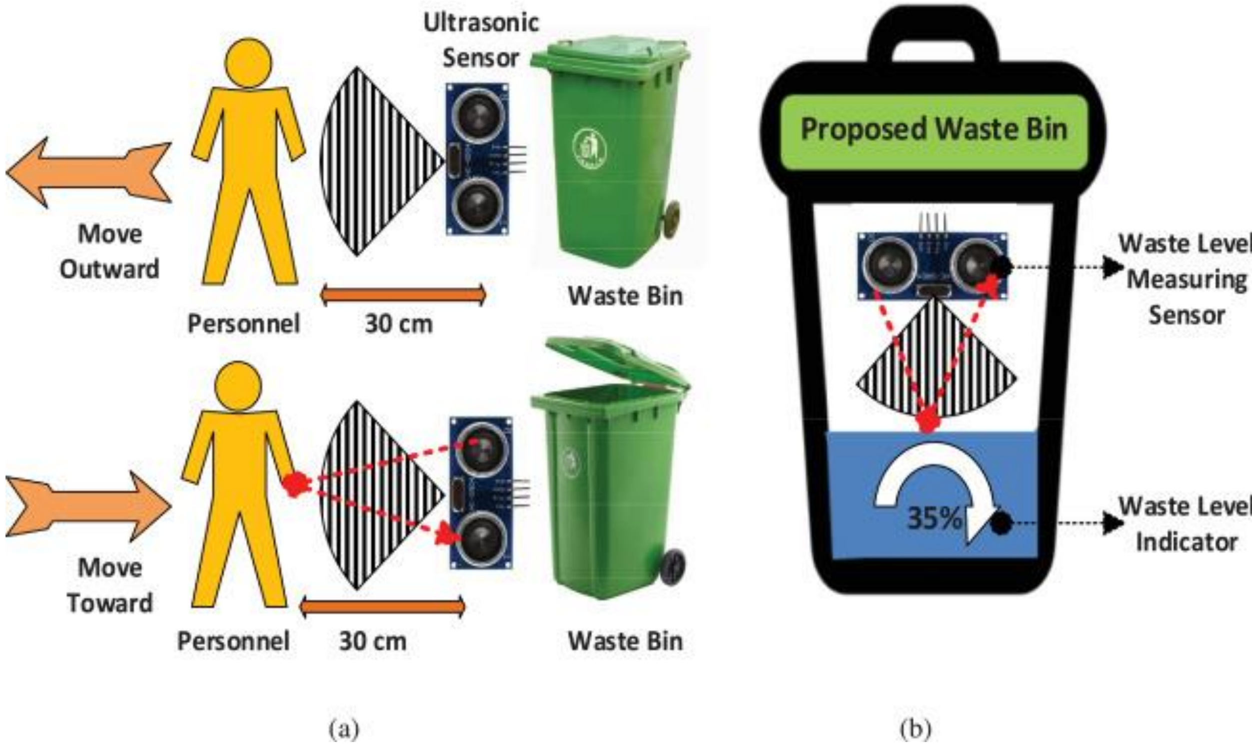

Fig 2.1: Smart dustbin concept

Addressing these challenges requires a paradigm shift towards smarter, more efficient waste management solutions. By leveraging IoT technology and automation, we can mitigate the shortcomings of conventional approaches and pave the way for a cleaner, healthier university environment. Our IoT-Based Smart Waste Management System offers a proactive and sustainable alternative, empowering universities to tackle waste management challenges effectively while promoting environmental stewardship and community well-being.

Chapter 3

Methodology

3.1 Algorithm:

- Turn on the battery or connect the arduino with a laptop.
- If The lid open sensor detects any object then open the lid of the dustbin.
- Then garbage level measuring sensor measures the garbage level(0-100%) and displays it on LCD monitor and blynk app
- When the garbage level reaches 100%, a message to empty the garbage will be displayed on the LCD, and the buzzer will start beeping and the motor will keep the lid close.

3.2 Components

The components we used in this project are:

1. Arduino
2. NodeMCU
3. Ultrasonic Sensor
4. Servo Motor
5. LCD Display
6. Buzzer
7. 6V Power Supply
8. Wires(F-F,M-M,F-M)

The cloud server we used: **Blynk**

The ide used: **Arduino uno ide**

3.2.1 Arduino:

Arduino, an open-source electronics platform, has become the go-to option for anyone working on interactive hardware and software projects. An Arduino board (such as the Uno) connected to a breadboard with plugins such as inputs, sensors, lights, and displays can be controlled by a code written in the Arduino development environment.[1]

3.2.2 NodeMCU and blynk server

NodeMCU is a popular development board based on the ESP8266 WiFi module, widely used for IoT projects. It integrates WiFi capabilities, making it ideal for connecting to the internet and accessing cloud services. When combined with Blynk, a platform for building IoT applications, NodeMCU enables easy remote control and monitoring of connected devices through a smartphone app. By integrating NodeMCU with Blynk, users can quickly prototype and deploy IoT projects without extensive programming knowledge, leveraging Blynk's intuitive drag-and-drop interface and extensive library of widgets.The working principle of blynk and nodemcu goes like the figure below[2].

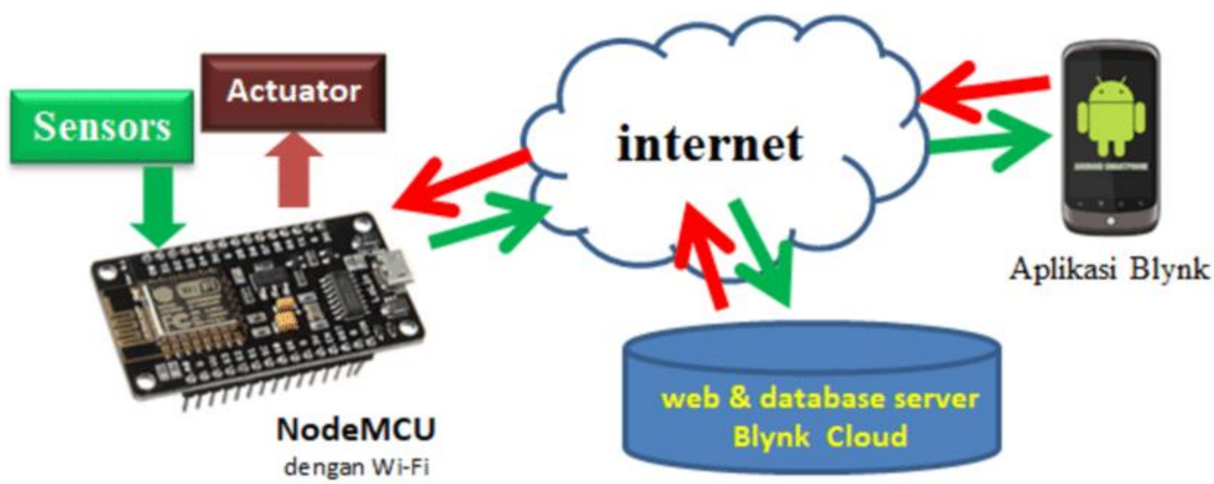

Fig 3.1: Hardware Module Design Based on NodeMCU with Blynk application

3.2.3 Ultrasonic Sensor:

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. The working principle of the ultrasonic sensor goes in the following figure[3]

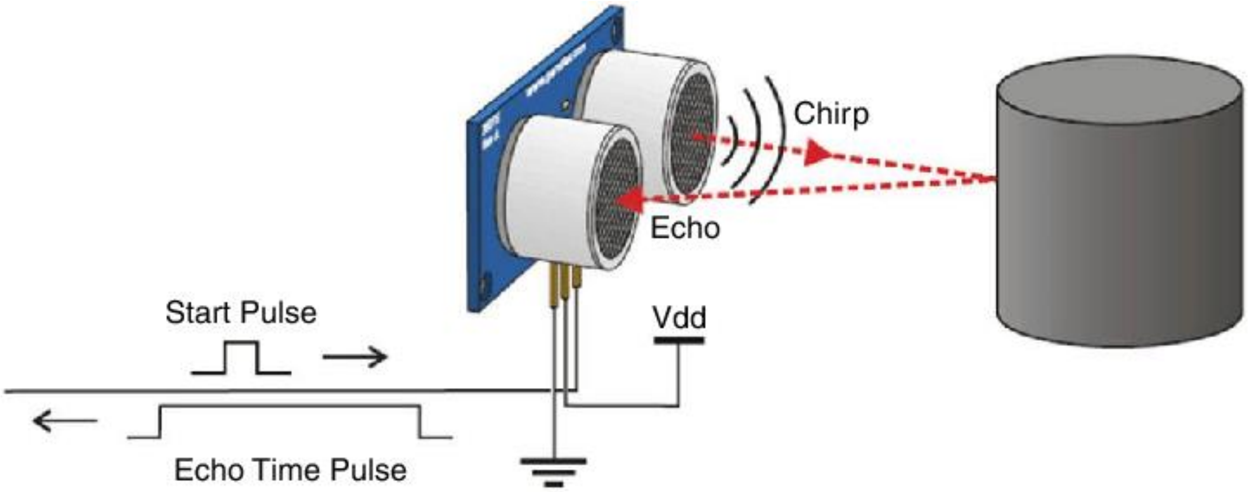

Fig 3.2:- The working principle of ultrasonic sensor

3.2.4 **Servo Motor**:

Servo motors are rotary actuators that allow precise control of angular position, speed, and acceleration, making them ideal for tasks requiring accurate movement control, such as robotic arms and remote-controlled vehicles.

3.2.5 **LCD Display:**

LCD displays provide a visual interface for displaying text, numbers, and graphical information, making them suitable for applications where real-time data presentation is required, such as digital clocks, weather stations, and instrumentation panels.

3.2.6 **Buzzer:**

A buzzer is an audio signaling device that produces audible tones or alarms, commonly used in electronic devices for alerting users to specific events, such as notifications, warnings, or alarms.

3.2.7 **6V Power Supply:**

A 6V power supply provides the necessary voltage to power electronic components and circuits, ensuring stable and reliable operation. In this project we used 6V power supply to provide power to the servo motor.

3.2.8 **Wires:**

(F-F, M-M, F-M): Wires with different pin configurations (female-female, male-male, and female-male) are used to establish connections between electronic components, facilitating communication and power distribution in circuits and projects.

9. Arduino uno ide

The Arduino Integrated Development Environment (IDE) is the main text editing program used for Arduino programming. It is where you’ll be typing up your code before uploading it to the board you want to program. Arduino code is referred to as sketches.[4]

3.3 Circuit Connection

The circuit diagram for lid opening includes one arduino, servo motor, ultrasonic sensor and 6V battery. When the sensor senses an object it instracts the servo motor to open the lid of the bin. 4 1.5V power in total 6V power supply was used to provide power to the motor.

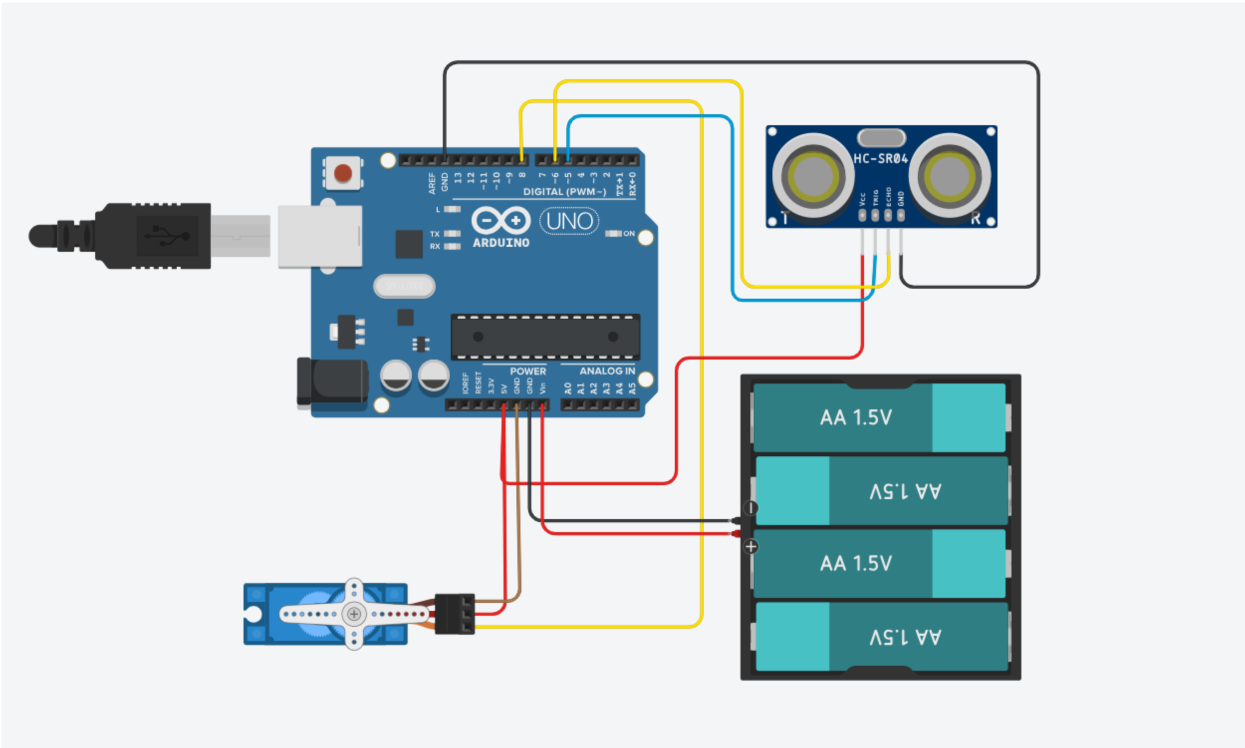

Fig 3.3:- The circuit diagram for lid opening

The garbage level checking circuit connection includes arduino, ultrasonic sensor, LCD display, buzzer. The ultrasonic sensor, LCD display and buzzer is connected to the arduino as following

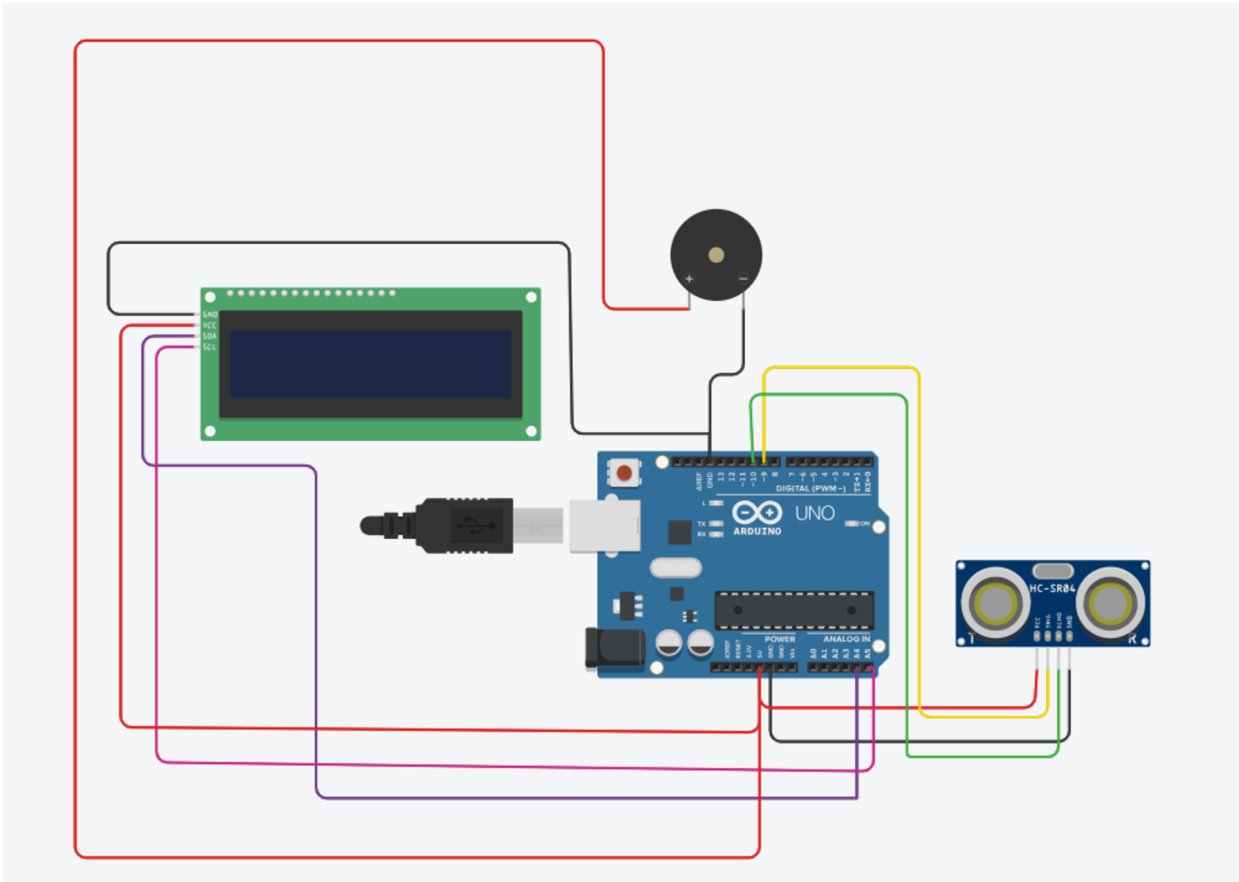

Fig 3.4:- The circuit connection of Garbage level measurement

The arduino and the NodeMCU is connected to pass the data from arduino to blynk server via nodemcu.The Rx of NodeMCU and Tx of arduino helps to pass data to nodemcu from arduino.

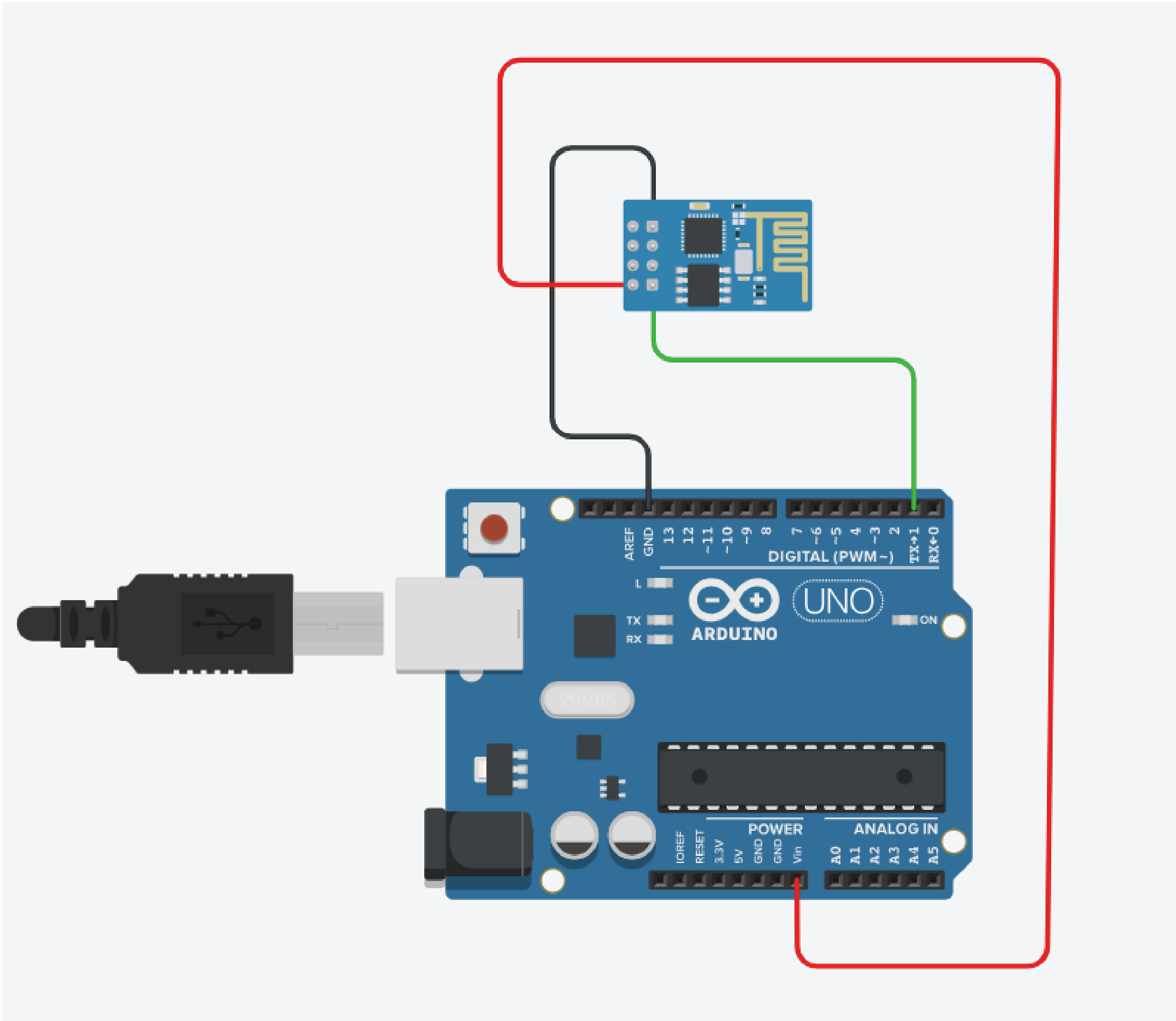

Fig 3.5:- Arduino and NodeMCU connection

3.4 Blynk setup

The Blynk setup for the IoT-Based Smart Waste Management System involves creating a user interface on the Blynk app to monitor and control the system remotely.

- **Creating a template for the interface**

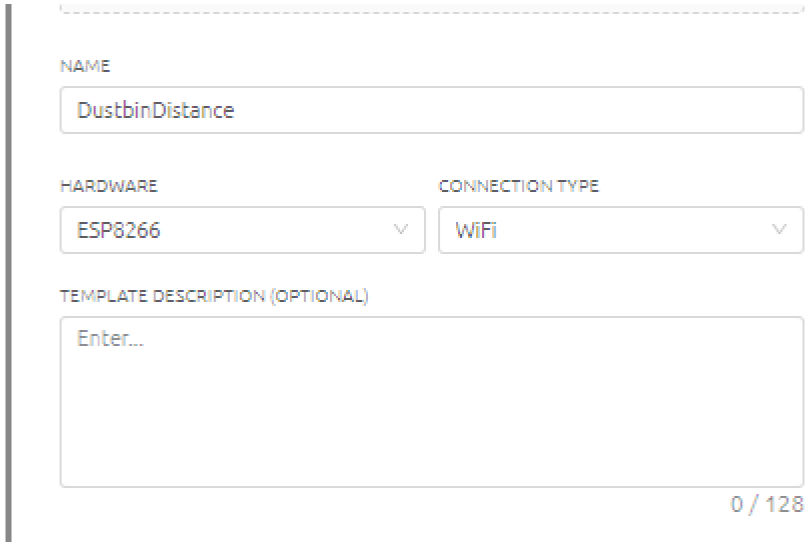

Fig 3.6:- template setting for blynk

- **Adding datastream and creating web dashboard**

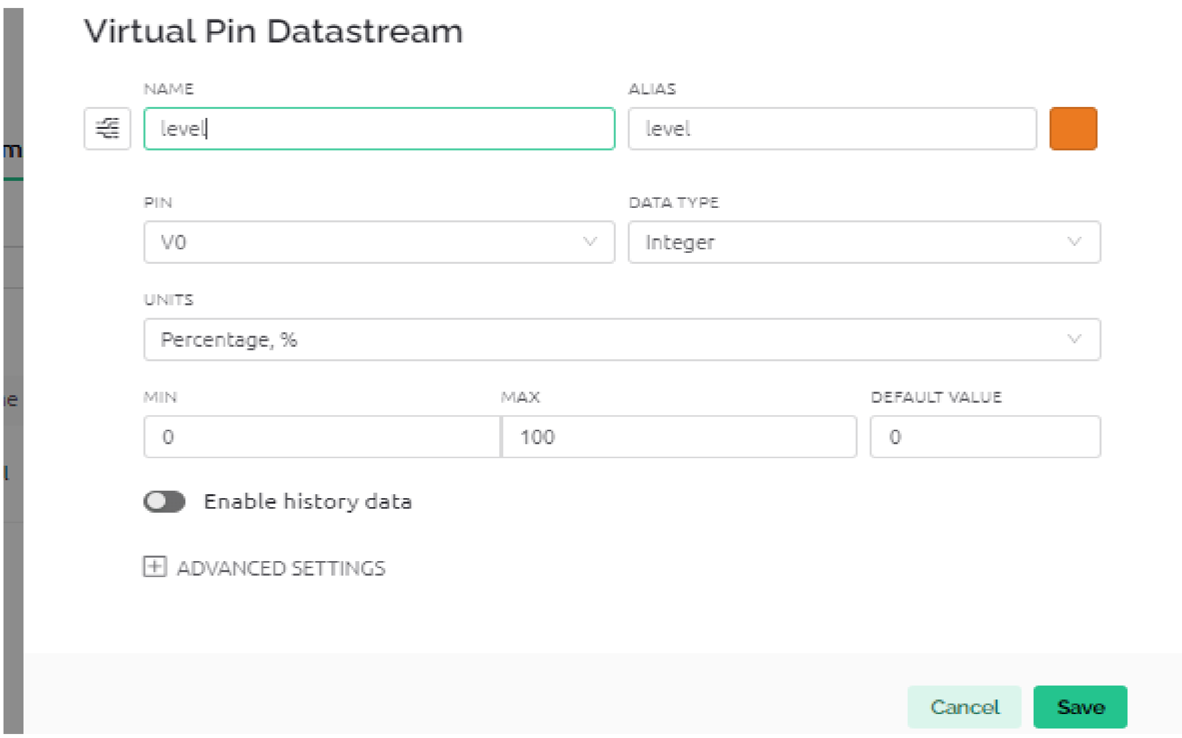

Fig 3.7:- Datastream setting for blynk

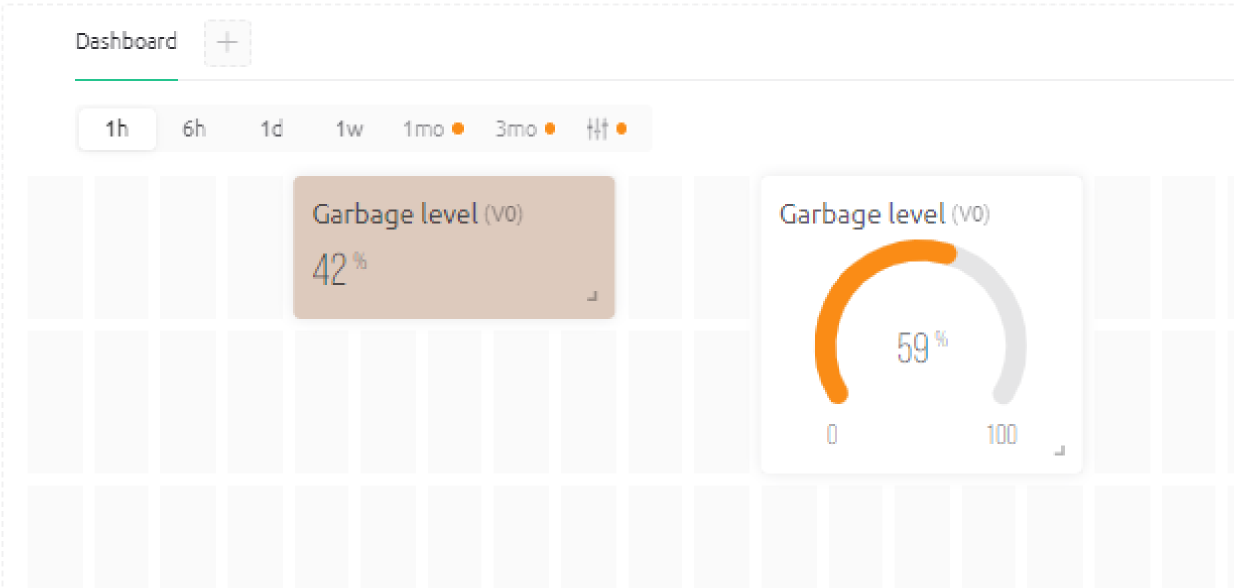

Fig 3.8: WebDashboard setting for Blynk

- **The device structre of blynk**

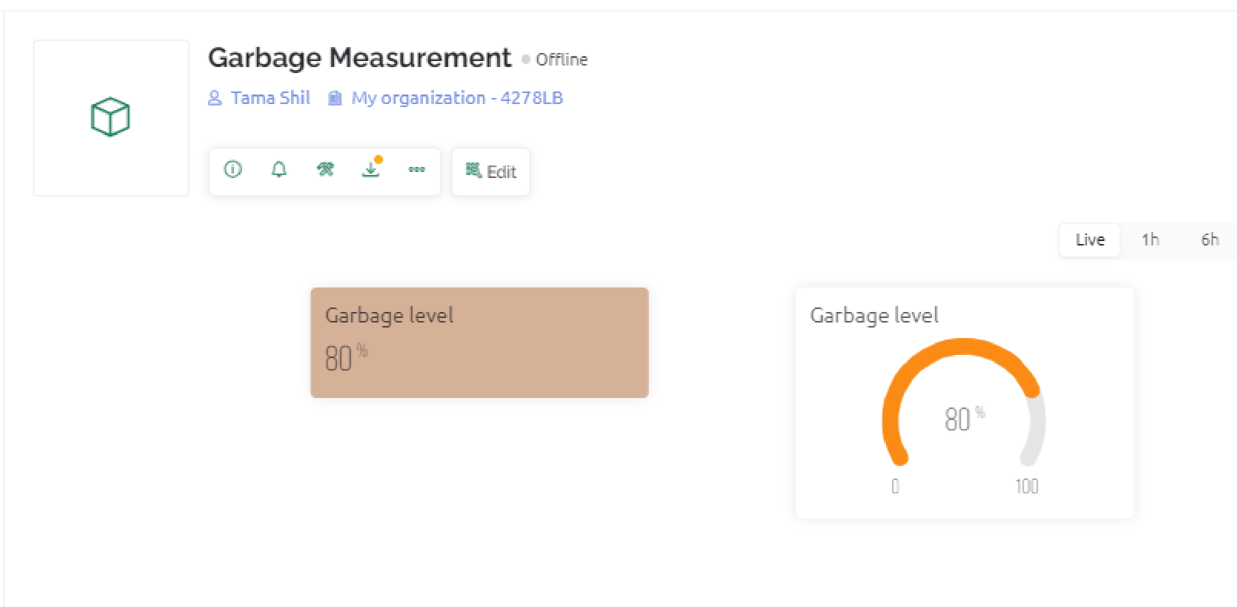

Fig 3.9:- The blynk dashboard for garbage level

3.5 Implemented codes

- **Wifi connection for blynk**

```
#define BLYNK_TEMPLATE_ID "TMPL6Q7nCFIkO"
#define BLYNK_TEMPLATE_NAME "DustbinDistance"
#define BLYNK_AUTH_TOKEN "qRFdAHinF_fTxb6F0ZCCnUSFMnuMi173"
#define BLYNK_FIRMWARE_VERSION "0.1.0"
#define BLYNK_PRINT Serial
#define USE_NODE_MCU_BOARD

#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

const char* ssid = "POCO M3"; // Your WiFi SSID
const char* password = "12312312"; // Your WiFi password

//const char* ssid = "Nikomma WIFI"; // Your WiFi SSID
//const char* password = "philocse422"; // Your WiFi password
char auth[] = BLYNK_AUTH_TOKEN;
const int trigPin = 9;
const int echoPin = 10;

long duration;
int distance;


void setup() {
  Serial.begin(9600);
  Serial.print("Connecting.. ");
  Blynk.begin(auth, ssid, password);
  Serial.print("Connected.. ");
}

void loop() {
  Blynk.run(); // Continuously process Blynk tasks

  if (Serial.available() > 0) {
```

```
    String distance = Serial.readStringUntil('\n'); // Read the
string until a newline
    //Serial.print("Distance: ");
    Serial.println(distance);
    //Serial.println(" cm");
    int distanceInt = distance.toInt(); // Convert string to
integer
    Blynk.virtualWrite(V0, distanceInt); // Send sensor value to
Virtual Pin V0
  }

  delay(1000); // Delay a little bit to improve stability
}
```

- SmartDustbin code

```
#include <Servo.h>  //servo
library
#include <LiquidCrystal_I2C.h>

const int trigPin = 9;
const int echoPin = 10;
const int btrigPin = 5;
const int bechoPin = 6;
int servoPin = 8;
const int buzzerPin = 11;

Servo servo;

LiquidCrystal_I2C lcd(0x27, 16,
2);

int distance1, distance2;
void setup() {
  Serial.begin(9600);
```

```
if (distance1 < 30) {
    int senddistance;

    if (distance1 < 30 &&
distance1 > 20) {
      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print("Garbage level:
");
      lcd.setCursor(0, 1);
      lcd.print("0%");
      senddistance = 0;

Serial.println(senddistance);

    } else if (distance1 <= 20 &&
distance1 > 16) {
      lcd.clear();
      lcd.setCursor(0, 0);
```

```
  servo.attach(servoPin);
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(btrigPin, OUTPUT);
  pinMode(bechoPin, INPUT);
  pinMode(buzzerPin, OUTPUT);

  servo.write(180);  //close cap
on power on
  delay(100);
  servo.detach();

  lcd.init();
  lcd.clear();
  lcd.backlight();
}
int SonarSensor(int
trigPinSensor, int echoPinSensor)
{

  digitalWrite(trigPinSensor,
LOW);                  // put trigpin
LOW
  delayMicroseconds(2);
// wait 2 microseconds
  digitalWrite(trigPinSensor,
HIGH);                 // switch
trigpin HIGH
  delayMicroseconds(10);
// wait 10 microseconds
  digitalWrite(trigPinSensor,
LOW);                  // turn it LOW
again
  long duration =
pulseIn(echoPinSensor, HIGH);
  int distance = duration * 0.034
/ 2;
  return distance;
}
```

```
      lcd.print("Garbage level:
");
      lcd.setCursor(0, 1);
      lcd.print("20%");
      senddistance = 20;

Serial.println(senddistance);

    } else if (distance1 <= 16 &&
distance1 > 12) {
      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print("Garbage level:
");
      lcd.setCursor(0, 1);
      lcd.print("40%");
      senddistance = 40;

Serial.println(senddistance);

    } else if (distance1 <= 12 &&
distance1 > 8) {
      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print("Garbage level:
");
      lcd.setCursor(0, 1);
      lcd.print("60%");
      senddistance = 60;

Serial.println(senddistance);

    } else if (distance1 <= 8 &&
distance1 > 4) {
      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print("Garbage level:
");
      lcd.setCursor(0, 1);
```

```
void loop() {


  distance1 =
SonarSensor(trigPin, echoPin);
  // Serial.print("Sensor1: ");
  //Serial.println(distance1);
  distance2 =
SonarSensor(btrigPin, bechoPin);
  //Serial.print("Sensor2: ");
  //Serial.println(distance2);
  if (distance2 < 30 && distance1
> 3) {
    //Change distance as per your
need
    servo.attach(servoPin);
    delay(1);
    servo.write(0);
    // Serial.print("motor
opening----");
    delay(5000);
    servo.write(180);
    // Serial.println("motor
closing");

    delay(1000);
    servo.detach();
  } else {
    servo.write(0);
  }

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Garbage level: ");
```

```
       lcd.print("80%");
       senddistance = 80;

Serial.println(senddistance);

     } else if (distance1 <= 4) {
       lcd.clear();
       lcd.setCursor(0, 0);
       lcd.print("The bin is
Full");
       lcd.setCursor(0, 1);
       lcd.print("Empty the bin");
       senddistance = 100;

Serial.println(senddistance);
       while (distance1 <= 20) {
         digitalWrite(buzzerPin,
HIGH);             // Activate
buzzer
         delay(500);
// On duration
         digitalWrite(buzzerPin,
LOW);              // Deactivate
buzzer
         delay(500);
// Off duration
         distance1 =
SonarSensor(trigPin, echoPin);   //
Update distance1 inside the loop
       }
     }
   }
   delay(2000);
}
```

Chapter 4

Result

The complete project covers lid opening with hand sensing, garbage level measurement and display, buzzer sound for full garbage and blynk app for level display.The IoT-Based Smart Waste Management System for Smart University has been successfully implemented and tested. The system effectively integrates various components including an ultrasonic sensor, servo motor, LCD display, buzzer, 6V power supply, Arduino Uno, NodeMCU, and Blynk platform to create a comprehensive waste management solution.

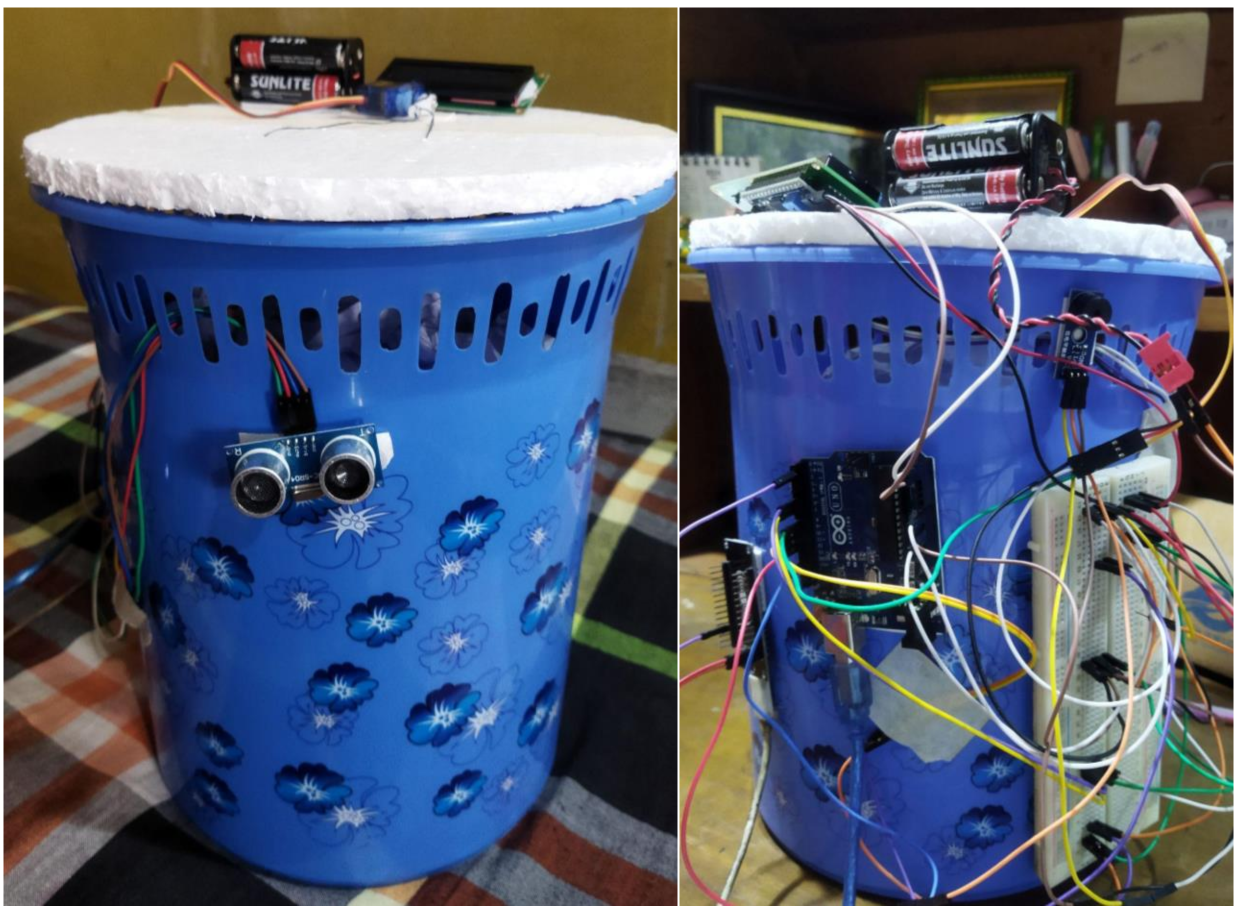

Fig 4.1: Smart Dustbin demonstration

Upon detection of an object, the ultrasonic sensor triggers the servo motor to open the lid, allowing garbage to be deposited into the bin. Subsequently, another ultrasonic sensor measures the distance of the garbage pile within the bin, displaying the garbage level on the LCD display in real-time and also to blynk app. The garbage level is represented as a percentage, ranging from 0% to 100%.

Fig 4.2: Lid opening with the sense of object

Fig 4.3: The garbage level message in LCD display

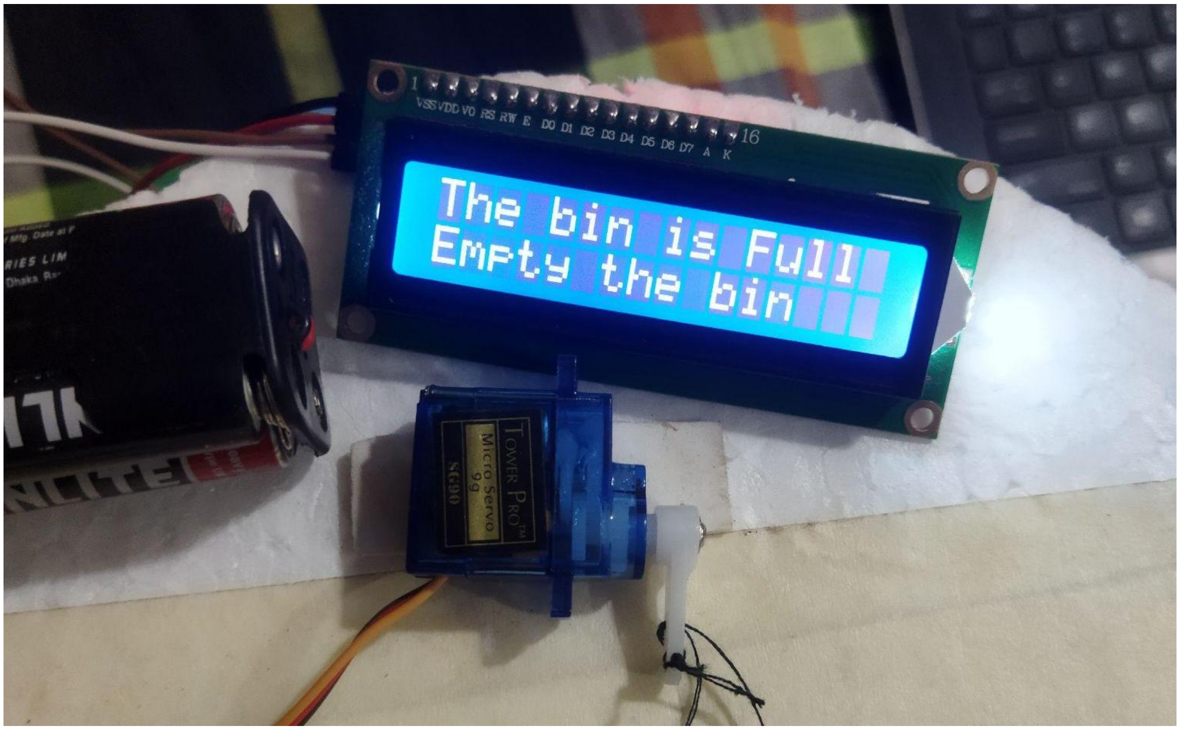

Fig 4.4: The garbage level full message in LCD display

When the level is 100% the buzzer starts buzzing until the level is 0%.The LCD display will display a message like “The bin is full. Empty the bin”. The motor also stops opening the lid when the level is 100%. Then someone needs to take out the garbage and make the bin empty. The buzzer will not stop until someone clear the bin completely. When the bin is clean the motor will start working again. And the LCD will also start showing the garbage level.

Chapter 5

Discussion and Conclusion

5.1 Discussion

Our IoT-Based Smart Waste Management System represents a significant step forward in managing waste on university campuses. By integrating real-time garbage level detection, automated lid-opening mechanisms, and remote management capabilities, our system not only addresses immediate waste disposal needs but also fosters proactive waste management practices. This technology-driven approach minimizes risks associated with waste overflow, which can lead to health hazards and environmental pollution.

The system's ability to provide detailed analytics on waste generation and disposal patterns empowers facility managers with the data needed to make informed decisions about resource allocation and operational scheduling. This level of granularity in data is crucial for optimizing waste collection routes and frequencies, which in turn reduces operational costs and carbon footprints associated with waste collection vehicles.

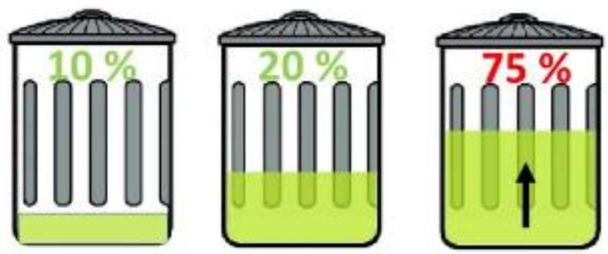

Fig 5.1: Correct Garbage level identification

Moreover, the system's experimental testing and stakeholder feedback have highlighted its effectiveness in enhancing the cleanliness of campus environments and its adaptability to the varying needs of different campus zones. The robust validation process not only tested the system under different scenarios but also involved feedback loops with stakeholders to ensure that the system met all practical requirements and user expectations.

5.2 Future scope

Looking forward, the scalability of our IoT-based system allows for its application beyond educational institutions to include cities, municipalities, and large industrial complexes. The next steps for our project include developing advanced algorithms that can predict waste generation rates based on historical data and event-driven spikes in waste production. Such predictive capabilities can revolutionize waste management, allowing cities to dynamically adjust waste collection services in anticipation of increased waste generation during events or peak seasons.

Additionally, future iterations of the system could integrate more sophisticated machine learning models to improve the accuracy of waste type identification and segregation. This technological advancement could facilitate more efficient recycling processes and support the circular economy goals of reducing waste, reusing materials, and recycling resources.

5.3 Conclusion

The development of the IoT-Based Smart Waste Management System for Smart University is a testament to the transformative power of technology in tackling some of the most pressing environmental challenges of our times. As technology continues to evolve, opportunities abound for the development of smarter, more adaptive solutions that address the unique challenges faced by universities and other community settings. Our project serves as a blueprint for future sustainable practices, demonstrating that through innovative thinking and technological empowerment, significant strides can be made towards creating more sustainable, clean, and healthy environments.

In conclusion, the IoT-Based Smart Waste Management System not only offers a tangible solution to the pressing issue of waste management but also exemplifies the transformative power of technology in creating cleaner, more sustainable environments. By embracing innovation and fostering partnerships, we can pave the way for a future where waste is managed efficiently, responsibly, and intelligently, ensuring the well-being of present and future generations.

References and links

[1] Hari Kishan Kondaveeti, Nandeesh Kumar Kumaravelu, Sunny Dayal Vanambathina, Sudha Ellison Mathe, Suseela Vappangi. (2021). "A systematic literature review on prototyping with Arduino: Applications, challenges, advantages, and limitations." Computer Science Review, 40, 100364. https://doi.org/10.1016/j.cosrev.2021.100364.

[2] Asnawi, R & Nugraha, Ariadie & Hertanto, Deny Budi & Surwi, Faranita. (2019). Development and Testing of Microcontroller-Based Learning Media for the Internet of Things Lab Work. Journal of Physics: Conference Series. 1413. 012007. 10.1088/1742-6596/1413/1/012007.

[3] Deepak, B. & Bahubalendruni, M V A Raju & Biswal, Bibhuti & Budiyono, Agus & Srigrarom, Spot. (2016). Development of in-pipe robots for inspection and cleaning tasks: Survey, classification and comparison. International Journal of Intelligent Unmanned Systems. 4. 10.1108/IJIUS-07-2016-0004.

[4] https://www.circuito.io/blog/arduino-code/