IoT based Smart Wastage Management

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Declaration

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Acknowledgments

All praises goes to the Almighty Allah (God) who enabled us to complete, as well as, to submit the thesis work successfully for the completion of the degree of Bachelor of Science in Computer Science and Engineering (CSE)

I would like to thank and express my sincere gratitude to my honorable supervisor, **Sadia Jahan Lecturer** Department of Computer Science and Engineering (CSE) University of Information Technology and Sciences (UITS) for his tireless supervision, intellectual guidance, continuous encouragement during completion of this thesis. His comments and suggestions were very stimulating and developed my ideas to accomplish this study.

Besides my supervisor, I would like to thank the rest of my supervisory committee members, **Al Imtiaz Assistant Professor and Head,Dept of CSE;A. S. M. Shafi Assistant Professor and; Director, ICT Cell; Fatema TujTarannom Esty Lecturer, Dept of CSE Lecturer;** Department of Computer Science and Engineering (CSE) for their insightful comments and encouragements, but also for the hard question which incented me to widen my research from various perspectives.

Lastly, but not leastly, I would like to thank my family: my parents and to my brothers and sisters for giving me mental support at different stages during completion of my research work.

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Abstract

Waste management is a global challenge, with improper disposal leading to environmental pollution, health hazards, and resource depletion. To address this issue, various strategies and initiatives are being implemented worldwide. One such initiative is the IOT-based auto Segregation and Recycle feature Waste Bin system, which aims to tackle the inefficiency of garbage collection systems and achieve smart cities. This system offers real-time bin status, automatic waste segregation; energy efficiency, decreased collection times, and saves money.

Keywords: Sensor, Segregation, Arduino, Sustainability, Smart city.

Preface

This BSC thesis is outlined based on the results obtained from the laboratory experiment. This is carried out in the Department of Computer Science and Engineering (CSE), Faculty of Engineering, at University of Information Technology and Sciences (UITS), Dhaka, Bangladesh.

This thesis includes 7chapters which are briefed as follows:

Chapter-1
Chapter 1 provides a basic introduction to IoT Devices & Sensor.

Chapter-2
Chapter 2 provides a literature review of our project.

Chapter-3
Chapter 3 provides component description.

Chapter-4
Chapter 4 provides circuit diagram & user interface diagram.

Chapter-5
Chapter 5 provides hardware implementation.

Chapter-6
Chapter 6 provides system implementation and result.

Chapter-7
Chapter 7 provides conclusion and future work.

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Chapter 1

Introduction

The increasing urbanization and technological advancements have led to a growing need for innovative and sustainable waste management solutions. The Internet of Things (IoT) offers a transformative paradigm for modern waste management systems, particularly in the realm of the humble dustbin. The book explores the concept, design, and implementation of an IoT-Based Smart Dustbin Project, which transforms dustbins into intelligent entities capable of communicating their fill levels, predicting usage patterns, and optimizing collection routes in real time.

The book focuses on the intricacies of designing and deploying a smart dustbin system that integrates seamlessly with the fabric of smart cities. It explores the foundational principles of real-time monitoring and the nuances of wireless communication protocols, contributing to a comprehensive understanding of how IoT can be harnessed to tackle waste management challenges.

The book also explores the heart of urban living, where the cleanliness of public spaces intertwines with community engagement, environmental sustainability, and the essence of a smart city. The IoT-based initiative not only optimizes waste management but also fosters a sense of responsibility among citizens and aligns with the broader vision of creating cleaner, healthier, and more livable urban environments.

In conclusion, the fusion of IoT and waste management can transform conventional dustbins into intelligent gatekeepers of cleanliness and sustainability, transforming waste management into a pivotal part of smart cities [1].

1.1Motivation

Motivation for an IoT-Based Smart Dustbin Project:

Environmental Sustainability:

- Addressing the growing concern of environmental pollution and waste management.
- Encouraging responsible waste disposal practices to reduce the ecological footprint.

Efficient Waste Management:

- Optimizing waste collection routes and schedules based on real-time data.
- Minimizing the overflow of bins,which can lead to littering and unsightly surroundings.

Resource Optimization:

- Ensuring efficient use of resources such as fuel and manpower in waste collection.
- Reducing unnecessary trips to partially filled bins through smart monitoring.

Public Health Improvement:

- Preventing the spread of diseases by minimizing the exposure to unattended waste.
- Creating cleaner and healthier urban environments for residents.

Data-Driven Decision Making:

- Providing actionable insights for city planners and waste management authorities.
- Enabling better decision-making through data analytics on waste generation patterns.

Community Engagement:

- Fostering a sense of community responsibility towards waste disposal.
- Encouraging citizens to actively participate in maintaining clean public spaces.

Technological Innovation:

- Showcasing the potential of Internet of Things (IoT) in solving real-world issues.
- Promoting innovation in the field of smart city technologies.

Cost Reduction:

- Minimizing the costs associated with inefficient waste collection practices.
- Potentially reducing the need for manual monitoring and collection in certain areas.

Real-time Monitoring and Alerts:

- Enabling quick response to unusual waste accumulation through instant alerts.
- Enhancing the overall responsiveness of waste management systems.

Educational Opportunities:

- Providing a platform for educational initiatives on waste management and IoT.
- Encouraging STEM (Science, Technology, Engineering, and Mathematics) learning through practical applications.

Scalability and Adaptability:

- Designing a system that can be easily scaled to accommodate the needs of various urban settings.
- Creating a solution that can adapt to different waste disposal patterns and behaviors.

Integration with Smart City Initiatives:

- Aligning with the broader goals of creating smart and sustainable urban environments.
- Supporting the integration of waste management into larger smart city frameworks.

By addressing these motivations, an IoT-based smart dustbin project can contribute significantly to creating cleaner, more efficient, and environmentally friendly urban spaces.

1.2 Aims and Objectives

Our proposed project aims to develop a smart dustbin that revolutionizes waste management and contributes to a cleaner and more sustainable environment. The smart dustbin will incorporate advanced technology to automate waste collection and optimize the overall waste management process. Overall, our smart dustbin project aims to create a scalable and adaptable solution that streamlines waste management processes and reduces waste pollution. By implementing this innovative technology, we aspire to create cleaner and healthier living environments while contributing to a more sustainable future.

We have proposed some special functionalities that is included in our projectand we worked for executing all those features cover-up in a single system.

- **Automatic Opening door:** Automatic opening door by object detection.
- **Fill-level Monitoring:** Real-time monitoring of bin fill levels to optimize collection routes and schedules.
- **Wet Detection:** Detect dry and wet waste to keep them separate.
- **Automated waste Segregation:**IR & Moisture sensor will keep them separate site.
- **Real-time Notification:**Showing fill level Percentage on a LCD display.

1.3 Challenges

- Inadequate infrastructure for waste collection, transportation, and processing.
- Lack of appropriate technology and equipment for waste sorting and processing.
- Budget constraints for implementing and maintaining a wastage segregation system.
- Inconsistent or inadequate waste management policies and regulations.
- Difficulty in coordinating and managing the logistics of waste collection, segregation, and disposal.
- Develop efficient logistics plans, including optimized collection routes and well-defined processes for waste handling at each stage.

Chapter 2

Literature Review

A literature review provides a concise overview and analysis of existing scholarly works relevant to a specific research topic. It summarizes key findings, methodologies, and theories from various sources, such as academic articles, books, and conference papers. The purpose is to establish the current state of knowledge, identify gaps, and contextualize the research within the broader academic discourse [2]. A literature review helps researchers understand the existing body of work, recognize trends, and formulate research questions or hypotheses. It is a critical component of scholarly research that contributes to the foundation of a new study.

2.1 Review of Existing Works

There are Some existing smart dustbin projects.

Smartup Cities – Fill-Level Detection

- Smart waste containers equipped with fill-level sensors and detectors with wireless connectivity allow for accurate planning, reporting, and optimization.

Ecube Labs – Solar-Powered Trash Compactor

- A waste compactor reads a waste bin's fill level in real-time by using sensors and then triggers automatic compaction. This increases the bin's capacity up to 5-8 times. Its Powerd solar system.

Smartsensor – Temperature Sensors

- During the fill-level measuring, in-build sensors also measure the current temperature inside a container and transmit this information to a server and other measured data. In case of sudden temperature changes, the system automatically informs operators via text or E-mail alerts.

EvoEco – Interactive Bin With Dashboard

- Innovative waste bins come equipped with screens, dashboards, or other interactive systems that capture the users' attention. For example, they can include elements of a game, can educate how to correctly sort waste, or motivate users every time they throw away their waste in the bins.

Sensoneo – Route Planning Optimization

- Smart route planning enables the automated management of waste collection routes, based on precise pre-defined analytical data regarding the condition of waste collection vehicles, container location, and filling level.

2.2 Identify Gaps

Identifying gaps in the existing literature on IoT-based smart dustbin projects is crucial for guiding future research and development. Here are some potential gaps that may exist:

Standardization and Interoperability:

- Existing literature may not extensively cover standardization efforts and interoperability challenges among different smart dustbin systems. A lack of standards could hinder the seamless integration of diverse solutions into a unified waste management framework.

Long-Term Performance and Maintenance:

- Limited studies may address the long-term performance and maintenance aspects of IoT-based smart dustbins. Understanding how these systems endure over time and the associated maintenance challenges is essential for sustainable deployment.

User Behavior and Acceptance:

- While some literature explores community engagement, there might be gaps in understanding user behavior and acceptance of IoT-based smart dustbins. Research on the social aspects, user perceptions, and factors influencing public participation is essential.

Cybersecurity and Privacy:

- The literature may not thoroughly cover cybersecurity and privacy concerns associated with IoT-based waste management. Assessing potential vulnerabilities and proposing robust security measures is crucial, especially when dealing with sensitive data from public spaces.

Cost-Benefit Analysis in Various Contexts:

- There might be gaps in literature regarding the context-specific cost-benefit analyses of implementing IoT-based smart dustbins. Research should consider the economic feasibility in diverse urban environments, taking into account varying infrastructure, population density, and waste generation patterns.

Integration with Other Smart City Components:

- Literature may lack in-depth exploration of how IoT-based smart dustbins integrate with other smart city components beyond waste management. Understanding the synergies and potential conflicts with broader smart city initiatives is crucial.

Human-Centric Design and Accessibility:

- Research may not extensively cover the human-centric design aspects of smart dustbins and their accessibility, particularly for diverse user demographics. Ensuring inclusivity and ease of use can contribute to the success of these systems.

Environmental Impact Assessment:

- Gaps may exist in literature regarding a comprehensive environmental impact assessment of IoT-based smart dustbin projects. Understanding the broader ecological consequences, including energy consumption and material usage, is essential for a holistic evaluation.

Regulatory and Policy Alignment:

- Limited studies may address the alignment of IoT-based waste management projects with local regulations and policies. Research should delve into the legal frameworks, potential regulatory hurdles, and policy implications that may impact widespread implementation.

Data Ownership and Governance:

- There may be gaps in understanding data ownership and governance structures associated with the data collected by smart dustbins [3]. Clarity on who owns and controls the data is essential for addressing legal and ethical considerations.

Addressing these gaps in the literature will contribute to a more comprehensive understanding of the challenges and opportunities in the domain of IoT-based smart dustbin projects, guiding future research and practical implementations.

Chapter 3

Microcontroller

3.1 Microcontroller

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

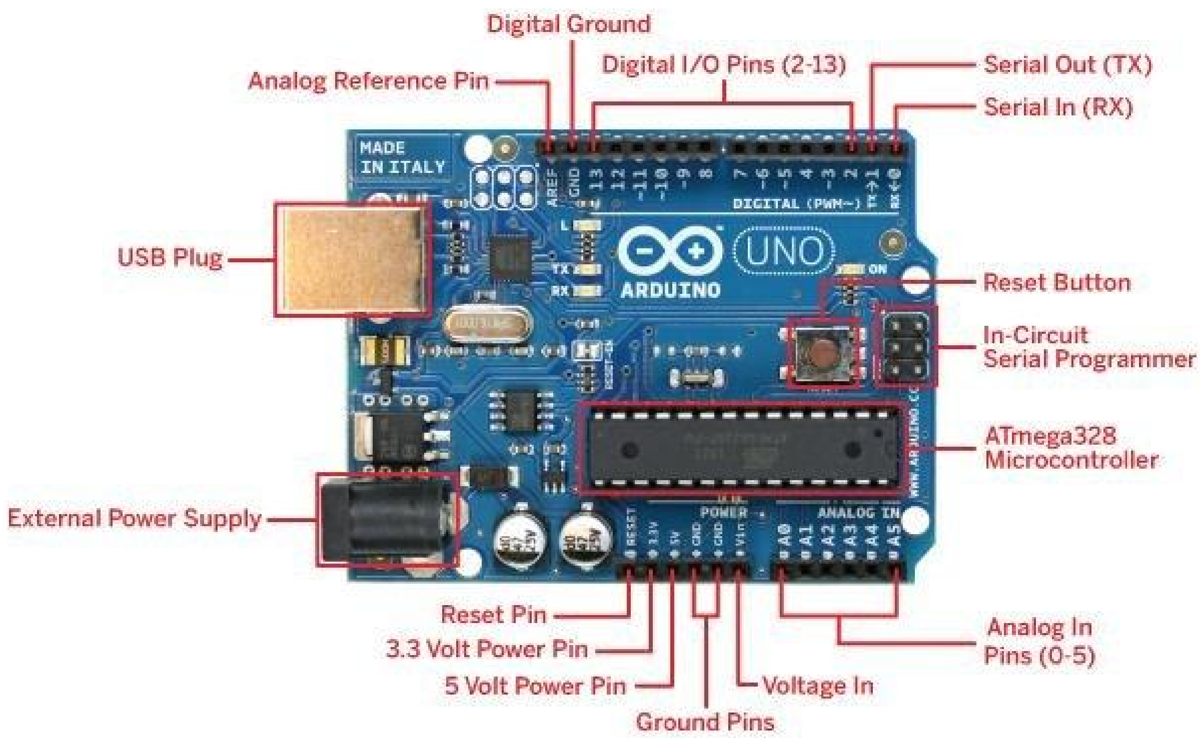

Figure 3.1: Microcontroller

3.3.1 Block Diagram of Microcontroller

This is the block diagram of Microcontroller, which is used in Arduino.

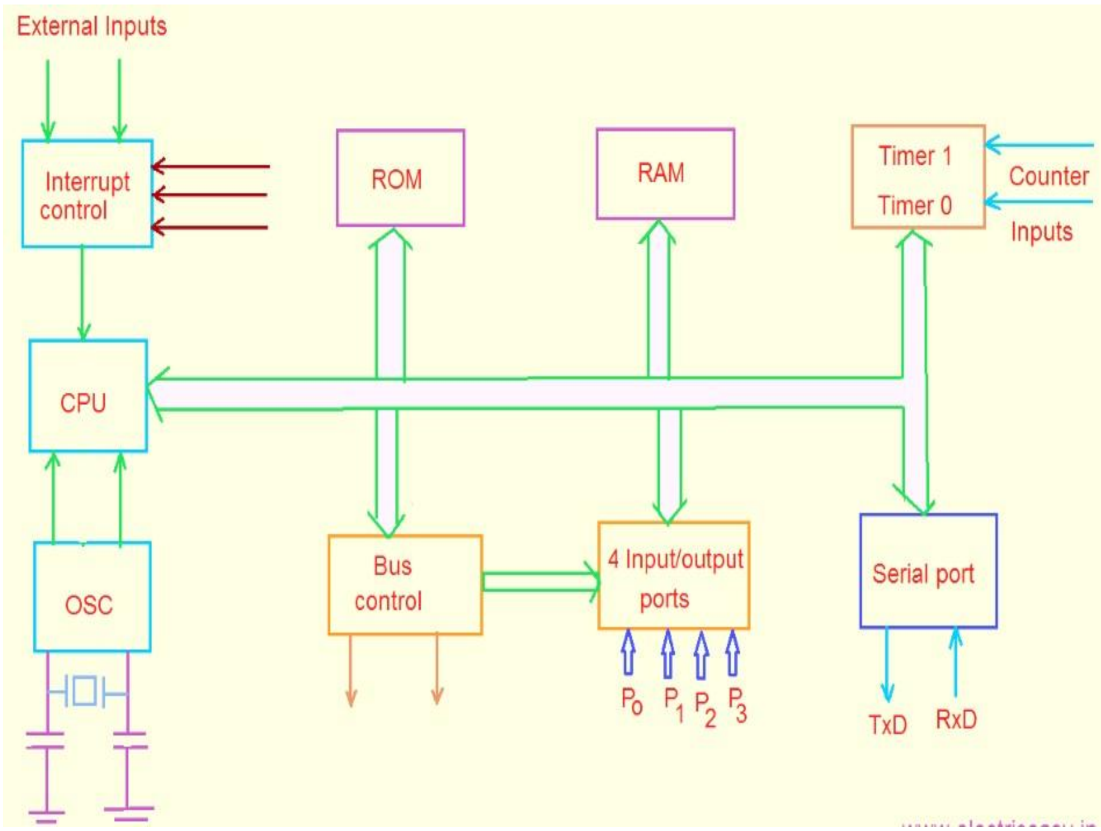

Figure 3.2: Block Diagram of Microcontroller

3.1.2 Pin Configurations of Microcontroller

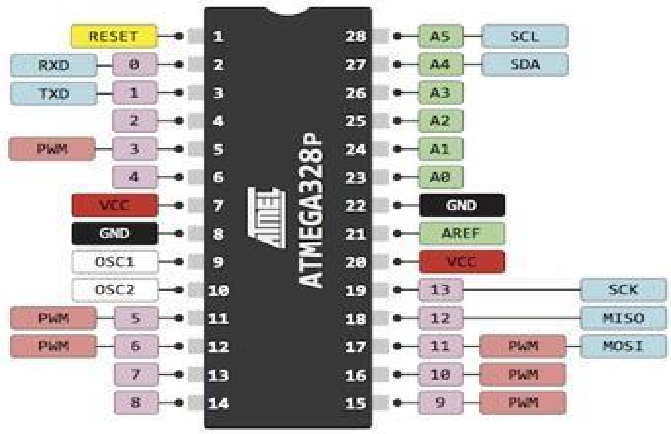

Figure 3.3: Pin Configurations of Microcontroller

3.3.3 Pin Description

The below gives a description for each of the pins, along with their function:

The four pins are as follows

- **VIN:** The input voltage to the Arduino board when it's using an external power source as opposed to 5 volts from the USB connection or other regulated power source). We can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V:** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3:** A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND:** Ground pins.

Input & Output of Arduino UNO

Each of the 14 digital pins on the Mega can be used as an input or output, using pin Mode, digital Write, and digital Read functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50k Ohms. In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

- **External Interrupts:** 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- **PWM:** 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write() function.
- **SPI:** 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- **LED:** 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- **I2C:** 20 (SDA) and 21 (SCL). The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino Software (IDE) includes a Wire library to simplify use of the I2C bus.

There are a couple of other pins on the board

- **AREF:** Reference voltage for the analog inputs. Used with analog Reference.
- **Reset:** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.
- **Memory:** The ATmega328 has 32 KB of flash memory for storing code (of which 0.5 KB is used for the boot loader), 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).
- **VIN:** The input voltage to the Arduino board when it's using an external pour source (as opposed to 5 volts from the USB connection or other regulated pour source).

3.2 Arduino UNO

In the controller unit, we are using an Arduino hardware board (with AVR microcontroller). With the help of Arduino software plate form, we can easily program AVR IC, as our requirement. Arduino is an open-source electronic prototyping platform based on flexible, easy-to-use hardware and software. Arduino Uno is a microcontroller board based on the ATmega328P.It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

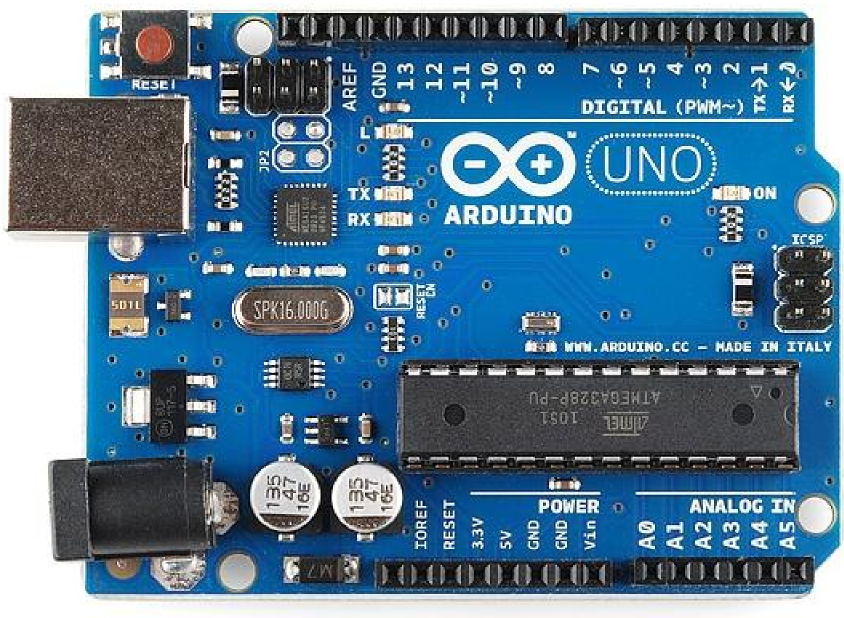

Figure 3.4: Arduino UNO

3.3 LCD Monitor

The monitor itself consists of liquid crystal cells arranged between two transparent layers. These cells can change their orientation based on the electric charge applied to them, controlling the passage of light. The display is divided into pixels, each containing three sub-pixels (red, green, blue) that combine to create various colors and images. The LCD monitor in a smart waste bin works by:

- Sensing waste levels and type using internal sensors.
- Processing this data via a microcontroller.
- Displaying information on the LCD based on the data received.

Figure 3.5: LCD Monitor

3.4 Sensors

In the context of IoT (Internet of Things), a sensor is a device that detects and responds to input from the physical environment. It gathers data about specific parameters such as temperature, humidity, light, motion, pressure, or other environmental conditions. Sensors are a fundamental component of IoT systems as they collect real-world data, which is then transmitted to other devices or systems for analysis, monitoring, or control purposes. These devices enable the IoT network to interact with and respond to changes in the physical world.

3.4.1 Working principle of Ultrasonic sensors

Ultrasonic sensors are used for reliable position detection and precise continuous distance measurement of solids, powders and liquids. They transmit and receive sound waves in the ultrasonic range. The object to be detected reflects the sound waves and the distance information is determined via time-of-flight measurement. Blister packages in packaging technology or transparent plastic bowls in the food industry, for example, can be reliably detected.

Figure 3.6: Ultrasonic sensors

3.4.2 Working principle of IR sensor

In Iot projects, an IR sensor operates by emitting infrared light and then detecting the reflected light. When an object is within the sensor's range, it reflects the emitted light back to the sensor. The sensor analyzes this reflection to determine the presence or absence of the object.

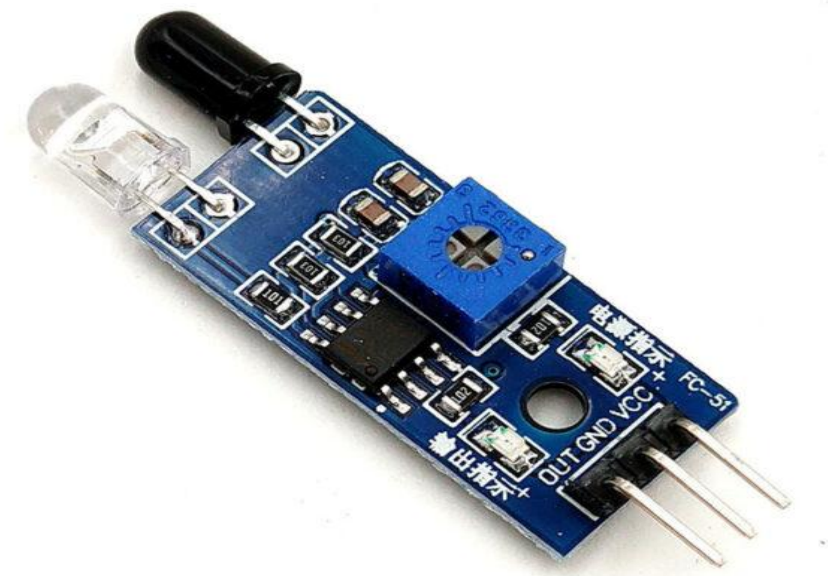

Figure 3.7: IR sensor

3.4.3Working principle of moisture sensor

A moisture sensor measures soil water content by assessing the electrical conductivity of the soil. When the soil is dry, resistance is high, and as it becomes moist, resistance decreases. The sensor's output signal, often voltage or current, reflects this moisture level and helps determine when to irrigate plants. Calibration is essential for accurate readings, considering variations in soil types.

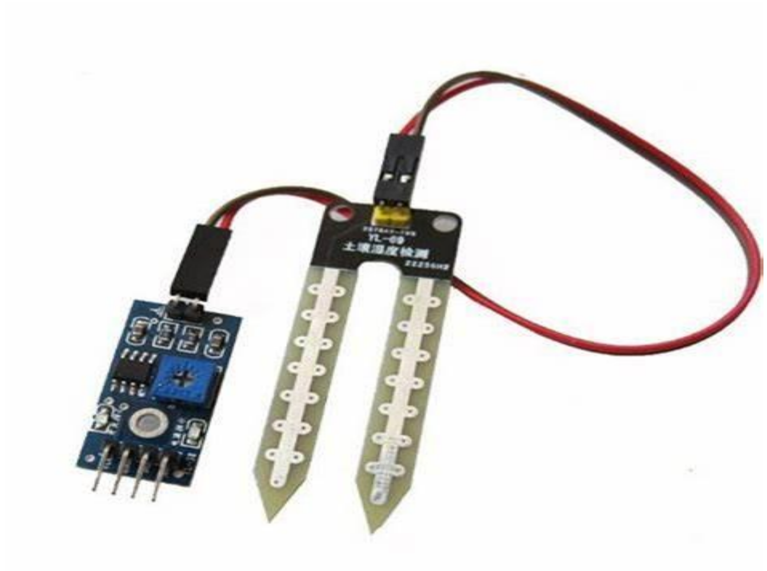

Figure 3.8: Moisture sensor

3.5 Working principle of servo motor

A servo motor operates on a closed-loop control system to achieve precise control of position, velocity, and acceleration. The key components include a DC motor, a feedback device (potentiometer or encoder) to determine the current position, a control system to compare the desired and actual positions, an amplifier to boost the control signal, a motor driver to regulate current flow to the motor, and a power supply. The closed-loop system continuously adjusts the motor's position based on feedback, making servo motors suitable for applications requiring high precision, such as robotics and automation.

Figure 3.9: Servo motor

3.6 Power Supply

The primary role of a battery in an electrical circuit is to provide a stream of electrons or current to power the circuit. It supplies electrical energy to the components of the circuit for them to operate. Batteries store the energy needed to power devices that require electricity, such as smart phones, laptops, and cars.

Figure 3.10: Power Supply

3.7 Buzzer

A buzzer in a smart dustbin's fill level monitoring system serves as an audible alert device. It is triggered when the dustbin reaches a predetermined fill level, indicating that it needs attention or emptying. The buzzer provides a quick and easily recognizable signal to prompt users or maintenance personnel to take action, ensuring timely waste management and preventing overflow.

Figure 3.11: Buzzer

Chapter 4

System Design

4.1 Block Diagram

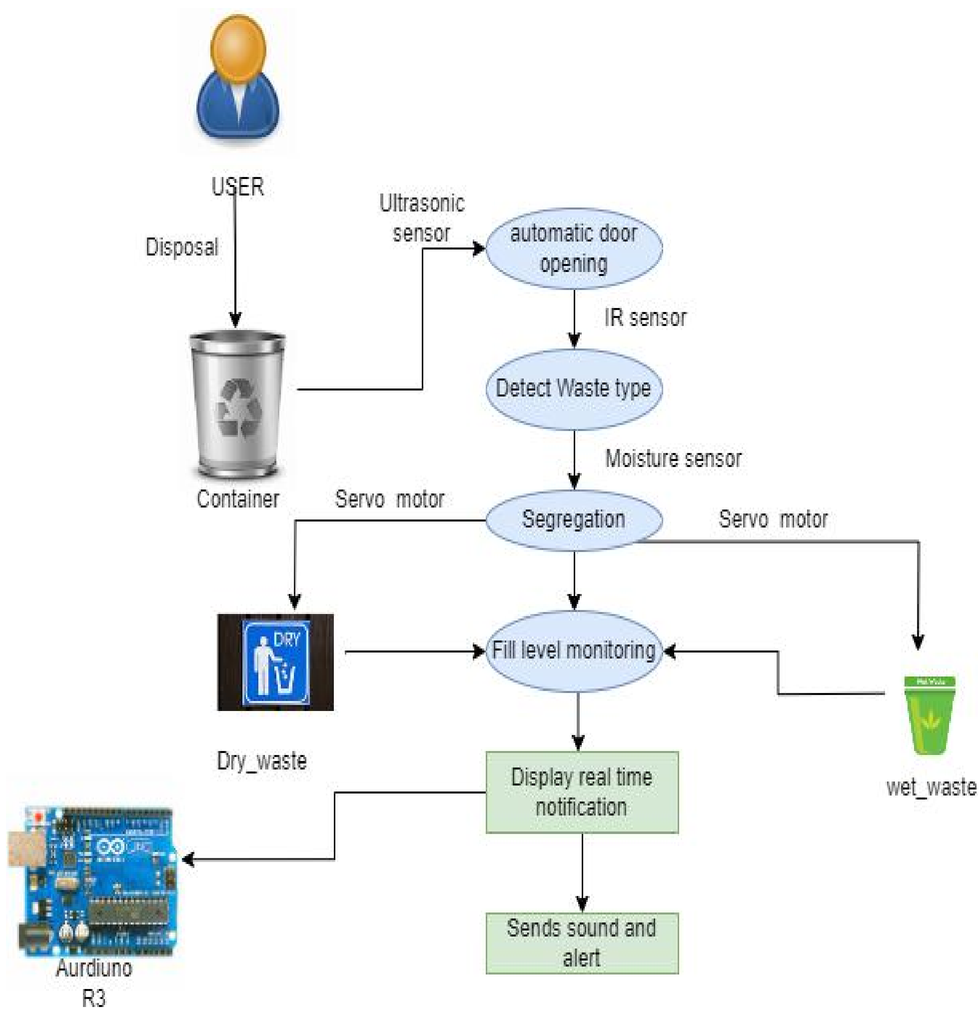

Figure 4.1: Block Diagram

4.2 Circuit Design and Analysis

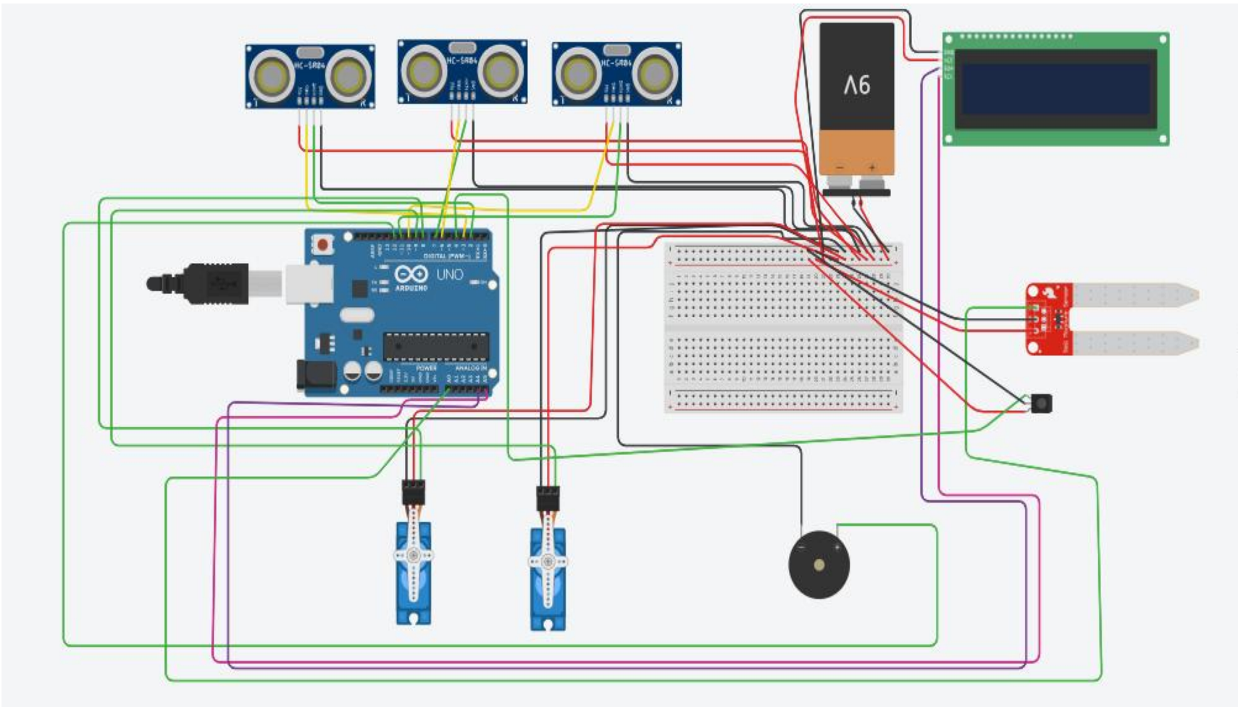

Figure 4.2: Circuit design of Wastage Management

4.3 **Working process of our project**

Here's a textual representation of the steps along with descriptions of which is given below:

Trash Disposal:

Smart waste bins use sensors to detect fill levels, optimizing trash disposal by alerting authorities or triggering collection services when bins reach capacity.

- The user disposes of trash into the smart bin.
- Ultrasonic Sensors.

Function: Detect the object.

- Infrared Sensors.

Function: Different types of waste materials, such as plastics, glass, paper, and organic waste, have distinct infrared signatures. The sensor can differentiate between these materials by analyzing their infrared characteristics.

- Moisture Sensors.

Function: The identification and segregation of wet waste.

Waste Segregation Mechanism:

Waste segregation mechanisms in smart waste bins utilize sensors and sorting technology to categorize and separate different types of waste materials upon disposal, enabling efficient recycling and proper waste management.

- Mechanical or automated system.

Function: Diverts waste based on predefined criteria. Mechanical arms or gates to redirect waste to different compartments.

Segregation Bins:

Segregation bins in smart waste systems are compartments within the bin that use technology or physical divisions to separate different types of waste, facilitating efficient sorting processes.

- Multiple bins within the smart bin for different waste types (dry, wet).

Function: Collect segregated waste.

Data Processing:

Data processing for smart waste bins involves analyzing the information collected from sensors, such as fill levels or waste composition, optimizing waste management strategies, and facilitating decision-making for efficient disposal processes.

Function: Analyzes the data received from the smart bin, e.g., fill levels.

Notifications:

Data user notifications for smart waste bins involve alerting or informing users, such as bin fill levels reaching capacity or maintenance requirements.

Chapter 5

Hardware Implementation

5.1 System Operation

The system operation in this project involves the integration of various components and technologies to enhance the functionality of the waste system. Here is an overview of the typical system operation in this smart dustbin project:

1st step: One ultrasonic sensor will detect human presence, if the ultrasonic sensor detect human object 1st servo motor will react 180^{o} to open the door.

2nd step: One moisture sensor will detect wet waste. If the waste is wet 2nd servo motor will react 180^{o} from 90^{o} to drop it right side, if the waste is not wet one IR sensor will detect whether the waste is there or not if, there is dry waste 2nd servo motor will react 0^{o} from 90^{o} to drop it left side.

3rd step: 2nd ultrasonic sensor is attached in the left side and right side and it will measure the distance and display the distance in an LCD if the bin is about 90cm full. The display will show "Dustbin is Full" and one buzzer will sound.

5.2 Cost Analysis

In this section, we will show the cost of the project which means the cost sheet representation of the project. Our equipment's cost is much cheaper than any other waste segregation system.

For example, A Project Report on "Smart Dustbin using IOT" By S Prabhakaran, and Danush Kumar S M costing is:

Table : 1 Cost Sheet (Existing Project)

S/N	**Component Name**	**Quantity**	**Price (TK)**
01	Arduino UNO MEGA	1	1500.00
02	IR sensor	1	100.00
03	Battery	1	450.00
04	Cell	1	900.00
05	Angle	1	1000.00
06	Battery Charger	1	370.00
07	Servo Motor	1	650.00
08	Labour Cost	…	1000.00
09	Wire	…	450.00
	Total Cost		= 6420.00

Which is very expensive? Now our cost Analysis of this project is given below:

5.3 Cost Sheet (Our Project)

Table :2 Cost Sheet (Our Project)

S/N	Component Name	Quantity	Price (TK)
01	Arduino UNO	1	860.00
02	IR sensor	1	90.00
03	Battery	4	300.00
04	Battery holder	1	80.00
05	Battery charger	1	370.00
06	Servo Motor(SG90)	1	194.00
07	Servo Motor(MG995)	1	400.00
08	Breadboard &Wires	…	200.00
09	PVC board	1	100.00
10	Moisture sensor	1	120.00
11	Ultrasonic sensor	3	280.00
12	Buck Converter	1	300.00
13	Buzzer	1	15.00
	Total Cost		=3310

Chapter 6

System Implementation and Result

6.1 Assembling process

Implement a sustainable waste management system with emphasis on waste segregation, public awareness, composting, waste-to-energy solutions, regulatory compliance, monitoring, community engagement and technological integration. There are number of servo motors, ultrasonic sensors and also used IR sensor.

Figure 6.1: Front Part

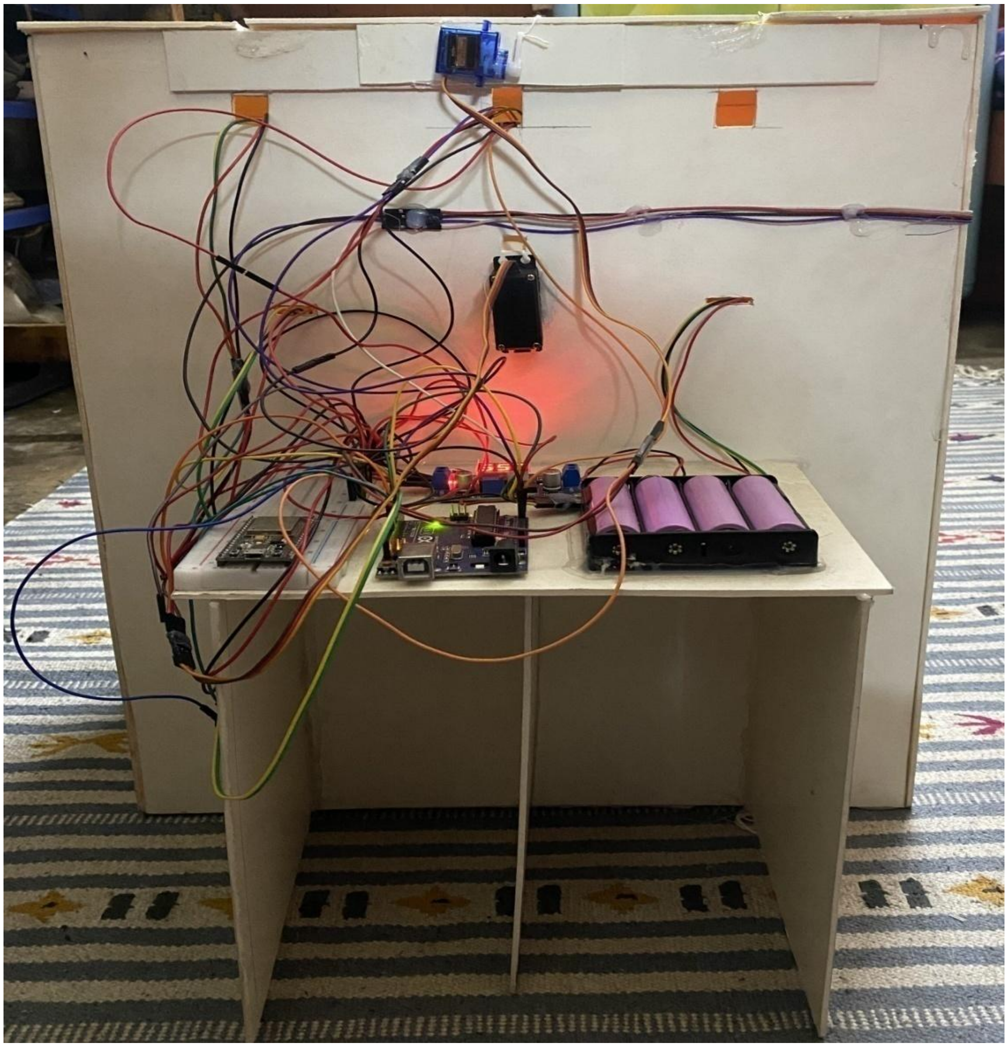

Figure 6.2: Back Part

Figure 6.3: Top Part

6.2 Completion of assemble our process

The final product on the picture below is the framework for the door movement which can gain momentum if connected to the power source. But for certain control of the momentum it needs different elements.

Ultrasonic sensor 1: Trigpin (yellow) = 3 pin
Echo pin (Green) = 2 Pin
VCC (Red) = Breadboard
GND (black) = Breadboard

Ultrasonic sensor 2: Trigpin (yellow) = 3 pin
Echo pin (Green) = 2 Pin
VCC (Red) = Breadboard
GND (black) = Breadboard

Ultrasonic sensor 3: Trigpin (yellow) = 3 pin
Echo pin (Green) = 2 Pin
VCC (Red) = Breadboard
GND (black) = Breadboard

Servo motor 1: Red (VCC) = Breadboard
Black (GND) = Breadboard
Orange (out) = 9 Pin

Servo motor 2: (+)Red = buck converter output pin
(-)Black = buck converter output pin
Orange = 8 pin.

Moisture sensor --> A_0 = A_0 pin
GND = bread
VCC = bread

IR sensor -->out (Purple) = bread pin.

GND (black) = bread
VCC(red) = bread

Buck converter = input port is connected to the battery holder, directly supplying Power to the buck converter to set a constant Power flow, we need constant Power we set output voltage Output from buck converter to 5V.

6.3 Advantage

A smart waste management system can offer several advantages over traditional waste management approaches. Here are some key benefits:

- **Efficient Collection and Routing:** Smart waste systems use sensors and technology to monitor the fill levels of waste containers in real-time. This enables efficient collection routes, as trucks can be directed to locations with the highest priority based on the fill levels.

- **Cost Savings:** By optimizing collection routes and schedules, smart waste systems can reduce fuel and labor costs associated with waste collection. This leads to overall cost savings for municipalities or waste management companies.

- **Reduced Environmental Impact:** Smart waste management systems contribute to environmental sustainability by minimizing unnecessary fuel consumption and vehicle emissions. Optimized routes reduce the carbon footprint associated with waste collection.

- **Preventive Maintenance:** Sensors in waste containers can also monitor the condition of the containers, allowing for proactive maintenance. This helps prevent issues such as overflowing containers or malfunctioning bins, ensuring that the waste collection process runs smoothly.

- **Data-Driven Decision Making:** The system generates valuable data on waste generation patterns, fill levels, and collection efficiency. Analyzing this data can help municipalities make informed decisions about resource allocation, waste management policies, and infrastructure improvements.

- **Improved Service Quality:** Smart waste systems help ensure that waste containers are emptied before reaching full capacity, reducing the likelihood of overflow and littering. This improves the overall cleanliness and aesthetic appeal of public spaces.

- **Real-Time Monitoring and Alerts:** Smart waste management systems can provide real-time monitoring of waste levels and send alerts or notifications when containers are nearing capacity. This enables prompt action and helps avoid situations where containers become overloaded.

- **Encourages Recycling:** Some smart waste systems include features to promote recycling. For example, they may include separate compartments for recyclables or provide incentives for residents to recycle. This aligns with sustainability goals and encourages environmentally friendly behavior.

- **Enhanced Public Health and Safety:** Timely waste collection reduces the risk of pests, odors, and other health hazards associated with unattended waste. This contributes to a cleaner and safer environment for residents.

- **Smart City Integration:** Smart waste management can be part of a larger smart city infrastructure, integrating with other systems such as traffic management, energy management, and public safety. This interconnected approach contributes to the overall efficiency and sustainability of urban environments.

Implementing a smart waste management system can lead to a more sustainable, cost-effective, and technologically advanced approach to handling waste, benefiting both the environment and the communities it serves.

6.4 Disadvantage

Smart waste bins come with several advantages, such as optimizing waste collection, reducing overflow, and enabling better waste management. However, they also have their drawbacks:

1. **Cost:** Smart waste bins can be expensive to install and maintain. The technology involved, including sensors, connectivity, and data management systems, can drive up the initial investment cost.

2. **Complexity and Reliability:** The technology used in smart waste bins can sometimes be complex, leading to potential issues or malfunctions. Sensors might fail or provide inaccurate readings, leading to inefficiencies in waste collection.

3. **Dependency on Technology:** Smart waste bins rely heavily on technology. If there are connectivity issues, power outages, or software glitches, it might disrupt the waste management process, causing delays or missed collections.

4. **Privacy and Data Security Concerns:** These bins often collect data about the type and amount of waste being disposed of. There are concerns about the privacy of this data and the potential for it to be misused or accessed by unauthorized entities.

5. **Maintenance Challenges:** Smart waste bins need regular maintenance to ensure proper functioning. This includes software updates, sensor calibration, and physical maintenance. Failure to maintain them properly can lead to inaccuracies or breakdowns.

6. **Compatibility and Integration:** Integrating smart waste bins into existing waste management systems or infrastructure can be challenging. Compatibility issues might arise when trying to synchronize these bins with other technologies or databases.

7. **Environmental Impact:** The production and disposal of electronic components in these bins can contribute to electronic waste, adding to environmental concerns if not managed properly.

Addressing these disadvantages requires careful planning, regular maintenance, and measures to ensure data security and privacy while maximizing the benefits of smart waste management.

6.5 Risk factor

Key risk factors in waste management projects include challenges related to regulatory compliance, health and safety issues, environmental impact, technological constraints, financial considerations, public opposition, variability in waste composition, operational inefficiencies, market dynamics, community engagement, susceptibility to climate change, and legal liabilities. Successful waste management projects require careful planning, ongoing risk assessment, and proactive measures to address these challenges and ensure sustainable and effective waste management practices.

Chapter 7

Conclusion & Future Work

In conclusion, the Smart Dustbin project has successfully implemented an innovative solution for efficient waste management. The smart dustbin incorporates various technologies, such as sensors, and IOT connectivity to automate waste collection and improve overall cleanliness. It has several advantages, including optimized waste collection routes, reduced operational costs, and improved sanitation. Additionally, the project promotes sustainability by encouraging waste segregation and recycling. The Smart Dustbin project has proven to be a practical and effective solution for modernizing waste management systems, leading to cleaner and more sustainable environments.

7.1 Summary

A smart IoT-based dustbin is an innovative waste management system that integrates Internet of Things (IoT) technology to optimize the collection and disposal of waste. Equipped with sensors, communication modules, and data processing units, these smart dustbins can monitor fill levels in real-time and transmit data to a central system. Users receive real-time notifications when the dustbin reaches a predetermined fill level, enabling timely waste collection. Additionally, these systems may incorporate user engagement features, such as feedback mechanisms and educational initiatives, to encourage responsible waste disposal practices. Future developments may focus on advanced sensor technologies, predictive analytics, smart city integration, and sustainability measures to further enhance the effectiveness and environmental impact of smart IoT-based dustbins.

7.2 Future Works

Future Work for IoT-Based Wastage Segregation:

- Advanced Sensor Technologies
- It can be made durable,by making it compact and cost effective.
- Two bin can be placed to collect wet and dry waste separately.
- Wet waste can be decomposed and used for making biogas.
- Smart Dustbins for Recycling.

Appendix

Executed code of our project:

```
#define servo1Pin 9 // Servo for ultrasonic sensor

#define moisturePin A0
#define irPin 4
#define servo2Pin 8 // Servo for waste disposal
// Define our Servo

#define trigPin1 6//Sensor Echo pin connected to Arduino pin 13
#define echoPin1 7//Sensor Trip pin connected to Arduino pin 12
#define trigPin2 10 //Sensor Echo pin connected to Arduino pin 13
#define echoPin2 11
#define buzz 12

int trigpin = 3;
int echopin = 2;
int distance;
float duration;
float cm;
// Create servo objects
Servo servo1;
Servo servo2;
LiquidCrystal_I2C lcd(0x27, 16, 2);
void setup() {
Serial.begin(9600);
  servo1.attach(9); // servo on digital pin 9
  servo2.attach(8);// servo on digital pin 8
pinMode(trigpin, OUTPUT);
pinMode(echopin, INPUT);

  // Initialize servos to default positions
  servo1.write(0);
  servo2.write(90);
  //delay(1000);
pinMode(trigPin2, OUTPUT);
pinMode(echoPin2, INPUT);
pinMode(trigPin1, OUTPUT);
pinMode(echoPin1, INPUT);
pinMode(buzz, OUTPUT);
lcd.begin(16,2);
lcd.backlight();
lcd.clear();
lcd.setCursor(0,0);
```

```
lcd.print("Welcome To ");
lcd.setCursor(0,1);
lcd.print("smart dustbin");
  delay(2000);
}

void loop() {
  // Step 1: Human Presence Detection using Ultrasonic Sensor and Servo Motor

long duration1, distance1,cm1,duration2, distance2,cm2;

digitalWrite(trigPin1, LOW);
delayMicroseconds(2);
digitalWrite(trigPin1, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin1, LOW);
  duration1 = pulseIn(echoPin1, HIGH);
  //distance = (duration/2) / 58.82;
    cm1 = microsecondsToCentimeters(duration1);


lcd.setCursor(0,0);  //Set cursor to first column of second row
lcd.print("             "); //Print blanks to clear the row
lcd.setCursor(0,0);
lcd.print("Left ");  //Set Cursor again to first column of second row
lcd.print(cm1); //Print measured distance
lcd.print(" cm Full");
  //Print your units.
  delay(250); //pause to let things settle

 if (cm1 <= 4 && cm2 <= 4) {
digitalWrite(buzz, HIGH);
lcd.clear();
lcd.print("Dustbin is full!");
    delay(2000);
lcd.clear();
digitalWrite(buzz, LOW);
  }


digitalWrite(trigpin, LOW);
delay(500);
digitalWrite(trigpin, HIGH);
delay(500);
digitalWrite(trigpin, LOW);
duration = pulseIn(echopin, HIGH);
cm = (duration/58.82);
distance = cm;
```

```
if(distance<20)
{
servo1.write(180);
delay(3000);
}
else{
servo1.write(0);
delay(50);
}

  // Step 2: Waste Moisture and Presence Detection using Moisture Sensor, IR Sensor, and Servo
Motors
  int moistureValue = analogRead(moisturePin);
  int irValue = digitalRead(irPin);

  if (moistureValue> 500) {
    // Waste is wet
    if (irValue == HIGH) {
      // IR sensor detects an object, drop waste to the left
      servo2.write(0);
      delay(100); // Adjust the delay as needed
    } else {
      // IR sensor does not detect an object, drop waste to the right
      servo2.write(90);
      delay(100); // Adjust the delay as needed
    }
  } else {
    // Waste is dry
    if (irValue == HIGH) {
      // IR sensor detects an object, remain stable
      servo2.write(180);
      delay(100); // Adjust the delay as needed
    }
    // No object detected, remain stable
  }
}
long microsecondsToCentimeters(long microseconds2)
{
  // The speed of sound is 340 m/s or 29 microseconds per centimeter.
  // The ping travels out and back, so to find the distance of the
  // object we take half of the distance travelled.
  return microseconds2 / 29 / 2;
}
long microsecondsToCentimeter(long microseconds1)
{
  // The speed of sound is 340 m/s or 29 microseconds per centimeter.
  // The ping travels out and back, so to find the distance of the
```

```
  // object we take half of the distance travelled.
  return microseconds1 / 29 / 2;
}
```

Reference

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