DON HONORIO VENTURA STATE UNIVERSITY

College of Engineering and Architecture

Automated Trash Segregation System for DHVSU Cleaners to Address Waste Disposal Challenges by 2024

Aguas, Cyrus Clifford R.

Alfaro, John Paul E.

Baking, Remiel R.

Cabrera, Scarlet N.

Camacho, Jhosua Carl C.

Cardeño, Paolo Gabriel F.

Cortez, Elmer M.

Cortez, Jeric Rance S.

Cuyugan, Clarissa M.

David, Raiza Mae C.

De Juan, Trisha Veronica J.

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Introduction

In awareness of the growing concern over environmental sustainability, waste management becomes an urgent problem in need of solutions. Waste management is turning into one of the main aspects in the struggle against environmental issues and making sure that sustainable practices are adopted. At present, Don Honorio Ventura State University faces notable challenges in waste management due to the absence of a dedicated waste management infrastructure and equipment facilitating proper waste segregation. The prevalent scenario involves the utilization of undifferentiated waste bins across the campus, resulting in the improper disposal of various types of waste into the same container.

This study will look at and recommend an automated waste management trash segregation system for DHVSU cleaners as it is essential, particularly in educational environments where the system is maintained by school cleaners. This innovative technology elevates environmental health in educational settings while also making trash segregation simpler and efficient. The purpose of this study is to offer insight into the nature of the current environment and emphasize how in need of such technologies the facilities are.

Background of the Study

Currently, human communities, including educational institutions like schools, generate a significant amount of diverse waste, and the management of these wastes has changed from simple dumping to multiple types of recycling. Waste from schools usually comes in several forms, such as paper, plastic, organic materials, and hazardous elements. Regular trash disposal

ways are frequently ineffective and do not address the expanding issues of resource depletion and environmental deterioration. School cleaners are frequently tasked with managing garbage since they have to deal with the difficult work of manually sorting and discarding wastes.

The paper discusses how much money and time are wasted as a result of the regular trips to the trash cans in the area. Sometimes workers discover that the containers are overflowing at times, and other instances when the bins are not even filled with stuff. As a result, there is effective use of time and maintains the cleanliness (Agarwal, et al., 2020).

To maximize resource utilization, the solution includes implementing automated bins capable of distinguishing the sort of garbage deposited. This approach minimizes the effects of human negligence and decreases the chance of contaminating recyclable materials. Automated trash bins represent a model of municipal waste segregators, enabling immediate segregation of stored waste and increasing the volume of recyclable paper. These "Smart bins" can transmit data approximately kept in garbage for appropriate action, utilizing different sensors and motors interfaces with a microcontroller inside the system (Endaya, et al., 2020).

General and Specific Problems

At DHVSU, waste management presents several challenges leading to environmental pollution and health hazards. One key issue is the lack of proper waste segregation techniques among cleaners, resulting in mixed waste disposal and hindering recycling efforts. Moreover, manual sorting of trash is both time-consuming and labor-intensive, posing health risks for workers and reducing overall efficiency. Lastly, the university lacks an automated waste

management system tailored to its specific needs, impeding efficient waste disposal strategies. Addressing these challenges is essential to improve waste management practices and mitigate environmental and health impacts at DHVSU.

General and Specific Objectives

The implementation of an Automated Waste Management Trash Segregation System for DHVSU Cleaners by 2024 seeks to enhance waste disposal effectiveness and address environmental concerns within the campus premises. This general objective reflects a commitment to modernizing waste management practices and promoting sustainability.

To achieve this objective, specific actions are outlined. Creation of an automated trash segregation system tailored to DHVSU's specific needs and waste composition is prioritized, aiming to simplify the waste sorting process while accommodating the diverse types of waste generated within the campus environment. Collaboration with relevant stakeholders, including DHVSU administration, cleaners, and environmental agencies, will be encourage to ensure the successful implementation of the automated waste management system. By working together, these parties can collectively address challenges and maximize the impact of the initiative on campus sustainability.

Importance of the Study

The study emphasizes the significance of implementing an automated waste management system at DHVSU, highlighting its role in addressing waste disposal challenges comprehensively. Simplifying trash segregation not only improves cleaner productivity by

reducing manual handling of garbage and safety but also advances environmental sustainability. This initiative serves as an example for other educational institutions, showcasing the transformative impact of technology in addressing modern issues effectively.

Scope and Delimitations

The Automated Waste Management Trash Segregation System includes automated waste segregation, achieved through sensor-based sorting mechanisms, to automatically categorize plastics, metals, and papers. It also involves utilizing a smart bin with sensor to monitor fill level and alert when full using a buzzer. When the bin is full, it automatically stops processing or accepting trash. This system also employs a sorting mechanism known as smart chute or selective chute system to distinguish the type of waste and then direct the chute's position to the designated bin through a sliding mechanism. Additionally, the project includes training and educating DHVSU cleaners on using the system effectively as well as establishing protocols for monitoring the system's performance and conducting regular maintenance to ensure its smooth operation.

The system faces limitations in these areas. The sequential processing mechanism sorts trash one item at a time, potentially slowing processing during peak times. Also, challenges in material discrimination persist, making accurate differentiation between biodegradable and non-biodegradable waste difficult due to material diversity.

Methods

Planning Phase

Results of Survey Session

Question: What are your thoughts or initial impressions about the idea of implementing an Automated Trash Segregation System at DHVSU?

The implementation of an Automated Trash Segregation System at DHVSU is widely supported for several reasons. It's considered to be easy to use, beneficial for employees, and helpful in keeping a safe and clean environment. This method would save time, lessen the effort of the maintenance staff, improve recycling, and enlighten the campus community about appropriate waste management. It solves the common problem of spreading rubbish on campuses, especially in Dubai, and is thought to be a practical way to improve environmental cleanliness.

It will help the environment safe and clean for the students.

Implementing automated trash segregation would be a big step towards efficient waste management

Implementing an Automated Trash Segregation System has the potential to significantly improve waste sorting efficiency, increase recycling rates, and reduce contamination. By leveraging technologies like robotics and AI, it could streamline the process and enhance overall waste management practices.

Implementing an Automated Trash Segregation System at DHVSU is great idea. It can help keep the campus cleaner, make recycling easier, and teach students and staff about proper waste management. Plus, it could save time and reduce the workload for the maintenance staff.

Could help to maintain a clean environment

It would be helpful if the system is properly implemented.

The garbage can be better segregated in this device

good

It would help for easily disposing waste and segregated at the same time.

Good

good, you can collaborate with the Environmental Society under College of Arts and Sciences (CAS)

nice

it is going to be convenient

Cleanliness

It is good, so that tha school will look good.

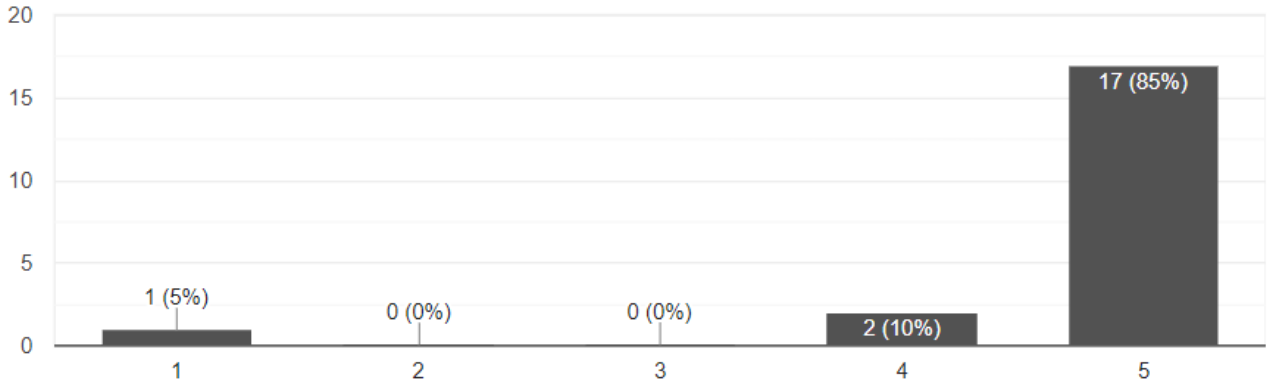
It would be great because it'll be convenient for everyone.

I think it is a great idea to create and implement this because it would be a great help to the workers. In addition, most of the people are lazy to segregate their trash. On the other hand, they're not knowledgeable

Implementing an Automated Trash Segregation System at DHVSU is great idea. It can help keep the campus cleaner, make recycling easier, and teach students and staff about proper waste management. Plus, it could save time and reduce the workload for the maintenance staff.
Could help to maintain a clean environment
It would be helpful if the system is properly implemented.
The garbage can be better segregated in this device
good
none
Good solution for the problem that is facing of dhvsu at this time. As a student i see so many trash that is scattered in the area specially in dubai. This project could save the environment or at least lessen the cause of trash in the area

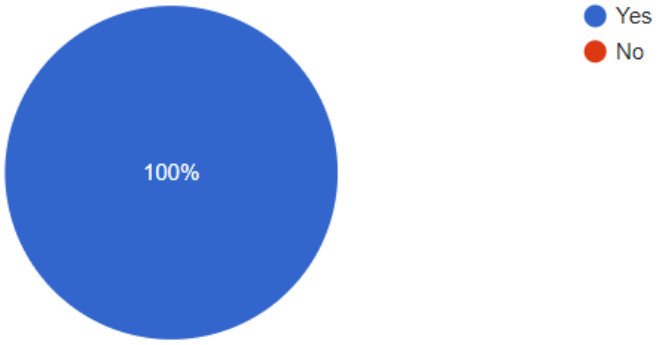
Question: How important do you think effective waste disposal practices are for the environment and campus cleanliness, on a scale of 1 to 5?

On a scale of 1 to 5, majority of respondents gave a 5 to the importance of efficient trash disposal procedures for the environment and campus cleanliness, meaning that it is important.



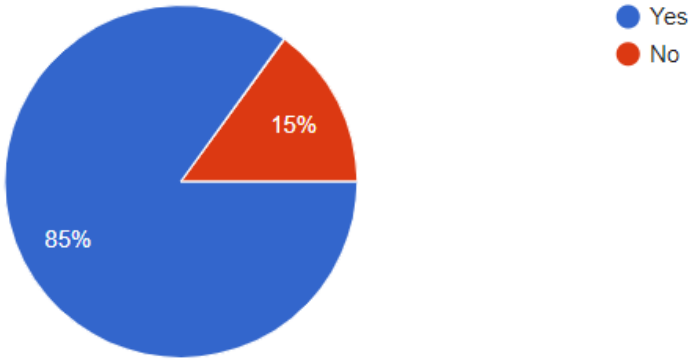
Question: Do you believe that an Automated Trash Segregation System would encourage greater environmental awareness and responsibility among DHVSU students?

Based on all respondents, DHVSU students would become more environmentally conscious and responsible if there was an automated trash segregation system in area.



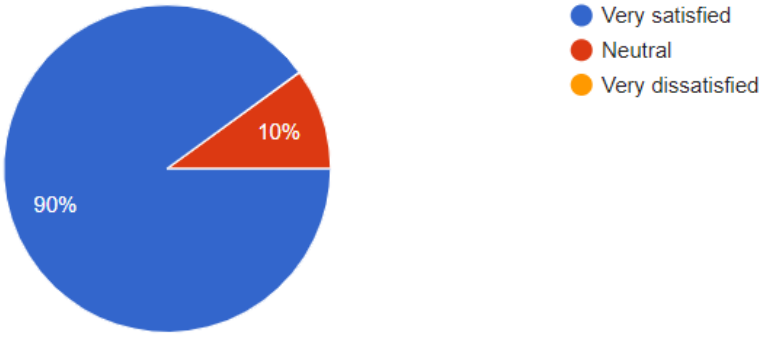
Question: Would you be willing to participate in awareness campaigns or activities promoting the proper use of an Automated Trash Segregation System?

85% of the respondents are open to taking part in projects or awareness-raising events that support the appropriate use of automated trash segregation systems.



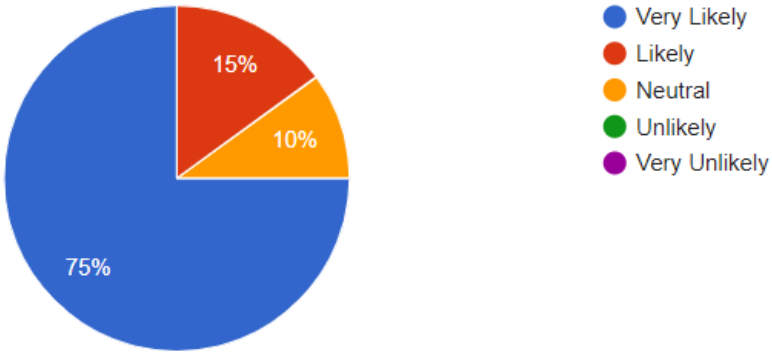
Question: How satisfied do you think students would be with the cleanliness of DHVSU premises if an Automated Trash Segregation System were implemented?

Most respondents believe that students would be very satisfied with the cleanliness of DHVSU premises if an Automated Trash Segregation System were implemented.



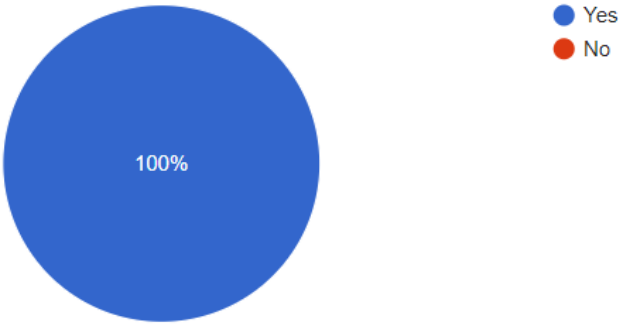
Question: How likely are you to recommend the Automated Trash Segregation System to fellow DHVSU students?

75% of respondents are very likely to recommend the Automated Trash Segregation System to fellow DHVSU students, 15% are likely, and 10% are neutral.



Question: In your opinion, would implementing an Automated Trash Segregation System contribute to a cleaner and more sustainable campus environment?

According to all respondents, implementing an automated trash segregation system would make campus environments cleaner and more environmentally friendly.



There is the no proper trash segregation system for the cleaners at DHVSU like how there are only 1 trash bin where all kinds of waste go to. The improper disposal of various types of waste into the same container. To address the lack of proper waste segregation and the issue of improper disposal at DHVSU, an Automated Trash Segregation System should be implemented for proper waste disposal.

List of Materials and their Description			
Qty.	**Materials**	**Description**	**Cost**
5 pcs.	NPN PNP Transistor BC557	The BC557 is a PNP transistor used for amplification and switching in electronic circuits	₱30
1 pc.	LM7805	The LM7805 is a linear voltage regulator integrated circuit (IC) that provides a stable output voltage of +5 volts.	₱40
1pc.	5.08mm Pitch 2 Pin Plug in Screw PCB Terminal Block	The 5.08mm Pitch 2 Pin Plug-in Screw PCB Terminal Block is a connector designed for printed circuit boards (PCBs).	₱25
1 pc.	Buzzer 5V	The 5V Buzzer is an electronic component that generates sound when an electrical signal of 5 volts is applied to it.	₱20
4 pair	Terminal wire connector	Terminal wire connectors are devices used to join electrical wires securely and reliably.	₱26
4 pcs.	Aluminum Electrolytic Capacitors (50V 0.1uF), (25V 10uf)	Aluminum electrolytic capacitors are components used in electronic circuits for filtering, bypassing, coupling, and energy storage applications.	₱60
10 pcs.	Ceramic Capacitor 18pF	The Ceramic Capacitor 18pF is a small electronic component used in circuits for various applications like filtering, tuning,	₱15

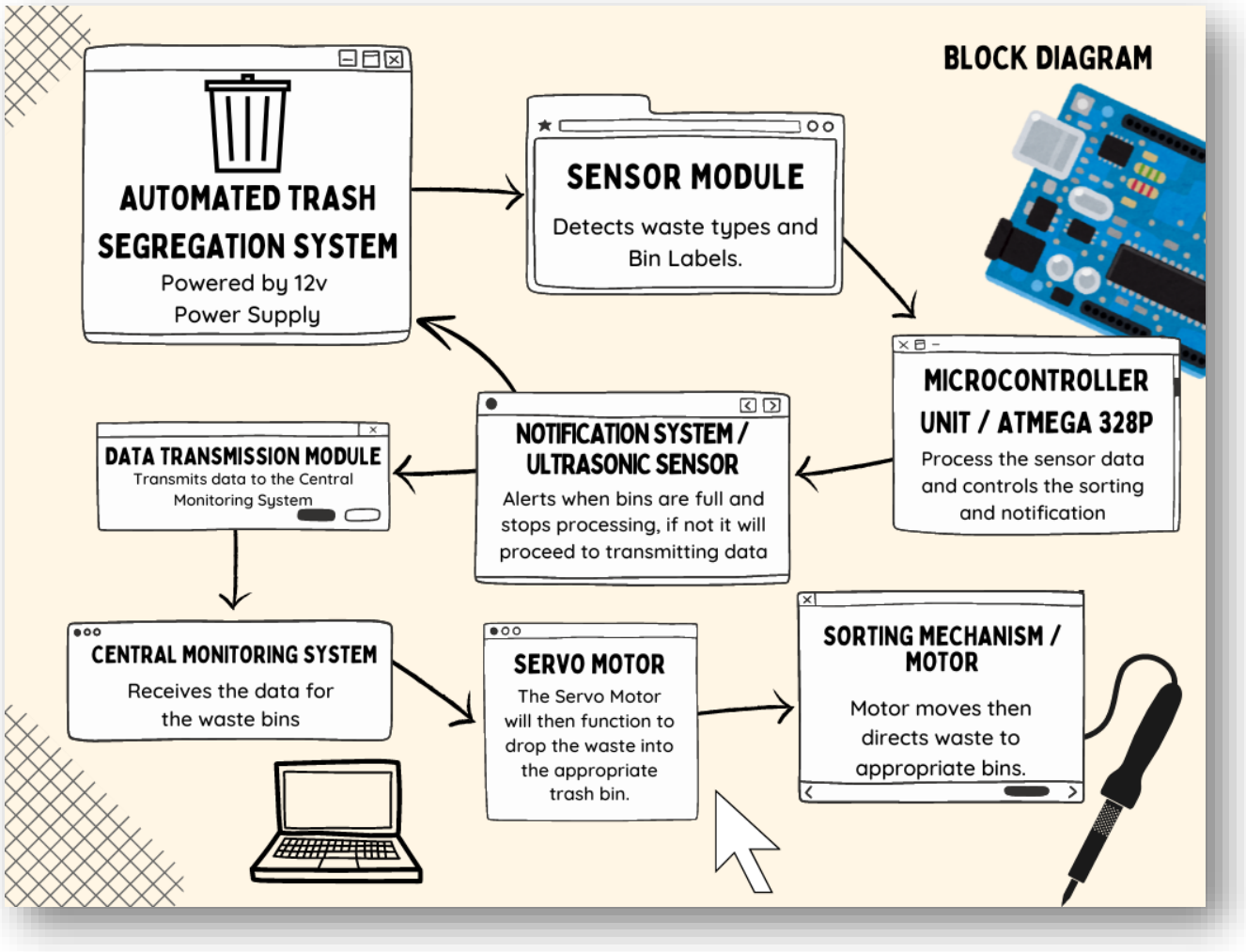
		coupling, and decoupling.	
5pcs.	Male Spade Insulated Wire Connectors	Male spade insulated wire connectors are commonly used in electrical and electronic applications for making secure and removable connections between wires and terminals.	₱40
5 pcs.	Optocoupler	Used to transfer electrical signals between two isolated circuits using light.	₱27
1pc.	16Mhz Crystal HZ	Used as a clock source in various electronic circuits and microcontroller-based systems to provide precise timing for digital operations.	₱14
15 pcs.	Resistors (10k, 5.1k, 1k)	Resistors are fundamental passive electronic components that restrict the flow of electric current in a circuit.	₱48
5 pcs.	Diode Rectifier	A diode rectifier is an electronic component used to convert alternating current (AC) to direct current (DC) by allowing current to flow in only one direction.	₱13
1 pc.	Power Relay	Power Relay is an electromechanical device used to control the flow of electrical power in a circuit.	₱128
2pcs.	Double Sided Copper Clad Laminate Circuit 4x4	A double-sided copper clad laminate circuit board is a type of printed circuit board (PCB) with copper foil bonded to both sides of the substrate material.	₱256
1pc.	Distance Sensor	A distance sensor is an electronic device that measures the distance between the sensor and an object or surface in its vicinity.	₱860
1pc.	Proximity Inductive 4mm Metal Sensor	is a type of sensor used to detect the presence or absence of metallic objects in close proximity to the sensor.	₱65
1pc.	Linear Rail Shaft Support	A linear rail shaft support is a mechanical component used to provide support and stability to linear shafts or rods in linear motion systems.	₱100
1pc.	U shape Servo Bracket	A U-shape servo bracket is a mechanical component used to mount and support a servo motor in various applications.	₱70
3pcs.	Right Angle Connector through Hole 2 pin	A right-angle connector through-hole, 2-pin, is a type of electrical connector with two pins designed to be mounted perpendicular to the circuit board surface.	₱133

7pcs.	Pin Male Plug	A right-angle connector through-hole, 2-pin, is a type of electrical connector with two pins designed to be mounted perpendicular to the circuit board surface.	₱245
1pc.	Switch Micro with Roller Lever 3 Terminal	A micro switch with a roller lever and three terminals is a type of electromechanical switch that features a lever with a small roller at the end and has three electrical terminals for connection.	₱81
1pc.	Timing Pulley	A timing pulley is a mechanical component used in conjunction with a timing belt or chain to transmit rotational motion between two parallel shafts in precise synchronization.	₱59
1pc.	AC DC 12V 5a Switching Power Supply	An AC/DC 12V 5A switching power supply is an electronic device that converts alternating current (AC) electrical power from a mains power source to direct current (DC) power at 12 volts with a maximum output current of 5 amps.	₱155
1pc.	Servo Motor	A servo motor is an electromechanical device that converts electrical signals into precise mechanical motion.	₱159
1pc.	Linear Bearing	A linear bearing is a mechanical component used to provide smooth, low-friction motion along a linear path.	₱110
1pc.	Capacitive Proximity Sensor	A capacitive proximity sensor is an electronic device used to detect the presence or absence of objects based on changes in capacitance.	₱167
3pcs.	Single Cable Wire Size Gauge (Black, Yellow, Red)	A single cable wire refers to a single conductor or insulated wire used for electrical connections or transmission of electrical signals.	₱300
10pcs.	1m Soldering Lead	Soldering wire is a thin, fusible metal alloy wire used in soldering operations to join two or more metal surfaces together.	₱150
1pc.	Copper Foil Tape with Conductive Adhesive	Copper foil tape with conductive adhesive is a versatile electrical tape used for various applications requiring electrical conductivity, shielding, or grounding.	₱75
100pcs.	Brass Eyelet	A brass eyelet is a small metal component commonly used in manufacturing and crafting	₱60

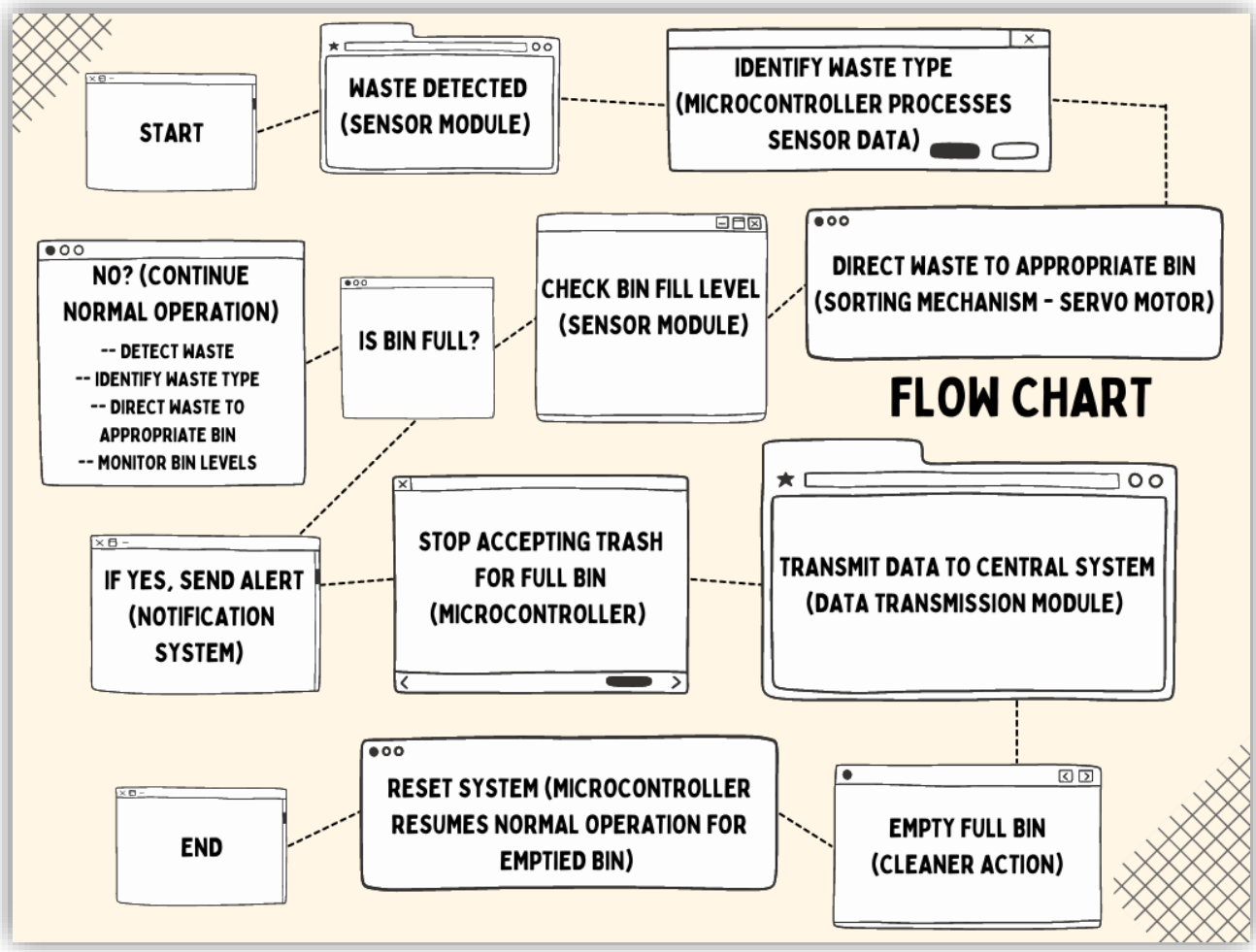
		for securing or reinforcing holes in fabric, leather, paper, and other materials.	
1pc.	Miniature DC Gear	Miniature DC gears are compact gear assemblies that are powered by direct current (DC) motors.	₱252
2pcs.	Ferric Chloride	Ferric chloride is widely utilized in the process of etching, particularly in the production of printed circuit boards (PCBs).	₱120

Designing Phase

Block Diagram



Flowchart


START
WASTE DETECTED (SENSOR MODULE)
IDENTIFY WASTE TYPE (MICROCONTROLLER PROCESSES SENSOR DATA)
DIRECT WASTE TO APPROPRIATE BIN (SORTING MECHANISM - SERVO MOTOR)
CHECK BIN FILL LEVEL (SENSOR MODULE)
IS BIN FULL?
NO? (CONTINUE NORMAL OPERATION)
-- DETECT WASTE
-- IDENTIFY WASTE TYPE
-- DIRECT WASTE TO APPROPRIATE BIN
-- MONITOR BIN LEVELS
FLOW CHART
TRANSMIT DATA TO CENTRAL SYSTEM (DATA TRANSMISSION MODULE)
STOP ACCEPTING TRASH FOR FULL BIN (MICROCONTROLLER)
IF YES, SEND ALERT (NOTIFICATION SYSTEM)
EMPTY FULL BIN (CLEANER ACTION)
RESET SYSTEM (MICROCONTROLLER RESUMES NORMAL OPERATION FOR EMPTIED BIN)
END

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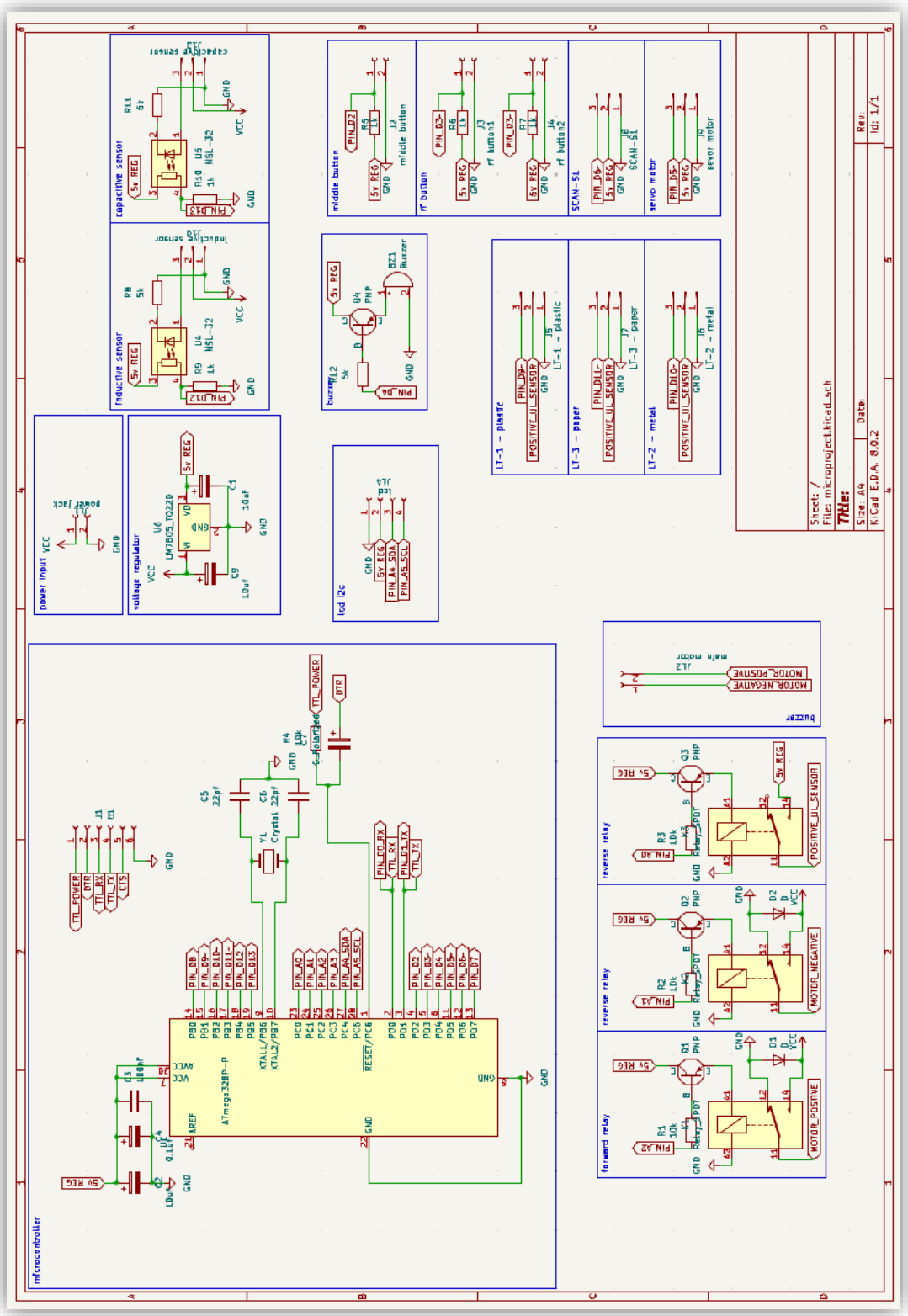
Circuit Diagram



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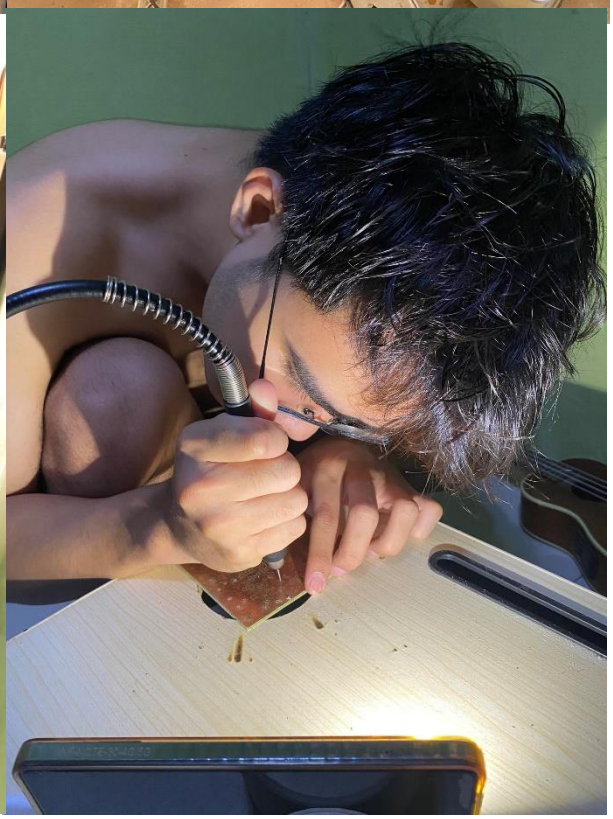
Development Phase

Documentation



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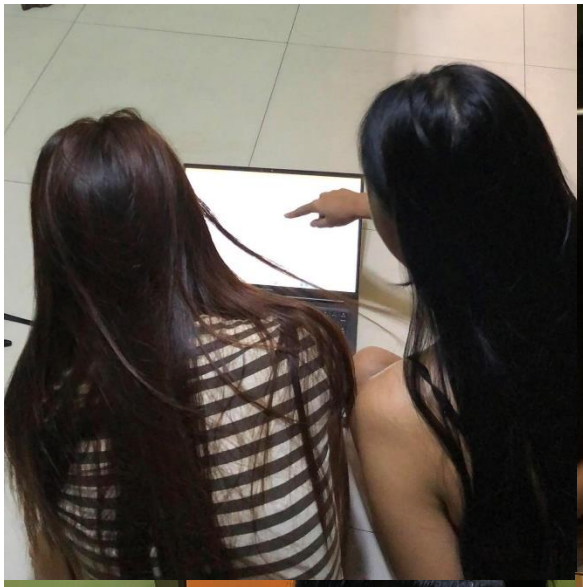
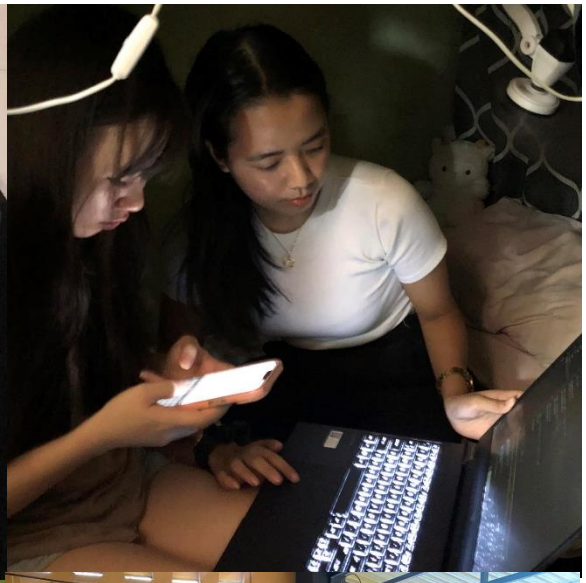


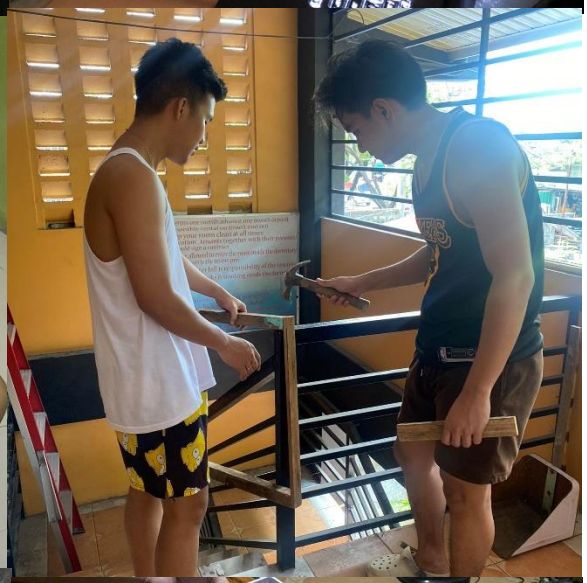
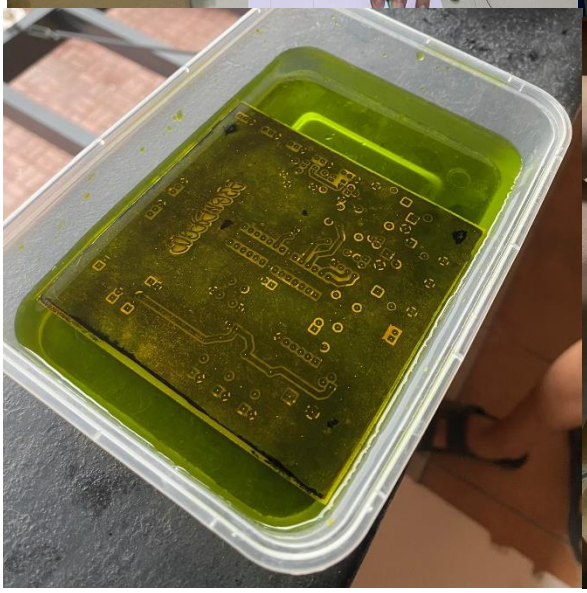
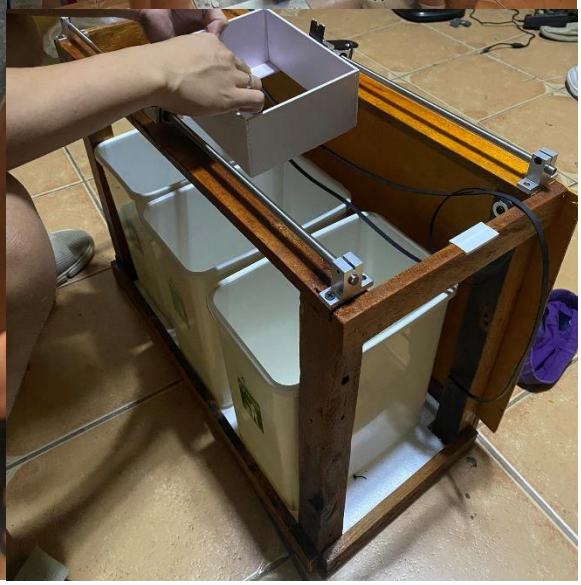

Hardware Requirements

Sensors: Inductive sensors (for metal detection), Capacitive sensors (for plastic and paper detection), Ultrasonic sensors (to detect bin fullness)
Processing Unit: Microcontroller Arduino ATmega328P
Actuators: 12V DC Motor, Servo Motors (for door mechanism)
Power Supply: **lagay mo**
Mechanical Components: Conveyor belts or rotating platform, Trash bins with automated lids, Frames and supports for structure, and Bearing

Software Requirements

Microcontroller IDE: Arduino IDE
Development Tools: KiCAD and Tinkercad

Development Process

- Waste Detection Module - Set up sensors by connecting inductive sensors to detect metal, capacitive sensors to detect plastic and paper. Interface the sensors with the microcontroller then write the code to read data from the sensors and develop algorithms to differentiate between plastic, metal, and paper based on sensor inputs. Test sensor readings with various waste types and calibrate the sensors for accurate detection.
- Motor Activation and Control Module - Move the waste to align it with the appropriate trash can based on the detection results by using DC motor for the movement mechanism. Design the conveyor belt or rotating platform to move waste. Write code to control the motor movements based on sensor inputs. Test the motor control system independently for accurate positioning.
- Door Mechanism Module - Design and build the door mechanism with sintra board. Attach servo motors to the doors for controlled opening and closing and then, write the code to control the servo motors. Lastly, test the door mechanism independently and then integrate with the motor control system.
- Full Bin Detection Module - Place ultrasonic sensors in each bin to measure the fill level and interface the ultrasonic sensors with the microcontroller. Create the code to read data from the ultrasonic sensors and develop logic to determine when a bin is full based on distance readings. Test the full bin detection system independently and calibrate it to ensure accurate readings.
- Disposal and Reset Module - Design the chute for waste to fall directly into the bin then program the microcontroller to close the door and reset the motor to its initial position after disposal. Integrate the sensors to detect successful disposal and test the disposal and reset mechanism with the detection and movement systems.

Prototyping and Testing

For initial prototyping, assemble basic versions of each module separately and test each module independently. Integrate modules in stages through detection and motor control, followed by door mechanism and disposal system. Integrate the full bin detection module to ensure the system stops accepting trash when any bin is full and perform integration tests to ensure modules work together. Collect feedback and performance data and refine algorithms, improve mechanical designs, and optimize control logic. Finally, assemble the final integrated system and conduct testing.

Testing and Evaluation Phase

Unit Testing

- Sensors - Test inductive sensor with various metals, capacitive sensor with different plastics and papers and ultrasonic sensor for bin fill levels.
- Motor Control Module - Move DC motor to specific positions and open/close servo motor doors at various angles.
- Microcontroller - Read sensor data and output correct signals.
- Mechanical Components - Run conveyor belt and check for smooth operation.

Integration Testing

- Sensor and Microcontroller - Connect sensors and verify data processing.
- Motor Control and Sensors - Trigger motor movements based on sensor input.
- Door Mechanism - Open/close bin doors in sync with motor movements.
- Full Bin Detection - Fill bins and verify system stops and alerts.

System Testing

- End-to-End Testing - Sort plastic, metal, and paper waste through the system.
- Performance Testing - Measure sorting time and throughput rate.
- Stress Testing - Continuously feed waste to test durability.
- Full Bin Scenario - Simulate full bins and verify system stops and alerts.
- Gather feedback from users on system performance.

References

Endaya J.P., Mabitasan Jr. F., Gonzales, J.C. (2020, October). Design and Implementation of Automated Waste Segregator with Smart Compression. https://lpulaguna.edu.ph/wp-content/uploads/2022/01/6.-Endaya-Mabitasan-Gonzales-Waste-Segregator.pdf?fbclid=IwAR1xaxtePL7lYu1eCcZcxQeyJswoj4RJm5bKca6NrWse0dKlk0iaHwrU17M

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Results and Discussions:

Results show that plastic, metal, and paper garbage may be detected with excellent accuracy—as detection rates are 100%. To ensure efficient waste segregation and reduce contamination, this high precision is essential. Inductive Sensor for metal detection and Capacitive Sensor for plastic and paper.

Waste Type	Detection Accuracy (%)
Plastic	100%
Metal	100%
Paper	100%

Table 1: Material Detection Accuracy

The fill level monitoring feature showed that bin capacities could be measured as the ultrasonic sensor is working well, with average fill levels constantly falling within the intended range upon testing.

Ultrasonic Sensor	Detection Accuracy (%)
Fill Level Detection	100%

Table 2: Fill Level Monitoring Sensor

Observations During Development and Testing:

Sensor Calibration - Obtaining optimal performance under various environmental conditions required fine-tuning sensor settings and calibration procedures. Accuracy and dependability were preserved during testing phases with constant observation and modification.

Chute Optimization: The chute malfunctioned due to incomplete system setup stemming from a connection error.

Algorithm Refinement: Extensive testing and validation were required to refine the algorithms, yet a persistent error hindered progress resulting to a failed or unfinished prototype.

Conclusions

In conclusion, the Automated Trash Segregation System deployment for Don Honorio Ventura State University is necessary for addressing trash disposal issues and advancing environmental sustainability. The system uses automated bin functions and sensor-based sorting processes to make waste sorting easier, more efficient, and less contaminated—not just for the cleaners but also for students, facilitators, the campus environment, and the waste system.

The development and testing of the Automated Trash Segregation System for DHVSU Cleaners revealed that while the sensors are functioning accurately, the overall system is not operational. Despite the successful detection of plastic, metal, and paper waste with high accuracy, challenges were encountered during system integration and functionality. Issues such as incomplete setup leading to chute malfunction and algorithm refinement difficulties hindered the system's successful implementation. Although the sensors demonstrated reliability, further refinement and troubleshooting are necessary to address the system's operational shortcomings. Moving forward, focused efforts on system optimization, comprehensive testing, and iterative improvements are recommended to ensure the successful deployment and functionality of the Automated Trash Segregation System at DHVSU.

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3D Design Model