DESIGNING A HETERONOMOUS FLOATING GARBAGE COLLECTOR SYSTEM

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A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronics Engineering in partial fulfillment of the requirements for the degree Bachelor of Science

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Declaration

It is hereby declared that

1. The Final Year Design Project (FYDP) submitted is my/our own original work while completing degree at Brac University.
2. The Final Year Design Project (FYDP) does not contain material previously published or Written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Abstract/ Executive Summary

Due to the lack of logistical planning and scientific knowledge and acknowledgement, the hazardous materials of industries, solid household waste, used medical/clinical products, and electrical wastes are thrown away intentionally or unintentionally in the water bodies regularly. Therefore, the contamination ruins the ecosystem of water and reduces the usability of it. Hence, the project is implemented to collect and discharge floating wastes to restore and protect water bodies from further contamination. However, the project is based on a human controlled system through a GSM module to make the process convenient. Notably, Autonomous solution for the problem is highly expensive, which can reduce the accessibility of it. Which reduces the maximum target of implementation. As a consequence, the project is focused on creating environmentally friendly solutions that will be handy, lightweight and affordable.

Keywords: floating waste; Arduino; GSM; Heteronomous; clean water surface;

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Chapter 1: Introduction- [CO1, CO2, CO10]

1.1 Introduction

One of the current issues with the highest priority nowadays is water contamination. It is more severe than usual, especially in developing nations like India, Bangladesh, Pakistan, Sri Lanka, etc. Most water bodies are covered with biodegradable and non-biodegradable floating materials. Collecting such materials is the gateway to preventing water pollution. Many organizations are working on this issue by creating awareness or conducting cleaning projects with volunteers. Also, the government needs more personnel in addition to funding and hard work for this cleaning operation. Thus, most of the projects that they are carrying out are inefficient manual processes. Therefore, the expected outcome is yet to meet. Moreover, in the project, a water waste collection system has been developed to complete the task more quickly, cost-effectively, and efficiently. Developing a remote-controlled garbage collector that can detect and gather floating wastes from rivers, lakes, and other small water bodies is the main vision of the project.

1.1.1 Problem Statement

Water pollution is a growing problem that threatens the health of marine ecosystems and the well-being of communities that rely on water for food and livelihood. One major contributor to water pollution is marine debris, including plastics, metals, and other materials that accumulate in the water and harm marine life. Traditional methods of marine debris removal are costly and time-consuming, often requiring manual labor and specialized equipment. To address this challenge, there is a need for a heteronomous floating garbage collector that can navigate and collect debris in the water bodies. The solution should be able to efficiently and effectively collect debris of various sizes and types while minimizing damage to marine life and ecosystems.

1.1.2 Background Study

Water contamination has become a global problem, necessitating a continuous evaluation of water resource policy [1]. Despite making up more than 70% of the planet's surface, only 2.5% of the water on the planet can be classified as freshwater [2]. According to estimates, 870 000 fatalities occurred in 2016 as a result of contaminated water, unsanitary conditions, and poor hygiene. [3][5]. The quality of the water is harmed when harmful non-biodegradable substances get into water bodies. In consequence, water contamination has a negative impact on people's health, the environment, and the economy.

Additionally, some of the earlier research based on the river system's waste collectors has described value. A project titled "Design and fabrication of remote-controlled sewage cleaning machine [4]" was completed by M. Mohamed Idhris and M. Elamparithi. The project's goal is to automate the sewage cleansing process in drainage to stop infections from spreading to people. By removing residues that can serve as a pest's food source and breeding ground, the black water cleaning method aids in the prevention of pest infestations. As soon as the setup is turned on, a wiper motor in the system activates. The wheel has two power window motors attached to it, and the remote-control system is used to operate them. Additionally, garbage that interferes with drainage is removed. This technique limits disease transmission to humans by limiting human involvement in the cleaning process. Services today are getting more divided.

Another project which has performed by Pankaj Singh Sirohi & Rahul Dev has reported about "Review on Advance River Cleaner.[5]. They also maintain the ecology of region and bring prosperity. In this project turbine rotates by flow of river water and through the mechanical gear arrangement they arranged two conveyor belts. The first conveyor belt is used to pick solid waste from rivers and the second conveyor belt is used to draw solid waste out of rivers for solid waste management. This project is designed for saving rivers from water garbage pollution. Nowadays the river pollution is the biggest problem for this planet so they introduced our society with an advanced river cleaner. It's an advanced river cleaning system. To make these water sources clean we made this project for looking into if. From this paper we get a lot of ideas about the water sources cleaning system policies.

Osiany Nurlansa and Dewi Anisa Istiqomah, have made an Automatic Garbage Collector Robot Model[6].Nowadays, environmental problems arise in many towns in Indonesia. These problems come along by developing activities such as construction of houses, offices, and other business areas. The Environment problems occur due to several reasons; there is low budget allocation on environment management and public awareness in protecting the environment. The Environment issue which comes up from year to year and still cannot be solved is about garbage and waste from various places dispose into rivers. This research aims to design and make AGATOR (Automatic Garbage Collector)[6], a rotor robot model as automatic garbage collector to counter accumulation of garbage in the river which has no flow effectively and efficiently. The method of implementation is design and construction. This method includes the identification of needs, analysis of the components required specifically, hardware and software engineering, developing, and testing. The test results obtained by specification of AGATOR includes IC ATMega16 with 5 Volt voltage and 1,1 ampere current, IC Driver with 12 Volt voltage and 1,2 Ampere current, and Limit switch as the controller. Support devices of the robot are mechanical robot, robot control system, sensor system, and actuator robot. The maximum load drives the garbage receptacle until 5 kg. The average speed of a robot when taking out the garbage is 0.26 m/s.

Overall, we have seen many works related to purification of water, proper distribution of water and garbage management. Yet, we have not seen a project which can be commercially distributed to common people. Moreover, we have seen huge projects which does not collect proper data after the garbage collection and some do not help with the treatment of the water.in our project topic discussion we thrived to minimize and possibly ending this gap in research and development.

1.1.3 Literature Gap

While extensive research has been conducted on various strategies and technologies for combating marine plastic pollution, there exists a notable literature gap regarding the role of our project in this context. Despite the urgency of addressing the escalating issue of marine plastic pollution, most existing studies primarily focus on traditional methods such as beach cleanups, waste management systems, and policies targeting reduction and recycling. While these approaches are crucial, they often overlook the specific challenges posed by plastic debris already present in marine ecosystems.

Understanding the potential of the project requires further investigation into several key aspects. Firstly, research should focus on evaluating the operational efficiency of these collectors, considering factors such as collection capacity, maneuverability, and adaptability to different marine environments. This includes studying the performance of various collection mechanisms, such as nets, skimmers, or drones, and their ability to capture different types and sizes of plastic debris. Secondly, the environmental implications of deploying floating garbage collectors need to be assessed. It is essential to investigate the potential impacts on marine ecosystems, including unintended bycatch, disturbance to marine organisms, and the overall ecological balance. Evaluating the long-term effects of these collectors on water quality, biodiversity, and ecosystem dynamics is crucial for understanding their viability and sustainability. Furthermore, research should address the economic feasibility and scalability of the project. Investigating the costs associated with design, manufacturing, operation, and maintenance of these systems, as well as potential funding mechanisms, will contribute to assessing their viability as a large-scale solution for marine plastic pollution. Lastly, the social and cultural dimensions of implementing floating garbage collectors need exploration. Understanding public perceptions, stakeholder engagement, and the integration of these technologies within existing waste management infrastructures is vital for successful adoption and long-term support.

In summary, while the need for effective strategies to mitigate marine plastic pollution is widely recognized, there is a significant gap concerning floating garbage collectors. Further research is necessary to evaluate their operational efficiency, environmental impacts, economic feasibility, and social acceptability. Addressing these gaps will provide valuable insights into the potential role of these technologies in combating marine plastic pollution and inform the development of comprehensive and sustainable solutions.

1.1.4 Relevance to current and future Industry

This project has significant relevance to the current and future industry due to its potential to address the pressing issue of marine plastic pollution. The impact of plastic debris on marine ecosystems, human health, and the economy has garnered increased attention, leading to a growing demand for innovative solutions. Here's why heteronomous floating garbage collectors are relevant to the industry:

Technological Advancements: The project's creation and implementation make use of developments in robotics, sensors, and data analytics. These technologies improve the industry's ability to combat marine plastic pollution by enabling more effective and targeted collection of plastic garbage in water bodies.

Environmental Responsibility: Industries from a variety of sectors are looking for solutions to lessen their environmental impact as a result of rising public awareness of the issue and governmental pressure to combat plastic pollution. A commitment to sustainability and environmental responsibility is shown by investing in floating garbage collectors, and this can enhance brand reputation and stakeholder connections.

Collaboration Opportunities: Provide opportunities for collaboration among different industries, including robotics, maritime technology, waste management, and environmental conservation. Collaborative efforts can facilitate the exchange of knowledge, expertise, and resources, leading to the development of more effective and scalable solutions.

Market Potential: The demand for effective solutions to combat marine plastic pollution is growing rapidly. As governments, environmental organizations, and private companies prioritize environmental protection, there is a market opportunity for the development, manufacturing, and operation of heteronomous floating garbage collectors. This emerging market can stimulate economic growth, job creation, and technological advancements.

Innovation and Research: Continuous exploration and innovation are necessary for the implementation. This offers prospects for technology development, collection mechanism optimization, and system improvement for engineers, and businesspeople. Through funding assistance, knowledge sharing, and research collaborations, industry involvement can promote innovation.

In conclusion, the project holds significant relevance to the current and future industry due to its potential to address marine plastic pollution. Their utilization aligns with technological advancements, environmental responsibility, collaboration opportunities, market potential, policy and regulation trends, innovation and research, and the need for future-proofing. By embracing these collectors, industries can contribute to a cleaner and more sustainable future while positioning themselves as leaders in environmental stewardship.

1.2 Objectives, Requirements, Specification and constraint

1.2.1. Objectives

1. Designing Floating Garbage collector.
2. A handy control system to clean small water sources (aquatic farms, lake).
3. Create a cost-efficient solution.
4. Collecting biodegradable and non-biodegradable floating waste. Such as, plastic bottles, Cardboards and, organic wastes
5. Increase clean water usage on small sources.

1.2.2 Functional and Nonfunctional Requirements

Table 1. Functional and Nonfunctional Requirements

Functional	Non-Functional
1. Moderate waste collecting capability	1.Lightweight
2. Moderate Object sensing capability	2.better buoyancy force
3. Optimal Transmission range	3.Eco Friendly
4. Better power efficiency	4.Moderate waste carrying capacity
5.System's length(2.5ft), breadth(1.5ft) & height(1ft)	

1.2.3 Specifications:

Table 2. Initial suggested component list specifications:

Subsystem	Component	Specification
Microcontroller	Arduino Board	Operating Voltage: 5V Input Voltage (recommended): 7-12V Digital I/O Pins: 14 (of which 6 provide PWM output) Analog Input Pins: 6
Proximity system	Ultrasonic Sensor	Operating Voltage (VDC): 5 Average Current Consumption (mA): 2 Frequency (Hz): 40000 Max. Sensing Distance (cm): 450 Dimensions: 5 × 4 × 3 cm
Power system	Solar Panel	Optimum Power Voltage (Vmp): 18.46V Optimum Operating Current (Imp): 3.25A, Open Circuit Voltage (Voc): 22.51V Short Circuit Current (Isc): 3.57A
	Lead Acid Battery	Voltage: 12V Plate/Cell: 9 Capacity: 50Ah Dimension/Size: 260 x 173 x 230
Control systems	DC motor	Rated Voltage: 24V Rated Speed: 7000RPM Dimensions: 10 × 5 × 5 cm Current Rating: 0.16A
	Stepper Motor	Holding Torque (Kg-Cm): 10.1 Operating Voltage (VDC): 2.3 Supply Current (A): 2.8 A/Phase Weight (gm): 650 Dimensions: 6 × 7 × 7 cm
	L298N H-Bridge Dual Motor Driver	Operating Voltage (VDC): 5 ~ 35 Peak Current (A): 2 Continuous Current (A): 0-36mA Max Power: 25W Dimensions: 7 × 7 × 3 cm

Weighing system	Weighing Sensor	Material: Aluminum Weighing Range (Kg): 0 ~ 15 Impedance (Ω): 1066 ± 10% Ω Output Impedance: 1000 ± 10% Ω Weight (gm): 29 Insulation Resistance (MΩ): 2000t Dimensions: 8 × 3 × 1 cm

Table 3. Final component list:

Subsystem	Component Name	Specifications
Power System	LiPo Battery	Capacity: 3300mAh,Cell Count: 3S,Nominal Voltage: 11.1V
	B3 Charger	Input Voltage: 100-240V AC,Output Voltage: 12.6V DC,Max Charging Current: 1A
	Buck Converter	Input Voltage: 12V DC,Output Voltage: 5V DC,Output Current: 3A
Control System	Arduino Nano	Operating Voltage: 5V DC,Input Voltage (recommended): 7-12V DC
	Bluetooth HC-06	Operating Voltage: 3.3V DC,Bluetooth Version: 2.0+EDR
	DRV8825 Stepper Driver	Input Voltage: 8.2V-45V DC,Output Current: up to 2.5A
	L298N Motor Driver	Operating Voltage: 5-35V DC,Peak Current: 2A,Continuous Current: 0.7A
	Nema 17 Stepper Motor	Holding Torque: 40Ncm,Voltage: 12V DC,Current: 1.2A
	IR Module	Operating Voltage: 5V DC,Detection Distance: up to 10m
Sensing System	Waterproof DS18B20	Temperature Range: -55°C to +125°C,Accuracy: ±0.5°C
	pH Sensor	Measurement Range: 0-14 pH,Accuracy: ±0.1 pH

	Load Cell + HX711	Rated Load: 5kg,Output Sensitivity: 1mV/V,Gain: 128
Communication	SIM900A Mini	Operating Voltage: 3.4V-4.5V DC,GSM Frequency Bands: 850/900/1800/1900 MHz
	Ship Shaft Propeller	Diameter: 50mm,Pitch: 40mm,Blades: 2,Rotation: Clockwise
	12V 1500RPM Geared Motor	Shaft Diameter: 8mm,Rated Voltage: 12V DC,Rated Speed: 1500RPM
	Universal Shaft Coupler	Material: Aluminum,Inner Diameter: 5mm,Outer Diameter: 8mm
	Stepper Motor Pulley	Teeth: 20,Bore Diameter: 5mm,Material: Aluminum
	Stepper Motor Belt	Width: 6mm,Length: 2m,Material: Rubber
	Rollar Pipe for Conveyor	Diameter: 20mm,Length: 1m,Material: PVC
	PVC Board	Thickness: 10mm,Dimensions: 30cm x 30cm,Material: PVC Foam
	Bearing	Type: Ball Bearing,Inner Diameter: 8mm,Outer Diameter: 22mm
	Pattern Belt for Conveyor	Width: 50mm,Material: Rubber
Mechanical System	PVC Foam (Coc) Sheet	Thickness 1.5 inches

1.2.4 Technical and Non-technical consideration and constraint in design process

Technical Considerations:

Memory Overhead: The garbage collector should have minimal impact on the memory usage of the executing program. It should not consume excessive memory resources, as this can lead to reduced overall system performance.

Latency: The garbage collector should minimize the pause times or interruptions it causes in the execution of the program. High latency can be disruptive, particularly for real-time or interactive applications.

Throughput: The garbage collector should strive to maximize the overall throughput or execution speed of the program. This involves efficiently collecting and recycling garbage objects while minimizing the impact on the program's performance.

Scalability: The garbage collector should be designed to handle large heaps and workloads efficiently. It should be able to scale with the size of the program and adapt to changing resource requirements.

Correctness: The garbage collector must correctly identify and collect garbage objects while preserving live objects. It should avoid premature collection or retention of objects that are still in use.

Non-Technical Considerations:

Compatibility: The garbage collector should be compatible with the programming language, runtime environment, and existing codebase. It should not introduce incompatibilities or require significant modifications to the existing software.

Portability: The garbage collector should be portable across different platforms and operating systems. It should not be tightly coupled to a specific hardware or software environment.
Maintainability: The garbage collector should be designed in a way that facilitates ease of maintenance and future enhancements. It should be modular, well-documented, and adhere to software engineering best practices.

Resource Utilization: The garbage collector should efficiently utilize system resources such as CPU cycles, memory, and disk I/O. It should avoid excessive resource consumption that could negatively impact other system components.

Performance Predictability: The garbage collector's behavior and performance characteristics should be predictable and consistent. This enables developers to reason about the program's resource requirements and plan system deployments accordingly.

Integration: The garbage collector should seamlessly integrate with other system components, such as the runtime environment, operating system, and developer tools. It should provide appropriate APIs and interfaces for interaction and configuration.
Security: The garbage collector should not introduce vulnerabilities or expose security risks to the executing program or the system as a whole. It should adhere to secure coding practices and prevent unauthorized access or manipulation of memory.

Constraints

1.Availability of Components
2.Limited Collecting Capability
3.Can not collect deep water waste
4.Can only operate in limited distance
5.Budget
6.Weight of the structure

1.2.5 Applicable compliance, standards, and codes

The main purpose of this Floating Garbage Collector is to dispose of non-biodegradable waste. These collectors will be operating in the local areas. Therefore we have to maintain some rules and regulations or standards.

Standards:
8.B.3.1 Definition of Characteristic Waste
8.B.4.1 Accumulation of Waste at the Location of Generation
8.B.6 Treatment and Disposal Options
8.B.6.1 Treatment and Recycling
8.B.7.1 Preparation for Off-Site Treatment or Disposal of Waste
8.C.1.1 Minimization of Mixed Waste

1.3 Systematic Overview/summary of the proposed project

The heteronomous floating garbage collector project has the objective of developing a garbage collection mechanism. The project aims to design and implement a garbage collector that can identify and collect unused memory objects without requiring explicit intervention from the executing program. Key goals include minimizing memory overhead, reducing latency, and maximizing throughput. The technical approach of the project involves several steps. Firstly, algorithms and techniques will be developed to detect garbage objects in memory. This may involve tracing object references, analyzing object reachability, or utilizing other established garbage collection algorithms. Next, a garbage collection strategy will be designed to determine when and how to reclaim memory occupied by garbage objects. Strategies such as mark-and-sweep, generational collection, or concurrent collection may be considered. Additionally, mechanisms will be implemented to efficiently recycle memory from collected garbage objects, optimizing resource utilization. Through these efforts, the heteronomous floating garbage collector project aims to deliver an independent garbage collection mechanism that is efficient, reliable, and enhances memory management in programming languages and runtime environments.

1.4 Conclusion

The project aims to create a garbage collector that can identify and collect waste. The approach involves a systematic technical process encompassing garbage detection, collection strategies, memory recycling, and integration. Non-technical factors such as compatibility, portability, maintainability, performance, and security are also taken into account. The project emphasizes testing, evaluation, and documentation to ensure comprehensive assessment, further improvements, and facilitate adoption by users and developers. Ultimately, the project strives to deliver a garbage collector that enhances the ease to implement it anywhere and contributes to the overall efficiency and reliability of programming languages and runtime environments.

Chapter 2: Project Design Approach [CO5, CO6]

2.1 Introduction:

This chapter delves into the approach to designing a heteronomous floating garbage collector. The design approach, which serves as a blueprint for the development process, is critical to the success of any project. The chapter identifies and describes various design approaches for the project, followed by a detailed analysis to determine the best one. Water pollution is a major environmental issue affecting the world today, and the design approach must account for the problem's complexities. As a result, the floating garbage collector project must consider factors such as the type and amount of pollutants in the water, the location and size of the body of water, the equipment and materials needed for the project, and the potential impact on the environment and marine life. We can identify the best approach to ensure the success of the floating garbage collector project by exploring and carefully analyzing different design approaches.

2.2 Identify multiple design approach:

We will identify and discuss various design approaches for a floating garbage collector project in this chapter. GSM-based control systems, WiFi-based garbage collector, and radio-controlled garbage collector are three specific design approaches that will be investigated.

The GSM-based control system approach involves remotely controlling and monitoring the floating garbage collector using a Global System for Mobile Communications (GSM) module. The operator would be able to remotely start and stop the collector, monitor its location and status, and receive alerts when it was time to empty the garbage bin using this system.

The WiFi-based garbage collector approach involves using a WiFi module to connect the collector to a local network, allowing the operator to control and monitor the collector via a web-based application. This approach may enable more advanced features such as real-time tracking, remote diagnostics, and automated garbage collection scheduling.

The radio-controlled garbage collector method involves using a radio control transmitter and receiver to remotely control the collector. This method is better suited for smaller-scale applications where the operator is close to the collector and has a clear line of sight.

Overall, each design approach has advantages and disadvantages, and the approach chosen will be determined by factors such as project size and scope, budget constraints, and the level of control and monitoring required. The following section will go over each design approach in greater detail.

2.3 Describe multiple design approach:

Approach 1(GSM based control system)

A GSM-based control system is one of the design approaches for a floating garbage collector project. The proposed plan calls for the creation of a rover-like vehicle with a collection box in the center. An ultrasonic sensor will be used by the vehicle to constantly monitor its surroundings and detect any obstacles. If an obstacle is detected, the system will analyze its movement pattern and, if necessary, activate the conveyor belt. The operator can direct the vehicle to move in a specific direction by using a GSM module.

When the vehicle detects floating garbage or the operator identifies an obstacle as garbage, the system uses the conveyor belt to collect the garbage. The garbage will be stored in compartments within the tank as the collection process continues, while water will be released through the permeated hole at the bottom. A weight sensor will be integrated into the system to detect the limit of the collected garbage and signal the conveyor belt to stop.

Overall, this design approach offers a feasible solution for collecting floating garbage in bodies of water. The GSM module enables remote vehicle control, while the ultrasonic sensor and weight sensor ensure accurate and efficient garbage collection.

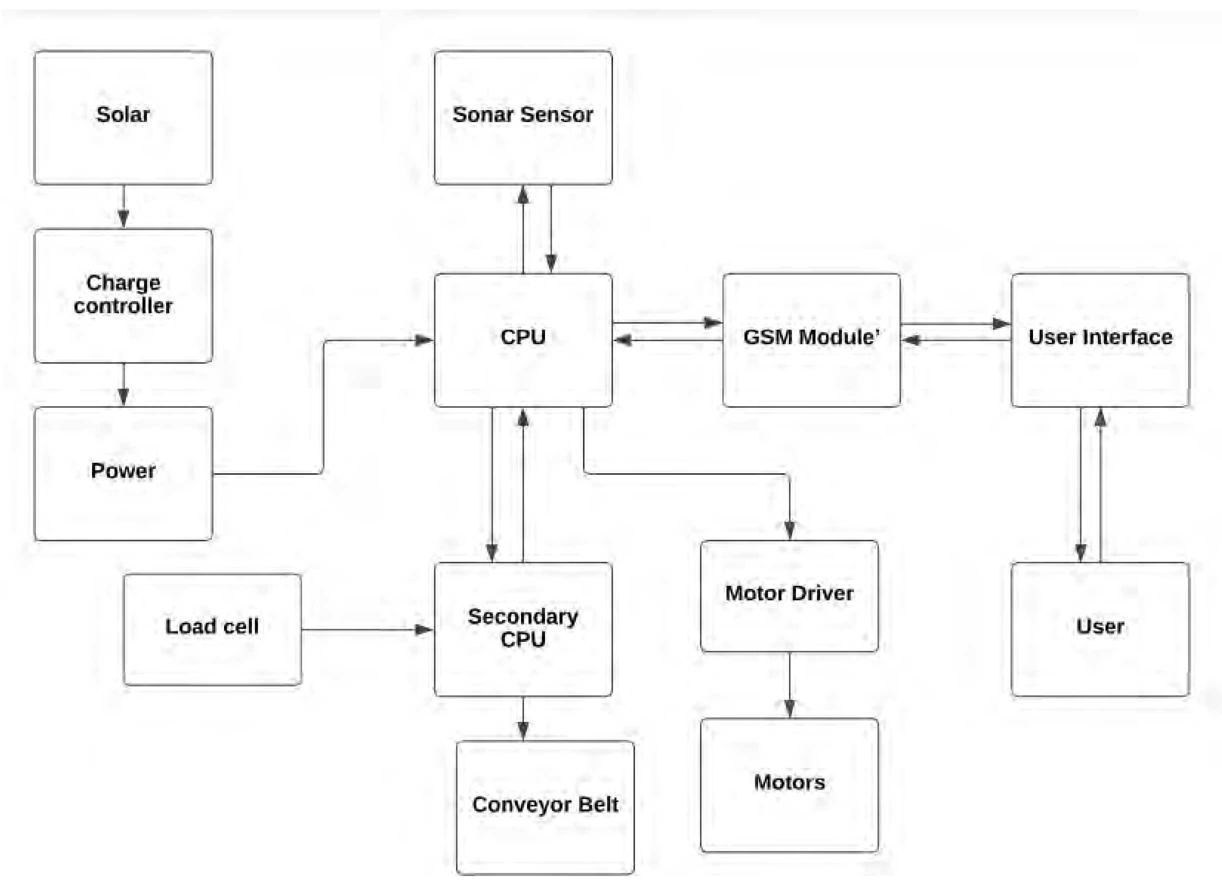


Fig.1- GSM based control and hybrid autonomous system [13]

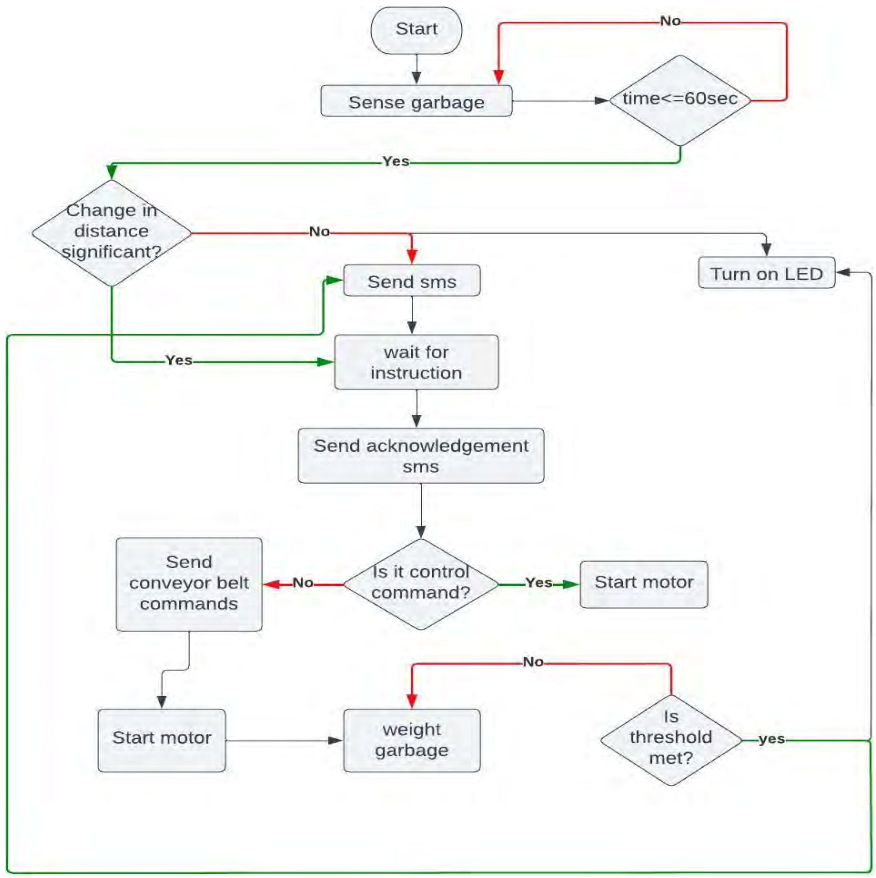


Fig: Workflow diagram of approach 1

A boat-like vehicle with a collection box will be modeled for the prototype of the Wifi-based garbage collector in this proposed design approach. The vehicle will be outfitted with an ultrasonic sensor that will constantly monitor its surroundings. Furthermore, the boat will have an advanced obstacle avoidance algorithm to avoid collisions or obstructions with minimal user intervention. When the vehicle detects garbage, it will use the DIY Seabin prototype to pick it up and notify the user to turn on the motor inside the suction chamber. When activated, the surrounding water and garbage are suctioned into the chamber. The garbage will be filtered and temporarily stored in the bin, while the water will be expelled from the craft's exterior via a one-way valve.

The vehicle will continuously send the user information about the amount of garbage collected, and when the threshold is reached, it will autonomously navigate to the docking station for recharging. To facilitate proper disposal, the docking station will be able to sort various types of garbage, such as floating, organic, and sedimenting garbage. This method will make use of WiFi technology to improve the efficiency of garbage collection.

Approach 2 (Wifi based garbage collector)

The proposed approach for a WiFi-based garbage collector entails the development of a boat-like vehicle equipped with a collection box and a sophisticated obstacle avoidance algorithm to navigate waterways. The vehicle uses an ultrasonic sensor to constantly monitor its surroundings and identify garbage to be picked up using a DIY Seabin prototype. When garbage is detected, the vehicle prompts the user to activate the motor inside the suction chamber, which suctions in both the garbage and the surrounding water. The collected garbage is filtered and temporarily stored onboard, while the water is expelled to the craft's exterior via a one-way valve.

To improve the performance of the garbage collector, the vehicle sends information to the user when the garbage reaches a pre-set threshold. To improve the garbage collector's performance, the vehicle sends information to the user when the garbage reaches a predetermined threshold, after which it returns to the docking station for recharging. The docking station also has a garbage sorting mechanism that separates floating, organic, and sedimenting materials.

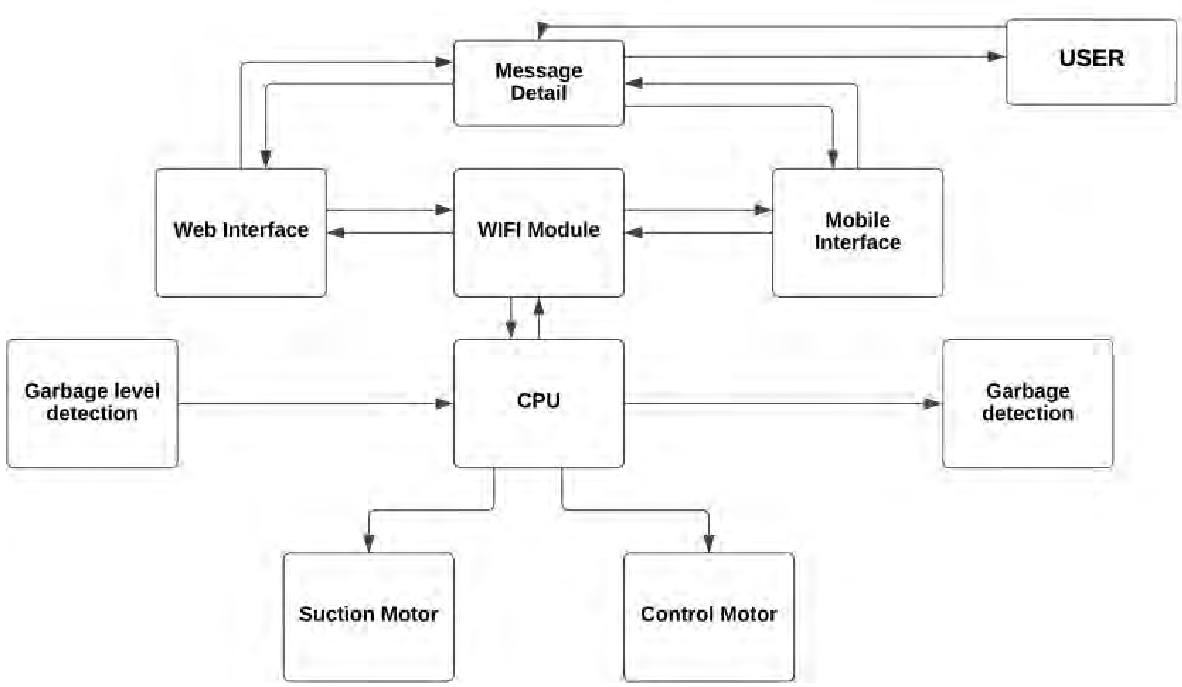


Fig.2-Wifi based garbage collector [12]

Overall, the proposed system offers an innovative solution to the problem of water pollution caused by floating debris. The use of a Wifi-based garbage collector that can navigate autonomously, pick up debris efficiently, and properly sort the collected garbage aligns with the need for long-term solutions to environmental problems. Future research could look into the viability of scaling up this technology for wider use and evaluating its effectiveness in real-world scenarios.

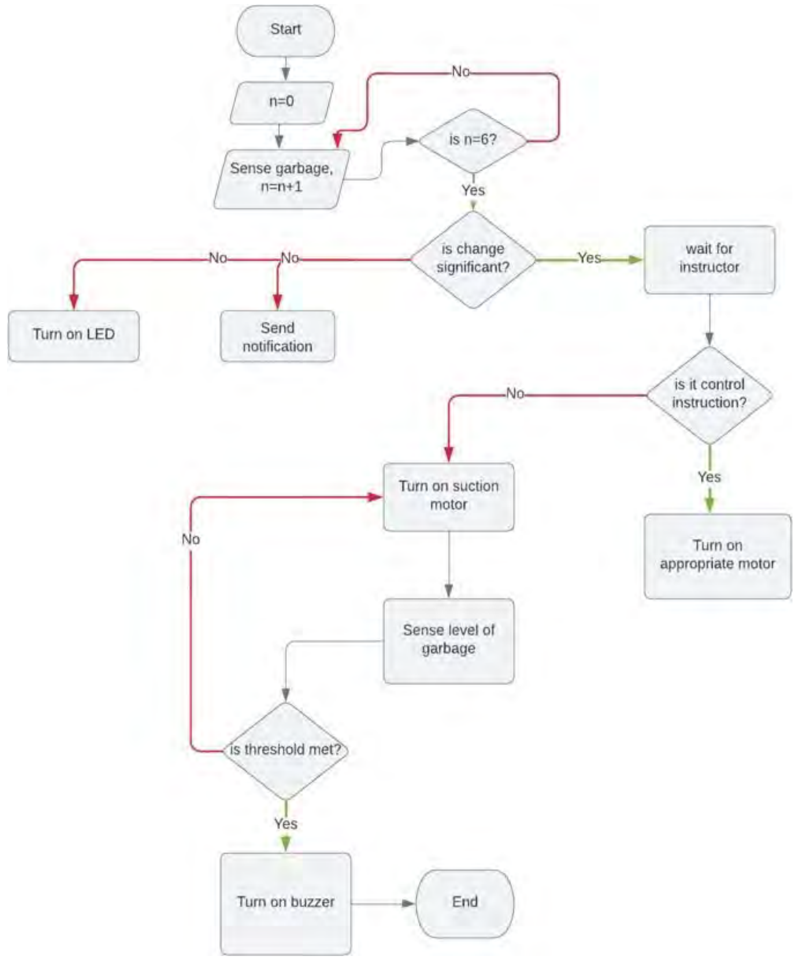


Fig: Workflow diagram of approach 2

Approach 3 (Radio Controlled Garbage Collector)

A radio-controlled boat-like vehicle with a centrally located collection basket is proposed for garbage collection. Infrared and LIDAR sensors are built into the vehicle to scan the environment and avoid obstacles. When floating garbage is detected, a mechanical arm with three servo motors is activated, and the garbage is collected and placed in a collection basket. Using a radio controller, the user has complete control over the vehicle's movement, allowing them to navigate through the water and prioritize garbage collection in areas of their choosing. To avoid any potential risks, the vehicle can also be controlled manually.

This method provides an efficient and user-friendly solution for garbage collection on bodies of water. The incorporation of infrared sensors and servo motors improves the vehicle's performance and ability to navigate through difficult conditions. The user's complete control over the vehicle ensures flexibility in garbage collection, allowing them to prioritize areas and optimize the collection process.

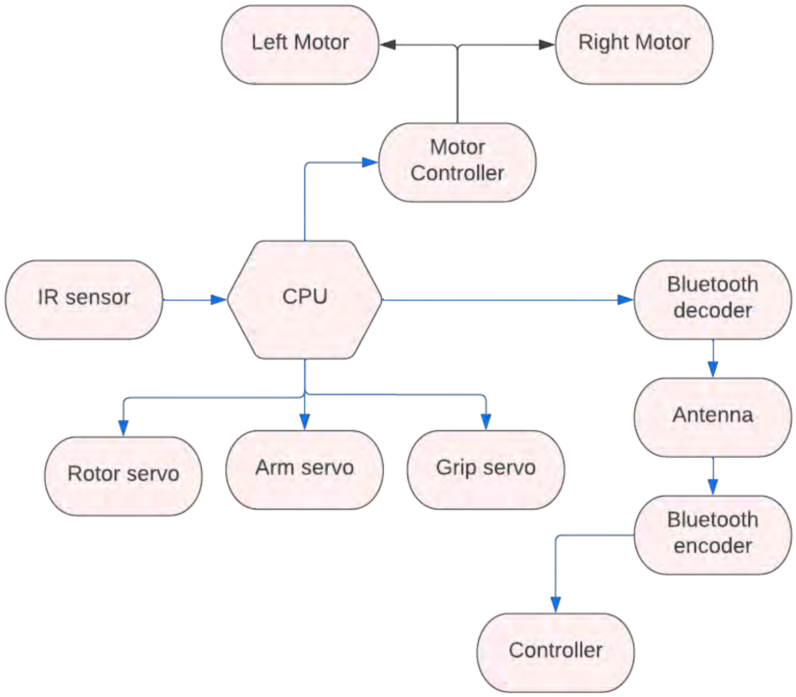


Fig.3-Radio based garbage collector[11]

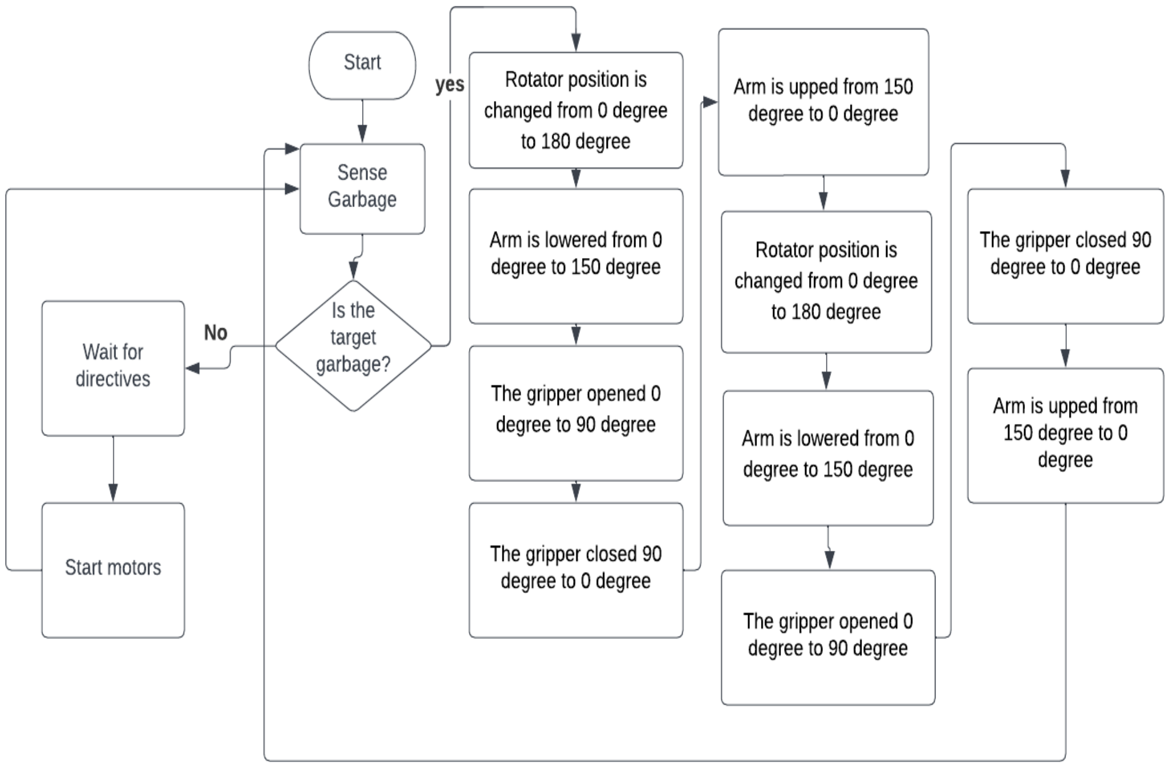


Fig: Workflow diagram of approach 3

2.4 Analysis of multiple design approach

Table 4. Comparative analysis between approaches:

	Approach 1	Approach 2	Approach 3
Controlling medium	GSM based	Wifi based	Radio based
Controlling interface	SMS	Software based ground station system	Controller and monitor required
Power	Only uses inefficient version of solar power	Requires hybrid of solar and grid power	Efficient power distribution(solar)
Acquiring information	SMS based information transfer	Blynk server	Physical means
Emergency	Sms alert	App Notification	N/A
Recovery	N/A	Recovery operation	N/A

Here all factors will be taken into consideration, price, dimensions, controllability, efficiency and will be put on a weighted chart (given below) and it will assess the optimal design to build. After deliberation and reading literature, the approaches will come out with almost similar pros and cons. But the proposed approach will have all the features and ease of construction for mass production and collection capability.

2.5 Conclusion

Last but not least, the chapter on the project design approach concentrated on identifying, outlining, and evaluating various design approaches to creating a waste collection system. Through this process, a number of potential solutions were examined, each with a distinct set of benefits and drawbacks.

The methods included using scooper arms, conveyor belts, seabins, and other devices, each with its own level of collection effectiveness and reach. The chapter then went on to analyze these strategies, based on some analytical comparison criterion and found that the first approach had some initial benefits to it.

Chapter 3: Use of Modern Engineering and IT Tool. [CO9]

3.1 Introduction:

Modern engineering and IT tool integration has revolutionized the fields of innovation and design. The development of technology has allowed engineers to produce intricate designs and products that were previously thought to be unattainable. Engineers can now develop and test their designs quickly and effectively thanks to the use of modern engineering tools like rapid prototyping, finite element analysis, and computer-aided design (CAD) software. However, the development of IT tools like the Internet of Things (IoT), cloud computing, and big data analytics has given engineers new opportunities to enhance their products and streamline their operations.

In this chapter, we'll talk about how modern engineering and IT tools have contributed to the creation of a practical, low-cost substitute for large commercial cleaning equipment for removing trash from confined spaces. The project aims to use a conveyor belt for garbage collection, GSM and Bluetooth control, pH and temperature sensors to monitor the water, and a conveyor belt for garbage collection. We have developed a low-cost, simple-to-assemble garbage collector that can be used by locals, small eco-friendly organizations, and agricultural businesses. This has been made possible by the use of

contemporary tools and technologies. The project's significance or impact is anticipated to be economic, social, and environmental.
The use of contemporary engineering and IT tools in the project's design and development will be discussed in this chapter. We will go over the different pieces of hardware and software used in the project, as well as the advantages and disadvantages of each tool. We will also look at how modern engineering and IT tools affect the project's overall effectiveness and efficiency. In general, this chapter will emphasize the crucial role that contemporary engineering and IT tools play in the creation of creative and long-lasting solutions to real-world issues.

3.2 Select appropriate engineering and IT tools

Table 5. Software Comparison Table:

Softwares	Portable	Import Facilities	Library (According to the project)	Usage	User Interface
Proteus	Simulation run time is fast.So,highly portable.	External libraries can be added.	Many libraries are available.	Schematic verification for digital circuits	User friendly
Pspice	Installation problems sometimes.	can add model from 3rd party websites	Several components are unavailable.	Analyze and design the basic performance of the circuit.	complex and hard to understand firstly.
Arduino	Easily accessible and no bug issues	No issues found during importing	many libraries are available	writing and uploading code is simple	simple interface that makes it easy to use.
Matlab	Crash issue occurs during simulink opening.	a lot of tools are available for analysis.	Only a few libraries are available. Add-ons are required.	Testing/ Data visualization	User friendly interface.

Proteus: Of them, we have found Proteus to be better served because of its attributes. Some of them as follows,

- Can interact with the running simulation, using switches.

- Wide range of components in its library.
- Design a schematic with the use of thousands of parts.
- Integration with popular toolchains

PSpice:

- Available at no cost
- Includes one of the largest model libraries in the industry, spanning our analog and power portfolio.
- can simulate complex mixed designs

Blender:

Blender is actually kind of a jack of all trade. It is built for multipurpose usage.

- Modeling: this is the primary aspect of this software.

Sculpting: Sculpting is pretty good in Blender. However, that is for anything less than one million polys.

- 2D &3D Diagram: Blender is the free and open-source 3D creation suite. It supports the entirety of the 3D pipeline—modeling, rigging, animation, simulation, rendering, compositing and motion tracking, even video editing and game creation. We used blender software for our 3d diagram because of its easy features.

Arduino: Another most used software for our project is Arduino uno and Arduino. Arduino Uno is a popular microcontroller development board based on 8-bit ATmega328P microcontroller.
It uses a simplified version of C/C++ language which is easily adaptable. It is an ideal board for beginners.it has multiple uses on our project.

Google Colab:

Google Colab is a free cloud-based Jupyter notebook environment that allows users to use a web browser to write and run Python code, as well as perform data analysis and machine learning tasks. It runs on Google Cloud and has access to powerful computing resources such as GPUs and TPUs.
The following are benefits of using Python and Google Colab for simulation and analysis:

- Powerful computing resources are readily available without the need for expensive hardware.
- Capabilities for cooperation and sharing with teammates or the community at large
- access to many Python libraries and packages for scientific computing and data analysis
- a single platform with the ability to document and share code and analysis
- Python's adaptability and flexibility enable quick simulation and model testing and prototyping.

Table 6. Software comparison table for 3D design:

Softwares	Criteria				
	Software Skills required	Learning Curve	3D perspective	Design Quality	Model Availability
Sketch Up	Moderate	Moderate	High	High	Low
Auto CAD	High	High	Moderate	Moderate	Low
Blender	High	Moderate	High	High	High

Table 7. Hardware comparison table(Microcontroller)

Microcontroller	Processing Power	Complexity	Cost	Ease of Use	Developer Community
Arduino Nano	Low	Simple	Low	Easy	Large
Raspberry Pi	High	Complex	Medium-High	Moderate	Large
ESP32	High	Complex	Medium-High	Moderate	Large

Table 8. Hardware comparison table(Motor Drivers; Stepper motor)s

Criteria	DRV8825 Driver	TB6612FNG Driver	A4988 Driver
Current Capacity	High	Low	Medium
Motor Compatibility	Larger motors or heavier loads	Smaller motors and lighter loads	Medium-sized motors and loads
Functionality	Similar to TB6612FNG and A4988	Similar to DRV8825 and A4988	Similar to DRV8825 and TB6612FNG
Cost	Moderately priced	Less expensive	Moderately priced
Availability	Widely available	Easily available	Widely available

Table 9. Hardware comparison table(GSM Module)

Module	Space	Range	Frequencies	Price	Energy Cost

	Requirements		supported		
SIM800L	Small	Up to 10km	GSM 850/900/1800/1900	Low-cost	Low
SIM900	Larger	Up to 35km	GSM 850/900/1800/1900	Mid-range	Moderate
SIM5320	Medium	Up to 40km	GSM 850/900/1800/1900	High-range	High

Table 10. Hardware comparison table(Bluetooth module)

	HC-05	HC-06	HM-10
Range	100m	10m	100m
Power consumption	Low	Low	Low
Price	Low	Low	High
Availability	High	High	Low
Usage in Bangladesh	Widely used	Widely used	Less common

Table 11. Hardware comparison table(Detection sensor module)

Sensor Type	Range	Accuracy	Cost	Ease of Use
IR Sensors	Short	Low	Low	Easy
Ultrasonic Sensors	Short to Medium	Medium	Medium	Moderate
LiDAR Sensors	Medium to Long	High	High	Difficult

Table 12. Hardware comparison table(Stepper motor)

Criteria	Nema 14	Nema 17	Nema 23
Torque	Lower than Nema 17	Medium	Higher than Nema 17
Speed	Higher than Nema 17	Medium	Lower than Nema 17
Load capacity	Lower than Nema 17	Medium	Higher than Nema 17
Price	Lower than Nema 17	Medium	Higher than Nema 17

Availability	Widely available	Widely available	Less common than Nema 17
Suitable for	Lighter loads and higher speeds	Medium loads and speeds	Heavier loads and slower speeds

Table 13. Hardware comparison table(Motor)

Motor Type	Advantages	Disadvantages
DC motors with L298 driver	Simple, low cost, compatible with Arduino boards	Limited speed and torque characteristics
Brushless DC motors	High efficiency, high speed, low noise	More complex control circuitry, higher cost
Servo motors	Accurate positioning, adjustable speed and torque	Limited range of motion, higher cost

Table 14. Hardware comparison table(Load Cell Amplifier)

Load Cell Amplifiers	Functionality	Noise levels	Accuracy
HX711	Popular and reliable	Low noise	Good
HX711AD	Similar functionality	Low noise	Medium
INA125	Similar functionality	Low noise	Good

Table 15. Hardware comparison table(Temperature Sensor)

Parameter	D18B20 Sensor	Thermocouple	Thermistor
Functionality	Digital output	Analog output	Analog output
Temperature range	-55°C to +125°C	-200°C to +1350°C	-50°C to +300°C
Accuracy	±0.5°C	±1-2°C	±0.1-1°C
Water resistance	water resistant	Needs waterproofing	Not waterproof
Price	Low	High	Low to moderate
Availability in Bangladesh	Available	Available	Available

Table 16. Hardware comparison table(pH Sensor):

Sensor	Functionality	pH	Sensitivity	Compatibility	Price	Water	Availability

		range				Resistance	in Bangladesh
pH sensor	Low-cost, easy-to-use	0-14	Moderate	Arduino boards	Extremely low	Water-resistant	Widely available
Glass electrode sensor	High accuracy, laboratory-grade	0-14	High	Specialized equipment	Moderate	Water-resistant	Limited availability
ISFET sensor	High accuracy, no reference electrode required	0-14	Moderate	Specialized equipment	Moderate	Water-resistant	Limited availability

3.3 Use of modern engineering and IT tools:

The design, testing, and implementation of the garbage collector were all made possible by the cutting-edge engineering and IT tools used in our project. The garbage collector was by the Arduino Nano and related hardware, while the pH and temperature sensors provided vital data for water monitoring. The Lipo Battery 3300mAh 3 cell powered the system, and the Buck Converter was used to control the voltage levels needed by the various hardware parts. The system's components could communicate wirelessly thanks to the Bluetooth HC-06 module, and it could be remotely controlled thanks to the SIM900A Mini module.
The conveyor belt was moved by the Nema 17 Stepper Motor and the DRV8825 Stepper Motor Driver, and the vehicle was propelled by the L298N Motor Driver and the 12V 1500 RPM Geared Motor.

For the 3D modeling and visualization of the garbage collector, Fusion 360 was used extensively. Before settling on the final design for production, you could create and test various design concepts using this software. The electronic circuits were tested and simulated using Proteus, allowing you to find and address any potential problems before putting the hardware in place. The microcontroller was programmed and the sensors and actuators were controlled using the Arduino IDE.
Finally, data analysis, table and visualization creation, and visualization of the performance of the garbage collector were performed using Python and Google Collab. With the aid of these tools, you were able to keep an eye on the pH and temperature of the water and modify the system as needed. A cost-effective and simple-to-make garbage collector that can be used by agricultural industries, small eco-friendly organizations, and locals was produced as a result of the use of these contemporary engineering and IT tools.

3.4 Conclusion:

Modern engineering and IT tools must be used in order to develop projects successfully and effectively. The selection and application of suitable engineering and IT tools are covered in this chapter. Engineering and IT tools should be chosen based on the project's unique needs and specifications. The right tool selection and use can lead to increased output, higher standards, and lower costs.

There was discussion of a number of contemporary engineering and IT tools, such as simulation tools and programming languages. We can create virtual models to test and simulate various scenarios using simulation tools, which eliminates the need for physical prototypes. The use of programming languages makes it possible to create software that can automate and control processes, improving their accuracy and efficiency.

All things considered, using modern engineering and IT tools is essential to the success of any project. The right tools must be chosen in accordance with the requirements of the project in order to boost output, boost quality, and cut costs. To ensure effective system development and testing in our project, we carefully considered and chose the right tools, including simulation and programming tools. We were able to test our model in a virtual testing environment by using these tools, which allowed us to avoid wasting time and money on building physical prototypes. In summary, using modern engineering and IT tools is an important and worthwhile investment for any project.

Chapter 4: Optimization of Multiple Design and Finding the Optimal Solution. [CO7]

4.1 Introduction:

In the design process, a solution is developed to satisfy a particular set of specifications. However, there are frequently multiple ways to fulfill these requirements, so the design strategy must be optimized. This chapter focuses on the optimization of various design approaches to identify the best answer to a particular issue.

The evaluation of various design alternatives according to their performance metrics is a step in the optimization of multiple design approaches. These metrics may take into account elements like electronic verification, physical verification, weighting charts, calculations, subsystem testing, and KPI verification. We can choose the strategy that best satisfies the project's requirements and constraints by weighing a variety of design options.

The next step is to develop and assess the effectiveness of the selected solution after the best design strategy has been determined. The developed solution's performance evaluation is covered in this chapter, which entails testing and assessing the system to make sure it satisfies the project's requirements.

In general, crucial steps in the design process include the optimization of various design approaches and the discovery of the optimal solution. The developed solution's performance evaluation ensures that the chosen design approach satisfies the project's requirements and produces a successful project result.

4.2 Optimization of multiple design approach

In our project there are two distinct verifications needed, electronic verification and physical verification. The following are both verification processes with test cases:

Electronic verification:

GSM Based model brief:
At the system level, we can now see that, for the initial incidence of a floating garbage, the sonic sensor senses if it is in range of the conveyor. If it senses the garbage, (for an average of 1 minute and it is fixed for the duration) then the equivalent led is lit. we then initialize the gsm module for sending messages by the AT commands for the gsm module[4][6], like AT+IPR=9600 to initialize the baud rate, AT+CMGF=1 to set SMS text mode or SMS PDU mode,AT+CNMI=2,2,0,0,0 to set the gsm to set to receive mode now for each command we send ie LEFT_MOVE, the module reads the sent data and controls the control motor accordingly.Through PIN2 to PIN5 to control the movement and PIN6 to control the NANO to start the steppers to control the conveyor belt. As the garbage reaches the threshold weight, the HX711 weight sensor sends the data to the nano and Gives LED indication to stop the motor.

Wifi based model brief:
At the initial condition, we had to set you a blynk server and connect our esp32 to it. It enables us to establish a web-based control interface. With the help of the blynk app we can also set the control interface as well as notification for particular actions. Now in the system as garbage is detected by the sonar sensor from the pulse sent by PIN 9 and an echo is sent back to PIN 8. We sense 5 echo input after the initial detection, if the distance is continuously changing more than 5%, it is assessed that it is wildlife else it is assessed as garbage and a blynk notification is sent to the user and The LED at PIN7 is Turned ON. Now, according to the user’s feedback on the web panel, the PINs 13 to 10 are turned ON or OFF to control the motor driver. Now when the user knows that garbage is nearby, they can

switch ON the internal motor that drives the suction which allows the nearby water to go through the filtered (with mesh) opening and passed through a one way valve to the back of the craft. As the garbage is collected, an external ultrasonic sensor with waterproof casing is tracking the level of the garbage and as the threshold is reached, the buzzer goes off telling the user to stop the motor. [5][13]

Radio frequency-based model brief:

The model is based on a RC controlled boat [4][6]. The user can control the vehicle heteronomously, the controls are encoded through M145026 encoder and decoded by M145027 decoder and sent to the Arduino. The IR sensor on board will continuously sense obstacles in front of it and send the data to PIN 2. If the device assesses that garbage is in front of the sensor the following occurred in order:

1. Rotator position is changed from 0 degree to 180 degree
2. Arm is lowered from 0 degree to 150 degree
3. The gripper opened 0 degree to 90 degree
4. The gripper closed 90 degree to 0 degree
5. Arm is upped from 150 degree to 0 degree
6. Rotator position is changed from 0 degree to 180 degree
7. Arm is lowered from 0 degree to 150 degree
8. The gripper opened 0 degree to 90 degree
9. The gripper closed 90 degrees to 0 degree
10. Arm is upped from 150 degree to 0 degree

Approach 1:

Testcase1: Garbage present 17cm away.

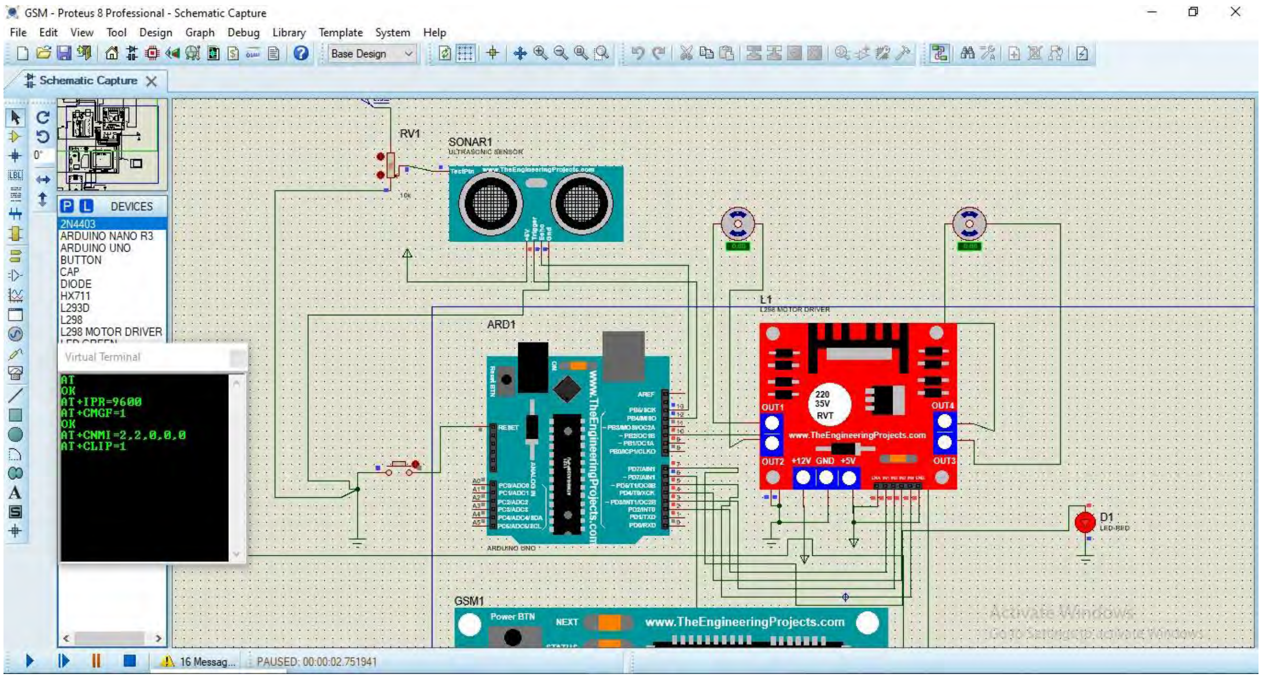


Fig: Garbage is detected and LED is turned on

Initially, as the craft nears an obstacle, it sends ultrasonic sounds and as it bounces off the target, it will assess the distance and will continuously assess it for 1 minute. If the target distance frequently changes then it will not sense the garbage otherwise it is assessed as garbage (if the frequency of change is little else it is assessed as a blockage). After garbage is assessed,(17cm in this case) a sms will be sent “Garbage detected” to the user by the gsm module and LED will light up.

Testcase2: Garbage present 10m away.

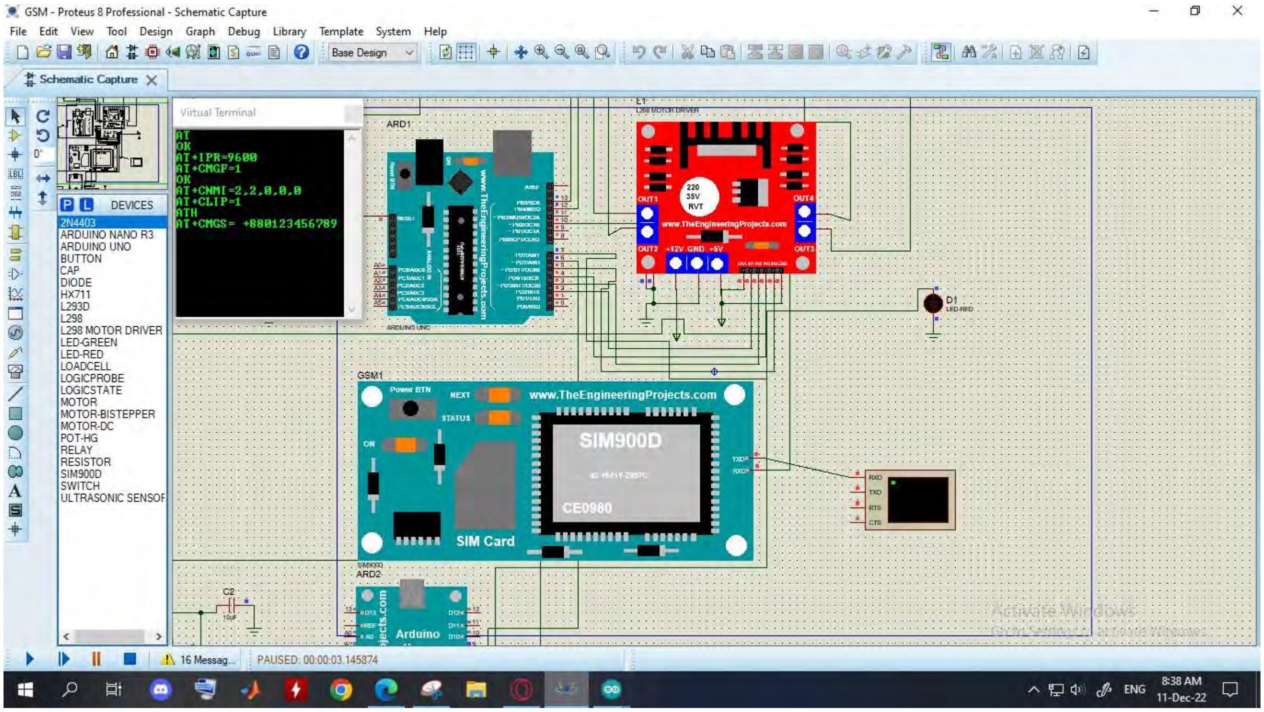


Fig: Garbage is not detected and LED is OFF

For the condition, after the initial preset settings (Baud rate is set to 9600 bps by AT+IPR,SMS mode by AT+CMGF=1 and SMS receive mode by AT+CNMI-2,2,0,0,0), As the distance of the target obstacle is more than the threshold distance. The craft will not sense anything and a sms will be sent "Garbage not detected".

Testcase3: User controls the vehicle to go to the garbage present 10m away.

As the user sees the sms "Garbage not detected", the user can send direction instructions (Forward_ motor, Backward motor, Left motor, Right motor) through sms.

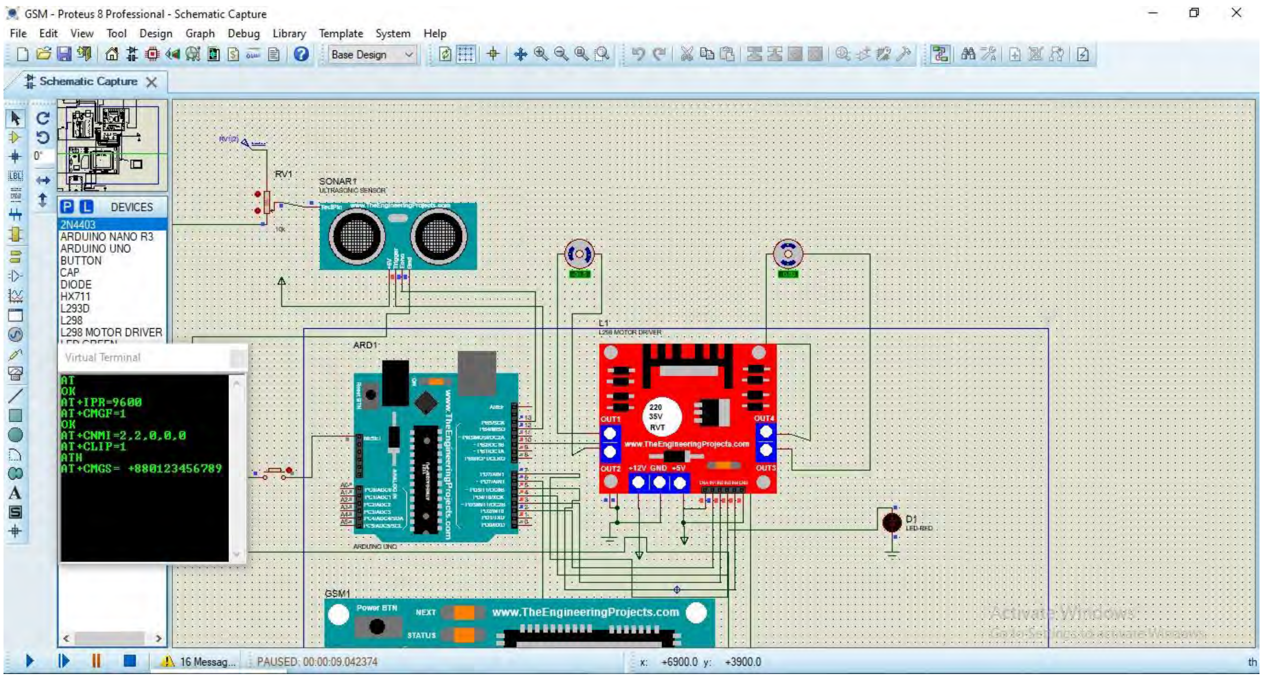


Fig: Craft is moving forward

As the forward instruction is received by the gsm module, the PIN 2 is in LOW state and PIN 3 is in HIGH state. And the DC motor in Input 1 will start(clockwise).

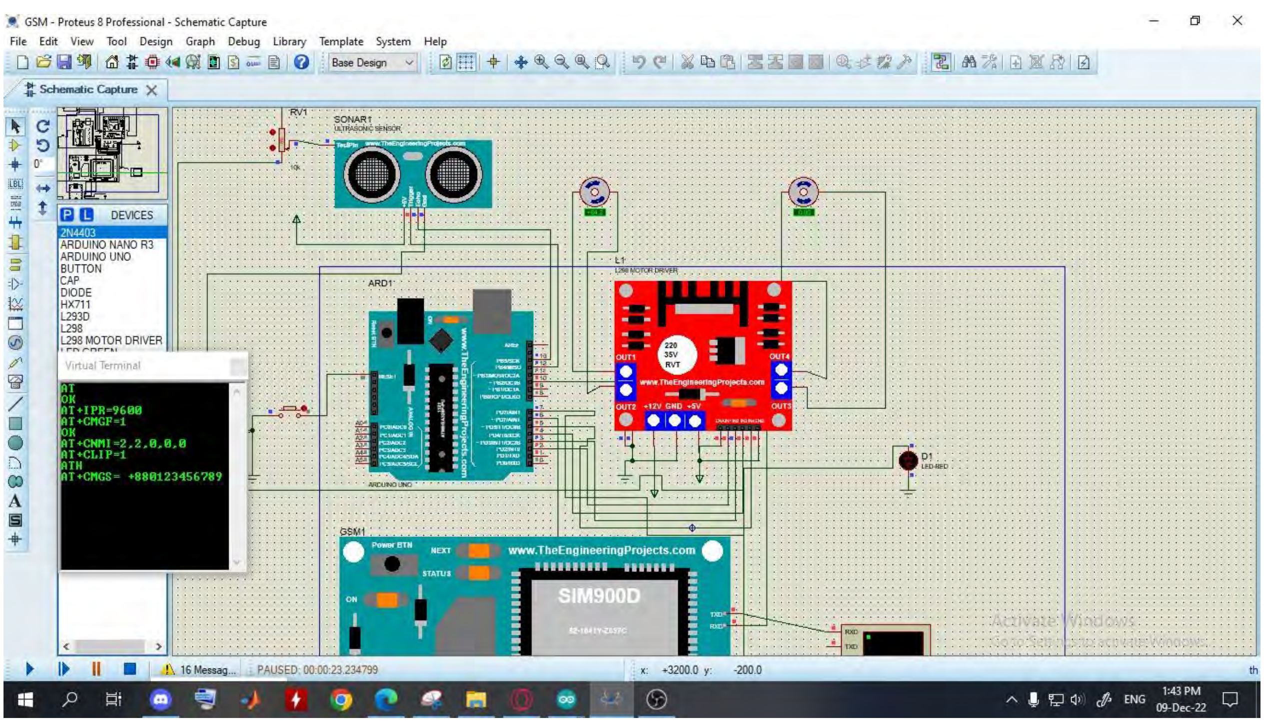


Figure: Craft is moving backwards

As the Backward instruction is received by the gsm module, the PIN 3 is in LOW state and PIN 2 is in HIGH state. And the DC motor in Input 1 will start(anticlockwise).

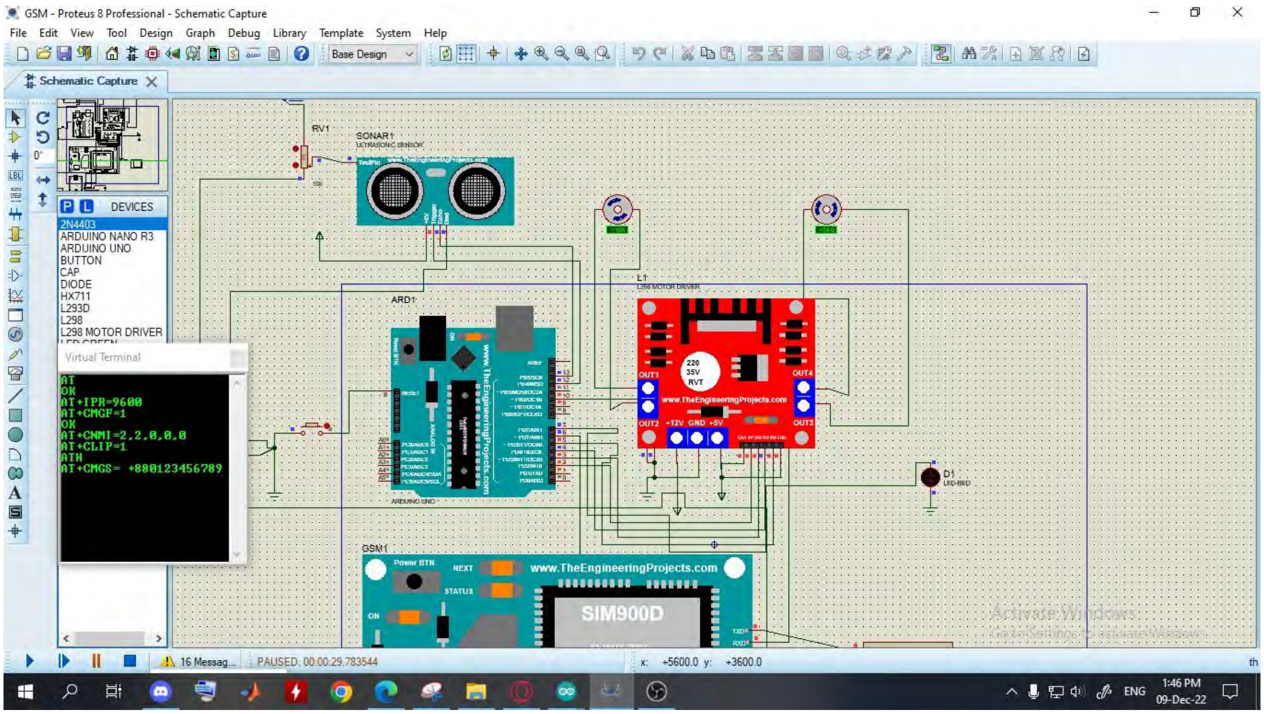


Figure: Craft is moving left

As the Left instruction is received by the gsm module, the PIN 4 is in LOW state and PIN 5 is in HIGH state. And the DC motor in Input 2 will start (clockwise).

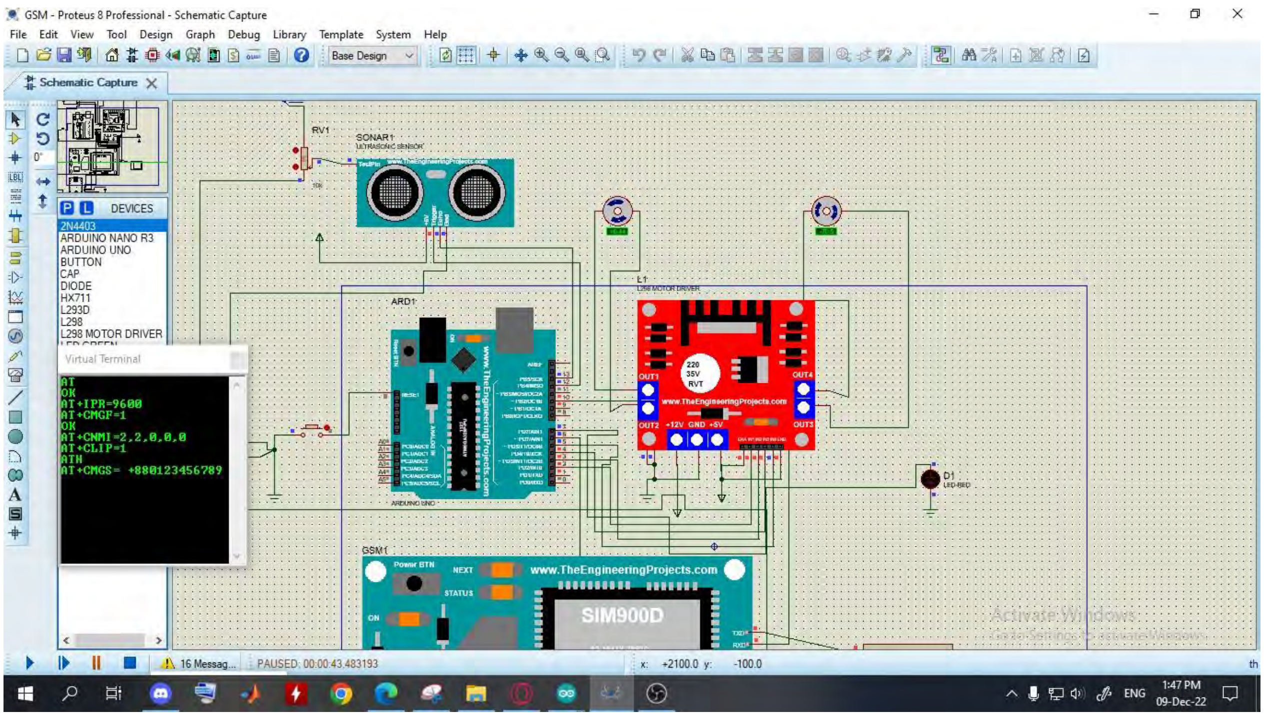


Figure: Craft is moving right

As the Left instruction is received by the gsm module, the PIN 5 is in LOW state and PIN 4 is in HIGH state. And the DC motor in Input 2 will start (anti-clockwise).

Test Case 4: Garbage is nearby and user is informed

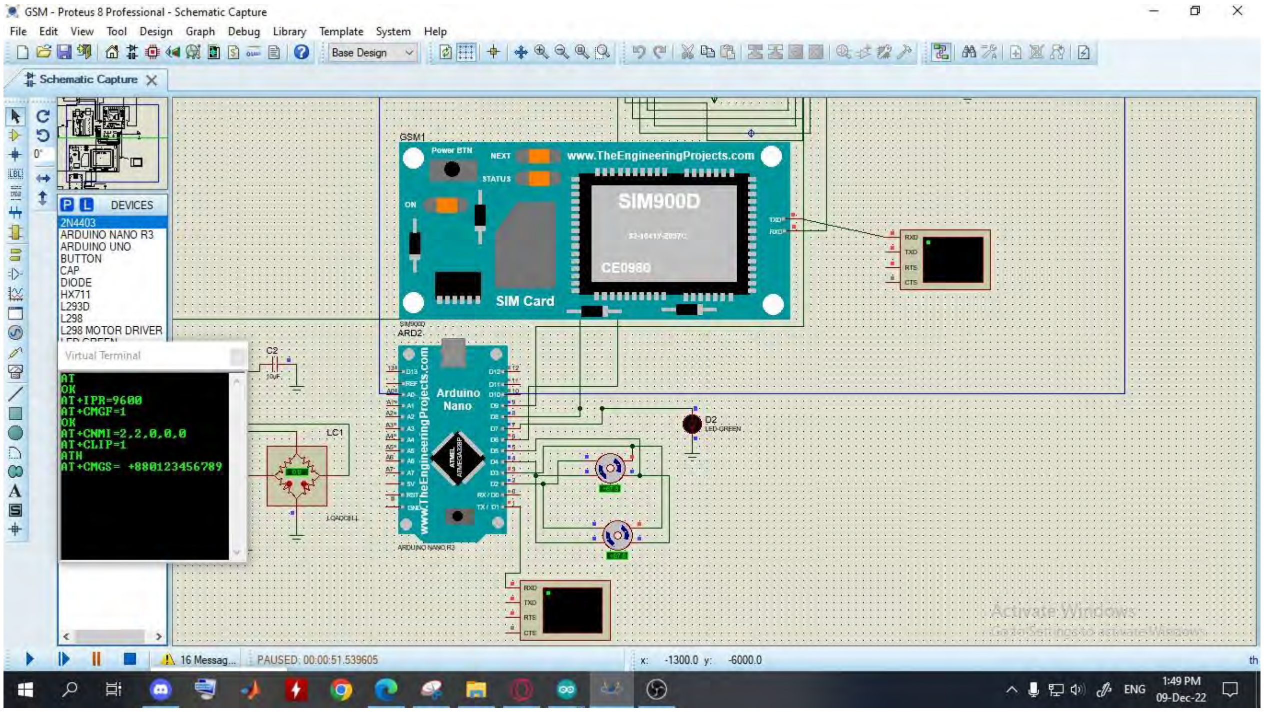


Fig:User turns on the conveyor belt

In this case, an sms was sent to the user.After the sms is sent the user gives instructions to turn on the conveyor belt.As the instruction is sent PIN 6 of the arduino uno sends information to the PIN 6 of Nano and the nano starts the stepper motors connected to PIN 2 to PIN 4.

Test case 5: Garbage is collected but threshold weight isn't reached

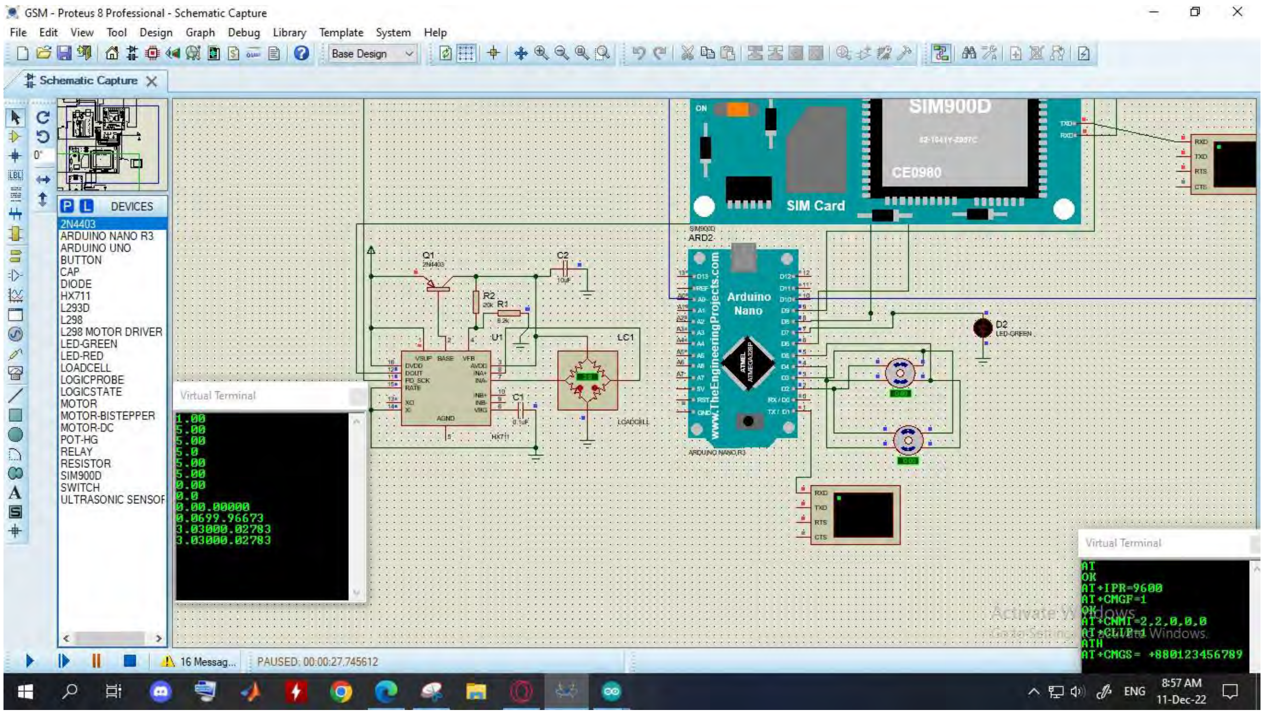


Fig:Weight max wasn't reached and LED is turned off

In this stage the HX711 calibrates with the average values the load cell puts out and checks for any abnormalities and then set to the preset voltage value for 0 as it removes any excess weight on it (Tare operation).The weight will then show for each kilogram of garbage collected.As the steppers are collecting garbage,the weight is measured every 4-5 sec (internally) and for this case the value did not surpass 9 kg thus the led did not light up and the feedback wasn't sent back to the gsm module.

Test case 6: Garbage is collected but threshold weight is reached

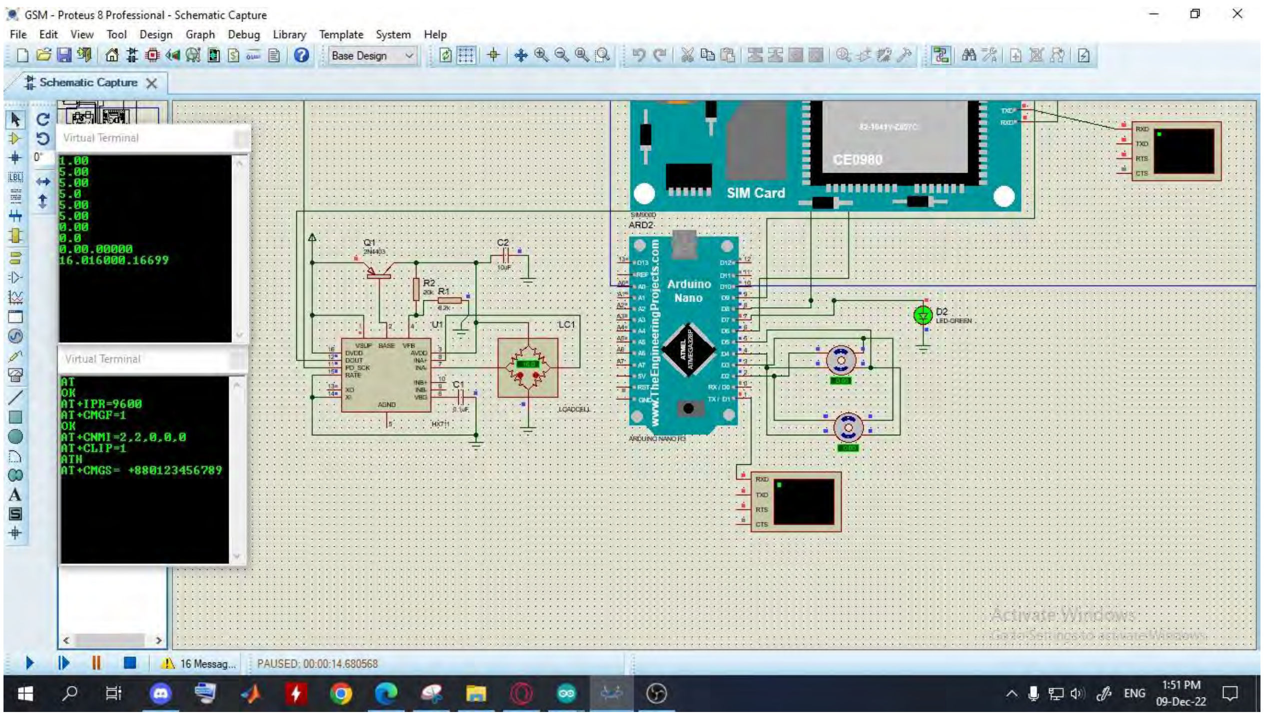


Fig: Weight max reached and LED is turned on

In this stage the HX711 calibrates with the average values the load cell puts out and checks for any abnormalities and then set to the preset voltage value for 0 as it removes any excess weight on it (Tare operation).The weight will then show for each kilogram of garbage collected. As the steppers are collecting garbage, the weight is measured every 4-5 sec (internally) and for this case the value (output/1000) did surpass 10 kg thus the led at PIN 7 lit up and the feedback was sent back to the gsm module.

Approach 2: Testcase1: Garbage present 17cm away.

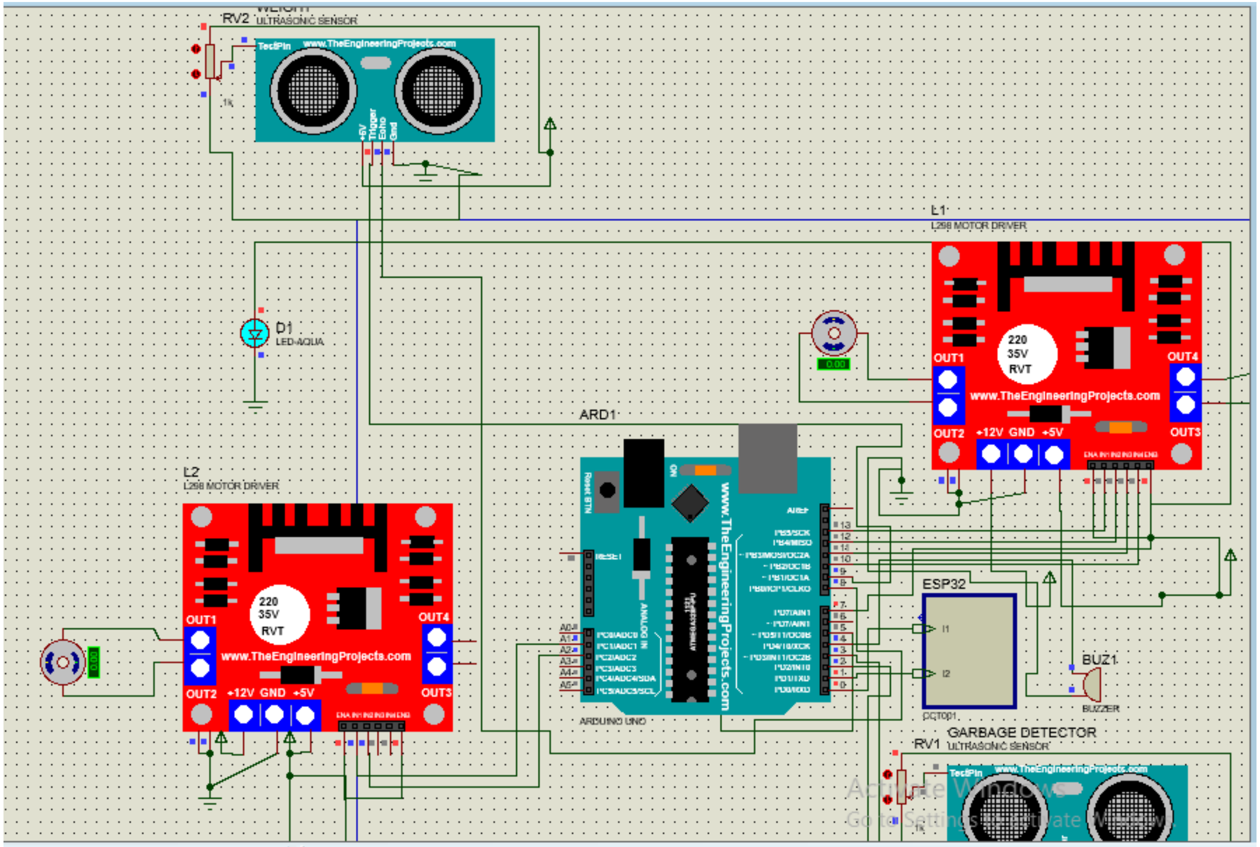
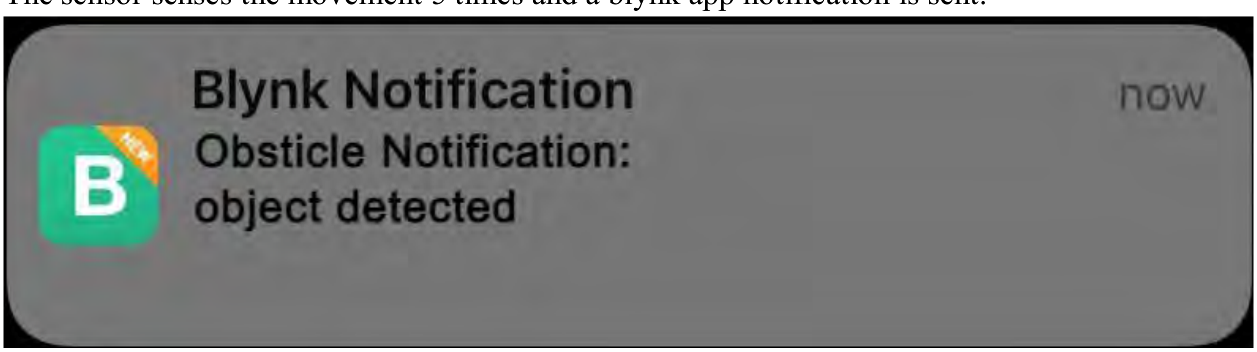


Fig: The Garbage is detected and LED is turned on

Initially, as the craft nears an obstacle, it sends ultrasonic sounds and as it bounces off the target, it will assess the distance and turn on the led at PIN 7 and continue to assess the distance 5 more times. If the target distance frequently changes (more than 5%) then it will not sense the garbage otherwise it is assessed as garbage(if the frequency of change is little else it is assessed as a blockage).After garbage is assessed,(17cm in this case) a Blynk app notification will be sent "Obstacle detected" to the user by the server.

Testcase1(b):

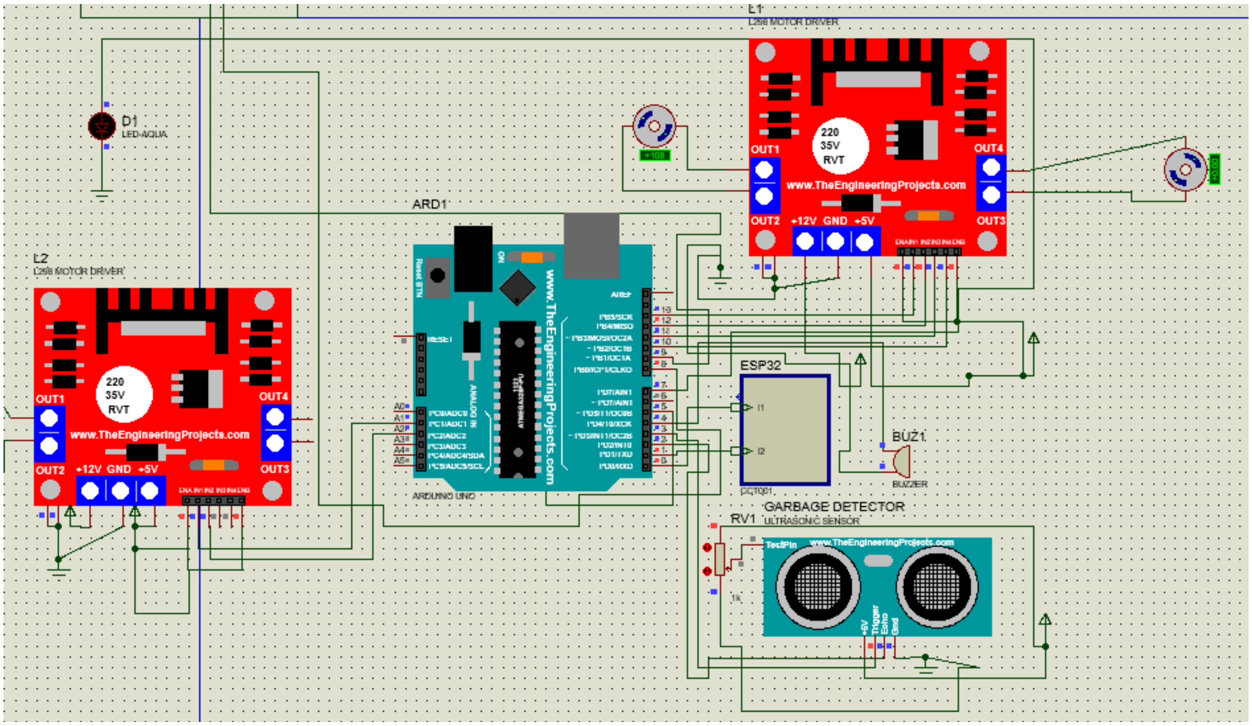
The sensor senses the movement 5 times and a blynk app notification is sent.



As the distance is read for the average 5 values, ESP32 will send a trigger signal to the blynk server.

The Blynk app sends a notification as it senses the event (the average 5 reading of the sensor is the trigger).

Testcase2: Garbage present 10m away.
Garbage is not detected and LED is OFF



In this instance the sonar sensor connected to PIN 8 and PIN 9 of the microcontroller sends data and for an average distance of 5 inputs it will assess if it is garbage or not. As the distance of the target obstacle is more than the threshold distance. The craft will not sense anything.

Testcase3: User controls the vehicle to go to the garbage present 10m away.

As the user sees no obstacle notification, the user can send direction instructions (Forward, Backward, Left, Right) through the Blynk web server.

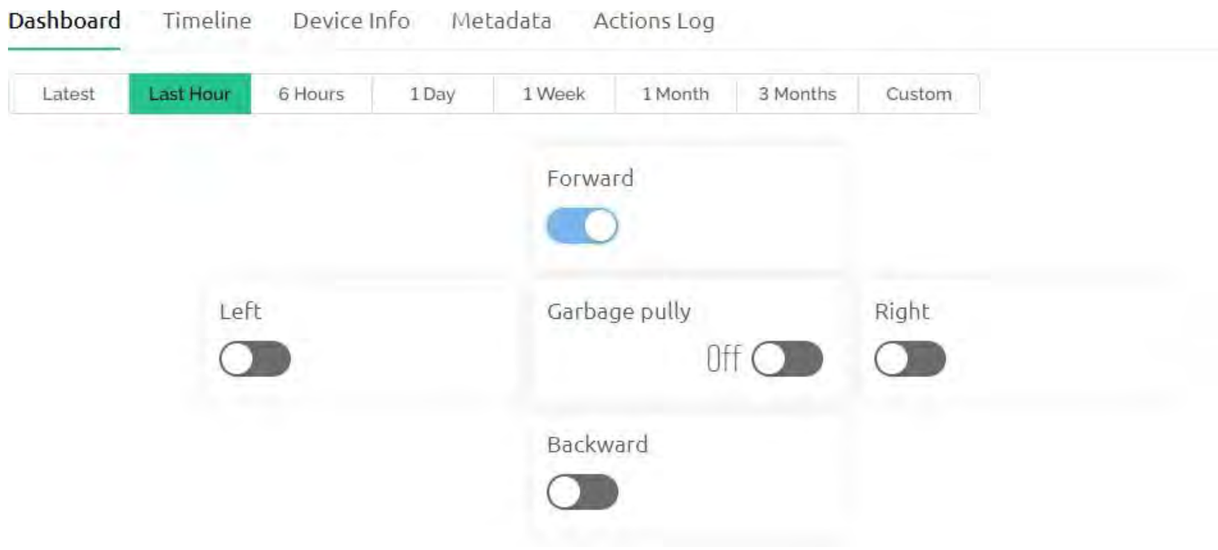
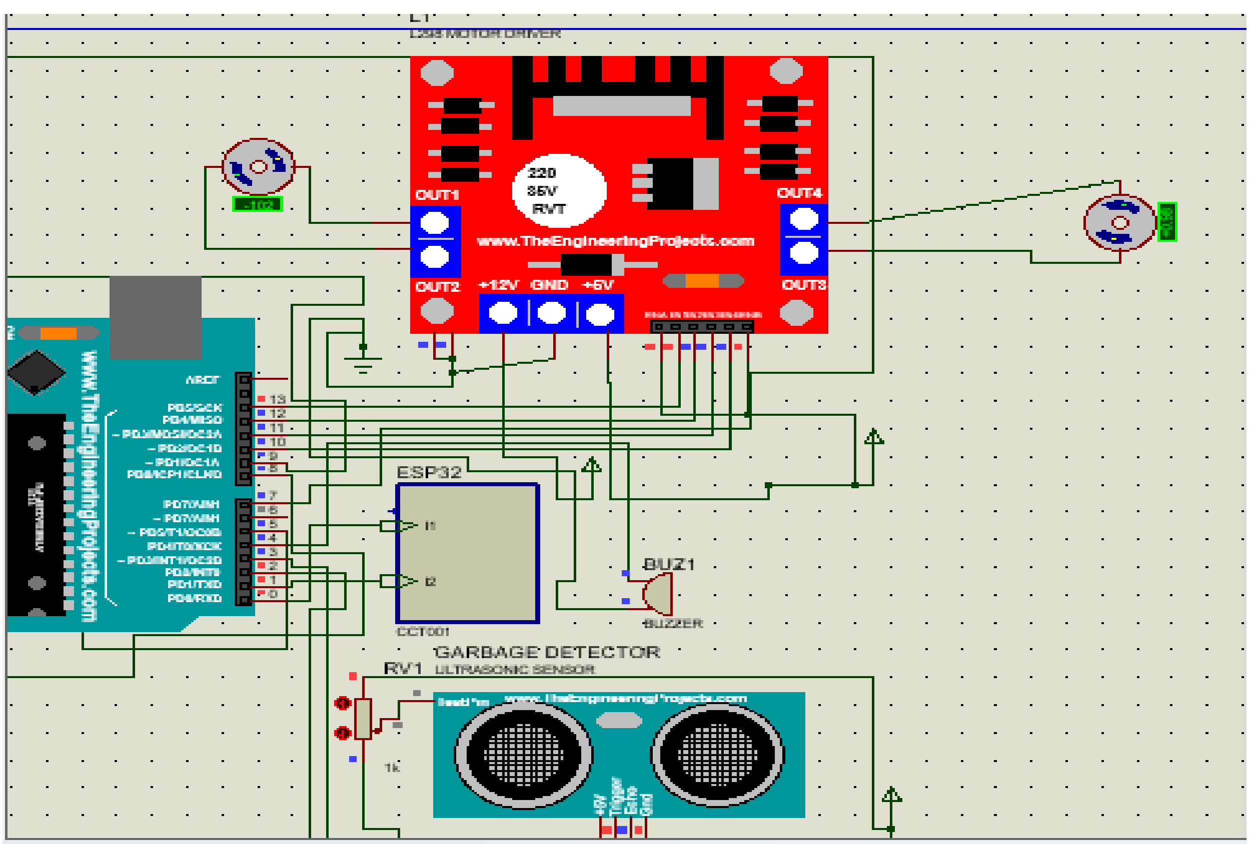


Fig: Web interface (Control system)



The web server interface has control buttons for movement (Forward is connected to PIN13, backward is connected to PIN12, Left is connected to PIN11, Right is connected to PIN10). For this instance, the user pushes the forward button. And the PIN13 is activated and motor of input 1 is activated(clockwise)

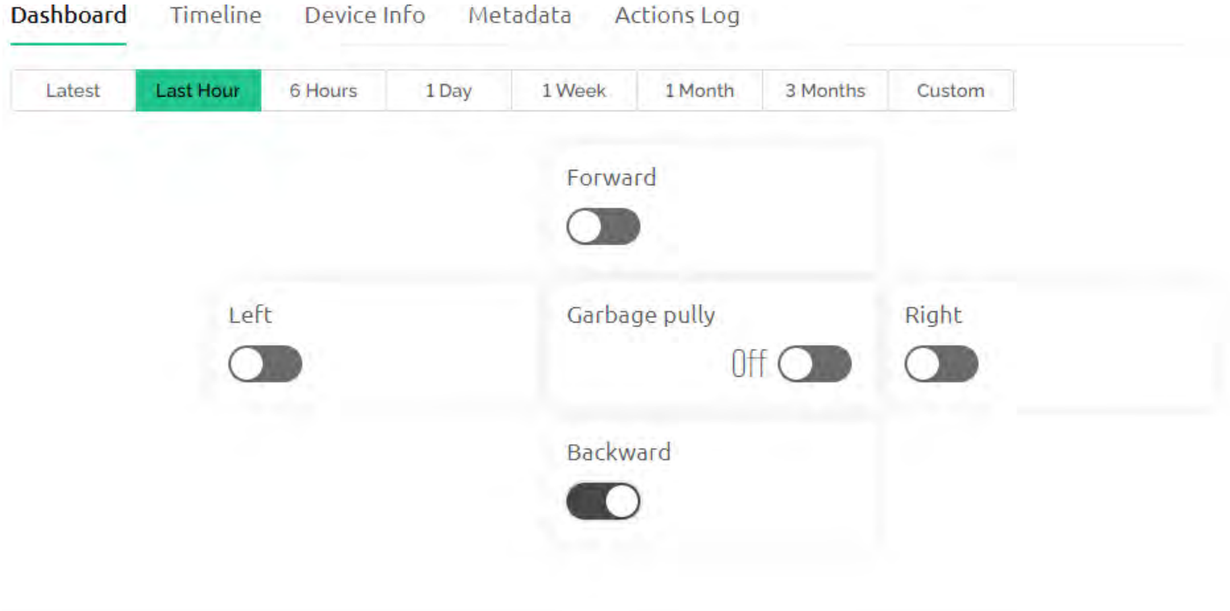
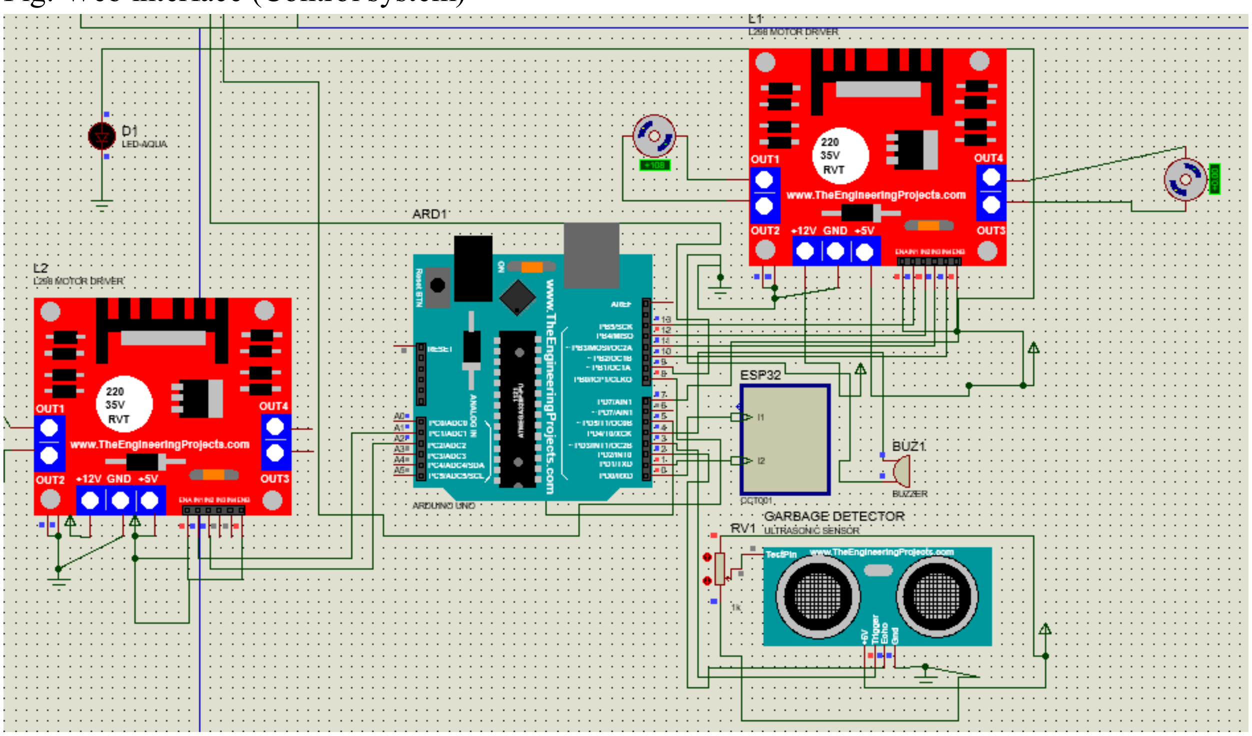


Fig: Web interface (Control system)



The web server interface has control buttons for movement(Forward is connected to PIN13,Backward is connected to PIN12,Left is connected to PIN11,Right is connected to PIN10).For this instance the user pushes the Backward button. And the PIN12 is activated and motor input activated(anticlockwise)

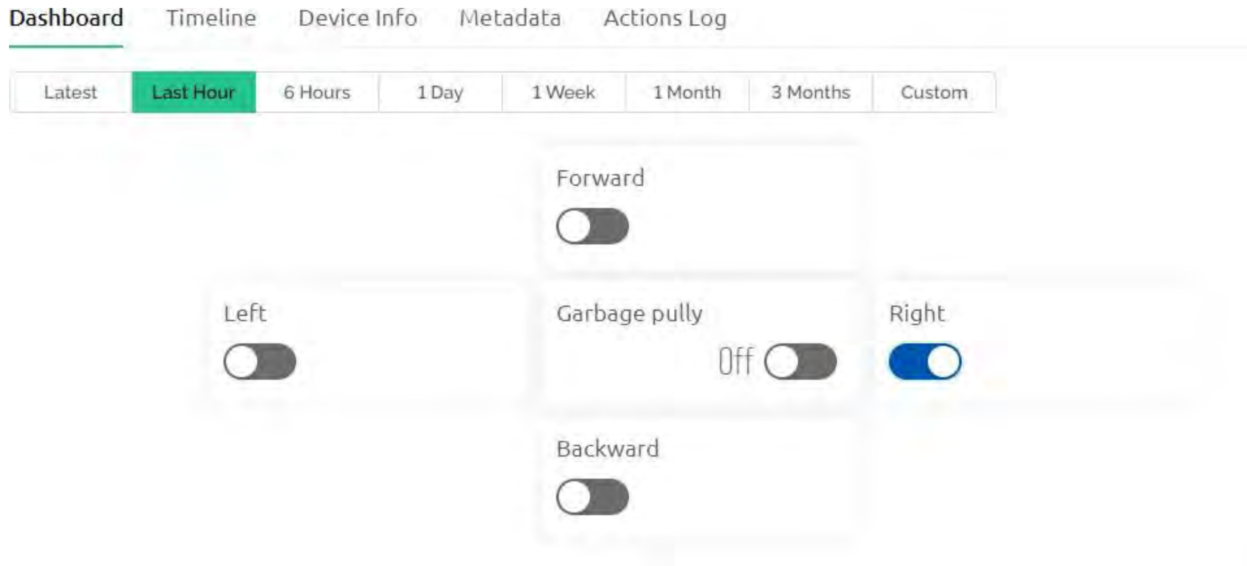
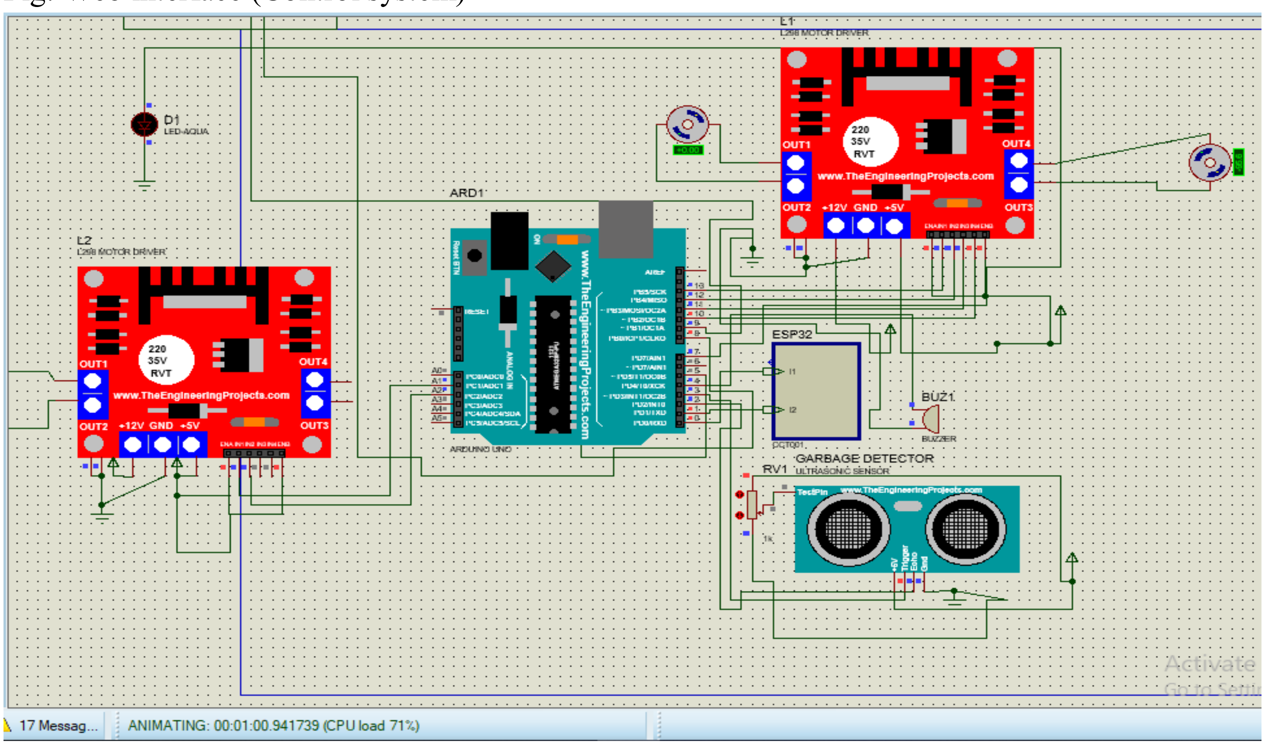


Fig: Web interface (Control system)



The web server interface has control buttons for movement (Forward is connected to PIN13, Backward is connected to PIN12, Left is connected to PIN11, Right is connected to PIN10). For this instance the user pushes the right button. And the PIN10 is activated andmotorofinput2isactivated(clockwise)

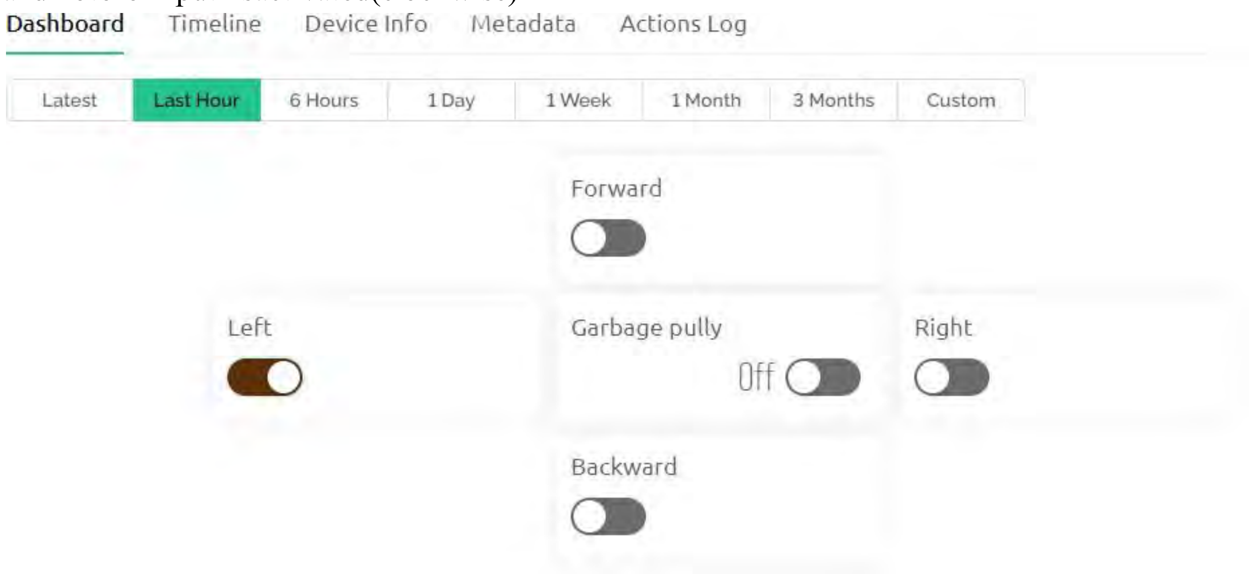
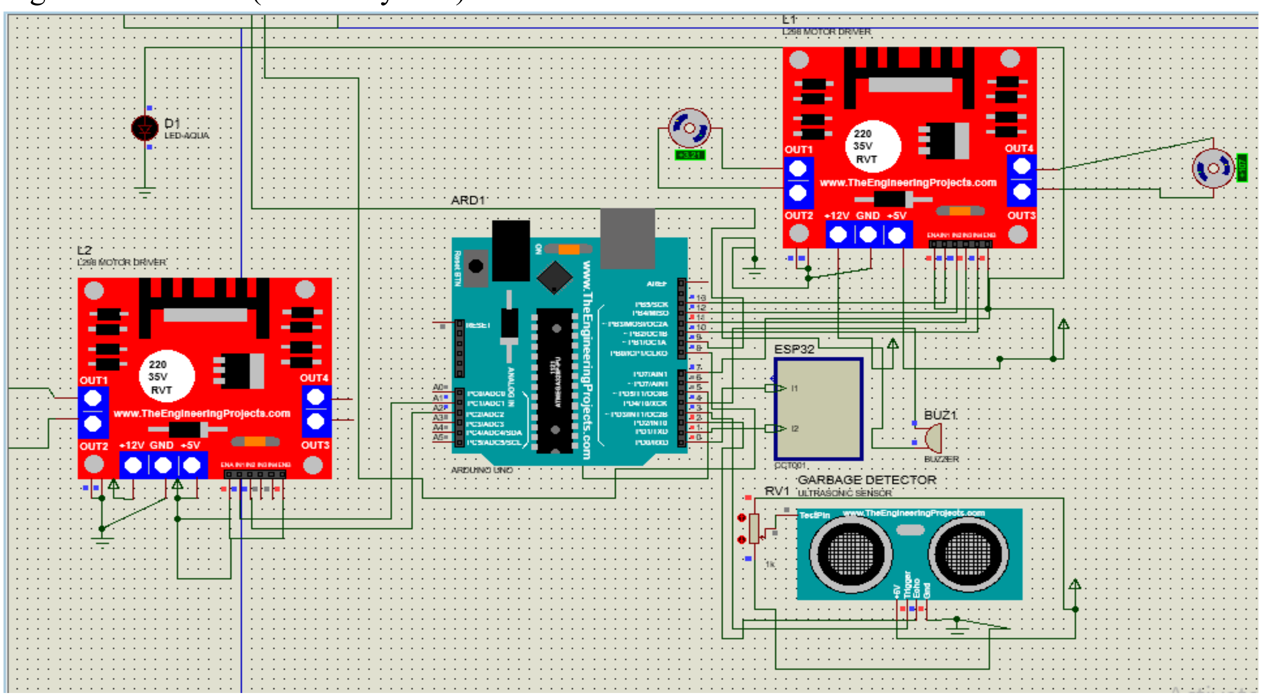


Fig: Web interface (Control system)



The web server interface has control buttons for movement (Forward is connected to PIN13, backward is connected to PIN12, Left is connected to PIN11, Right is connected to PIN10). For this instance, the user pushes the left button. And the PIN11 is activated and motor of input 2 is activated(anticlockwise)

Test Case 4: Garbage is nearby and user is informed

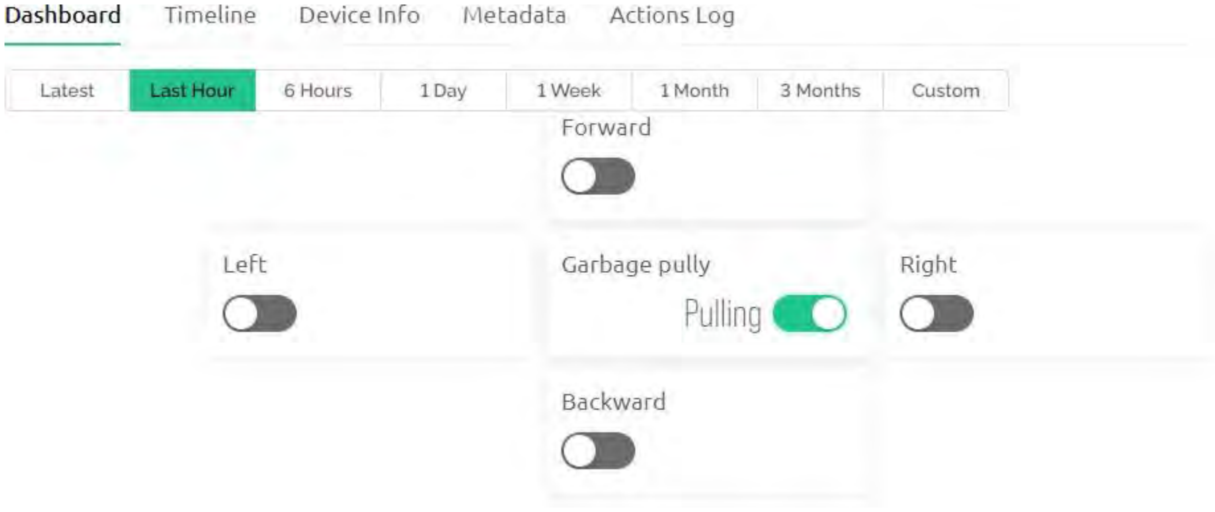
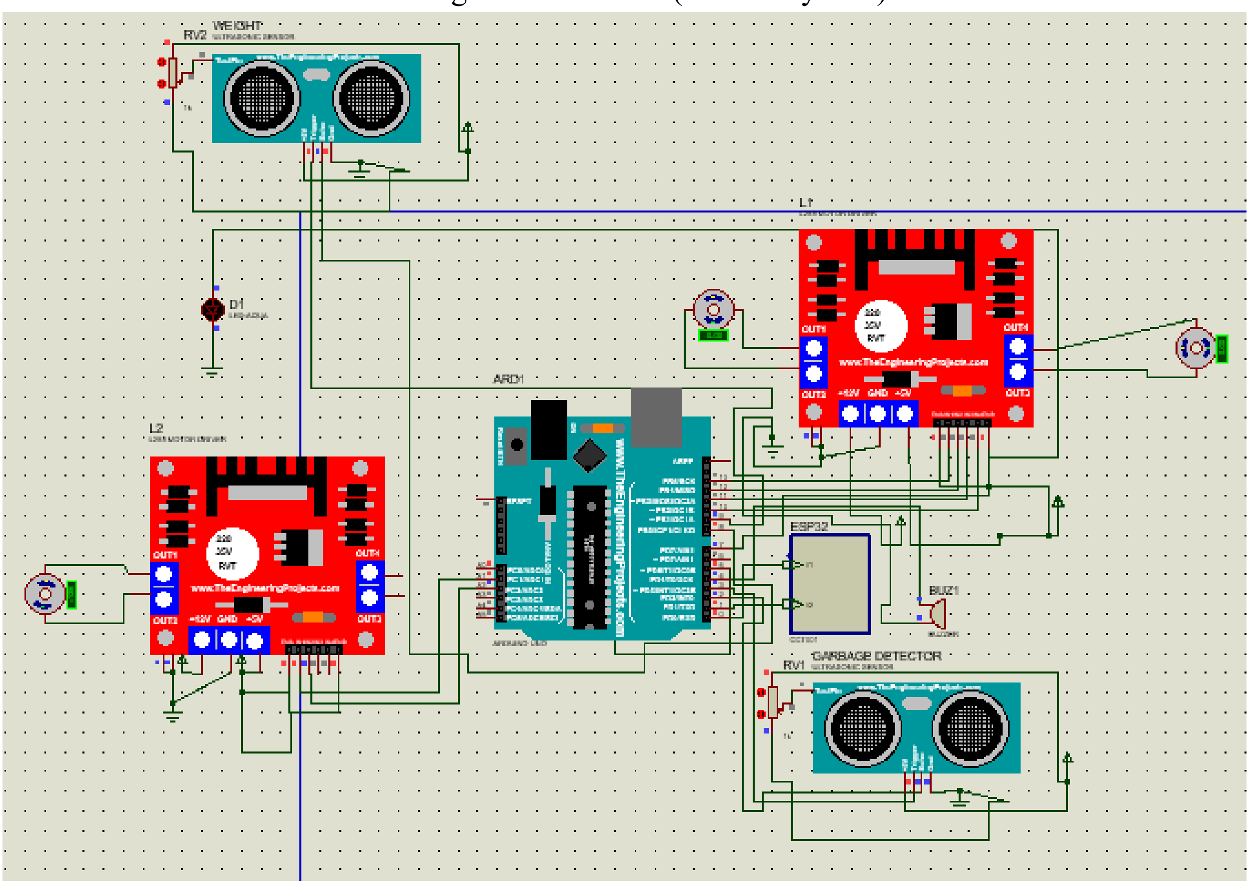


Fig: Web interface (Control system)



Initially as the garbage is detected and the user is sent a notification, the user can press the pulling button to start the suction motor. Which will activate the motor connected to PINS A1 and A2 inside the chamber and the filtered water will be passes through a one-way valve to the back of the craft.

Test Case 5: garbage is collected but threshold isn't met.

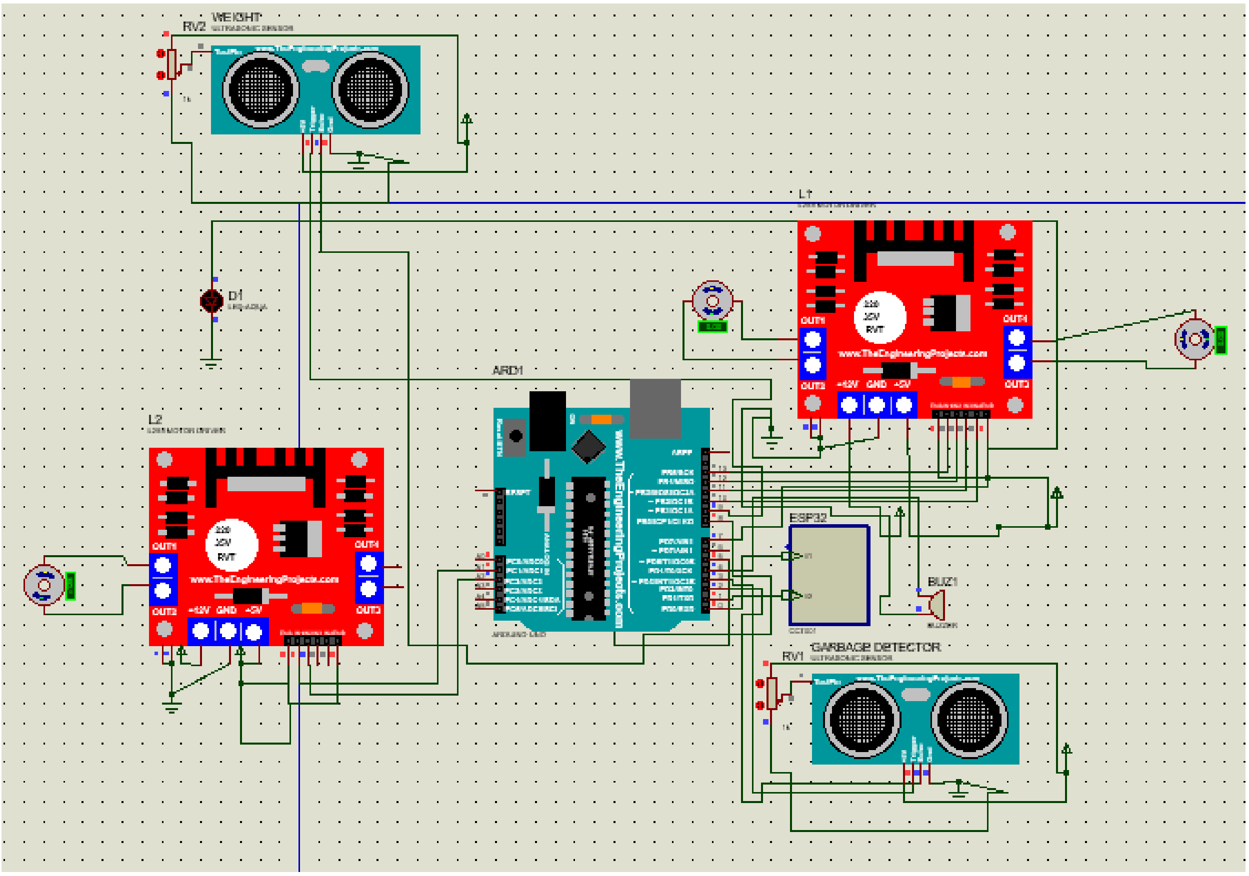
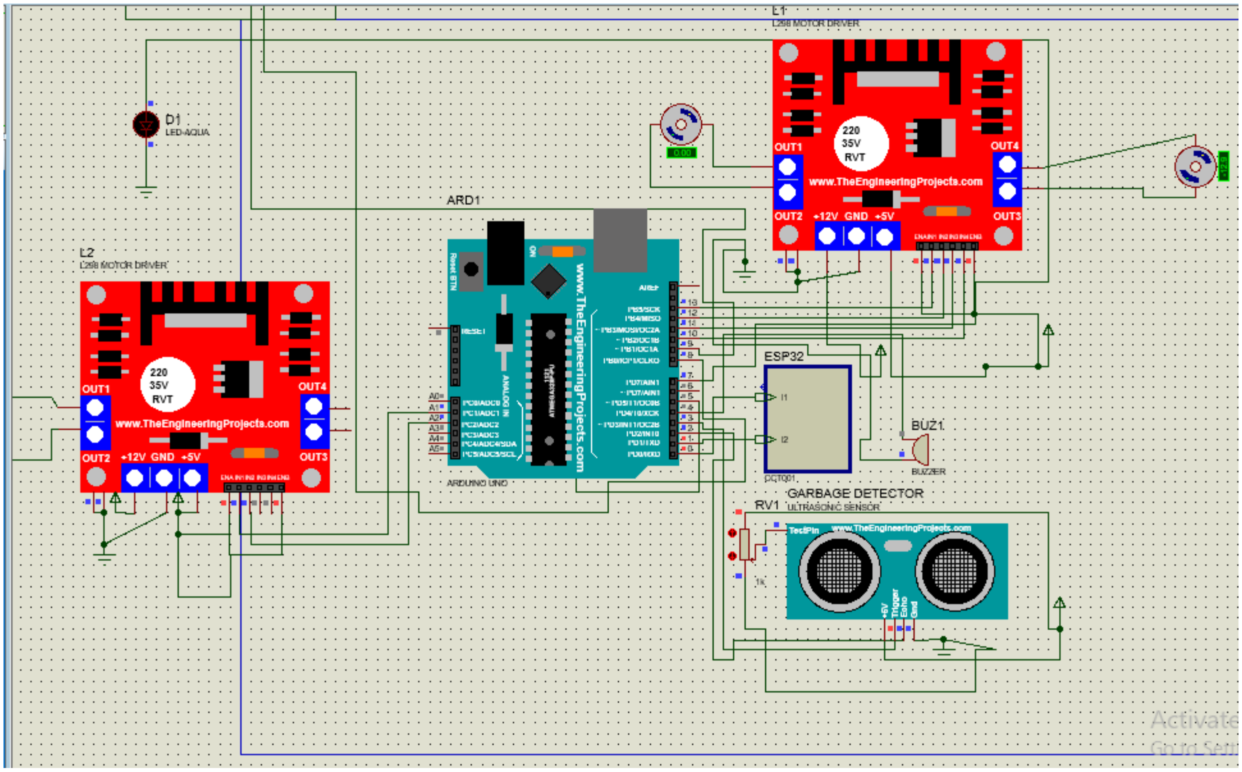


Fig: garbage is being collected (Garbage threshold is not met)

As the craft is sucking the nearby water as well as the garbage, it is trapping it inside the cone in front of the craft. The ultrasonic sensor will constantly check if 60% (80cm total separation) of the height is reached (any more and the garbage will float away). The case shows that the threshold is not reached thus no indication was given by the boat

Test case 6: Garbage is collected but threshold weight is reached

Threshold is detected and buzzer is turned ON



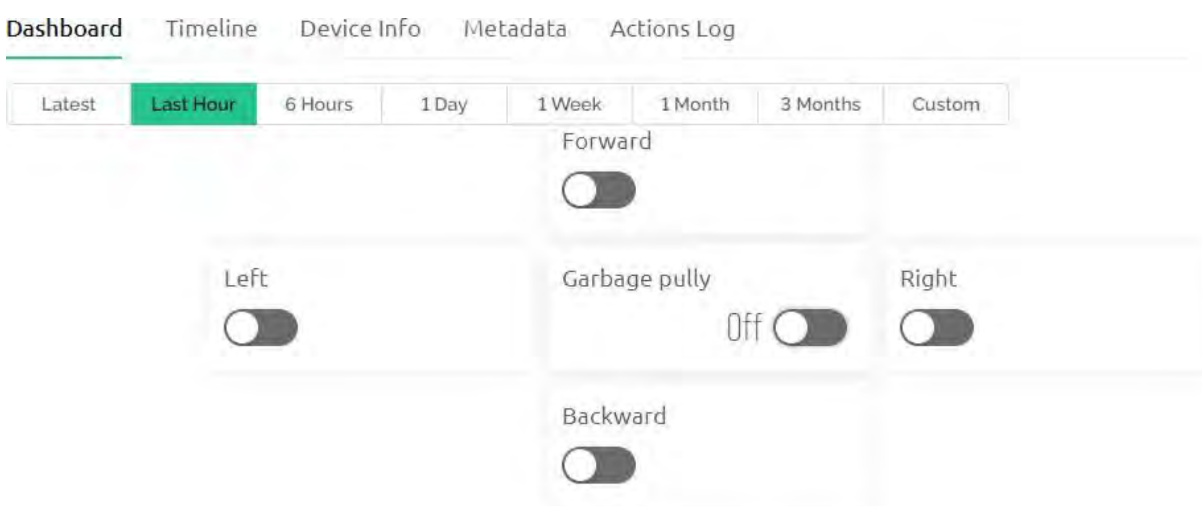


Fig: Web interface (Control system)

As the craft is sucking the nearby water as well as the garbage, it is trapping it inside the cone in front of the craft. The ultrasonic sensor will constantly check if 60% (80cm total separation) of the height is reached (anymore and the garbage will float away). The case shows that the threshold has been reached thus the buzzer will go off and give indication to the user to turn off the suction motor(as shown above the user turned off the garbage pulley button).

Approach 3:

Testcase1: Garbage present 17cm away.

Garbage is detected and the arm goes to collection mode and performs the following action in order.

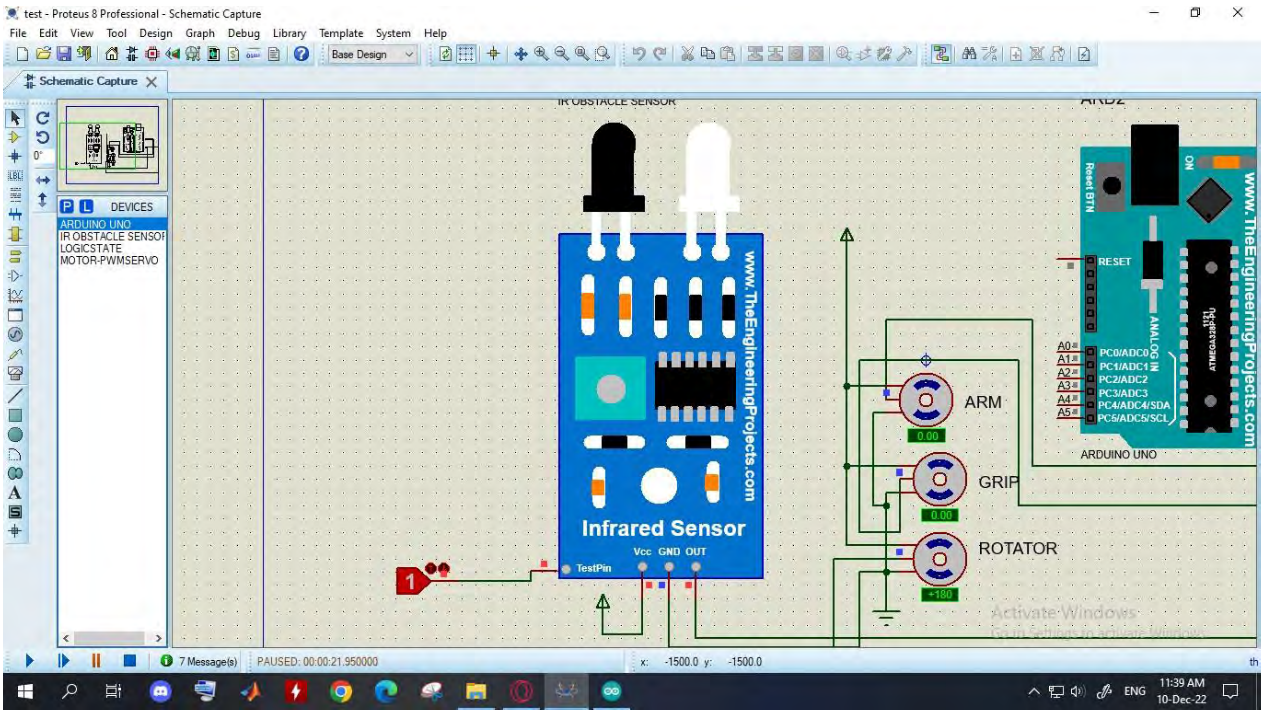


Fig: Mechanical Arm rotates towards the ocean

The IR sensor will trigger as the target is near and the servo connected to PIN3 will rotate to 180 degrees towards the garbage.

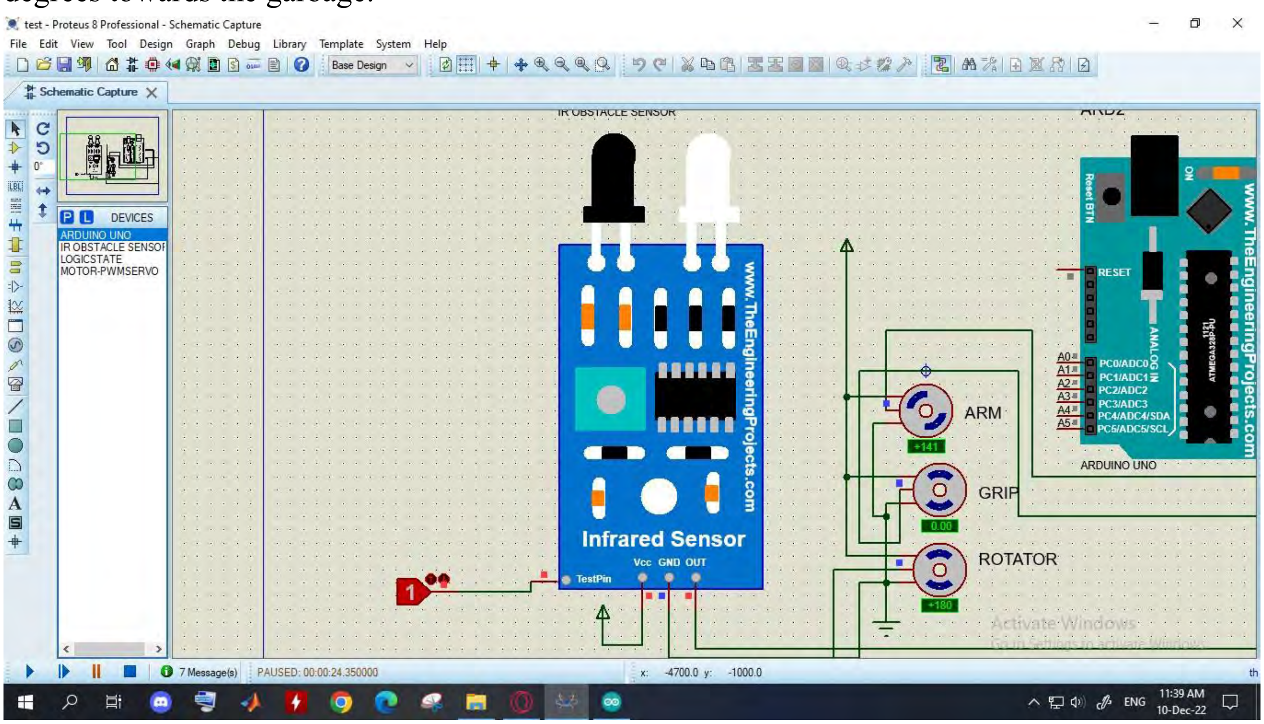


Fig: Arm goes down to sea level

As the rotator servo (connected to PIN 3) rotates to 180 degrees, the Arm motor(connected to PIN 9) goes down to sea level at 150 degree angle.

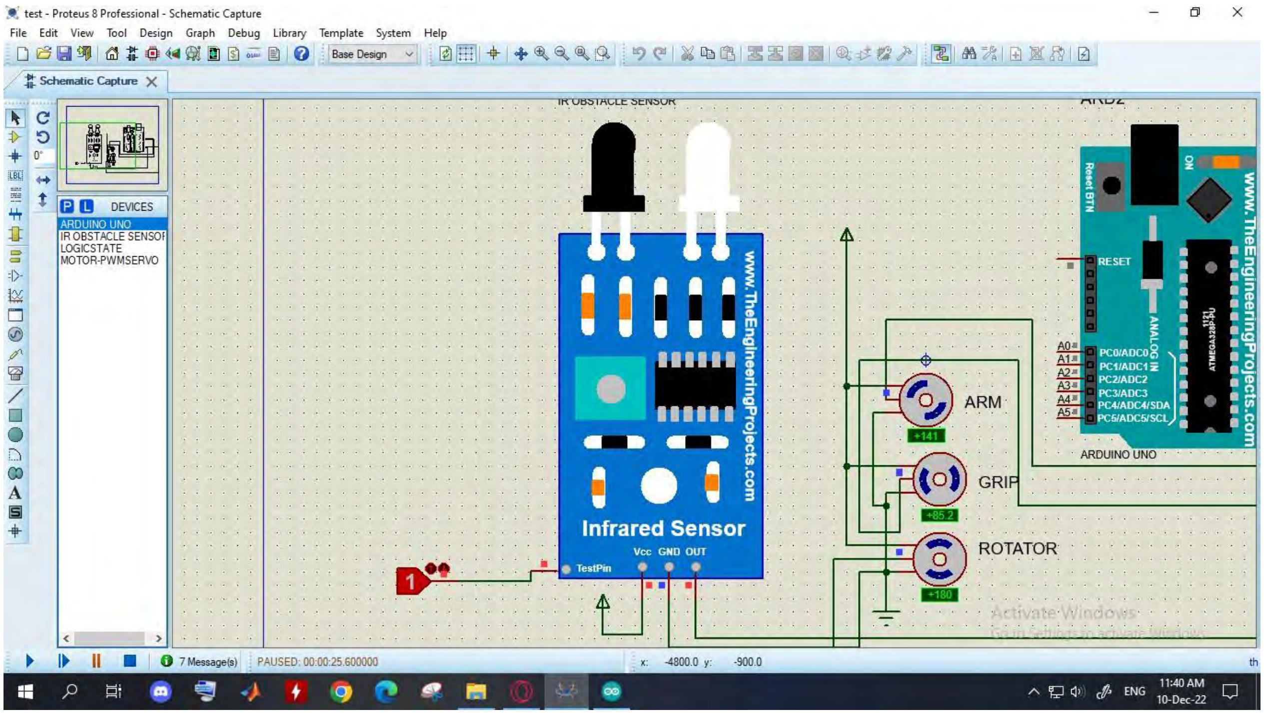


Fig: Scooper opens and collects floating garbage

After the Arm motor(connected to PIN 9) goes down to sea level at 150 degree angle. The scooper/grip servo opens going from 0 degree to 90 degrees.

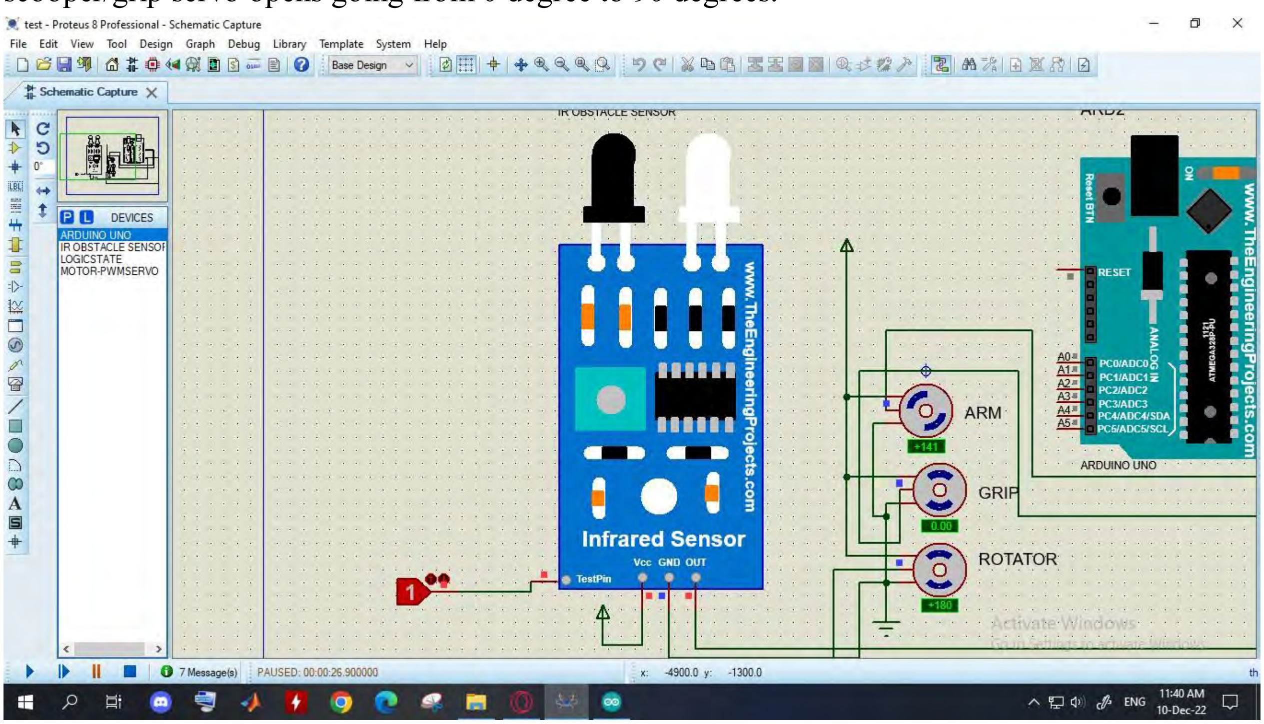


Fig: Scooper is closed

Similar to the previous action, the servo goes from 90 degrees to 0 to close the grip of the mechanical arm.

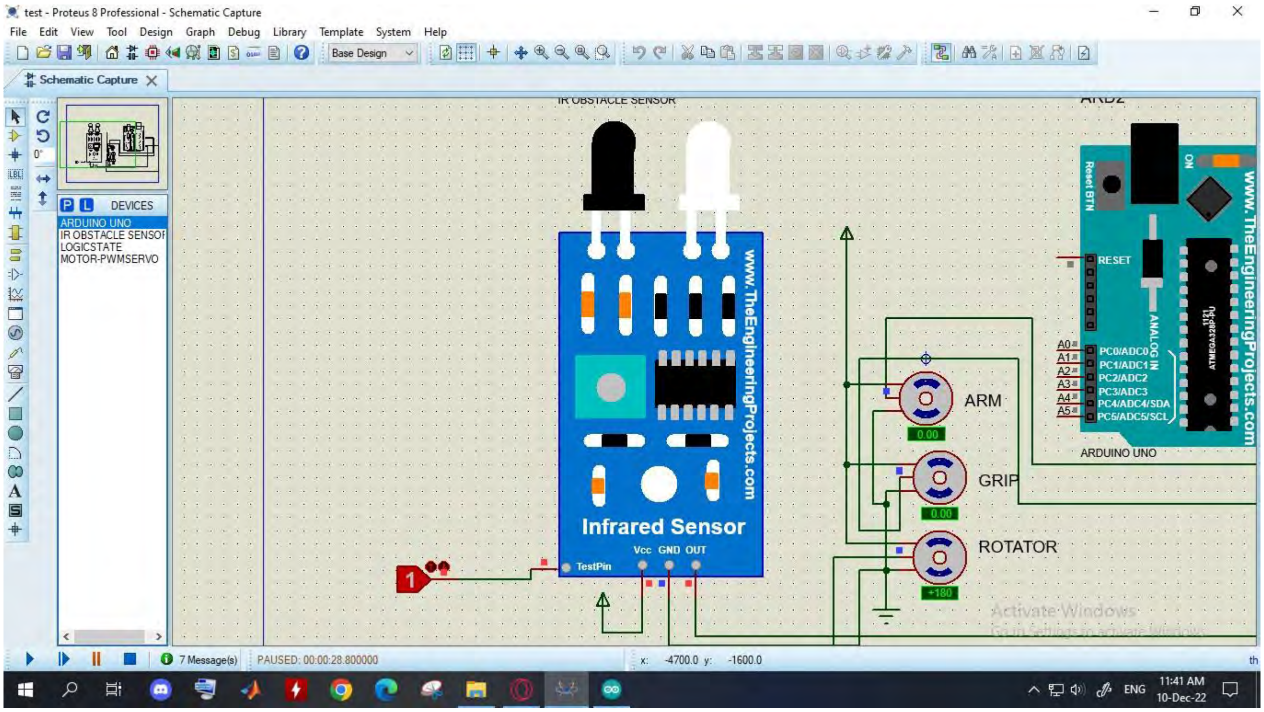


Fig: Arm goes up to 0 degree position

After the grip has caught a sufficient amount of garbage, the arm moves back to its original place at 0 degrees. After the Arm goes back to its original position, A set of movements occur to dump the garbage into the centralized collection area(Rotator position is changed from 0 degree to 180 degree, Arm is lowered from 0 degree to 150 degree, The gripper opened 0 degree to 90 degree, The gripper closed 90 degree to 0 degree, Arm is upped from 140 degree to 0 degree)

Testcase2: Garbage present 10m away.

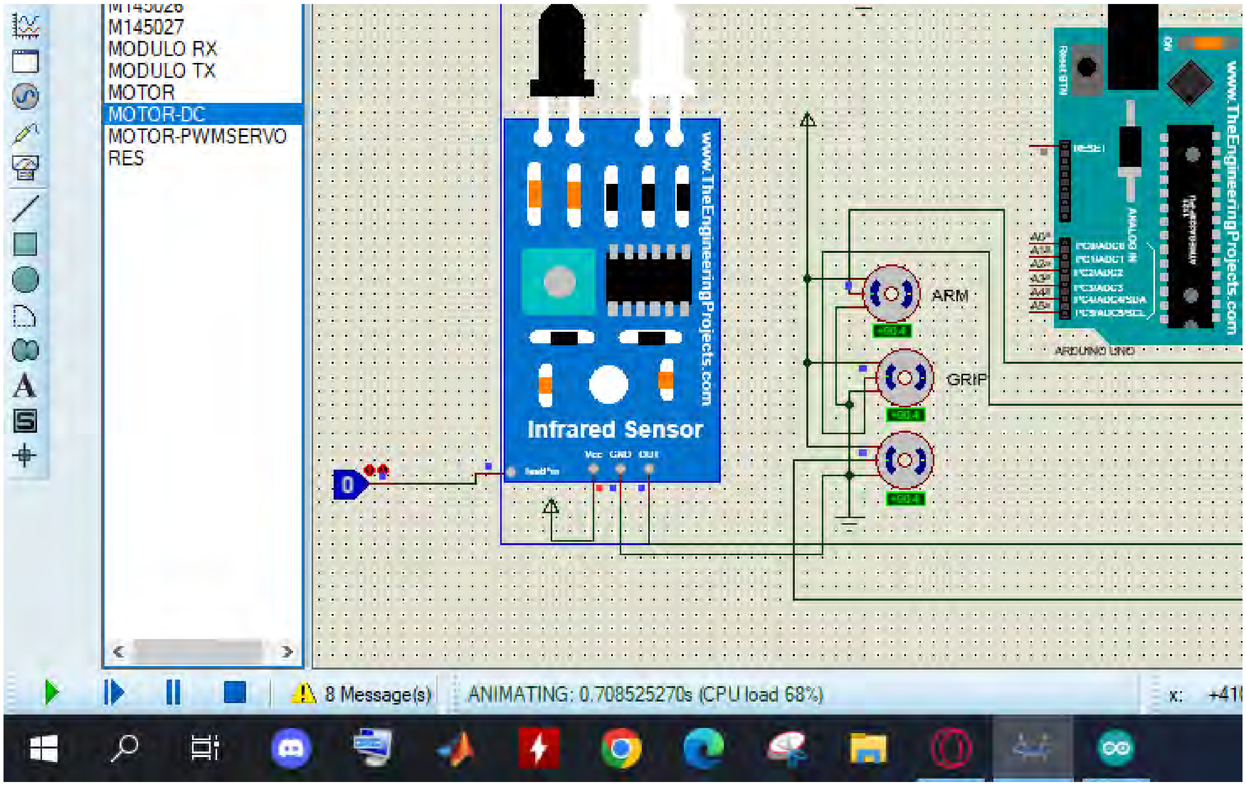


Fig: Garbage is not detected and the servo is in the initial position.

The IR sensor will not sense any obstacle in front of it and the automated mechanical arm will stay at its original position.

Testcase3: User controls the vehicle to go to the garbage present 10m away.

As the target garbage is initially far away from the vehicle, the user can send movement instruction from a controller (Here demonstrated by logic states)

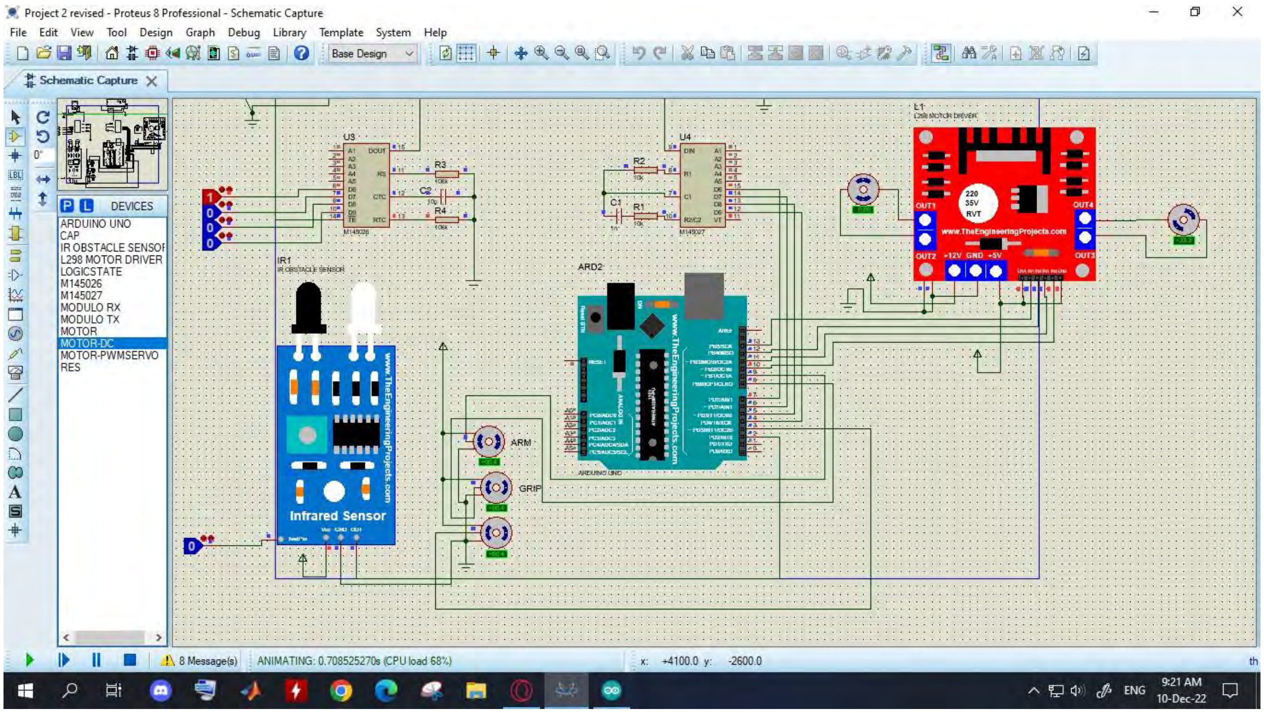


Fig Forwards movement

The user sends 1000 as the input, the encoder encodes these bits and the transmitter sends it to the receiver. The data is then decoded and from the data output D6-D9 pins we can get the bits transmitted. The microcontroller inputs the data and PIN10 and PIN11 are activated accordingly to get clockwise turns from the motor at the input 2.

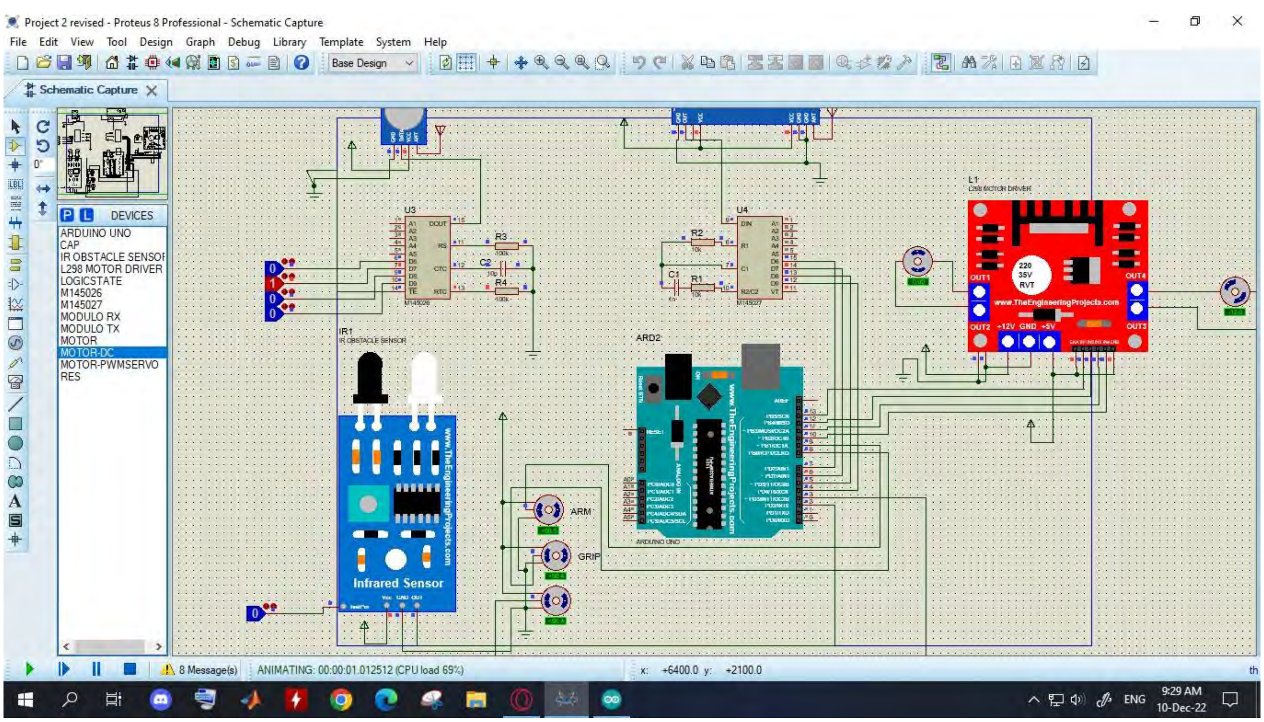


Fig: Backward movement

The user sends 1000 as the input, the encoder encodes these bits and the transmitter sends it to the receiver. The data is then decoded and from the data output D6-D9 pins we can get the bits transmitted. The microcontroller inputs the data and PIN10 and PIN11 are activated accordingly to get anti-clockwise turns from the motor at the input 2.

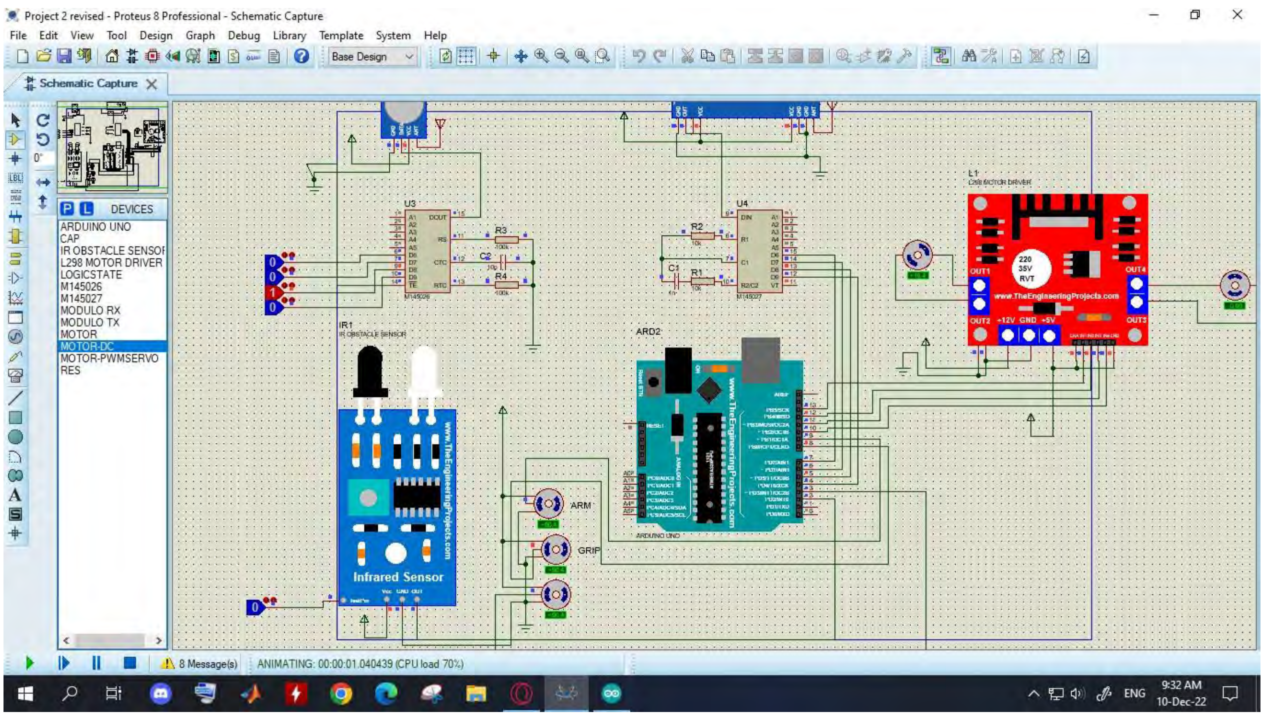


Fig: Left movement

The user sends 1000 as the input, the encoder encodes these bits and the transmitter sends it to the receiver. The data is then decoded and from the data output D6-D9 pins we can get the bits transmitted. The microcontroller inputs the data and PIN12 and PIN13 are activated accordingly to get clockwise turns from the motor at the input 1.

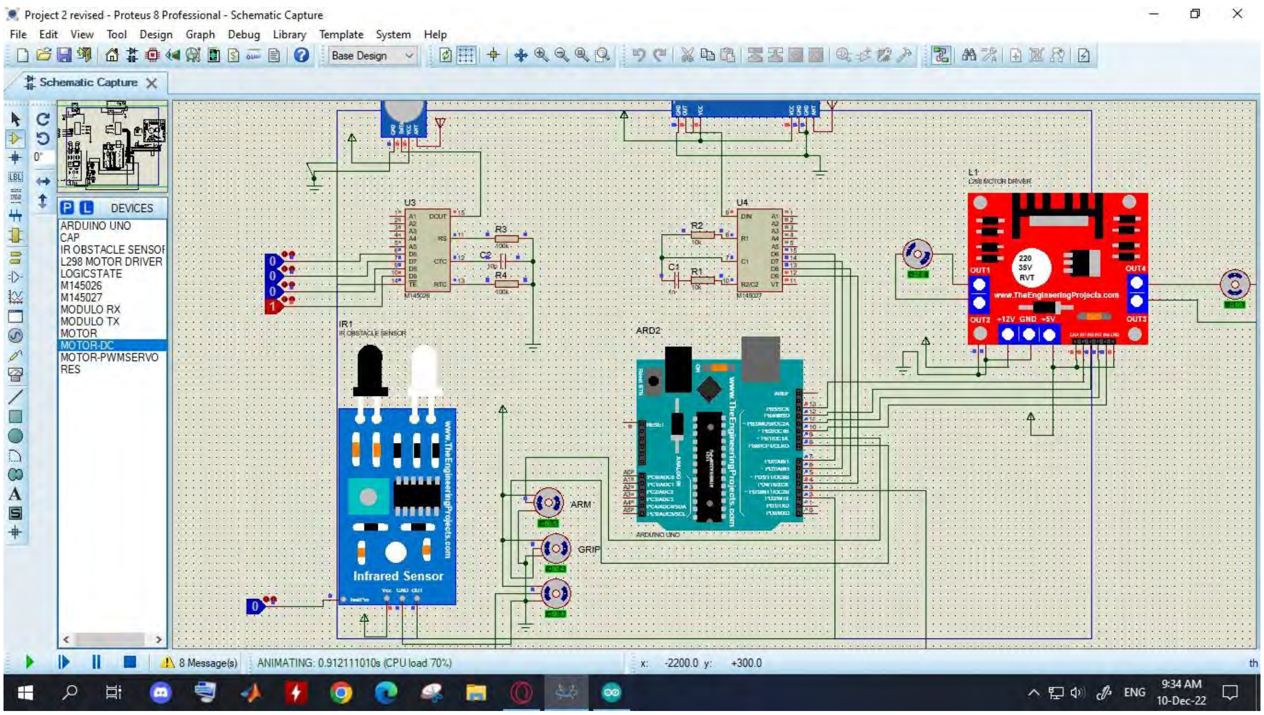


Fig: Right movement

The user sends 1000 as the input, the encoder encodes these bits and the transmitter sends it to the receiver. The data is then decoded and from the data output D6-D9 pins we can get the bits transmitted. The microcontroller inputs the data and PIN12 and PIN13 are activated accordingly to get anti-clockwise turns from the motor at the input 1.

Physical verification:

We constructed a 3d representation of our collector bot and optimized the design according to the papers [5][6][7][8] we mentioned.

3D Model of the Project:

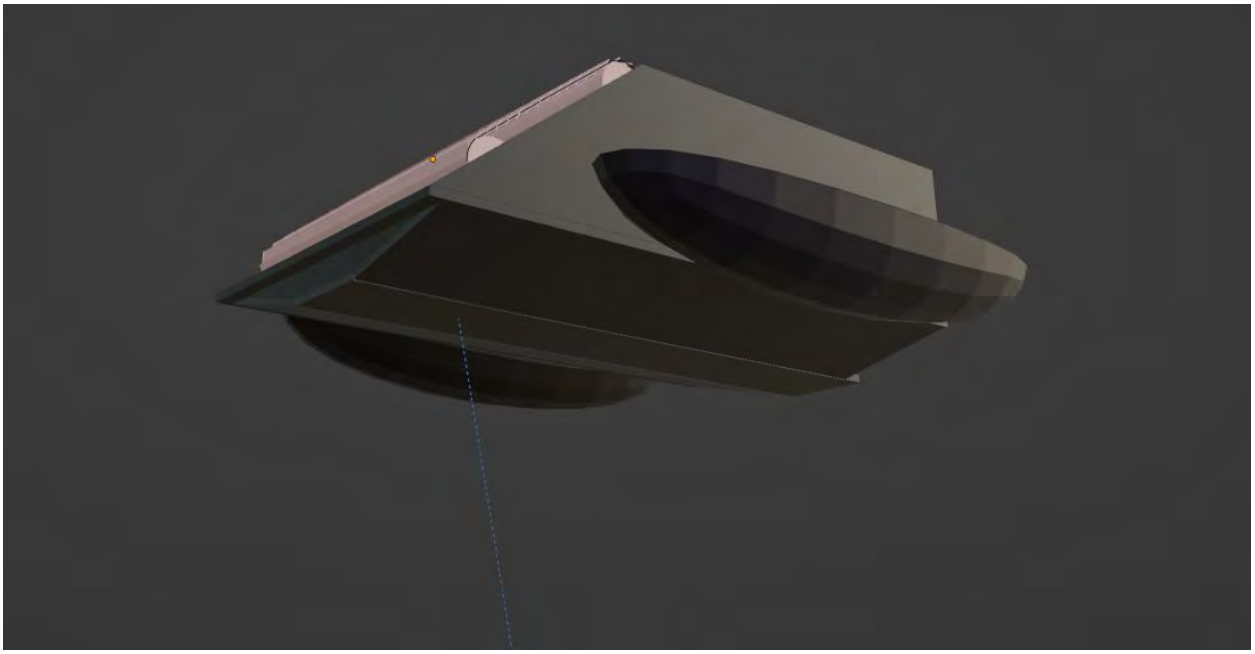


Fig: Bottom view

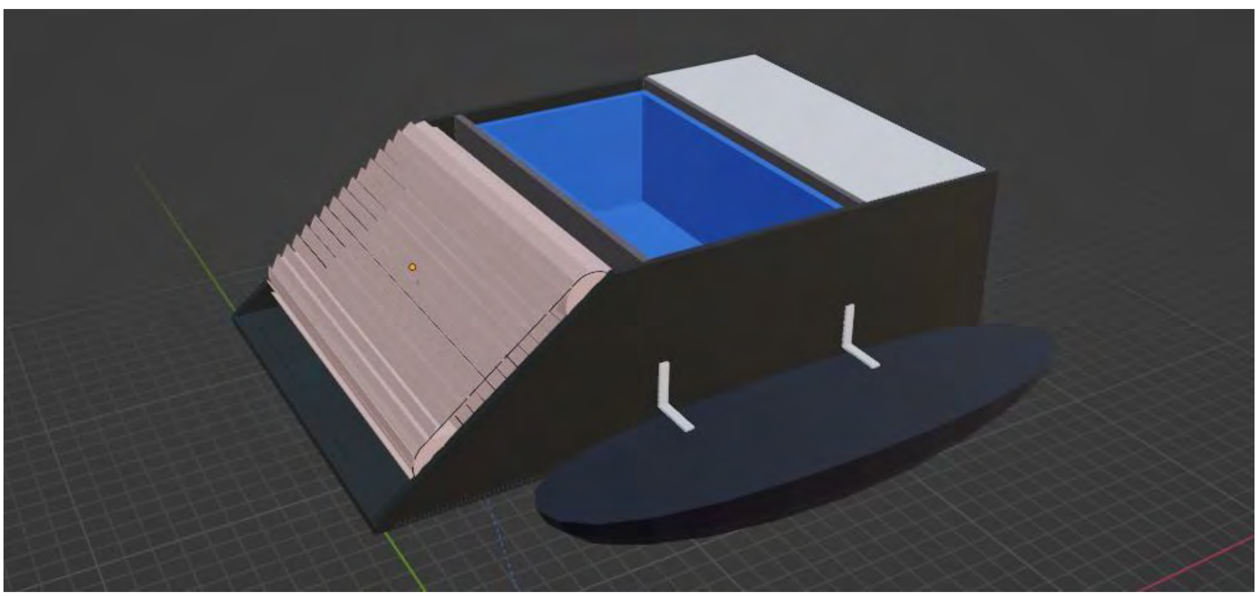


Fig: side view

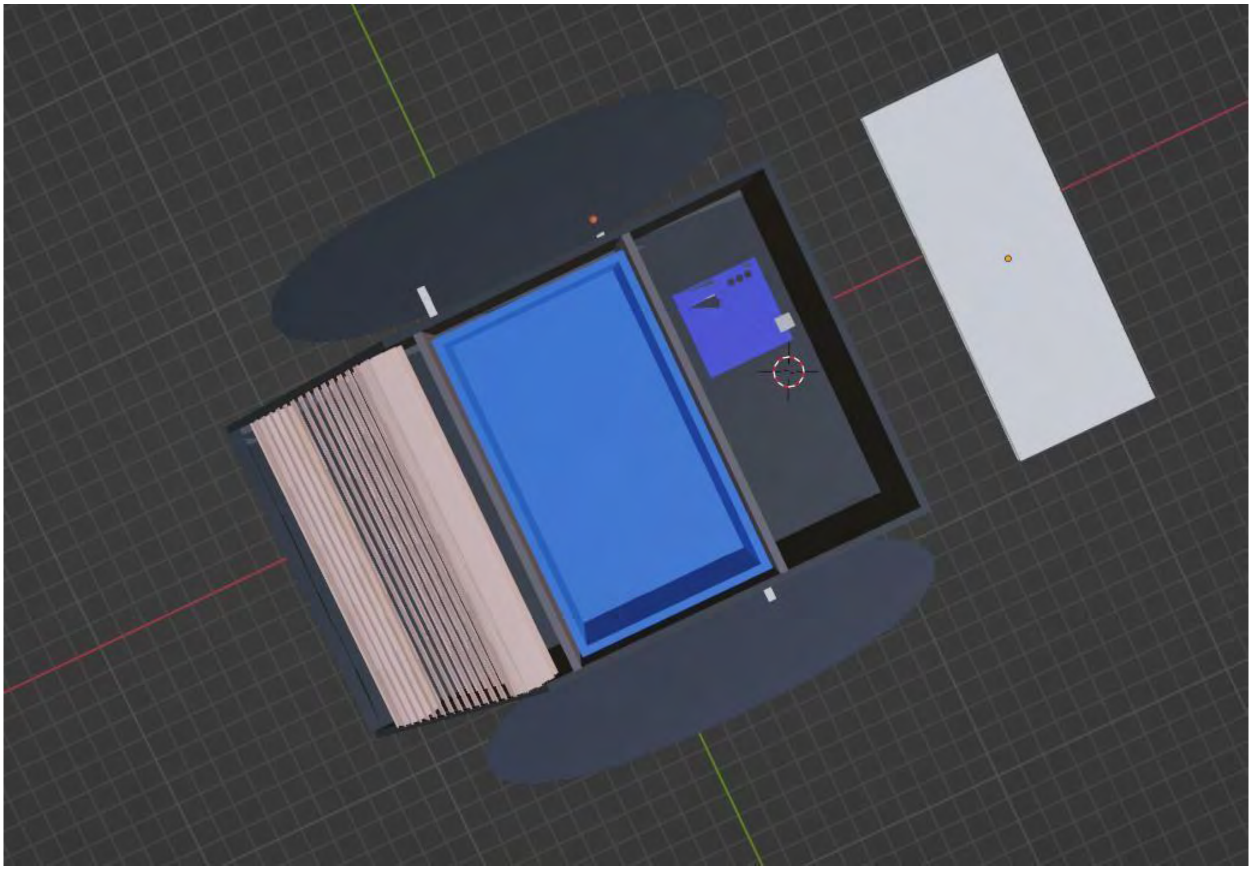


Fig: Top view

We tested this model with the appropriate weights and the following calculations is done:

Proposed design and hypothetical weights:

Table 17. Calculation for the Flotation of boat:

Mass of the wooden chassis	12 kg
Volume of the wooden chassis	0.013888 m^3
Approx. base area of the wooden chassis	0.4 m2
Mass of the collection area	2.1 kg
Volume of the collection area	0.00392 m^3
Mass of the conveyor belt	0.7 kg
Density of cedar wood	0.45g/cm^3

Density of water	1g/cm^3
Total mass of the assembly(approximately)(24.8kg+1.2kg for components)	26kg
ρw/ρwood =total volume/V V1= Volume submerged	V1= 0.00625 m^3
Initial submerged height of the bot= V1/base area	15.624mm
V2* ρw * g =Total mass * g V2=Volume required to be submerged	V2 =0.026 m3
H=V2/base area H= Height submerged after adding the load	H= 130 mm

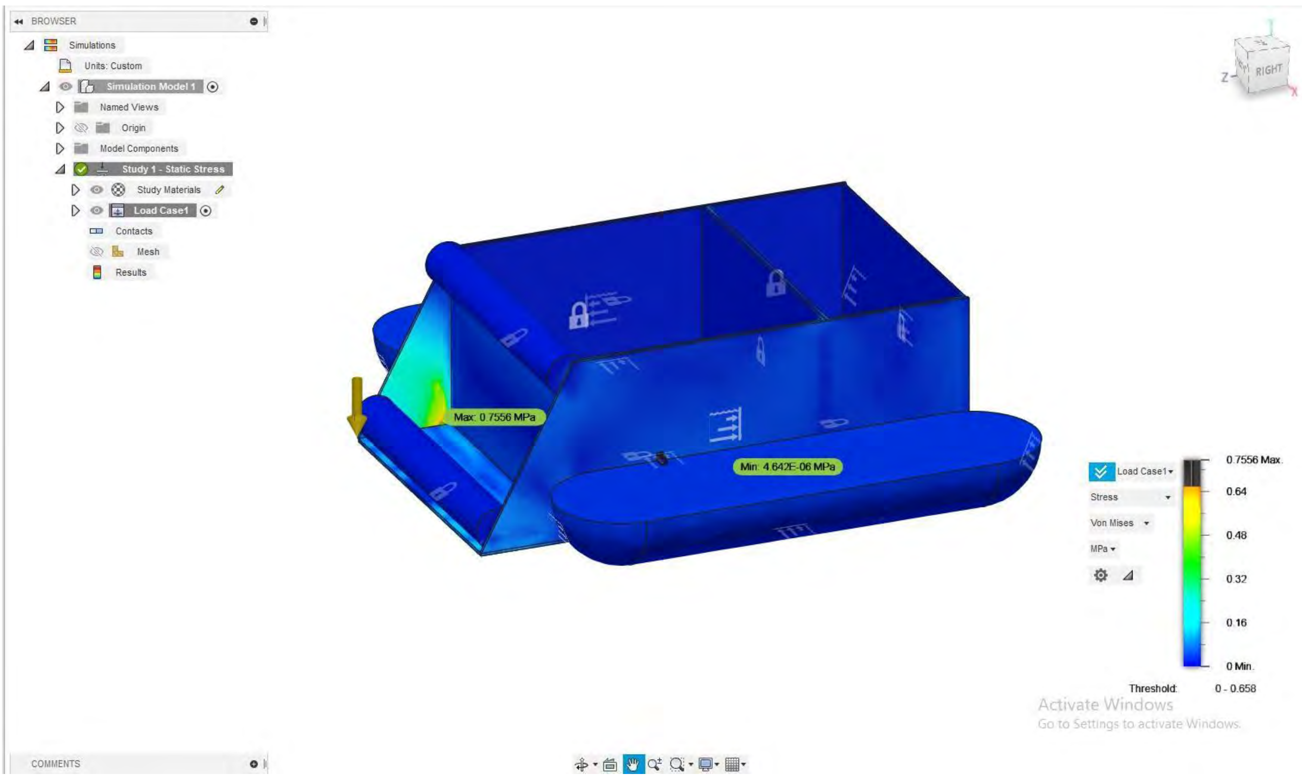
Here, our system will submerge maximum till 130 mm of its height whereas the total height of the system from its lowermost surface is 25cm and so it will float.

Table 18.With final design and weights:

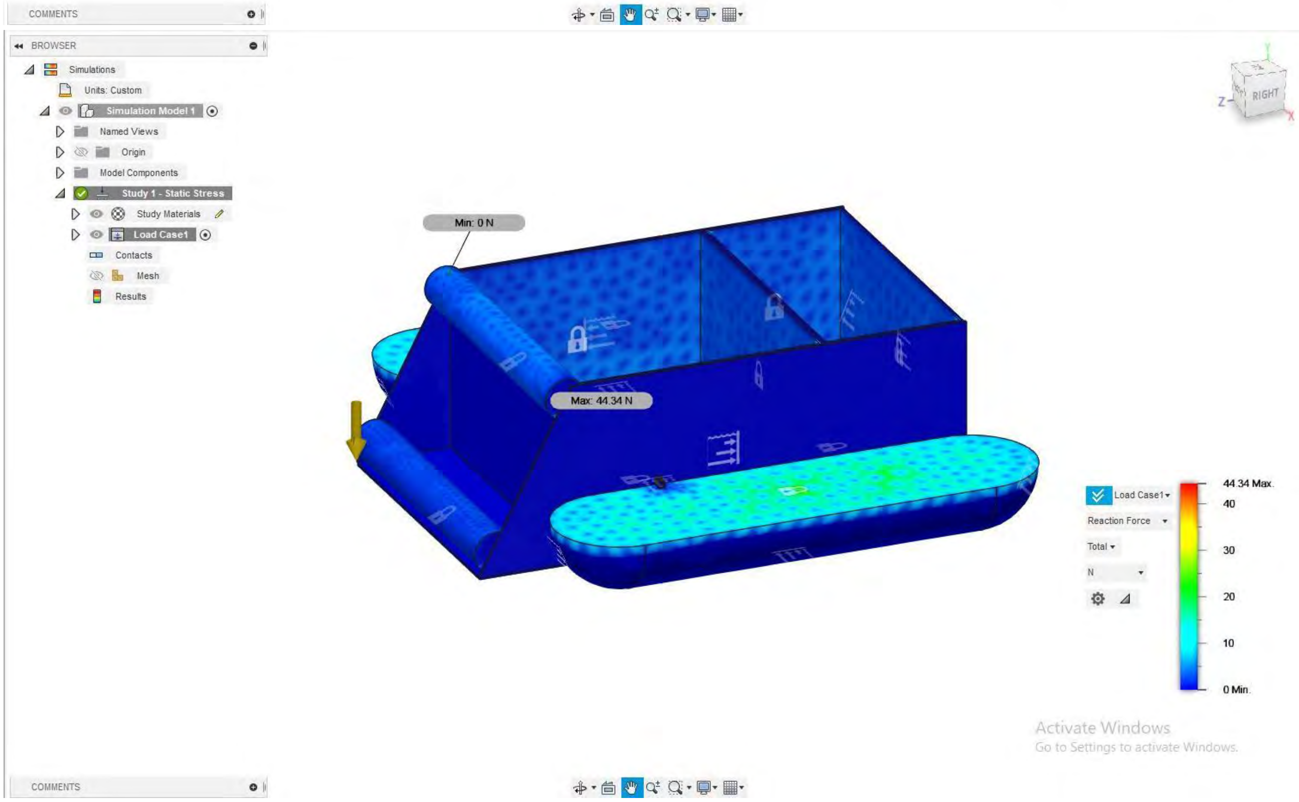
	Without Garbage	With Garbage	Formulas
Weight (W)	5.5 kg	10 kg	W
Volume (V)	0.0263 cubic meter	0.0263 cubic meter	LxBxH
Density of water (p)	1000 kg/m^3	1000 kg/m^3	
Acceleration due to gravity (g)	9.81 m/s^2	9.81 m/s^2	
Displacement (D)	26.3 kg	26.3 kg	V x p
Buoyancy (B)	258.123 N	258.123 N	D x g
Center of Gravity (CG)	28.13 cm from origin	18.05 cm from origin	(W1 x d1 + W2 x d2 + ... + Wn x dn)

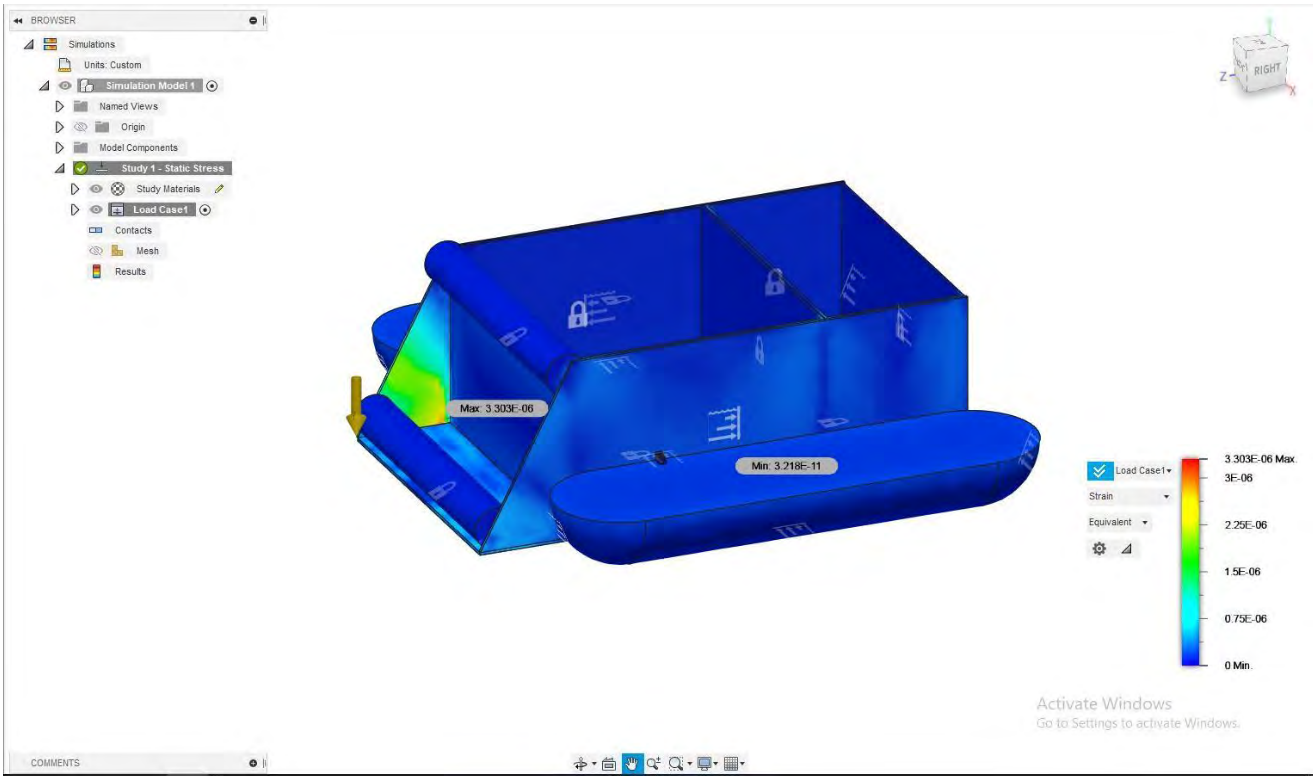
			/ (W1 + W2 + ... + Wn)
Center of Buoyancy (CB)	0.01315 m^3	0.01315 m^3	V/2
Metacentric Height (GM)	0	0	I / V

The 3d model is also stress tested within fusion 360 to get the optimal design.the following is the findings:




BROWSER
Simulations
Units: Custom
Simulation Model 1
Named Views
Origin
Model Components
Study 1 - Static Stress
Study Materials
Load Case1
Contacts
Mesh
Results
Max: 0.01269 mm
Min: 0 mm
Load Case1
Displacement
Total
mm
0.01269 Max.
0.012
0.009
0.006
0.003
0 Min.
RIGHT
Activate Windows
Go to Settings to activate Windows.
COMMENTS


BROWSER
Simulations
Units: Custom
Simulation Model 1
Named Views
Origin
Model Components
Study 1 - Static Stress
Study Materials
Load Case1
Contacts
Mesh
Results
Min: 0 N
Max: 44.34 N
Load Case1
Reaction Force
Total
N
44.34 Max.
40
30
20
10
0 Min.
RIGHT
Activate Windows
Go to Settings to activate Windows.
COMMENTS



4.3 Identify optimal design approach:

Table 19. Comparative Analysis of Multiple Design approach

Multiple design Approach (Criteria)	Design Approach 1:	Design Approach 2:	Design Approach 3:
Efficiency in fulfilling Requirements	The measurements are up to the standards we set and conveyor belt pickup rate per hour is higher than the other approaches	The measurements are greater than the standards we set and the pickup rate per hour is approximately 0.39kg (10 hour day)[seabin paper reference]	The measurements are greater than the standards we set and the pickup rate per hour fluctuates depending on the user's accuracy to control the robot arm(10 hour day)
Cost	Moderate	Moderate	Moderate
Usability/how easy it	Slight delay in controls	Nearly instant controls	Moderately instant

is to use			controls
Garbage Carrying Weight	10kg	3.9kg	5kg
Size	Compact and small	Bulky and biggest	Moderate
Power	Solar dependent	hybrid	Solar dependent
Manufacturability	Easy to mass-produce	A decent number of components and time required as well as 3d printed parts	Easy to mass produce but a lot of components are required
Maintainability	Easiest to maintain and troubleshoot	Requires app development/blynk server & app use knowledge and harder to troubleshoot	Moderately easy to troubleshoot as component is distributed and easy to access
Upgradability	MIT app inventor tool can be used to connect to SMS app and streamline the AT commands and connect the controlling prompts to buttons decreasing the delay in moments	Using ESP32Cam to get camera details for OpenCV image processing to notify the user with visual as well as notification data	Make a more dynamic robotic arm to collect more waste

Table 20. Weightage chart:

Multiple design Approach	Weightage	Design Approach 1: (GSM)	Design Approach 2: (Wifi)	Design Approach 3: (RC)
Efficiency in fulfilling Requirements	25	19	15	18
Cost	15	10	9	10
Usability/how	15	12	13	13

easy it is to use				
Garbage Carrying Weight	15	14	7	9
Size	10	7	6	7
Power	5	4	3	4
Manufacturabilit y	5	4	3	3.5
Maintainability	5	4	3	4
Upgradability	5	3	4	3
Total	100	77	63	71.5

Multiple design Solutions of Optimal Approach

Subsystem 1: Obstacle detection System The device has to sense any obstacle and garbage that is present in front of the device

Table 21. Subsystem Testing (Object Detection)

Object detection system	Design solution 1 (Sound Wave)	Design solution 2 (Sound Wave)	Design solution 3 (IR Rays)
Method	measuring the time it takes for a sound wave to return after sending high-frequency sound waves	measuring the time it takes for a sound wave to return after sending high-frequency sound waves	Using infrared rays and measuring distance based on the angle of the reflected beams
Cost	Low	Low	Moderate
Range	450 cm	450 cm	2 ~ 30 cm

Subsystem 2: Notification System If an obstacle or water surface is sensed in front of the user, the device will have to notify the user.

Table 22. Subsystem Testing (Notification System)

Notification System	Design solution 1 (Light wave and SMS)	Design solution 2 (Light Wave and Blynk App notification)	Design solution 3 (N/A)
Method	As it senses an obstacle, a LED light will glow and SMS text will be sent	As it senses an obstacle, a LED light will glow and an on pin value will go to the virtual pin and send a notification to the user on the blynk app.	(N/A)
Cost	Low	Low	(N/A)
Range	Depending on lighting conditions (75-100 yards)	Depending on lighting conditions (75-100 yards) and wifi connection status	(N/A)

Subsystem 3: Collection system, if the object sensed is garbage and user has given the command to collect,

Table 23. Subsystem Testing (Collection System)

Collection System	Design solution 1 (Conveyor belt)	Design solution 2 (Seabin method)	Design solution 3 (mechanical scooper)
Method	As it senses garbage, a notification is sent to the user, if the user sends the SMS to turn off the collection system, the conveyor motors will start and the belt will start the collection to the center box.	As it senses garbage, a notification is sent to the user, as the user presses the pulling switch in the Blynk web page, the internal suction motor sucks the filtered water through a one-way valve to the back of the craft	When garbage is detected, the rotator servo rotates towards the garbage and the arm servo drops to the sea level as the scooper opens and picks up the garbage and the action is reversed and the garbage finally is dropped to the center garbage bin

Cost	Low	Moderate	Low
Range	6 cm in front of craft	79.248cm cone to meshed opening container	76.2 cm(Arm + scooper)

Subsystem 4: Collection box filling notifier system:

If the garbage collection limit is reached, the device will notify the user.

Table 24. Subsystem Testing (Load Detection System)

Load detection system	Design solution 1 (Hx711 and load cell and LED)	Design solution 2 (Ultrasonic waves and buzzer)	Design solution 3 (N/A)
Method	The load cell continuously measures the weight of the collection box 12kg(10kg garbage +2kg appx box weight) and as soon as it is reached the conveyor belt stops and sends LED indication	measuring the time it takes for a sound wave to return after sending high-frequency sound waves and then sounding a buzzer.	N/A
Cost	Low	Low	N/A
Range	10kg load cell	450 cm (80cm detection)	N/A

4.4 Performance evaluation of developed solution

In our project we detailed three different approaches, all distinct in Navigation accuracy, detection of garbage, battery life, efficiency of garbage collection. To perform evaluation of the developed solutions we established some key performance indicators or KPIs. We established a testing environment in Proteus and online server IoT services (Blynk) and Product specification pages as well as in real life testing to compare the performance. The following is the few KPIs in some situations:

Table 25. Performance Evaluation (Efficiency of garbage collection)

Approaches	Detection Methods	measured detection range	actual detection range	Efficiency in test result	Test results	validation reference
GSM Based Approach	Ultrasonic sensor	30 cm	27 cm	90%	can detect with minimal loss, using waterproofing methods	[23]
WiFi Based Approach	IR	2m	1.7m	85%	can detect with minimal loss due to refraction, without using waterproofing methods	N/A
Bluetooth Based Approach	IR + LIDAR	6.5m	4.5 m	69%	Can detect but with huge losses	[24]

Table 26. Performance Evaluation (Navigation accuracy)

Approaches	Method Used	Reaction time	Path deviation	Maneuverability
GSM Based Approach	GSM technology	30 sec	High	Low
WiFi Based Approach	WiFi Server+ IoT platform	17 millisec	Low	High
Bluetooth Based Approach	Bluetooth Transmissi on	5.6 millisec	Low	High

Table 27. Performance Evaluation(Collection Efficiency)

Approaches	Method Used	material	Efficiency
GSM Based Approach	Conveyor Belt	Rubber	80%
WiFi Based Approach	Scooper Arm	Plastic and aluminum	70%
Bluetooth Based Approach	Seabin	Plastic and Permeable membrane	85%

4.5 Conclusion:

In conclusion, the optimization of several designs made it possible to pinpoint the advantages and disadvantages of every strategy. The GSM-based control system, the scooper arm strategy, and the Seabin technique were the three designs that were taken into consideration. While each strategy had advantages of its own, it was discovered that the hybrid GSM/Bluetooth communication/control method with a conveyor belt and IR sensor proved to be the best option. The conveyor belt demonstrated the highest collection efficiency, and this method allowed for precise obstacle detection using the IR sensor. Furthermore, the combination of weight and HX711 sensors for capacity and weight detection turned out to be a practical and affordable way to make sure the conveyor belt didn't go over its limit. Overall, a hybrid approach that combined the advantages of each approach while minimizing their drawbacks turned out to be the most practical method for a garbage disposal and water monitoring system.

Chapter 5: Completion of Final Design and Validation. [CO8]

5.1 Introduction

A crucial step in achieving the intended result of any engineering project is the completion of the final design and validation. The process of finishing the final design and assessing the created solution to satisfy the required need is the main topic of this chapter. To guarantee that the final design meets the performance criteria, the systematic and logical design approach is maintained throughout the project.

This chapter's activities include obtaining the final design by making the necessary modifications in light of the performance evaluation results and creating the solution in accordance with the final design. To determine whether the design solutions satisfy the required need, the performance criteria are assessed. To ensure the desired result is realized, the final design is modified and developed in accordance.

To finish the project successfully, it is imperative to maintain a well-structured and organized approach. A crucial step in ensuring the quality, effectiveness, and efficiency of the developed solution is the completion of the final design and validation. The chapter focuses on the tasks and performance standards required to guarantee the project's successful conclusion.

5.2 Completion of final design:

The purpose of this research project is to develop and design a highly effective garbage collection system. In order to identify various approaches and solutions to the problem of garbage collection, we reviewed the body of existing literature and research papers for this project. We have determined three different approaches based on performance and testing that satisfy our desired needs after careful analysis and evaluation.

A "GSM-based garbage collection system" with conveyor collection is the first strategy we thought about. This system uses a conveyor belt to collect the trash and GSM technology for communication. The system is intended to operate in a semi-automated mode with little assistance from humans. To estimate a rough final design prototype, we considered the battery life, structural integrity, speed, and efficiency of the system, among other things. This prototype will be put to the test to improve its functionality and reduce its drawbacks.

A "Bluetooth-controlled collection system" with a mechanical arm collection is the second strategy we looked at. The garbage collection is controlled by Bluetooth technology, and the garbage is collected by a mechanical arm. In order to estimate the final design prototype, we also considered the battery life, structural soundness, speed, and efficiency of this system. This prototype will be put to the test to improve its functionality and reduce its drawbacks.

Finally, we assessed a "WiFi server with IoT-based garbage collection system" using Seabin data. WiFi is used in this system for communication, and an Internet of Things-based Seabin garbage collection system is used for garbage collection. To estimate a rough final design prototype, we considered the system's battery life, structural integrity, speed, and efficiency, among other things. This prototype will be put to the test to improve its functionality and reduce its drawbacks.

We first built models in Proteus and Scilab to test and validate each method. We ran into issues with Scilab's library, so we sought advice from online communities and forums for libraries and simulation data for related project components. We only created a model using Proteus because the library was scarce, and it performed as expected. We were unable to accurately express the limitations, such as the delay and transmission power in communication experiences caused by path loss, due to the self-contained nature of the model. Based on our discoveries, we modified our final component list accordingly.

We initially used an M145026 encoder and an M145027 decoder for the radio transmission for the radio-controlled garbage collection system, but it resulted in significant simulation delays. We couldn't get accurate simulations on Proteus because we couldn't find a precise library that would cut down on delay.

We initially considered building an ESP32-based system for the WiFi-based system and using an IoT service like Blynk or Particle for communications. Using Wakwi software, we created a primary model with an LED serving as a process indicator. Wakwi is a fantastic online tool for ESP32 work, but we were unable to complete the full design in Wakwi due to the lack of a library, so we switched to Proteus and completed the design. We observed that the simulation satisfied the needs of the project and our expectations.

For each approach, we discovered that some optimizations were required. Although the first method, a GSM-based garbage collector, is still the best, we switched the GSM control to a Bluetooth module because we needed an instant control method. To create an effective and efficient garbage collection system that satisfies our desired needs, we intend to keep experimenting with and improving these methods.

As we set our Final optimal design as a hybrid of GSM communication with Bluetooth connectivity and retaining the weight sensor and IR sensor for detection work, we added pH and temperature sensor as pH and temperature is an important factor of microbial growth [1].the following is a schematic diagram of the final design:

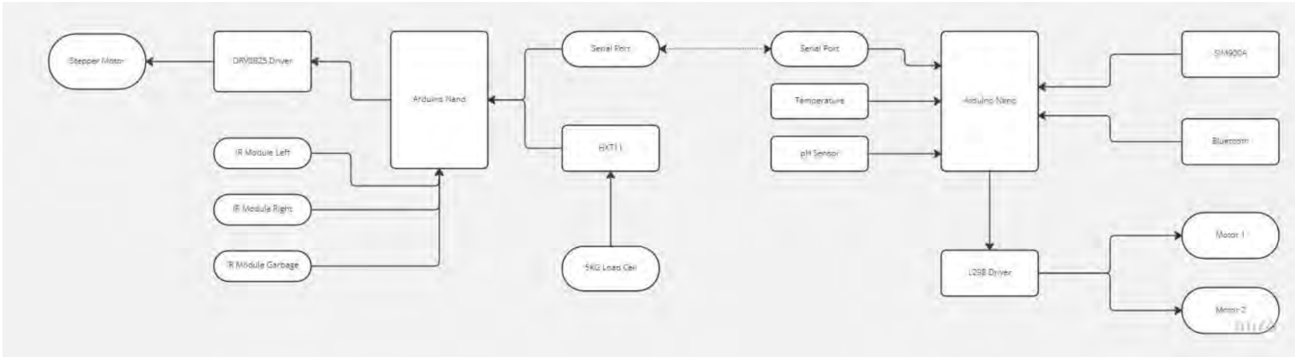


Figure: Block diagram of final design

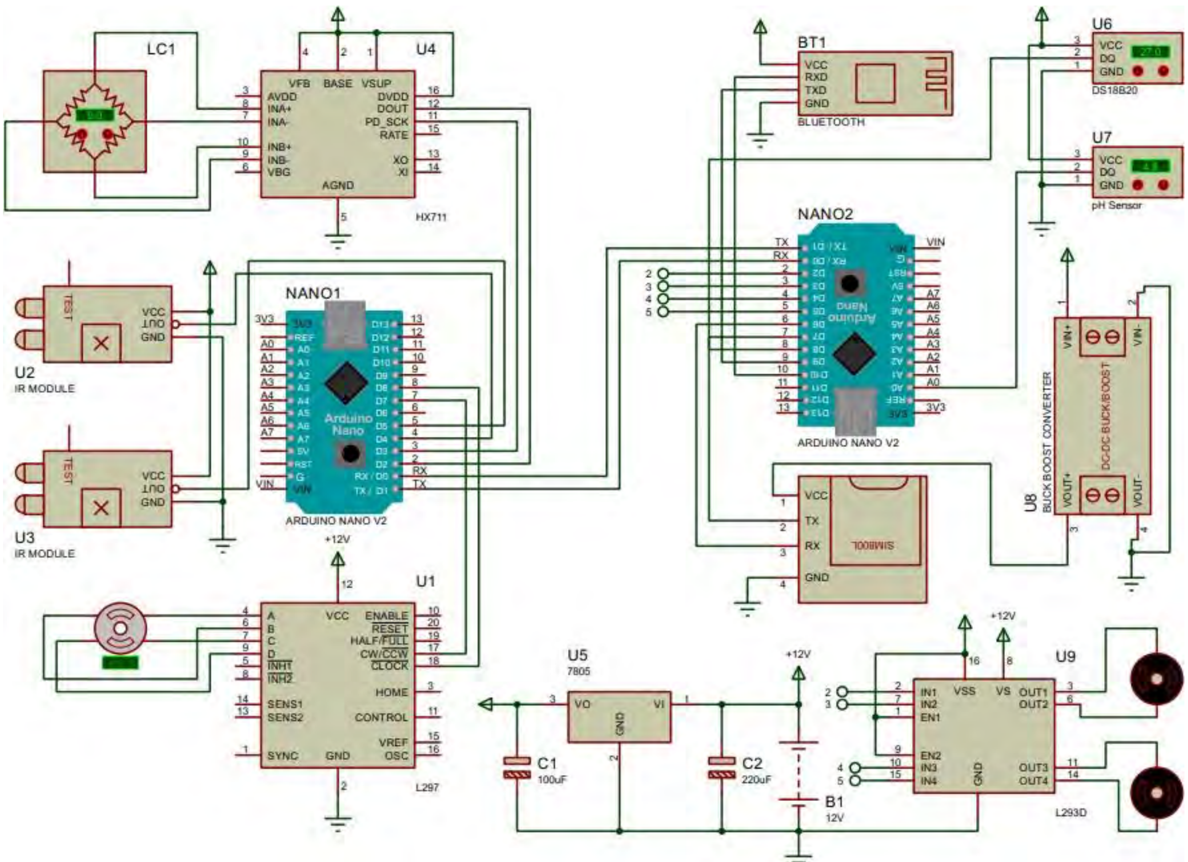


Figure: Schematic diagram of final design

We modeled the following finalized pcb according to the schematics:

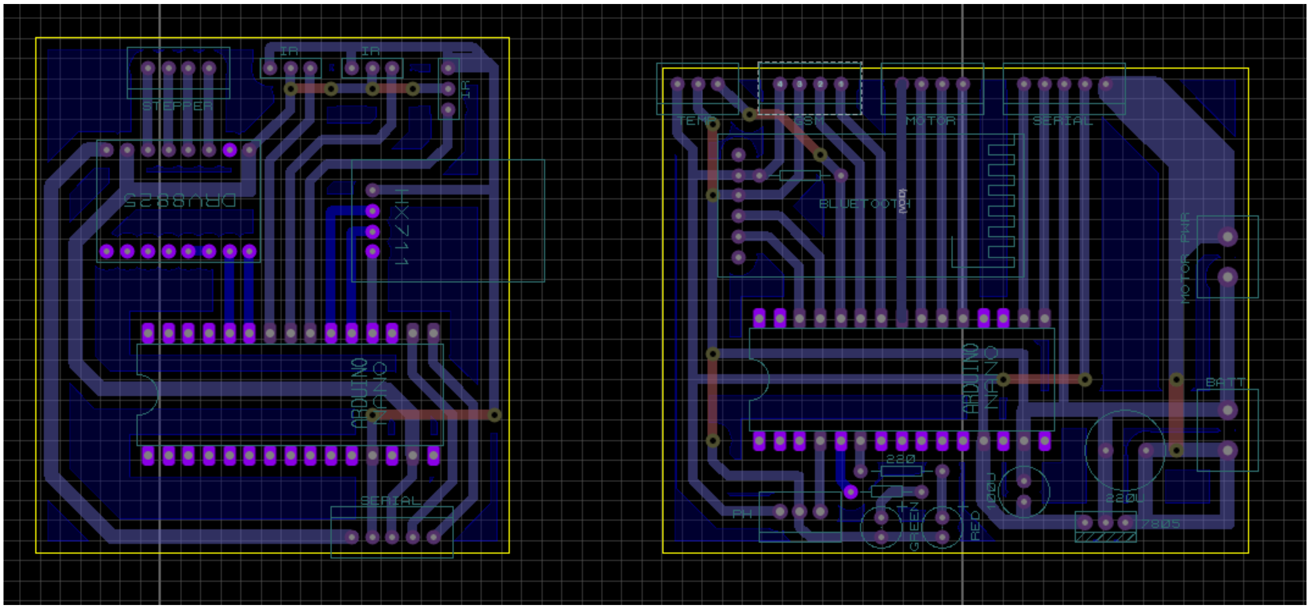


Figure: PCB of final design

In this project, a final design that closely resembles the schematic was created, and the prototype was then tested using predetermined test cases and criteria. Google Collab/Python was used to analyze and visualize the collected data in order to gain insights into the performance of the prototype. The prototype was put through a variety of tests during the experimental phase to determine its usability, dependability, and suitability for the intended use. After carefully considering the findings, the data was processed to create visually compelling and illuminating representations. Overall, the evaluation of the prototype was successful, and the findings imply that the final design is an effective remedy for the intended use.

5.3 Evaluate the solution to meet desired need:

The purpose of this project is to create a less expensive and simpler-to-make alternative to large commercial cleaning equipment for removing trash from confined spaces. In order to accomplish this, we intend to combine GSM and Bluetooth control, a garbage conveyor belt for garbage collection, and pH and temperature sensors for water monitoring. We hope to develop a garbage collector that is affordable, simple to make, and useful for locals, small eco-friendly organizations, and agricultural businesses. By reducing the amount of waste in small areas, encouraging sustainable waste management techniques, and offering an affordable solution for communities with limited resources, the solution we propose is anticipated to have a significant positive impact on the environment, society, and the economy.

Firstly we started to review our findings in the previous reports and papers of similar approaches, we derived to three different approaches to our needs based on performance and testing done, we found that a “GSM based garbage collected system” with conveyor collection, “Bluetooth controlled collection system ” with mechanical arm collection, and lastly “WIFI Server with IoT based garbage collection system” with Seabin collection was some of the more efficient models of collection.

We took into account some of the data widely found in similar project papers as well as product spec sheets. We evaluated battery life, structural integrity, speed and efficiency as well as many other factors to determine a rough estimated final design prototype. This hypothetical prototype will then be tested to minimize the limitation of the final design and optimizing

We assessed three strategies for our garbage collection system during the testing and technical verification phase. The first strategy involved modeling a GSM-based system with conveyor collection in Proteus and Scilab. However, we were limited to using Proteus for the model because Scilab lacked the necessary libraries. Although it lived up to our expectations, path loss prevented us from accurately expressing constraints like delay and transmission power.

We used an M145026 encoder and an M145027 decoder for radio transmission in the radio-controlled system. However, the simulation had a lot of delays, and we couldn't find a library to fix them.

Finally, we developed a WiFi-based system with ESP32 and Wakwi software. But because the required libraries were missing, we had to switch to Proteus and finish the design there. We discovered that some adjustments were required for each strategy, but in the end, we found that the GSM-based system was the most effective when Bluetooth was used in place of instant control.
We designed the final approach and made the PCB accordingly and tested the final design with many criteria in mind. The following table is the results from the test:

Criteria	Verification	Remarks
Cost-effectiveness	Compare cost with corporate machines	Cost is significantly lower
Efficiency	Measure garbage collection time	Takes less time to collect compared to manual collection process
	Measure amount of garbage collected	Collects a considerable amount of garbage per per second
Reliability	Measure number of breakdowns	No breakdowns observed during testing
	Maintenance requirements	Maintenance is low, occasional lubrication and cleaning is needed
Environmental impact	Measure energy consumption	Energy consumption is low, making it environmentally friendly

	Measure waste generated during operation	Minimal waste is generated during operation as it doesn't have any chemical components
User-friendliness	Evaluate ease of use and convenience for users	Easy to operate and user-friendly, due to serial monitor app and SMS
Safety	Evaluate safety features	Uses sensors and safety switches, making it safe to use
Durability	Test ability to withstand harsh conditions	Durability is good, components can last for a maximum of 5 years
Scalability	Evaluate ability to scale up or down	Easily scalable, can be adapted to different area sizes
Water monitoring	Test pH and temperature sensors	Sensors work properly, monitors water quality

The test was all done using the finished model in an open environment and using research data and the following test cases:

Table 28. Final Design verification checklist

Test Case Criteria	Components	Verification status
testcase 1: Testing of weight sensor	Load Cell 5kg + HX711	verified
test case 2: Testing of pH and temperature sensors	pH + D18B20 Sensor	verified
test case 3 :Testing of obstacle detection system	IR Sensor	verified
test case 4: Testing controllability	HC-05 + GSM800L	verified
testcase 5: Testing capacity	IR Sensor + Load Cell 5kg + HX711	verified

We ran a number of tests to confirm our garbage collector solution's performance in various scenarios in order to assess its efficacy. In order to test the precision of the weight sensors, we first performed a weight testing scenario in which we put various objects into the collection box. We obtained the results from the Bluetooth SPP protocol's serial monitor feature and contrasted them with the weights determined by an electronic scale. We discovered that the weights were 99% of the time accurate.

Similar to this, we performed a space test to determine whether the box height was greater than the height of the collected trash. We discovered that the solution passed this test with flying colors, with the sensors taking precise measurements.

We used temperature and pH sensors to track the water slurry’s pH and temperature. We discovered that the temperature sensor consistently produced a result of 31 degrees, with only very slight variations brought on by human error. The pH sensor indicated that as we added lime juice to tap water, the pH fell from 7.5 to 4.5.

In order to confirm the solution's capability to identify obstacles in its path, we lastly performed an obstacle test. As soon as we put our hand in front of the sensor/craft, it recognized the obstruction.

Overall, our testing demonstrates that our solution is accurate in measurements and capable of detecting obstacles in a variety of scenarios. We input the exported data to our Google colab environment and presented them as follows:

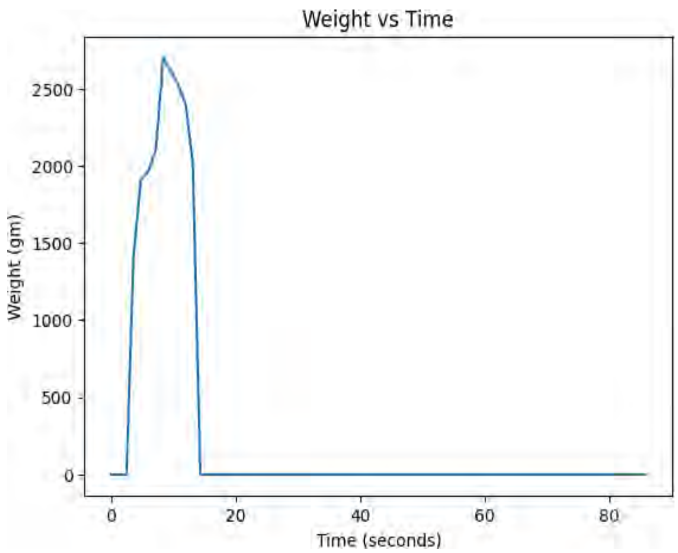


Figure: Weight versus time graph

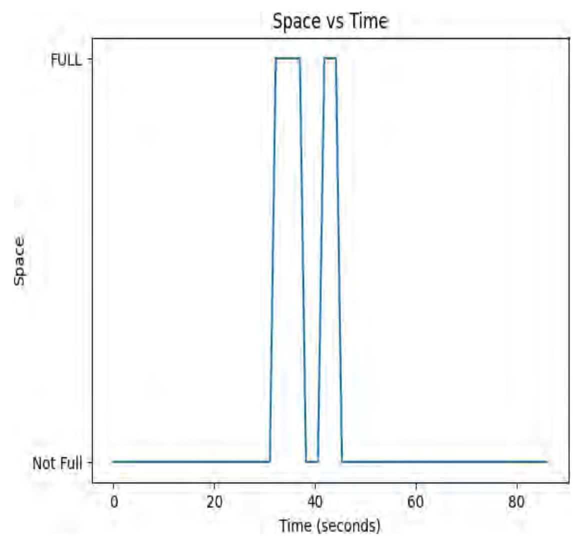
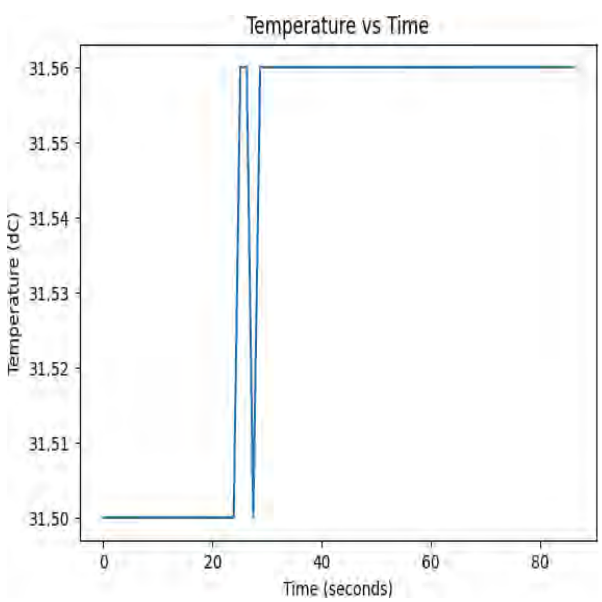


Figure: Weight versus time graph



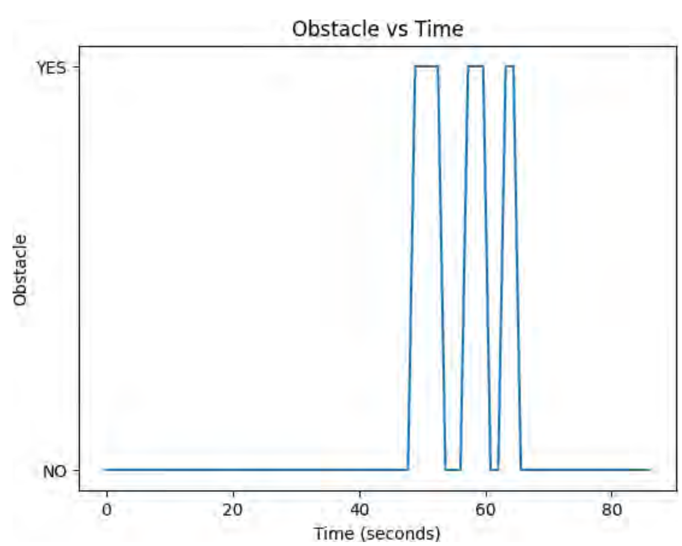


Figure: Temperature versus time graph   Figure: Obstacle present versus time graph

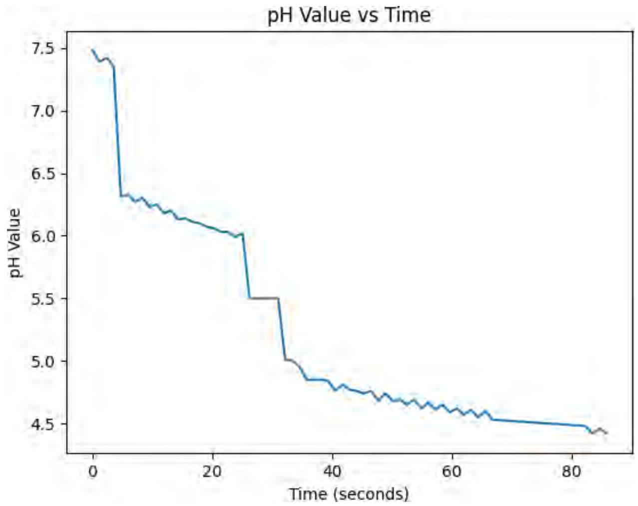


Figure: Weight versus time graph

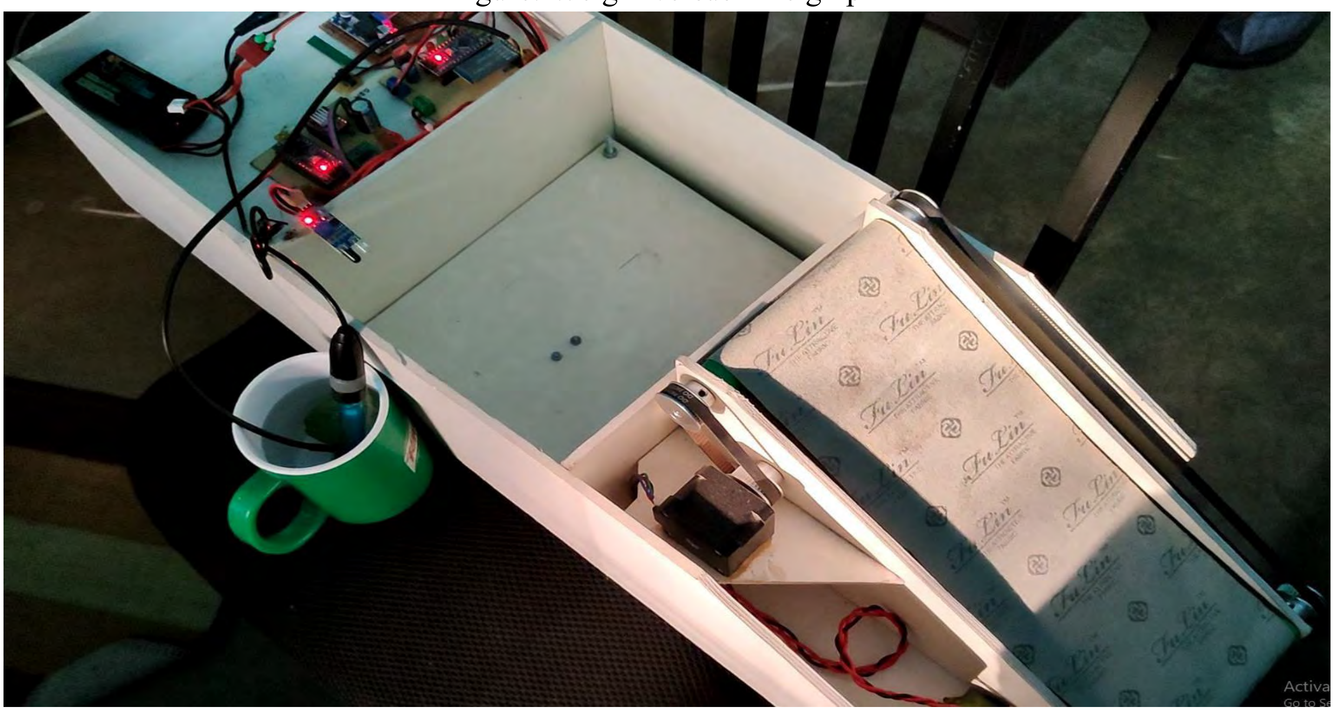


Figure: Final Prototype

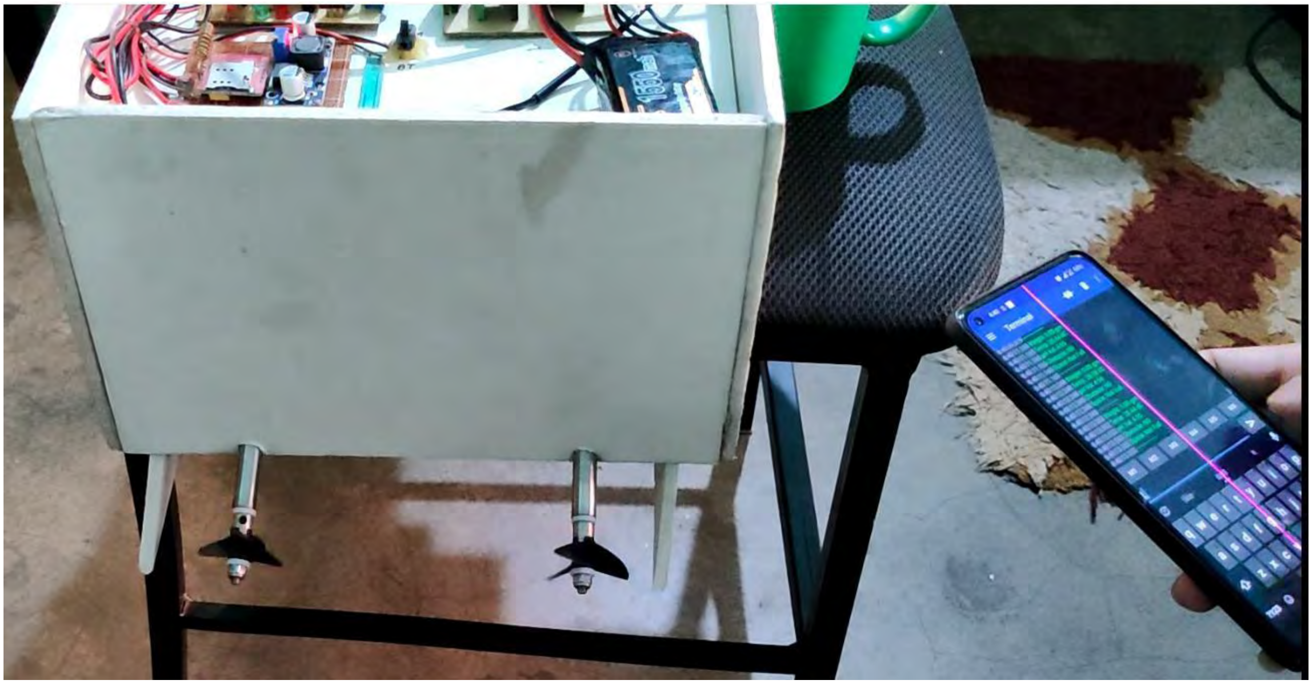


Figure: Testing mobility of the final prototype

Figure: Testing Data transmission of the final prototype

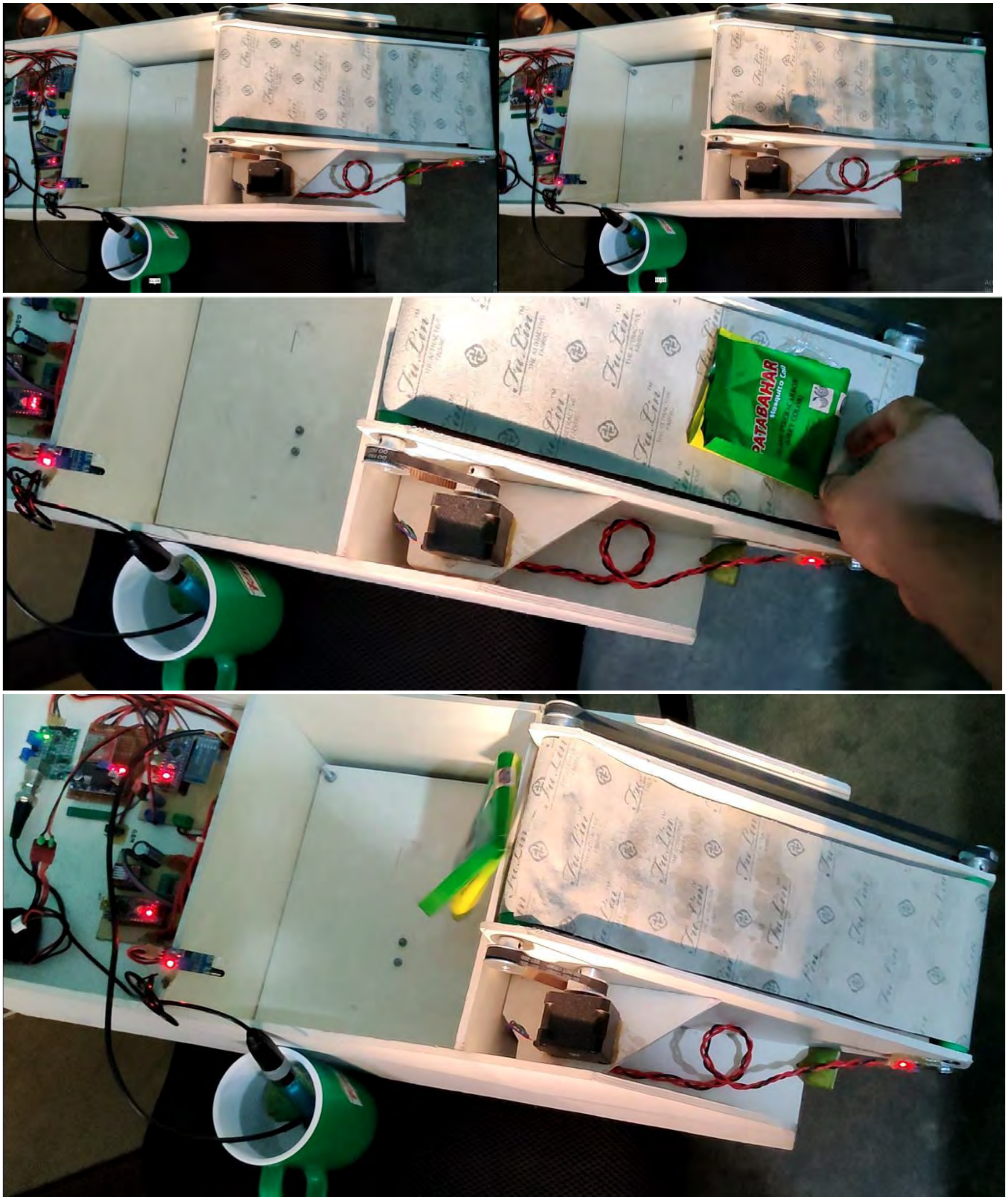
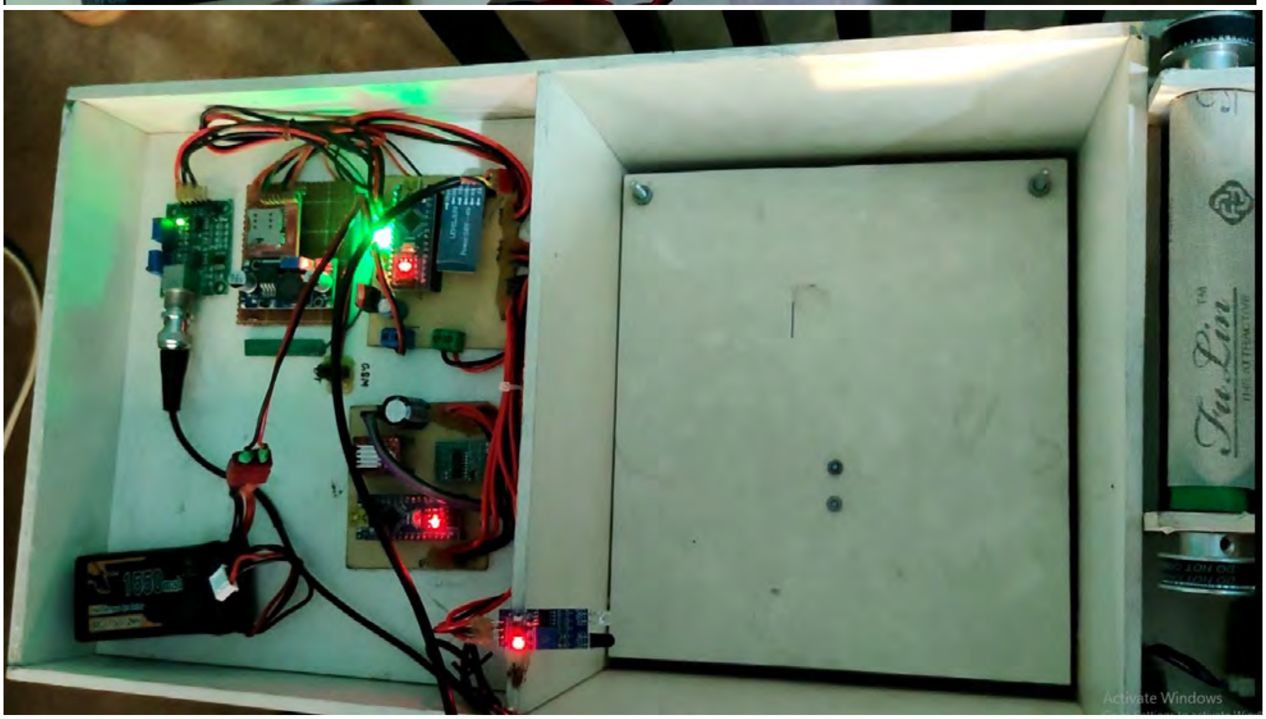


Figure: Testing conveyor belt of the final prototype


Activate Windows

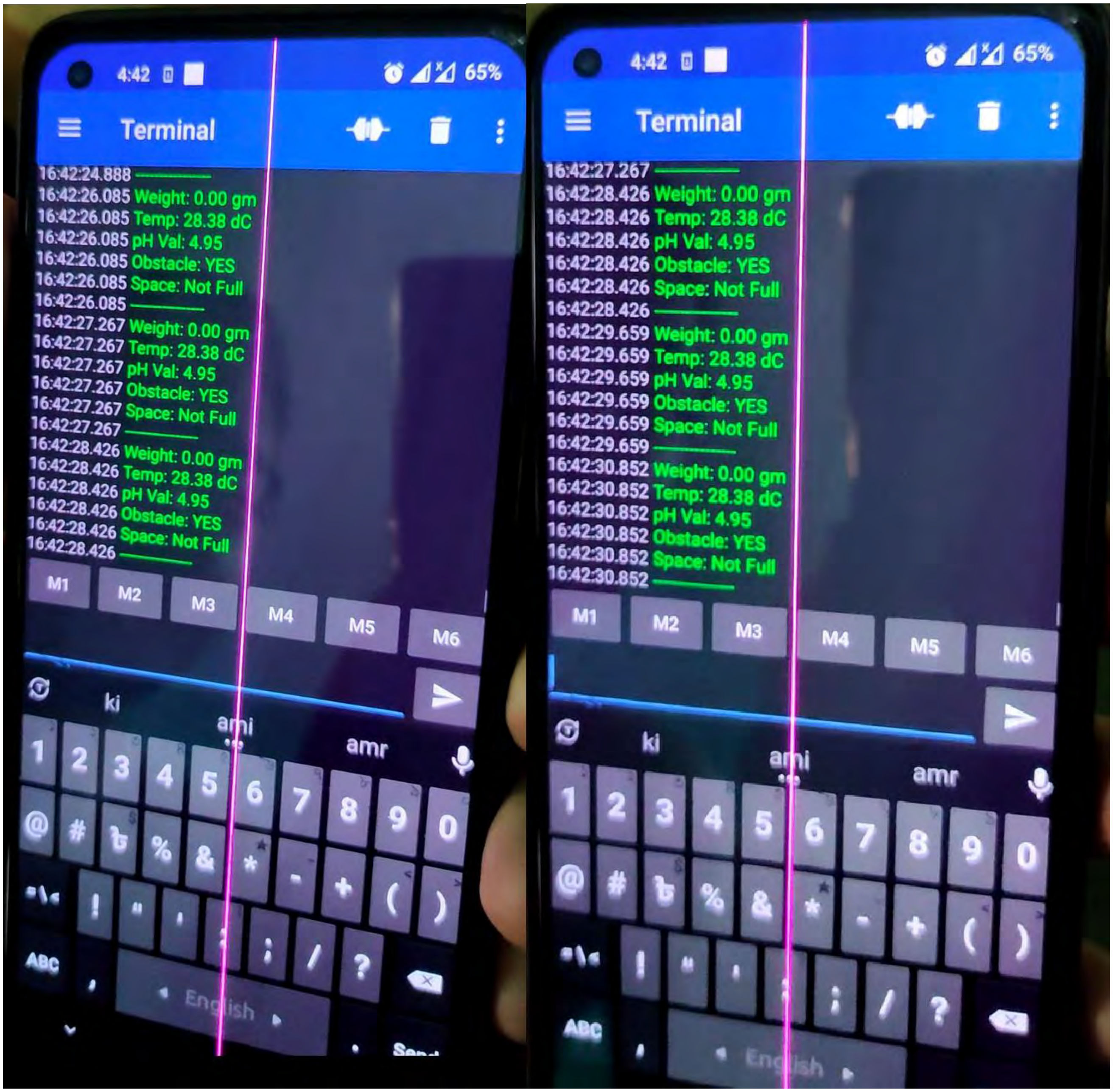


Figure: Obstacle detection test of the final prototype

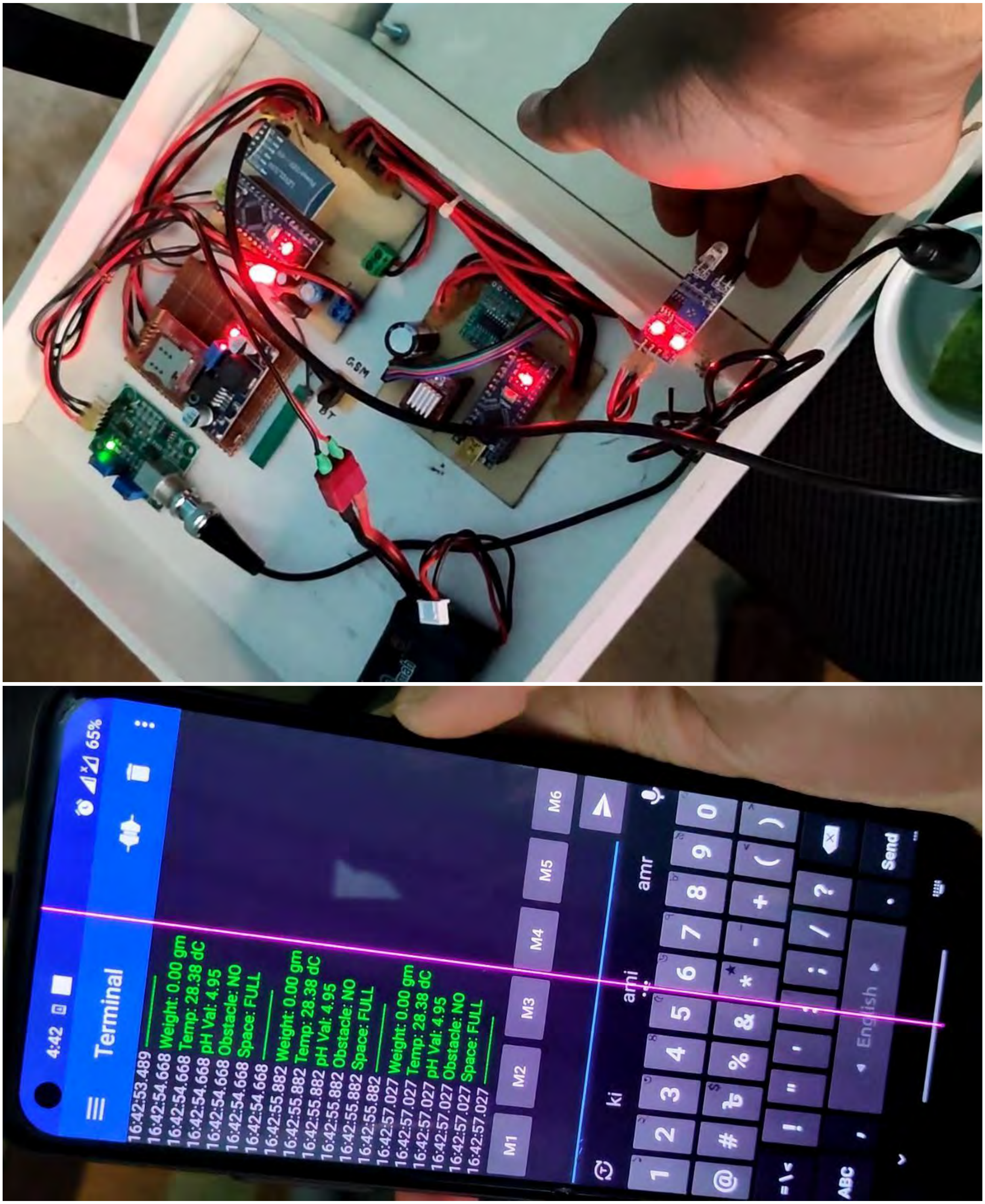


Figure: Garbage level detection test of the final prototype

We have evaluated whether the solution satisfies the desired need by comparing the results of our testing to the original goals and criteria, which are outlined in the project plan.

When compared to corporate machines, the garbage collector's cost-effectiveness was found to be significantly lower, providing value for money. In terms of effectiveness, the garbage collector collects a sizable amount of garbage in a relatively short amount of time compared to manual collection. By counting breakdowns, the garbage collector's dependability was evaluated, and during testing, there were none. Low levels of maintenance were found to be necessary, with only sporadic lubrication and cleaning being required.

The energy consumption and waste produced during operation of the garbage collector were evaluated in order to determine its environmental impact. Its low energy consumption and low waste production during operation make it environmentally friendly. The garbage collector was evaluated for user-friendliness and was found to be simple to use and friendly. Sensors and safety switches were used to test the safety features, making it safe to use.

The garbage collector's resilience to harsh environments was tested, and it was discovered to be good, with components that can last for years. The garbage collector's scalability was assessed and found to be easily adaptable to various area sizes. Finally, the garbage collector's water monitoring function was examined, and it was discovered that the pH and temperature sensors are effective at keeping track of water quality.

Based on the results of our testing, we can say that the garbage collector, with its affordability, efficiency, reliability, environmental impact, user-friendliness, safety features, durability, scalability, and water monitoring capabilities, meets the desired need as described in the project plan.

5.4 Conclusion

In conclusion, the project development process must include a critical step called the final design and validation chapter. It entails completing the solution's final design and development while making the necessary corrections in light of performance evaluation. To make sure the design solution satisfies the desired need, the performance criteria are assessed. To make sure that the solution is created in accordance with the final design, it is crucial to maintain a methodical and logical design approach throughout the project. Obtaining the final design and creating the solution in accordance with the final design are activities involved in this chapter. The project is prepared for the last phase of implementation and deployment after finishing this chapter.

Chapter 6: Impact Analysis and Project Sustainability

6.1 Introduction: With every innovation the world seeks a positive impact. And a system without any impact is a system that is considered to be a worthless one. So, this project aims to be a very impactful one along with being the most sustainable one in the available market. For this, several criteria need to be served.

6.2 Assess the impact of solution

We hope to have so many positive changes in different sectors with our desired project. Some of which are stated below-

Societal- Better livelihood for people (fisherman, farmer etc.) depending on water from different sources like lakes, ponds etc. Even though agriculture does not play the most significant role in our economy anymore, still there is a huge portion of the population who depends on the water directly or indirectly. This project can be a life saver for them with proper implementation.

Health- Reduced health risk due to less polluted water not only for humans but also for aquatic life. Also, our system can take actions depending on the readings of the machine regarding oxidation, pH etc. Livelihood beside polluted water remains under huge health risk. Different water borne diseases like Polio, Malaria, Cholera, Dengue, Scabies, Typhoid, etc. creates so much threat throughout the year. If we manage to clean the water at least for a significant portion, it would have a huge impact on the health condition of not only the mentioned people but also the aquatic life forms of all useful kinds.

Safety- The project is going to be safe as it will be well built and controlled. The materials used to build the system would be mostly environment friendly, ethical (won't harm any marine life), so that it cannot cause any harm to anything that is harmless to mother nature. Moreover, with this process, marine live will get a better environment to reside with safer and sounder atmosphere.

Cultural context- People are not yet used to this type of machine for water. But, with the changing wind of advanced technology, people of Bangladesh should be really compatible with the project and enjoy the fruitful benefits of this. If our project comes to be successful and people see the effect, they surely will use this technology frequently in future. That definitely would create a cultural impact which is much needed at that moment.

6.3 Evaluate the sustainability

By different standards, the sustainability of a project is measured. But it can also be calculated prior to completion of the project with the help of different theories. We have considered SWOT analysis and a weighted decision matrix for this case.

Table 29. SWOT Analysis

Sl no.	Strengths	Weakness	Opportunity	threat
1	Easy to construct and control	Depends on weather	A refined model can be mass produced	Risks of water contamination through sinking
2	Gives necessary info about water purity	Slightly higher budget for common people	Can be fully automated	
3	Optimizing collection of floating wastes	Cannot give information on Chemical pollutants and metals	Can be designed to clean submerged wastes	
4	Efficient power distribution system	Not applicable in sea or river with heavy current and long range	Can be designed to control and obtain information remotely from anywhere on earth.	
5	Portable	Needs extra attention to keep the circuitry away from water		
6	Ecologically friendly.	Operates only in surface level		

Table 30. Weighted Decision Matrix

Activity	Rating	weight	weighted score	weighted score (%)	Approach 1	Weight of approach 1	Approach 2	Weight of approach 2	Proposed Approach	Weight of proposed approach
Pricing	5	0.7	3.5	70	2	1.4	1	0.7	4.5	3.15
Features	3	0.4	1.2	40	2	0.8	3	1.2	2.5	1
Low power consumption	3	0.4	1.2	40	2	0.8	2	0.8	3	1.2
Lightweight	4	0.7	2.8	70	2	2.1	1	0.7	3	2.1
New product to the market	1	0.02	0.02	2	0.5	0.01	1	0.02	0.7	0.014

ease of use	2	0.2	0.4	20	2	0.4	2	0.4	2	0.4
Controllability	4	0.2	0.8	20	3	0.7	3	0.6	2.5	0.5
Ecologically safe	5	0.9	4.5	90	4	3.6	5	4.5	4	3.6
	27		14.42			9.81		8.92		11.964

Here the graph shows a few factors which will impact our project throughout its project lifecycle (from inception to completion). Every factor is assigned a weight within <1 and rating of 0 to 5 where 0 means least and 5 means the best influence. Here our approach 1 got a weighted score of 10(approximately 9.81 rounded), our approach 2 got a lower rating of 8.92 and our main approach got 12 (approximately 11.96 rounded) out of 14.42. Here we see our main approach is very cost effective, is feature packed and will consume less power as it has an efficient onboard power distribution system and as it is RC controlled, it is mostly user friendly. All factors considered; we assess that our main approach will be more sustainable for all markets.

6.4 Conclusion

The outcome of this project would be really impactful as well as sustainable as per above mentioned analysis. Now, for further progress the target audience needs to be convinced regarding the whole process and the system needs to be updated day by day upon the changing trends and upon demand of the consumers. This way, the proper goal of this project would be served.

Chapter 7: Engineering Project Management. [CO11, CO14]

7.1 Introduction

An efficient and successful system for collecting floating trash must be designed, built, and deployed, which requires the coordination and execution of numerous technical and operational components. Multiple engineering fields, including mechanical engineering, materials science, robotics, and environmental engineering, among others, must be integrated to complete this ambitious project. In the planning stage, a detailed project plan is created, outlining all project milestones, a work breakdown structure, and the distribution of both human and material resources. Collaboration among different engineering fields, meticulous planning, and proficient execution are necessary to create, construct, and implement an effective and environmentally friendly solution. Successfully managing this engineering project can play a significant role in safeguarding marine ecosystems, protecting marine life, and enhancing the overall health of our environment.

7.2 Define, plan and manage engineering project

Project plan for 400P:

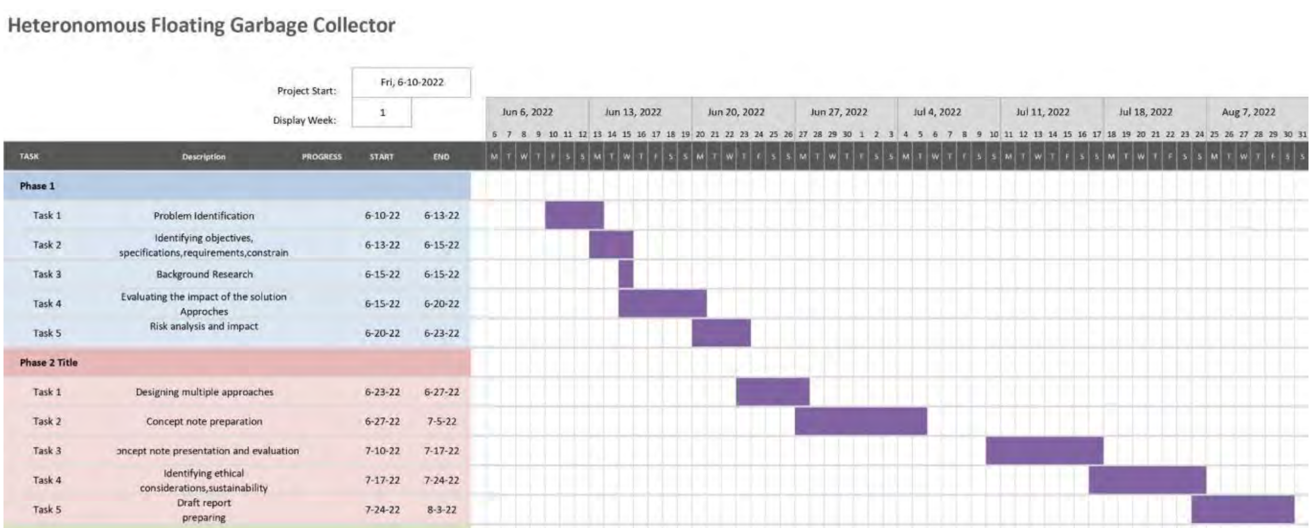


Fig: Gantt chart for 400P

The group members' responsibilities were distributed evenly among them. When necessary, rescheduling and replanning were carried out. For instance, we would have to take into account a person's contribution if they had an exam that day. Apart from that, the work management timeline has been designed earlier to complete the project efficiently. First of all, everyone needs to contribute in the problem identification and topic selection. Afterward, responsibility of identifying objectives, specifications, requirements , and constraints were assigned to Ebon and Anik. Though, every member contributed in background research. However, Saki has assigned for the impact of the solution. Moreover, Risk analysis and contingency plans were prepared by Fahim. From studying multiple published papers, we had come up with some design approaches. Whereas, Anik has completed the block diagram for each approach. Next, we prepared the concept note and completed the first presentation. After the feedback received from ATC panel on concept note we started our project proposal report according to the correction. During the preparation of Project Proposal Ethical considerations, Sustainability, and ethical consideration was done by Fahim. In the meantime, Ebon was searching for the components price related to the project and made a tentative budget. Also, he was keeping the track of all the works by the help of logbook. Finally, contribution of all the members lead us to the completion of each task and maintaining of the timeline.

Project plan for 400D:

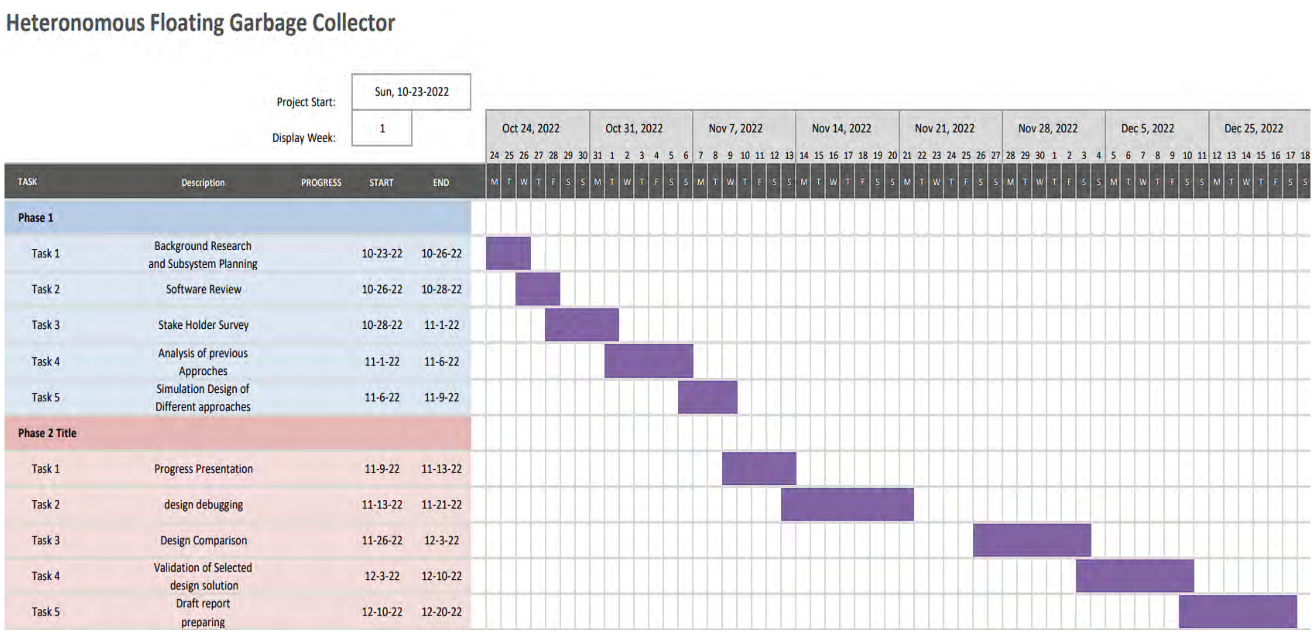


Fig: Gantt chart for 400D

The project plan has continued from the first week of Development by designing alternative solutions and getting used to the relevant softwires required. Continuing with the plan an analysis has been done to find the best solution possible by week 2. The prototype will be designed and stress tested to find whether the model fulfills the requirement of the project. If the prototype does not meet the mark, Appropriate changes made and simulations of required tests continued until the requirements are met by weeks 4 and 5. After that the prototype functioning codes go through the development phase and then to synthesizing phase by weeks 6 and 7. A software-based design has formed to run the aforementioned codes by week 10. After week 10, the plan is to finalize the draft and subsequent design and report which will conclude the development phase.

Project plan for 400C:

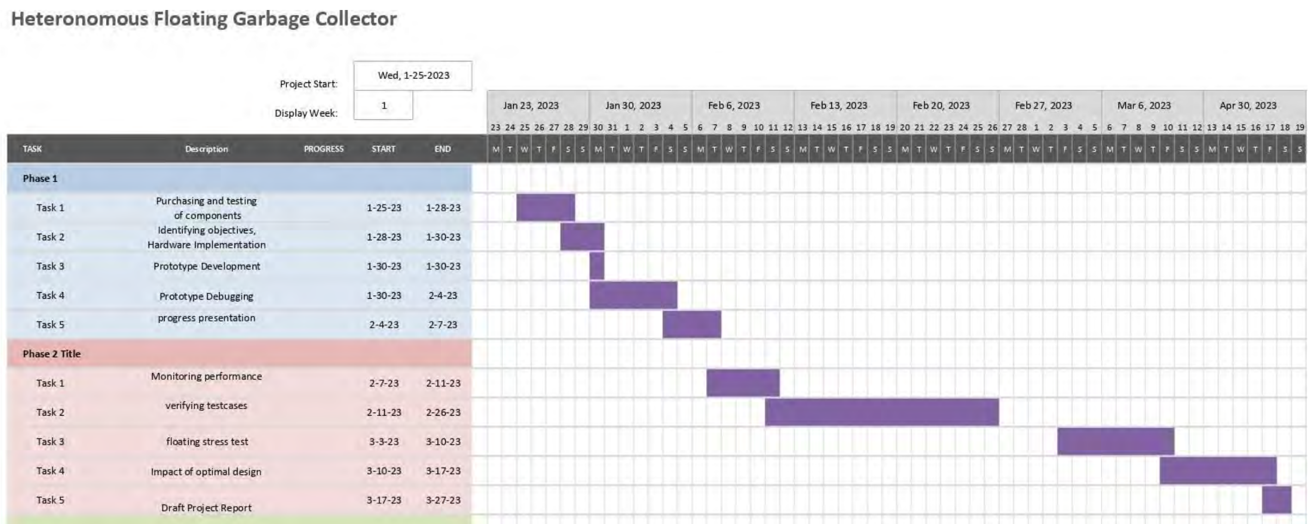


Fig: Gantt chart for 400D

The plan after development will continue from the first week of Completion by application of the solutions and purchasing components for the developed approach. After purchasing the components, relevant testing will be required thus the group will form a test analysis by the end of week 1,2 and 4 respectively. After the tests are concluded, the hardware implementation work will proceed and an approximate timeline of this will be the weeks 3 to 5. Weeks 6 and 7 will be the weeks where the prototype will be constructed and ready for the synthesis phase of hardware implementation. After week 8, a small performing cost benefit and economic analysis by week 10 and the last two weeks will be the test run and final report writing week.

7.3 Evaluate project progress

A few dangers exist at the component level. The sensors could be broken, which would cause serious issues with the system. To fix these problems, error data from backup sensor pairs might be kept. Also, the vessel should not exceed the connectivity range to avoid the risk of disconnectivity.

Table 31. Risk Response Matrix

Risk events	Response	Contingency plan
1.Over collection of garbage	Bringing back the vessel back to shore	using a waste level management system [9]
2. going out of range	Closing the distance between user and prototype	Operating the vessel in sub parts of the water body

5. Electrical failure	Troubleshooting the prototype	Troubleshooting and applying proper fixes
4. animal disturbance	Operating the vessel closer to the shore	Monitoring wildlife in the waterbody and manually changing course
5. Electrical failure	Troubleshooting the prototype	Troubleshooting and applying appropriate fixes
6. weather disturbance	Bringing back the vessel back to shore	Monitoring forecast beforehand and manually changing course
7. Leaks in vessel	Bringing back the vessel back to shore	using of water level detector [3]
8.vessel sinking	Arrange a rescue party	Using sos signal

7.4 Conclusion

One of the major achievements in project management was the development and implementation of a comprehensive plan, which involved defining clear objectives, conducting extensive research on the structure and functioning of the floating garbage collector, and carefully choosing the most effective tools and methodologies to address the problem. The project team followed the plan closely, guiding them through various stages, from initial idea to final execution.

Chapter 8: Economical Analysis. [CO12]

8.1 Introduction

Any project, whether it be a sizable infrastructure project or a small business endeavor, must include an economic analysis [27]. An economic analysis's goal is to ascertain the project's financial viability, taking into account all potential costs, gains, risks, and returns. This analysis entails determining the project's economic viability, estimating its potential economic impact, and locating any potential economic risks or difficulties [27]. The project managers and stakeholders can create a strong project plan and make informed decisions about the project's viability with the aid of economic analysis.

For carrying out an economic analysis of a project, a number of techniques and resources are available, including cost-benefit analysis, cost-effectiveness analysis, and return on investment analysis [28]. These techniques entail estimating the costs and benefits of the project, contrasting them, and determining its overall economic viability. Additionally, they aid in the identification of any potential economic risks or difficulties and the development of strategies to address them.

In addition to assessing the project's economic viability, an economic analysis takes into account the project's effects on the larger economy and society. Examining the project's potential effects on job creation, economic expansion, and environmental sustainability is part of this [29]. Therefore, it is crucial to take into account the project's direct and indirect economic impacts.

Finally, performing an economic analysis is an essential step in the project planning process. It aids in the development of a strong project plan and assists stakeholders and project managers in determining the project's economic viability and potential impact. Project managers can make sure a project is long-term financially viable and sustainable by conducting a thorough economic analysis [27].

8.2 Economic Analysis

Table 32. Cost of Components

Name	Quantity	Unit Price	Price
Arduino Nano	2	500	1000
Bluetooth HC-06	1	320	320
Buck Converter	1	80	80
Lipo Battery 3300mAh 3cell	1	2600	2600
B3 Charger	1	350	350
Nema 17 Stepper Motor	1	1300	1300

DRV8825 Stepper Motor Driver	1	300	300
IR Module	3	50	150
Waterproof DS18B20	1	150	150
pH Sensor	1	2500	2500
SIM900A Mini	1	600	600
L298N Motor Driver	1	300	300
Ship Shaft Propeller	2	1200	2400
12V 1500RPM Geared Motor	2	500	1000
Universal Shaft Coupler	2	200	400
Load Cell 5kg + HX711	1	600	600
Stepper Motor Pulley (Teeth) 5mm	1	150	150
Stepper motor Belt 6mm	2	400	800
Roller Pipe for conveyor	2	100	200
PVC Board 10mm	1	1200	1200
Bearing	2	50	100
Pattern belt for conveyor	1	500	500
PVC foam (Coc) sheet 1.5in	1	500	500
Sum			= 17500

8.3 Cost benefit analysis

Costs:

- Cost of the project: 17,500 BDT
- Project lifespan: Based on the average lifespan of the components listed below, we predict that the project will last for about 5 years.

Components and estimated lifespan:

- Arduino Nano (2): 5 years
- Bluetooth HC-06: 5 years
- Buck Converter: 5 years
- Lipo Battery 3300mAh 3cell: 2 years
- B3 Charger: 5 years
- Nema 17 Stepper Motor: 5 years
- DRV8825 Stepper Motor Driver: 5 years
- IR Module (3): 5 years
- Waterproof DS18B20: 5 years
- pH Sensor for Arduino: 5 years
- SIM900A Mini: 5 years
- L298N Motor Driver: 5 years
- Ship Shaft Propeller (2): 3 years
- 12V 1500RPM Geared Motor (2): 3 years
- Universal Shaft Coupler (2): 5 years
- Load Cell 5kg + HX711: 5 years
- Stepper Motor Pulley (Teeth) 5mm: 5 years
- Stepper motor Belt 6mm (2): 5 years
- Rollar Pipe for conveyor (2): 5 years
- PVC Board 10mm: 5 years
- Bearings (2): 5 years
- PVC foam (Coc) sheet 1.5in: 5 years

Benefits:

- Reduction of floating trash in small water sources: This project will help reduce water pollution by collecting both biodegradable and non-biodegradable floating trash. Water pollution reduction can have a number of positive effects, including improved water quality and the preservation of aquatic life.

- Increased use of clean water on small sources: This project will increase the amount of usable clean water available by removing floating trash from small water sources, which may benefit the neighborhood.

- Savings on costs: This project can help lower the costs related to manual cleaning and the disposal of floating waste by offering a cost-effective method for cleaning small water sources.

We can conduct the following cost-benefit analysis using the estimated costs and benefits:

Costs in total over five years: 17,500 BDT
Total advantages over a period of five years:

Reduced floating trash in small water sources: Although this benefit is difficult to measure financially, it can have a big impact on the environment and the neighborhood.
Increased use of clean water from small sources: Although this benefit is difficult to measure financially, it can have a big impact on the neighborhood.
Savings on costs the cost savings can be calculated at roughly 10,000 BDT per year, or a total of 50,000 BDT over five years, assuming that the project can replace manual cleaning and disposal of floating waste.

Five years' worth of benefits: 50,000 BDT

Benefit over the course of five years: 50,000 BDT - 17,500 BDT = 32,500 BDT.

Accordingly, the project has a net benefit of 32,500 BDT over a five-year period based on this analysis.

8.4 Evaluate economic and financial aspects

Economic aspect:

Estimated Project Cost: The estimated project cost for the inexpensive and simple substitute for expensive commercial cleaning equipment is 17.5k BDT. This sum includes the price of all project-related materials and parts.

Target Market and Potential Demand for the Project: The project's target market consists of locals who require an affordable and simple-to-build garbage collector as well as small eco-friendly organizations. The number of potential customers in the target market and the number of large corporate cleaning machines already in use in the region can both be used to estimate the project's potential demand.

Benefits to the Environment and Society Expected from the Project: The project is anticipated to have substantial benefits to the environment and society. It can assist in lowering the amount of waste and pollution in small areas by offering an affordable and simple-to-build garbage collector. Both the environment and the local population's quality of life may benefit from this.

Potential Economic Benefits of the Project: The project may generate more money and save money in the long run. Small businesses can save money with the project's assistance by lowering the cost of waste management. If the project is successful, it might also make money from product sales.

Economic Impact on Stakeholders and Affected Communities: By providing employment opportunities for those involved in the manufacture and distribution of the garbage collector, the project may have a favorable economic impact on stakeholders and affected communities. By lowering pollution and making waste disposal more affordable, it can also enhance the quality of life for locals.

Financial Assessment:

Project Lifespan Estimate: The project's estimated life expectancy will be influenced by how long each individual component is expected to last. The project should last for several years with proper maintenance, based on the corrosion and lifespan of the parts offered.

Cost of All Required Materials and Components: The total cost of all required materials and components is estimated to be 17.5k BDT. This includes the Arduino Nano, Bluetooth HC-06, Buck Converter, Lipo Battery 3300mAh 3cell, B3 Charger, Nema 17 Stepper Motor, DRV8825 Stepper Motor Driver, IR Module, Waterproof DS18B20, pH Sensor for Arduino, SIM900A Mini, L298N Motor Driver, Ship Shaft Propeller, 12V 1500RPM Geared Motor, Universal Shaft Coupler, Load Cell 5kg + HX711, PVC Board 10 mm, Bearings, and PVC foam (Coc) sheet 1.5in.

Operating costs: Electricity consumption and maintenance/repair expenses will affect the system's operating costs. Estimated cost of electricity consumption is between 1-2 BDT per hour, depending on usage.

Potential Revenue Sources: Sales of products and the provision of services are two potential revenue sources for the project. The amount of money made will depend on how popular the product is and how much marketing is done to promote it.

Financial Return on Investment Expected: The project's expected financial return on investment will be based on the revenue produced after deducting production, marketing, and operating costs. To calculate the return on investment, a thorough financial analysis is essential.

Availability of Financing or Funding Sources: Depending on the region and market the project is aimed at, financing or funding sources may or may not be accessible. It is advised to look into different sources of funding, such as investors, loans, and grants from the government.

Comparative analysis: The project's cost is relatively low when measured against other similar projects on the market, like Watershark[30] and Seabin[13]. It's crucial to keep in mind though that these projects might also have extra features and abilities that might be pertinent to particular use cases.

8.5 Conclusion

In conclusion, the project's economic analysis section offers a thorough assessment of the project's financial and economic aspects. Considering the costs associated with its implementation and the benefits that it can produce in the long run, the cost-benefit analysis gives a clear understanding of the project's economic viability. The project's economic and financial aspects are evaluated to help identify elements that may have an impact on the project's viability and sustainability. Stakeholders can ensure the project's success and long-term viability by carefully analyzing its economic and financial aspects before deciding how to proceed with it. In the end, the project's economic analysis section plays a crucial role in ensuring that it achieves its financial and economic objectives and lays the groundwork for future success. In the end, the project's economic analysis section plays a crucial role in ensuring that it achieves its financial and economic objectives and lays the groundwork for future success. In the end, the project's economic analysis section plays a crucial role in ensuring that it achieves its financial and economic objectives and lays the groundwork for future success.

Chapter 9: Ethics and Professional Responsibilities

9.1 Introduction

Throughout the whole process, it will be strictly monitored that the project does not cause any trouble for anyone not only ethically or morally but also professionally. This project meant for a sustainable solution. So, social, economic and environmental effects will be considered and dealt with rigorously from an ethical and professional viewpoint. And, society demands these attributes from engineers.

9.2 Identify ethical issues and professional responsibility

This project will basically be used in water bodies where different kinds of aquatic lifeforms exist. Also, sometimes, the farmers use the water from these water bodies for farming purposes. Not only that, but also the fishermen depend on these water bodies. So, it would be wise to monitor properly that the end result does not make the water worse to use for the mentioned people. Moreover, this project would be a benefit to them as they do not have the economic strength to spend lots of money to make the water surface free from garbage whereas this project is meant to be cheap for their assistance. Also, the machine is designed to be really easy to control targeting those people. Now, for the professional angle, there are particular authorities who are in charge of the garbage collection and disposal process. Also, it's not legal to just go and have a test run on somebody else's property. So, there are professional responsibilities too. A consent would be needed from every doorstep of this process.

9.3 Apply ethical issues and professional responsibility

For the above-mentioned ethical issues, the group members need to be really concerned. The toxic elements which can cause harm to the water would be avoided actively with no exception so that aquatic life remains safe. The build quality of the machine would be strongly made as this would contain electrical joints and there would be a battery which need not be exposed in the water by any means. For the professional responsibilities, proper authorities are already well informed about the whole process and they understand the necessity of this project. All the required permissions would be in written consent forms. Also, safety guidelines of waste disposal would be followed properly. So, all kinds of responsibilities will be dealt with accordingly. A consent form for the research paper will also be provided for the participants which is stated below-

Consent for Participation in FYDP research and interview

1. I gladly volunteer to participate in a research study for BRAC University lead by Group 9 (student names and IDs) from the FYDP-C course. I understand that the goal of this study is to collect data on the local pollution of the water body. I realize that I will be questioned with about 29 other people as part of this study.

2. I freely choose to participate in this experiment, fully aware that there will be no monetary recompense for my participation. I have the option to withdraw from the program at any time without penalty. It is vital to stress that neither my initial refusal to participate nor my departure from the study will be made public to anyone in my community.

3. I recognize that the majority of interviewees will find the talk fascinating and thought-provoking. Nonetheless, I reserve the right to deny answering any questions or to end the interview if I am uncomfortable during the process.

4.Participating in the project necessitates an interview with researchers from Brac University. The interview will last between 30 and 45 minutes, and the interaction will be documented through note-taking.

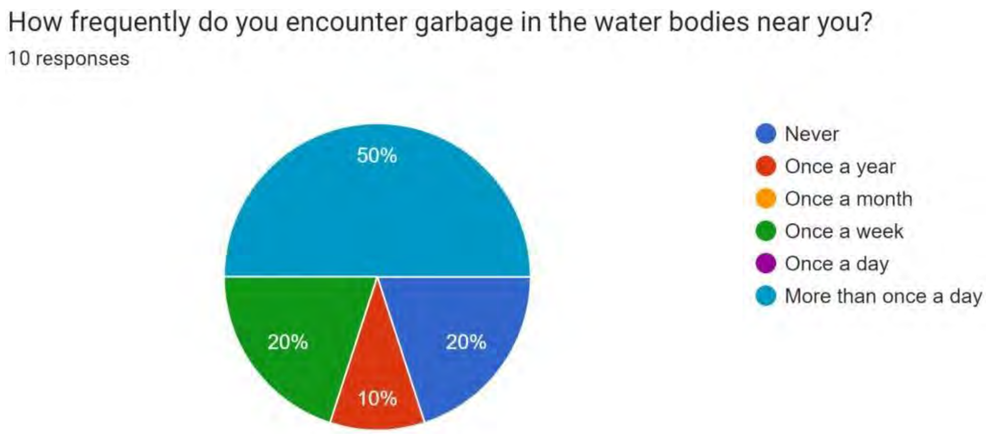
5. As a participant in this study, I accept that my confidentiality will be rigorously preserved, and the researcher will not use my name or any personally identifying information in any publications resulting from this interview. In the future, the use of records and data will correspond to universally acknowledged data usage guidelines, safeguarding the privacy of both organizations and individuals involved.

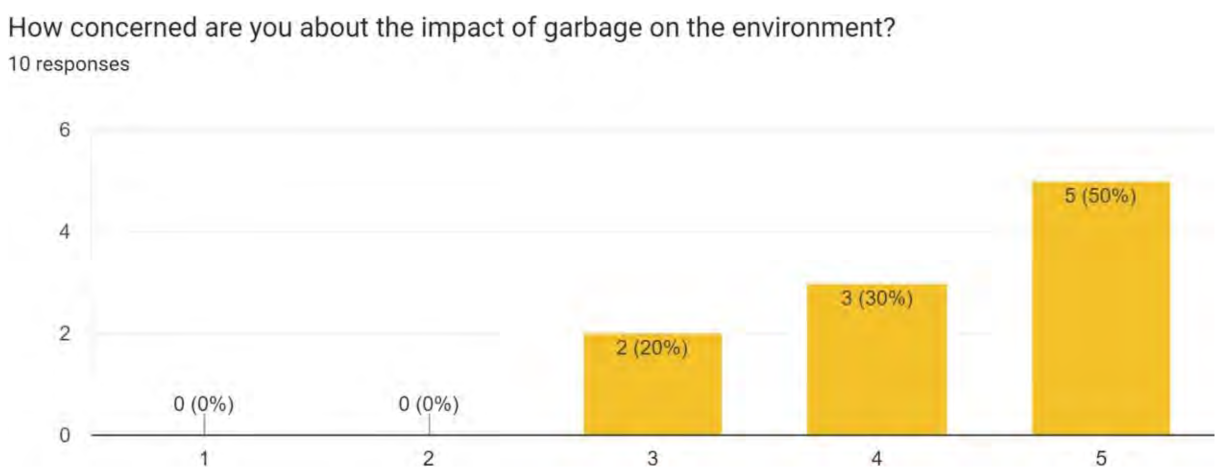
6. I acknowledge that my confidentiality as a participant in this study will be respected, and that the researcher will not use my name in any publications based on the information collected during this interview.

7……….

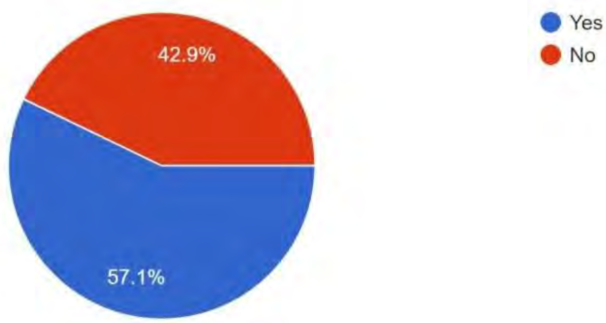
__________________________	__________________________
My Signature	Date
__________________________	__________________________
My Printed Name	Signature of the Investigator

We have run several surveys to be clear about the ethical and professional responsibilities related to this project. These are shown below-

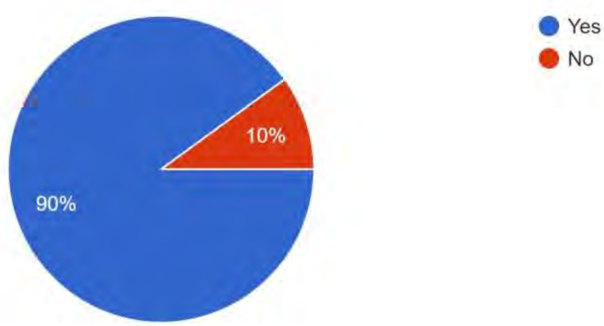


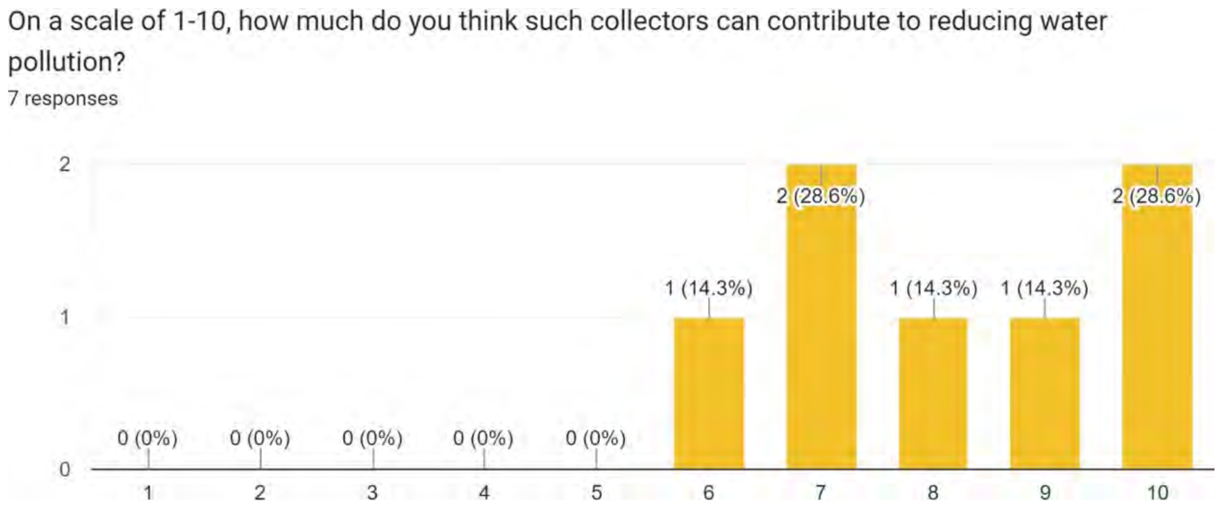


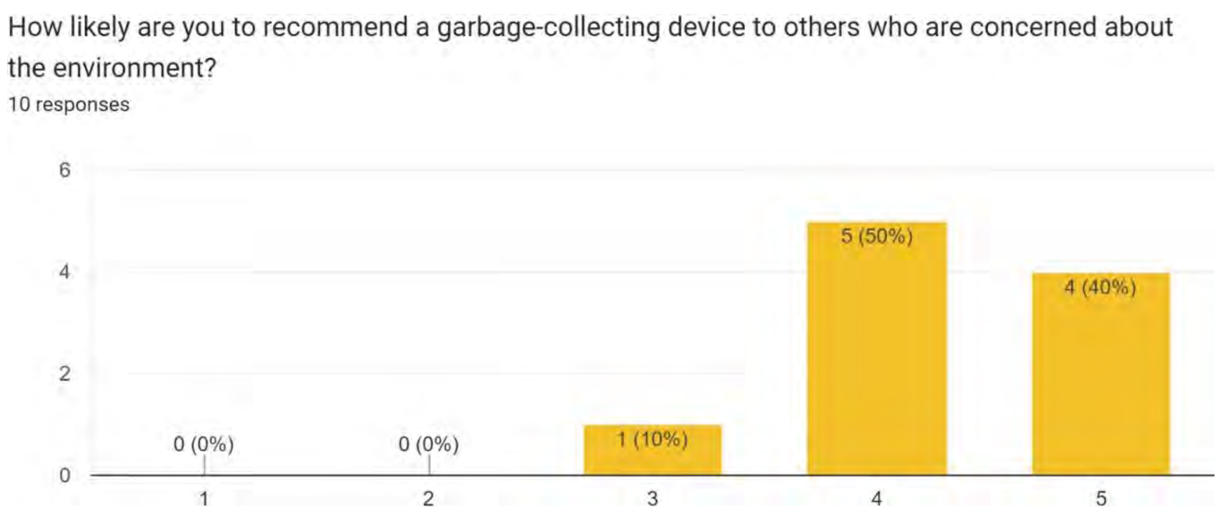
Have you heard of or seen heteronomous (Controllable) floating garbage collectors before?
7 responses



Would you be willing to pay for a device or service that could effectively collect garbage from water bodies?
10 responses







9.4 Conclusion

The main purpose of this project is to create an easy and sustainable solution to maintain a clean and safe water surface for everyone. Proper dealing with ethical issues and professional responsibilities are doorways to gain trust for this project to become reality and gain success. Therefore, all measures will be taken care of accordingly to make this happen.

Chapter 10: Conclusion and Future Work

10.1 Project summary/Conclusion

All life forms on earth, especially humans, depend on water as a vital resource. Water accessibility and availability are central to the development of communities, but sadly, pollution of this vital resource occurs every day. Water pollution is a serious issue that requires immediate attention. It includes everything from toxic waste being dumped in rivers to plastic bottles. Numerous environmental organizations have launched extensive projects to collect trash from oceans and water bodies in response to this problem. However, these initiatives demand a significant amount of resources, including money and labor, and they may also have unintended environmental and marine life effects. A project was started with the intention of addressing this and making water pollution mitigation more approachable and highly controllable.

It was crucial to develop a system that the general public could use easily without endangering the environment in order to accomplish this goal. Users needed a simple and well-known method of communication with the boat, such as SMS, a controller, or buttons. During the testing phase, additional factors were taken into account as well, including the range of sensibility, notification identifiers, power source, load capacity, and collection method. To validate the anticipated results, strategies were tested in real-world settings, and modifications were made to maximize each strategy. A GSM and Bluetooth hybrid-based conveyor belt collection system was found to be the most effective design after extensive testing. Bangladesh uses Bluetooth and SMS extensively, making it a user-friendly method of control. The addition of weight sensors and algorithms that can detect and distinguish between trash and other types of obstacles also allows the conveyor belt system to pick up dirtier areas more quickly and effectively. Last but not least, this strategy can be applied without the aid of grid power in small communities or lakes, is more cost-effective than the other suggested solutions, and only requires one user.

Overall, this project shows how cutting-edge engineering and IT tools can be used to develop long-term solutions for reducing water pollution. The project emphasizes the significance of utilizing technology to develop cutting-edge solutions that address environmental issues and improve society.

10.2 Future work

Although the created prototype for a cheap and simple garbage collector can be seen as a success in achieving the project's goals, there are still a number of improvements and future works that can be done to further increase its functionality and efficiency.

First, by adding more sensors to the garbage collector's sensing system, other water parameters like turbidity and dissolved oxygen can be monitored, giving more accurate information on the water's quality. The information gathered can be used to tweak the collector's settings and enhance its performance.[35][39]

Second, in order to make the garbage collector more portable and simpler to maneuver in tight spaces, future work can concentrate on reducing the garbage collector's size and weight. This can be accomplished by looking into strong, lightweight materials for the collector's structure, like composites or aluminum.[40]

Thirdly, using the Arduino Nano and Bluetooth HC-06, a mobile application can be created to provide real-time monitoring and control of the garbage collector. The sensors and control system of the garbage collector can be integrated with the mobile application to enable remote monitoring and control of the device, improving its convenience and usability.[41][38]

Last but not least, future works may also investigate how to incorporate Internet of Things (IoT) and artificial intelligence (AI) technologies into the garbage collector's system as well as adding more sensors like dissolved oxygen, turbidity sensors. IoT technologies can make it possible for the device to be connected to a larger network for more effective and coordinated waste management, and AI algorithms can be trained to analyze the data gathered by the sensors and optimize the garbage collector's performance.[42]

Overall, these upcoming projects can aid in the development and advancement of the garbage collector by enhancing its usability, functionality, and effects on the environment, society, and the economy. The relevant literature on water pollution, such as [31]–[34], as well as comparable works on garbage collection and cleaning equipment, such as [4]–[6][13], [36]–[38], can be taken into consideration when making these improvements.

Chapter 11: Identification of Complex Engineering Problems and Activities.

11.1 : Identify the attribute of complex engineering problem (EP)

	Attributes	Put tick (√) as appropriate
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	
P3	Depth of analysis required	√
P4	Familiarity of issues	√
P5	Extent of applicable codes	
P6	Extent of stakeholder involvement and needs	√
P7	Interdependence	√

11.2 : Provide reasoning how the project address selected attribute (EP)

P1- This project required various knowledge about sensors, circuits, physics, and virtual simulation software

P3- Analyzing the final design, connecting technique, control system, and communication system in-depth was crucial for this project. To fully comprehend these elements, a variety of software applications were used. This level of study was required to guarantee the proposed system's dependability, functionality, and best performance, enabling wise decision-making and successful deployment.

P4- Project requires the familiarity of local problematic area due to pollution

P6- Local communities, environmental groups, and governmental organizations are all clearly involved in the project and have requirements that must be met. Local communities supply insightful opinions, environmental organizations offer expertise, and government organizations support regulations. The project's effectiveness and sustainability are ensured by this cooperative collaboration.

P7- The system is also interdependence in terms of Communication, Control system and Sensor data

11.3 Identify the attribute of complex engineering activities (EA)

	Attributes	Put tick (√) as appropriate
A1	Range of resources	√
A2	Level of interaction	√
A3	Innovation	√
A4	Consequences for society and the environment	√
A5	Familiarity	

11.4 Provide reasoning how the project address selected attribute (EA)

A1- The project requires the information on local waste disposal methodology and modern tools for theoretical simulation on best approaches to maintain

A2- The project necessitates intensive communication between a wide range of stakeholders, including engineers, scientists, technicians, managers, clients, and end users. For these stakeholders' efforts to be coordinated and incorporated, effective communication and collaboration are essential.

A3- This project suggests a novel strategy to improve waste collection techniques. The detection and control of spillages can be enhanced by incorporating weight and IR sensors. A hybrid communication technique combining Bluetooth serial connection and SMS is also recommended. By making waste collection systems more effective and responsive, this strategy advances waste management.

A4- The project will significantly improve the quality of life.

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Appendix

FYDP (C) Fall 2022 Summary of Team Log Book/ Journal

Date/Time /Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
28.1.22	1.Fahim Arshadur 2.Anik Mazumder 3.Amir Nazib Saki 4.Ebon Ahmed	Discussion about various approaches to complete the prototype	Equal Contribution	Task Completed
5.2.23	1.Fahim Arshadur 2.Anik Mazumder 3.Amir Nazib Saki 4.Ebon Ahmed	1. Researching on the availability of the components 2. Finalizing required components	Equal Contribution	N/A
12.2.23	1.Fahim Arshadur 2.Ebon Ahmed	1. Components testing 2. Planning to complete first subsystem	Equal Contribution	N/A
19.2.23	1.Fahim Arshadur 2.Anik Mazumder 3.Ebon Ahmed	Code development	Fahim,Ebon	All task completed
24.2.23	1.Fahim Arshadur 2.Ebon Ahmed	Code synthesizing test and runtime check.	Ebon	Need Code debugging to minimize error
26.2.23	1.Fahim Arshadur	Planning to design the	Equal	N/A

	2.Anik Mazumder	prototype body.	Contribution	
28.2.23	1.Fahim Arshadur 2.Anik Mazumder 3.Amir Nazib Saki 4.Ebon Ahmed	Creating progress presentation slides	Equal Contribution	N/A
01.3.23	1.Amir Nazib Saki 2.Fahim Arshadur 3.Ebon Ahmed	Making of the conveyor belt subsystem	Anik,Fahim	All Task completed
10.3.23	1.Fahim Arshadur 2.Ebon Ahmed	Assembling of all subsystem and synthesize test	Equal Contribution	N/A
12.3.23	1.Fahim Arshadur 2.Anik Mazumder 3.Amir Nazib Saki 4.Ebon Ahmed	Discussion on further development and upgrading of code to run prototype	Ebon,Fahim	N/A
19.3.23	1.Anik Mazumder 2.Amir Nazib Saki 3.Ebon Ahmed	Modification of design. and circuit improving	Anik	Task Completed
29.3.23	1.Ebon Ahmed 2.Anik Mazumder	Functionality checking	Equal contribution	N/A
2.4.23	1.Fahim Arshadur 2.Anik Mazumder 3.Amir Nazib Saki 4.Ebon Ahmed	Feedback on the prototype	Equal contribution	Partially completed and Improvement required

7.4.23	1.Fahim Arshadur 2.Anik Mazumder 3.Amir Nazib Saki 4.Ebon Ahmed	Connectivity and response check with mobile app	Ebon & saki	N/A
8.4.23	1.Anik Mazumder 2.Amir Nazib Saki	Start preparing draft report	Equal contribution	Report writing must be better.
12.4.23	1.Ebon Ahmed 2.Anik Mazumder	Floating, response range, and water resistance test	Equal contribution	N/A
13.4.23	1.Ebon Ahmed 2.Anik Mazumder	Object detection accuracy, and collection efficiency test	Equal contribution	N/A
20.4.23	1.Fahim Arshadur 2.Anik Mazumder 3.Amir Nazib Saki 4.Ebon Ahmed	Make necessary updates in the report and mail to ATC	Equal contribution	All task completed
24.4.23	1.Fahim Arshadur 2.Anik Mazumder 3.Amir Nazib Saki 4.Ebon Ahmed	Final prototype test updates	Fahim,Anik	All task completed
25.4.23	1.Fahim Arshadur 2.Anik Mazumder	Banner Making for showcasing	Equal contribution	N/A
28.4.23	1.Amir Nazib Saki 2.Ebon Ahmed	Updating report according to the feedback from ATC panel	Equal contribution	All task completed

Related code/theory:

Code for the final prototype:

Code 1:

```
#include <HX711.h>

#include <AccelStepper.h>


// HX711 pins

const int HX711_SCK_PIN = 3;

const int HX711_DT_PIN = 2;


// DRV8825 pins

const int SPEED = 500;

const int DRV8825_STEP_PIN = 8;

const int DRV8825_DIR_PIN = 7;

const int DRV8825_EN_PIN = 6;


// IR module pins

const int IR1_PIN = 4;

const int IR2_PIN = 5;


// Load cell calibration values

const float LOAD_CELL_CALIBRATION_FACTOR = 200.0; // Change this value to calibrate your load cell


HX711 loadCell;
```

```
AccelStepper stepper(AccelStepper::DRIVER, DRV8825_STEP_PIN, DRV8825_DIR_PIN);

long pms, startms;

void setup() {
  Serial.begin(9600);

  // Initialize HX711
  loadCell.begin(HX711_DT_PIN, HX711_SCK_PIN);
  loadCell.set_scale(LOAD_CELL_CALIBRATION_FACTOR);

  // Initialize IR module pins
  pinMode(IR1_PIN, INPUT);
  pinMode(IR2_PIN, INPUT);
  pinMode(DRV8825_EN_PIN, OUTPUT);
  digitalWrite(DRV8825_EN_PIN, 1);

  // Set up stepper motor
  stepper.setMaxSpeed(SPEED); // Change this value to adjust stepper motor speed
  stepper.setSpeed(SPEED); // Change this value to adjust stepper motor acceleration
}

void loop() {
  // Read load cell data
  float load = abs(loadCell.get_units()) - 150;
  if (load < 0) load = 0;
```

```
// Read IR sensor data
bool ir1 = !digitalRead(IR1_PIN);
bool ir2 = !digitalRead(IR2_PIN);

// Send data to Serial
if (millis() - pms > 1000) {
  Serial.print(load);
  Serial.print(",");
  Serial.print(ir1);
  Serial.print(",");
  Serial.print(ir2);
  Serial.println(",");
  pms = millis();
}

// Check for Serial input
if (Serial.available() > 0) {
  char cmd = Serial.read();
  if (cmd >= '1' && cmd <= '9') {
    digitalWrite(DRV8825_EN_PIN, 0);
    stepper.setSpeed(-SPEED);
    int timeout = 1000 * ((int)cmd - 48);
    startms = millis();
    while(millis() - startms < timeout) {
      stepper.runSpeed();
```

```
      }
      digitalWrite(DRV8825_EN_PIN, 1);
    }
  }}
```

Code 2:

```
#include <OneWire.h>
#include <DallasTemperature.h>
#include <SoftwareSerial.h>

// DS18B20 pins
const int DS18B20_PIN = 8;

// Bluetooth HC-06 pins
SoftwareSerial bt(9, 10);  // RX, TX
// SIM800 pins
SoftwareSerial gsm(7, 6);  // RX,` TX

// Motor pins
const int MOTOR_A_PIN1 = 2;
const int MOTOR_A_PIN2 = 3;
const int MOTOR_B_PIN1 = 4;
const int MOTOR_B_PIN2 = 5;

// pH sensor pin
const int PH_SENSOR_PIN = A0;
```

```
// LED pins
const int GREEN_LED_PIN = A1;
const int RED_LED_PIN = A2;

// Mode pin
const int MODE_BUTT_PIN = 12;

// Set up the OneWire and DallasTemperature libraries
OneWire oneWire(DS18B20_PIN);
DallasTemperature ds18b20(&oneWire);

int cp;
long pms;
float tempC, weight, ph;
bool isFull, isObject;

void setup() {
  Serial.begin(9600);
  bt.begin(9600);
  gsm.begin(9600);

  // Set up motor pins
  pinMode(MOTOR_A_PIN1, OUTPUT);
  pinMode(MOTOR_A_PIN2, OUTPUT);
  pinMode(MOTOR_B_PIN1, OUTPUT);
```

```
  pinMode(MOTOR_B_PIN2, OUTPUT);
  stop();

  // Set up LED pins
  pinMode(GREEN_LED_PIN, OUTPUT);
  pinMode(RED_LED_PIN, OUTPUT);

  // Set up mode pin
  pinMode(MODE_BUTT_PIN, INPUT_PULLUP);

  // Start the GSM Module to SMS service
  digitalWrite(RED_LED_PIN, 1);
  gsmInit();
  digitalWrite(RED_LED_PIN, 0);

  // Start the DallasTemperature library
  ds18b20.begin();
}

void loop() {
  if (!digitalRead(MODE_BUTT_PIN)) btCommnad();
  else checkForNewSMS();

  if (millis() - pms > 1000) {
    // Read temperature from DS18B20
    ds18b20.requestTemperatures();
```

```
  float tmp = ds18b20.getTempCByIndex(0);
  if (tmp != DEVICE_DISCONNECTED_C) tempC = tmp;

  // Read pH value from pH sensor
  int phValue = analogRead(PH_SENSOR_PIN);
  ph = (phValue * 14.0) / 1024.0; // Convert analog value to pH value
  pms = millis();
}

if (Serial.available()) {
  String msg = Serial.readString();
  weight = msg.toFloat();
  process(msg);
  isFull = msg.toInt();
  process(msg);
  isObject = msg.toInt();

  digitalWrite(RED_LED_PIN, isFull);
  digitalWrite(GREEN_LED_PIN, isObject);

  bt.println((String)"Weight: " + weight + " gm");
  bt.println((String)"Temp: " + tempC + " dC");
  bt.println((String)"pH Val: " + ph);
  bt.println((String)"Obstacle: " + (isObject ? "YES" : "NO"));
  bt.println((String)"Space: " + (isFull ? "FULL" : "Not Full"));
  bt.println("---------------");
```

```
  }
}

void process(String &msg) {
  int i = msg.indexOf(",");
  msg.remove(0, i + 1);
}

void checkForNewSMS() {
  gsm.listen();
  if (gsm.available()) {
    char rxd = gsm.read();
    if (rxd == '+' && cp == 0) cp++;
    else if (rxd == 'C' && cp == 1) cp++;
    else if (rxd == 'M' && cp == 2) cp++;
    else if (rxd == 'T' && cp == 3) cp++;
    else if (cp == 4) {
      while (rxd != '\n') rxd = gsm.read();
      String msg = gsm.readString();

      if (msg.indexOf("Forward") != -1) forward();
      else if (msg.indexOf("Backward") != -1) backward();
      else if (msg.indexOf("Left") != -1) left();
      else if (msg.indexOf("Right") != -1) right();
      else if (msg.indexOf("Stop") != -1) stop();
      else if (msg.indexOf("Con1") != -1) Serial.print("1");
```

```
      else if (msg.indexOf("Con2") != -1) Serial.print("2");
      else if (msg.indexOf("Con3") != -1) Serial.print("3");
      else if (msg.indexOf("Con4") != -1) Serial.print("4");
      else if (msg.indexOf("Con5") != -1) Serial.print("5");
      else if (msg.indexOf("Con6") != -1) Serial.print("6");
      else if (msg.indexOf("Con7") != -1) Serial.print("7");
      else if (msg.indexOf("Con8") != -1) Serial.print("8");
      else if (msg.indexOf("Con9") != -1) Serial.print("9");
      cp = 0;
    } else cp = 0;
  }
}

void gsmInit() {
  delay(5000);
  delay(5000);
  delay(5000);
  gsm.print(F("AT\r\n"));
  delay(500);
  gsm.print(F("ATE0\r\n"));
  delay(500);
  gsm.print(F("AT+CMGF=1\r\n"));
  delay(500);
  gsm.print(F("AT+CNMI=1,2,0,0,0\r\n"));
  delay(500);
}
```

```
void btCommnad() {
  bt.listen();
  if (bt.available()) {
    char cmd = bt.read();
    if (cmd == 'f') forward();
    else if (cmd == 'b') backward();
    else if (cmd == 'l') left();
    else if (cmd == 'r') right();
    else if (cmd == 's') stop();
    else if (cmd >= '1' && cmd <= '9') Serial.print(cmd);
  }
}

void forward() {
  digitalWrite(MOTOR_A_PIN1, 1);
  digitalWrite(MOTOR_A_PIN2, 0);
  digitalWrite(MOTOR_B_PIN1, 1);
  digitalWrite(MOTOR_B_PIN2, 0);
}

void backward() {
  digitalWrite(MOTOR_A_PIN1, 0);
  digitalWrite(MOTOR_A_PIN2, 1);
  digitalWrite(MOTOR_B_PIN1, 0);
  digitalWrite(MOTOR_B_PIN2, 1);
```

```
}


void left() {
  digitalWrite(MOTOR_A_PIN1, 1);
  digitalWrite(MOTOR_A_PIN2, 0);
  digitalWrite(MOTOR_B_PIN1, 0);
  digitalWrite(MOTOR_B_PIN2, 0);
}


void right() {
  digitalWrite(MOTOR_A_PIN1, 0);
  digitalWrite(MOTOR_A_PIN2, 0);
  digitalWrite(MOTOR_B_PIN1, 1);
  digitalWrite(MOTOR_B_PIN2, 0);
}


void stop() {
  digitalWrite(MOTOR_A_PIN1, 0);
  digitalWrite(MOTOR_A_PIN2, 0);
  digitalWrite(MOTOR_B_PIN1, 0);
  digitalWrite(MOTOR_B_PIN2, 0);
}
```

Google colab/Python Code:

```
import matplotlib.pyplot as plt

# read the data from file
with open('/content/drive/MyDrive/FYDP videos/FYDP project data/Project data 3.txt', 'r') as f:
    data = f.readlines()

# create empty lists to store the data
time = []
weight = []
temp = []
ph_val = []
obstacle = []
space = []

start_time = None

# iterate through the data and extract the values
for line in data:
    if 'Weight:' in line:
        weight.append(float(line.split('Weight: ')[1].split(' ')[0]))
    elif 'Temp:' in line:
        temp.append(float(line.split('Temp: ')[1].split(' ')[0]))
    elif 'pH Val:' in line:
        ph_val.append(float(line.split('pH Val: ')[1]))
    elif 'Obstacle:' in line:
        obstacle.append(line.split('Obstacle: ')[1].strip())
    elif 'Space:' in line:
        space.append(line.split('Space: ')[1].strip())
    elif '----------------' in line:
        if start_time is None:
            start_time = line.split(' ')[0]
        time_in_seconds = sum(float(x) * 60 ** i for i, x in enumerate(reversed(start_time.split(':'))))
        current_time = line.split(' ')[0]
        current_time_in_seconds = sum(float(x) * 60 ** i for i, x in enumerate(reversed(current_time.split(':'))))
        time.append(current_time_in_seconds - time_in_seconds)

# plot the data for each variable in a separate graph
plt.plot(time, weight)
plt.xlabel('Time (seconds)')
plt.ylabel('Weight (gm)')
plt.title('Weight vs Time')
plt.show()

plt.plot(time, temp)
plt.xlabel('Time (seconds)')
plt.ylabel('Temperature (dC)')
plt.title('Temperature vs Time')
plt.show()

plt.plot(time, ph_val)
plt.xlabel('Time (seconds)')
plt.ylabel('pH Value')
plt.title('pH Value vs Time')
plt.show()

plt.plot(time, obstacle)
plt.xlabel('Time (seconds)')
plt.ylabel('Obstacle')
plt.title('Obstacle vs Time')
plt.show()

plt.plot(time, space)
plt.xlabel('Time (seconds)')
plt.ylabel('Space')
plt.title('Space vs Time')
plt.show()
```