Design and Implementation of an Aqua Rover to Collect Surface Trash

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

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Design and Implementation of an Aqua Rover to Collect Surface Trash

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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Approval

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Summer 2023 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science on 26.08.2023.

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Ethics Statement

We declare and confirm that the project " Design and Implementation of an Aqua Rover to Collect Surface Trash" has fulfilled all the requirements of the Final Year Design Project.The project has been completed by the group members. To accomplish this project, assistance was sought from numerous research papers, journals, articles, which were summarized in the literature review and appropriately cited. In conclusion, we affirm that we have identified 8% similarity in the entire project report.

Abstract/ Executive Summary

The Aqua Rover initiative offers a novel approach to reducing water pollution in still bodies of water, with both environmental and economic benefits. With the help of modern technology, this remotely operated rover efficiently collects surface trash, enhancing water quality and sustaining aquatic habitats. The waterproof design, obstacle detection sensors, and wireless data transmission for remote control and monitoring are some of the project's standout characteristics. Beyond its technological accomplishments, the Aqua Rover project represents a dedication to environmental protection and public awareness. It seeks to educate communities about water pollution while collaborating with environmental agencies to ensure compliance with regulations. It further strengthens its societal impact by involving stakeholders and upholding ethical standards.The Aqua Rover project's core market is government organizations, with possible applications in various water bodies. The project's economic feasibility is promising, with a positive cost-benefit analysis indicating long-term profitability.

Keywords: Aqua Rover; Water Pollution; Environmental Preservation; Public Awareness; Remote Control; Cost-benefit Analysis.

Dedication

We would like to express our sincere gratitude to Tasfin Mahmud, a lecturer in the BRAC University EEE Department, for his important advice and support during our project. His knowledge and guidance have been crucial in forming our project. We also like to sincerely thank Md. Nazrul Islam and Jahirul Islam, the FYDP Lab assistants, for their help and technical advice, which were very helpful to the success of our project. Shabbir Hossain Shuvo, Ferdous Arnab and Kousik Das, our devoted classmates and friends, your cooperation, support, and shared expertise have been crucial in overcoming obstacles and attaining our goals. The success of this project is a result of the teamwork and assistance of these people, and we are sincerely appreciative of their contributions.

Acknowledgement

We want to elevate our ATC panel as a gesture of gratitude for their valuable insights and unwavering support. This gesture underscores our sincere appreciation for their contributions, which have significantly enriched our operations. By acknowledging their role in providing astute opinions and invaluable assistance, we seek to strengthen our collaboration and further enhance the synergy between our team and the ATC panel.

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Chapter 1: Introduction

1.1 Introduction

The pollution of the world's water supplies is becoming an increasingly urgent problem that endangers aquatic ecosystems, human health, and the environment. The collection of floating garbage and litter on the surface of water bodies is a major contributor to water pollution. The aesthetic value of waterways is diminished, aquatic life is harmed, ecosystems are upset, and the accessibility of clean water is threatened by this type of pollution. The project "Design and Implementation of an Aqua Rover to Collect Surface Trash" presents a novel solution to this critical issue by creating a semi-autonomous robotic vehicle called the Aqua Rover to collect trash from the surface of the ocean.

The goal of this research is to develop cutting-edge rovers that can successfully cruise waterways, recognize floating waste, and remove it. The Aqua Rover's primary goal is to help lessen water pollution by collecting trash floating on the water's surface. The project's goal is to improve the quality of water used for aquaculture and drinking water supply while also reducing the detrimental effects of water pollution on aquatic ecosystems.

The declining ecological health of Hatirjheel Lake, a key water body in Dhaka, Bangladesh, informed the project's scope. Finding efficient ways to mitigate pollution is urgent due to the lake's importance in the local drainage system and its appeal among inhabitants for recreational purposes. When it comes to removing trash from the water's surface, the methods now in use fall short, making it necessary to adopt a fresh strategy that makes use of technology and creativity.

The goal of this project is to create an operational prototype of a semi-autonomous robotic vehicle called the Aqua Rover that can navigate water surfaces, identify garbage, and collect garbage. To achieve its aims of cleaner water bodies and better ecosystems, the initiative integrates engineering concepts, technological skills, and a dedication to ethical and environmental considerations. The initiative aims to contribute to ongoing efforts to preserve the environment and improve the quality of life for communities dependent on water resources through careful design, rigorous calculations, adherence to safety requirements, and ethical concerns.

1.1.1 Problem Statement

Lake water is essential for many purposes, including irrigation, aquaculture, and animal use. Getting access to clean drinking water is a top priority for those who live in developing countries. Freshwater conservation is currently a top priority on a global scale since it is one of the most crucial resources for treating water so that it can be utilized as drinking water. The centrally positioned Hatirjheel Lake is an important part of the city’s drainage system. It was formerly linked to the Begun Bari Khal at the Rampura Bridge as well as a string of other lakes, including the Banani, Dhanmondi, and Gulshan Lakes. Therefore, the environmental conditions of these lakes have a significant impact on the residents of the city and its surroundings. Different forms of municipal trash are caught in each lake. The excessive waste water is destroying the lake ecosystem. As a result, biodiversity is changing more dramatically. Fish & other aquatic plants or organisms of the lake have been affected. The worst issue arises from floating garbage. Therefore, the plants that used to grow in lake beds and provide food for fish or other living things are no longer present. Furthermore, the panoramic beauty of the site has made Hatirjheel, a popular destination for relaxation among city residents. As the city offers few options for open space, the 302-acre Hatirjheel has evolved into an open place where people may spend their free time with natural beauty. Visitors frequently visit this location from morning till midnight, affecting the Hatirjheel's landscape. The majority of the site's areas were seen to be littered with things like plastic water bottles and bags, cigarette butts, cigarette packets, papers, paper bags, polythene bags, waste from different food items, coconut shells, and tissue paper as visitors threw these things into the lake because there weren't many trash cans nearby. Additionally, filthy water sources serve as mosquito breeding grounds.

Figure 1: Surface Waste of Hatirjheel

According to BD news, Hatirjheel is losing its charm to pollution as published in their January issue of last year. where they raise the concern that plastic is the most polluting material in Hatirjheel, as evidenced by the paper, plastic tea or coffee cups, food boxes, polythene bags, chip packets, and other waste debris that can be found there. Despite the fact that Hatirjheel is one of the few open spaces and a popular recreational area for Dhaka city residents, this is the situation we are faced with. Unfortunately, pollution and visitor-generated trash are causing Hatirjheel's attractiveness to diminish [1, Fig 1].

1.1.2 Background Study

The technology in the proposed projects in the past was mechanical in nature and dependent on human pedaling. As electronics were not included in the design, there is no automatic control over the trash pickup [2].

- “Chen Su et al. [3] reported "An Autonomous Ship for Cleaning the Waste Floating on a Lake." The ship was built with a motion control system that could be handled manually or automatically and was based on ultrasonic distance sensing. The biggest issue was that there was no control over the garbage collection and that the ship’s motion was not smooth.

- Water Surface Cleaning Robot’ was developed by Raghavi et al [4]. The development of a surface vehicle was the primary goal of the task suggested. Sensors for measuring water quality were used with the robot. The main drawback of this method is that the production process is complicated and not very cost-effective.

- With the ability to work underwater, scan the target surface, and record biological reactions, an industrial underwater cleaning rover was developed [5], and presented a revolutionary concept for a flexible crawling mechanism. The device’s design was limited to clearing biofouling from water surfaces.

- In a publication, a method for removing floating debris from aquatic bodies was described. The robot's job is to scoop up debris off the water's surface and place it in the designated tray. The system did not, however, immediately identify the trash.[6]

- A ”Pond Cleaning Robot” was proposed by Soumya et al. to clean up the lake’s debris. The device is controlled by a smartphone. Based on the AT89S51 controller, the device is constructed. The robot couldn’t be guided by the system’s sensors, which were supposed to automatically detect trash [7].

- With the use of a motor and chain drive setup, Madhavi N. Wagh et al. [8] investigated and demonstrated the automated operation of river cleaning. The cleaning machine is managed by an RF transmitter and receiver. To accomplish this at a low cost, many technologies like computers, hydraulics, pneumatics, and robotics are used. The main issue with this technology is that the wireless communication range is insufficient. From these works, we can conclude that there has not been a proper initiative to analyze and evaluate the problem of cleaning the surface of water bodies, especially still water bodies. This is mainly because of the lack of proper equipment and the necessary knowledge and awareness of supplementary issues. Thus, we are trying to overcome this predicament by proposing a project that can make it easier to keep large water surfaces clean.

1.1.3 Literature Gap

The existing literature on water surface cleaning and pollution mitigation has addressed several important aspects, but certain gaps remain:

- **Comprehensive Autonomous Solutions:** While there are many approaches to cleaning up polluted water, there is a knowledge gap when it comes to fully autonomous systems created for efficiently collecting surface debris. When compared to a completely or semi-automated solution like the Aqua Rover, the flexibility and efficiency of current approaches relying on physical labor or static devices fall short.

- **Limited Application Scope:** There have been a lot of studies done on how to best remove pollutants from various bodies of water. Still water bodies like lakes, ponds, and reservoirs all have their own unique challenges with surface debris, but there aren't many universal methods available to deal with all of them.

- **Technological Integration:** Integration of cutting-edge technologies such as real-time monitoring is typically overlooked in the literature. There is a paucity of research on how these innovations might improve the efficiency and adaptability of water-surface cleaning infrastructure.

- **Economic Viability:** While the positive effects of pollution reduction on the environment are generally agreed upon, research on the financial viability and possibility of profit from autonomous water cleaning technologies is lacking. For the successful execution and long-term viability of such projects, an understanding of the economic elements is essential.

- **Long-Term Environmental Impact:** Short-term consequences, such as quick debris collection, are typically highlighted in the literature. There has been little investigation into how persistent debris removal might affect aquatic ecosystems, nutrient cycles, and natural sedimentation processes in the long run.

- **Community Engagement and Education:** Not enough has been written about the importance of public engagement and education in reducing water pollution. There needs to be an effort to educate the public, promote environmentally sound waste management practices, and instill a sense of pride in one's local water supply in the surrounding towns.

In order to move the field of water pollution mitigation forward and encourage the use of novel technologies like the Aqua Rover that aim to produce a cleaner and more sustainable aquatic environment, it is crucial that these literature gaps be filled.

1.1.4 Relevance to current and future Industry

In terms of environmental protection, technological progress, and responsible business practices, the Aqua Rover project will have lasting significance in the marketplace for years to come.

Environmental Technology: Industries are actively looking for new ways to reduce pollution and its harmful effects as environmental concerns rise. The increasing need for technology that can actively contribute to enhancing water quality and managing pollution in various water bodies is in line with the Aqua Rover's semi-autonomous and efficient water surface cleaning capabilities.

Smart Cities and Infrastructure: Sustainable solutions that can preserve the quality of urban water sources are in demand due to the growth of "smart cities" and other forms of urban infrastructure. The Aqua Rover's ability to clean water surfaces automatically is a great example of how smart city efforts can improve people's lives.

Aquatic Tourism and Recreation: Clean and attractive water bodies are good for the tourism, boating, and recreation industries. The Aqua Rover's contribution to keeping lakes and ponds clean will benefit these sectors by encouraging more tourism and making water-based activities less dangerous and more available.

Technological Advancements: Robotics, sensors, real-time monitoring, and remote control are just some of the cutting-edge technologies incorporated into the Aqua Rover. In the robotics and automation sectors, these technologies help propel development in areas such as navigation and data analytics.

Waste Management and Sustainability: This work is in line with a worldwide trend towards more eco-friendly methods of trash disposal. The Aqua Rover's ability to collect and dispose of floating garbage contributes to healthier water bodies and is in line with broader sustainability aims as industry looks for ways to minimize waste and reduce environmental impacts.

Collaboration with Environmental Organizations: The Aqua Rover project's public-private partnership with environmental groups serves as an example for future endeavors of this kind. By working together towards common goals of environmental protection and corporate social responsibility, this method can serve as an inspiration to other sectors to join conservation efforts.

Research and Innovation: The Aqua Rover project opens up new avenues for exploration and development of autonomous watercraft technology. Industries engaging in such projects can help in the advancement of state of the art sensor technology, energy efficiency, and data analysis, all of which can have far-reaching implications.

1.2 Objectives, Requirements, Specification and Constant

1.2.1. Objectives

- To study, understand, and analyze different existing systems and existing devices that are used for floating trash collection.
- To overcome the difficulty of removing waste particles floating on the water surface.
- To design and do the analysis of proposed floating trash handling vehicles with suitable software.
- To develop the prototype of the proposed floating trash handling vehicle.

1.2.2 Functional and Nonfunctional Requirements

Table 1: Functional and Non-functional Requirements

Functional	**Non-functional**
Collecting floating trash from the water surface.	Plug-in charging capability
Has to be capable of carrying waste storage	Backup Power System
Setting an operating range to collect trash	Figuring out how much garbage is being stored
Minimum runtime of the rover is 30 minutes.	Cost-Effective and easy to maintain

1.2.2 Specification

Table 2: Specifications of Aqua Rover

Component	**Parameters**	**Value**
Rover	Length (L)	2 meters
	Width (W)	1 meters
	Height (H)	0.4 meters
	Velocity of the Rover	3 km/hr
	Rover Weight	20-25 kg
	Conveyor Belt’s Speed	0.05 m/s
	Roller Diameter	0.05 meters
	Operating Range	0.5 km - 1 km
	Length (L)	0.5 meters
	Width (W)	0.5 meters

Trash Collecting Bin	Height (H)	0.2 meters
	Estimated Capacity of Garbage	2.5 kg
	System Stops at 80% Full	Yes

1.2.3 Technical and Non-technical consideration in design process

Table 3: Technical and Non-technical consideration in design process

Technical Considerations	Non-Technical Considerations
Functionality and Performance:	**Environmental Impact:**
- Efficient trash and contaminant removal	- Use of renewable energy and energy-efficient components
- Operation in various environmental conditions	- Careful waste management
Power Source and Energy Efficiency:	**Regulations and Compliance:**
- Selection of the appropriate power source	- Adherence to local rules and regulations
- Maximizing energy efficiency through motor choice and power management	- Compliance with water body management policies and safety requirements
Sensors and Perception:	**Ethical Considerations:**
- Integration of precise sensors like ultrasonic detectors	- Silent and minimal impact operation
- Obstacle recognition	**Community Acceptance:**
- Facilitating semi-autonomous operation	- Public outreach and community engagement
Materials and Durability:	**Aesthetic Integration:**
- Construction from tough, water-resistant materials	- Blending with the natural aesthetics of water
- Corrosion-resistant components for longevity	**Cost and Economic Viability:**
- Endurance in water and harsh conditions	- Budget balancing with project capabilities and benefits
Communication and Data Transmission:	- Demonstrating long-term economic worth
- Secure channels of communication	**Cultural and Social Factors:**
- Reliable wireless connectivity	- Consideration of local customs and social dynamics
Safety Measures:	**Public Awareness and Education:**
- Emergency stop mechanisms and collision	- Addressing water pollution and proper trash

prevention	disposal
- Ensuring safety of aquatic environments and species	**Risk Management:**
Maintenance and Upgradability:	- Anticipating and planning for unforeseen challenges
- Efficiently repairable and upgradable components	- Technical failures and negative environmental effects

These technical and non-technical considerations are essential for guiding the design and development of the Aqua Rover, ensuring it meets both functional and ethical objectives.

Constraints:

- During collection, large debris could become lodged.
- Floating aquatic plants might get stuck in the system during trash collection.
- Water vessels will impede the vehicle's route.
- Small waves will cause the vehicle to sway, increasing its chance of capsizing.

1.2.4 Applicable compliance, standards, and codes

Adherence to applicable IEEE (Institute of Electrical and Electronics Engineers) rules and standards is critical to ensuring the quality, safety, and efficacy of the Aqua Rover during development. Among the IEEE norms that can be relevant are:

Table 4: Applicable compliance, standards, and codes

IEEE Standard	Description	Applicability in Aqua Rover
IEEE 45-2018	Recommended Practise for Electric Installations on Shipboard	Marine environments and electrical installations on the Aqua Rover
IEEE 802.11	Wireless LAN (WLAN) Standards	Wireless data transmission for reliable and secure connectivity
IEEE 802.15	Wireless Personal Area Network (WPAN) Standards	Short-range wireless communication between Aqua Rover components
IEEE 802.16	Broadband Wireless Access (BWA) Standards	High-speed wireless communication over longer distances

IEEE 2030.5	Smart Energy Profile	Integration of renewable energy sources or energy management systems
IEEE 29119	Software Testing Standards	Quality and reliability testing of software components in the Aqua Rover
IEEE 1451	Smart Transducer Interface Standards	Interface standards for integrating sensors into the Aqua Rover
IEEE 1528	Standard for Software Life Cycle Processes	Software development and lifecycle management within the project
IEEE 1596	Scalable Coherent Interface (SCI) Standard	Complex communication between multiple Aqua Rover components
IEEE 2675	Standard for Architecture and Protocol for Wireless Sensor Networks	Integration of wireless sensor networks for data collection
IEEE 2030	Information Technology and Energy Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads: A Guide for Smart Grid	Integration with smart grid technologies for interoperability
IEEE 802.3	Ethernet Standards	Use of Ethernet for communication within the Aqua Rover

It's important to review and consider the specific clauses and recommendations within these IEEE standards that align with the Aqua Rover's design and intended operation. Adhering to these standards can help ensure that the project follows established best practices, promotes safety, and facilitates interoperability within the broader technological landscape.

1.3 Systematic Overview/summary of the proposed project

Water pollution is a growing problem in many parts of the world. Litter and refuse adrift on the surface of aquatic environments not only tarnish the visual appeal of nature but also pose detrimental consequences for the well-being of aquatic ecosystems and their inhabitants. The Aqua Rover represents an innovative robotic solution crafted to combat this issue by gathering drifting litter and debris from the water's surface. This remarkable device boasts a compact design, featuring a waterproof body, propellers, and a dependable debris collection system. Its energy source stems from a rechargeable battery, granting it the ability to function effectively in a wide range of aquatic conditions, whether calm or turbulent. The collection mechanism comprises a conveyor belt and flaps meticulously designed to efficiently amass floating debris, with the added convenience of effortless emptying when it reaches capacity.

The Aqua Rover offers the flexibility of remote control operation or the option to function autonomously, adhering to predefined routes and schedules. Its adept navigation skills enable it to traverse bodies of water adeptly, proficiently collecting floating debris, consequently playing a pivotal role in mitigating the environmental repercussions of water pollution. The compact nature of this robot equips it to access challenging terrains, including narrow canals and riverbanks, where drifting debris typically accumulates. In summary, the Aqua Rover emerges as a highly promising technological innovation poised to combat water pollution stemming from floating litter and debris. Its compact design, highly effective debris collection system, and adaptability to varying aquatic conditions render it a valuable tool for upholding the cleanliness of water surfaces. Its commendable environmental impact and its contribution to the preservation of aquatic ecosystems underscore its significance within the realm of environmental technology. It is noteworthy, however, that both remote control and autonomous operation possess their unique advantages and constraints. Remote control offers greater precision and flexibility but necessitates human supervision and dependable communication. In contrast, autonomous operation guarantees continuous functionality and reduces the need for human intervention, although it may be less adaptable to unforeseen environmental changes.

1.4 Conclusion

The Aqua Rover initiative presents a technology-driven response to the issue of water pollution through the utilization of semi-autonomous vehicles to gather floating debris in stagnant water bodies. This study is of paramount importance for several compelling reasons, encompassing the amelioration of water quality, the safeguarding of aquatic ecosystems, and the promotion of ecologically responsible practices. In the subsequent segments of this examination, a more comprehensive exploration will delve into the project's design approach, research methodology, resulting outcomes, economic assessment, and the potential future implications associated with the Aqua Rover initiative.

Chapter 2: Project Design Approach

2.1 Introduction

The design and development of the Aqua Rover stands out as a significant and challenging endeavor in the effort to reduce the growing environmental issue caused by water pollution. This chapter provides a crucial framework for understanding the complex design strategy that supports the development of the Aqua Rover, a highly specialized aquatic robot designed to address the pressing problem of surface garbage accumulation in aquatic environments. In this chapter, a complete design exploration journey is initiated, exploring the many factors, tactics, and ideas that have been exhaustively looked at as part of the unwavering quest to create a ground-breaking response to this worldwide problem.

2.2 Identify multiple design approach

Two design methods were chosen after extensive investigation and analysis.

Remote Control (RC) Operation:

Within this approach, a remote control apparatus takes center stage as the means to oversee the rover's operations manually. This setup allows for real-time manipulation by an operator, rendering it particularly suitable for scenarios that demand meticulous control or immediate human intervention.

Autonomous Design:

In this particular method, the Aqua Rover functions autonomously, depending on sensors, algorithms, and pre-defined instructions to traverse and execute tasks without the need for human intervention.

2.3 Describe multiple design approach

In this section, multiple design approaches were considered to develop the Aqua Rover. The identified approaches encompassed various methods for navigating water surfaces, detecting and collecting debris, and ensuring efficient and safe operation. Each approach was evaluated based on its potential to fulfill the project's goals.

2.3.1 Design Approach 1

Remote Control Trash Collecting Rover: In this approach, a base station will be present from which an operator can manage the entire system. A camera will be mounted in front of the rover to record the lake's surroundings. The base station's display allows the operator to view the live footage. Through the controlling unit, the operator can operate the rover and conveyor belt. By means of a conveyor belt, the surface trash will be gathered and put into a storage bin. The garbage level detection system on the rover will also send a notification to the operator to tell them to stop collecting waste when it reaches a certain level. The operator will then direct the rover to the base station where they will empty the trash. The waste will then be collected by the trash cleaners and disposed of from the disposal station via a garbage truck.

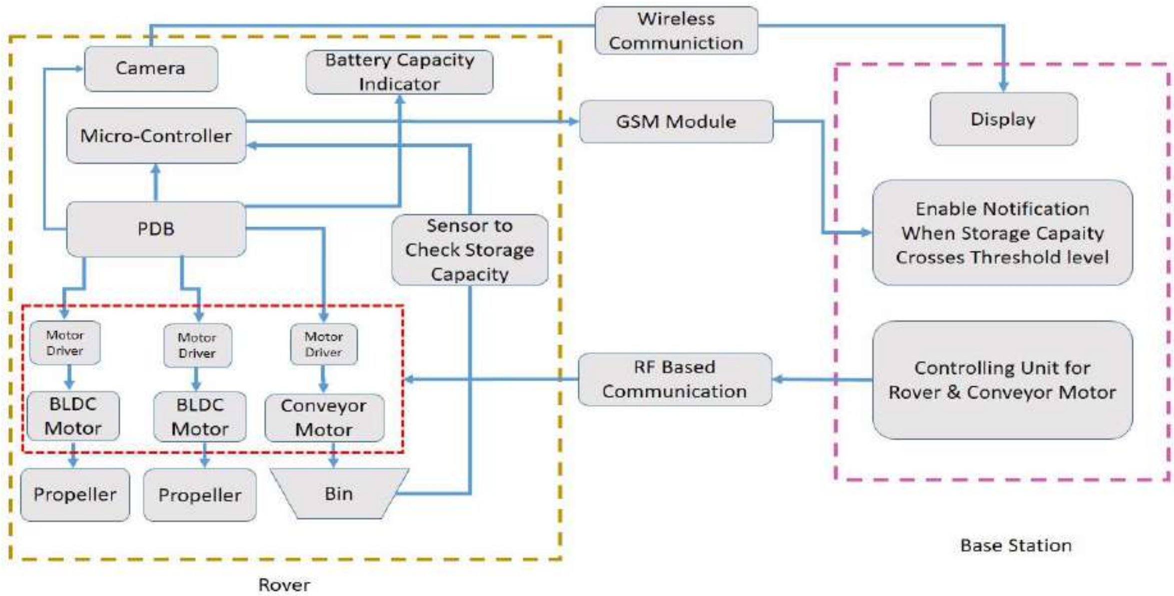


Figure 2: Remote Control Based System

2.3.2 Design Approach 2

Autonomous Trash Collecting Rover: In this approach, the rover will continuously circle the lake while using image processing to find any floating debris on the surface. The garbage collection system will begin to gather the surface waste after the rover starts to navigate toward the trash. It can be noticed that there is a large obstacle detector in this subsystem. A large impediment, such as a rover, jetty, or the edge of a lake, will cause the rover to modify its course in order to avoid a collision. A sensor to assess the bin's storage capacity will be part of the waste collection system. The garbage collection system will halt collecting the waste when the bin's storage capacity exceeds the threshold level, and it will then begin to navigate toward the dumping site. The waste will then be collected by the trash cleaning workers and disposed of from the disposal facility via a garbage truck. The rover will restart collecting surface garbage in the same way after disposing of the waste.

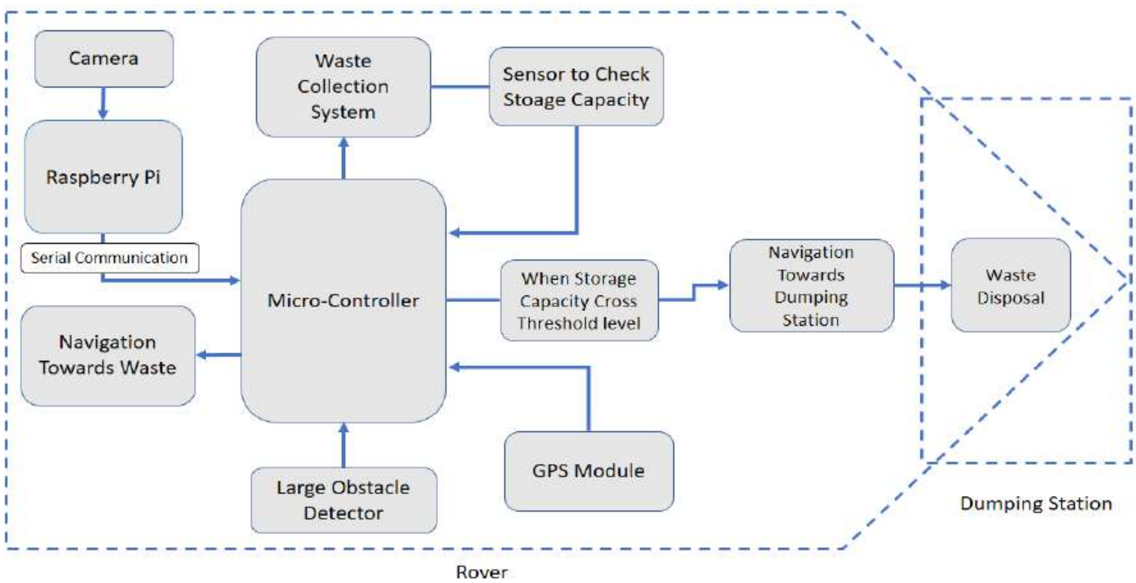


Figure 3: Autonomous System

2.4 Analysis of multiple design approach

Table 5: Comparative analysis of multiple design approach

Factors	**RC-Based Design Approach**	**Autonomous-Based Design Approach**
Cost	Simpler hardware and control systems have a lower initial cost.	Potentially increased start-up costs because of intricate sensors and control systems.
Efficiency	Real-time management with hands-on human involvement. Due to manual guidance, specified debris is collected more effectively.	Potential for continuous, round-the-clock operation, precise navigation, and coverage of greater areas. inaccuracies brought on by flawed algorithms and sensors.
Usability	Direct and intuitive human action. using operator expertise.	Simplicity of usage requiring little operator involvement. quick decision-making and little adaptability.
Manufacturability	Easier to produce and put together. accelerated production and cheaper manufacturing.	Since sensors are integrated, manufacturing is more complicated. increased expenses and production times.
Impact	Impact is based on operator judgment and competence. Operators who have received proper training can reduce unwanted outcomes.	The effectiveness of algorithms and sensors determines the impact. Environmental impact can be minimized with proper optimization.
Sustainability	Lower operating impact on the environment. Real-time choices can be made by human operators to protect sensitive regions.	Although there is potential for sustainable operation, energy consumption for ongoing operation should be taken into account.
Maintainability	Visual examination and operator troubleshooting make maintenance simple.	Maintenance can be difficult and requires knowledge of both hardware and software. It is crucial to do regular upgrades, sensor calibration, and troubleshooting.

2.5 Conclusion

The chapter concludes by highlighting the design approaches and their pros and cons. The analysis assists in justifying the final design choice and sets the stage for the subsequent stages of the project, including the detailed design, implementation, and testing of the Aqua Rover.

Chapter 3: Use of Modern Engineering and IT Tool

3.1 Introduction

The use of modern engineering and IT tools is integral to the development and validation of engineering solutions. This chapter looks into the thoughtful choice and use of these technologies, highlighting their importance in successfully resolving challenging engineering issues.

3.2 Select appropriate engineering and IT tools

The success of the Aqua Rover project depends on a number of engineering and IT tools, which span a wide variety of both software and hardware solutions. Each element of this toolkit has been methodically chosen with extraordinary precision using trial and error, and has been especially created to exactly match the one-of-a-kind and difficult problems given by the project. Modern modeling and simulation technologies are used to create the Aqua Rover's intricate design, allowing precise adjustments to its performance characteristics. Thanks to this software,the rover's capabilities can be effectively changed. Furthermore, the rover's operations can be monitored in real-time due to the deployment of sophisticated data analytics software, considerably enhancing its capability to gather rubbish and navigate a range of aquatic habitats. The project combines the software package with contemporary hardware components. In order to enable accurate data collection and task execution, the Aqua Rover's design seamlessly incorporates robust sensors and actuators that are intended for durability and accuracy. Furthermore, it is feasible to make decisions fast and adapt to changing environmental conditions by incorporating potent computing technology that serves as the central processing unit. This computer system supports the rover's onboard processing, enabling quick responses to shifting environmental circumstances. Strong computational hardware also supports the onboard processing, enabling quick decisions and flexible responses to shifting environmental conditions. Furthermore, the incorporation of remote communication technologies ensures that the Aqua Rover remains connected to the project's control center, allowing for remote guidance, diagnostics, and data retrieval. This connectivity not only enhances the efficiency of the rover's operations but also ensures the safety of its navigation, particularly in challenging or hazardous environments. In essence, the careful selection and integration of these engineering and IT tools represent a cornerstone of the Aqua Rover project, enabling it to meet its objectives of combating water pollution, preserving ecosystems, and promoting the well-being of the community while contributing significantly to environmental sustainability.

Table 6:Software Simulator Comparison Table

Tool	Description	Key Features	Community	Use Cases
Proteus	Electronic circuit and microcontroller sim.	- Intuitive GUI - Extensive component library - Simulation and PCB design - Microcontroller	Large and active user community	Circuit design, simulation, and testing, especially for embedded systems.

		support		
Pspice	Electronic circuit sim. with focus on analog.	-Industry-standard - Vast component models - Mixed-signal simulation - Advanced analysis tools	Widely used in academia & industry	Analog and mixed-signal circuit simulation, especially in power electronics.
Arduino IDE	IDE for programming Arduino microcontrollers.	- Simple interface - Library support - Real-time code upload - Open-source	Large Arduino community	Writing, testing, and uploading code to Arduino-based circuits.
Matlab	High-level environment with Simulink.	- Powerful mathematics tools - Simulink for system-level simulation - Comprehensive toolboxes	Diverse user base	System-level modeling and simulation, control system design.

Proteus (Selected):

- Chosen for its intuitive GUI, extensive component library, and microcontroller support.
- Ideal for electronic circuit design, simulation, and PCB design.
- Strong user community for support and resources.

Matlab (Selected):

- Selected for its powerful mathematical tools, Simulink for system-level simulation, and comprehensive toolboxes.
- Enables mathematical calculations, data analysis, system-level modeling, and graphical user interface (GUI) development.
- Diverse user base for adaptability to different project needs.

Arduino IDE (Selected):

- Chosen for its simplicity, library support, real-time code upload, and open-source nature.
- Facilitates writing, testing, and uploading code to Arduino-based circuits.
- Large Arduino community for extensive resources and support.

Table 7:Image Processing Coding Tools Comparison Table

Tool	Description	Features	Languages	Community	Use Cases
PyCharm	Python IDE with code editing,	Code editing, debugging, Virtual	Python	Active community &	Python development

	debugging, and more	environments support		third-party plugins	
Google Colab	Cloud-based Jupyter notebook with ML resources	Cloud-based, no local installation needed, GPU and TPU support & Real-time collaboration	Python	Large user community & Google resources	Collaborative ML, data analysis, including image processing with GPU acceleration
MATLAB	High-level environment for numerical computing	Comprehensive image processing, GUI development & integration with Simulink	MATLAB	Dedicated user base, extensive resources	Academic and industrial image processing, algorithm development, and industrial applications.

Google Colab (Selected):

- Selected for requiring no local installation, it offers GPU and TPU support and real-time collaboration.
- A cloud-based Jupyter notebook environment with ML resources.
- Supports Python and has a large user community with Google resources.
- Ideal for collaborative machine learning, data analysis, including image processing with GPU acceleration.

Table 8:Microcontroller comparison table

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

Arduino Nano (Selected):

- Selected for its simplicity, low cost, and ease of use, making it an ideal choice for the project.
- Well-suited for writing, testing, and uploading code to Arduino-based circuits.
- Supported by a large and active Arduino community, ensuring ample resources and assistance.

Table 9:Wireless Communication Module Comparison Table

Criteria	Range	Power Consumption	Use Cases	Interference Sensitivity	Ease of Use
Bluetooth	Short to Medium(10-100 meters)	Low	Short-range data exchange,IoT	Susceptible	Moderate
Wifi	Medium to long (up to Kilometers)	Moderate to High	High-Speed data transfer	Susceptible	Moderate
RF (Radio Frequency)	Short to Long (up to Kilometers)	Low to Moderate	Long-range communication	Resilient	Easy

RF(Selected):

- Chosen for covering short to long distances, up to kilometers, ideal for various project scenarios.
- It consumes little power, ensuring energy efficiency and extended operation.
- RF communication is robust against interference, ensuring reliable data exchange even in challenging environments.
- Known for simplicity, it's easy to integrate without complex setup or maintenance.

Table 10:Camera Module Comparison Table

Camera Type	Transmission Range	Video Quality	Real-time Streaming	Use Cases	Mobility
FPV Camera	Short to Medium Range	High Resolution	Real-time Video Transmission	FPV Drones, Racing, RC Vehicles	Highly Mobile
Wi-Fi Camera	Medium to Long Range	High Resolution	Real-time Video Transmission	Home Security, Baby Monitors	Moderate Mobility
RF Camera	Short to Long Range	Varies (can be high)	Real-time Video Transmission	Surveillance, Remote Monitoring	Mobile

FPV Camera (Selected):

- Opted for the FPV camera because of its ability to provide high-resolution video, ensuring detailed footage for our rover's monitoring needs.
- The FPV camera supports real-time video transmission, enabling effective remote monitoring of the rover's surroundings.
- This camera type is well-suited for highly mobile applications like rovers, ensuring the ability to capture and transmit high-quality video while the rover is in motion.
- The FPV camera aligns perfectly with our project's requirements for real-time monitoring and mobility, making it the optimal choice for our rover.

Table 11:Battery Comparison Table

Battery Type	Voltage (V)	Capacity (mAh)	Energy Density (Wh/kg)	Charge/Discharge Rate	Cycle Life	Cost
LiPo (Lithium Polymer)	12	Varies	High	High	Moderate	Moderate
Li-ion (Lithium ion)	12	Varies	Moderate to High	Moderate to High	High	Moderate
NiMH (Nickel Metal Hydride)	12	Varies	Moderate	Moderate	High	Low to Moderate
Lead-Acid	12	Varies	Low to Moderate	Low to High	Moderate to High	Low

LiPo Battery (Selected):

- Selected LiPo batteries for our project because they offer a range of voltage and capacity options, enabling us to choose the most suitable configuration.
- LiPo batteries were chosen due to their ability to provide ample power relative to their compact size and weight, making them an excellent fit for our portable project.
- These batteries efficiently handle high discharge rates, a critical requirement for powering our project's motors and components.
- LiPo batteries align well with our project's budget and longevity requirements, offering a cost-effective solution with sufficient cycle life.

Table 12:PDB Comparison Table

PDB Type	Material	Size	Voltage Rating	Current Rating	Features
Basic PDB	PCB(FR-4)	Small	Up to 12V	Up to 30A	Basic Distribution, no additional features
Compact PDB	PCB(FR-4)	Small to Medium	Up to 12V	Up to 60A	Compact Design, Minimul features
Modular PDB	PCB(FR-4)	Small to Large	Up to 48V	Up to 100A	Modular Design with separate outputs
High Current PDB	PCB(FR-4)	Medium to Large	Up to 48V	Up to 200A	High Current handling capability
PDB with BEC	PCB(FR-4)	Small to Medium	Up to 12V	Up to 30A	Built in Battery Eliminator Circuit (BEC)

Compact PDB (Selected):

- Selected for the Compact PDB's small to medium size aligns perfectly with our project's spatial constraints, ensuring it can be easily integrated into our system without taking up excessive space.
- With a current rating of up to 60A, this PDB provides the necessary current handling capabilities for our project, supporting the power requirements of our components and motors.
- The Compact PDB's minimalist design simplifies its integration into our project, minimizing complexity and potential points of failure.
- It offers a cost-effective solution for our power distribution needs, ensuring efficient use of project resources while meeting our requirements.

Table 13:Motor Comparison Table

Specification	Efficiency	Speed Control	Maintenance	Starting Torque	Cost
BLDC Motor	Highly efficiency, less energy loss	Precise control, suited for variable speeds	Low maintenance, longer lifespan	Typically lower starting torque	Moderately expensive
Gear DC Motor	Moderate efficiency, some energy loss	Limited speed control, typically fixed speed	Low maintenance, durable	Higher starting torque	Affordable
Stepper Motor	Variable efficiency depending on the load	Precise control, multiple steps per revolution	Low maintenance, durable	Moderate starting torque	Affordable

BLDC Motor for Propeller (Selected):
- Chosen for high efficiency and precise speed control.
- Ensures efficient propulsion with minimized energy loss.
- Enables high-speed movement, critical for stable rover operation.
- Requires minimal maintenance, ensuring long-term reliability.

Gear DC Motor for Conveyor (Selected):
- Selected for robustness and reliability in conveyor operation.
- Offers moderate efficiency matching conveyor power needs.
- Provides a fixed speed suitable for continuous material transport.
- Possesses a higher starting torque, ideal for moving heavy loads

Table 14:Motor Driver Comparison Table

Motor Driver type	Functionality	Motor Compatibility	Cost	Ease of Use	Availability
DRV8825 Driver	Control stepper motor movement	Stepper motors	Moderate	Moderate	Widely Available
TB6612FNG Driver	Control DC motor, bidirectional	DC motors	Low to Moderate	Easy	Widely Available
A4988 Driver	Control stepper motor movement	Stepper motors	Low to Moderate	Easy	Widely Available
Brushed ESC	Control brushed DC motor speed	Brushed DC motors	Low to Moderate	Easy	Widely Available
ESC (Electronic Speed Controller)	Control motor speed and direction	Brushless DC motors (BLDC)	Moderate to High	Moderate	Widely Available

Motor Driver for BLDC Motor (Selected):

- Selected this ESC for the BLDC motor due to its precise speed and direction control, aligning perfectly with our project's requirements for optimal motor performance..
- It is designed to work seamlessly with BLDC motors, ensuring optimal performance and responsiveness.
- Available at a moderate cost, making them a cost-effective choice for our project.
- Relatively easy to configure and use, making them suitable for our project, even for those with limited experience.

Motor Driver for Gear DC Motor (Selected):

- Selected brushed ESCs for gear DC motor due to precise speed control requirement and effective support for unidirectional motor rotation, aligning perfectly with project needs.
- Designed specifically for use with Brushed DC motors, ensuring compatibility and effective control.
- User-friendly and easy to set up, making them a suitable choice for projects, even for users with limited experience.

Table 15:Object Detection Sensor Comparison Table

Sensor Type	Description	Key Features	Use Cases
IR Sensors	Detects proximity or presence using infrared radiation.	Compact and low-cost , Suitable for short-range applications, Works well in low-light conditions	Object detection, obstacle avoidance, and proximity sensing.
Ultrasonic Sensors	Uses sound waves to measure distance and detect objects.	Accurate distance measurement, Suitable for various environments, Non-contact sensing	Object detection, distance measurement, and navigation.
LiDAR Sensors	Utilizes laser light to measure distances with precision.	High accuracy and resolution , Works in various lighting conditions & Generates detailed 3D maps	Autonomous vehicles, robotics, and terrain mapping.

Ultrasonic sensors (Selected):

- Chosen ultrasonic sensors for their exceptional accuracy and reliability in distance measurement, essential for monitoring the garbage capacity in our project.
- These sensors are well-suited for various environmental conditions, ensuring their reliability in different scenarios.
- Ultrasonic sensors operate without physical contact, minimizing wear and tear and enabling non-invasive object detection.
- Ultrasonic sensors find applications in object detection, distance measurement, and navigation, aligning perfectly with our project's requirements.

Table 16:GSM Module Comparison Table

Module	Space Requirements	Range	Frequencies supported	Price	Energy Cost
SIM800L	Small	Up to 10km	GSM 850/900/1800/1900	Low-cost	Low
SIM900	Larger	Up to 35 km	GSM 850/900/1800/1900	Mid-range	Moderate
SIM5320	Medium	Up to 40km	GSM 850/900/1800/1900	High-range	High

Sim 800L (Selected):

- The SIM800L module's small form factor makes it a practical choice for our project, allowing for efficient use of space within our device.
- With a communication range of up to 10 kilometers, the SIM800L module ensures reliable long-distance connectivity for our project.
- Supporting GSM frequencies of 850/900/1800/1900, the module aligns with common cellular networks, facilitating seamless communication.
- The SIM800L module is budget-friendly, ensuring that our project remains cost-efficient without compromising on communication capabilities.

Table 17:Converter Comparison Table

Converter Type	Functionality	Input Voltage Range	Output Voltage Range	Efficiency	Cost	Ease of Use
Buck Converter	Step-down voltage converter	Wide range	Adjustable	High	Low to Moderate	Moderate
Boost Converter	Step-up voltage converter	Wide range	Adjustable	High	Low to Moderate	Moderate
Buck-Boost Converter	Step-up and Step-down voltage converter	Wide range	Adjustable	High	Moderate	Moderate
Flyback Converter	Isolated voltage converter	Wide range	Adjustable	Moderate	Moderate	Moderate

Buck Converter (Selected):

- Selected LiPo batteries for their versatility in voltage and capacity options, ample power-to-size ratio, efficient high-rate handling, sufficient cycle life, and budget-friendliness, all of which align with project requirements.
- Its wide input voltage range suits different power sources and scenarios.
- Adjustable output voltage matches component requirements precisely.
- High efficiency minimizes energy loss, enhancing overall power efficiency and battery life.

Table 18:PCB Board Comparison Table

PCB Type	Material	Layers	Cost	Lead Time	Complexity
Single-Sided PCB	FR-4	1	Low	Short	Low
Double-Sided PCB	FR-4	2	Moderate	Moderate	Moderate
Multi-Layer PCB	FR-4 or Others	4+	High	High	High
Flexible PCB	Polyimide	1-4	High	Moderate to High	Moderate to High

Single-Sided PCB (Selected):

- Opted for a single-sided PCB due to its availability in Bangladesh, ensuring we could source the required components conveniently.
- The lower cost of single-sided PCBs aligned with our project's budget constraints.
- Single-sided PCBs offer simplicity in design and fabrication, reducing complexity and potential issues during development.
- With a shorter lead time compared to multi-layer PCBs, single-sided PCBs allowed us to expedite the project timeline and meet our deadlines effectively.

3.3 Use of modern engineering and IT tools

The successful development and refinement of the Aqua Rover project depend significantly on the strategic utilization of modern engineering and IT tools, which encompass both software and hardware components. This comprehensive toolkit includes a wide array of techniques, resources, and software applications geared towards aiding simulation, modeling, analysis, and optimization processes. By utilizing these instruments with skill and precision, engineers can forecast, scrutinize, and refine solutions, effectively tackling the intricate engineering hurdles that the project may confront. In addition, the inclusion of durable hardware components like sensors and computing systems plays a pivotal role in this toolkit, guaranteeing that the Aqua Rover's design is not only well-informed but also technologically cutting-edge. Collectively, these resources act as the project's guiding beacon, directing it toward a triumphant culmination.

Proteus:

Proteus, which served as the platform for simulating the Aqua Rover's electronic systems, was important in the project. The main objective was to carefully check that these systems worked. This involves precisely configuring the behavior of each component and creating a digital model of Proteus' internal circuitry. The overriding goal remained unchanged throughout a series of simulations involving different inputs and scenarios: to make sure that these electrical systems performed with the utmost precision, strictly according to the project's specifications, and without any compromises.This scientific and systematic approach made it possible to identify and address potential problems, which ultimately helped to improve the Aqua Rover's electronic circuitry to match the high standards of the project.

MATLAB:

MATLAB, the project's computational engine, was essential to its success since it handled complex computations with ease. Processing vast volumes of data, running complex algorithms, and conducting operations-related mathematical modeling all required it. An easy graphical user interface (GUI) was created using MATLAB to speed up the retrieval of findings and make it simpler for people with limited technical expertise to input data.In addition to its computational purpose, this was done. MATLAB's capable graphing and visualization features were also used to clearly present project findings, including data trends, system performance, and simulation results. MATLAB's exceptional versatility, which provided essential computational capabilities, improved user involvement, and allowed for the transparent and illuminating presentation of data, acted as a backbone for the entire project, it can be said.

Arduino IDE:

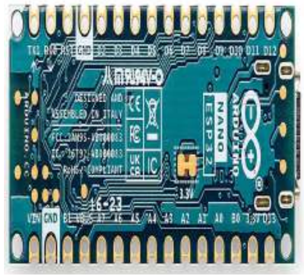
The Arduino Integrated Development Environment (IDE), which was essential to the project's success, was used to greatly facilitate the development of the codebase for the Smart Monitoring Bin. This adaptable and user-friendly platform provided the optimal setting for developing software, running tests, and uploading it to an Arduino-based system. It simplified the process of implementing the smart monitoring solution, ensuring that everything went according to plan and that everyone could use it.

Google Colab:

Google Colab played a crucial role in the project, particularly in the domain of waste management. With a dataset encompassing 5,000 images depicting various waste items, such as plastic bottles, Google Colab functioned as the primary platform for image processing tasks. Making use of its cloud-based Jupyter notebook environment, the project team took advantage of the powerful machine learning resources at their disposal, including GPUs and TPUs, for training and fine-tuning data models. Moreover, the platform's real-time collaboration features and extensive access to Python libraries and packages greatly accelerated the efforts involved in image processing. Through the utilization of Google Colab, the project successfully navigated the complexities of waste recognition and categorization, making a substantial contribution to the efficiency of the waste management solution.

Arduino Nano:

The pivotal role in the Smart Monitoring Bin project was fulfilled by the Arduino Nano microcontroller. It harnessed versatile input and output pins to interface with various sensors and actuators, enabling real-time data collection and control. Custom software developed in the Arduino IDE allowed the microcontroller to process sensor data, implement logic for waste level monitoring, and trigger actions such as compaction or alerts. Compatibility with communication modules facilitated remote monitoring. Thanks to its reliability and low power consumption, the Arduino Uno ensured efficient, robust, and eco-friendly waste management. Extensive support from the Arduino community further bolstered the project's success.



RF (Radio Frequency):

In order to achieve previously unheard-of levels of accuracy and flexibility in remotely managing the system, the project fully utilized the capabilities of RF-based wireless communication as a key component of the control infrastructure. An 8-channel receiver and transmitter that served as the key component of the remote control method was the key component of the RF integration. The receiver took on the function of the system's "listening mechanism," intently spotting signals coming from the transmitter, which also doubled as a simple joystick. The smooth, in-the-moment contact with the operator was made possible by this mutually advantageous relationship between the receiver and transmitter. Operators were given an incredibly simple and responsive control approach by using the transmitter as a joystick. This was especially useful for performing complex movements and jobs that required extreme precision. Beyond communication, RF technology formed the basis of the control systems, enabling the system to function remotely without the limitations of wires or the requirement for direct line-of-sight. The result was a flexible and adaptive system that could handle a variety of tasks in a variety of environments all because of the powerful capabilities of RF technology. This resulted in the development of a flexible and adaptable system that could manage a variety of jobs in a variety of settings.

FPV Camera:

A significant capability improvement in the project was the addition of a First-Person View (FPV) camera system. The FPV camera was strategically positioned as a crucial component and played a significant part in improving situational awareness and remote monitoring capabilities. The transmitter and camera for this project were carefully connected, allowing for smooth communication. A special display unit was intelligently used on the receiving end to provide an immersive, real-time perspective

of the system's surroundings. The FPV camera effectively served as a set of "ground-level eyes," allowing for remote observation and evaluation of environments that required either careful visual analysis or were impossible to access. Its uses included a variety of scenarios like traveling challenging terrain and doing in-depth examinations in perilous or remote areas. The FPV camera and the display unit worked together to enable operators to make knowledgeable judgments, respond quickly to changing circumstances, and complete jobs with extraordinary precision. This technical advancement improved safety while simultaneously broadening the project's scope and opening up new possibilities for remote exploration, surveillance, and data collection.

LiPo Battery:

A 12-volt LiPo (Lithium Polymer) battery performed a critical and essential part as the project's primary source of power. Numerous important parts, such as motors, a camera-transmitter set-up, a Nano board, and a SIM800L module, received power from it. This battery functioned as the source of electrical energy and provided the necessary force for movement, accuracy, and management, powering the project's motors. It also gave the camera-transmitter system electricity, enabling real-time image capture and transmission while also increasing awareness of the situation. The project's central processing unit, the Nano board, received consistent and dependable power from the LiPo battery, enabling effective data processing and component communication. The dependability and adaptability of this integrated power solution significantly contributed to the project's excellent performance and flexibility in a variety of operational circumstances.

PDB:

The Power Distribution Board (PDB) served as the main hub responsible for supervising and distributing power to all the aforementioned components, playing a crucial part in the electrical setup of the project. The main energy source, a 12V LiPo battery, supplied power directly to it, and it distributed this power to all the subsystems in an effective manner. The PDB played a crucial role in preventing component overload or underpowering by assuring a balanced distribution of power. The performance and dependability of the system as a whole were significantly enhanced by this meticulous power management. The PDB streamlined our electrical arrangement by efficiently distributing electricity and minimizing complicated wiring and connections. In the end, this simplified method improved our project's capabilities, making it more reliable and effective in operation.

BLDC & Gear Dc Motor:

Brushless DC (BLDC) motors were used in the project to control the rover's movement, ensuring precise and quick mobility necessary for navigating varied terrains. In addition, gear DC motors were used to drive the conveyor belt, ensuring streamlined and effective rubbish collecting. In order to achieve precision, power, and efficiency in carrying out the objective, multiple motor technologies were purposefully integrated, which was crucial in maximizing project performance.The cooperation of Gear DC motors for the conveyor belt and BLDC motors for rover control demonstrated the peaceful equilibrium attained by utilizing various motor technologies inside the project. This balance allowed for efficient execution of the crucial task of waste collecting while also facilitating effective navigation through the environment, showcasing the remarkable capacities of these motors operating together.

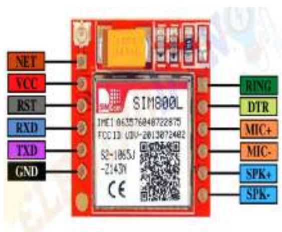
ESC:

Electronic Speed Controllers (ESCs) and brushed ESCs were combined in the project to manage the management of both BLDC and gear DC motors, which was done so in a strategic manner. In order to provide the BLDC motors with precise control over their speed and direction, the ESCs performed a critical role in managing power distribution to them. The performance of the gear DC motors, on the other hand, was carefully controlled by brushed ESCs, enabling them to operate at their best for the conveyor belt. The combination of brushed ESCs for the gear DC motors and BLDC motors created a powerful and flexible motor control system that significantly aided in the success of the project.

Ultrasonic sensor:

The project intentionally included ultrasonic sensors to enable precise object detection at a 5 cm distance. The main goal of this integration was to improve applications for smart bin monitoring. These sensors quickly conveyed signals to the Nano board when an object within this defined range was detected, enhancing the capabilities of the smart monitoring bin and enabling real-time data collecting.The bin's accuracy and versatility in a variety of applications were made clear by this technological integration, which also significantly improved the bin's effectiveness and capacity to respond to different waste management circumstances.

SIM800L:

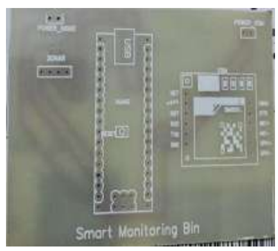


The primary objective of including the SIM800L module in the project was to enable immediate notifications when the trash volume in the smart monitoring bin surpassed a certain limit. This module successfully established communication with the Nano board, allowing for effective data transfer and the creation of alerts at the appropriate times. The SIM800L module started notifications whenever the waste level went above the predetermined threshold, ensuring prompt responses and proactive waste management. This functionality significantly improved the smart monitoring bin's capabilities, enhancing its effectiveness in maintaining cleanliness and efficiency during waste collection operations.

Buck Converter:

The project's success depended on a smartly incorporated buck converter, which transformed the 12V power source to match the precise voltage requirements of vital components. In the beginning, it successfully reduced the voltage to 7V, ensuring that the Nano board received the best possible power supply for its purposes. Additionally, the buck converter expertly set the voltage to 5V, providing the precise amount of power required for the SIM800L module. It also increased its functionality by switching from 12V to 5V voltage in order to fit the camera. This precise voltage regulation significantly increased the project's electrical system's overall robustness and dependability by ensuring that the components received the proper voltage and protecting them from any overvoltage problems.

PCB:



The smart monitoring bin subsystem's electrical and electronic components are organized around the printed circuit board (PCB), which serves as their center and most important component. The precisely designed PCB made it possible for many components, including as communication modules, controllers, and sensors, to be seamlessly integrated and interconnected. It gave these parts a solid and well-organized base on which to work together, ensuring the precision and dependability of the smart monitoring bin in carrying out its waste management responsibilities.The PCB demonstrated the project's dedication to efficient and well-organized design concepts, greatly aiding in the overall success of the smart monitoring bin subsystem.

3.4 Conclusion

The integration of contemporary engineering and information technology resources marks a significant achievement in tackling intricate engineering dilemmas. These resources enable engineers to create, simulate, validate, and enhance solutions with an exceptional level of accuracy. By thoughtfully choosing, incorporating, and employing these suitable resources, engineers can adeptly overcome intricacies, boost performance, and enhance the overall excellence of engineering resolutions. This section highlights the utmost significance of selecting the appropriate instruments for navigating the perpetually evolving landscape of engineering innovation and issue resolution. In this manner, engineers can fully exploit the capabilities of technology to address and triumph over the challenges presented by the dynamic realm of engineering.

Chapter 4: Optimization of Multiple Design and Finding the Optimal Solution

4.1 Introduction

The emphasis in this chapter is shifted to the optimisation procedure for several design strategies created for the Aqua Rover project. The main goal is to identify the best design solution that best satisfies the project's demands, criteria, and objectives. by observing the established restrictions. This project's phase attempts to improve and choose the best design strategy to ensure the project's success and effectiveness.

4.2 Optimization of multiple design approach

4.2.1 Design Approach 1

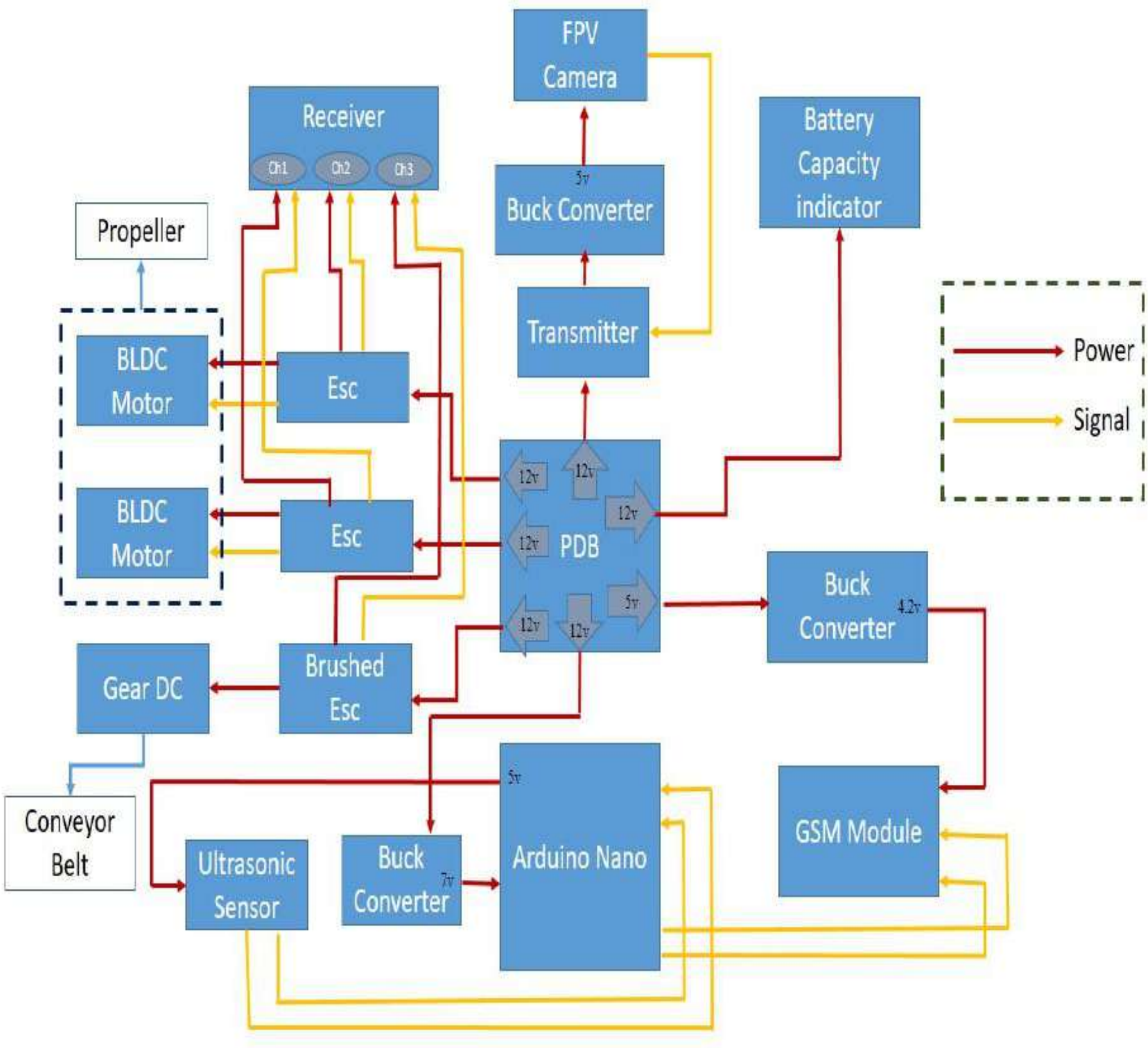


Figure 4: Circuit Diagram of Design Approach 1

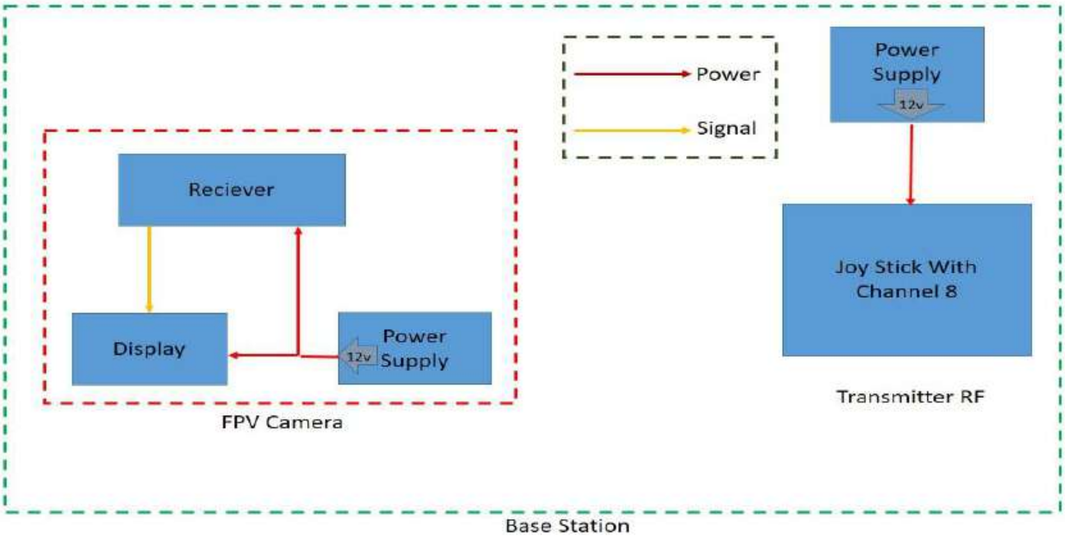


Figure 5: Base Station block diagram

The Aqua Rover's system architecture and circuit diagram are presented in great depth in Design Approach 1. With the help of this graphic, you may get a clear grasp of all the functioning parts and management systems that make the Aqua Rover work. This graphic depiction offers important insights into how the various components of the system interact and work together to fulfill the project's goals.

Power Distribution:

- A 12V LiPo battery serves as the primary power source for the Aqua Rover.
- The battery is connected to a power distribution board (PDB), acting as a centralized point for power management.
- Two brushless DC (BLDC) motors are employed for propulsion, while a gear DC motor drives the conveyor belt for debris collection.
- The PDB routes power to electronic speed controllers (ESC), which regulate the BLDC motors' speed and direction.
- A brushed ESC is dedicated to controlling the gear DC motor, facilitating smooth conveyor belt operation. RF-based wireless communication is adopted for remote control.
- An 8-channel joystick on the RF transmitter interfaces with an 8-channel RF receiver. ESCs for BLDC motors are connected to receiver channels 1, 2, and 3, enabling intuitive control through the joystick.

Propeller Control System:

Table 19: Logic Table for Controlling Rover

Left Propeller	**Right Propeller**	**Direction**
Clockwise	Clockwise	Forward
Clockwise	Stop	Right
Stop	Clockwise	Left

FPV Camera Integration:

- An FPV (First-Person View) camera enhances situational awareness by monitoring the Aqua Rover's surroundings.
- A 12V output from the ESC powers the FPV camera transmitter.
- To ensure compatibility, a buck converter reduces the voltage from 12V to 5V, meeting the camera's maximum input voltage requirement.
- The camera is connected to the transmitter to transmit live footage.

Base Station Display:

- At the base station, the FPV camera receiver is connected to a display, allowing operators to observe real-time video feeds.
- This setup enables effective remote navigation and debris collection.

Smart Monitoring Bin Subsystem:

- Another pivotal aspect of the system is the smart monitoring bin, designed to gauge storage levels within the Aqua Rover.
- This subsystem comprises an Arduino Nano, an ultrasonic sensor, and a GSM SIM800L module.
- The Arduino Nano receives power from a 12V source. To ensure the Arduino Nano compatibility, a buck converter reduces voltage from 12V to 7V.
- The ultrasonic sensor, receiving 5V from Arduino Nano, measures the debris storage level.
- For the GSM module, another buck converter reduces the 5V input to 4.2V, in accordance with its operational requirements.
- When the storage exceeds a predetermined threshold, the ultrasonic sensor triggers Arduino Nano to signal the GSM module, initiating the transmission of notifications to alert operators.
- Upon triggering the notification, the Aqua Rover initiates a predefined sequence of actions to ensure efficient debris management. After sending the notification, the operator navigates the rover back to the base station. Once stationed at the base, the collected debris is systematically emptied. Following this, the Aqua Rover resumes its mission, recommencing the debris collection cycle.

This comprehensive design approach integrates power distribution, propulsion, debris collection, wireless control, FPV monitoring, and smart storage monitoring. It forms the foundation for an efficient and effective Aqua Rover capable of addressing water pollution and debris accumulation in aquatic environments. The detailed circuit diagram and system overview illustrate the synergy of components crucial to the Aqua Rover's successful operation.

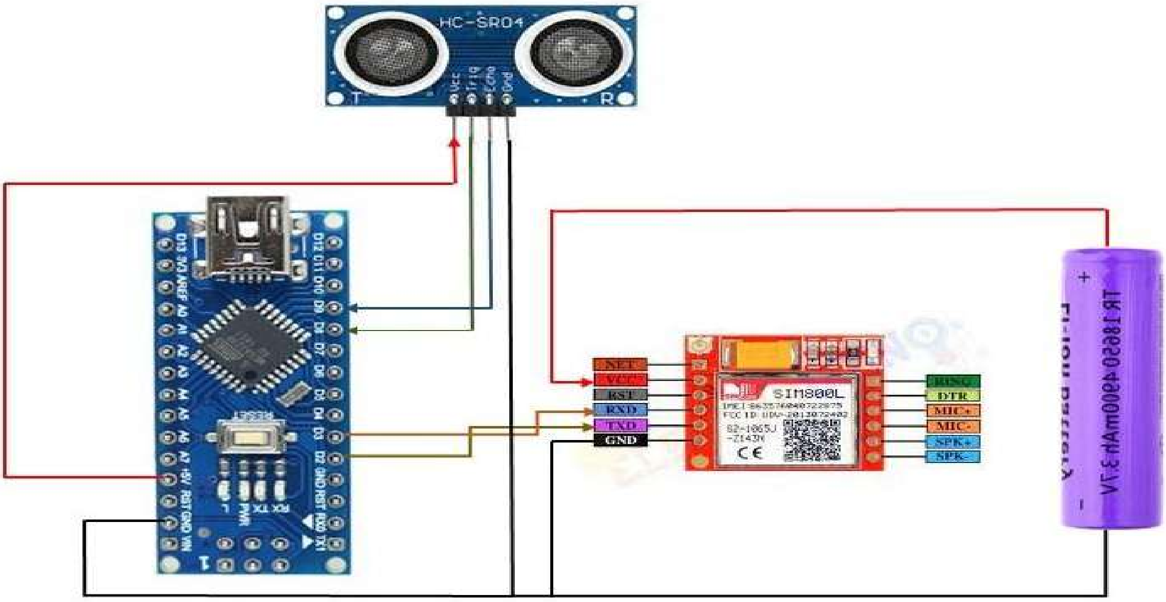


Figure 6: Schematic Diagram of Smart Monitoring Bin

The smart monitoring bin shown in the figure makes use of an ultrasonic sensor that has four pins labeled VCC, GND, ECHO, and TRIGGER. The sensor's TRIGGER pin is connected to the D8 pin of the Arduino Nano, and the ECHO pin is attached to the Nano's D9 pin in this configuration. The Nano's 5V pin supplies power to the VCC pin, and the GND pin acts as a common ground. The ultrasonic sensor instantly sends a signal to the Arduino whenever it detects an object within a 5 cm range. Also built in is the SIM800L module, which has the same four pins as the others (VCC, RXD, TXD, and GND). The module's VCC and GND pins are wired to an external 3.7V supply. The module's TXD pin is connected to the Nano's D2 pin, and the RXD pin is connected to D3. When the Nano's ultrasonic sensor detects an object inside the allotted 5 cm range, it can successfully send out a notification signal. The code includes a discrete number option to specify who should receive the alert. The SIM800L module and ultrasonic sensor work together to make the smart monitoring bin as efficient as possible. If debris is detected to be taller than 5 cm, the appropriate people will receive timely and detailed alerts. Efficient waste management is achieved by the careful integration of hardware components and coding expertise.

Figure 7: PCB Design

The figure above shows a PCB design, which stands for Printed Circuit Board design,which is the process of creating the layout and schematic for a printed circuit board. PCBs are crucial components in electronic devices, serving as a physical platform for connecting and interconnecting various electronic components and providing electrical pathways for the flow of current. Furthermore, PCB design is a complex and iterative process that involves creating a blueprint for the physical platform upon which electronic components are connected. It plays a vital role in the development of electronic devices, enabling them to function reliably and efficiently. In our Project we design the PCB for simplifying the complexity of the wires and allowing them to operate dependably and effectively.

4.2.2 Design Approach 2

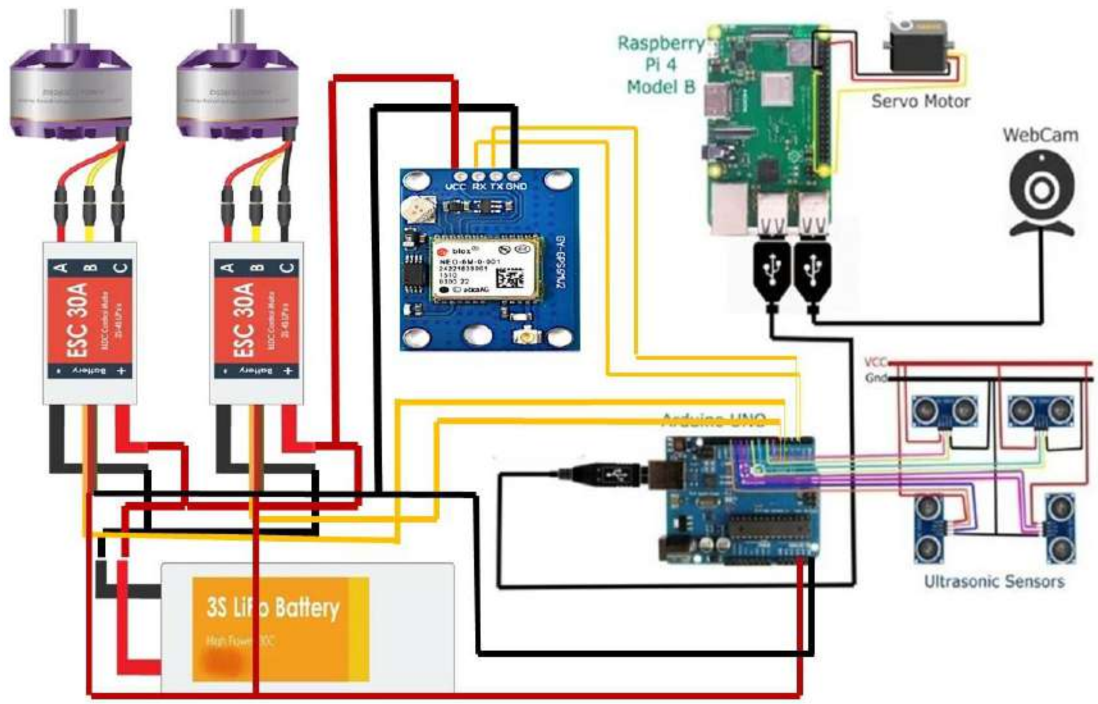


Figure 8: Circuit Diagram of Design Approach 1

The autonomous circuit diagram represents a remarkable leap in waste collection technology, driven by the integration of advanced components. At its core, the design features a Raspberry Pi, a computational powerhouse responsible for intricate image processing to detect plastic surface debris. Guided by image processing algorithms, a strategically positioned servo motor facilitates dynamic camera rotation, ensuring comprehensive coverage of the target area. A seamless partnership between the Arduino Uno and Raspberry Pi forms the backbone of this autonomous system. The Arduino Uno establishes crucial serial communication with the Raspberry Pi, facilitating seamless data exchange. Once plastic debris is detected through the image processing pipeline, the Arduino Uno takes the reins, orchestrating the propulsion system. This pivotal propulsion system consists of two BLDC motors connected to the Arduino Uno, enabling swift and responsive navigation towards the identified debris. The system's navigational acumen is further amplified by the integration of four ultrasonic sensors. While three ultrasonic sensors contribute to the avoidance of substantial obstacles, one is dedicated to measuring the garbage storage level. This multifaceted approach ensures not only safe navigation but also precise monitoring of storage capacity. A GPS module acts as the compass of the system, enhancing autonomy. When the garbage storage exceeds a predetermined threshold, the Arduino Uno's sophisticated guidance system triggers navigation towards the base station for efficient waste disposal, streamlining operations and enhancing overall system efficiency.

Image processing Subsystem:

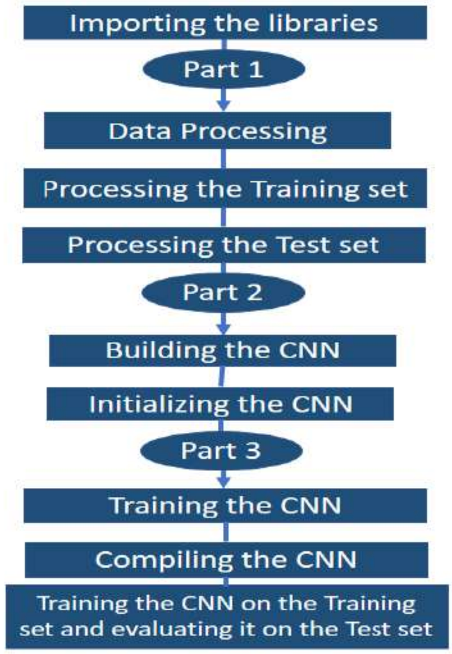


Figure 9: Flow Graph of CNN Algorithm for Image Processing

This diagram displaying flow charts pertains to the construction of a Convolutional Neural Network (CNN) for image classification. The first part of the flow charts imports necessary libraries such as TensorFlow, Keras, OpenCV, and Matplotlib. Then it mounts the Google Drive to Collab for access to the plastic dataset. The second part of flow charts is for preprocessing the data, which includes loading the training and test datasets and applying data augmentation techniques to the training dataset. 5000 images of a dataset have been used to train this model. The dataset was split into two parts: 80 percent of the images were used for training the model, and the remaining 20 percent were used for testing its accuracy. The third part of the flow charts is for building the CNN architecture using the sequential model from Keras. The model consists of a series of convolutional layers followed by batch normalization, max pooling, and a fully connected dense layer for classification. To prevent overfitting, regularization is also applied to the convolutional layers. The CNN is trained on the training set in the final section of the flow charts, and its performance is assessed on the test set. Additionally, it describes callbacks for lowering the learning rate and uses Matplotlib to display the training and validation accuracy. The model is then tested against the test set, and the accuracy is shown.

Dataset:

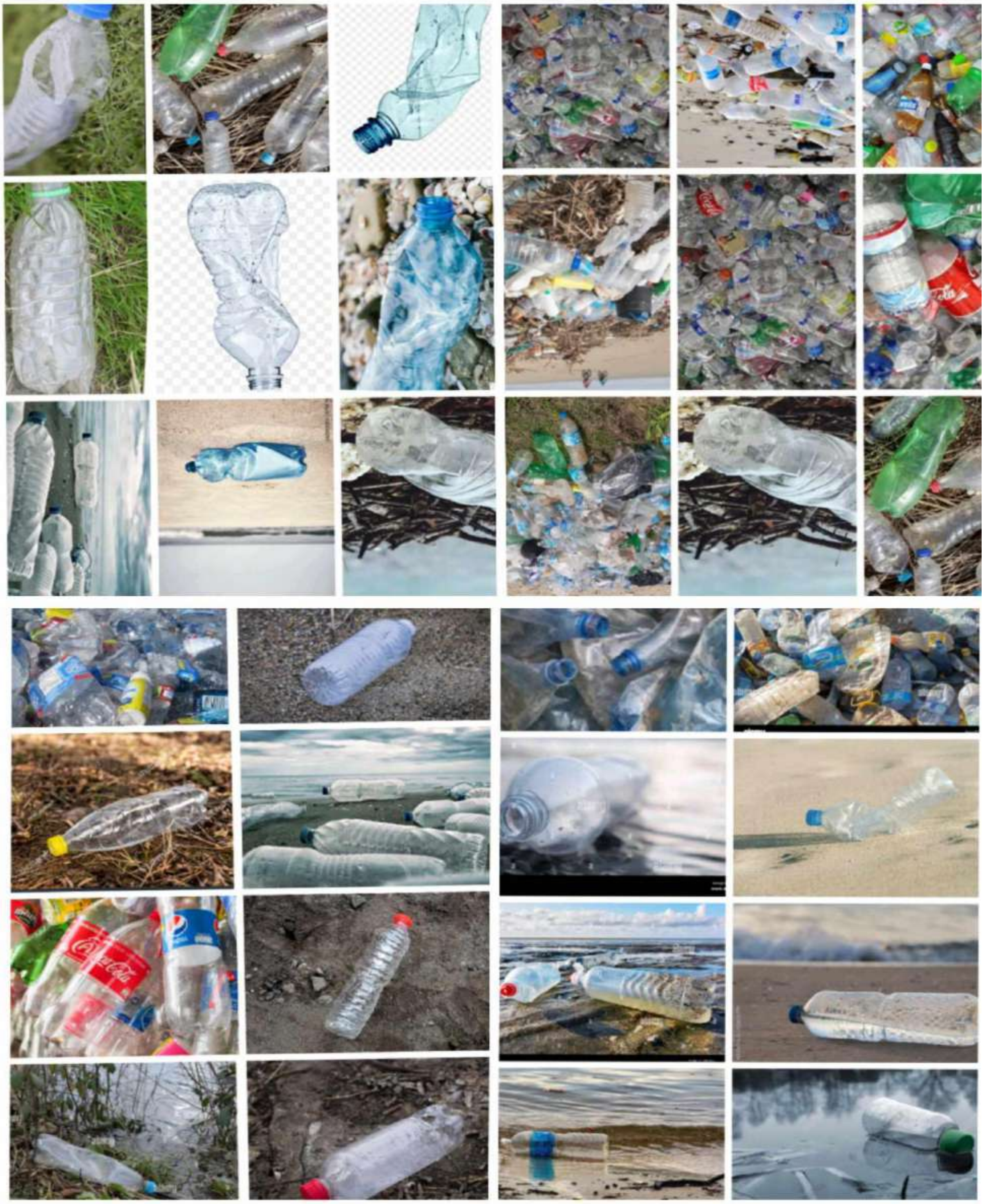


Figure 10: Dataset of Plastic Bottle from 'Kaggle'

Result:

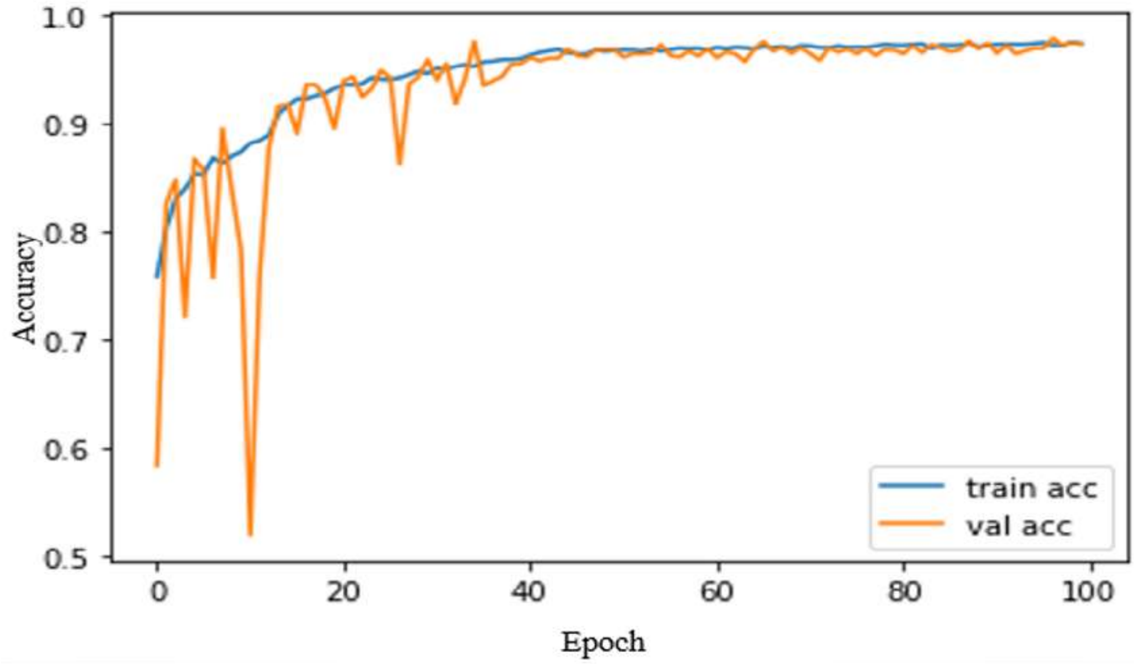


Figure 11: Model Accuracy Graph

The Convolutional Neural Network (CNN) model's performance during the training and validation phases is revealed by the accuracy model graph. The graph illustrates the model's accuracy throughout several epochs. The y-axis displays the accuracy percentage, and the x-axis displays the number of epochs. In this graph, the blue line represents training accuracy while the orange line represents validation accuracy. This visualization makes it easier to comprehend how the accuracy of the model changes over time and enables the evaluation of potential problems like overfitting or underfitting. The trained model's accuracy in the aforementioned situation is close to 97 percent, which is regarded as extremely satisfactory.

4.2.3 Calculation and selection of electronics components

Propeller Motor:

The rule of thumb for calculating minimum thrust for a rover is a commonly used guideline. The calculation is based on the general idea that a rover needs at least 2 pounds of thrust for every 100 pounds of weight to move through the water effectively [9]. Make sure to amount for the heaviest possible weight when estimating the weight of a rover, which includes the weight of a rover that is fully loaded with garbage.

In this case, the estimated maximum weight of the rover is 90 pounds [approx. 40kg]

According to the rule of thumb,

$$T_{min} = [(90/100) \times 2] \text{ lbs of thrust}$$
$$= 1.8 \text{ lbs of thrust}$$

This is the minimum thrust which is required for the rover.

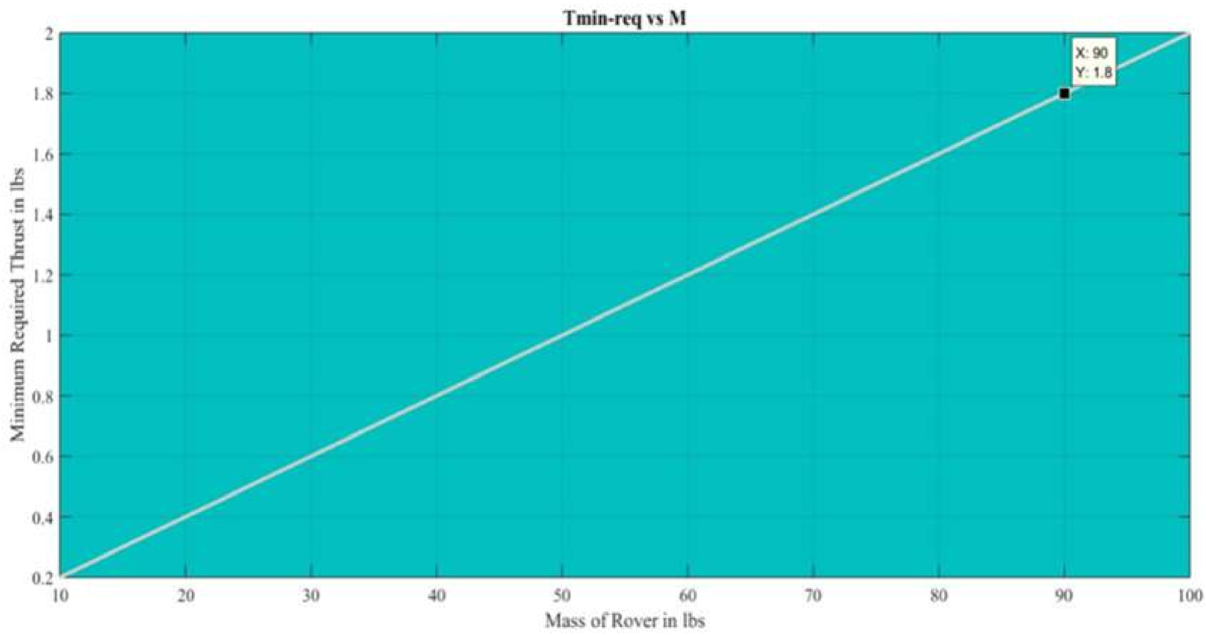


Figure 12: Tmin-req VS Mass of Rover

The figure above, depicting the relationship between the minimum required thrust and the mass of the rover, clearly indicates a proportional correlation between these two variables. As the mass of the rover increases, the minimum thrust required to move it also increases proportionally. This relationship is entirely expected, as a larger mass naturally demands a greater amount of thrust to set it in motion. The existence of this proportional relationship holds significant implications for rover design. To guarantee that the rover can move effectively, the thrust system must be meticulously designed to deliver an adequate amount of thrust, commensurate with the rover's mass. This ensures that the rover can navigate and perform its tasks efficiently, taking into account the physical constraints imposed by its mass and the need for propulsion. Additionally, the relationship between thrust and mass must be considered when selecting the materials and components for the rover, as the total mass of the rover will affect its propulsion system requirements. The point shown on the graph is the optimal point that has been chosen for the design.

Table 20: In general voltage / thrust ratio

Motors	**Quantity of thrust**
12v	55 pounds or less
24v	Over 55 pounds up to 80 pounds
36v	Over 80 pounds up to 115 pounds

[10]

According to the table, 12V motors of 55 pounds or less thrust are needed.

For the rover , the 12 V BLDC Motor , whose name is A2212 1400 kV brushless outrun-ner BLDC Motor is selected. The specification of this BLDC motor is given below:

$$V = 12V,$$

$$I = 16A,$$

$$Prated = 150W,$$

$$kV = 1400\ RPM/V$$

$$RPM = kV \times V$$

$$= 1400 \times 12$$

$$=> RPM = 16800$$

The 1045 3 blades propeller is suitable for this BLDC motor according to the motor specifications. Specification of the 1045 propeller is given below:

Diameter, D = 10 inch

Propeller Pitch = 4.5 inch

According to Static Thrust Equation:

$$T = 4.392399(10-8)) \times RPM \times ((d3.5)/\checkmark Pitch) \times (4.23333(10-4) \times RPM \times Pitch)\ [11]$$

Here,

T = Thrust in Newton

d = Diameter of Propeller in inch = 10 inch

Propeller pitch = Pitch in inch = 4.5 inch

RPM = Speed of Motor

Then,

$$1.8 = 4.392399 \times (10-8) \times RPM \times ((103.5)/\checkmark 4.5) \times (4.23333(10-4) \times RPM * 4.5)$$

$$=> RPM = 16024$$

Here, a total of 16024 rpm motor speed is required to move through the water effectively and produce 1.8 lbs of thrust. In the rover, four propellers will be used. So, the required single motor speed for the rover will be

$$= 16024/4\ rpm$$

$$= 4006\ rpm$$

Based on the information provided, it appears that the selection of the BLDC motor is justi-fied for the rover’s propulsion system. The calculation shows that a motor speed of 4006 rpm is required to move the rover effectively through the water, and the motor specification states that it can generate up to 16800 rpm, which is well above the required minimum speed. Hence, the BLDC motor selection is justified.

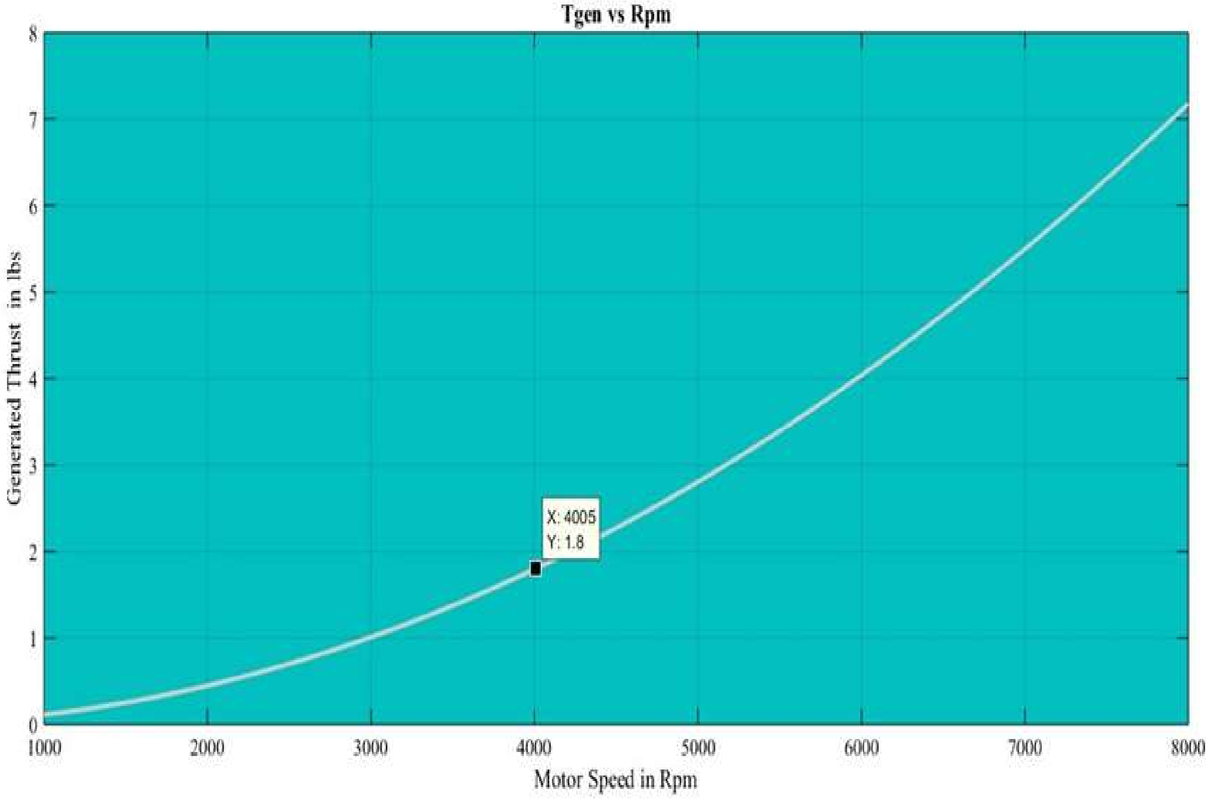


Figure 13: Tgen vs Rpm

The 2D graph that shows the link between a propeller's motor speed in RPM (revolutions per minute) on the X-axis and the thrust produced on the Y-axis is a useful tool for understanding the functionality and effectiveness of the propeller system. RPM denotes how quickly the propeller revolves on the X-axis. This factor is crucial in deciding how much thrust the propeller will generate. In essence, the amount of air the propeller can move increases with speed, increasing the thrust produced. The generated thrust on the Y-axis shows how much force the propeller system is producing. Increased thrust enables the rover to travel through its environment more quickly and effectively. It is feasible to visually analyze the relationship between these two important factors by graphing RPM versus generated thrust on a 2D graph. The performance of the propeller system can be improved by using this graphical depiction to better understand how variations in motor speed affect thrust generation. Higher amounts of thrust can enable the rover to travel faster and more efficiently through the environment, hence this is a crucial component in determining the propeller system's overall performance and functioning.The link between these two variables can be seen by graphing RPM and generated thrust on a 2D graph. The best RPM range for the propeller system to create the most effective and efficient level of thrust can be determined using this visualization.

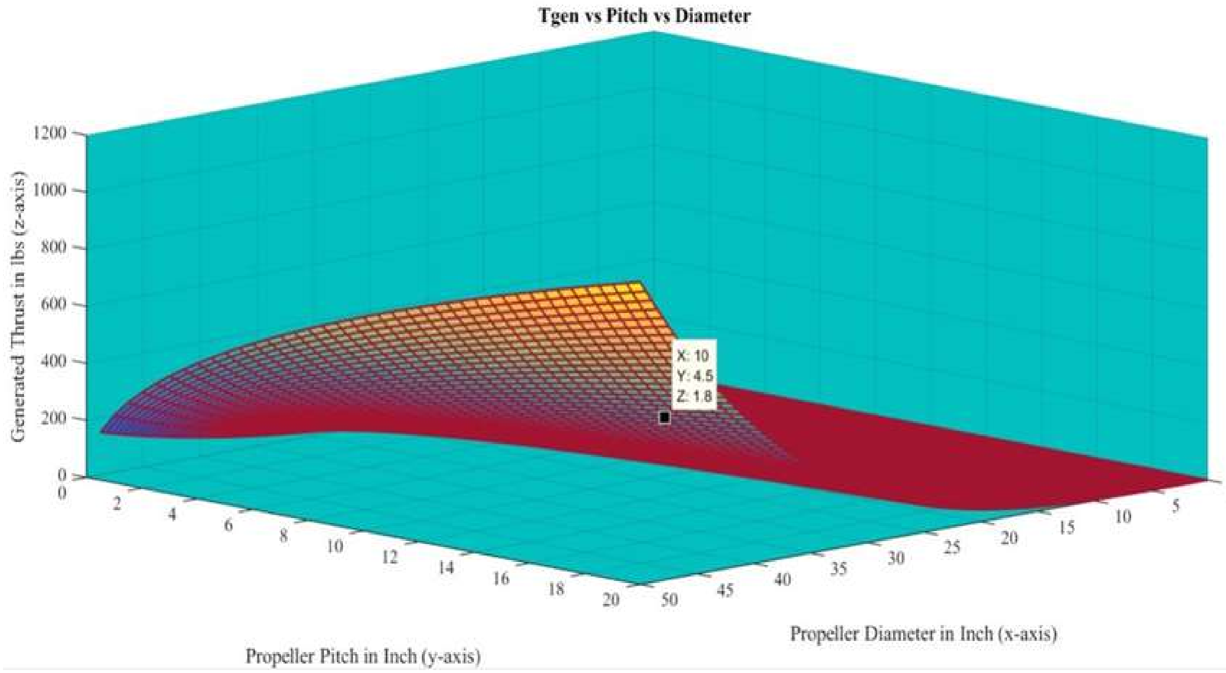


Figure 14: Tgen vs Pitch vs Diameter

This 3D graph, which shows a propeller's diameter of the propeller, represented by the X-axis, in-dicates the size of the thrust-producing propeller. This affects the propeller's overall functionality and performance because bigger propellers may provide greater thrust. The propeller pitch, or Y-axis, displays the angle at which the propeller blades are mounted. The pitch angle has a sig-nificant impact on how much water the propeller blades displace, which impacts how much thrust the propeller produces. Last but not least, the Z-axis, which symbolizes created thrust, demon-strates how much thrust is produced by the propeller system. The link between the diameter of the propeller, propeller pitch, and generated thrust can be seen by merging these three variables in a 3D graph. This visualization can be helpful in pinpointing potential areas for the propeller system's improvement or optimization, such as altering the pitch angle to maximize the amount of thrust produced or enlarging the propeller's diameter to produce more thrust. The point shown on the graph is the optimal point that has been chosen for the design.

Required Power for the Propeller:

$$\text{Required Power} = \text{Required Force} \times \text{Velocity of Rover}$$

According to the specifications, the speed of the rover is 1 m/s. Now, the required force must be determined for a 1 m/s velocity.

$$\text{Total Resistance of Rover} = \text{Frictional Resistance} + \text{Residual Resistance [12]}$$

$$\text{Frictional Resistance} = 2 \times r \times (v^2) \times As \times Cf$$

$$r\text{, Density of Water} = 1000 \text{ kg/m}^3$$

As, Hull's Weighted Area = (20.5) m^2

Cf, Resistance Coefficient = 0.1

Velocity of Rover = 1 m/s

Residual Resistance = R(R/Δ) ×(∇ρg) [13]

R(R/Δ), Residual Resistance, Ratio = 0.07

ρ, Density of Water = 1000 kg/m^3

∇, Rover Volumetric Displacement = (Length × Width × Depth of immersion of rover) m3

Depth of Immersion of Rover: According to the specification,

Length = 2m,

Width = 0.5m,

Height = 0.4m

Volume of the Rover = 0.4m^3

Weight of Water Displaced = Density of Material Rover Made × Volume of the Rover × Gravity

= 9550 × 0.4 × 9.81
= 3747.5N

The rover is made of polyethylene, which has a density of 955kg/m3.

Weight of Water Displaced = Weight of Rover

The Volume of Water Displaced = (Weight of Water Displaced/Weight Density of Water)

= [3747.5/(1000 × 9.81)]
= 0.382m^3

The volume of the Body in Water = Volume of Water Displaced

= 2 × 0.5 × h

= 0.382

h = 0.382 m from base [14]
Depth of Immersion of Rover (h) = 0.382/2 = 0.191 m

∇, Rover Volumetric Displacement = 2 × 0.5 × 0.191m^3
= 0.191 m
Total Resistance of Rover = 2 × r × v^2 × AS × Cf + R(Δ) × (∇ × ρ× g)
= 0.5 × 1000× 12 × 1× 0.1 + 0.07 × 0.191 × 1000 × 9.81
= 50N + 131.16N = 181.16N

The 181.16 N force is needed for a 1 m/s velocity of the rover.

Required Power = Required Force × Velocity of Rover

= 181.16 × 1

= 181.16 W

As 4 propeller is used, total generated power = 4 × 150
= 600 W

Preq < Pgen

Hence, the design is safe.

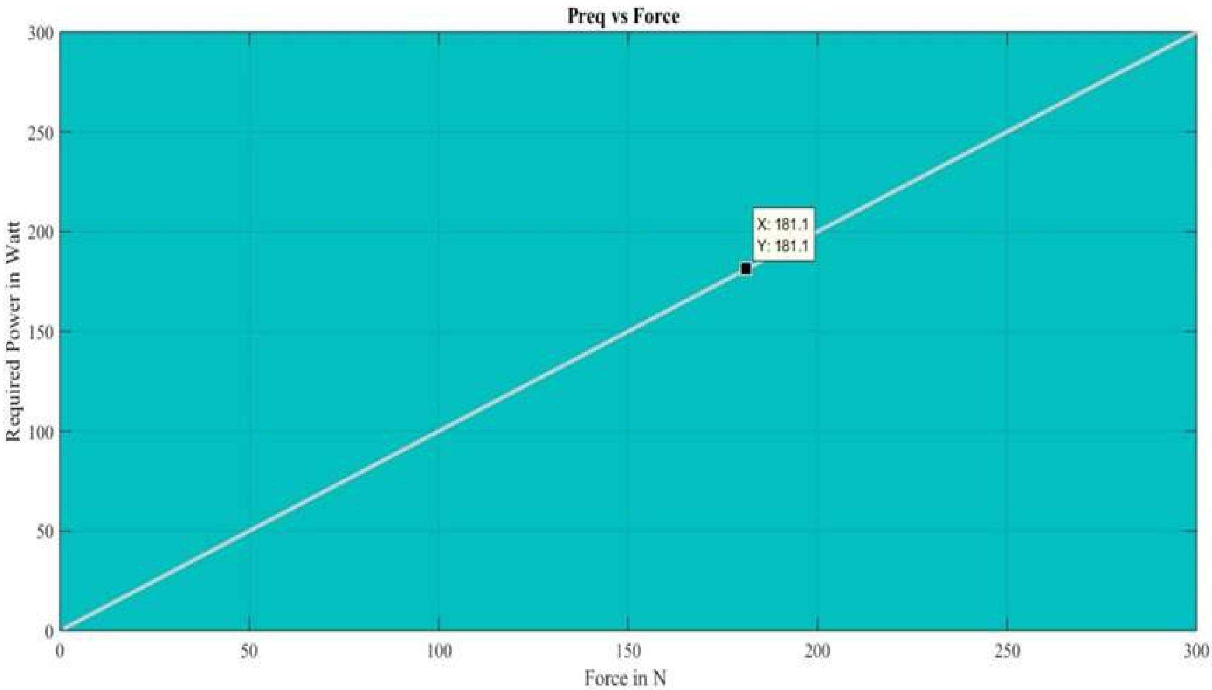


Figure 15: Preq vs Force

By plotting force and power on a 2D graph, it becomes possible to visualize the relationship between these two variables. This visualization can be useful in identifying the optimal balance between motor power and gearing to generate the necessary force required to accelerate the rover while minimizing the power consumption of the system.

Conveyor Motor:

Maximum Mass of Garbage, W = 5 kg

Roller Diameter, D = 0.05 m

Frictional Coefficient, H = 0.5

Roller Radius, r = 0.025 m

$$T_{req} = (\text{Frictional Force} + \text{External Force}) \times \text{Radius of Roller} \ [15]$$

$$= (H \times W \times g + W \times g) \times 0.025$$

$$= (0.5 \times 5 \times 9.81 + 5 \times 9.81) \times 0.025$$

$$T_{req} = 1.84 \text{ Nm}$$

Here, Planetary Gear can be used as a DC motor – 10 RPM / 12V for the conveyor belt, as its rated Torque is 2.2555295 Nm.

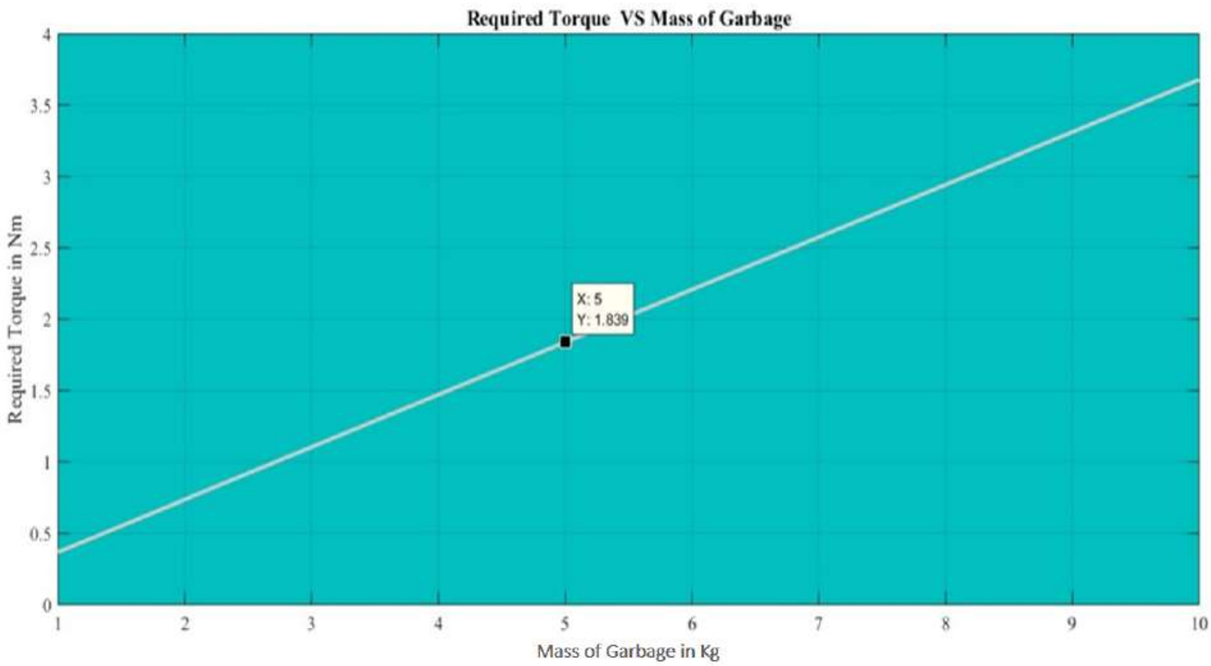


Figure 16: Required Torque vs Mass of Garbage

In the above figure, the torque vs. mass graph for a conveyor belt, as shown, is a plot of the torque required to move a certain mass of material along the length of the belt. The X-axis represents the mass of the material being transported at once, while the Y-axis represents the torque required to move that mass. The graph shows that as the mass of the material being transported on the conveyor belt increases, more torque is required to move it. When constructing conveyor systems and choosing the right motors and drives, it is crucial to consider the torque vs. mass graph to make sure the system can handle the anticipated loads and run effectively. The design has chosen the best point, which is indicated on the graph.

For the torque found, T, the required power is calculated.

$$P_{req} = (2 \times V \times T_{req}) / D \quad [16]$$
$$= (2 \times 0.05 \times 1.84) / 0.05 \text{ W}$$
$$= 3.68\text{W}$$

The velocity of the conveyor belt, V = 0.05 m/s
Diameter, D = 0.05 m

For a constant speed of 0.05 m/s with maximum garbage load, the conveyor motor needs 3.68 W power.

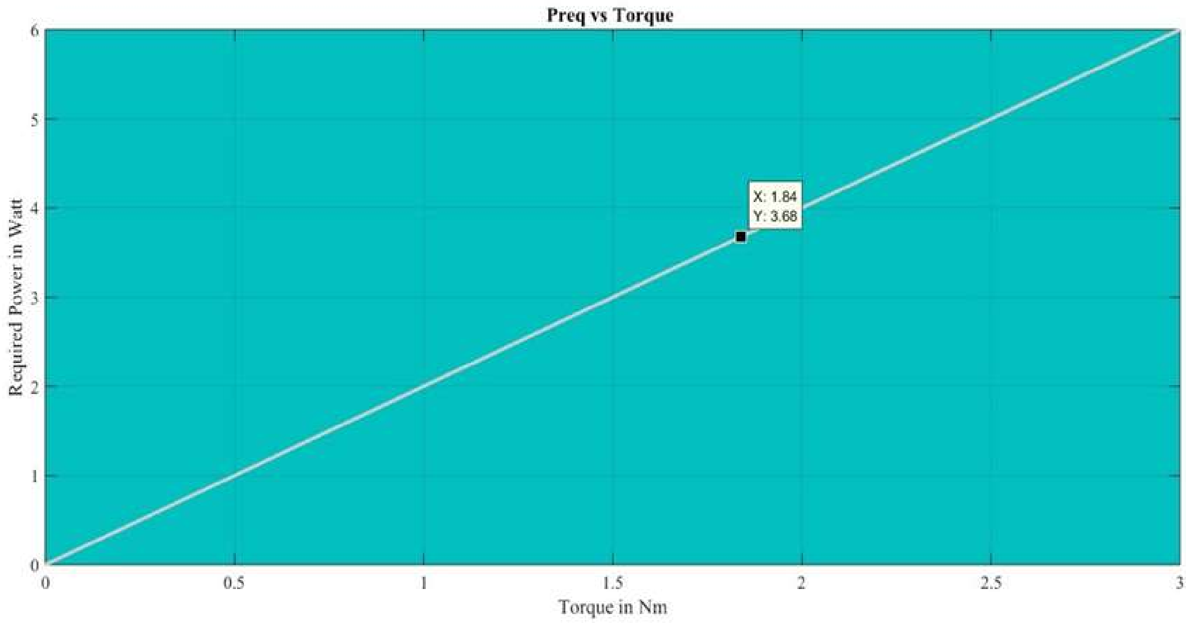


Figure 17: Preq vs Torque

In the provided figure, the required power vs. torque plot for a conveyor belt illustrates the connection between the torque necessary to move a load and the power required to achieve a speed of 0.05 m/s. The X-axis of the graph represents the torque, while the Y-axis represents the power. Under steady-state conditions, the graph will typically exhibit a linear relationship between torque and power. This means that as the required torque to move the load increases, the power needed to maintain the specified speed will also increase in a proportional manner. This linear relationship signifies that changes in torque directly influence changes in power when the conveyor is operating consistently and efficiently.This means that as the torque increases, the power required to maintain a constant speed also increases. In general, larger loads require more torque to move, which means a more powerful motor drive is needed to maintain the required speed. By analyzing the required power vs torque plot, engineers can determine the most efficient motor and drive combination for the specific application. The point shown on the graph is the optimal point that has been chosen for the design.

Graphical User Interface (GUI):

An efficient tool for a variety of applications, GUI has also been utilized for calculations that can make the process quicker, more precise, and more user-friendly.

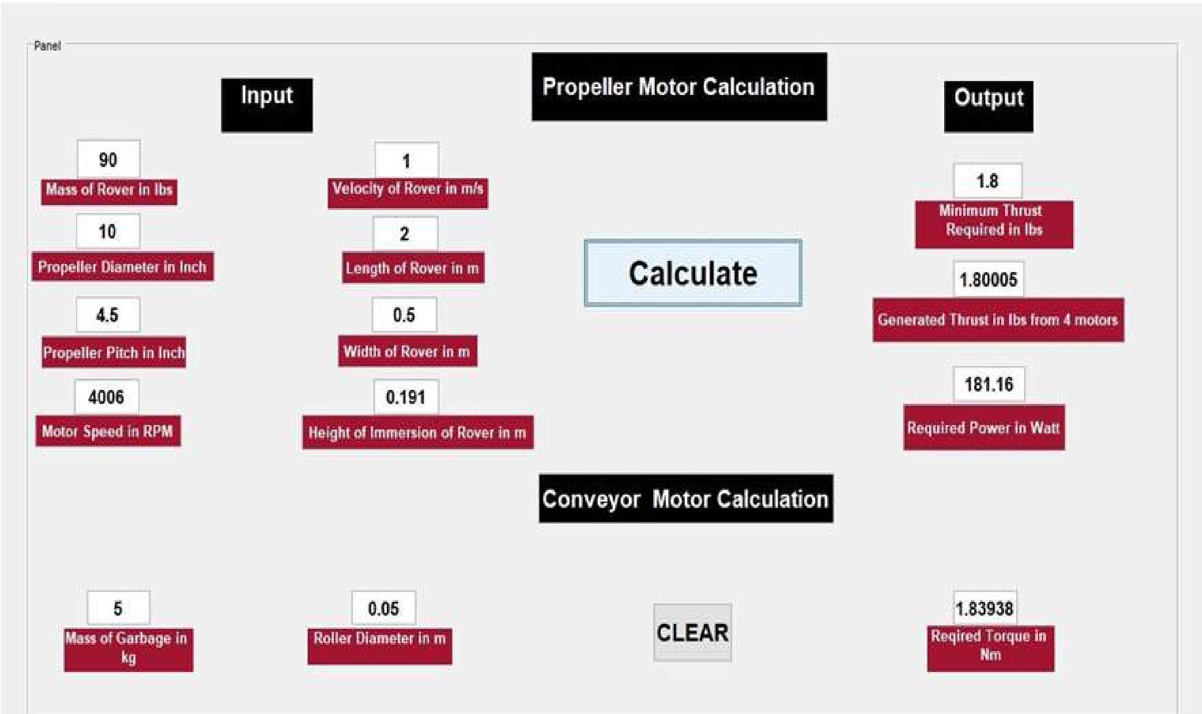


Figure 18: Motor Calculations in GUI

Subsystems Power Calculation:

Table 21: Calculation of total power of subsystems

Component	Rated Voltage (V)	Rated Current (I)	Rated Power (W)
Camera Transmitter	12	0.280	3.36
Arduino Nano	7	0.019	0.1333
GSM Module	3.8	0.350	1.33
Total Required Power for Subsystems			4.8233

Total Required Power for Rover:

= Propeller Required Power + Conveyor Required Power + Subsystems Required Power

= 181.16 W + 3.66 W + 4.8233 W

= 189.6433 W

≈ 190 W

The Pie Chart of Total Power Distribution is given below:

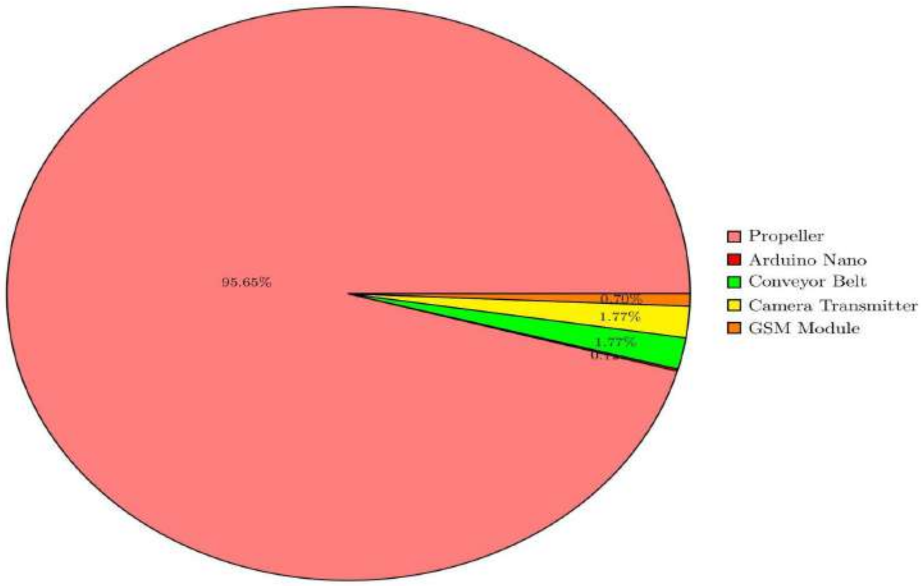


Figure 19: Power Distribution

This pie shows the distribution of power among different subsystems of the project, and it comes with a legend for easy interpretation. The largest segment in the pie chart, colored in red, represents the "Propeller" subsystem. This subsystem consumes the majority of the power, accounting for 95.65% of the total power distribution. A tiny portion of the chart, colored in pink, is dedicated to the "Arduino Nano" subsystem. This subsystem consumes a very minimal amount of power, only 0.12% of the total. The "Conveyor Belt" subsystem is depicted by the green segment, making up 1.77% of the total power distribution. Similar to the "Conveyor Belt," the "Camera Transmitter" subsystem also consumes 1.77% of the total power and is represented by the yellow segment. Lastly, there is the "GSM Module" subsystem, represented by the orange segment. This subsystem consumes 0.70% of the total power. The numbers associated with each subsystem indicate the percentage of the total power distribution that each subsystem consumes. This pie chart provides a clear visual representation of how power is allocated among different project components, making it easy to identify which subsystems consume the most power and which ones are more energy-efficient.

Battery:

According to our functional requirement, the minimum run time of our rover is 30 min.

Current Draw = Total Power / Voltage [17]

= 190 /12

≈ 16 A

$$\text{Battery Capacity in Amperes-hour} = \text{Run Time} \times \text{Current Draw [18]}$$

$$= (30/60) \times 16$$

$$= 8\text{Ah}$$

$$= 8000\text{mAh}$$

For the rover, a Powerhobby 3s 12V 8000MAH 100C Lipo Battery w XT90 Plug Hard Case can be used.

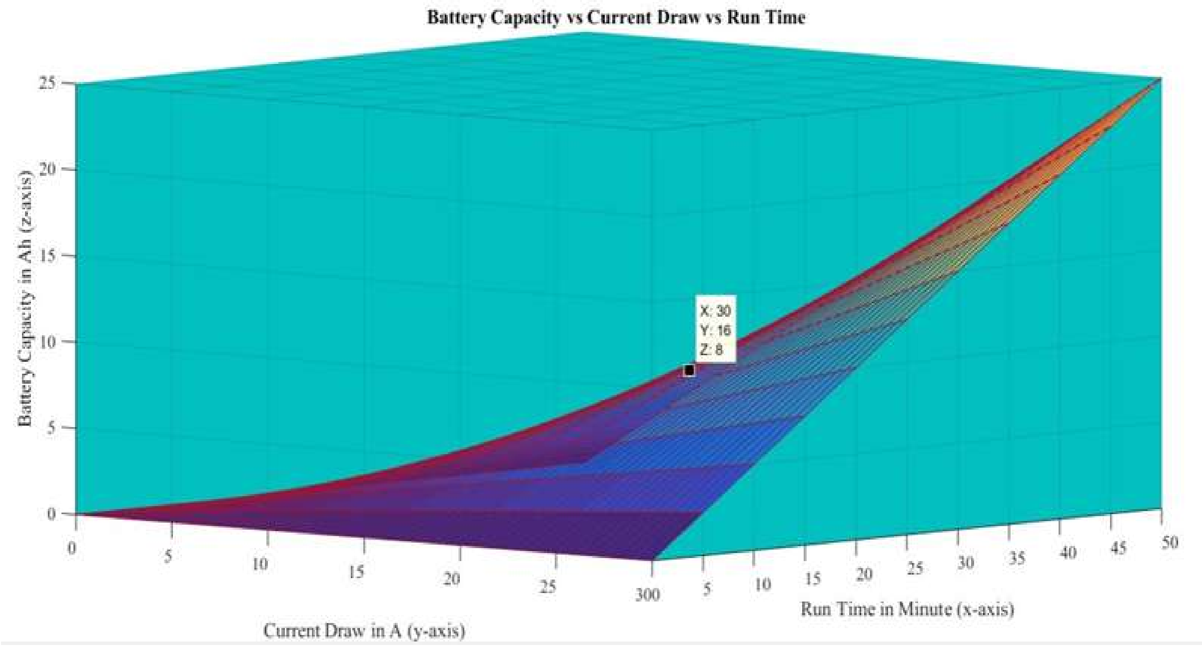


Figure 20: Battery Capacity vs Current Draw vs Run Time

The X-axis in the provided graph represents battery run time, indicating how long the battery can power the rover before requiring recharging or replacement. Longer battery run times are critical for extending mission durations and enhancing overall productivity. The Y-axis, which represents current draw, reveals the amount of electrical current drawn by the rover's components from the battery system. This parameter is crucial in assessing whether the battery system can supply sufficient electrical power to meet the demands of the rover's components. If the current draw exceeds the battery system's capacity, it may lead to performance issues or system shutdown. The Z-axis signifies battery capacity, denoting the amount of electrical charge the battery system can hold. Higher battery capacity enables longer battery run times and accommodates higher current draws. By plotting these three variables in a 3D graph, it becomes possible to visualize the intricate relationship between battery run time, current draw, and battery capacity. This visualization aids in identifying potential areas for improvement or optimization in the battery system to enhance the rover's performance and operational capabilities.

ESC:

$$\text{ESC Current} = \text{Draw Current} \times \text{Safety factor [19]}$$

$$= 16 \times 2.5 = 24\text{A}$$

So, 25A ESC can be used for the rover.

4.3 Identify optimal design approach

4.3.1 Analysis and Comparison

Table 22: Analysis and Comparison between Design Approach 1 and Approach 2

Criteria	**Remote Control (Approach 1)**	**Autonomous (Approach 2)**
Safety	Relies on human operator	Autonomous algorithms and sensors can mitigate most risks
Efficiency	May require continuous human involvement and attention, less efficiency	Can operate continuously without human intervention, more efficiency
Flexibility	Allows for real-time decision-making and adaptability	May be limited in flexibility
Learning Curve	May have a relatively low learning curve	May require advanced programming skills and training
Cost	Typically, lower in cost as remote-control devices are readily available	May require higher investment in advanced sensors, AI algorithms etc.
Scalability	Can be easily replicated and deployed to multiple rovers	May require more complex integration and coordination
Adaptability	Can be easily adjusted and modified	May require reprogramming and updates
Control	Provides direct control	Operates autonomously
Accuracy	Provides precise control over rover	Relies on accuracy of pre-programmed instructions and sensors

4.3.2 Weighted chart

Table 23: Weighted Matrix of Design Approach 1 and 2

Criteria	**Approach 1**	**Approach 1**	**Approach 2**	**Approach 2**	**Weights**
Criteria	Ratings (5)	Score	Ratings (5)	Score	
Control	5	0.5	3	0.3	10%
Flexibility	4	0.6	2	0.3	15%
Accuracy	5	0.6	3	0.36	12%
Efficiency	3	0.3	4	0.4	10%
Adaptability	5	0.65	2	0.26	13%
Learning Curve	4	0.4	2	0.2	10%
Safety	3	0.3	4	0.4	10%
Cost	5	0.5	2	0.2	10%
Scalability	4	0.4	3	0.3	10%
Total	4.25		2.72		100%

According to the different criteria of analysis, it can be seen that approach 1 was the most accurate according to the requirements set in the proposal phase. To determine the optimal design approach based on the weighted decision matrix, the total weighted score is needed to calculate for each design approach by summing up the weighted scores for each aspect. Here are the total scores for each design approach:

Remote Control scored 4.25 out of 5 and Autonomous scored 2.72 out of 5.

Based on these total scores, it appears that remote control is the optimal design approach for our project, given preferences and weighted factors. It scored higher in most categories, including control, flexibility, safety, and cost, which are more important considerations for a rover designed to collect surface trash.

4.4 Performance evaluation of developed solution

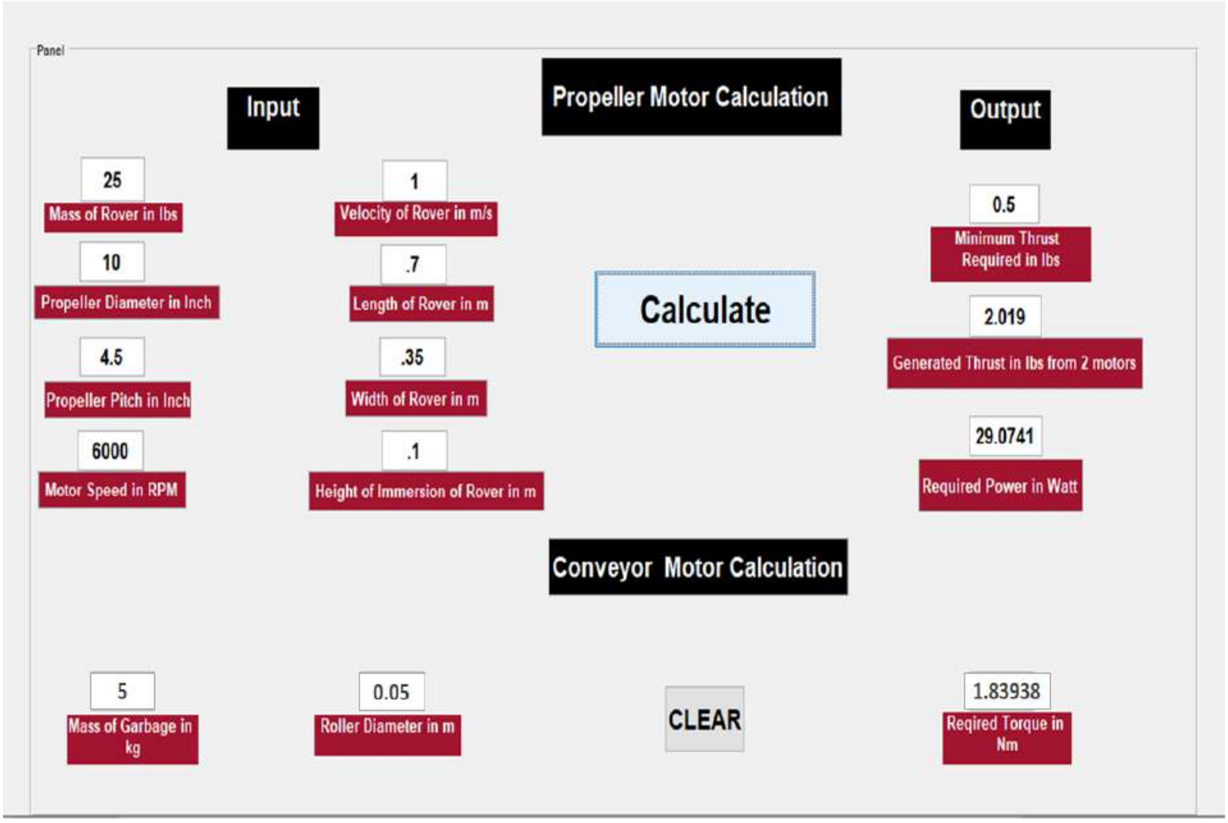


Figure 21: Motor Calculation for Developed Design using GUI

Total Required Power for Developed Rover:

Table 24: Total Power Required to Run the Developed Rover

Subsystems	Required Power
Propeller Motor	29.0741
Conveyor Belt	3.36
Other Subsystems	4.8233
Total	37.25

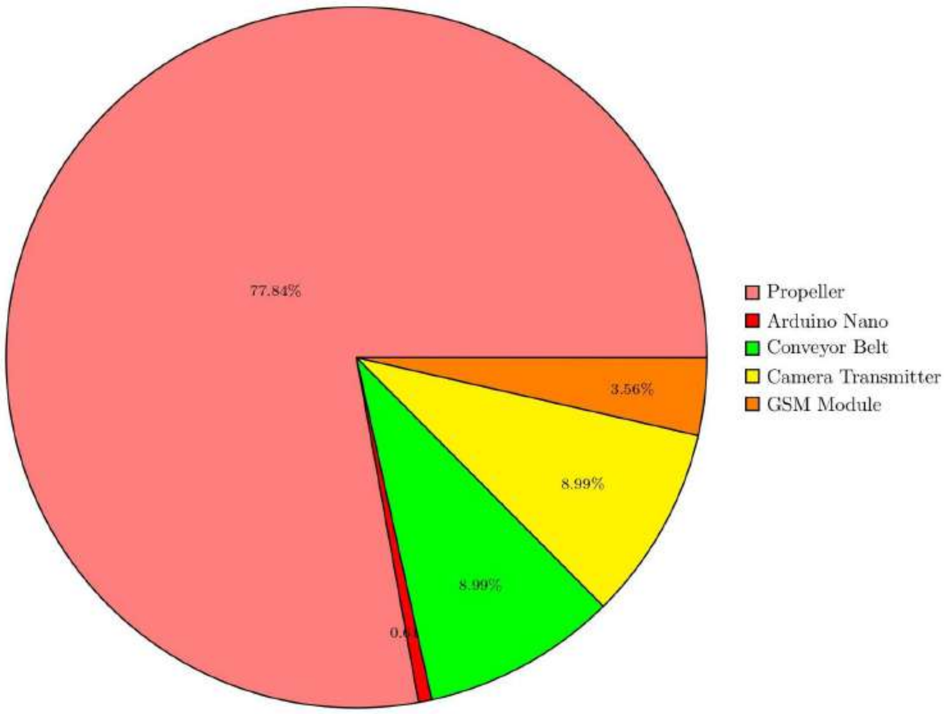


Figure 22: Power Distribution for Developed Rover

Run time and current draw can indeed be measured directly from the required power for the developed rover. Here are the calculations:

Current Draw = Total Power / Voltage

= 37.25 /12

= 3.1A

Run Time = Battery Capacity in Amperes-hour / Current Draw

= 4.2 / 3.1

= 1.35 hour

= 81.3 min

So, for the developed rover the calculated current draw is approximately 3.1 A, and the total run time is approximately 81.3 min.

Note: In the system, a 12 V, 4200 mAH lipo battery has been used.

From the test run time of 71.3 minutes, the calculations for current draw and total power for Test 1 have been determined based on this provided run time and the battery capacity. Here are the calculations:

$$\text{Current Draw} = \text{Battery Capacity in Amperes-hour} / \text{Run Time}$$

$$= 4.2 / 1.19$$

$$= 3.39 \text{ A}$$

$$\text{Total Power} = \text{Voltage} \times \text{Current Draw}$$

$$= 12 \times 3.39$$

$$= 40.68 \text{ W}$$

So, for Test 1, the calculated current draw is approximately 3.39 A, and the total power consumption is approximately 40.68 W.

Similarly, the calculations for the remaining tests have been carried out in the same manner, utilizing the provided run times and battery capacities to determine current draw and total power for each respective test.

Table 25: Performance Metrics Comparison for Three Tests

No. of Test	Actual experimental data			Theoretical values			Efficiency (%)	Error Rate (%)	
	Run Time (min)	Current Draw (A)	Power (W)	Run Time (min)	Current Draw (A)	Power (W)	Run Time	Current Draw	Power
Test 1	71.3	3.39	40.68	81.3	3.1	37.25	87.7	11.4	11.2
Test 2	68.7	3.66	43.92				84.5	15.7	15.4
Test 3	70	3.6	43.2				86.1	6	13.4

The table provides a comprehensive dataset from three distinct tests (Test 1, Test 2, Test 3) conducted as part of the project. It encompasses various parameters, including actual experimental values, theoretical values, efficiency percentages, and error rates, all presented in an organized format for easy analysis.

In the "Run Time" column, the actual time taken for each test to run in minutes (min) is indicated. For instance, Test 1 required 71.3 minutes, Test 2 took 68.7 minutes, and Test 3 took 70 minutes. The "Current Draw" column represents the actual current drawn during each test, measured in amperes (A). Test 1 drew 3.39 A, Test 2 drew 3.66 A, and Test 3 drew 3.6 A. In the "Power" column, the actual power consumed or generated during the tests, typically measured in watts (W), is displayed. Test 1 consumed 40.68 W, Test 2 consumed 43.92 W, and Test 3 consumed 43.2 W. The "Theoretical Values" section contains theoretical or expected values for Run Time, but notably, it lacks theoretical values for Current Draw and Power. The efficiency, in percentage, section displays the efficiency for each test that was determined by comparing the actual results to the predicted results. As an illustration, Test 1's efficiency was 87.7%, Test 2's was 84.5%, and Test 3's was 86.1%. In the "Error Rate (%)" section, which shows the error rates in both Current Draw and Power for each test, it is shown how far real values deviate from those calculated in theory.

In conclusion, this table gives a thorough dataset that permits a full comparison of test results, allowing for the examination of performance metrics, effectiveness, and error rates for the three tests carried out as part of the project or experiment.

4.5 Conclusion

The Aqua Rover project's considerable optimization efforts have culminated in this chapter. It lists the outcomes, decisions, and significant accomplishments made throughout the optimization process. The chapter's main focus is on choosing the best design strategy out of those that were considered, emphasizing the reasoning of this decision in light of the project's overall aims and objectives. Different design techniques were thoroughly reviewed in the chapters before, along with an examination of their strengths, shortcomings, and prospective outcomes. This thorough investigation enabled the examination of a wide range of options and helped in decision making so that well-informed choices were made based on practical feasibility and real-world evidence. It is critical to stress the critical significance that these findings played in directing the Aqua Rover project in the direction that it was meant to go. The project's goals of bettering water quality, protecting ecosystems, and enhancing community well-being are all seamlessly met by the chosen design approach, which not only reflects the conclusion of efforts but also a strategic course forward. Additionally, the performance evaluation results provide important insights into the project's effectiveness and prospective effects on environmental sustainability. These results were produced through extensive testing and optimization. These findings verifiable proof of achievement and growth, reinforcing the dedication to having a significant impact.

Chapter 5: Completion of Final Design and Validation

5.1 Introduction

This chapter marks the initiation of the final phase of the Aqua Rover project. Building on the groundwork laid during the comprehensive design and prototype development phases, the primary focus now turns towards finalizing the design and executing crucial validation processes. Within this chapter, detail the essential activities and factors that come into play as the project approaches its completion.

5.2 Completion of final design

5.2.1 Plan the Prototype

The extent of the Aqua Rover prototype will be determined by the project's stated objectives and standards. When deciding the scope, take into account the following features and capabilities that the prototype might have.

Basic Mobility: The prototype must be capable of easily navigating through water. This includes turning, going forward, and moving backward.

Trash Collection Mechanism: Create and put into action a system for catching floating rubbish. A conveyor belt or another comparable technique might be used in this.

Navigation and Obstacle Avoidance: Use a camera to portray the environment visually so that you can navigate and avoid obstacles. The operator should have the ability to recognize impediments and steer clear of them.

Data Transmission: For the transfer of data in real time, set up a communication system. RF modules or other wireless communication techniques might be used in this.

Power Management: Make sure the Aqua Rover has a dependable power management system so it can run for long periods of time. This may involve picking the right battery type and reducing power consumption.

User Interface: Think of including a user interface, such as a web-based dashboard or a remote control system, for managing and controlling the Aqua Rover.

Safety Features: To avoid accidents while operating, incorporate safety features like emergency stop mechanisms and collision avoidance algorithms.

Testing and Data Collection: Include tools for evaluating the prototype's performance and gathering information on power usage, trash collection effectiveness, and navigational precision.

When choosing the scope, the objectives of the project and the resources at hand should be taken into account. It's crucial to create a balance between the complexity of the prototype and the likelihood that it can be implemented within the allocated spending and time frame. As the project moves along in the development process and gathers information through testing and experimentation, the scope can be further clarified and changed.

A list of sensors, motors, controllers, and other hardware

Table 26: Materials and Components for Aqua Rover

Category	Materials and Components
Chassis and Structure:	Waterproof Chassis
	Propulsion Mechanism (Motors and Propellers)
	Trash Collection Mechanism (Conveyor Belt)
	Trash Collection Bin
Electronics	Microcontroller (Arduino Nano)
	PCB
	ESC & Brushed ESC
	FPV Camera
	Sensors:
	Ultrasonic Sensors (Obstacle Detection)
	Current and Voltage Sensors (Power Monitoring)
	Power Supply:
	LiPo Battery (High-capacity and Lightweight)
	Power Distribution Board (PDB)
	Buck Converter
	Communication:
	RF Modules (Wireless Data Transmission)
	GSM Module
	Control Interface (Joystick or Remote Control)
Miscellaneous	Fasteners and Waterproofing Materials (Nuts, Bolts, Seals, Gaskets, etc.)
	Cables and Connectors (Wires, Waterproof Connectors, etc.)
	Mounting Hardware (Brackets, Mounts, etc.)
	Buoyancy Materials

5.2.2 Gather Materials and Components

The procurement of materials and components for the Aqua Rover prototype involved a comprehensive effort spanning various sources and locations. To assemble the necessary components, a journey that included both online and offline avenues was embarked upon. Here's an overview of the procurement process:

Online Procurement:

Roboticsbd.com: Several critical components and electronics were sourced from the robotics.bd online platform. This included items like sensors, motor controllers, and specialized electronic modules essential for the project.

TechShopbd.com: From TecShopBD, an order was placed for the PCB (Printed Circuit Board) required for the Aqua Rover project. TecShopBD provided a valuable service by manufacturing the PCB to the project's specifications, ensuring the efficient operation of the prototype. This collaborative effort with TecShopBD played a crucial role in the successful development of the prototype.

Offline Procurement:

Swadesh, Patuatoli, Puran Dhaka: In the heart of Puran Dhaka's bustling Patuatuli market, local Swadesh Electronics shop was scoured for specific components that were readily available. These shops often proved to be treasure troves of essential parts required for the project.

Speedy Tech, and Robiul Electronics in Mirpur 1: In Mirpur 1, Speedy Tech, and Robiul Electronics, there were other hardware and electronics stores where parts could be found. These places provided a wide variety of materials, such as chassis parts, motors, and power distribution equipment.

Gulistan: The colorful Gulistan market was reached on the quest for parts, and there, more materials and parts required to finish the Aqua Rover were discovered.

It took careful work and attention to implement this multifaceted strategy to material buying. To make sure the specific parts required for the Aqua Rover prototype were acquired, it included physically traveling to numerous regions, conducting in-depth market research, and interacting with local merchants. The successful completion of the project was made possible by the effective combination of online and offline procurement, which provided access to a wide range of materials.

5.2.3 Assemble the Hardware

Assembling the Aqua Rover hardware is a pivotal phase that brings the design to life. Follow these steps to effectively construct the Aqua Rover:

Chassis Construction:

Begin by constructing the chassis of the Aqua Rover based on the design created. This involves assembling structural components using stainless steel. Ensure the chassis is sturdy, watertight, and designed to withstand aquatic conditions. Proper sealing is essential to prevent water from entering sensitive electronics.

Figure 23: Frame of the Aqua Rover

Motor and Installation:

Mount the BLDC (Brushless DC) propeller motor in the designated location on the chassis, using stainless steel for added durability. Ensure it is securely fastened to prevent any movement during operation. Attach the propeller to the motor shaft, ensuring a secure connection, and verify that the propeller is correctly aligned for efficient water propulsion. For the conveyor belt, a gear DC motor has been employed to drive the conveyor system. A robust belt system has been set up to facilitate the efficient movement of collected trash.

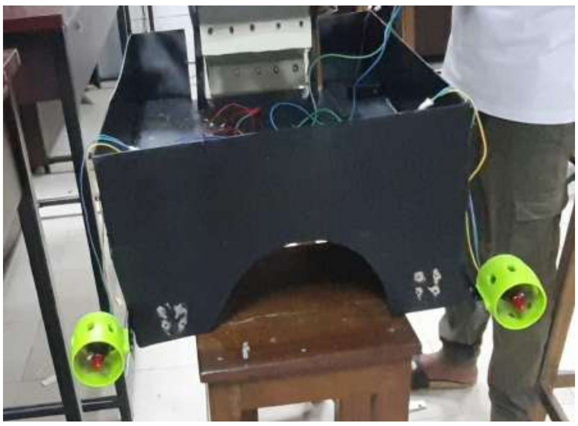


Figure 24: Propellers

Figure 25: Conveyor Belt

Additionally, to hold the collected trash securely, specially designed flaps have been integrated into the conveyor belt system. These flaps ensure efficient trash collection and retention during the Aqua Rover's operation.

Sensor Integration:
Connect sensors, such as ultrasonic to their designated positions on the chassis. Ensure that sensors are properly aligned and securely fastened to minimize vibrations and false readings. Establish electrical connections between the sensors and the main control unit Arduino Nano.

PCB Implementation:
The implementation of the PCB design is a pivotal milestone in the Aqua Rover project, as it directly impacts the system's performance, reliability, and long-term functionality. By meticulously executing each step in the PCB implementation process, the project moves closer to its goal of effectively addressing waterborne trash and environmental challenges.

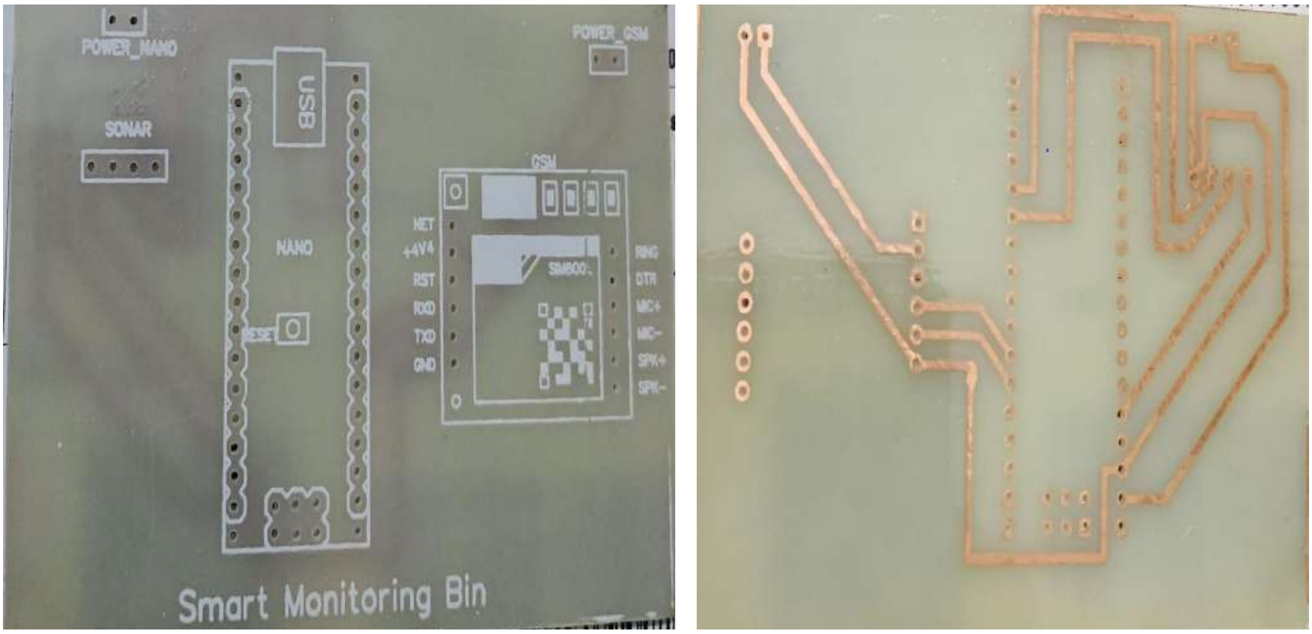


Figure 26: PCB Design

Electronic Component Connection:
Assemble the PCB (Printed Circuit Board) according to the circuit design, ensuring that all components are correctly soldered or connected. Carefully connect the PCB to the relevant subsystems, including motor drivers, power sources, and sensors. Pay close attention to wire routing to prevent tangling and ensure a clean and organized layout.

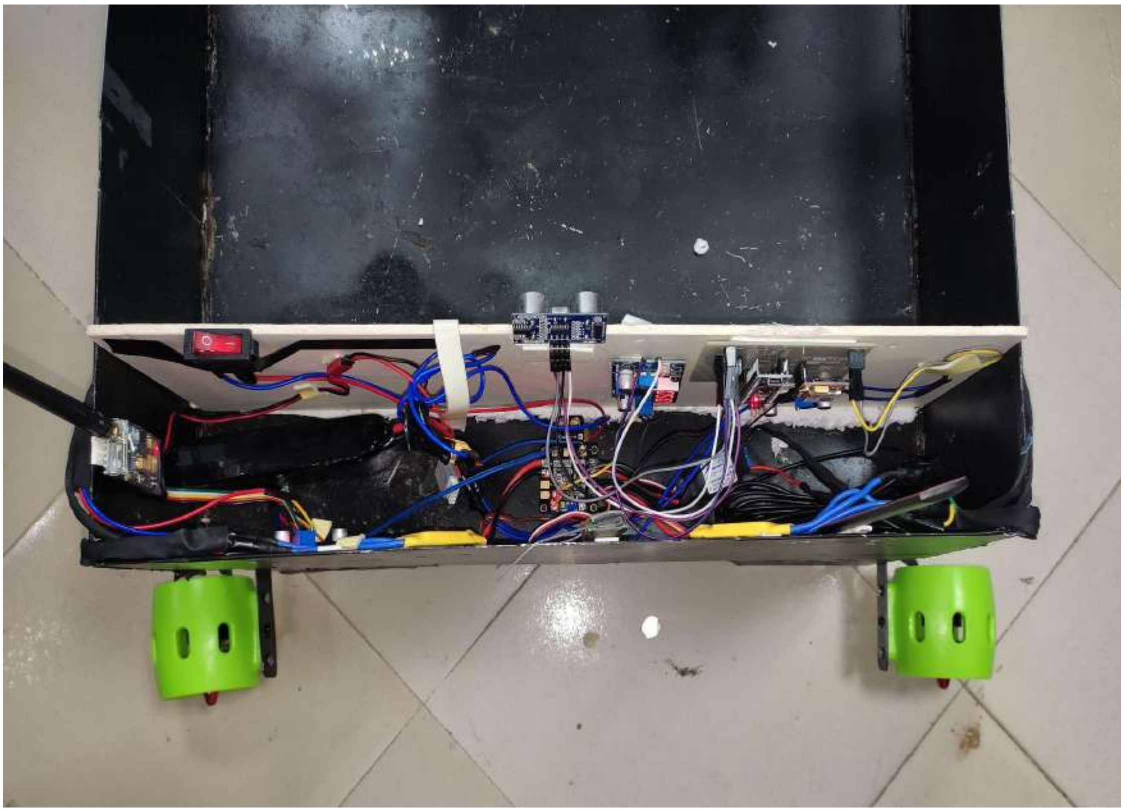


Figure 27: Electrical Connections

Power Supply and Distribution:
Connect and secure the power source, which is a LiPo battery, to the designated power input on the PDB. Implement proper buck converter and protection mechanisms to ensure stable power distribution. Confirm that all power connections are insulated and protected from water exposure.

Communication Setup:
The Aqua Rover is equipped with an RF (Radio Frequency) system for controlling its mobility and operating the conveyor belt during trash collection. It features an FPV (First Person View) camera, which plays a crucial role in providing a real-time view of the surroundings. The FPV camera is connected to its transmitter for seamless data transmission and monitoring. Additionally, it includes communication modules like the GSM module with antennas correctly positioned and connected for remote control and communication with the control system.

Inspection and Testing:
Proper inspection of all connections, parts, and wiring to be done thoroughly before the assembly is complete. It is checked that the motors, sensors, and communication modules function initially to ensure they are up and running as they should. To avoid short circuits or water damage, it is made sure that every component is correctly insulated.

Sealing and Waterproofing:
Apply waterproofing measures to safeguard sensitive electronics from water ingress. This involves using waterproof enclosures for the electrical components. Conduct water tests to ensure the Aqua Rover's integrity against water intrusion.

Secure Fastenings:
Confirm that all fastenings, including screws, bolts, and brackets, are securely tightened to prevent loosening during operation.

Documentation:
Maintain detailed documentation of the assembly process, including photographs and notes. This documentation will be valuable for troubleshooting and future reference. By following these assembly steps meticulously and ensuring that all connections are secure, well-insulated, and water-resistant, the Aqua Rover will be on its way to becoming a fully functional prototype.

Final Prototype:

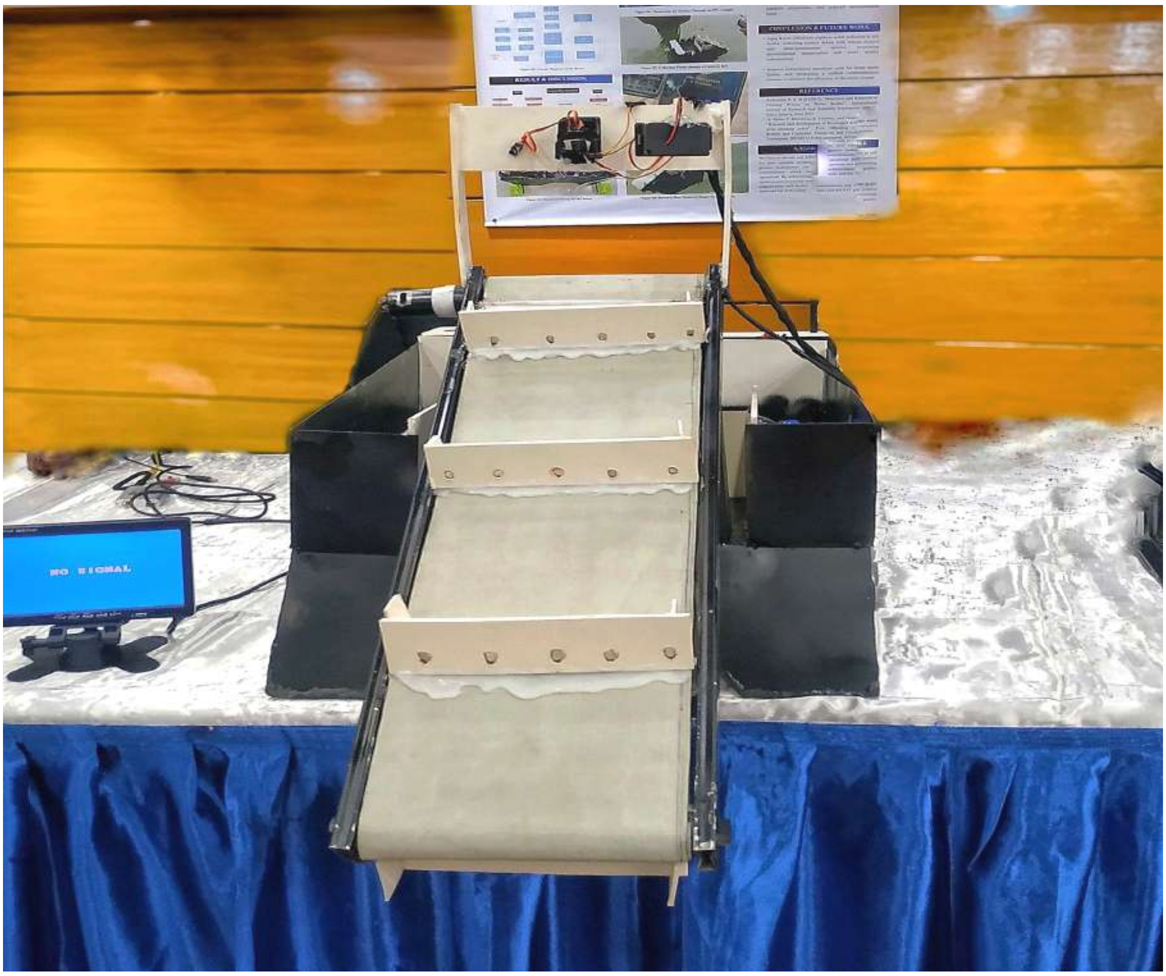


Fig 28: Final Prototype

Test the Prototype:
Testing the Aqua Rover prototype is a critical phase to verify its functionality and identify any issues that require refinement. Follow these steps to thoroughly test the prototype:

Functional Testing: Start with basic functionality tests to confirm that the Aqua Rover can execute fundamental operations like movement and sensor responses. Check the reliability of motors, propellers, and sensors.

Control Testing: Examine the control for accurate interpretation of commands and seamless communication with hardware.

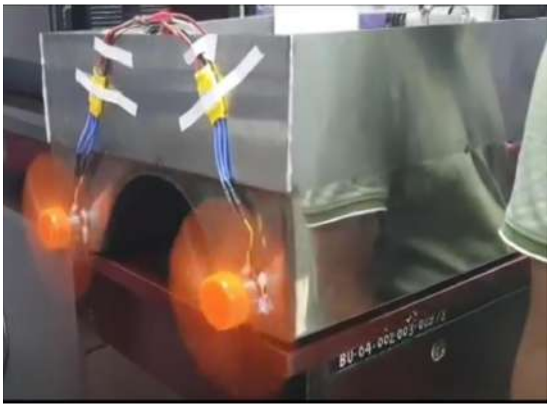
Communication Testing: For models with communication modules, ensure that data transmission is reliable. Verify remote control functionality and data transfer capabilities.

Power Management: Assess the power management system's efficiency and monitor power consumption during different tasks.

Data Logging and Analysis: Implement data logging to record performance metrics. Analyze test results to identify areas for improvement.

Safety: Prioritize safety during testing. Ensure emergency stop mechanisms are functional, and safety protocols are in place.

Refine and Optimize:
An essential part of the development process is iteratively improving and refining the prototype based on test findings and user feedback. The Aqua Rover project will advance and advance over time by addressing any power efficiency, stability, or performance difficulties. Standard BLDC motors were used during the project's earliest phases. A tactical choice was made to convert to waterproof BLDC motors, nonetheless, based on test findings and performance assessments. Improvements in performance and reliability were the end results of this improvement, which was motivated by the requirement for greater durability and water resistance in the aquatic environment. Similar considerable changes were made to the conveyor system. At first, a conveyor system based on chains was used. A roller-based conveyor system clearly offered improved functionality and efficiency after extensive testing and evaluation. As a result, difficulties with stability and overall performance were addressed by modifying the design to include the roller-based conveyor. The commitment of the Aqua Rover project to attaining the best outcomes and pushing the envelope is exemplified by this iterative approach to development, driven by real-world testing and feedback-driven adjustments. The initiative is making progress toward its goals of improving water quality, preserving ecosystems, and promoting community well-being by staying open to adaptation and improvement.



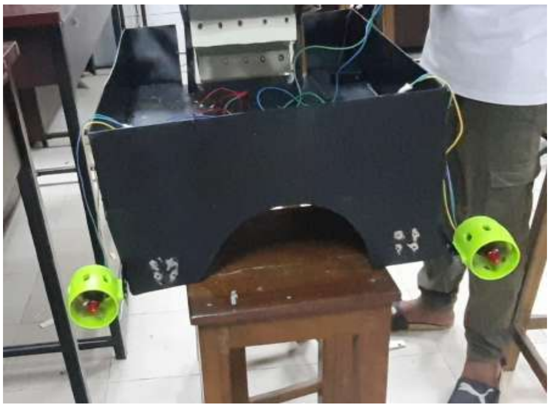


Figure 29: Initial Propeller

Figure 30: Refined Propeller

Figure 31: Initial Conveyor Belt

Figure 32: Refined Conveyor Belt

Test in Real Environment:

The Aqua Rover's final design and certification depend heavily on how well it performs in aquatic situations. A number of tests and evaluations are carried out to guarantee its efficacy and durability in water bodies. An outline of the evaluation procedure is given below:

Buoyancy Assessment: The Aqua Rover's capacity to navigate and function effectively in water is largely dependent on buoyancy. To verify the prototype's ability to float, retain stability, and perform duties while floating, buoyancy tests are performed on it. The Aqua Rover's ability to stay on the water's surface and gain access to surface-level garbage and contaminants is determined by the buoyancy evaluation.

Water-Tightness Testing: Water-tightness testing is done to protect the Aqua Rover's internal parts and electronics from water damage. While submerged in water, the prototype is being attentively watched for any water intrusion into crucial parts. The efficiency of stringent water-tightness measures, such as seals, gaskets, and waterproof casings, is evaluated. Through this testing, it is confirmed that the Aqua Rover can function dependably in damp environments without endangering its internal systems.

Mobility Evaluation: Various scenarios are used to evaluate the Aqua Rover's mobility and dexterity among aquatic bodies. The prototype is put to the test in a variety of water conditions, including still waters, moving water, and maybe turbulent ones. Its underwater obstacle-clearing skills, ability to steer steadily, and ability to carry out jobs like trash collecting are all examined. The Aqua Rover's applicability for various water environments is determined by mobility assessments.

Environmental Adaptability: The prototype is subjected to a variety of environmental factors typical of water bodies. This includes changes in the water's temperature, illumination, and quality. These tests determine how well the Aqua Rover performs under various conditions, confirming its adaptability to aquatic situations in the actual world.

Trash Collection Performance: The Aqua Rover's main goal is to manage and collect floating waste. As a result, rigorous testing is done to evaluate its rubbish collection skills. The prototype's capacity to gather and manage different forms of garbage is assessed once it is deployed in water bodies where there is a known concentration of rubbish. To evaluate the success of the system, performance measures including waste collection capacity and effectiveness are monitored.

Figure 33: Final Test

An iterative technique is used to develop a prototype for a project like the Aqua Rover. To get the intended degree of functionality and effectiveness, testing, tweaking, and improving may be necessary numerous times. For a working prototype to be developed successfully, each phase is essential.

5.3 Evaluate the solution to meet desired need

This chapter's examination of the Aqua Rover solution to see whether it satisfies the intended goals and requirements is essential. The project's success depends on its capacity to resolve environmental issues and promote healthier water sources. This phase's activities include:

5.3.1 Performance Evaluation

To determine the success of the solution, thorough performance evaluations are carried out. These assessments take into account a number of factors, including watertightness, environmental adaptation, waste collecting effectiveness, and mobility.

Controlling the Rover by Remote control:

Figure 34: Controlling the Rover by Remote control

This diagram illustrates the fundamental process of controlling the Aqua Rover. To achieve precise command over the rover's movements, a well-defined control logic algorithm, as explained earlier, acts as the guiding framework. By meticulously following this algorithm, the operators can execute commands that enable them to control the rover's actions seamlessly. This remote control system plays a crucial role in directing the Aqua Rover through aquatic environments with accuracy and efficiency. By following the logic algorithm, operators can guide the rover to collect surface debris and effectively address environmental challenges. It represents the successful integration of engineering, technology, and environmental stewardship, leading to the effective and purposeful control of the Aqua Rover to accomplish the project's objectives.

Monitoring the Surface Through an FPV Camera:

Figure 35: Monitoring the Surface

This figure portrays the pivotal element of monitoring the water surface through the deployment of a First-Person-View (FPV) camera system. The FPV camera is strategically incorporated into the Aqua Rover, providing a live and immersive view of the rover's surroundings, particularly the water surface it traverses. This monitoring system equips operators and project personnel with a direct and live feed of what the rover sees through a display from base station. Indeed, the inclusion of an FPV camera with a transmitter enables continuous surveillance of the environment, thereby facilitating the assessment and identification of debris, as well as the evaluation of the overall condition of the rover's operational area.. The FPV camera plays a crucial role in enhancing situational awareness, ensuring effective debris collection, and guiding the rover's precise movements. It supports informed decision-making and real-time adjustments to optimize the Aqua Rover's performance.

Collecting Plastic through a Conveyor Belt:

Figure 36: Collecting Plastic

This figure illustrates a crucial phase of the Aqua Rover's operation, which involves the collection of plastic debris through the use of a conveyor belt mechanism. The Aqua Rover's design incorporates a vital component, the conveyor belt, which plays a crucial role in the efficient retrieval of plastic waste from the water surface. As shown in the diagram, the conveyor belt system is strategically positioned to scoop up floating plastic debris from the water. This system conveys the plastic waste along the belt, ensuring its methodical collection and containment within the rover's storage capacity. This process highlights the project's dedication to addressing the pressing issue of waterborne plastic pollution, which poses a significant environmental threat. The conveyor belt represents a practical and effective solution for the removal of plastic debris, aligning with the project's overarching objectives of promoting environmental sustainability.

Notification system:

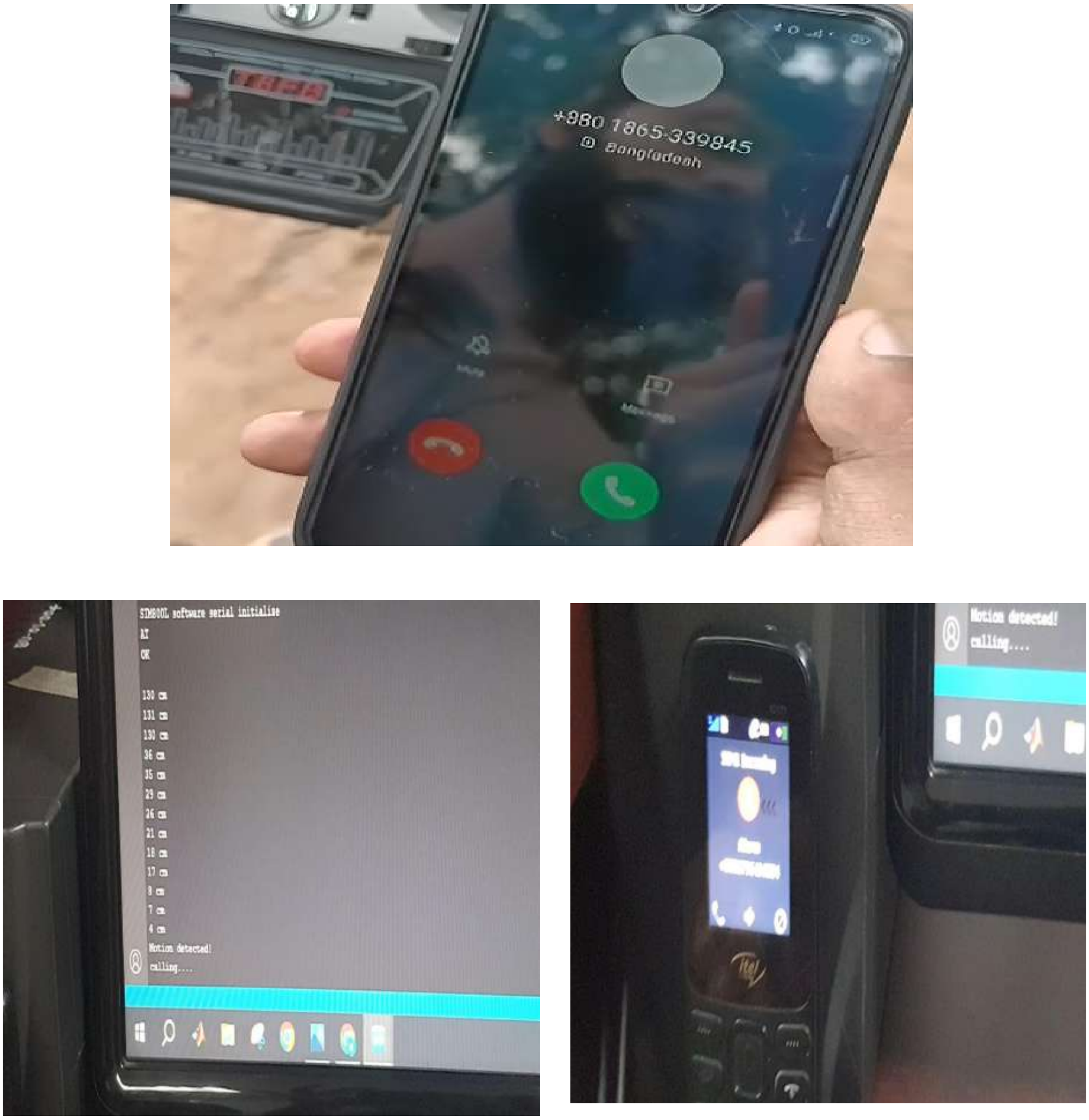


Figure 37: Enable Notification when Storage Capacity Crosses the Threshold Level

These figures highlight a pivotal aspect of the Aqua Rover's design and functionality.These systems showcase the ability to activate notifications as soon as the Aqua Rover's storage capacity either reaches or exceeds a predefined threshold level. In practical terms, this functionality ensures that project operators and personnel receive immediate alerts when the rover's storage capacity nears its limit. When the threshold is crossed, a notification system is triggered, alerting the relevant individuals or control center to the necessity for waste disposal or further actions. By incorporating notifications for capacity thresholds, the Aqua Rover enhances its operational efficiency, minimizing the risk of overfilling and potential issues related to waste containment. This feature also illustrates the project's commitment to intelligent and effective waste management.

Return to Base Station to Empty the Storage Bin:

Figure 38: Return to Base Station

This figure encapsulates a pivotal phase within the Aqua Rover's operational cycle, highlighting a scenario of utmost significance.In this illustration, witnesses a fundamental aspect of the Aqua Rover's behavior: its autonomous return to a designated base station with the explicit purpose of emptying its storage bin. This action serves as a tangible representation of a critical operational necessity – the need to manage and maintain the rover's trash storage capacity effectively. In practical terms, this scenario unfolds when the Aqua Rover has reached its storage limit due to the accumulation of waterborne trash and debris during its mission. To ensure uninterrupted and efficient operation, the rover is navigated back to the strategically located base station. At this base station, the essential process of waste disposal takes place, allowing the Aqua Rover to empty its storage bin and prepare for its next mission. By instituting a system of periodic returns to the base station for emptying, the Aqua Rover maximizes its trash collection efficiency. This strategic approach minimizes interruptions in the rover's mission to cleanse water surfaces from pollution and debris, ensuring that it can continuously and effectively fulfill its environmental objectives. This thoughtful design consideration lies at the core of the Aqua Rover's mission to enhance water quality, preserve aquatic ecosystems, and contribute to the well-being of communities impacted by waterborne pollution.

5.3.2 Alignment with Objectives

The solution is assessed against the project's primary objectives, ensuring that it remains faithful to its core mission of removing floating trash and pollutants from water bodies.

Table 27:Final Design verification checklist

Test Case Criteria	Components	Verification status
Test case 1: Testing Capacity	Aqua Rover (10kg)+ Load 5kg	verified
Test case 2: Testing Conveyor Belt's Trash Collection Capability	Conveyor belt	verified
Test case 3: Testing of Smart Monitoring System	Ultrasonic Sensor and gsm module	verified
Test case 4: Testing Camera and Monitor	FPV Camera, Monitor	verified
Test case 5: Testing Controllability	Control Systems (BLDC Motor)	verified
Test case 6: Testing Battery Duration	Battery Capacity Indicator	verified

This table summarizes the different test cases, the specific components involved in each test, and their verification status. All test cases have been verified, indicating that they have been successfully completed or passed. These tests are crucial for assessing the Aqua Rover's functionality, performance, and reliability.

5.4 Conclusion

As the Aqua Rover project nears its conclusion, commitment to excellence is unwavering. The dedication to developing a technology solution to address watery waste and its negative environmental effects has not wavered throughout the whole process, from conceptualization to design and development. A critical milestone in achieving the vision is entering the final design and validation phase. The Aqua Rover is more than just a technical endeavor; it symbolizes the shared obligation to address the pressing problem of water contamination. The Aqua Rover must function with the utmost accuracy and efficiency in order to remove debris from water surfaces, contribute to the improvement of aquatic ecosystems, and clean up polluted waterways. The importance of precise attention to detail increases in these last stages.Every part is put through extensive testing and certification, from the propulsion system to the waste collection device. The capabilities of the Aqua Rover must perfectly complement the original goals, which included lowering water pollution, protecting biodiversity, and enhancing the standard of living for populations that depend on water resources. The Aqua Rover is a symbol of ethical innovation as well as a tool for problem-solving. It raises awareness of correct waste disposal procedures and designs its activities to have the least possible negative environmental effects. The importance of community interaction is increasingly recognized as the project nears deployment. The Aqua Rover project's success is determined not just by its technical skill but also by how well it is accepted and integrated into the communities it serves.

Chapter 6: Impact Analysis and Project Sustainability

6.1 Introduction

The proposed engineering project's impact analysis and sustainability evaluation are the main topics of this chapter, which also places a strong emphasis on the most practical RC-based design strategy. The chapter assesses the project's implications in a number of domains, including societal, health, safety, legal, cultural, and environmental aspects.

6.2 Assess the impact of solution

In terms of impact assessment, the RC-based design approach has a number of benefits:

Societal Impact:

A survey of the Korail Slums is a crucial first step in identifying the extent of the issue and its consequences on the entire neighborhood, where plastic pollution in Hatirjheel has severely harmed residents. In Hatirjheel, the effects of plastic pollution are serious and noticeable right away, especially for those living in the Korail Slums. These people mostly use the waters of Hatirjheel for bathing, drinking, and washing clothes. However, the widespread use of plastic trash has made it difficult for them to obtain clean, potable water, leading to a number of major issues. One of the most obvious results is water contamination, which creates a health emergency. The slum dwellers' health has been severely impacted by the contaminated water, which has turned into a breeding ground for diseases. The community is constantly at risk for developing a waterborne ailment because they have grown so common. In addition, the stagnant, dirty water has made mosquito infestations perfect. As mosquitoes are disease carriers, this not only increases the health concerns but also makes life more difficult for the locals. The difficulties these people currently experience are exacerbated by the persistent presence of disease-carrying mosquitoes. Aquatic flora and fauna are negatively impacted by the plastics in the water and the surrounding environment, which have a negative impact on the ecology. Hatirjheel, once a beautiful natural environment, is now marred by the unsightly presence of plastic trash, which not only detracts from its natural charm but also harms the environment.

In summary, the impact of plastic pollution in Hatirjheel, experienced by the residents of Korail Slums, is extensive and devastating. It affects not only their daily lives and health but also the environment's well-being and the aesthetic appeal of the area. Addressing this issue is not just a matter of convenience; it's a critical step towards improving the well-being of these communities and preserving the natural beauty of Hatirjheel.

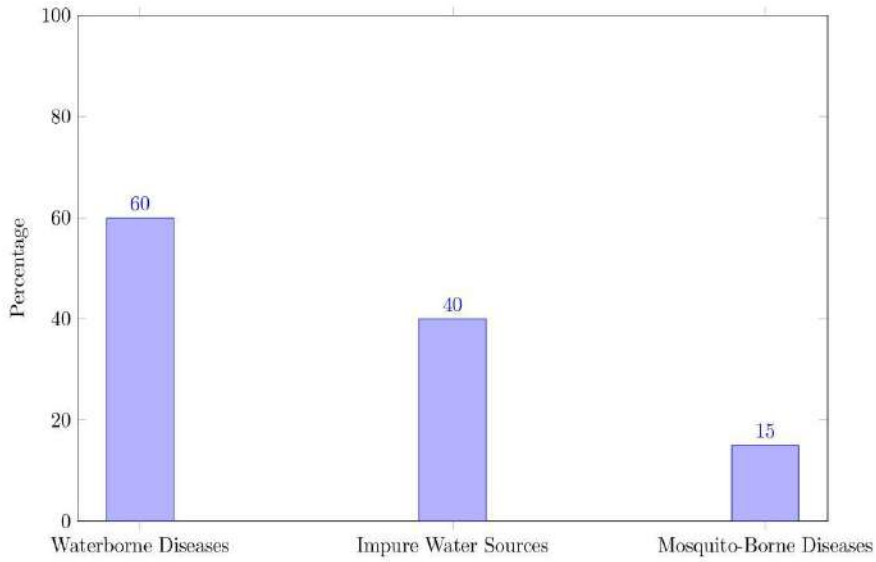


Figure 39: Water-Related Health and Environmental Parameters on Investigation

Figure 39 presents crucial health and sanitation issues currently being faced by the populace near water bodies without the Aqua Rover project. This single bar chart encapsulates the main health implications faced by the general public at Korail Basti (Slums).

Residents with Waterborne Diseases: An estimated reduction of 20% in the prevalent 60% of waterborne diseases among residents living near Hatirjheel, signifying the project's positive influence on public health.

Access to Clean Water Sources: A notable 15% increase in access to clean water sources is estimated as more clean water will be available after using the Aqua, emphasizing the project's contribution to improving sanitation and access to safe drinking water.

Mosquito-Borne Diseases: The chart below underscores a 5% reduction in mosquito-borne diseases from its initial 15%, reflecting the project's comprehensive approach to enhancing community well-being. These metrics collectively affirm the project's commitment to environmental conservation and its positive impact on public health and sanitation.

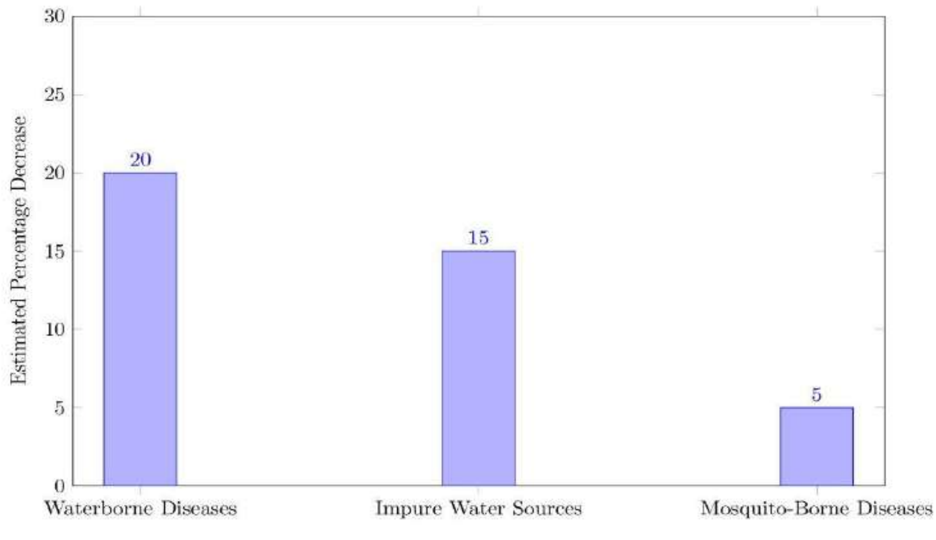


Figure 40: Estimated decrease in Water-related issues from water bodies

Certainly, the deployment of the Aqua Rover offers a compelling prospect for lowering the incidence of water-related diseases in a particular region. Through its effective collection and removal of waterborne litter and debris, the Aqua Rover plays a vital role in enhancing water quality, thereby reducing the risk of contamination and the transmission of diseases linked to polluted water sources. This innovative approach not only addresses the immediate challenge of waterborne diseases but also aligns with broader objectives of environmental preservation, the safeguarding of aquatic ecosystems, and the advancement of community health and well-being. It highlights the constructive influence that technological and engineering solutions can exert on public health and the sustainability of our environment.

Health and Safety:

At its essence, the project envisions a transformative impact on public health, particularly within vulnerable communities like the Korail Slum, where access to clean water is a pressing concern. The project's primary goal is to reduce waterborne diseases caused by pollution, making it a lifeline for residents in areas such as the Korail Slum who depend on water sources like Hatirjheel for their daily needs. The importance of the Aqua Rover project in relation to the Korail Slum and Hatirjheel cannot be emphasized. The pollution of Hatirjheel, a crucial water source for many populations, poses serious health dangers. In this region, waterborne illnesses are common and have a negative impact on many people's health. The project directly addresses this public health concern by using the Aqua Rover to fight diseases and pollutants in Hatirjheel. The project's design stresses the safety and wellbeing of persons residing in and around these places as well as the cleansing of water sources. By reducing the amount of time that people are exposed to potentially harmful cleanup procedures, it protects the health of the locals who depend on Hatirjheel for their daily needs. In essence, the Aqua Rover initiative is a light of hope for better public health within the setting of the Korail Slum and Hatirjheel. Restoring clean and safe water supplies, lowering the incidence of waterborne illnesses, and ensuring the security of the people it serves are its main goals. In addition to its technical components, the initiative represents a dedication to the health and wellbeing of those who have long suffered the effects of water pollution.

Legal Compliance:

The project places a high priority on abiding by all applicable legal mandates and environmental standards in the fight against water pollution and environmental protection. This commitment to stringent compliance has many benefits, including ensuring that the project runs within the law and preserving its core values of environmental care. Respecting the law is not just a formality when it comes to the Aqua Rover's job in locations like Hatirgheel and Korail Slum; it is a moral and ethical responsibility. In order to protect the environment and the health of people who depend on water sources like Hatirgheel, pollution control rules have been put in place.The initiative actively contributes to the wellbeing of these communities by abiding by these regulations. Strict legal compliance also reduces the danger of future legal issues that can obstruct the project's progress. In complex endeavors like pollution control, legal issues can pose significant obstacles. By proactively adhering to environmental standards, the project ensures a smoother path toward achieving its objectives.

In summary, the project's unwavering commitment to legal compliance underscores its dedication to environmental responsibility and community well-being. It not only upholds the law but also exemplifies a strong ethical stance in the battle against water pollution.

Cultural Sensitivity:
In the specific context of Hatirjheel and Korail Slum, the Aqua Rover project is distinguished by its deep commitment to cultural sensitivity and ecological preservation, seamlessly interwoven with its engineering innovations. These areas hold profound cultural significance for the local communities that have coexisted with these water bodies for generations. Hatirjheel, in particular, has been an integral part of the cultural and environmental heritage of the region. In recognition of this, the project approaches its construction with profound respect for local culture. It acknowledges the importance of preserving the historical and cultural connections that residents of Korail Slum and neighboring areas have with these aquatic ecosystems. The Aqua Rover project serves as a testament to the harmonious coexistence of engineering innovation and cultural sensitivity. By actively integrating these values into its design and implementation, the project ensures that its actions align with the rich cultural heritage of the region. Furthermore, the project's commitment to ecological preservation complements its cultural sensitivity. It recognizes that the health and preservation of these aquatic ecosystems are not only vital to the environment but also hold deep cultural significance for the local communities. Through the safeguarding of these ecosystems, the project demonstrates a holistic approach that benefits both the environment and the cultural identity of the area. In doing so, it reaffirms its dedication to fostering a harmonious relationship between engineering advancements, cultural heritage, and ecological sustainability.

6.3 Evaluate the sustainability

Sustainability assessment of the RC-based design approach:
The Aqua Rover project actively mitigates water pollution, which contributes to environmental sustainability. It helps protect aquatic environments by removing floating trash and contaminants. The technology is also built to cause as little ecological damage as possible, so the rover's actions won't have an adverse effect on delicate aquatic ecosystems.

Table 28: SWOT analysis

SI no.	Strengths	Weakness	Opportunity	Threat
1	Simple to construct and operate	Weather dependent	Mass production of an improved model is possible	A collision with a water vessel is possible
2	Easier to keep large water surfaces clean	A little higher budget for average people	Can be made such that it can be used to remotely operate and get information from any place on	Electrical circuits on the water's surface will be used, which obviously poses the threat that one wrong

			Earth	connection could lead to charges flowing through the water
3	Maximizing floating trash collection	Extra care must be used to prevent contact with water on the circuits	May be modified to clean up submerged waste	
4	Semi-automated system	Not suitable for use in rivers or seas with strong currents or tides		
5	Ecologically friendly	Only works at surface level		

Long-Term Viability:
Sustainability is at the very core of the project's design and methodology, and this concept extends to its long-term viability. The Aqua Rover project does not merely aim to address immediate concerns; it is constructed to withstand the test of time. Central to the project's approach are continuous research and development (R&D) efforts. These endeavors are focused on improving the Aqua Rover's effectiveness, durability, and adaptability. Through ongoing refinement of technology and methods, the project ensures that its solutions remain pertinent and efficient in the face of evolving challenges. Furthermore, the project incorporates regular maintenance protocols and technology updates as essential components of its long-term viability. These measures are not sporadic interventions; they are systematic processes designed to extend the operational lifespan of the project. Through proactive maintenance and staying at the forefront of technological advancements, the project positions itself as a sustainable and enduring solution to water pollution.
In essence, the Aqua Rover project's dedication to long-term viability underscores its commitment to environmental stewardship and its vision of a cleaner, healthier future for places like Hatirjheel and Korail Slum. It is not a short-term remedy but rather an enduring commitment to the well-being of communities and their environments.

6.4 Conclusion
Significant societal, health, safety, legal, cultural, and environmental effects are displayed by the best RC-based design method for the Aqua Rover project. Cleaner water bodies, better public health, greater legal compliance, and increased cultural sensitivity are all outcomes of the project's effective response to water pollution. Furthermore, its sustainability activities, such as resource efficiency and long-term profitability, are consistent with environmental conservation objectives. A strong solution, the RC-based design method mixes engineering concepts with environmental and societal issues for a more sustainable future while resolving a pressing issue.

Chapter 7: Engineering Project Management

7.1 Introduction

The Aqua Rover project places a strong emphasis on efficient engineering project management. This chapter explores the crucial part that project management plays in the endeavor's success. The seamless operation of the development process, adherence to the established timeframe, and achievement of the project's goals are all ensured by effective project management. The definition, planning, and management of the engineering project, monitoring project progress, and the significance of efficient project management are the three main topics covered in this chapter.

7.2 Define, plan and manage engineering project

Before project management begins, the scope, objectives, and requirements of the Aqua Rover project are thoroughly outlined. This demands a clear understanding of the objectives to be achieved and the resources required. It is the responsibility of project managers to specify tasks, define deliverables, and pinpoint important milestones. Identifying possible risks and creating mitigation strategies are also part of this step. The following stage is to put together a comprehensive project plan including a timetable, resource allocation, risk management and communication plan.

Project managers are responsible for keeping an eye on each of these elements and ensuring that they are in line with the project's objectives. To follow the project's set timeline, this calls for managing timeframes, properly assigning resources, and coordinating team work.

A maintained timeline is necessary for a proper project process. For better understanding, "Gantt Charts" have been prepared for sections 400P, 400D, and 400C in this section. The first section addressed the overall timetable for developing and carrying out 400P. Future ideas for 40D and 400C have also been revealed, along with their timeline.

Project Plan for 400P:

Final Year Desing Project

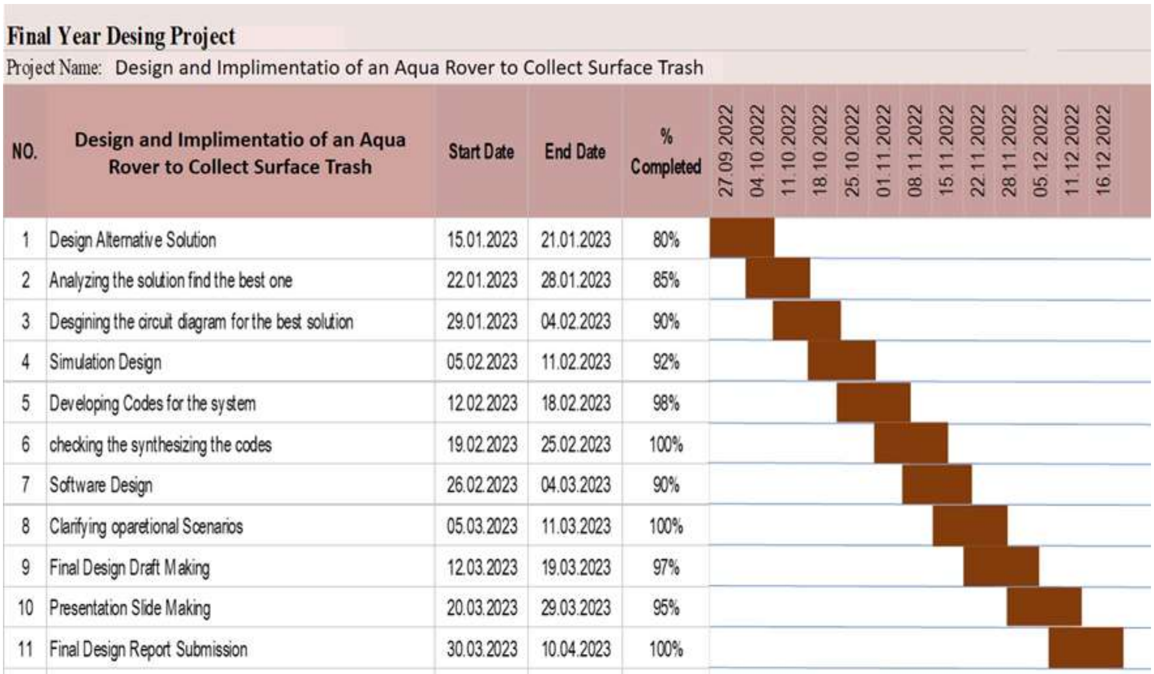
Project Name: Design and Implimentatio of an Aqua Rover to Collect Surface Trash

NO.	Design and Implimentatio of an Aqua Rover to Collect Surface Trash	Start Date	End Date	% Completed	27.09.2022	04.10.2022	11.10.2022	18.10.2022	25.10.2022	01.11.2022	08.11.2022	15.11.2022	22.11.2022	28.11.2022	05.12.2022	11.12.2022	16.12.2022
1	Problem identification and topic selection	27.09.2022	03.10.2022	60%													
2	Identifying Objectives,specifications,requerm ents	04.10.2022	10.10.2022	80%													
3	Constrains and Background Research	11.10.2022	17.10.2022	100%													
4	Evaluate the impact of the solution	18.10.2022	24.10.2022	100%													
5	Risk analysis and Impact	25.10.2022	31.10.2022	100%													
6	Designing Multiple approaches	01.11.2022	07.11.2022	88%													
7	Making of Concept Note	08.11.2022	14.11.2022	90%													
8	Concept Note presentation and Evaluation	15.11.2022	21.11.2022	100%													
9	Identifying Ethical Consideration,Sustainability	22.11.2022	27.11.2022	80%													
10	Identifying ethical considaration	28.11.2022	04.12.2022	78%													
11	Preparing Draft Project Proposal	05.12.2022	10.12.2022	80%													
12	Final Project Proposal slide submission and presentation	11.12.2022	15.12.2022	98%													
13	Final project proposal Report submission	16.12.2022	21.12.2022	99%													

Figure 41: Project Plan for 400P

The group's members were assigned equal responsibility for each task, and rescheduling or adjustments were made as needed to accommodate individual commitments. For instance, considerations were made for individuals with exams on specific days. Additionally, the project's work management schedule was proactively created to ensure efficient completion. First and foremost, active participation from all team members was required in the problem identification and topic selection processes. Following that, Swapnil Paik and Bipro Bhattacharjee took charge of determining the project's objectives, specifications, requirements, and constraints, with each team member contributing to background research. Jobaar Hossain was responsible for assessing the solution's impact. Furthermore, Sanjida Hoque conducted risk analyses, outlined expected outcomes, impacts, and contingency plans. After extensive research, several design strategies were developed. Bipro Bhattacharjee completed the block diagram design for each strategy. The team then proceeded to finalize the initial presentation and prepared the concept note. Subsequent to receiving feedback from the ATC panel regarding the concept note, work on the project proposal report commenced with the necessary corrections. Swapnil Paik considered ethical considerations, sustainability, and other factors when drafting the project proposal. Jobaar Hossain worked on a preliminary budget while researching component prices associated with the project. He diligently maintained a notebook to track all his work on this aspect. Ultimately, through the collective efforts of all team members, every task was successfully completed while adhering to the established schedule.

Project Plan for 400D:



Final Year Desing Project

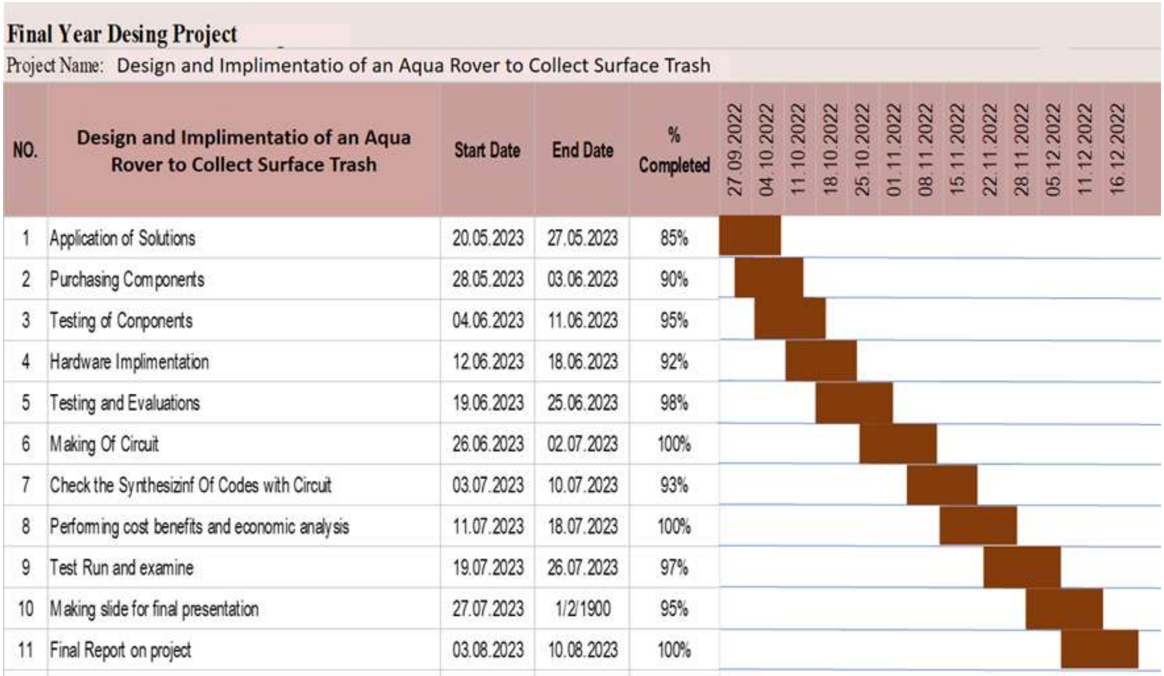
Project Name: Design and Implimentatio of an Aqua Rover to Collect Surface Trash

NO.	Design and Implimentatio of an Aqua Rover to Collect Surface Trash	Start Date	End Date	% Completed
1	Design Alternative Solution	15.01.2023	21.01.2023	80%
2	Analyzing the solution find the best one	22.01.2023	28.01.2023	85%
3	Desgining the circuit diagram for the best solution	29.01.2023	04.02.2023	90%
4	Simulation Design	05.02.2023	11.02.2023	92%
5	Developing Codes for the system	12.02.2023	18.02.2023	98%
6	checking the synthesizing the codes	19.02.2023	25.02.2023	100%
7	Software Design	26.02.2023	04.03.2023	90%
8	Clarifying oparetional Scenarios	05.03.2023	11.03.2023	100%
9	Final Design Draft Making	12.03.2023	19.03.2023	97%
10	Presentation Slide Making	20.03.2023	29.03.2023	95%
11	Final Design Report Submission	30.03.2023	10.04.2023	100%

Figure 42: Project Plan for 400D

In the first week of development, the project plan continued with the design of alternative solutions and familiarization with the required software. As per the schedule, by week 2, an analysis had been conducted to determine the most viable solution. A prototype was then created and subjected to stress testing to assess its alignment with the project's requirements. If the prototype did not meet the criteria, necessary adjustments were made, and simulation tests continued until the requirements were met, anticipated to be by weeks four and five. By weeks 6 and 7, the development phase of the prototype's operational codes had been completed, and the project transitioned to the synthesis phase. By week 10, four software-based designs had been developed to execute the aforementioned codes. Following week 10, the plan was to finalize the draft, followed by the design and report stages, which marked the conclusion of the development period.

Tentative Project Plan for 400C:



Final Year Desing Project

Project Name: Design and Implimentatio of an Aqua Rover to Collect Surface Trash

NO.	Design and Implimentatio of an Aqua Rover to Collect Surface Trash	Start Date	End Date	% Completed	27.09.2022	04.10.2022	11.10.2022	18.10.2022	25.10.2022	01.11.2022	08.11.2022	15.11.2022	22.11.2022	28.11.2022	05.12.2022	11.12.2022	16.12.2022
1	Application of Solutions	20.05.2023	27.05.2023	85%													
2	Purchasing Components	28.05.2023	03.06.2023	90%													
3	Testing of Conponents	04.06.2023	11.06.2023	95%													
4	Hardware Implimentation	12.06.2023	18.06.2023	92%													
5	Testing and Evaluations	19.06.2023	25.06.2023	98%													
6	Making Of Circuit	26.06.2023	02.07.2023	100%													
7	Check the Synthesizinf Of Codes with Circuit	03.07.2023	10.07.2023	93%													
8	Perfoming cost benefits and economic analysis	11.07.2023	18.07.2023	100%													
9	Test Run and examine	19.07.2023	26.07.2023	97%													
10	Making slide for final presentation	27.07.2023	1/2/1900	95%													
11	Final Report on project	03.08.2023	10.08.2023	100%													

Figure 43: Project Plan for 400C

Following the completion of the development phase, the implementation of the solutions and the procurement of components for the chosen approach commenced in the first week of the execution phase. Test analyses were conducted at the end of weeks one, two, and four, respectively, after the necessary component purchases for testing were completed. The hardware implementation effort began after the testing phase, spanning a period of three to five weeks for completion. In weeks 6 and 7, the construction of the prototype and preparation for the hardware implementation of the developed solution took place. After week 8, an evaluation and cost-benefit analysis, along with an economic standpoint analysis, were carried out, expected to be completed by week 10, alongside multiple test runs. The final two weeks were dedicated to report writing.

7.3 Evaluate project progress

Project progress evaluation is a fundamental aspect of successful project management. It involves continuous monitoring of various project elements to ensure alignment with project goals, timelines, and resource utilization. Here is a visual representation of how project progress evaluation can be illustrated using a pie chart and an elaborate on its significance.

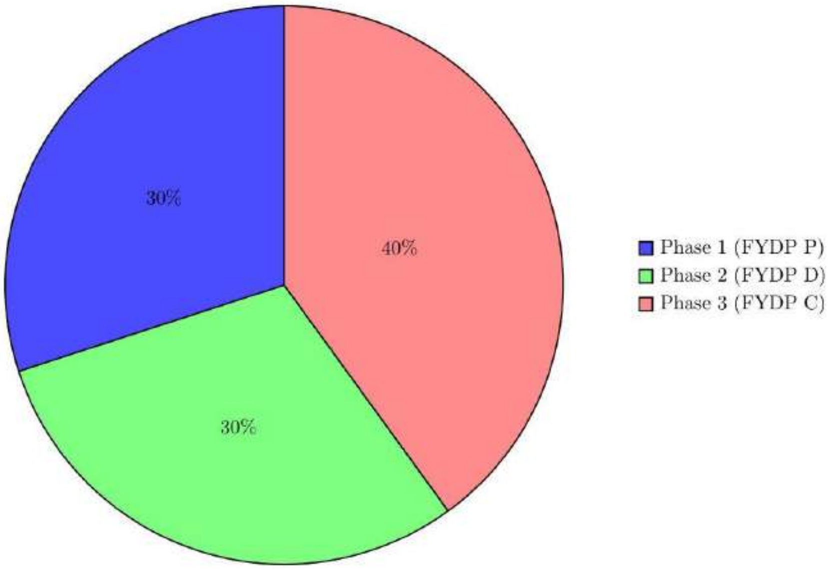


Figure 44: Work Percentage for FYDP Phases

Phase 1 (FYDP P):

- Duration: September 27, 2022, to December 21, 2022 (12 weeks)
- Work Percentage: 30%

Elaboration: Phase 1, known as FYDP P, represents the initial stage of the project. It commenced on September 27, 2022, and extended until December 21, 2022. This phase took 12 weeks to complete, and it accounts for 30% of the overall project work. During this phase, the focus was on project planning, requirements gathering, initial design, multiple design approaches and concept note analysis.

Phase 2 (FYDP D):

- Duration: January 15, 2023, to April 10, 2023 (12 weeks)
- Work Percentage: 30%

Elaboration: Phase 2, referred to as FYDP D, followed the first phase. It commenced on January 15, 2023, and concluded on April 10, 2023. Like the previous phase, Phase 2 spanned 12 weeks and contributed 30% to the overall project work. During this stage, the development, simulation, 3D design and calculations of the Aqua Rover were completed, focusing on turning the design concepts into a functional simulation model.

Phase 3 (FYDP C):

- Duration: May 20, 2023, to August 10, 2023 (12 weeks)
- Work Percentage: 40%

Elaboration: Phase 3, identified as FYDP C, marks the final leg of the project. It started on May 20, 2023, and wrapped up on August 10, 2023. Similar to the previous phases, Phase 3 spanned 12 weeks, but it carries a slightly higher work percentage of 40%. During this stage, the focus was on comprehensive testing, fine-tuning the Aqua Rover, conducting trials in real water bodies, and preparing for the project's final deliverables. The amount of additional effort illustrates how crucial this stage is to guaranteeing the Aqua Rover's operation and efficiency in combating waterborne pollution. A planned progression toward the successful completion of the Aqua Rover project is made possible by this staged strategy, which has specific timetables and work percentages.

To ensure that the Aqua Rover project continues on track and completes its goals within the allocated time frame, it must be continuously monitored. The following crucial processes are set up to evaluate the project's development:

Milestone and Task Monitoring: To make sure that tasks and milestones were completed on time, the project was carefully monitored at all times. Every task is watched to make sure it is completed on time and in accordance with the project's objectives.
Resource Utilization Assessment: To measure the effective use of resources, regular assessments were made. The resources mentioned here include people, things, and money. The success of the project as a whole depends on ensuring that resources are distributed effectively and used efficiently.
Deviation Identification and Resolution: Any unexpected issues that caused deviations from the plan or scope of the project were quickly found and fixed. This proactive strategy reduced the effects of unforeseen difficulties and permitted for rapid modifications and alterations.
Regular Project Meetings: Team members could discuss progress, obstacles, and potential solutions at scheduled project meetings with the ATC panel and ask the instructors for advice. These team sessions, along with online sessions among groupmates, encouraged efficient communication and cooperation.
Status Reports: The project's status has been updated on a regular basis in status reports, which is a separate problem-sharing file to which each member had access to. These reports gave team members a quick overview of the progress, problems, and any necessary actions.
Team Updates: It was essential to keep the team members updated on the project's status. The team received regular updates to make sure everyone was on the same page with the project's objectives and could participate successfully. The control over the project's course was maintained in large part because of this meticulous evaluation method. It made it possible for the project management to take well-informed decisions, adjust to new problems, and make sure the Aqua Rover project moved swiftly in the direction of its goals.

7.4 Conclusion

The Aqua Rover initiative's cornerstone is project management, which guarantees the project's continuity, effectiveness, and uncompromising dedication to its objectives. This chapter laid the groundwork for a planned and carefully managed execution phase as the project moved forward. It emphasized the critical role that strong project management played in directing the creation of the Aqua Rover, a device created to fight water pollution in bodies of water. The team wanted to increase the chances of a successful and on-time project completion by implementing strong project management methods.

Chapter 8: Economical Analysis

8.1 Introduction

In this section, the financial feasibility of the proposed Aqua Rover project is examined with an eye toward the most efficient RC-based design strategy. It assesses the project's economic viability by analyzing its costs, possible revenue streams, and other financial factors.

8.2 Economic analysis

Indeed, the cleaning and improvement of Hatirjheel can have a positive impact on tourism, which, in turn, can contribute to the national GDP (Gross Domestic Product). Here's how this positive economic effect can be analyzed:

Increased Tourist Arrivals:

The bar chart titled "Tourist Distribution by Region in Hatirjheel," illustrates the distribution of tourists among four distinct regions in December, 2017 [20]. These regions include the "Centre area of Hatirjheel," contributing to approximately 56.93% of tourists, the "Other area near Hatirjheel" with around 25.61%, the "In Dhaka Metropolitan area" accounting for 13.02%,

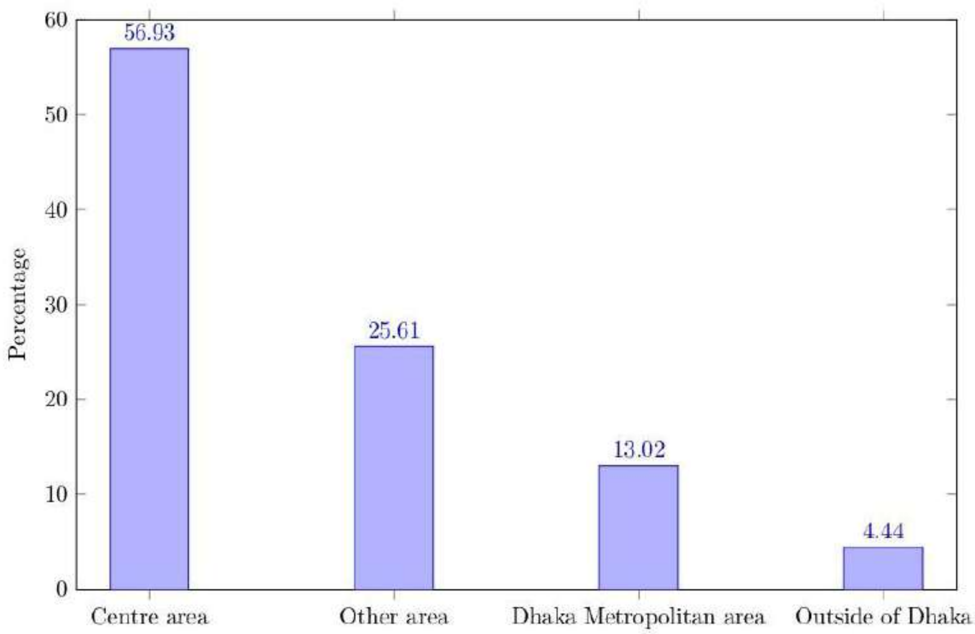


Figure 45: Tourist Distribution by Region in Hatirjheel

and the "Outside of Dhaka Metropolitan area" comprising the smallest portion at 4.44%.

Indeed, the bar chart vividly illustrates that Hatirjheel is a highly valued destination for tourists, with a significant percentage of tourists originating from various regions. However, it's essential to note that the recent BD News report, published in January 2022, has raised concerns about Hatirjheel's environmental degradation due to plastic waste pollution.

Figure 46: The trash littering at Hatirjheel

The pollution issue has started to affect Hatirjheel's attractiveness as a favored recreational spot for Dhaka residents. The report underscores the urgency of addressing the pollution problem promptly to safeguard Hatirjheel's natural beauty and its role as a recreational hub. The findings serve as a critical call to action, emphasizing the need for concerted efforts to combat pollution, ensuring that Hatirjheel continues to be a cherished destination for both tourists and the local community.

The Aqua Rover is designed to effectively clear various forms of pollution, such as plastic waste and debris, from water bodies from Hatirjheel. This addresses the pollution issue highlighted in the recent BD News report from January last year. By systematically removing pollutants from the water's surface, the Aqua Rover contributes to restoring the area's natural beauty and recreational value which can help to increase tourism..

Tourist Spending:

As more visitors come to Hatirjheel, it is expected that they will spend money on a variety of goods and services, including lodging, dining, shopping at the neighborhood markets, transportation, and entertainment. For homeowners and local businesses, this spending brings in money.

Job Creation:

Jobs in a variety of industries, including hospitality, food services, transportation, and retail, may become available as a result of the increase in tourists. As a result, there are more people employed and more money being made.

Local Economic Development:
Businesses around Hatirjheel will expand as a result of increased tourist traffic. Hotels, restaurants, gift stores, and entertainment centers fall under this category. Local businesses will see an increase in revenue and prospects for growth.

Government Revenue:
Taxes on lodging, commodities, and services are just a few of the taxes that tourism-related activities frequently bring in for the government. Infrastructure improvement and public services can both benefit from these additional funds.

Infrastructure Investment:
There may be a need for infrastructure upgrades, such as better roads, transportation systems, and recreational facilities, to handle the increasing number of tourists. These investments may help to strengthen the local economy even further.

Cultural Exchange:
Tourists who experience local customs, cuisine, and art might encourage cultural exchange. The rise of cultural industries and the income of artisans may result from this.

Increased Property Values:
Property values in the Hatirjheel region may rise as tourism spurs economic growth, benefiting both homeowners and municipal governments.

Health Well-being:
The Aqua Rover initiative has the potential to be a source of optimism for the Korail slum's inhabitants. Beyond its technological components, it holds the promise of better socioeconomic prospects, enhanced health, and a stronger feeling of community. It serves as evidence of the transformative potential of innovation in resolving some of the most urgent problems encountered by underprivileged populations.

Positive GDP Impact:
The local and national GDP can experience a measurable increase as a result of increased visitor spending, job creation, business expansion, and government revenue.

8.3 Cost benefit analysis

A thorough cost-benefit analysis compares a project's advantages to its costs in order to determine its economic viability:

8.3.1 Total Cost

Production Costs:

Table 29: Design cost

Components	**Unit**	**Price**
Arduino Nano	1	BDT 450
FPV Camera with Transmitter and Receiver	1	BDT 7000
4200mAH 12V Lipo Battery	1	BDT 3500
Underwater thruster brushless motor 4-blade propeller propulsion	2	BDT 6000
Ultrasonic Sensor	1	BDT 390
25A Esc	3	BDT 2700
Gear DC Motor	1	BDT 1050
Radiolink T8FB BT 2.4G 8CH Remote Control Transmitter with R8EF Receiver	1	BDT 4800
Body	1	BDT 15000
PDB (Power Distribution Board)	1	BDT 450
Buck Converter	3	BDT 750
Display Monitor	1	BDT 3000
Miscellaneous	1	BDT 3000
Total		BDT 48090

Operating and Maintaining Costs:

An operator needs to manually control the Aqua rover twice a week to clean trash and do maintenance.

Table 30: Operating and Maintaining Costs

Operator's Compensation	**Amount (BDT)**
Daily Compensation for Manual Control	500
Daily Compensation for Trash Collection	
Daily Compensation for Maintenance	
Monthly Compensation (2 days a week)	4,000

Research and development Cost:
Investing in ongoing research and development (R&D) efforts is crucial for enhancing the Aqua Rover's efficiency, durability, and capabilities. These efforts can lead to innovations that make the system more effective in its mission to combat water pollution. Therefore, allocating resources to R&D is essential for the project's long-term success. The yearly cost of 50,000 BDT reflects the commitment to continuous improvement and innovation, ensuring that the Aqua Rover remains a cutting-edge solution for water pollution control.

8.3.2 Benefits

Assigning precise monetary values to benefits can be challenging, especially for intangible benefits like environmental conservation and improved public health.Here are some estimated values for the benefits of the Aqua Rover project:

Water Pollution Reduction:
Estimation: Reduction in waterborne diseases and healthcare savings due to cleaner water.
Value: BDT 20,000 per year.

Improved Livelihoods:
Estimation: Positive impact on communities dependent on cleaner water for agriculture and fishing.
Value: BDT 25,000 per year.

Tourism Revenue:
Estimation: Increased tourism revenue due to restoring the area's natural beauty and recreational value
Value: BDT 100,000 per year.

Environmental Conservation:
Estimation: Long-term benefits to biodiversity and the environment.
Value: BDT 10,000 per year.

Note: These are rough estimates and should be considered conservative.

8.3.4 Calculations and Analysis

Table 31: Government Estimated Benefits

Category	Value per Year (BDT)	Total over 5 Years (BDT)
Reduction in Waterborne Diseases and Healthcare Savings	20,000	100,000
Improved Livelihoods	25,000	125,000
Tourism Revenue	100,000	500,000
Environmental Conservation	10,000	50,000
Total Estimated Benefits	1,55,000	7,75,000

Table 32: Government Estimated Costs

Cost Component	Amount per Year (BDT)	Total Amount for 5 Years (BDT)
Production Cost (One-Time)	48,090	48,090
Operating and Maintaining Costs (Yearly)	48,000	2,40,000
Research and development Cost	50,000	2,50,000
Total Estimated Cost	1,46,090	5,38,090

Table 33: Government Estimated Profits

Duration	Total Estimated Benefits (BDT)	Total Cost (BDT)	Profit (BDT)
5 Years	7,75,000	5,38,090	2,36,910
1 Year	1,55,000	1,46,090	8,910
1 Month	12917	12174	743

Indeed, when looking at the initial profit margins of the Govt. for the Aqua Rover project, they may seem relatively modest, especially over the first 5 years. However, there are several key factors to consider that make this project a worthwhile investment in the long run.

Economies of Scale: The cost per unit often decreases as production is scaled up, as was already indicated. Over time, this can considerably increase profit margins. Research & development, prototyping, and establishing production facilities are examples of initial expenditures. After making these investments, manufacturing more units is more economical.

Longevity and Durability: A significant benefit is the lengthy lifespan of the Aqua Rover. Although the upfront cost may appear costly, it offers years of service. This longevity guarantees that the project will continue to produce advantages for a considerable amount of time, maybe greatly outweighing the initial costs.

Environmental Impact: The improvement of water quality and reduction of pollution are the project's key goals. These initiatives have the potential to significantly improve Hatirjheel's environment over time. As previously indicated, cleaner water bodies may draw more tourists, increasing overall profitability.

Future Growth: The popularity of Hatirjheel as a vacation spot is probably going to rise. Visitors might grow as more people become aware of and appreciate the enhanced environment. This can increase revenue even more and make the initial expenditure justifiable.

Social and Health Benefits: The project will have a major effect on local community health, even though it cannot be measured directly in monetary terms. A population that is healthier and more productive as a result of decreased waterborne diseases and better living circumstances benefits from wider social and economic advantages.

In essence, the Aqua Rover project's ultimate value resides in its long-term influence, even though the initial years may show only minor financial gains. It has the potential to develop into a sustainable and successful business that benefits both the local community and the larger economy by lowering pollutants, improving the environment, and luring more tourists over time.

8.4 Evaluate economic and financial aspects

8.4.1 Economic Aspects

Target Market: Governmental organizations and agencies looking for a cost-effective and effective waste collection system comprise the project's main target market. Local governments, environmental agencies, and related governmental bodies are included in this. The number of regional government agencies that require efficient water pollution management solutions can be used to estimate the prospective demand for the project.

Anticipated Environmental and Social Advantages: There will likely be significant societal and environmental advantages from the initiative. It could lessen trash and pollution in highly populated places by providing an easy and economical waste collection service. Both the ecology and the local community are benefited by this.

Potential Financial Gains: Long-term cost savings and cash advantages from the project are both possible outcomes. It might assist small firms in lowering their waste management costs, resulting in monetary savings. Additionally, the successful implementation of the project could generate revenue through product sales.

Economic Influence on Stakeholders and Impacted Communities: The Aqua Rover project exerts a significant economic impact on stakeholders and the communities it serves. It generates employment opportunities, stimulates local manufacturing, and reduces water pollution-related costs. The allure of cleaner water bodies attracts tourists, benefiting local businesses. Furthermore, the reduction in healthcare expenses, owing to a decrease in waterborne diseases, contributes to the overall economic well-being of these communities.

In summary, the Aqua Rover project encompasses a comprehensive economic perspective, ranging from its target market to the anticipated environmental and social benefits, potential financial gains, and its profound economic influence on stakeholders and impacted communities.

8.4.2 Financial Aspects

Project Lifespan Estimate: How long each individual component is anticipated to last will have an impact on the project's predicted life expectancy. With proper maintenance, the project is poised to remain operational for several years, ensuring that the government's investment yields long-term benefits.

Operating Costs: Operating costs, such as electricity consumption and maintenance/repairs, are an integral part of the project's sustainability. Estimating electricity usage at approximately 1 to 2 BDT per hour, the government's investment covers the ongoing operational expenses, making it a sustainable endeavor.

Potential Revenue Sources: In the context of government funding, revenue sources may differ. While the project may not directly generate revenue for the government, its societal and environmental benefits can translate into long-term economic advantages for the region. Reduced healthcare costs, enhanced tourism revenue, and improved livelihoods within communities are indirect financial returns for the government.

Expected Investment and Financial Return: The government's investment is aimed at achieving societal and environmental goals rather than direct financial returns. Therefore, the financial return on investment is primarily measured in terms of the project's positive impact on public health, tourism, and the local economy.

Availability of Funding Sources: With government backing, funding sources are readily accessible. Government financing can significantly reduce the reliance on external investors, loans, or grants, ensuring the project's continuity and scalability. This government-funded initiative aligns with the broader goal of environmental conservation and public welfare.

8.5 Conclusion

The economic analysis of the Aqua Rover project based on RC vehicles highlights its potential to provide monetary and non-monetary advantages. The project's long-term impact extends beyond the initial investments and operations costs due to its contribution to economic growth, healthcare savings, improved quality of life, and ecosystem advantages. The incorporation of risk mitigation techniques guarantees the project's robustness in the face of economic uncertainties, making it a financially feasible and sustainable effort.

Chapter 9: Ethics and Professional Responsibilities

9.1 Introduction

Ethical and professional obligations related to the Aqua Rover project are discussed in this chapter. It delves at the moral quandaries of ecological preservation, community education, and accountable engineering.

9.2 Identify ethical issues and professional responsibility

Beyond its technological and operational features, the Aqua Rover project represents a set of ethical ideals and professional obligations. These moral issues and obligations are inextricably linked to the organization's goal to reduce water pollution and promote environmental health. An expanded viewpoint on the project's ethical concerns and professional obligations is provided here:

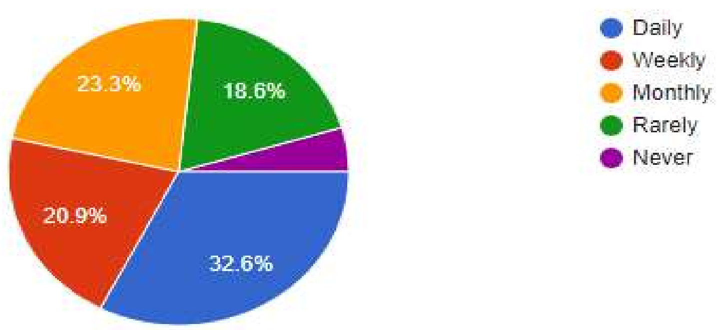
Environmental Preservation: The project Aqua Rover is fundamentally motivated by a strong desire to protect the environment. It acknowledges that the natural environment is a limited and fragile resource that needs to be preserved for both the present and the future. The project actively removes pollutants from water bodies, which not only purifies these surroundings but also illustrates a moral need to save the planet's ecosystems. This dedication is consistent with more general ethical standards of sustainability and ecological stewardship.

Public Awareness and Education: While physically removing pollutants is the Aqua Rover's main duty, it also plays a vital role in promoting public awareness and education. According to the project, sustainable environmental practices require informed and involved individuals. It works to instill a sense of accountability and environmental stewardship in communities by educating them about the negative effects of water contamination. This educational component stands for a moral position that puts the welfare of both people and the environment first.

Several surveys have been done to better understand the ethical and professional responsibilities related to this project. These are shown below

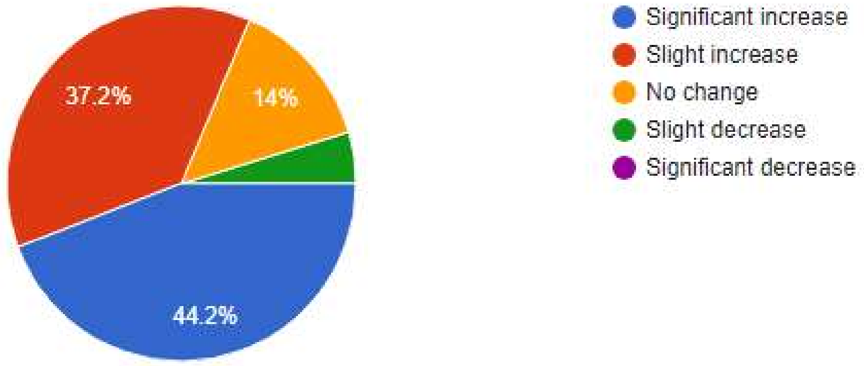
1. How often do you personally encounter garbage in local water bodies like rivers, lakes, or ponds?

43 responses



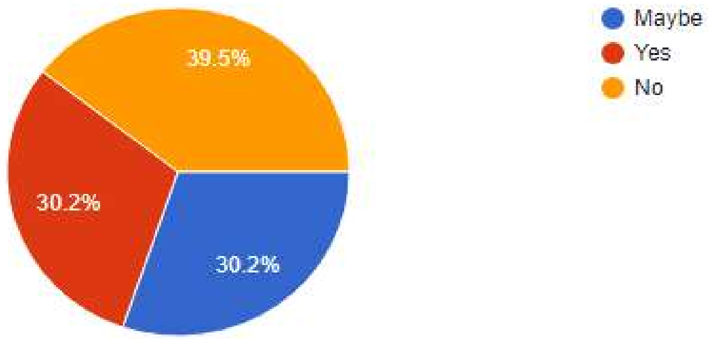
2. Have you observed an increase or decrease in the amount of garbage in water bodies over the past year?

43 responses



3. Do you believe that local authorities are actively addressing the issue of garbage in water bodies?

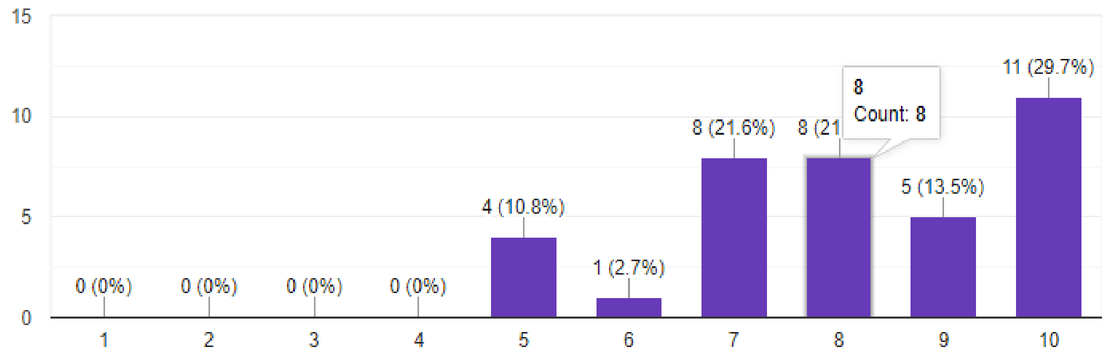
43 responses



4. On a scale of 1 to 10, where 1 indicates "Strongly Disagree" and 10 indicates "Extremely Agree," Do you think projects like the Aqua Rover to collect surface garbage can make a significant difference in reducing waterborne garbage?

Copy

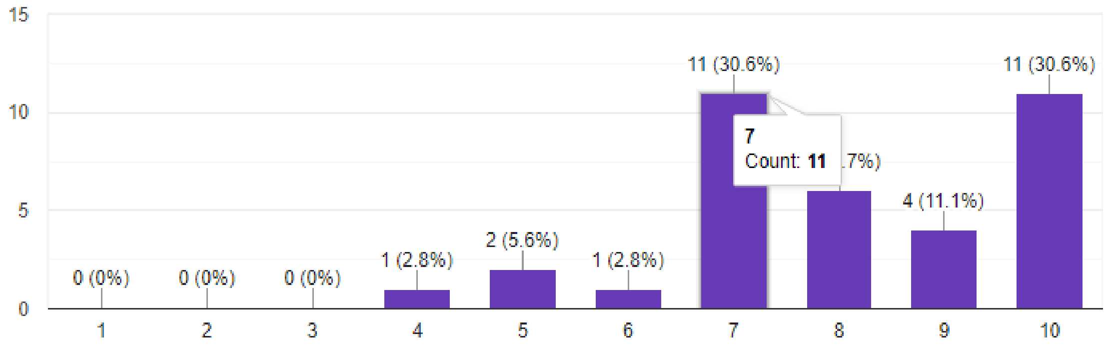
37 responses



5. On a scale of 1 to 10, where 1 indicates "Not at all effective" and 10 indicates "Extremely effective," please rate the potential effectiveness of projects like the Aqua Rover in reducing waterborne garbage in your community.

Copy

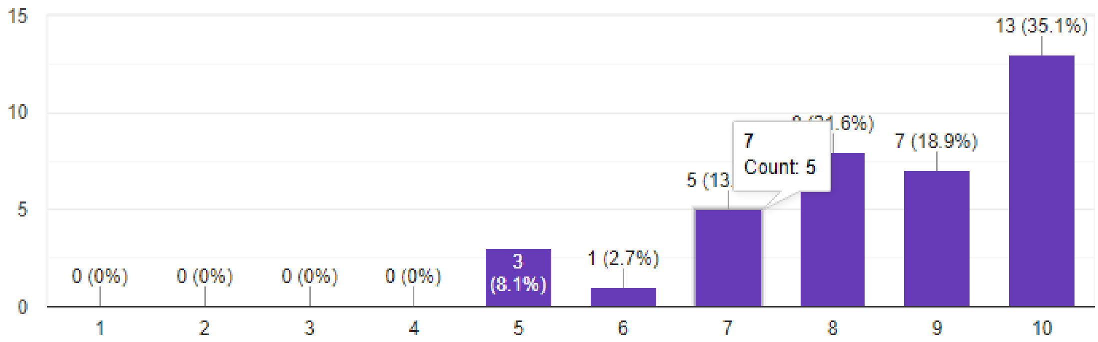
36 responses



6. On a scale of 1 to 10, how optimistic are you about the long-term impact of projects like the Aqua Rover on water pollution in your community?

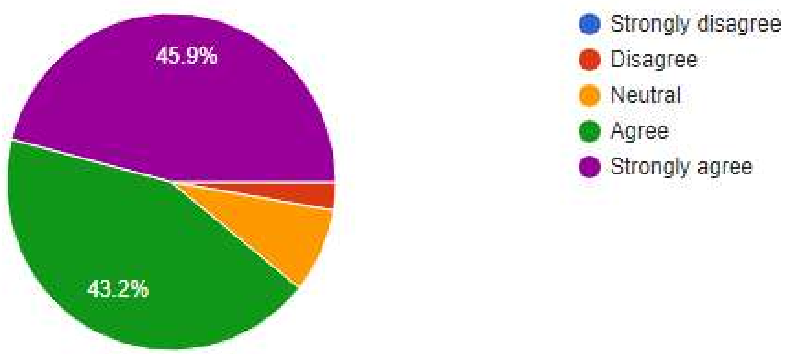
Copy

37 responses



Do you believe that raising awareness about the importance of clean water bodies can lead to positive changes in your community?

37 responses



Collaboration with Environmental Agencies: The project recognizes the value of working with regulatory and environmental agencies. This cooperation is morally required as well as legally necessary. The project makes sure that its operations comply with existing environmental standards and laws by collaborating closely with these organizations. This dedication to compliance demonstrates a sense of ethical and professional accountability.

Community and Stakeholder Engagement: The Aqua Rover initiative prioritizes community and stakeholder engagement over technological issues. It acknowledges that local communities must be included for environmental solutions to be successful. It is ethically required to involve communities in projects, solicit their feedback, and respond to their concerns. Doing so will increase the project's legitimacy and social impact.

Transparency and Ethical Conduct: The project upholds the principles of transparency and good conduct in all of its interactions. It contends that building confidence with stakeholders including political entities, investors, and the general public necessitates performing honestly, morally, and with integrity. This dedication to moral behavior demonstrates a feeling of professional accountability that permeates all facets of the project's activities.

The Aqua Rover project represents moral values and legal obligations in addition to being a technical endeavor. It strives to protect the environment, educate the public, collaborate with relevant organizations, engage with communities, and behave honestly and morally. The project's commitment to eliminating water pollution while respecting moral and professional standards is highlighted by these ethical issues, which are a crucial part of the project's identity.

9.3 Apply ethical issues and professional responsibility

Environmental Responsibility:

When it comes to decreasing pollution and its damaging effects on water sources, the Aqua Rover project has a remarkable moral fortitude. It displays a deep feeling of obligation to the environment. By implementing this cutting-edge technology and focusing on cleaning up surface trash in a city lake, the initiative acknowledges the critical necessity of preserving and enriching the natural environment. The major goal of this initiative is to provide more dependable, clean water sources that provide several advantages to both people and the environment.

The Aqua Rover initiative's ability to drastically lower pollution levels in the municipal lake is one of its main benefits. Surface litter frequently contains non-biodegradable components that harm aquatic life, disturb the environment, and detract from the lake's natural beauty. By utilizing the Aqua Rover to effectively remove this debris, the initiative can restore the lake to a healthier state, promoting the flourishing of diverse plant and animal species.

In addition to the immediate benefits, the Aqua Rover initiative aligns with the global movement towards sustainable environmental practices. By showcasing a commitment to cleaner water sources and healthier ecosystems, the initiative sets an example for other communities to follow suit. It promotes a collective understanding of the importance of preserving natural resources and encourages responsible waste management practices.

The Aqua Rover initiative stands as a shining example of environmental responsibility, demonstrating moral fortitude by addressing pollution in city lakes. Its positive impacts encompass a cleaner and more sustainable environment, improved quality of life for the residents, and a broader influence in promoting responsible environmental stewardship at a larger scale. Such initiatives are essential steps toward creating a more sustainable and harmonious coexistence with the natural world.

Public Engagement: The project's goal is to instill a sense of personal and communal responsibility for watershed conservation through the implementation of public awareness campaigns and educational activities.

Several surveys have been conducted to gain clarity on the ethical and professional responsibilities related to this project. The findings from these surveys were presented in 9.2.

Compliance with Regulations: Ethics and professionalism have been maintained by the project's observance of environmental requirements and the incorporation of expert feedback.

9.4 Conclusion

The Aqua Rover initiative is built on a foundation of ethics and professional accountability. The project is congruent with larger societal norms and responsible engineering concepts because it addresses ethical issues relating to environmental conservation, public awareness, and responsible engineering procedures. In addition to enhancing water quality, it promotes moral decision-making and civic duty in the context of preserving natural resources.

Chapter 10: Conclusion and Future Work.

10.1 Project summary

The Aqua Rover initiative is a giant leap forward in the fight against water pollution in lakes and reservoirs, especially in Dhaka, Bangladesh's Hatirjheel Lake. This research has created a novel solution in the form of an semi-autonomous robotic vehicle that is able to efficiently collect surface litter and debris by taking a comprehensive design approach. The Aqua Rover might have far-reaching positive effects on water quality, aquatic ecosystems, and public health thanks to its innovative use of engineering knowledge, state-of-the-art technology, and moral considerations.

The success of the project is demonstrated by the fact that two different design approaches were developed: an RC-based one and an autonomous one. The RC-based design method was found to be the best option after careful consideration of its cost-effectiveness, flexibility, and environmental impact. This method of design integrates radio frequency (RF) wireless communication, brushless DC (BLDC) motors, electronic speed controllers (ESCs), a first-person view (FPV) camera, and a smart monitoring bin to produce an effective garbage collection system.

Finally, the Aqua Rover project is in line with international initiatives to reduce water pollution and strengthen the resilience of water systems worldwide. Not only will it have an immediate effect on operations, but it will also have the potential to inform and motivate people to become more conscious of their environments.

10.2 Future work

The Aqua Rover project lays the foundation for future advancements and potential refinements in multiple areas:

Enhanced Automation: Advanced sensors, machine learning algorithms, and obstacle avoidance capabilities could be implemented in future updates to increase the system's autonomy.

Improvements: Less channels can be used to further improve the rover, e.g. currently three channels have been used but it can be improved such that only one channel will be enough to completely operate all the functions of the rover.

Eco-Friendly Materials: The project's environmental impact may be lessened and the project's sustainability goals might be bolstered through the study and use of environmentally friendly materials e.g. Solar Panels .

Diverse Applications: The system has potential in other domains, such as water quality monitoring, water sample collection, and disaster relief.

The Aqua Rover will continue at the forefront of environmental conservation and water pollution reduction thanks to persistent research and development efforts and a dedication to ethical engineering principles. The positive effects of this project on water quality and the communities that rely on them will last long after the project has been completed.

Chapter 11: Identification of Complex Engineering Problems and Activities

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

Attributes of Complex Engineering Problems (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)

Certainly, here are the attributes of complex engineering problems (EPs) relevant to the Aqua Rover project, along with ticks (√) next to the three most suitable points:

Depth of Knowledge Required (P1): √

- **Description:** The project demands a deep understanding of various engineering domains, including mechanical, electrical, and software engineering.

- **Relevance:** Engineers working on the Aqua Rover project must possess in-depth knowledge to design and develop a multifunctional water surface cleaning system that integrates these domains seamlessly.

Range of Conflicting Requirements (P2): √

- **Description:** Conflicting requirements such as robustness vs. agility and buoyancy vs. payload capacity must be balanced.

- **Relevance:** The Aqua Rover must navigate effectively in aquatic environments, carry debris, and remain buoyant. Balancing these conflicting requirements is a significant challenge that engineers must address during design.

Depth of Analysis Required (P3): √

- **Description:** The project requires rigorous analysis, including fluid dynamics, propulsion systems, control algorithms, and structural integrity.
- **Relevance:** In-depth analysis is essential for optimizing the rover's performance, ensuring safety, and achieving operational efficiency in various aquatic conditions.

Familiarity of issues (P4): √

- **Description:** The Aqua Rover project demands a deep familiarity with various environmental issues, particularly those related to water pollution and ecosystem conservation. It's noteworthy that this knowledge was largely self-acquired, as it extended beyond the scope of our formal coursework.

- **Relevance:** Recognizing and understanding environmental challenges, as well as the consequences of water pollution, is essential for crafting effective solutions. This proactive self-learning approach enabled us to tackle complex real-world problems.

Interdependence (P7): √

- **Description:** The Aqua Rover project exemplifies interdependence between its various components and subsystems. Its success relies on the seamless interaction between mechanical components, electronics, control systems, and sensors.

- **Relevance:** In this multifaceted project, interdependence is a core feature. Mechanical components, such as the chassis and trash collection mechanism, must work in concert with electronic systems, like the microcontroller and sensors. Failure in one aspect can disrupt the entire project, underscoring the importance of interdependence in engineering integration.

11.3 Identify the attribute of complex engineering activities (EA)

Attributes of Complex Engineering Activities (EA)

	Attributes	Put tick (√) as appropriate
A1	Range of resource	√
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)

Certainly, here are the three most suitable attributes of complex engineering activities (EAs) for the Aqua Rover project, along with ticks (√) next to the selected points:

Range of Resource (A1): √

- Reasoning: The Aqua Rover project involves a broad range of resources, including various electronic components, sensors, motors, and materials for construction. Managing these resources efficiently is crucial for project success.

Level of Interaction (A2): √

- Reasoning: The project requires a high level of interaction among various engineering disciplines, such as mechanical, electrical, and software engineering. While all team members belong to the electrical and electronics engineering field, their diverse specializations, such as circuit design, control systems, and power electronics, necessitate close cooperation to ensure successful integration of their expertise.

Consequences for Society and the Environment (A4): √

- Reasoning: The Aqua Rover project directly impacts society and the environment by addressing the critical issue of water pollution. By collecting debris from water bodies, it contributes to environmental conservation, improved water quality, and healthier aquatic ecosystems.

These three attributes align with the project's complexity and emphasize the need for resource management, interdisciplinary collaboration, and considering the societal and environmental consequences of the project's outcomes.

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Appendix

Log-book for FYDP-P

Date/Time	Attendance	Summary of Meeting	Responsible	Comment by ATC
27.09.2022	1.Sanjida Hoque 2.Bipro Bhattacharjee 3.Md. Jobaar Hossain 4.Swapnil Paik	Discussed several solvable problems from our findings & selected the topic	Equal contribution	Task completed
04.10.2022	1.Sanjida Hoque 2.Bipro Bhattacharjee 3.Md. Jobaar Hossain 4.Swapnil Paik	Discussed various aspect of of the selected topic like- 1.Problem statement 2.Objective 3.Requirement	Task1:Equal contribution Task2:Sanjida Hoque & Md. Jobaar Hossain Task3:Swapnil Paik & Bipro Bhattacharjee	All task completed except requirement
11.10.2022	1.Sanjida Hoque 2.Bipro Bhattacharjee 3.Md. Jobaar Hossain 4.Swapnil Paik	1.Discussion on multiple design approach 2.Background research 3.Specification	Task1:Md. Jobaar Hossain Task2:Sanjida Hoque & Bipro Bhattacharjee Task3:Swapnil Paik	Task1:Partially completed Task2:Completed Task3:Partially completed
18.10.2022	1.Bipro Bhattacharjee 2.Md. Jobaar Hossain 3.Swapnil Paik	1.Preview multiple design approach 2.Evaluate the impact of the solution	Task1:Equal distributed Tak2: Sanjida Hoque	Task1:Partially completed Task2:Completed

25.10.22	1.Sanjida Hoque 2.Bipro Bhattacharjee 3.Md. Jobaar Hossain 4.Swapnil Paik	1.Preview multiple design approach 2.Risk analysis & impact 3.Modified Requirement,Specification according to the feedback from ATC panel	Task1:Md. Jobaar Hossain Task2:Swapnil Paik Task3:Bipro Bhattacharjee	Task1:Partially completed Task2:Completed Task3: completed
01.11.2022	1.Sanjida Hoque 2.Md. Jobaar Hossain 3.Swapnil Paik 4.Bipro Bhattacharjee	1.Preview multiple design approach 2.Methodology, Expected outcome & applicable standards & codes	Task1:Md. Jobaar Hossain & Bipro Bhattacharjee Task2:Swapnil Paik & Sanjida Hoque	All task completed

Log-book for FYDP-D (Meeting-with-group-member)

Date/Time/Place	Attendance	Summary of Meeting	Responsible	Comment by ATC
30.01.23	All Members	Discuss about whole project and think about it more	ALL	Nil
02.02.23	All Members	Try to do simulation Part	Md Jobaar Hossain	Not finished
07.02.23	All Members	Work About Image Processing Part	Md Jobaar Hossain, Sanjida Hoque Otondrila, Swapnil Paik	Nil
11.02.23	All Members	Find out some mistakes in simulation and try to fix it	All	Nil
15.02.23	All Members	Try to do 3D Modeling	Sanjida Hoque Otondrila	Nil
19.02.23	All Members	Start the Latex Part	Swapnil Paik	Nil
22.02.23	All Members	Make Slide for MOC Presentation	All	Put more information

26.02.23	All Members	Make Slide for MOC Presentation	All	Nil
01.03.23	All Members	Star doing Calculation Part	Md Jobaar Hossain, Bipro Bhattacharjee	Not accurate , Have to fix it .
16.03.23	All Members	Start to fix the mistakes part of Calculation	All	Improved but still not perfect .
19.03.23	All Members	Think about the calculation more	All	Think More
21.03.23	All Members	Think how to avoid the complexity of this project	All	Think more
27.03.23	All Members	Do some changes in code	Bipro Bhattacharjee	Think About the difficulties
29.03.23	All Members	Start to write the elaborate point of the report	All	Nil
01.04.23	All Members	software implementation	Md Jobaar Hossain, Bipro Bhattacharjee	Task complete
06.04.23	All Members	1.objective, Latex 2.Problem statement ,Requirement, specification, 3d model , using interface 3. design approach , methodology,Matlab work 4. applicable code and conclusion	Task 1: Swapnil Paik Task 2: Sanjida Hoque Otondrila Task 3: Md Jobaar Hossain Task 4 : Bipro Bhattacharjee	Have to overview some points
09.04.23	All Members	Report review	All	Nil
13.04.23	All Members	Discuss About the mistakes	All	Nil
15.04.23	All Members	Make Slide for Final Presentation	All	Organized more
18.04.23	All Members	Overview the slides	All	Nil

24.04.23	All Members	Complete the 3d Modeling	Sanjida Hoque Otondrila	Task Complete
26.04.23	All Members	Done the slide for final presentation of FYDP D	All	Task Complete
28.04.23	All Members	Complete the Report	All	Task Complete

Log-book for FYDP-D (meeting-with-ATC-every-week)

Date/Time/Place	Attendance	Summary of Meeting	Responsible	Comment by ATC
30.01.23	All Members	Discuss about the total project and Image processing part .	All	Think More
06.02.23	Md Jobaar Hossain, Bipro Bhattacharjee, Sanjida Hoque Otondrila	1.Collect image for Image processing part. 2.Develop in Simulation Part	Task 1: Sanjida Hoque Otondrila,Swapnil Paik Task 2: Md Jobaar Hossain, Bipro Bhattacharjee,	Couldn't finish the task
13.02.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Do the Mathematical Calculation	Md Jobaar Hossain.	Some corrections have to do
20.02.23	All Members	1.Do some correction software implementation. 2. 3D Modeling 3.Mathlab work and Graphs.	Task 1: Swapnil Paik,Bipro Bhattacharjee. Task 2 : Sanjida Hoque Otondrila Tasl 3: Md Jobaar Hossain.	Task complete

27.02.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	1.Latex 2.objective,problem statement, Requirement, specification, 3. design approach , methodology, project plan 4. applicable code and conclusion	Task 1: Swapnil Paik Task 2: Sanjida Hoque Otondrila Task 3: Md Jobaar Hossain Task 4 : Bipro Bhattacharjee	Have to overview some points
20.03.23	Md. Jobaar Hossain, Sanjida Hoque Otondrila, Swapnil Paik	Make Slide and overview the previous report.	All	Nil
27.03.23	All Members	Discuss About the mistakes and try to fix it	All	Nil
03.04.23	All Members	Discuss About the mistakes and try to fix it	All	Task Complete
10.04.23	All Members	Overview the slides and report	All	Nil

Log-book for FYDP-C (Meeting-with-group-member)

Date/Time/Place	Attendance	Summary of Meeting	Responsible	Comment by ATC
07.06.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Discuss about whole project and think about it more	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Nil
14.06.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Think how to built prototype	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Not finished
21.06.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Research about our project that how to build it	Md Jobaar Hossain, Sanjida Hoque Otondrila, Swapnil Paik	Nil

24.06.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Find out some mistakes	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Nil
03.07.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Buy elements for the prototype	Md Jobaar Hossain, Bipro Bhattacharjee	Nil
05.07.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Buy elements for the prototype	Md Jobaar Hossain, Bipro Bhattacharjee	Nil
08.07.23	Md Jobaar Hossain, Bipro Bhattacharjee	Start to build the prototype	Md Jobaar Hossain, Bipro Bhattacharjee	Incomplete
10.07.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Work to build the prototype	Md Jobaar Hossain, Bipro Bhattacharjee	Incomplete
20.07.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Make Slide for MOC Presentation	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Nill
24.07.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Start to fix the mistakes part.	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Improved but still not perfect .
27.07.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Research more to build it perfectly	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Think More
02.08.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Think how to avoid the complexity of this project	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Think more
05.08.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Do some changes in elements	Md Jobaar Hossain, Bipro Bhattacharjee	Improved

09.08.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Start to write the elaborate point of the report	Md Jobaar Hossain,Swapnil Paik	Nil
12.08.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Start the Latex Part	Swapnil Paik	Nil
16.08.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	1.objective, Latex 2.Problem statement ,Requirement, specification, 3d model , using interface 3. design approach , methodology,Matlab work 4. applicable code and conclusion	Task 1: Swapnil Paik Task 2: Sanjida Hoque Otondrila Task 3: Md Jobaar Hossain Task 4 : Bipro Bhattacharjee	Have to overview some points
17.08.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Demonstrate the prototype physically and capture the video	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Did not work properly
19.08.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Fix the problem and again demonstrate the prototype physically and capture the video	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Improved
20.08.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Fix some mistakes	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Organized more
22.08.23	All Members	Overview the prototype	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Nil
23.08.23	All Members	Make the poster for the showcase	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Task Complete
24.08.23	All Members	Done the prototype for the showcase of FYDP C	All	Task Complete

Log-book for FYDP-C (meeting-with-ATC-every-week)

Date/Time/Place	Attendance	Summary of Meeting	Responsible	Comment by ATC
06.06.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Discuss about total project and how to build the prototype	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Think More
13.06.23	Md Jobaar Hossain, Bipro Bhattacharjee	Have to buy elements for the prototype	Md Jobaar Hossain, Bipro Bhattacharjee.	Couldn't finish the task
20.06.23	Md Jobaar Hossain, Swapnil Paik	Do the Mathematical Calculation and have to make the prototype properly	Md Jobaar Hossain for mathematical calculation , All for the prototype	Some corrections have to do
05.07.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	To fix the prototype I have to buy some elements .	Md Jobaar Hossain, Bipro Bhattacharjee.	Have to follow the instruction
11.07.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	1.Latex 2.objective,problem statement, Requirement, specification, 3. design approach , methodology, project plan 4. applicable code and conclusion . 5. Also show the prototype to the ATC	Task 1 and Task 2: Swapnil Paik Task 3: Md Jobaar Hossain Task 4 : Bipro Bhattacharjee Task 5: Md Jobaar Hossain, Bipro Bhattacharjee	Have to overview some points
25.07.23	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Overview the project and show the demonstrated video .	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Nil
08.08.23	All Members	Discuss About the mistakes and try to fix it	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Nil

20.08.23	All Members	Discuss About the mistakes and try to fix it	Md Jobaar Hossain, Bipro Bhattacharjee, Swapnil Paik	Task Complete
22.08.23	All Members	Overview about the whole project and completely show it in front of ATC.	All	Nil

Related code

Code of Smart Monitoring Bin:

```
#include <SoftwareSerial.h>
const String PHONE = "+8801865339845";

//GSM Module RX pin to Arduino 3
//GSM Module TX pin to Arduino 2
#define rxPin 2
#define txPin 3
SoftwareSerial sim800(rxPin,txPin);

//the pin that the pir sensor is attached to
#define trigPin 8
#define echoPin 9

void setup() {
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  Serial.begin(9600);          // initialize serial
```

```
  sim800.begin(9600);
  Serial.println("SIM800L software serial initialize");

  sim800.println("AT");
  delay(1000);
}

void loop(){

while(sim800.available()){
  Serial.println(sim800.readString());
}
while(Serial.available())  {
  sim800.println(Serial.readString());
}
  long time_duration, distance_in_cm;
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  time_duration = pulseIn(echoPin, HIGH);
  distance_in_cm = time_duration / 29 / 2;

  Serial.print(distance_in_cm);
  Serial.println("5 cm");

  //Ranging Distance − 2 cm – 400 cm
```

```
  //if the distance is equal or less than 10 cm
  if (distance_in_cm <= 5) {
    Serial.println("Motion detected!");
    Serial.println("calling....");
    sim800.println("ATD"+PHONE+";");
    delay(20000); //20 sec delay
  }

  delay(500);
}
```

Image Processing:

Importing the libraries

```
import tensorflow as tf
from keras.preprocessing.image import ImageDataGenerator
from keras.layers import BatchNormalization
from sklearn.metrics import classification_report, confusion_matrix

import os

import cv2
from keras.preprocessing import image
import numpy as np
import matplotlib.pyplot as plt


from google.colab import drive
drive.mount('/content/drive')
```

Part 1 - Data Preprocessing

Preprocessing the Training set

```
train_datagen = ImageDataGenerator(rescale = 1./255,
                                   shear_range = 0.2,
                                   zoom_range = 0.2,
                                   horizontal_flip = True)


training_set = train_datagen.flow_from_directory('/content/drive/MyDrive/FYDP/Bottle/train',
                                                 target_size = (64, 64),
                                                 batch_size = 32,
                                                 class_mode = 'binary')
```

Preprocessing the Test set

```
test_data_dir = '/content/drive/MyDrive/FYDP/Bottle/test'

dirs = sorted(os.listdir(test_data_dir))


test_datagen = ImageDataGenerator(rescale=1./255)


test_set = test_datagen.flow_from_directory(test_data_dir,
                                            target_size=(64, 64),
                                            class_mode='binary')

target_names = list(test_set.class_indices.keys())
target_names
```

Part 2 - Building the CNN

Initializing the CNN

```
cnn = tf.keras.models.Sequential()
```

Step 1 - Convolution

```
cnn.add(tf.keras.layers.Conv2D(filters=32,
                               kernel_size=3,
                               activation='relu',
                               input_shape=[64, 64, 3],

bias_regularizer=tf.keras.regularizers.l2(l2=0.0001 )))
cnn.add(BatchNormalization())
cnn.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))



cnn.add(tf.keras.layers.Conv2D(filters=64,
                               kernel_size=3,

bias_regularizer=tf.keras.regularizers.l2(l2=0.0001 )
                               ))
cnn.add(BatchNormalization())

cnn.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))


cnn.add(tf.keras.layers.Conv2D(filters=64,
                               kernel_size=3,
```

```
bias_regularizer=tf.keras.regularizers.l2(l2=0.0001 )))
cnn.add(BatchNormalization())
cnn.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))


cnn.add(tf.keras.layers.Conv2D(filters=128,
                               kernel_size=3,

bias_regularizer=tf.keras.regularizers.l2(l2=0.0001 )))
cnn.add(BatchNormalization())
cnn.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))


cnn.add(tf.keras.layers.Conv2D(filters=256,
                               kernel_size=3,

bias_regularizer=tf.keras.regularizers.l2(l2=0.0001), padding =
                               'same'))
cnn.add(BatchNormalization())
cnn.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))
```

Step 3 - Flattening

```
cnn.add(tf.keras.layers.Flatten())
```

Step 4 - Full Connection

```
cnn.add(tf.keras.layers.Dense(units=256, activation='relu'))
```

Step 5 - Output Layer

```
cnn.add(tf.keras.layers.Dense(units=1, activation='sigmoid'))
```

Part 3 - Training the CNN

```
callbacks = [
tf.keras.callbacks.ReduceLROnPlateau(factor=0.1,
                                     patience=5,
                                     min_lr=0.00001,
                                     verbose=1)]
 Metrics=['accuracy',
          [tf.keras.metrics.AUC(name='auc')],
          [tf.keras.metrics.Recall(name='recall')],
          [tf.keras.metrics.Precision(name='precision')]]
```

<u>Compiling the CNN</u>

```
cnn.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics = Metrics)
```

Training the CNN on the Training set and evaluating it on the Test set

```
r = cnn.fit(x = training_set, validation_data = test_set, epochs = 100, callbacks=callbacks)
 plt.plot(r.history['accuracy'], label='train acc')
plt.plot(r.history['val_accuracy'], label='val acc')
plt.legend()
plt.show()
cnn.evaluate(test_set)
```

<u>Graphical User Interface Drive Link:</u>

https://drive.google.com/drive/folders/1Pu6V3toX4PWT2I6dRdyYWvaer4Tur2Kk?usp=sharing