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Solar Powered Cleaning Boat with Surveillance
(Control Movements)

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Report Submitted to Fulfill the Partial Requirements
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Universiti Kuala Lumpur

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DECLARATION

I declare that this report is my original work and all references have been cited adequately as required by the University.

Date: 23/10/2023

Signature: ……………………………………
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APPROVAL

I have supervised and examined this report and verify that it meets the program and University's requirements for the Diploma in Electrical & Electronics Engineering.

Date: 23/10/2023

Signature: ……………………………………
Supervisor: SUZILAWATI BINTI ABDULLAH SANI
Official Stamp:

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LIST OF ABBREVIATION

MFI	Malaysia France Institute
UniKL	University Kuala Lumpur
ID	Identification
EX	Example
LED	Light Emitting Diode
RF	Radio Frequency
IR	Infrared Frequency
GPS	Global Positioning System
3D	Three Dimensional
BTK	Bandar Tasik Kesuma
Rev	review

ABSTRACT

The Solar Powered Cleaning Boat with Surveillance prototype is a product that aims in preventing the environment from being polluted. It acts as a method to clean floating trash over the surface of the water with an environmentally-friendly approach apart from implementing crime prevention measures in a community. By gaining valuable information from the internet, a Bluetooth-controlled cleaning boat which applies the conveyor system mechanism is its main design. Through this project, it is found that the solar panel can supply the batteries with voltage at a rate of 0.012 V/min under the sunlight. It is also discovered that the product's limit distance in which it can be controlled is a radius of 20m from the controller device and the conveyor belt can carry up to 100g of mass. However, the product is unable to be used for a lengthy amount of time due to the conveyor belt's absorption of water, causing it to stop; thus more trash cannot be collected. We consider the impact of this product has already been made and anticipate its contributions to a cleaner and more sustainable future.

CHAPTER 1: INTRODUCTION

1.1 Overview

Water covers about 71% of earth's surface as written by Water Science School in The United States Geological Survey (USGS) website ("How Much Water is There on Earth?"). As it is one of the essential needs for living beings to survive, cooperation in keeping the environment clean as a society is a must. Unfortunately, due to pollution, the water surface is scattered with various kinds of trash, causing multiple environmental problems. Figure 1.1 shows the example of pollution at one of the rivers in Malaysia.

Figure 1.1: The State of a River in Malaysia

The Solar Powered Cleaning Boat with Surveillance prototype aims in aiding the endeavor to maintain a clean ecosystem. Envisioned as a catalyst for environmental awakening, this product aspires to elevate public consciousness.

1.2 Problem Statement

Based on the overview and background of the project, there are several problems that need to be addressed to completes this project. The problems are:

1) A method in cleaning floating trash over the surface of the water.

2) An environmentally-friendly approach in developing the device.
3) Implementing crime prevention measures in the community.

1.3 Objectives

In the implementation of this project, several objectives need to be achieved. As a group, we collectively agree that this project has three main objectives which are:

1) To design cleaning boat prototype

2) To construct the boat with solar panel

3) To equip the boat with surveillance camera

By the end of this project, The Solar-Powered Cleaning Boat with Surveillance must be equipped with, as its name suggests, at least one solar panel, a camera for surveillance and be able to achieve its main purpose as a cleaning boat.

1.4 Scope of Project

The Solar-Powered Cleaning Boat with Surveillance as a prototype uses conveyor mechanism to collect floating trash and can be remotely-controlled by using an application on mobile devices through Bluetooth with the help of Arduino Uno.

This product uses the energy received from the sun in light rays, an environmentally-friendly source to further emphasize the importance of caring for the ecosystem. By using solar panels, it can convert these energies into electrical current which can then be utilized in the functions required for the boat such as:

1) The motor used for the movements of the boat.
2) The conveyor used to pick up the trash scattered on the water's surface.

In doing so, this product would not waste energy by using cell-powered batteries which often have a lower energy capacity than that of solar panels.

Alongside the utilization of solar panels, the addition of a surveillance camera to the cleaning boat would offer benefits for the community in keeping tabs of any misdeeds conducted. An article written in The Star (Balasegaram, 2019) states that those caught dumping waste illegally can be prosecuted under Section 71(2) of the Solid Waste and Public Cleansing Management Act 2007 that carries a minimum fine of RM10,000 and maximum RM100,000, or a jail term of six months to five years. This is a step in making sure that society will be more mindful of their actions.

1.5 Significance of Project

Environmental pollution has become a dire concern for all of us especially in recent centuries due to industrialization, population growth, and technological advancements. To combat all these changes would be nigh or impossible. Though this project is the first step in keeping the surface of bodies of water clean, this would not be sufficient in reversing the effects of water pollution. Nevertheless, the product will be a huge leap in our attempt to revive what was lost, inducing a sense of realization and responsibility among society.

1.6 Report Organization

The process of turning this idea into reality is described in the following chapters covering design, engineering, implementation, and results. The goal is to foster a shared consciousness for environmental preservation.

The first part of this thesis paper, this chapter, is an introduction to the project, giving the readers a preview on the solar-powered cleaning boat with surveillance. Chapter 2 describes the research done. Chapter 3 explains the methodology for the development of the project prototype which covers the project sketching, designing, developing and evaluation. Chapter 4 discusses the results of the project obtained from the evaluations and Chapter 5 concludes this project.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

There has been a lot of research put in creating the solar-powered cleaning boat with surveillance. This chapter presents discussion on the related and previous works conducted by other researchers and scholars. The chapter is divided into four sections: Section 2.2 showcases the mechanical design based on an existing prototype, Section 2.3 delves into the research dedicated to constructing the control movement and Section 2.4 explains the thought process behind the circuit connecting the batteries to the solar.

2.2 Mechanic Design

As one of the aims of a cleaning boat is to collect floating trash on a body of water, this project needs a mechanism to accomplish the task. A few designs were considered to create a mechanism that will collect the trash from the river. Among these are:

2.2.1 Scoop/Filter Mechanism

In a video,' How to make a SOLAR POOL CLEANING BOAT' posted by Max Imagination (2019); he uses a sifter which acts as a filter to scoop in dead leaves floating on the water surface of the pool (https://www.youtube.com/watch?v=iQhZesZ4ddE).

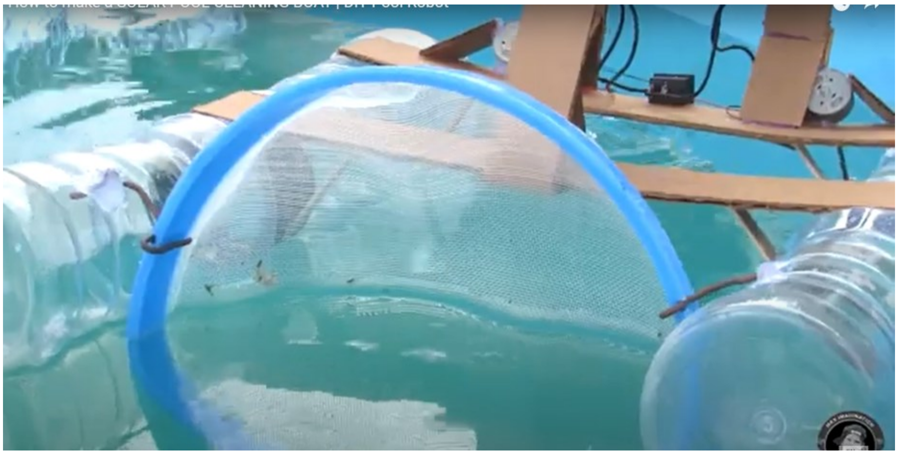


Figure 2.1: Filter Mechanism Design

Figure 2.1 shows a screenshot of a frame in the video in which the cleaning boat uses a sifter as a filter mechanism. It seems to be an effective way in collecting trash by sifting through the water's surface in search of floating, solid particles or impurities. However, it is apparent that this method does not allow large amounts of trash to be collected.

2.2.2 Vacuum Mechanism

A video titled 'DIY POOL SKIMMER' posted by DillysADV on 17 Jun 2017 shows how a vacuum mechanism is used to skim the pool from leaves (https://www.youtube.com/watch?v=YuhbYpdDn7A). Figure 2.2 shows a screenshot of a frame in the video in which the vacuum mechanism is used to collect trash.

Figure 2.2: Vacuum Mechanism Design

This is a much more efficient way of collecting trash compared to the previous scoop or filter mechanism since it could collect more trash. Even so, this vacuum mechanism might not be the best due to its inability to suck larger items such as plastic bottles which are usually found floating on polluted rivers or even large organic matters, for example sticks.

2.2.3 Conveyor Mechanism

The last mechanism that was considered as a method in collecting trash is the conveyor systems. While doing online research, it is apparent that many scholars consider that using conveyor mechanism in collecting floating trash is the best. One video, by CNET(2021), shows the usage of conveyor system in their video titled 'Razer helped design a trash collecting robot to clean up plastic pollution' (https://www.youtube.com/watch?v=2IbgBvtvpeg). Figure 2.3 shows a screenshot of a frame in the video by CNET demonstrating how the trash is collected by using a conveyor belt.

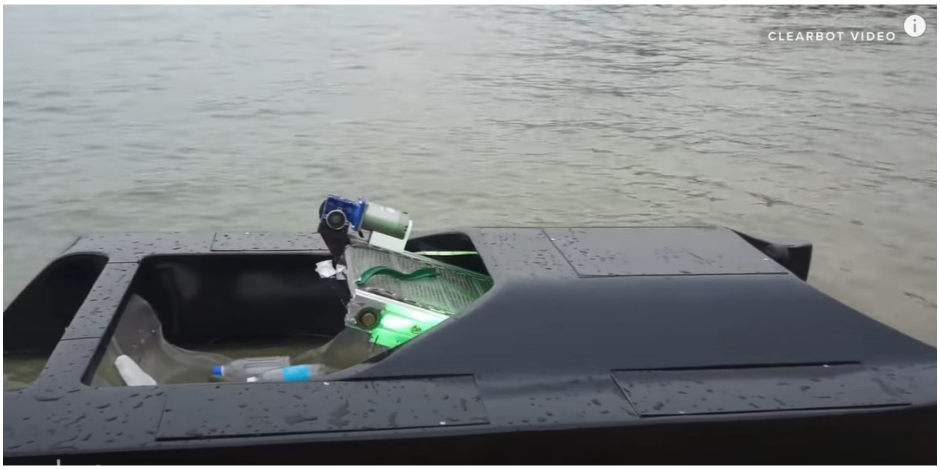


Figure 2.3: Conveyor Mechanism Design

Ultimately, the conveyor mechanism is chosen as this project's mechanical design in trash collection. Not only is it able to collect large amounts of trash, it is also able to collect larger-sized floating trash.

2.3 Control Movement

The solar-powered cleaning boat with surveillance which aims to be accessible to all people needs a solution for it to be remotely controlled for ease of use. It has been decided that this project would use Arduino Uno as its main microcontroller platform. This section will be divided into three parts; 2.2.1 which discusses Arduino Uno, 2.2.2 explains the types of controllers that can be used to control movements, 2.2.3 introduces the application used on device to control the product and 2.2.4 describes the motor driver shield L293D.

2.3.1 Arduino Uno

Arduino Uno exemplifies a microcontroller-based system, bridging human-readable code with tangible electronic outcomes. It serves as the brain of countless projects through languages like C/C++, ranging from simple tasks like illuminating LEDs to orchestrating intricate robotics and decision algorithms. This microcontroller embodies a realm where creativity meets functionality, as it facilitates the conversion of algorithmic instructions into physical manifestations.

One of the key attributes of Arduino Uno is its exceptional versatility. Through its rich array of input/output pins, this microcontroller can seamlessly interface with an extensive spectrum of components. Whether it involves connecting analog or digital sensors, commanding actuators, driving displays, or establishing communication with various modules, the Arduino Uno offers a seamless bridge between software and hardware.

In the context of this project, the Arduino Uno assumes a pivotal role in orchestrating the control that propels the product. As the project seeks to interweave environmental stewardship with technology, the Arduino Uno emerges as the conduit through which the intentions of its controllers are transformed into precise commands for the motor drivers.

2.3.2 Types of controllers

There are two types of controllers that were considered to act as the control movements inputs which are:

1. Transmitter-Receiver

   When appraising the controllers that this product may utilize, the transmitter-receiver controller seems to be an obvious choice.

Its key features are exactly what is needed for the control movements.

When prompted with “What is the features of a transmitter-receiver controller?”, the ChatGPT (OpenAI, 2023) generated the following texts:

The key features of this type of controller are as such:

- **RF or IR Communication**: Traditional transmitter-receiver controllers use either radio frequency (RF) or infrared (IR) technology for communication. RF controllers offer greater range and do not require line-of-sight, while IR controllers need direct line-of-sight.
- **Dedicated Hardware**: It often comes as a dedicated hardware device with physical buttons, switches, or joysticks for control. The controller unit may require batteries or power.
- **Range**: RF transmitter-receiver controllers can offer extended range, sometimes reaching several kilometres. IR controllers, on the other hand, are limited to shorter distances and require line-of-sight.
- **Cost**: They can vary in cost, with more advanced controllers often being more expensive due to specialized features.
- **Specific Applications**: Transmitter-receiver controllers are commonly used in applications like remote-controlled cars, drones, industrial machinery, and hobbyist projects.
- **External Antennas**: Some RF transmitter-receiver controllers may have external antennas to extend their range and improve signal strength.

It is important to note that these features are only plausible with the assistance of modules. Modules are the main components of a controller which allows communication between the controller and its device.

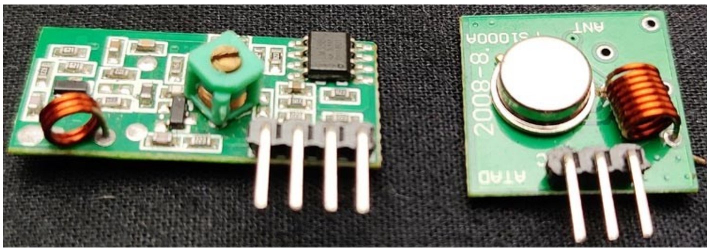


Figure 2.4: Receiver and Transmitter Modules

The transmitter-receiver controller operates with the receiver and transmitter modules. Figure 2.4 shows the receiver module on the left and the transmitter modules on the right. With these modules, an input from the transmitter could be sent to the receiver. The receiver would then send instructions to the motor driver and operates when the product receives the signal to move accordingly.

2. Bluetooth

   The Bluetooth controller, compared to the transmitter-receiver controller, is considered more advanced in multiple ways. That is the consideration for it to be considered as the product's movements controls.

   When prompted with "What is the features of a Bluetooth controller?", the ChatGPT (OpenAI, 2023) generated the following texts:

   The characteristics of a Bluetooth controllers are:

   - **Wireless Connectivity**: Bluetooth controllers use wireless technology to communicate with the controlled device (EX a robot or boat). They operate in the 2.4 GHz ISM (Industrial, Scientific, and Medical) band.
   - **Compatibility**: Bluetooth controllers are often compatible with a wide range of devices, including smartphones,

tablets, and computers, which typically have built-in Bluetooth capabilities.

- **Range**: Bluetooth controllers typically offer a range of up to 100 meters, depending on the class of Bluetooth and environmental factors.
- **Bi-Directional Communication**: They often support two-way communication, enabling not only control commands to be sent but also feedback and data to be received from the controlled device.
- **Ease of Use**: Bluetooth controllers are known for their ease of use due to the familiarity of smartphone and tablet interfaces. They do not require specialized training to operate.
- **Cost**: They can be cost-effective, especially if users already own Bluetooth-enabled devices like smartphones or tablets.
- **Integration**: Bluetooth controllers can easily integrate with other smart technologies, sensors, and apps, expanding their functionality beyond basic control.

To create a Bluetooth controller, similar to the receiver and transmitter controller, it needs a module which could enable wireless communication between the controller and the product. There are two types of Bluetooth modules which are HC-05 and HC-06. Both module types are shown in Figure 2.5 and 2.6.

Figure 2.5: Bluetooth Module HC-05

Figure 2.6: Bluetooth Module HC-06

While both modules' functions are primarily the same, each has its own special features and advantages. One of the more apparent differences in features is the configuration for each module. The HC-06 module usually comes with a fixed baud rate, and its configuration options are more limited compared to the HC-05 module where it is more versatile. Due to its simpler setup and limited features, the HC-06 is often used in projects where one device needs to communicate with another device over a wireless serial connection. Thus, using the HC-06 is advantageous for the project.

After comparing both types of controllers, the Bluetooth type was chosen as the control movement's controller. Choosing a Bluetooth controller over a traditional transmitter-receiver controller system for the project involving a Solar Powered Cleaning Boat with Surveillance prototype can offer several advantages. These are the advantages listed by ChatGPT (OpenAI, 2023):

1. **Wireless Range**: Bluetooth controllers typically provide a substantial wireless range, which can be advantageous for controlling a boat over a wider area, especially in applications like cleaning or surveillance in larger bodies of water.

Traditional transmitter-receiver systems may have limited range depending on their frequency and power.

2. **Ease of Use**: Bluetooth controllers often come in the form of readily available devices such as smartphones or tablets. This means we can use familiar and user-friendly interfaces to control the boat, reducing the learning curve for operators.
3. **Reduced Hardware Complexity**: Bluetooth controllers eliminate the need for additional transmitter and receiver modules, antennas, and associated circuitry. This reduces the overall complexity of the boat's control system, making it more compact and potentially more reliable.
4. **Remote Monitoring**: Bluetooth controllers can often provide two-way communication, allowing us not only to send commands to the boat but also to receive data and feedback from onboard sensors or cameras. This is particularly useful for surveillance applications, where real-time data is crucial.
5. **Cost-Efficiency**: Bluetooth technology is widely available and cost-effective. Most smartphones and tablets already come equipped with Bluetooth capabilities, eliminating the need to invest in additional hardware for control.
6. **User-Friendly Interface**: Bluetooth controllers can leverage the touchscreens and graphical interfaces of smartphones and tablets, offering a more intuitive and visually appealing way to control the boat. Traditional transmitter-receiver controllers often rely on physical buttons or joysticks, which can be less user-friendly.
7. **Software Flexibility**: Bluetooth controllers can take advantage of smartphone apps and software, allowing us to easily customize the control interface to suit our specific project needs. This level of flexibility may be harder to achieve with traditional controllers.

8. **Integration with Other Smart Technologies**: Bluetooth controllers can easily integrate with other smart technologies and sensors. For example, you can incorporate GPS, environmental sensors, or even autonomous navigation algorithms into the boat and control them seamlessly through a Bluetooth-enabled device.
9. **Accessibility**: Bluetooth controllers are more accessible to a wider range of users because they do not require specialized training or equipment. This can be important if the project aims to involve a diverse group of operators or if it is intended for public use.

In summary, choosing a Bluetooth controller for our project can provide advantages in terms of range, user-friendliness, reduced hardware complexity, remote monitoring capabilities, and cost-efficiency.

2.3.3 Applications on Device for Bluetooth

The boat, as mentioned in Section 2.3.1, needs one device to communicate with it over a wireless serial connection to allow the input commands to be transmitted. The boat can connect with any mobile devices through Bluetooth with the help of module HC-06. The application Bluetooth RC Controller aids in sending these commands. The interface of the application is designed such that it looks like a toy controller for entertainment purposes. Figure 2.7 shows the application icon while Figure 2.8 shows the interface of the application.

Figure 2.7: Bluetooth RC Controller App Icon.

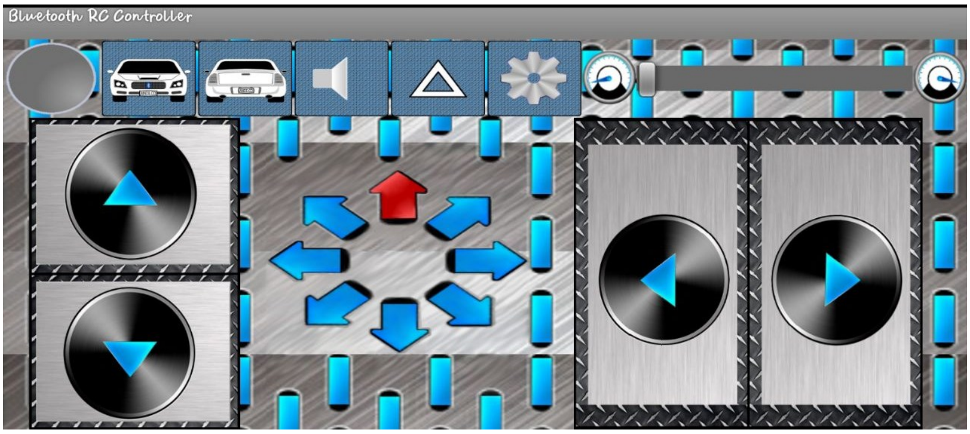


Figure 2.8: Interface of Application.

2.3.4 L293D Motor Driver Shield

The L293D is a commonly used motor driver integrated circuit that can control the direction and speed of DC motors. A motor driver shield is an add-on board that simplifies the process of interfacing the L293D motor driver with a microcontroller or other control circuitry.

For this project, this motor driver shield is used in the boat movement's circuit to control the movement of motors. It provides connectors easy attachment of motors and power sources, as well as pins for controlling motor direction and speed as shown in Figure 2.9.

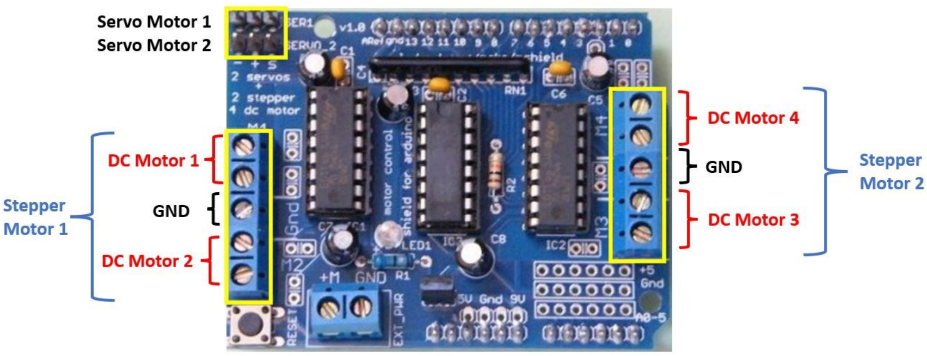


Figure 2.9: L293D Motor Driver Shield

All the components used in the control movements' circuit were primarily selected after thorough research on multiple websites on the internet. While some options may not be optimal for the product, either due to power inefficiency or limited connectivity potentially impeding advanced functionalities, the main consideration for their selection was the cost and time-saving benefits.

One notable choice was the utilization of the L293D motor driver shield due to its convenient usage, effectively eliminating the need for multiple other components to achieve similar functionality. The circuit design for controlling the product's movement was inspired by a video created by DIY Builder (2019), showcasing a similar project on YouTube titled 'How to Make A Simple DIY Arduino Bluetooth Controlled Car At Home' (https://youtu.be/Q36NbjPMV5k). The L293D driver shield also serves as an extension for the Arduino Uno R3 board, simplifying the required coding to control the product. The coding for this project is a revised version of the one shared in the video (See Appendix B for Coding). The same application used in the video was also applied in this project.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter demonstrates the process of constructing the product from sketching, designing, developing, testing and evaluation. Figure 3.1 shows the methodology flowchart for this experiment. (See Appendix A for project's Gantt Chart.)

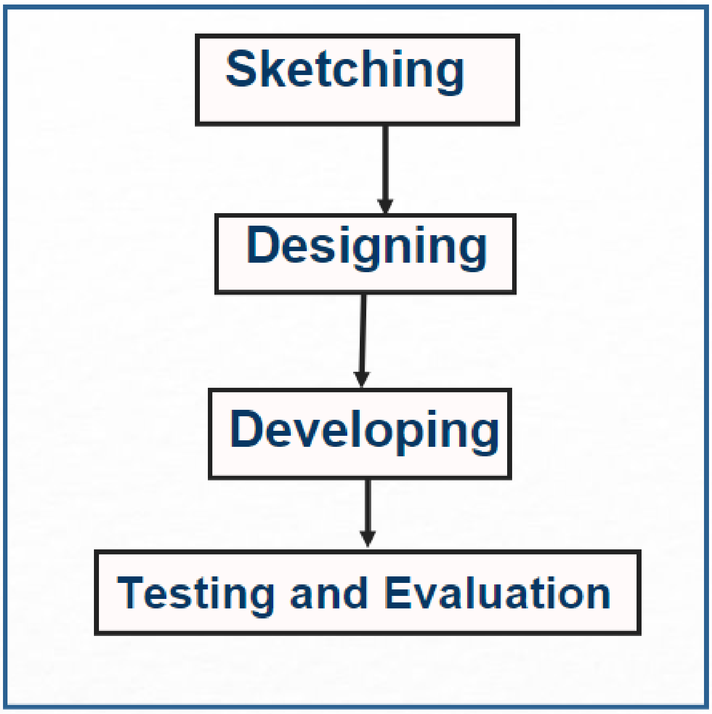


Figure 31: Project Flowchart

As such, Sections 3.1 to 3.4 will further clarify the methods according to the flowchart respectively.

3.2 Project Sketching

Initially, before proceeding with construction of the boat, an early design needed to be sketched out. This sketch served as a baseline. After ample consideration, through multiple online research (refer Chapter 2), a design had been conceptualized.

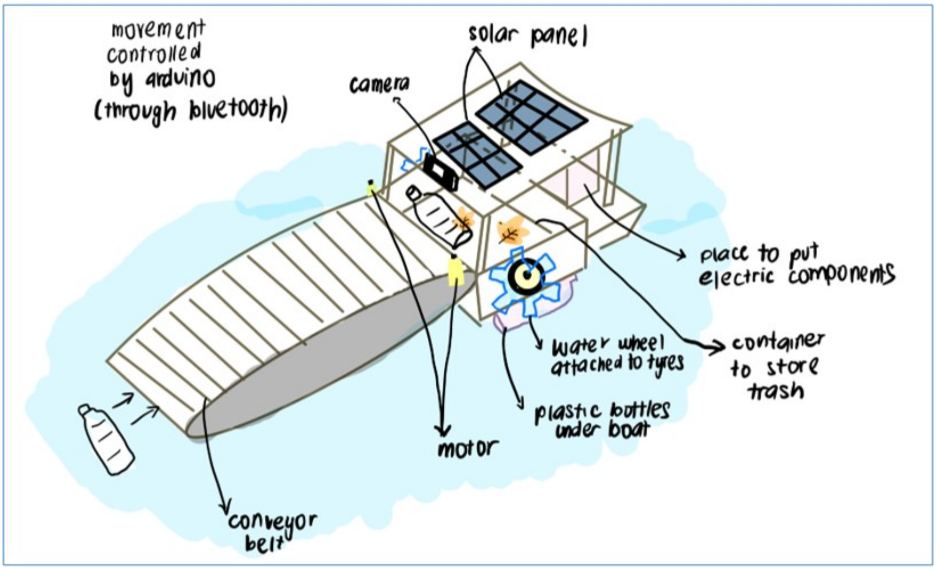


Figure 3.2: Rough Sketch of the Product's Body Design

In addition to the design of the product's main body, the wiring circuit sketches needed to be drawn as well. There are two circuit designs which are control movements' wiring circuit and the conveyor's wiring circuit. Figure 3.3 shows a sketch of the wiring circuit of the boat's control movements using Arduino Uno while Figure 3.4 shows a sketch of the wiring circuit for the conveyor's movement. (See Appendix C for the circuit's block diagrams.)

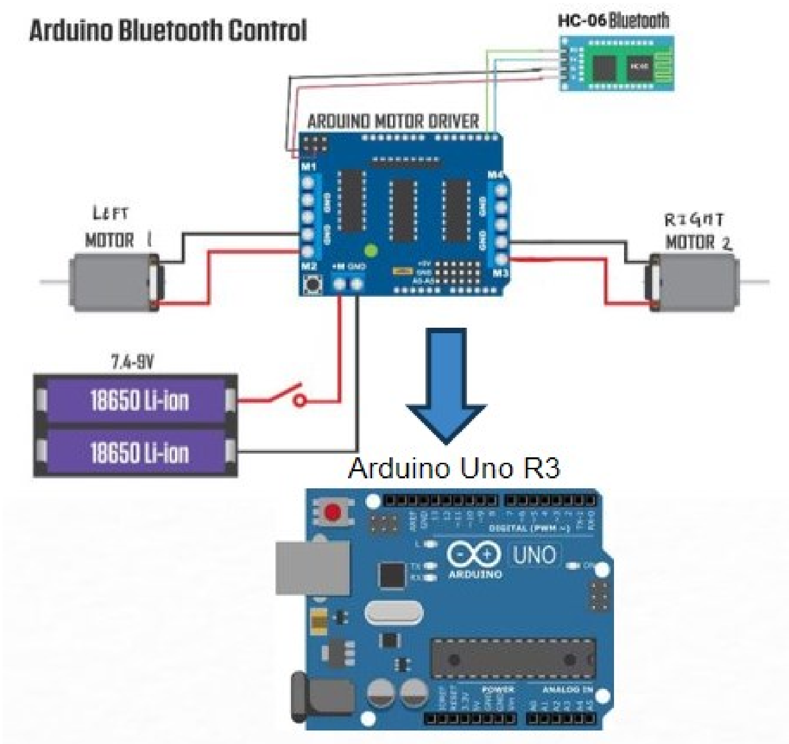


Figure 3.3: Control Movements' Wiring Circuit

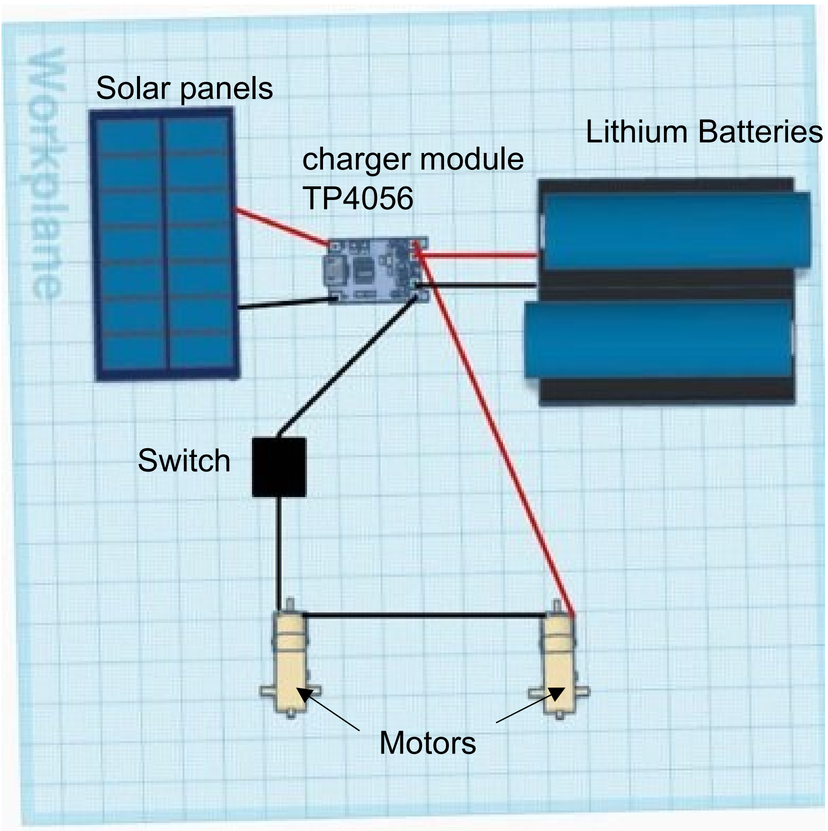


Figure 3.4: Conveyor’s Wiring Circuit

3.3 Project Designing

After a general idea of the product’s structure had been developed through the sketch shown in Section 3.1, a 3D replica of product’s body was drawn through AutoCAD program software.

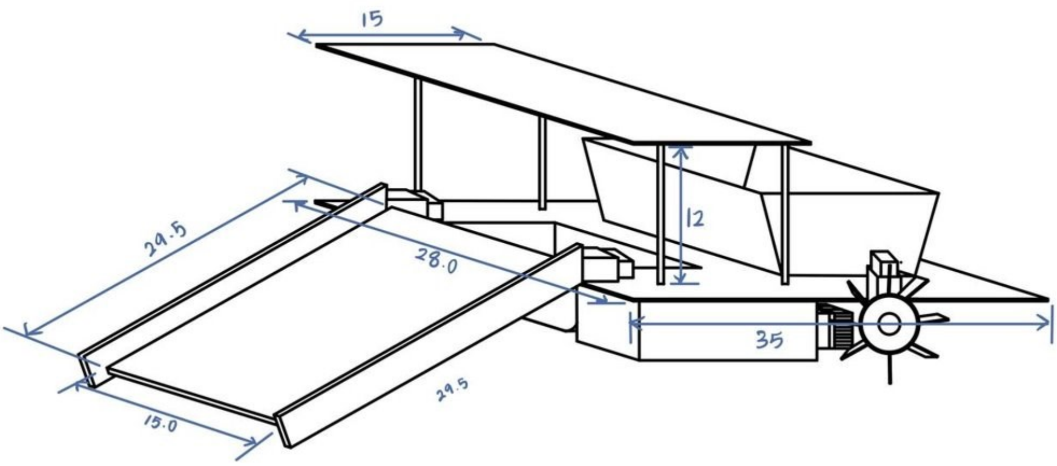
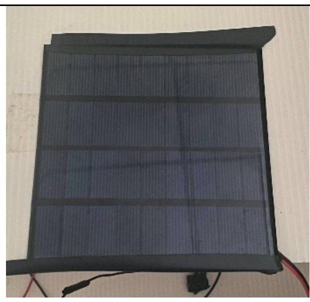


Figure 3.5: 3D Drawing of Product’s Body

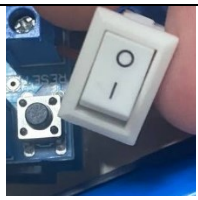
3.4 Materials and Apparatuses

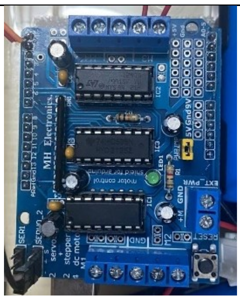
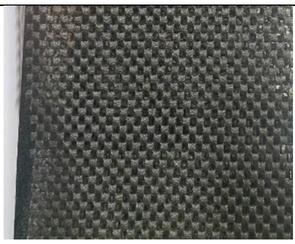
Table 3.1 lists all the materials and apparatuses used in the creation of this project according to the design. Each item's details, pictures and prices are also listed in the table. A total of 26 items were used for this project.

Table 3.1: List of Materials and Apparatuses Used

No	Item Name	Details	Picture	Price
1	Solar panel	1 unit – 9V 2W 222mA		RM22.50
2	Battery holder	2 units – 2x18650 Holder		RM5.00
3	Li-Ion battery 18650	4 units – 3.7V 4200mAH		RM11.13
4	Plastic corrugated board	2 units – 1mx1m		RM8.00

5	Plastic container	2 units		RM0.00
6	Plastic bottles	3 units		RM 0.00
7	Dual shaft DC motor	2 units		RM5.80
8	Dual shaft DC motor + wheel set	2 units		RM7.80
9	Hot glue gun with glue gun stick	1 unit		RM10.00
10	Soldering set	1 unit		RM34.90
11	Mini camera	1 unit		RM19.98

12	Basin	1 unit		RM0.00
13	Wires	10 units – 15 cm 20 units – 20 cm		RM3.40 RM8.40
14	2-Pin Mini boat switch	2 units		RM3.80
15	Battery charger TP4056	1 unit		RM1.69
16	Bamboo stick	7 sticks		RM0.00
17	Plastic paddle wheel	2 units – 10 cm		RM6.00
18	Solder lead metal wire	1 unit – 50g		RM8.90

19	Multimeter	1 unit		RM0.00
20	Arduino Uno DIP UNO R3	1 unit		RM39.90
21	DC Motor Driver Controller Shield L293D	1 unit		RM14.90
22	HC 06 Wireless RF Data Transfer Bluetooth Serial Port TX RX Module	1 unit		RM13.90
23	PVC Board	1 unit		Rm8.00
24	Dashboard Mat (Non-slip cushion mat)	1 unit		Rm2.00

25	Diode 1N4007	2 units		RM0.40
26	Female to male jumper wire	4 units		RM0.37
			Total:	RM236.77

Note: The items used with no price values were either recycled or borrowed from other sources.

3.5 Project Developing

The acquisition of these materials and apparatus took roughly around a week. As soon as the materials were gathered, the development of the product took progress. First, the product's main body was constructed by connecting a cut-up piece of plastic corrugated board, a plastic container, plastic bottles, and shortened bamboo sticks using hot glue gun according to the design created. Figure 3.6 shows a picture taken when constructing the body of product.

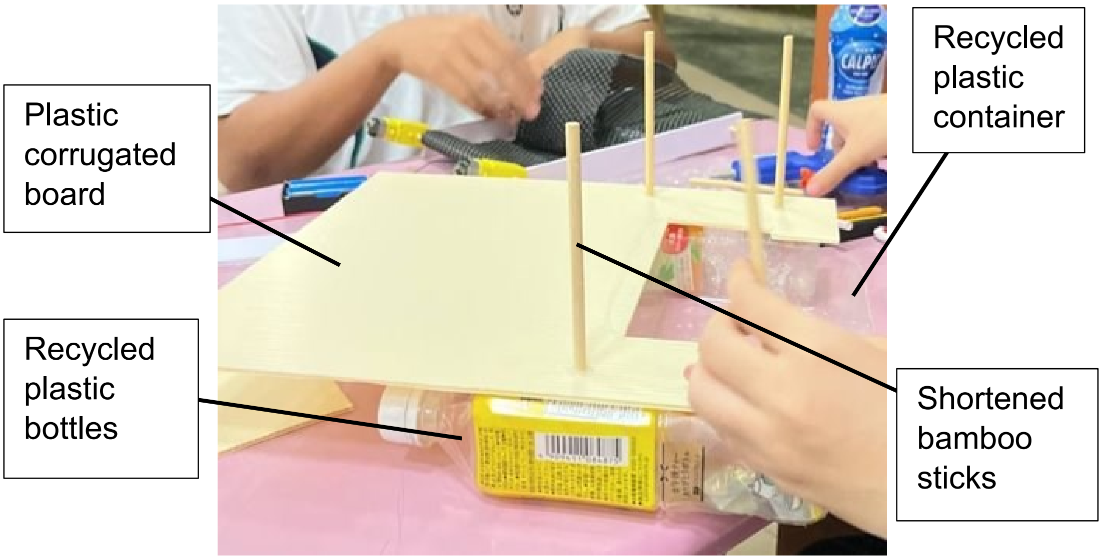


Figure 3-6: Process of Constructing the Body of Product

The development of the conveyor and circuits proceeded after the body had been fully constructed. As stated in Section 3.1, there were two circuits to be constructed: conveyor's wiring circuit and control movements' wiring circuit. Figures 3.7, 3.8 and 3.9 show the pictures taken during the process respectively.

Figure 3.7: Process of Constructing the Conveyor

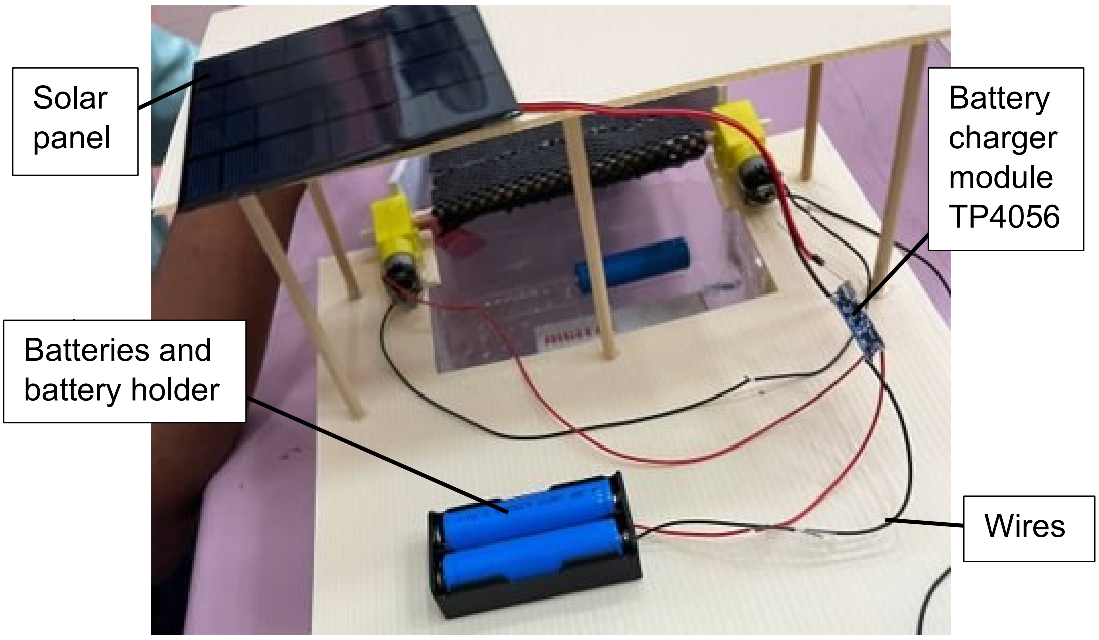


Figure 3.8: Process of Constructing the Conveyor's Circuit

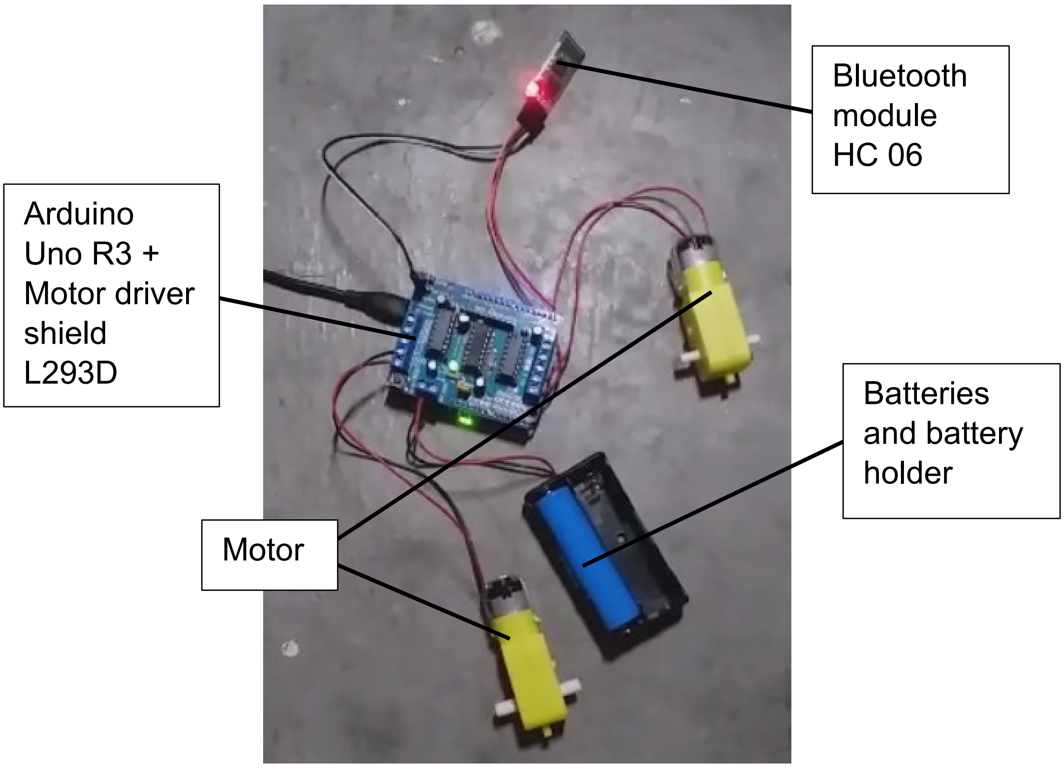


Figure 3.9: Process of Constructing the Control Movements Circuit

The full product’s assembly; the main body with the conveyor and both circuits. Figure 3.9 shows the picture of the product during the assembling process.

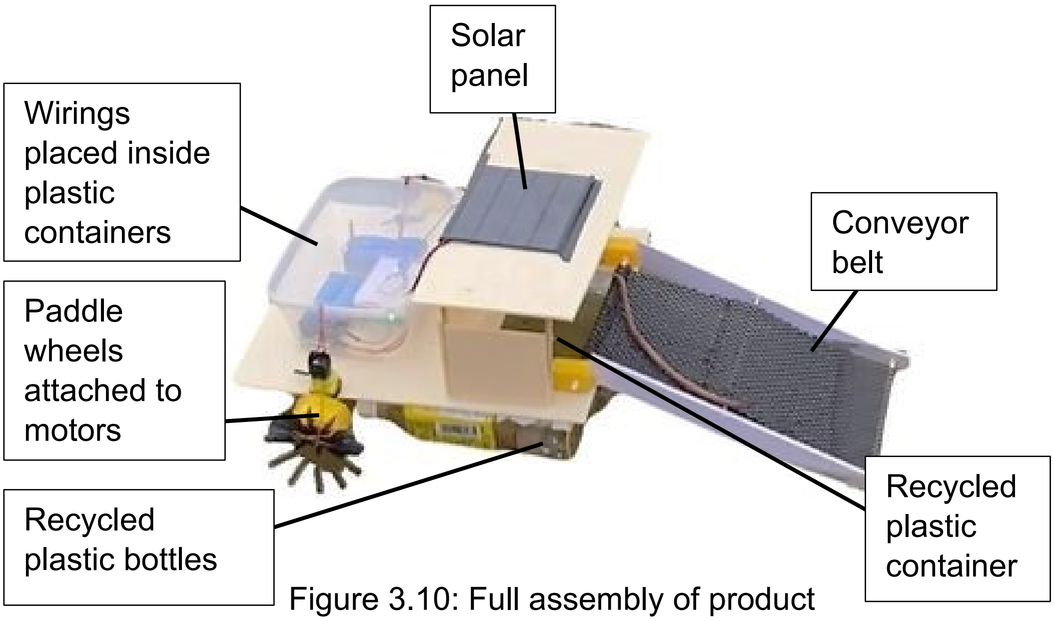


Figure 3.10: Full assembly of product

3.6 Testing and Evaluation

For this project, there were three experiments conducted in achieving a hypothesis for discussion. The first test was to check the solar panel’s efficiency in charging batteries. The second test was to observe the measures taken to assess the conveyor’s potential. Lastly, the third test describes the trial run done in various places.

3.6.1 Solar Panel Charge Test

The solar panel was installed with the intention to charge batteries of the device. Voltage changes of the rechargeable batteries can be an indication whether the batteries were charging. After fully connecting the solar panel to the batteries and conveyors, the initial voltage was read by using a digital multimeter. The reading was then recorded.

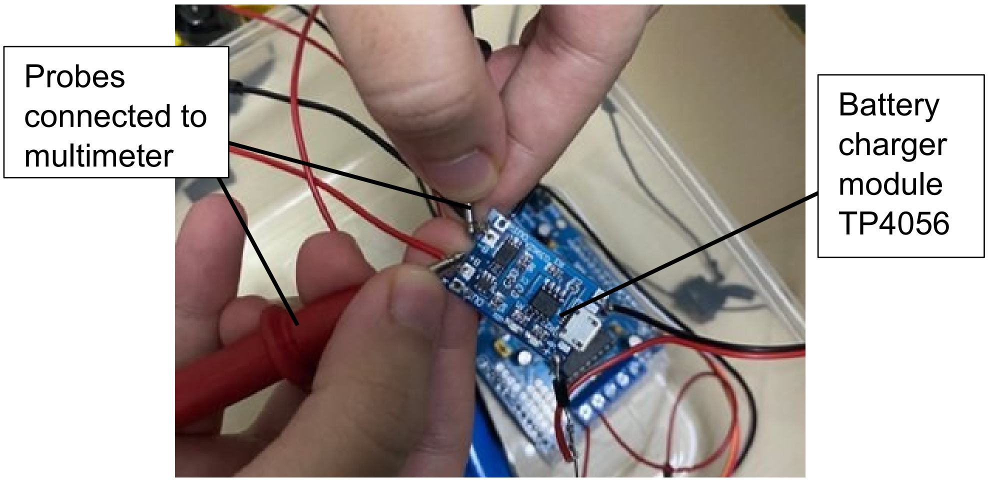


Figure 3.11: Measuring the Initial Value of Voltage

The product was then brought to a place with plenty of sunlight. When the solar panel is charging the batteries, the LED on the charger module connected to it will light up. As shown in Figure 3.11, the solar panel was charging the batteries.

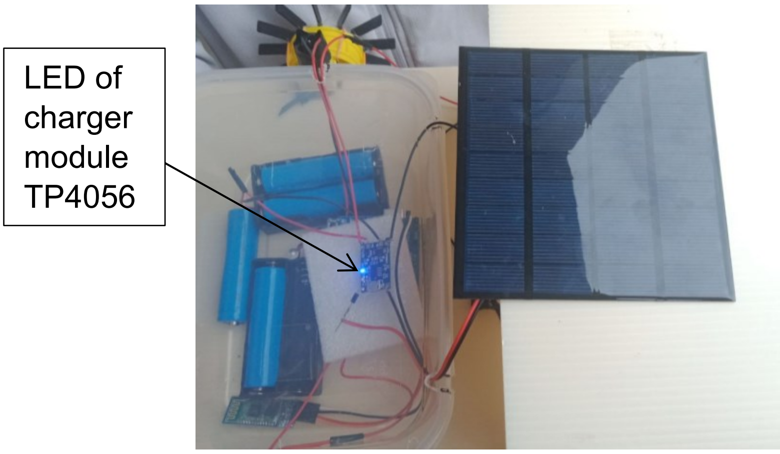


Figure 3.12: Charging Module LED Lighting Up

The product was then left under the sunlight for a minute before measuring its voltage value for the second time using a multimeter.

Figure 3.13: Second Voltage Reading

3.6.2 Conveyor's Capability Test

As the product is a cleaning boat, its primary function is to collect trash depending on how much mass it can handle. Trash from masses 20g, 40g, 60g, 80g and 100g were measured using a weighing scale and set aside. Since this project acts as only a prototype, only a maximum of 100g were measured. The capability of the conveyor belt in carrying these trash into the container were recorded for each mass respectively.

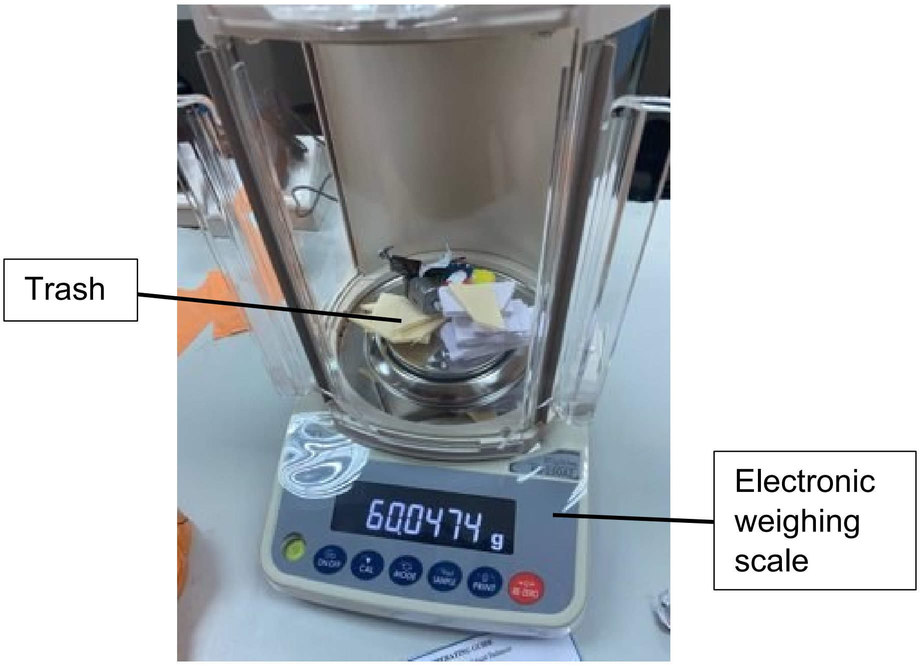


Figure 3.14: 60g Weight of Trash

3.6.3 Test Run

The test for functionality of the conveyor and movement of the boat on a body of water occurred in three places which are the sink, basin, and lake (located in BTK). Figure 3.15 shows a picture of the product collecting the weighed-out trash (refer Chapter 3.5.2) at the lake.

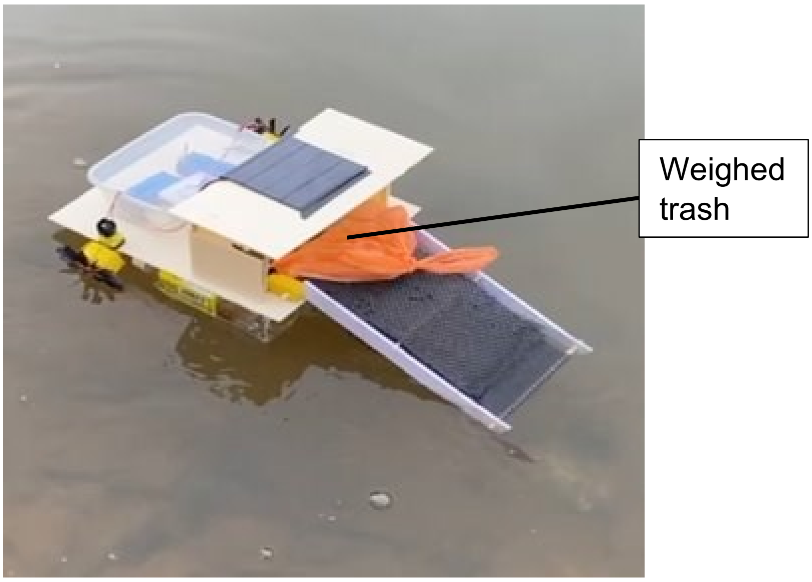


Figure 3-15: Product Test Run at Lake BTK

The condition of the product was constantly monitored throughout the test.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

This chapter is divided into three sections. Section 4.2 displays the final product. Section 4.3 presents the results obtained from the project and Section 4.4 discusses the findings and problems faced throughout the project.

4.2 The Final Product

Figures 4.1, 4.2, 4.3 and 4.4 are the top, front, back and side views of the product respectively.

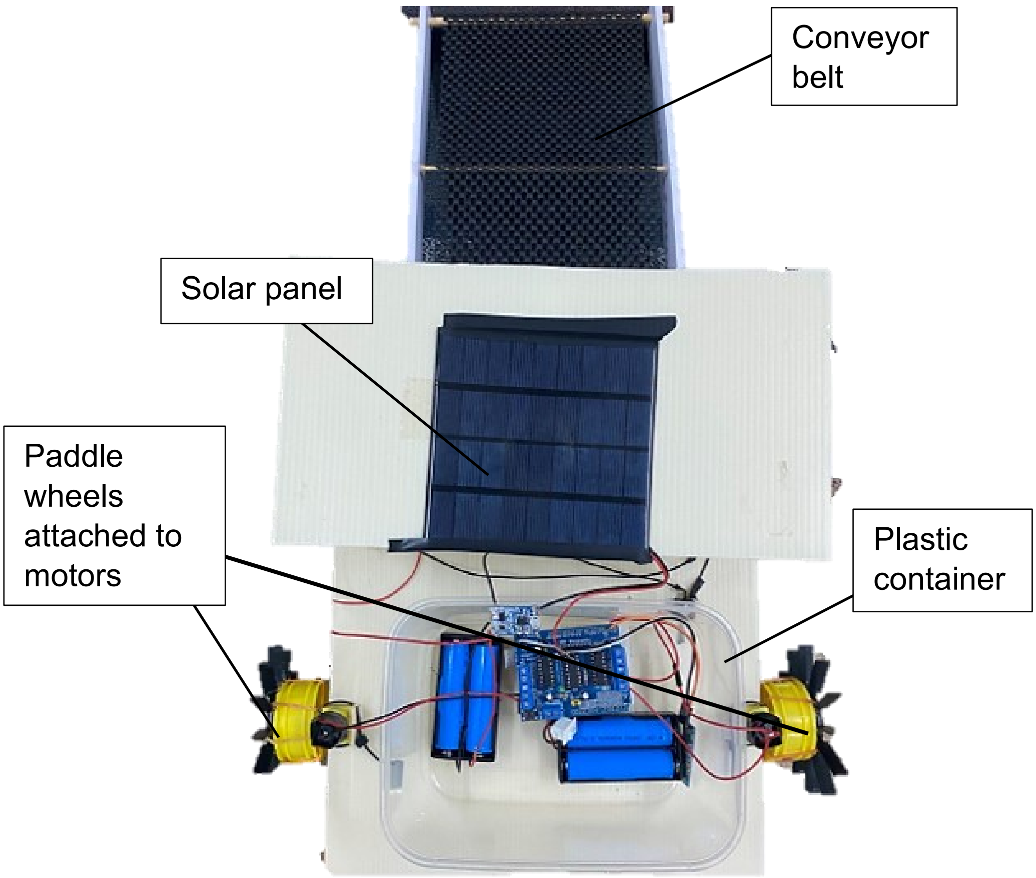


Figure 4.1: The Top View of the Product

The plastic container is used as a compartment for the boat’s wiring circuits.

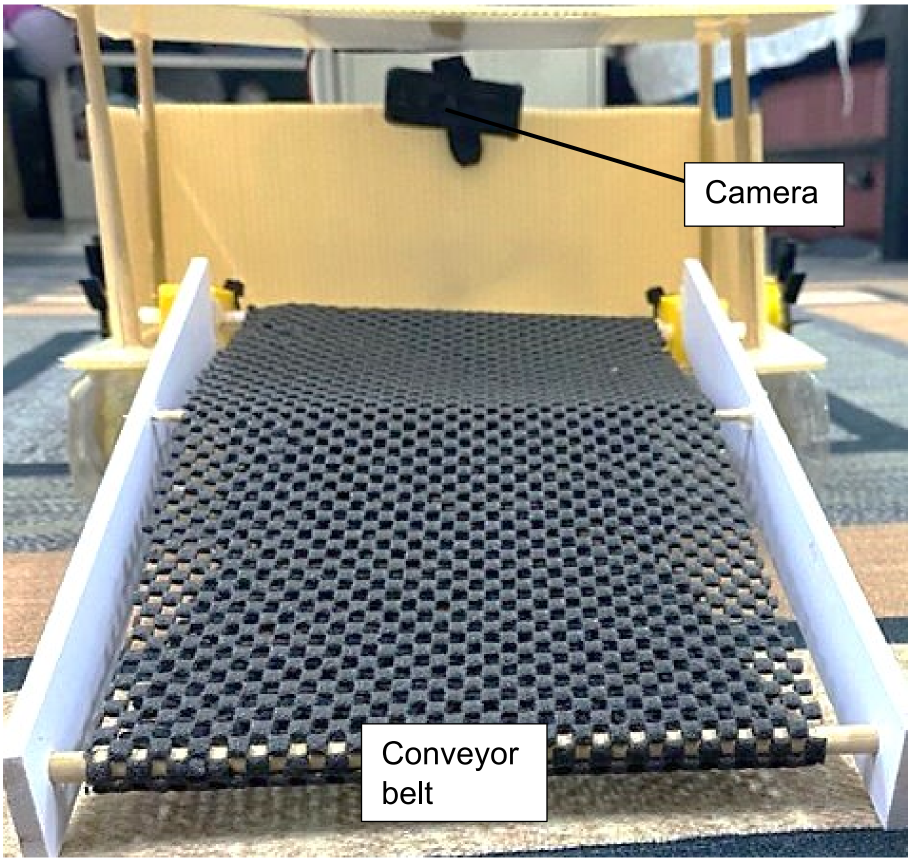


Figure 4.2: The Front View of the Product

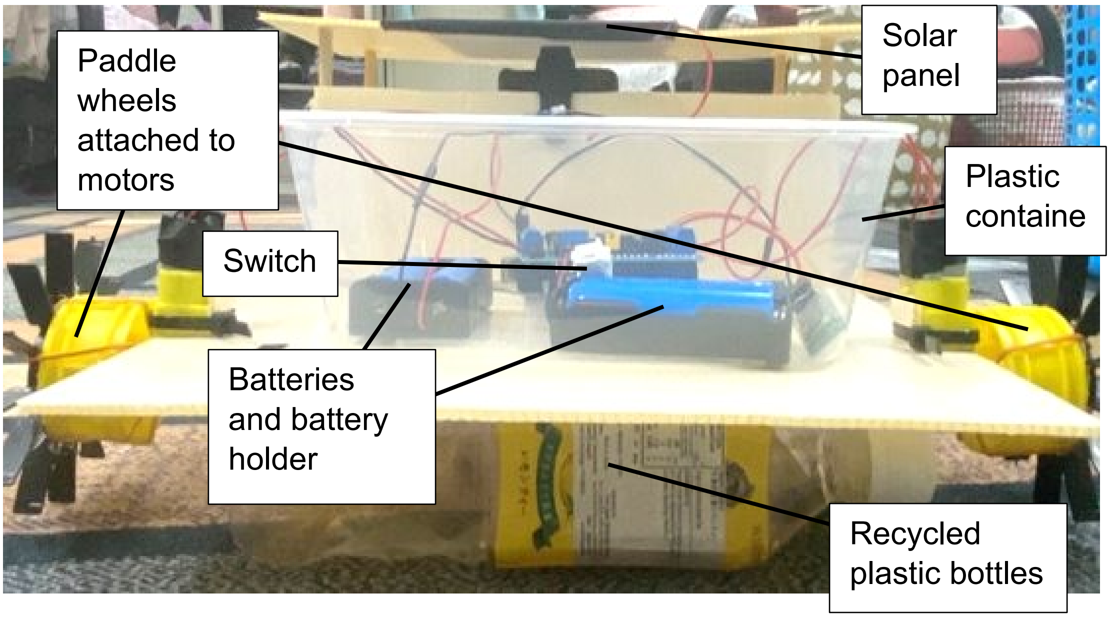


Figure 4.3: The Back View of the Product

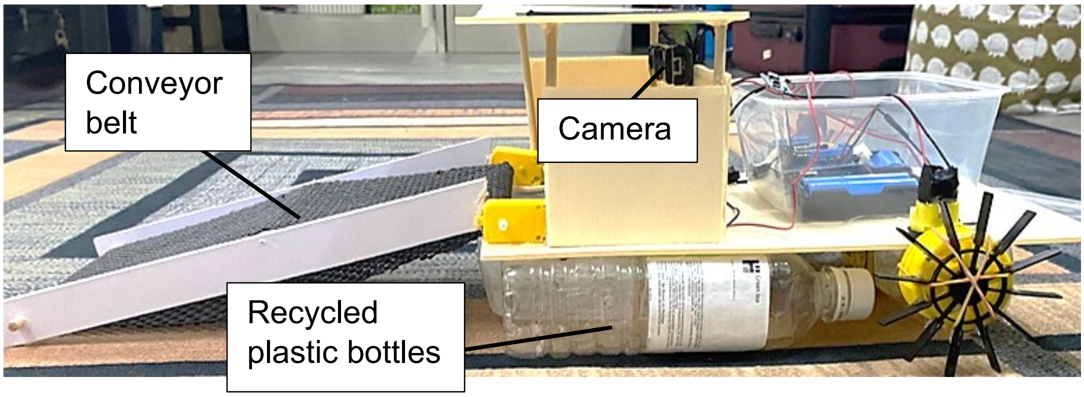


Figure 4.4: The Side View of the Product

4.3 Results

There are four results obtained from the test conducted (refer Section 3.5). These include the charging time for the battery of solar panel, Bluetooth connectivity test, conveyor's condition in water over time and the conveyor's capability to collect trash.

4.3.1 Charging Time for Battery from Solar Panel

The table shows the voltage readings of the batteries recorded before and after placed under the sunlight for 10 minutes. This is the result obtained from the test done in Section 3.5.1.

Table 4.1: Voltage Reading of Batteries

Time (min)	**Voltage (V)**
0	3.072
10	3.190

Table 4.1 has two columns: times which are recorded in minutes and voltage readings recorded. It has two rows: the 0^{th} minute with a voltage reading of 3.072 and the 10^{th} minute with a voltage reading of 3.190.

4.3.2 Bluetooth Connectivity Test

The distance in which the product responds to the controller device through Bluetooth connection was investigated. At a fixed point in which the product is stationed, the connectivity is observed at each 2 meter-intervals until it becomes disconnected. This is shown in Table 4.2.

Table 4.2: Bluetooth Connectivity over Distance

Distance (m)	Bluetooth Connectivity
2	Connected
4	Connected
6	Connected
8	Connected
10	Connected
12	Connected
14	Connected
16	Connected
18	Connected
20	Connected
22	Disconnected

Table 4.2 has two columns: distance in meter and the connectivity of Bluetooth. It has 11 rows; each row is in the multiple of 2 and it stops at 22 meters when the Bluetooth was disconnected completely from the control device.

4.3.3 Conveyor's Capability to Collect Trash

This is the results from the test done which had already been mentioned in Section 3.5.2

Table 4.3: Conveyor's Capability for Different Masses

Mass(g)	Capability
20	Excellent
40	Good
60	Good
80	Good
100	Moderate

Table 4.3 has two columns: mass in grams and capability of the conveyor observed. It has 10 rows; generally, the capability of the conveyor did not change drastically for each mass.

4.3.4 Conveyor’s Condition in Water over Time

This is the data collected through observation from the trial run performed mentioned in Section 3.5.3.

Table 4.4: Conveyor’s Condition over Time

Time(min)	Condition
5	Excellent
10	Excellent
15	Good
20	Significant Drop
25	Stopped

Table 4.4 has two columns: times in minutes and condition of conveyor observed. It has 5 rows; the conveyor’s condition was excellent for the first 10 minutes before deteriorating and worsening at the 20th minute before it completely stopped at the 25th minute.

4.4 Discussion

In this section, we delve into the key findings derived from the experiment and an analysis of the Solar Powered Cleaning Boat with Surveillance prototype. These findings shed light on the operational parameters and limitations of the product, paving the way for a deeper understanding of its capabilities.

4.4.1 Solar Panel Performance

The solar panel showcased a commendable performance, providing a consistent voltage of 0.118V over a span of 10 minutes.

By using the formula,

$$\frac{\Delta y}{\Delta x}$$

where Δy is the difference in voltage and Δx is the difference in time.

This translates to a charging rate of 0.012 V/min. This charging rate is pivotal in maintaining the operational capabilities of the boat, as it directly influences the power supply to the onboard batteries. While this rate demonstrates the solar panel's ability to harness solar energy effectively, further optimization could potentially enhance the boat's runtime and efficiency.

4.4.2 Remote Control Limitation

The effective operational radius of the prototype was determined to be approximately 20 meters from the controller device. This could be shown using a circle as such:

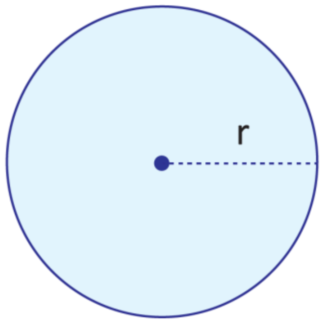


Figure 4.4: Circle with Radius r.

By using the formula for the area of a circle, A,

$$A = \pi r^2$$

where r is the radius and π is a constant with a value of approximately 3.14.

Within this radius, the product remains under remote control, thereby defining an operational area of approximately 1256.63 square meters with the controller device as its central reference point. This limitation in control distance impacts the navigational range of the boat, dictating its ability to traverse and cover water surfaces efficiently. It is worth considering how this constraint aligns with the intended applications and whether extending this radius could enhance operational capabilities.

4.4.3 Capacity for Mass Transportation

The prototype demonstrated its ability to transport mass efficiently with the conveyor belt capable of carrying up to 100 grams of weight. This attribute enhances the boat's efficiency by allowing it to collect and transport various forms of debris and pollutants from water surface. Furthermore, the potential for the conveyor belt to manage even larger masses opens doors for broader applications and enhances efficacy in environmental cleaning endeavors.

4.4.4 Conveyor Belt Durability and Mass Handling

An intriguing insight emerged from the experiments which is the conveyor belt's interaction with water. It was observed that the conveyor belt's prolonged exposure to water led to a change in its mass due to water absorption. Consequently, this affected the conveyor's functionality, potentially leading to its cessation. This finding underscores the importance of addressing the material composition and design of the conveyor belt to ensure its durability and sustained performance especially in aquatic environments.

In conclusion, the findings presented in this discussion offer valuable insights into the Solar Powered Cleaning Boat with Surveillance prototype's performance and limitations. While the solar panel exhibits promising charging capabilities, the remote-control radius, conveyor belt durability, and mass transportation capacity are all present areas for consideration and potential improvement. These revelations contribute to a more comprehensive understanding of the prototype's current capabilities and provide a solid foundation for future enhancements, positioning the product as a contender in addressing environmental challenges and promoting sustainable aquatic ecosystems.

CHAPTER 5: CONCLUSION

5.1 Introduction

In this concluding chapter, we examine the successful outcomes and promising potential of the Solar Powered Cleaning Boat with Surveillance project. The project has achieved its core objectives, creating a prototype cleaning boat that can be operated remotely by integrating solar panels for sustainable power, and enhancing its capabilities with a surveillance camera. This chapter not only summarizes the project's accomplishments but also explores the broader implications and prospects of this innovative solution.

5.2 Implications

This product could be promoted to the public as a mean to raise awareness, leveraging its innovative features that can be controlled remotely. The project holds the promise of captivating public attention. Its engaging and innovative features, combined with the capability for remote control, position it as a potential tool for awareness-raising campaigns. By capturing the imagination of the public, the prototype could inspire increased environmental consciousness and generate conversations about water pollution and its solutions.

5.3 Limitations

There are a few weaknesses to this project. These are the main problems that were discovered during the project:

- Batteries took too long to charge.

  The use of solar panels as a source of power would indicate that the batteries can only be charged when there is sunlight. This would cause a problem for the product if it was to abruptly stop due to loss of power.

- The boat did not move straight when controlled.
  During the test run conducted at lake BTK, it was found that as the forward button is pressed, the boat would ever so slightly move to the right. After careful contemplating, it is obvious that this happens due to the mass of the product being larger on one side.

- Product could be lost after being disconnected.
  When running the Bluetooth connectivity test, it is also observed that after passing the maximum distance the product could be apart from the controller device, it would keep moving despite being disconnected. This means that the product could get lost easily.

- The conveyor was unable to stay in water for long periods of time.
  As discussed in section 4.4.4, the conveyor's material was water-absorbent, making the conveyor heavier over time. It needs to be dried ever so often before the product can be used again.

- The amount of trash that can be collected is limited.
  The product, while it can carry most trash, it is still limited to smaller sized floating trash.

5.4 Future work

Henceforth, the improvements that could be implemented to improve this product is as such:

- Adding another component to the circuit: capacitor.
  Capacitors, an electronic device that stores electrical energy, are a perfect addition to the circuit. Since it takes a shorter time than a battery to charge up, it could serve as a replacement for when the batteries run out of power.

- Equal distribution of the components' mass on the boat's body.
  Hypothetically, if the product's mass is heavier on one side and causing the product to not be moving straight, it would be logical that the solution is to equally distribute the masses.

- Creating a return route when it gets disconnected.
  A function should be added to the control for when the product becomes disconnected that would assist it in returning to its' original position or stay at its' current position for easier retrieval. This should prevent it from getting lost.

- Replacing the material used for the conveyor belt to prevent it from absorbing water.
  A replacement for the conveyor belt's material to become non-absorbent of water would cause a significant change in the product. It would lengthen the time the product could be used in water and there would be no need to leave the conveyor belt dry every few minutes in fear of it damaging the product.

- Using a bigger-sized container to collect trash.
  Since the main aim is to collect floating trash, it would be meaningless if it could not even collect floating sticks due to its' size. As such, the countermeasure for this would be to increase the size of the product and container of the trash altogether.

- Applying 'surveillance' to the product
  This product, despite being equipped with a camera, failed to fully encompass what 'surveillance' means. In the Cambridge Dictionary, surveillance is the careful watching of a person or place, especially by the police or army, because of a crime that has happened or is expected. The product only manages to record and not to surveil the surroundings of the polluted areas.

- Applying the usage of solar panel as the source for charging batteries of the boat’s motor movements.

  As a final addition, due to the lack of time, the boat’s movements’ circuit was not able to be equipped with solar panel. For future work, one of this product’s goals is to apply solar panel as a source of energy for the boat’s movements for it to truly be solar-powered cleaning boat.

5.5 Summary

The prototype demonstrates impressive performance metrics. It effectively charges its battery at a rate of 0.012 V/min as well as displaying a remarkable mobility across a sizeable area of 1256.63 m^2 centered around its controller device. Apart from that, it exhibits the capability to transport 100g of mass without any hindrance. These achievements underscore the project's technical prowess and its potential for addressing challenges related to water pollution in various aquatic environments, ranging from rivers to lakes and other small bodies of water .

Beyond its technical achievements, the prototype possesses a significant societal dimension. Its compact size and multifunctional design make it a feasible candidate for combatting water pollution, particularly in environments where larger vessels struggle to navigate. By harnessing renewable solar energy and incorporating remote controllability, the project not only offers an effective solution but also presents a sustainable approach to addressing environmental concerns.

As we conclude this chapter, we reflect on the journey that brought the Solar Powered Cleaning Boat with Surveillance from concept to a tangible prototype. We consider the impact it has already made and anticipate its contributions to a cleaner, more sustainable future. This chapter not only celebrates the project's achievements but also paves the way for further exploration, innovation, and action.

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APPENDIX A - GANTT CHART

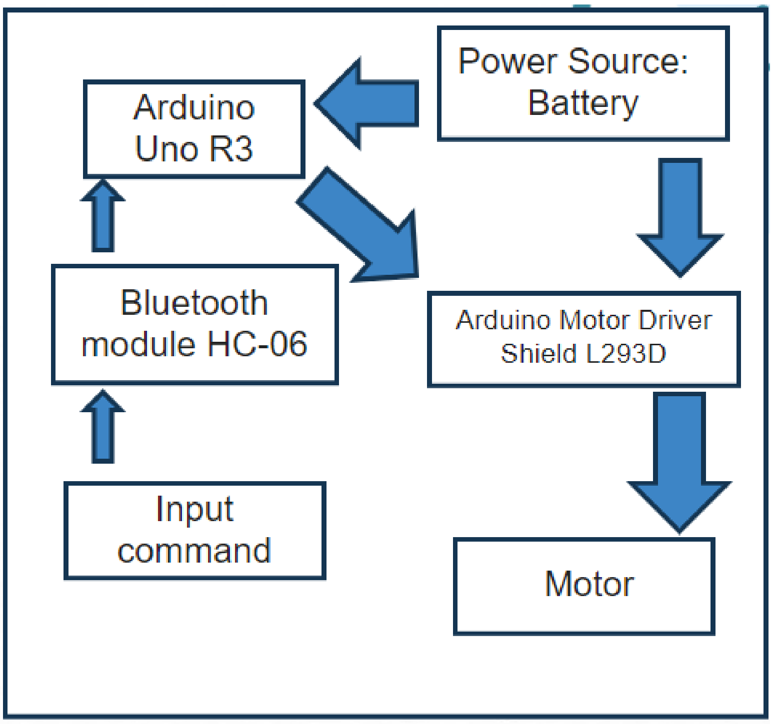
APPENDIX B - BOAT MOVEMENTS' CODING

The following is the code implemented into the Arduino Uno used to control the boat's movements:

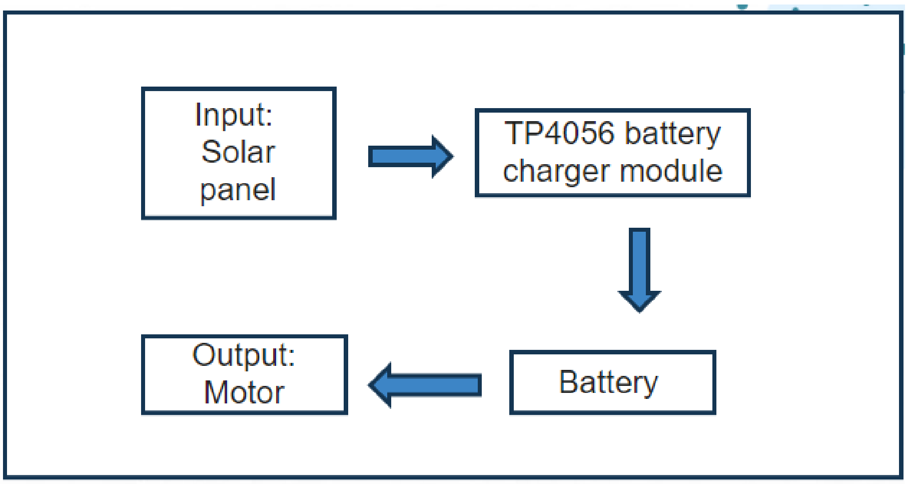
```
#include <AFMotor.h> // Constants for motor speeds
const int MAX_SPEED = 255;
const int MIN_SPEED = 0;
// Motor objects
AF_DCMotor motor2(2, MOTOR12_1KHZ);
AF_DCMotor motor3(3, MOTOR34_1KHZ)
char command;
void setup()
{Serial.begin(9600);}
void loop() {if (Serial.available() > 0)
  {command = Serial.read();
    Stop(); //initialize with motors stopped
 switch (command)
    {case 'F': forward();
      break;
    case 'B': back();
      break;
    case 'L': left();
      break;
    case 'R': r ight();
```

```
      break;}}}
void motorControl(int speed2, int speed3, uint8_t
direction2, uint8_t direction3)
{motor2.setSpeed(speed2);
 motor2.run(direction2);
 motor3.setSpeed(speed3);
 motor3.run(direction3);}
void forward() {
motorControl(MAX_SPEED, MAX_SPEED, FORWARD, FORWARD);}
void back() {
motorControl(MAX_SPEED, MAX_SPEED, BACKWARD, BACKWARD);}
void left() {
motorControl(MAX_SPEED, MAX_SPEED, BACKWARD, FORWARD);}
void right() {
motorControl(MAX_SPEED, MAX_SPEED, FORWARD, BACKWARD);}
void Stop() {
motorControl(MIN_SPEED, MIN_SPEED, RELEASE, RELEASE);}
```

APPENDIX C - BLOCK DIAGRAMS OF CIRCUITS



Block Diagram for boat's movement



Block Diagram for conveyor's movement