LAKE DEBRIS CLEANER

Report submitted to the
Indian Institute of Technology Mandi
For the course of

Design of Practicum (IC201P)

by

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September, 2021

CERTIFICATE OF THE MENTORS

September 30, 2021

Certified that the report entitled THE LAKE DEBRIS CLEANER submitted by Shubrah Gupta, Shikha Chaudhary, Varsha Meena, Vikram Singh Meena, Mohit Sharma, Karan Doshi to the Indian Institute of Technology, Mandi, for the course "Design of Practicum (IC201P)", performed under our supervision, is a record of bona fide work and we consider it worthy for evaluation.

(Dr Viswanath Balakrishnan) (Dr Srinivasu Bodapati) (Dr Neha Kaushik)

DECLARATION

I certify that

a. The work detailed in this report is original and has been done by ourselves under the general supervision of our supervisors.

b. We have followed the guidelines provided by the Institute in writing this report.

c. We have conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute.

d. Whenever we have used materials (data, theoretical analysis, and text) from other sources, we have given due credit to them by citing them in the text of the thesis and giving their details in the references.

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Digital signatures of the Students

Acknowledgment

We would like to thank our mentors, Dr Viswanath Balakrishnan, Dr Srinivasu Bodapati, and Dr Neha Kaushik for constantly guiding and supporting us. They took out time from their busy schedule to guide us all along the current phase of our project. We express our heartfelt gratitude to them.

Abstract

Keeping the water bodies clean from the effluents and the pollutants is a challenging task and requires manual cleaning after every regular interval. Realising the importance of efficient cleaning methods or machines in accomplishing this task, we designed a remotely-operated device which can be used to pick up wastes floating on the surface of the static water body. The machine would catch the Bluetooth signals send by the operator, which would provide the machine with instructions on navigation and waste collection. The waste collection operation features the use of a conveyor belt to carry the waste to the bin. The navigation operation will be controlled by the Arduino micro controller which would provide instructions to motors on translation and rotation. In the fabrication phase of the Design Practicum, we plan to complete the prototype building and testing.

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Chapter 1
Introduction

1.1 Motivation

Water is a very important resource for the functioning of life on the earth. It can correctly be said that "Water is Life, Life is Water". Therefore, we should preserve all our water resources. 71% of our earth is covered with water, out of which, 97% is found in oceans and seas. Only 3% of earth's water is fresh which is in ponds, lakes, rivers, underground water , wells and glaciers. Thus, a small quantity of water is available for our daily consumptions. As the population is growing day by day, pressure on the existing sources is increasing very drastically. So, in order to preserve our resources for future generations, we should become more careful about this. In absence of garbage disposal facilities, people are throwing or dumping wastes into the water bodies which increases the pollution level.

Figure 1.1: Water body polluted by waste : A common site in India

Figure 1.2: Manual cleaning process

It can be clearly observed that the river is badly polluted and chocked by a large amount of garbage like paper, polythene, food products, metals etc. present near the river or floating on the surface of the water which is not only harmful for humans but also for the marine population, terrestrial plants and animals. It directly or indirectly affects our ecosystem. Industrial, commercial, domestic and agricultural wastes is directly dumped into the water bodies which degrades the water quality. It creates many health problems and also not suitable for other living organisms. Huge manpower is required to clean the river, creating drain of the hard-earned tax payers' money. This task is also very dangerous for the people involved in cleaning.
Government has spent a lot of money on the river cleaning projects like **"Namami Gange"**, **"Narmada bachao"** and on many other major projects. As India is a developing country, we need modern solutions for our growing problems which saves our time and costs as well. In every field, government is encouraging everyone to use digital technology rather than using analog technology. So, by keeping all these concerns in mind, we designed a machine in a very efficient, effective and sustainable manner to clean the surface of the lake.

1.2 Objectives

- This machine will be used in those places where there is waste debris on the water surface which are to be removed and therefore reduces the pollution

of water bodies. It also reduces the manpower and time consumption.

- **Human interference** : It will be controlled by an operator and thus not an autonomous device.

- **Powering of the device** : Power is given by the battery. Here, we are not using solar energy or hydro-power for powering of the system.

- **Collect different types of wastes** : Our machine is design in such a way that it collects all types of wastes floating on the surface of the lake like plastic bottles, polythene, agricultural waste, industrial waste, domestic waste and commercial waste.

- **Amount of waste** : It will collect 5kg amount of waste from the lake surface at a time.

- **Safe disposal** : Waste debris is easily removed from the collector box.

- **Environmental friendly** : We have used fish repellent sound to deflect them away from the system. Also we are not using any equipment which produce any adverse effect on the water sources.

- Cost effective and durable.

1.3 State-of-the-art

After doing a thorough search on the internet and going through many articles, we came across the mentioned solutions-

- Lake Cleaning Machine by Mishra et al. (2019): It is more of a manual lake water cleaner that requires a human to operate it. The driver has to paddle to generate power which is transferred to make the waterwheel rotor shaft move and hence make navigation of the machine possible. The waste collection is done by the operator.

- Design of River Cleaning Machine by Khan et al. (2020) : The solar-powered device helps to clean water by using a blade to trap wastes and collects them.

- Clearwater Mills made a water-cleaner device which has become a tourist attraction in the city of Baltimore. It is a durable device built for the purpose of waste collection from the rivers, with the help of conveyor belts.
- Khanna from Deccan Herald stated that state of the art electric weeders are used by the muncipalities in metropolitan cities like Mumbai for cleaning the lakes. They have blades to cut through the weed and collect them.

1.4 The product

"Lake Debris Cleaner" will be used in those places where there is waste in the water body which is to be removed. This machine consists of waterwheel driven conveyer belt mechanism which collects & removes the wastage, garbage, and plastic from water bodies. This also reduces the difficulties which we face when the manual process of collection of waste takes place. A machine will lift the waste surface debris from the water bodies, which will ultimately result in reduction of water pollution and lastly the damage to aquatic flora and fauna will be minimized.

Chapter 2
Methodology

2.1 System level proposed solutions and its feasibility

2.1.1 SWOT analysis

Strength

- Rapidly collect and dispose off the waste at regular points on the shore and at far points also from the shore.
- This cleaning system is easy to operate and flexible
- Less human interference or contact with water i.e. safe to use
- Cost effective, once the design gets manufactured in bulk in industries.
- Easy to dispose off the waste.
- This requires less man power.
- Skill Workers not required to drive the system.

Weakness

- The machine cannot distinguish between Biodegradable and non-biodegradable waste or different category of wastes. It needs to be done manually after taking out the waste.
- Cannot collect waste in deep water, only useful for surface level waste.

- Sounds repellent will be used to repel aquatic animals but if exceptions occurs then it may harm the aquatic animals
- Waste collecting capacity is limited
- More technology usage implies somewhat reduce in employment – suppose one machine cleans one lake reduces the employment of 5-6 people
- Use of material and electrical components implies power usage, so power consumption is required and it is not renewable energy source.

Opportunity

- India is among the largest garbage generator . It produces around 62 million tonnes of waste every year. About 63% of it is collected. Usage of machine can increase the efficiency.
- Government launches many programs like 'Namami ganga programme' and provide financial support. It can help us in improving our product.
- It is useful for small lakes but by doing some modification in its size and capacity it can use in big lake and river like Ganga.
- No competition in market.

Threat

- No specific skill set is required in collecting waste, for manufacturing this we need skilled manufacturers and lack of skilled workers can effect the future production.
- Power is required as it is non-renewable energy source and if it causes any kind of pollution, government may put ban in it.

2.1.2 Risk analysis

Variables involved and their description:

				E_P	E_C	E_I	R_L	
		Project Planning						
Milestone -1		Design freeze		4	5	4	80	High
		Regular concept ,tool selection		4	4	4	64	High
		Material Selection		2	3	1	6	Low
Process design/fabrication								
		Inadequate knowledge of process 5		4	2	1	10	Low
		Design flaw		3	3	2	18	Low
Electrical components		Failure of part		3	5	2	30	Medium
		Faults in Technology- machines during mechanical process		3	3	1	9	Low
		Wrong manufacturing		4	5	2	40	Medium
Financial		Crossing barrier of 30,000		3	2	1	6	Low
Environmental		Harm to aqautic animals		1	2	1	2	Low

Table 2.1: Risk Analysis

- R_L : activity risk level in three-dimensional analysis of project activity risk
- E_P : probability that a risk event will occur
- E_C : estimate of consequences of a risk event
- E_I : estimate of recurring risk event incidence

$$R_L = E_P \times E_C \times E_I$$

Criteria :

- If $R_L \leq 24$ (risk probability is up to 20%), the risk is low.
- If $25 \leq R_L \leq 60$ (risk probability is between 20 and 50%),the risk is medium.
- If $R_L \geq 61$ (risk probability is more than 50%), the risk is high.

Ratings: 1 - Very Low; 2 - Low; 3 - Medium; 4 - High; 5 - Very High;

2.1.3 Working principle: system level approach

This device is a remotely-operated floating device which is made to be used for debris collection from the surface of a static water body. It performs 2 broad operations: **Navigation** and **Waste collection**. The navigation phase is initiated by a remote user on a mobile Bluetooth application which is used to transmit signals to the device. The Bluetooth module in the device receives the signals, which is further used in controlling Arduino board and then, the motor drivers. The motor drivers are based on H-bridge which will be used to control the direction of motor's rotation, thus controlling the direction of waterwheels attached. The waste-collection phase starts with the floating waste onboarding the front flat panel of the device, which is transported to bin using a conveyer belt. This conveyer belt will be mechanically powered from the power of the waterwheels transferred using the chain-gear-shaft combination. The working principle is accurately described in the sequential system-level block diagrams, mentioned below. The electronic components are written in violet blocks, electrical components in pink, and mechanical moving parts in orange-colored blocks.

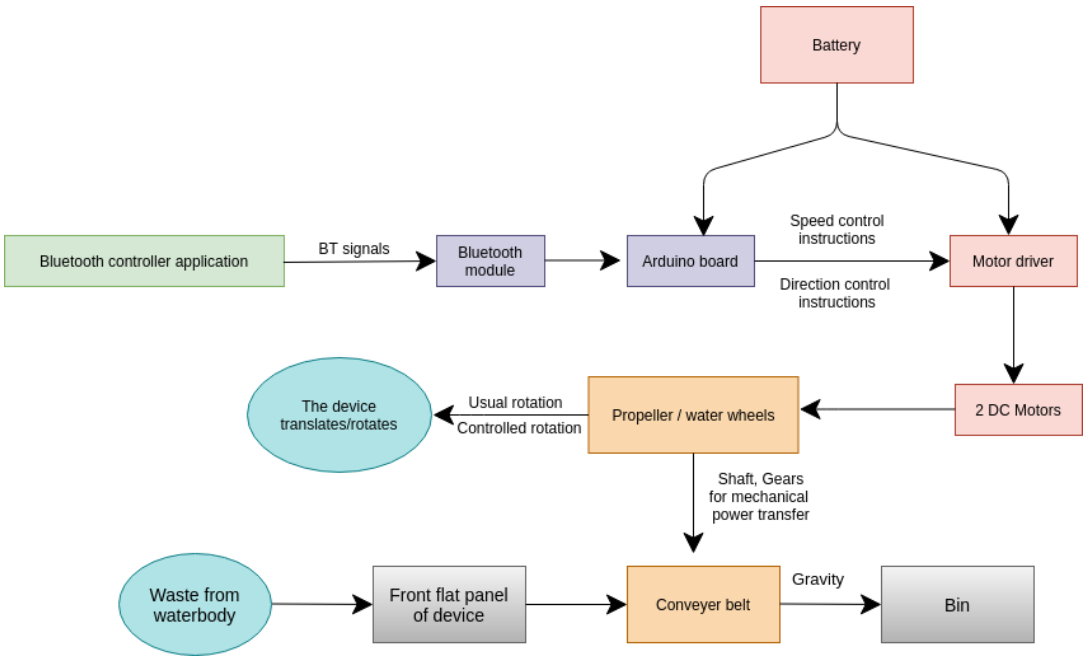

Figure 2.1: System-level block-diagram

2.2 The design

2.2.1 Electrical/Electronics aspects

Electrical/Electronics Components -

- Battery:
  We will use a lead acid rechargeable battery, 12V and high energy density 4200 mAh. Dimensions: Length: 2.76" Width: 1.85" Height: 3.98"

- DC Motor:
  Here we are using two dc motors for controlling the direction of the propellers.
  Voltage = 12 V Rpm = 500-700
  Shaft = 20mm
  Max current = 5A

- Arduino Board:
  Arduino Uno board is based on the **ATmega328P**. It consists of 22 digital input/output pins in which 6 can be used as PWM outputs, 8 analog inputs, 16 MHZ quartzcrystal, a USB connection, a power jack, an ICSP header and a reset button.

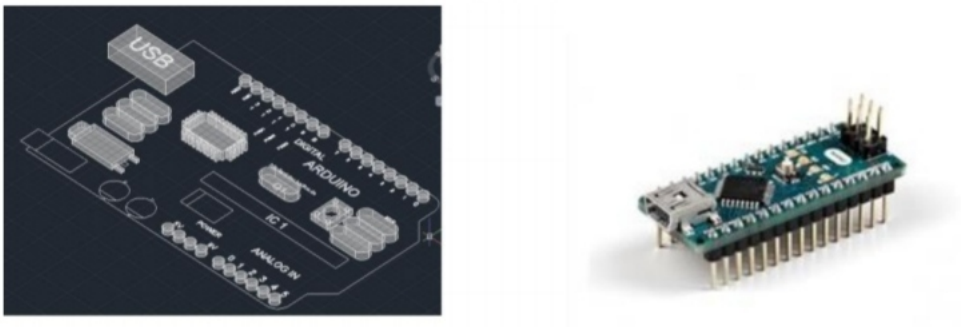

Figure 2.2: Micro-controller ATmega328[1]

- HC-05 Bluetooth module:
  This Bluetooth module is designed for transparent wireless serial connection.

[1]Madhavi and Munde (2018)

This can be used in a Master
or Slave configuration; it makes a good solution for wireless communication.

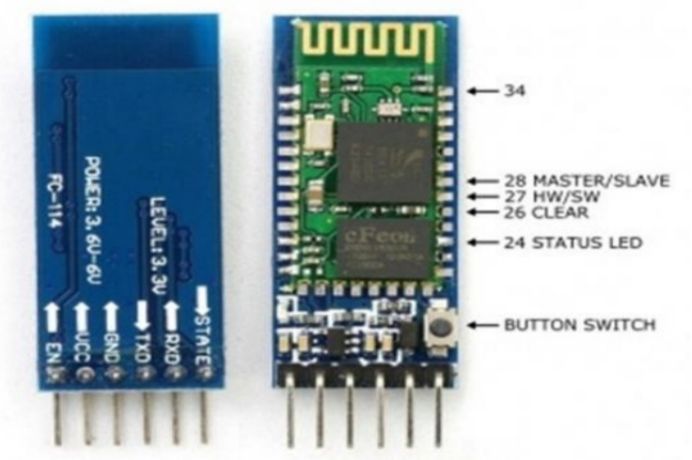

Figure 2.3: HC-05 Bluetooth module[2]

- Relay module:
  This module provides the protection to the micro-controller from the higher load current

Calculation and principles involved -

- Motor Calculation:
  Type: DC motor
  Power = V× I
  where, Voltage = 12V
  Current = 5 A
  Power =12 × 5 = 60 watt

- **Reversing the direction of rotation of the motor using H-bridge**.
  So, in order to change the direction of the motor, we have to reverse the voltage supplied to the motor and thus change the direction of the current flow to the load. So, here we are using H bridge to reverse the voltage and current flow to the load. So, in the above figure (left),there is a motor having terminal A and B. If we connect the A terminal with positive

[2]Madhavi and Munde (2018)

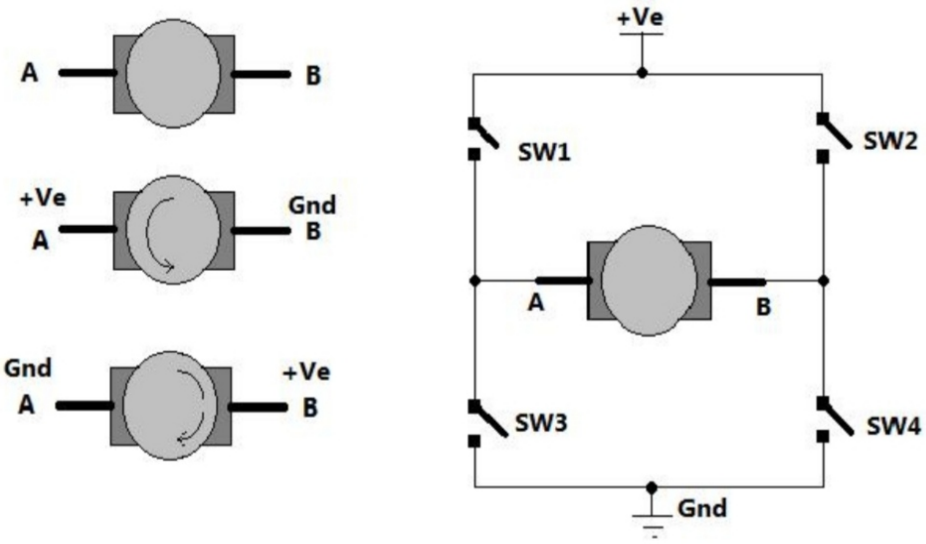

Figure 2.4: H-Bridge circuit for controlling the direction of a DC Motor

supply and terminal B with negative or ground then the current will flow in motor from A to B and the motor is rotating in forward direction or clockwise direction. Now, if we connect the A terminal with negative supply or ground and B with positive supply then the direction of the current reverse i.e from B to A and thus the motor will rotate in the anti-clockwise direction or reverse direction.

So, in the right figure the arrangement is known as H bridge because it looks like a letter H. Using this H-bridge we change the supply to the motor. There are four switches sw1, sw2, sw3, sw4 and a motor between terminal A and B.If switches sw1 and sw4 are ON simultaneously and sw2,sw3 are OFF then current will flow from +Ve-sw1-A-B-sw4-Gnd. So, motor will rotate in forward direction. If switches sw2 and sw3 ON simultaneously and sw1 and sw4 are OFF then the direction of the current flow is +Ve-sw2-B-A-sw3. So. motor's rotation direction is changed.

- **Varying the speed of the DC motor using pulse width modulation (PWM)**

  The speed of the motor can be varied by varying the input voltage supply. As the input voltage increases the speed of the motor increases or vice-versa. At the rated voltage, the motor will rotate at full speed. We give the varying input voltage using PWM.

  Pulse width modulation means varying the width (duty) of pulse. Width

means ON time T_{on} of pulse. The average output voltage (V_{dc} or V_{avg}) is given by equation $V_{dc} = [T_{on}/(T_{on} + T_{off})] \times V_s$ It directly depends upon

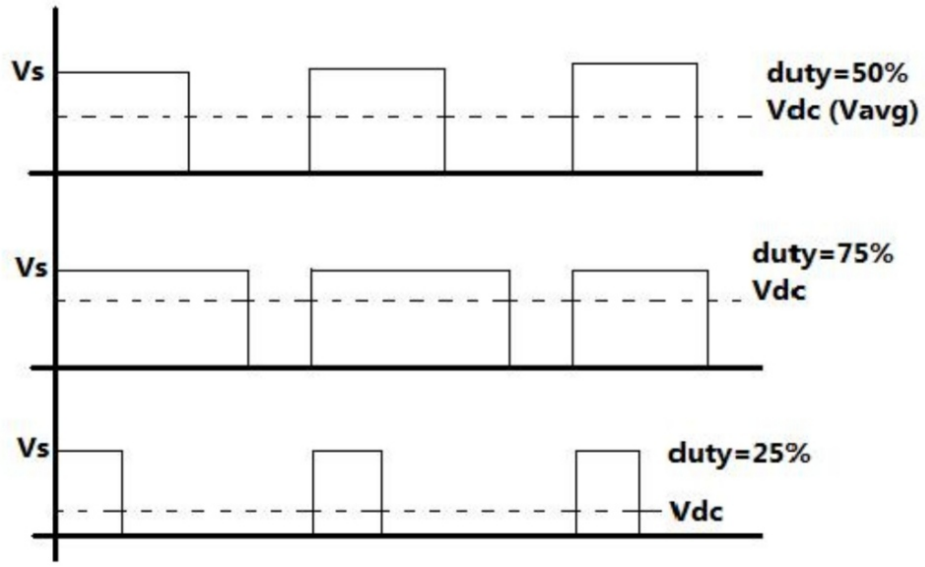

Figure 2.5: Pulse Width Modulation for controlling the motor speed

T_{on}. As shown in above figure if duty is 50% the average output voltage V_{dc} is exactly the half of Vs. If duty is increased to 75%, V_{dc} also increases to 3/4th of Vs and if duty is decreased to 25%, V_{dc} reduces to 1/4th of Vs. Thus as pulse width varies the average output voltage varies. So we have to apply PWM to DC motor to vary its speed .

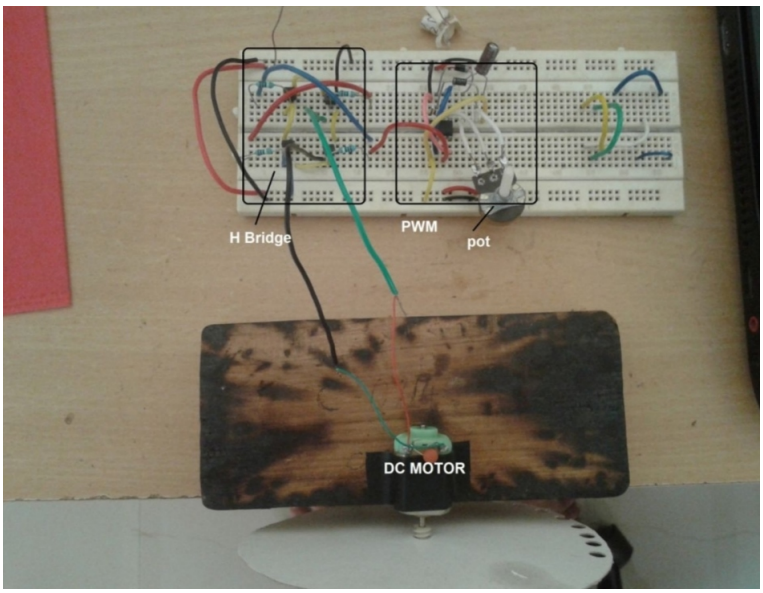

Figure 2.6: Prototype of H-bridge and PWM circuit built on breadboard

2.2.2 Software part

Our device uses the Bluetooth application on smartphones for giving Bluetooth signals.

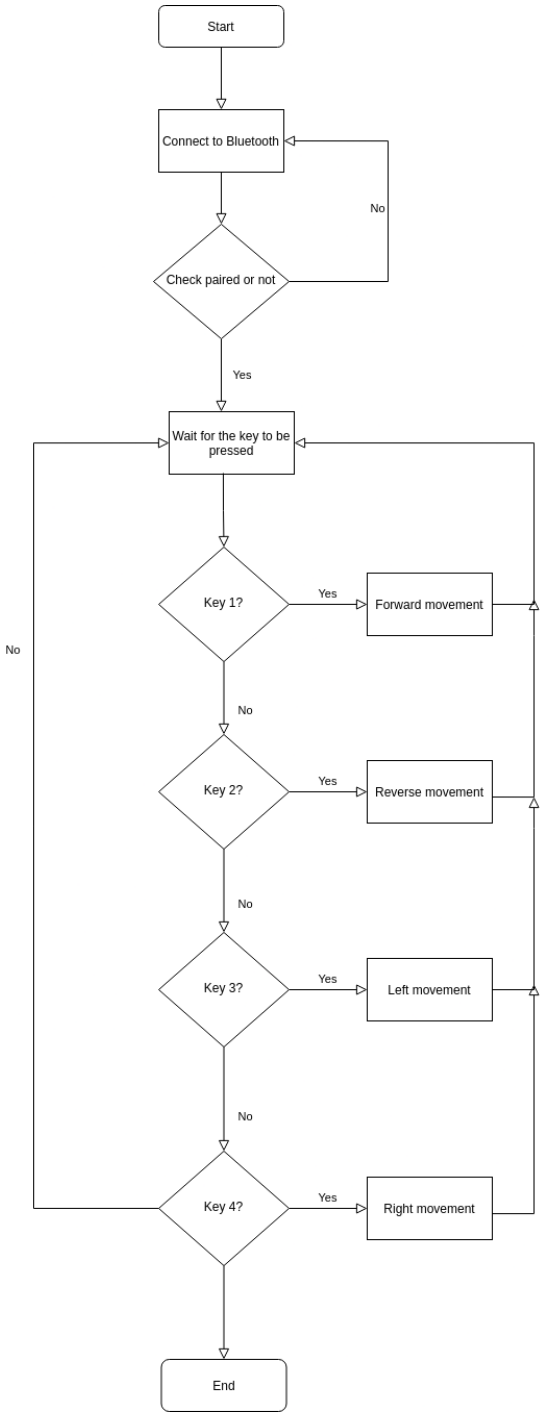

Figure 2.7: Flowchart

2.2.3 Mechanical aspects

Mechanical components-

- Conveyer belt : Aluminium net for conveyor belt will be used because pores in it will easily pick up the trash and move it towards the bin and store it in. Specifications: Belt Length: 65 cm $\times$ 2 = 130 cm, Belt Width: 50 cm, Belt Speed: 5-35ft./min, Material: PUC pipes, aluminium net, Roller Diameter: 10mm

- Shaft : Shaft is used to transmit the torque from motor to chain drive. There are two shafts assembled in the machine. Conveyor is drawn by the grooved aluminum shaft with orderly groove which is powered by the propeller. The shaft is made up of AL6061 T6 Alloy having Young's Modulus = 70 GPa

- Gears : Gear drive is a power transmission drive used to transmit the power from motor to chain drive as required to carry a load as desirable to complete the project objective. Range of operational Speed = 300-700 rpm.

- Chain Drive: Chain drive is a way of transmitting mechanical power from one place to another. The power is conveyed by a roller chain, known as the drive chain, passing over a sprocket gear, with the teeth of the gear meshing with the holes in the links of the chain. The gear is turned, and this pulls the chain putting mechanical force.

- Fish repellent device: This device will produce sounds which would help in repelling the fish away from the device.

Calculation and principles involved-

Manufacturing process-
1. Manufacturing begins with the selection of materials.
2. Cutting of sheet metal according to specifications.
3. Need of shearing machine and bent it down to our required angle using bending machine, later we will join all the sheet metal and bars through gas welding process.
4. We will check the floating of our boat can use metacentric height experiment to check it.

5. After receiving the various mechanical components, we can assemble them.
6. Painting process will be started with the cleaning of the product with chemical treatment. Later it will be painted by the means of powder coating of black and silver colour.

Propeller-

To find the Diameter of Propeller, we need power and shaft speed.

Crouch's Formula : Boat speed = C x $\sqrt{(Power/boatweight)}$
where boat speed = 0.25 m/s, C = 0.176 = a constant
Suppose Boat weight = 20 Kg

After substituting the values-
Power = 44 W (It may change according to the speed and weight)
For 20 Kg weight-

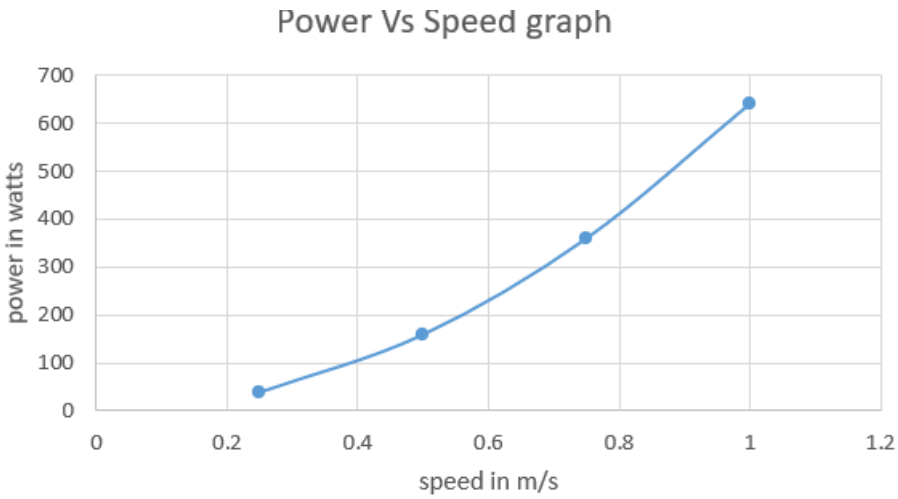

Figure 2.8: Power vs Speed graph

Speed(m/s)	power(W)
0.25	40.035
0.5	160.147
0.75	360.323
1	640.565

Table 2.2: Speed vs Power Table

For different angular speeds,we can calculate propeller diameter
Diameter = 632.7×(Power in HP)$^{0.2}$ / (angular speed of rotor)$^{0.6}$ = 8.62 inches = 21.89 cm [considering angular speed of shaft to be 500 rpm]

To find propeller pitch: Optimum pitch ratio formula,
Pitch ratio = 0.46 × (boat speed)$^{0.26}$ = 0.3207 inches

So for x" Diameter, Pitch ratio = Pitch / Diameter
0.3207 = pitch / x ⇒ **pitch** = 2.76 inches

Thrust provided by the propeller = 326 × SHP × e / V_a where SHP = Shaft horsepower = 0.0589, e = Prop efficiency = 0.65 (From the Propeller's handbook) V_a = Speed of water at the propeller, in knots = pitch x rpm = 2.76" × 500 = 1380 inch/min = 1.135 knots

We get, Thrust = 10.99 pounds= 48.88 N We have, Power = Force x velocity
44 = 48.88 x v ⇒ **Velocity** = 0.9 m/s (theoretical value)

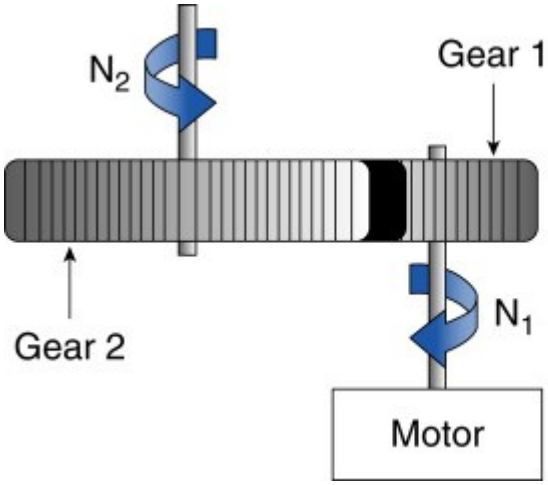

Figure 2.9: Interaction of 2 gears

Ideally if the 2 gears are in contact, and the angular speed of the 1st gear = angular speed of the motor = N_1
then, the angular speed of the 2nd gear and the shaft = $N_2 = N_1 \times d_1/d_2$ as in Fig. 2.8.

Floating of boats can be explained by using Archimedes principle which states that net upward force applied on a partially or fully submerged body is equal to the weight of water displaced by the body. This force, called buoyancy force, is the reason to float any object on the water. Buoyancy force acts on the centre of buoyancy of the submerged part of the body and gravitational force acts on the centre of gravity of the body. Metacentre (M) is the intersection point of line passing through centre of gravity (G) and centre of buoyancy (B) with vertical line passing through new centre of buoyancy (B1), when ship is displaced. Metacentric height is the distance between the centre of gravity and metacentre.

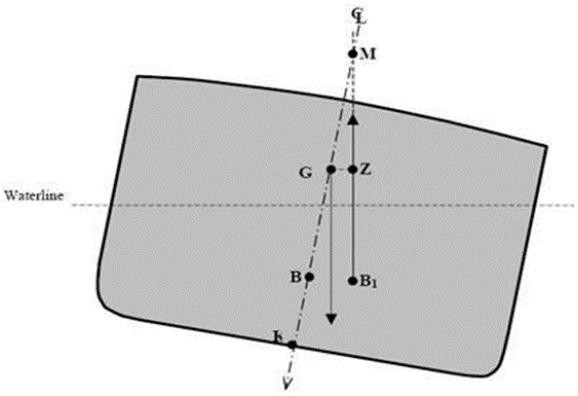

Figure 2.10: A floating body[3]

$$GM = I/V\text{-}BG = BM\text{-}BG$$

where : I = moment of inertia of cross-sectional area of the body,
V = Volume of submerged body in water,
BG = distance between centre of buoyancy (B) & centre of gravity. [4]

S. No.	Equilibrium Condition	Floating body	Wholly Submerged body
1.	Stable Equilibrium	M is above G	B is above G
2.	Unstable Equilibrium	M is below G	B is below G
3.	Neutral Equilibrium	M & G coincide	B & G coincide

Table 2.3: Three equilibrium conditions of a body

[3]@CultOfSea
[4]@AboutMech

Chapter 3

Execution plan

3.1 Ready for execution drawings

3.1.1 Electronic and electrical

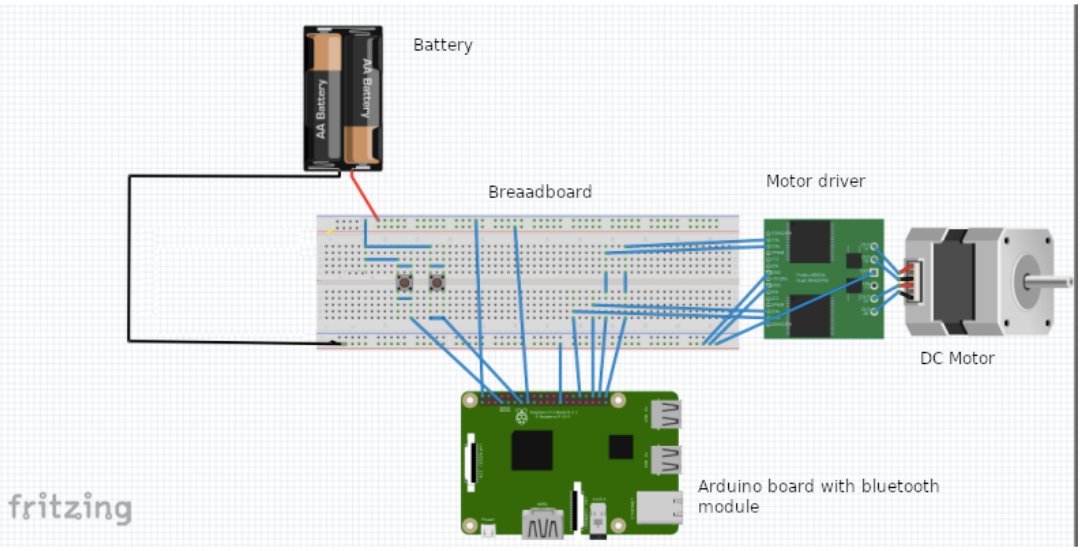

Figure 3.1: Breadboard-based electric circuit for the device

3.1.2 Assembly of the product

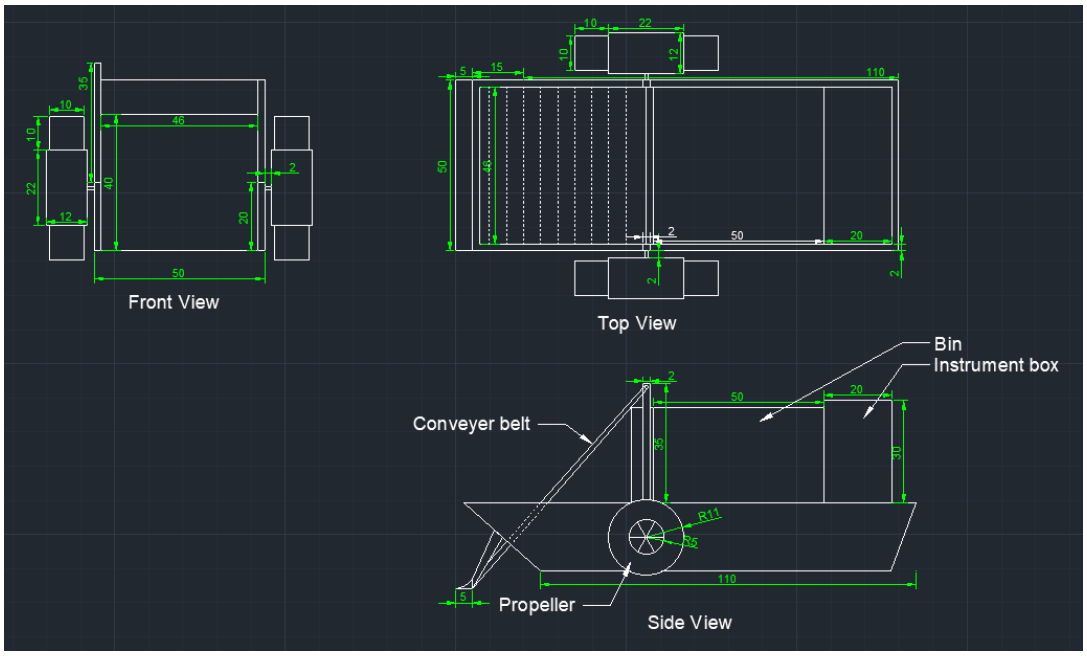

Figure 3.2: Different views of the CAD model of the device

3.1.3 Methodology

1. Switch On the device with the help of toggle switch.

2. Bluetooth module and smartphone are paired for navigation purpose.

3. Four keys are used to navigate the project key1 (forward), key2(Reverse), key3 (left), and key4 (Right).

4. Device is moved in forward and reverse direction with the help of propellers and can also be turned around by using navigation keys i.e.(Right/Left)

5. Waste from water bodies is collected with the help of conveyor mechanism.

6. Collected garbage is stored in the bin.

7. Once the bin is full it should be emptied manually.

3.2 Expedited execution plan

We will follow this timeline during fabrication of our product. We have completed our proper designing and modelling of our device in CAD. First we will start with the building of the debris navigation prototype as soon we get the supplies. In the next week, we will proceed with the control system by connecting our prototype to the remote by using a Bluetooth device. In week-3, we will focus on adding a waste collection system in prototype. In the final week, we

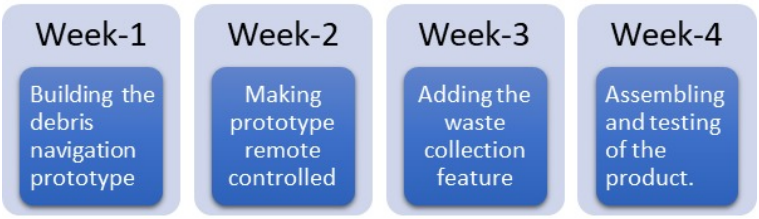

Figure 3.3: Proposed Timeline

will assemble all parts of the prototype to test the working of the product. We hope to complete our product according to the plan.

3.3 Cost estimate

Component name	**Price (in Rs)**	**Quantity**	**Total**
Arduino	1500	1	1500
Propeller	1000	2	2000
Sheet Metal	1500	1	1500
DC Motor	800	2	1600
Motor driver L293D	120	2	240
Bluetooth module HS-05	800	1	800
Gears	300	4	1200
Battery 12V 4200 mAh	2650	1	2650
Conveyor belt	160 (1 square feet)	10	1600
Miscellaneous	4000	-	4000
Total			**17090/-**

Table 3.1: Cost analysis

3.4 Contributions

The work down by the team members are mentioned below:

- **Shubrah Gupta** : Team lead, Abstract & Conclusion, Product construction planning, Working principle, System level block diagram, LaTeX report writing
- **Varsha Meena** : Introduction (Motivation and objectives), LaTeX report writing, Product construction planning, Electrical/electronic aspects (section 2.2.1)
- **Shikha Chaudhary** : SWOT analysis, Risk Analysis, Mechanical aspects, Product construction planning, Cost Analysis

- **Vikram Singh Meena** : CAD modelling, Timeline planning for execution, Mechanical aspects, Product construction planning
- **Karan Doshi** : State-of-the-art, Product construction planning,
- **Mohit Sharma** : Product construction planning, Component description

3.5 Conclusion

In our project, we aim to automate the waste collection process from the surface of a static water body. We have completed the design of CAD models of the our waste-collecting device. It has 2 phases of operation, navigation controlled externally by an operator using Bluetooth application and the waste collection with the help of conveyer belt mechanism. We strive to complete building our prototype within the suggested timeline and budget.

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