# Self-propelled water waste material collector using image processing


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# Final Approval

This is to certify that we have read the report submitted by ***Haider Ali (14457), Muhammad Ali Raza (14884), Muhammad Raveel Tariq (12415), and Shaheryar Ali (15441)*** for the partial fulfillment of the requirements for the degree of the Bachelors of Science in Information Technology (BSIT). It is our judgment that this report is of sufficient standard to warrant its acceptance by Riphah International University, Faisalabad Campus for the degree of Bachelors of Science in Information Technology (BSIT).

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# Declaration

We hereby declare that this document **"Self-propelled water waste material collector using image processing."** neither as a whole nor as a part has been copied out from any source. It is further declared that we have done this project with the accompanied report entirely on the basis of our personal efforts, under the proficient guidance of our teachers especially our **supervisor Aysha Ashraf and co supervisor Farah Naz**. If any part of the system is proved to be copied out from any source or found to be reproduction of any project from anywhere else, we shall stand by the consequences.

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# Dedication

We dedicate this work to our respected teachers, fellow and to our respected parents who remained steadfast during this hard time of our life and for their endless love, support and encouragements.

# Acknowledgement

First of all, we are obliged to Allah Almighty the Merciful, the Beneficent and the source of all Knowledge, for granting us the courage and knowledge to complete this Project.

This project requires a huge amount of work and dedication. The Team Member's contributions made this possible. We would like to express our deepest gratitude to the teachers. We are grateful for their aspirational guidance, invaluable constructive criticism, and friendly guidance throughout the work of the project.

Let us thank God for the wisdom and perseverance He has given us throughout this project, and even, throughout our lives: "we can do anything with his strength, strong for us. My fellows, for their unwavering support and encouragement throughout the Year.

We would like to thank our respected supervisor, Aysha Ashraf for his excellent supervision and management. I am extremely grateful to him and much obliged to respect him. It is his pure dedication to giving us time from his hectic routine which makes this project possible

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# Abstract

This project aims to create an automated waste detection system using image processing that will gather the waste images or a video from a camera with object recognition, detection and put the waste material to the bin. The work has been done looking at the current situation of our national rivers which are dump with crores of liters of sewage and loaded with pollutants, plastic, papers etc., by taking this all into account, this machine has been designed for an effort not to put floating garbage into water bodies. Wastes which are thrown on water areas are the main causes of water pollution. It greatly impacts the life on water and the place it is surrounding. People going on water to collect wastes can sometimes be dangerous and risky for their health. The result of this study is to collect the wastes from water without risking the health of a person. The present design of this project is to minimize human effort on manual picking of wastes. There are several methods to achieve the above-mentioned objective but in this project we shall discuss a mechanically simple yet efficient method. And also, with an effort to minimize human intervention throughout the process by automating it.

**Keyword:** Automated waste detection, image processing, and pollutant.

# Table of Contents

# List of Figures

# List of Table

# Chapter 1: Introduction

# Chapter 1: Introduction

For all living things on the world, including humans, water is essential to daily life. Given that 70% of the planet's surface is covered in water, the world has access to abundant water resources. However, as time passes, the amount of clean water becomes insufficient for people or other living things to use due to the wastes that are gradually encircling the waterways and spreading to various water regions.

One of the biggest issues produced by humanity in the world is water waste. The biggest threats to both wildlife and people is polluted water, which endangers both health and lives. Therefore, it is crucial to conduct more research on water waste reduction. The aim of this project is to propose a method for collecting floating garbage that helps reduce water wastes.

Water is an important natural resource vital for all forms of life on this planet. Despite being blessed with an enormous amount of water, water pollution is a major crisis in many countries. As per ‘Water aid’, an organization striving towards attaining fulfilment in hygiene and water sanitation has reported that 80% of World’s water sources are polluted. Water bodies are being polluted by floating garbage, weeds, debris plastic, sewage, effluents and toxic materials from industries. Water pollution with floating garbage is a serious issue that needs immediate attention in developing countries. River surface cleaning for the purpose of removal of the solid floating waste is one of the main goals of this projects.

An Arduino based garbage collector is a trashcan-like wireless controlled floating prototype that helps in collecting wastes in water areas. The user uses a wireless controller to control its movement on the water. With the help of the conveyor belt, it collects and lifts small floating wastes on its path and place it directly to the bin. This prototype helps in making the job of water cleaners easier by simply controlling with the joystick and wait for it to accumulate the certain amount of waste in the water rather than manually picking up the wastes one by one. With the use of this technology, it would be possible to clean the water areas without endangering anyone's health. In the proposed system, the machine is operated with a remote controller to clean the sewage. Hence, system avoids the several impacts from the sewage waste and its related harmful gases.

## 1.1 Background

In many water places around the world, water waste is a widespread issue. To prevent water contamination, fish kills, and the extinction of various aquatic species, clean water and sanitation are crucial issues that must be closely monitored. All of these pollutants and contaminations on the water can have an impact on nearby wildlife and people. Many people are irresponsible when it comes to waste disposal. The most common areas that people are irresponsibly throwing out their wastes are on rivers near bridges, tourist spot beaches, and ship terminals. When a major increase of water level happens in river, all the wastes are deposited to the canals on rural and urban areas. These events result in flooding of areas and major catastrophes both on the environment and on the people living in the area. Not only these wastes can block the canals, but they can also spread harmful and deadly diseases. People going through the flood would have high risk of infection, especially if they have an open wound on them and would also cause skin irritations on people with sensitive and allergic skin. Also, the fouling smell coming from the wastes is one of the major causes of health problems, especially on children who have significantly lower immunity to these things.

The wastes on the water areas are not only causing trouble on the people around it but also on the living organisms in the water. The fish and other living organisms are affected by the lack of oxygen because of the wastes scattered along the river. The waste results in the incapability of the water to sustain marine wildlife.

Manual collection of rubbish near water can be time-consuming and extremely exhausting. Various water species can be impacted by a simple plastic waste. Observing all of these events inspired us to do a study that will benefit not just humans but also aquatic life that is now struggling. The study of this project is concerned with gathering water wastes that can stop the deterioration and waste pollution of the various water locations.

## 1.2 Motivation and challenges

Water waste is a common problem in different water areas around the world. This prototype provides fresh and creative methods for reducing waste in various water locations. People can collect trash without it getting into the water by using an Arduino and wireless controller. Water cleaners can utilize the prototype to gather wastes without

entering the water and endangering their safety and health. The impacts of human waste are greatest on wildlife that lives near water. Eliminating trash would enable the water areas to support life for the many living organisms.

## 1.3 Objective and goals

The objective of the study is to create a prototype used in collecting floating wastes that can help to reduce the amount of wastes present on different water areas. It also aims to ensure the health and safety of every people and water species.

1. The prototype features a water proof garbage collector that will be implemented in water areas.
2. The prototype has a wireless controller for the user in controlling its direction.
3. The conveyor belt will lift the wastes collected from water and place it directly to the bin.

## 1.4 Solution overview

The innovative system that we propose offers a unique and automated way to tackle water pollution by eliminating manual labor it will increase efficiency and decrease the cost and time needed. The main aim of this floating waste collector project is to clean the waste that gets accumulated on the surface of water bodies that results in keeping the water clean hence decreasing the pollution. This project being remote-operated is controlled by an RC remote using which it can operate accordingly, we use DC motor to provide the direction control and servo motor arrangement for the steering.

## 1.5 Report outline

A project report outlines the software product, its requirements, and its objectives. This paper outlines the user interface, hardware, and software requirements as well as the intended audience for the project. A project report's main goals are to assist in decision-making and determine whether the project is progressing as planned. The next chapters of this report cover the background analysis for the project's development, its requirements, the design phase, the implementation phase, and the testing phase of software development.

**Chapter1: Introduction**

In this chapter, we introduce our project of water waste material collector using image processing. Then we describe the background, objective solution and motivation of this.

**Chapter 2: Literature review**

In this chapter, a many different research papers were investigated to collect relevant information about the project. With a reference from different sources, for example, expert interaction, research papers, journals, and books; the data has been gathered and discussed in this section.

**Chapter 3: Requirement Analysis**

In this chapter, the functional and non-functional requirements of our project have been discussed.

**Chapter 4: System Design**

In this chapter, we try to describe the design and flow of project. First of all, architectural design of the project has been discussed, then detailed design and UML diagrams have been used. In UML diagrams we use data flow diagram, use case diagram, activity diagram, sequence diagram, class diagram and block diagram.

**Chapter 5: Implementations**

In this chapter, we describe the implementation of our project. Pseudo codes, presentation layers, components libraries, mobile app have been discussed in this chapter.

**Chapter 6: Testing and evaluation**

In this chapter, we test the performance of our project. In testing phase we conduct three test scenarios. After test scenario we write functional and non functional testing of our project.

**Chapter 7: Conclusion and outlook**

In this chapter, we conclude our project by discussing improvements and achievements of our project. Then we write a review of our project at the end we discuss what are future recommendation of our project.

# Chapter 2:
# Literature Review

# Chapter 2: Literature Review

## 2.1 Introduction

With a reference from different sources, for example, expert interaction, research papers, journals, and books; the data has been gathered and discussed in this section. In this section a many different research papers were investigated to collect relevant information about the project. For constantly growing the water pollution inside the lakes, ponds and all the others water resources that are come inside the human touch and beneficial to the people for lots reasons. This is the important issue for the human society that the water required for each and every motive to the human being must be safe, clean and without pollution. But the lack of the equipment and the coast of the pollution controlling equipment it's more difficult to make rivers garbage and pollution free for this motive the river cleaning a system is designed.

## 2.2 Literature Review

The literature review is based on other projects that will helps to clarify the conceptual issues of your research related area. In addition, with the results of the project that has been successfully produced can improve the research of methodology.

**(Soumya, Gadgay et al. 2018)** The proposed method indicates that the lives of aquatic animals are being hampered and put in risk due to an increase in water pollution in the form of waste material. We are working to create a water cleanup equipment in an effort to lessen water pollution. A "water cleanup machine" is a device that removes waste materials from water surfaces and securely discards them in the water body. The water cleansing device extracts waste water debris, plastics, and rubbish from rivers and swimming pools.

**(Rafique and Langde 2017)** The waste system cleaner is a device that promotes waste management by removing trash from the drainage system, so assisting in protecting the environment from various environmental risks. If these wastes are not removed, they either settle in residential areas where they are burned and contribute to climate change, or they clog drainage systems and result in flooding. The machine is made to create motion for its operations on its own by the action of flowing water, eliminating the risks associated with powering the machine with external sources of energy due to the

harshness of the rain on these external sources. This initiative was created to clean the river, lakes, and pools. After completing this project, we will be able to reduce river pollution, which will be very advantageous for our society. In this project, a turbine turns in response to river water flow, and two conveyor belts are set up using a mechanical gear arrangement. For solid waste management, the first conveyor belt is used to remove solid waste from rivers, while the second conveyor belt is used to pull solid trash out of rivers. The source of life is water. The planet is 70% covered by it. Only a small percentage of this priceless natural resource, however, is suitable for human use. 97% of the water on Earth is contained in the oceans, which are unfit for human consumption. The remaining 3 percent is held in a variety of places, including glaciers, rivers, lakes, and underground aquifers.

**(Daniels and Science 2014)** The majority of the time, trash like nylon, plastic bottles, and empty cans that collect together and make their way into drainage systems obstruct such systems. If this waste is allowed to flow, it would eventually flow to tourist-friendly recreational beaches, creating an unpleasant sight; alternatively, it will flow to residential areas where it will be burned, contributing to climate change. When there is no water in the drainage systems, or when it is not raining, the drainage systems can be cleaned, but when it is pouring, they cannot be cleaned due to the difficult weather conditions, which no one would volunteer to suffer to prevent trash from entering the drainage systems. The Drainage System Cleaner is discovered to be a cost-effective device that may boost waste management, therefore taking care of the garbage without human intervention under the challenging conditions of the rain. The incidence of environmental problems like flooding and climate change is decreased by this drainage system cleaner.

**(Li, Tian et al. 2020)** Manual salvage operations are the mainstay of traditional water decontamination, which is not only challenging, dangerous, and ineffective, but also has some limits. Dustmen will be hindered if cleaning operations are carried out in small rivers, artificial lakes, and water parks where ships cannot travel due to confined spaces and shallow water. Workers should not clear rubbish in some water locations with substantial chemical pollution, at the same time. Additionally, artificial cleaning will lessen the beauty of the two-scale detection for various landscape lakes and rivers by removing the final scale, which better ensures real-timeness.

**(Kulshreshtha, Chandra et al. 2021)** The research on robotic trash-cleaning is covered in this section. A conveyor belt was utilized in the mechanical design of the robot created to function on water bodies to collect floating rubbish from the surface of rivers. The robot used broom bristles to sweep trash under the control of a servo motor, and the collecting bin was regularly opened to empty this trash. Some of the trash-collecting robots carried out the task of trash-picking using a robotic arm. In some of the trash-collecting robots and prototypes, the remote-controlled robots were operated by mobile applications through Wi-Fi.

**(Bhusari, Patil et al. 2011)** The project's goal is to automate the sewage cleansing process in drainage to stop infections from spreading to people. The procedure of cleansing the water serves to protect both aquatic and human life. Additionally, it increases the food products' sensory appeal and shelf life. In the suggested approach, the device that cleans the sewage is controlled remotely. As a result, this system mitigates the effects of sewage waste and associated hazardous gases. This aids in preventing the breeding of new mosquitoes. When the setup is turned on, a motor in the system turns on and begins to run. The wheel has two power window motors attached to it, and the remote control system is used to operate them. The procedure begins by employing the arm to gather sewage wastes, which are then thrown back into the trash can.

**(Kandare, Kalel et al. 2018)** The project focuses on creating a technique for cleaning rivers. The technique is effective at more thoroughly cleaning the floating solid waste on the surface of the river. This technique works to achieve its social goal of purifying rivers and other bodies of water. Its operating principles mimic the mechanisms of employing conveyors that are typically utilized. The manual, boat, or other traditional and often used methods of cleaning or, more specifically, collecting the floating garbage are left near the river's edge. However, these techniques are costly, time-consuming, dangerous, and labor-intensive. By considering all the parameters of river surface cleaning systems and eliminating the drawback of all the methods mention earlier, the remote operated river cleaning machine has been design and constructed which helps in river surface cleaning effectively, efficiently and ecofriendly. The main aim of the project is to reduce the cleaning the river. In this project, we have remotely controlled the operation of river cleaning with the help of motor, Arduino microphone.

**(Pakhmode, Dudhe et al. 2019)** This article describes the rubbish pickup robot that uses wireless connection on the beach, in rivers, and in swimming pools. The robot is constructed with caterpillar wheels and is powered by batteries. A controller can be used to steer a robot. Bluetooth is used to transmit the user's command for processing. It also has an IP camera with additional functionality, which transmits feedback data to the human operator. The performance of the robot revealed that it can travel at an average speed of 0.5 meters per second. The robot that picks up trash uses an Arduino microcontroller. Programming the Arduino is used to control the robot in the present. The robot is intended to gather trash from beaches, rivers, and swimming pools. Muddy surfaces cannot be utilized by the robot. The robot is designed such that when it is turned on, it will follow the program's instructions for movement. Depending on the program's conditions, the robot continues to move after hitting the obstruction before climbing up the trash.

**(Bamnote, Dudhe et al.)** Utilizing a conveyor belt to lift the rubbish out of the water is the fundamental technique for trash collection. The rubbish is gathered in a trash can that is fastened to the boat's rear. There has been use of the DC motors. Manual control of the boat is provided using a wireless remote. Two motors have been driven using the Motor Driver Module. In order to man oeuvre the boat easily forward and backward, it also has an H-bridge. Through its antenna linked to pin ANT, an RF-module that operates on the electromagnetic radiation theory has been employed for wireless serial data communication. The RF-module transmits data at a rate that ranges from 1 to 10 Kbps. The boat is controlled remotely from the shore when it is in the water. The boat was constructed using foam sheets for simple maintenance. Waste such as polythene, plastic, and other materials can be collected on the conveyor belt, which is kept thin. The boat is brought back to shore when the trash can is full. To remove the trash, the trash can is removed. Once the rubbish has been removed, the boat is reattached before being thrown back into the water to be cleaned. It is a suction-based garbage-cleaning robot for water surfaces. There are two components to the robot. The first part is the upper computer that is the APP control terminal of the mobile phone which is used to control the moving track of the robot. And the second part is the lower computer, consisting of Wi-Fi module.

**(Kumar and Medicine)** Robotic garbage collector with wireless connectivity on the sand. The robot system comprises of a Bluetooth module for wireless connection and an IP Camera that transmits live feed to the user. The ESP-32 WiFi module will be at the hub of the autonomous garbage collector bot. The motors are made to rotate in accordance with the pre-programmed instructions once the ultrasonic sensors identify the impediments. Here, the image processing method only determines whether or not the object is an animal. Garbage collecting proposal employing wireless technologies, a robot. With the use of a programmed created from a web application, the user can operate a robot. Everything was done on water; the robot was never fully tested on actual ground.

## 2.3 Customer Survey

It is required to conduct a customer survey at the start of the design process. It serves as a mechanism to further define the need statement and provided an opportunity to review other attempts in solving the problem. Potential Customers include municipalities, laborers who clean the lake, and private contractors. A survey had been carried out with some people and their problems and suggestions had been noted down.

- The kind of wastes collected while cleaning the lake and dangers faced while cleaning. If any kind of danger was faced while cleaning. This included solid waste floating on the water. Manual cleaners developed a lot of skin diseases, hence the need to develop a cost-effective and eco-friendly machine.
- How much time is required to stay in the water and how much waste is collected in a day? What is the cost of labor and how many laborers are needed to clean? What cost is expected if a product is made for cleaning the lake?
- A few hours, because pollution keeps on increasing day by day. Near about 400 kgs is collected in a day, but the value is not constant.

## 2.4 Tools used

- Arduino
- ESP32 WiFi Module
- Battery
- DC Motors
- Conveyor Belt
- Servo Motor

- Jumper Wires
- Charging Ports
- Ultrasonic Sensor

### 2.4.1 Arduino Uno

Arduino is an open-supply electronics platform primarily based on easy-to-use hardware and software. Arduino forums are able to observe inputs - light on a sensor, a finger on a button, or a Twitter message - and flip it into an output activating a motor, turning on an LED, publishing something online. To do so you use the Arduino programming language (based totally on Wiring), and the Arduino Software (IDE), based totally on Processing. Over the years Arduino has been the mind of plenty of projects, from ordinary gadgets to complicated scientific instruments. Arduino have become born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed toward students without records in electronics and programming. As soon because it reached a much broader community, the Arduino board started out changing to conform to new dreams and challenges, differentiating its provide from easy 8-bit boards to products for IoT

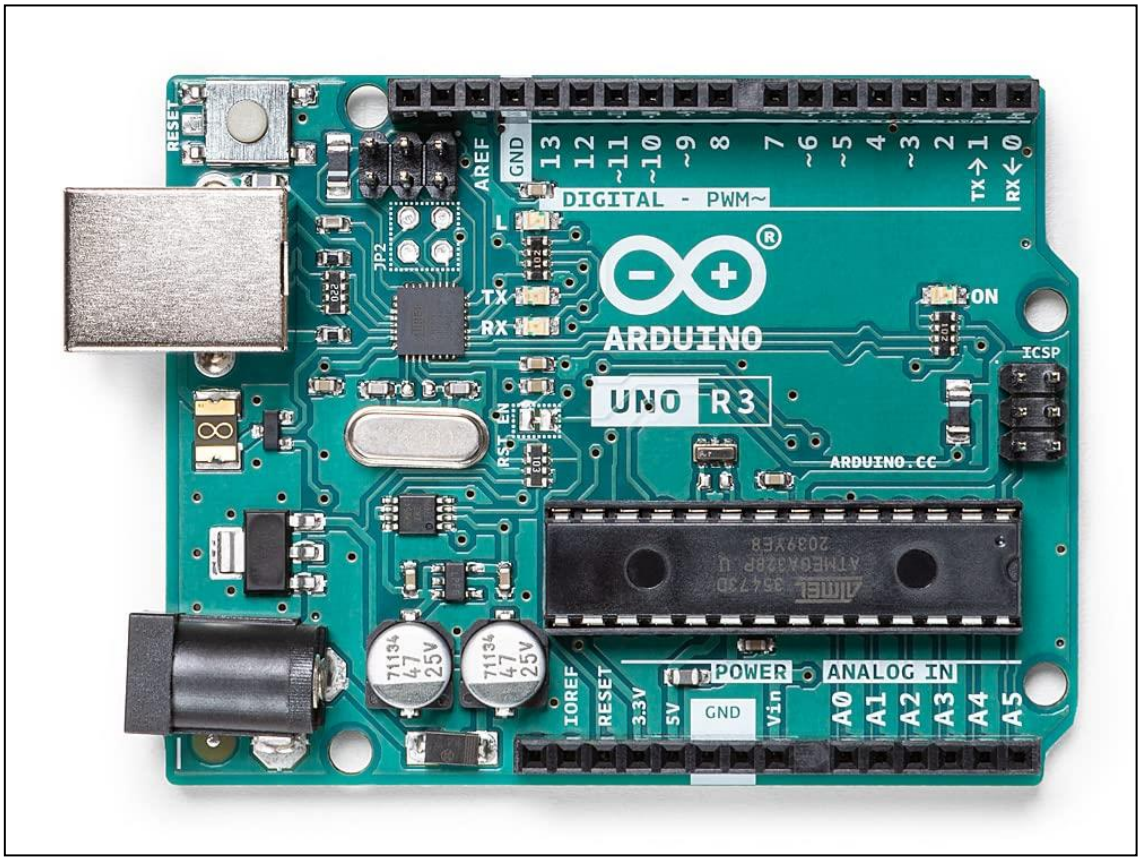


**Figure 1: Arduino Uno**

applications, wearable, 3-D printing, and embedded All Arduino boards are absolutely open-supply, empowering customers to construct them independently and sooner or later adapt them to their specific needs. The software, too, is open supply, and its miles developing via the contributions of customers worldwide. The Arduino programming language is based on a very simple hardware programming language called processing, which is similar to the C language.

### 2.4.2 ESP32 WIFI Module

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 is a very versatile System on a Chip that can be used as a general purpose microcontroller with quite an extensive set of peripherals including WiFi and Bluetooth wireless capabilities. One big advantage to using this module instead of designing from scratch is that Espressif has already pre-loaded the low-level device drivers, the wireless protocol stacks for WiFi. Another module commonly referred to as an ESP32 is what is more appropriately called an ESP32 Development Module. This is basically an ESP32 module mounted on a board with additional support circuitry such as a voltage regulator and a serial to USB IC. It allows direct connection to a desktop PC that can then be used to compile, download, and run programs directly on this module. One has more of the pins of the ESP module available than the other one, and is slightly more expensive. Otherwise, they are very similar. They each allow a direct connection to a desktop development system through a USB.

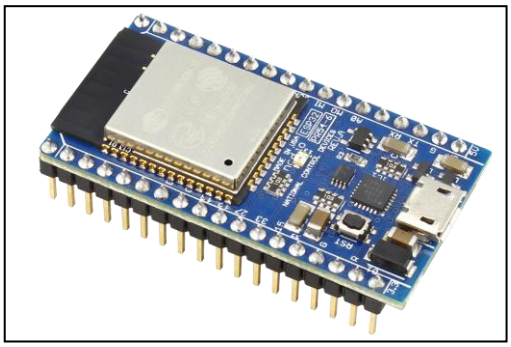

**Figure 2: Esp-32 Wi-Fi module**

### 2.4.3 Battery

Batteries are a collection of one or more cells whose chemical reactions create a flow of electrons in a circuit. All batteries are made up of three basic components: an anode (the '-' side), a cathode (the '+' side), and some kind of electrolyte (a substance that chemically reacts with the anode and cathode). Battery, in electricity and electrochemistry, any of a class of devices that convert chemical energy directly into electrical energy. Every battery has a cathode or positive plate, and an anode, or negative.

### 2.4.4 DC Motors

A DC motor is any of a category of rotary electrical motors that converts direct current electrical energy into mechanical energy. The most common types depend upon the forces produced through magnetic fields. Nearly all sorts of DC motor have some inner mechanism, both electromechanical or electronic, to periodically change the path of current in part of the motor DC motors have been the first form of motor extensively used, as they can be powered from present direct current lighting energy distribution systems. A DC motor's speed can be managed over a wide range, using either a variable deliver voltage or by using changing the power of modern in its discipline windings. Small DC motors are utilized in gear, toys, and appliances. The universal motor can perform on direct cutting-edge but is a lightweight brushed motor used for portable energy tools and appliances.

**Figure 3: DC Motor**

### 2.4.5 Conveyor Belt

The conveyor belt is a composite product made of rubber, fiber, metal, or plastic and fabric, which is used in concrete conveyor to carry and transport materials. Conveyor belt is widely used in cement, coking, metallurgy, chemical industry, steel, agriculture, industrial and mining enterprises, cement industry and transportation industry to transport various solid block and powdery materials or items. The conveyor belt can work continuously, efficiently even at large angles. The operation of concrete conveyor belt is safe. The conveyor belt is easy to use, easy to maintain, and it can shorten the transportation distance, reduce the project cost and save manpower and material resources. The conveyor belt is easy to use, easy to maintain, and it can shorten the transportation distance, reduce the project cost and save manpower and material resources. The conveyor belt can work continuously, efficiently even at large angles. Belt conveyor is necessary in the production line of gravel and construction waste, and is mainly used to connect the broken equipment of different levels, sand production facilities, and screening equipment.

### 2.4.6 Servo Motor

A servo motor is a type of motor that can rotate with great precision. Normally this type of motor consists of a control circuit that provides feedback on the current position of the motor shaft, this feedback allows the servo motors to rotate with great precision. If you want to rotate an object at some specific angles or distance, then you use a servo motor. It is just made up of a simple motor which runs through a servo mechanism. A servo consists of a Motor (DC or AC), a potentiometer, gear assembly, and a controlling circuit. First of all, we use gear assembly to reduce RPM and to increase torque of the motor. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer. Now an electrical signal is given to another input terminal of the error detector amplifier.


**Figure 4: Servo Motor**

### 2.4.7 Jumper Wires

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed. Fairly simple. In fact, it doesn't get much more basic than jumper wires. Though jumper wires come in a variety of colors, the colors don't actually mean anything. This means that a red jumper wire is technically the same as a black one. But the colors can be used to your advantage in order to differentiate between types of connections, such as ground or power. Jumper wires typically come in three versions, male-to-male, male-to-female and female-to-female. The difference between each is in the end point of the wire. Male ends have a pin protruding and can plug into things, while female ends do not and are used to plug things into. Male-to-male jumper wires are the most common and what you likely will use most often. When connecting two ports on a breadboard, a male-to-male wire is what you'll need. A jump wire is an electrical wire or group of them in a cable with a connector or pin at each end. Wires are used to connect components to each other on the breadboard or other prototypes.

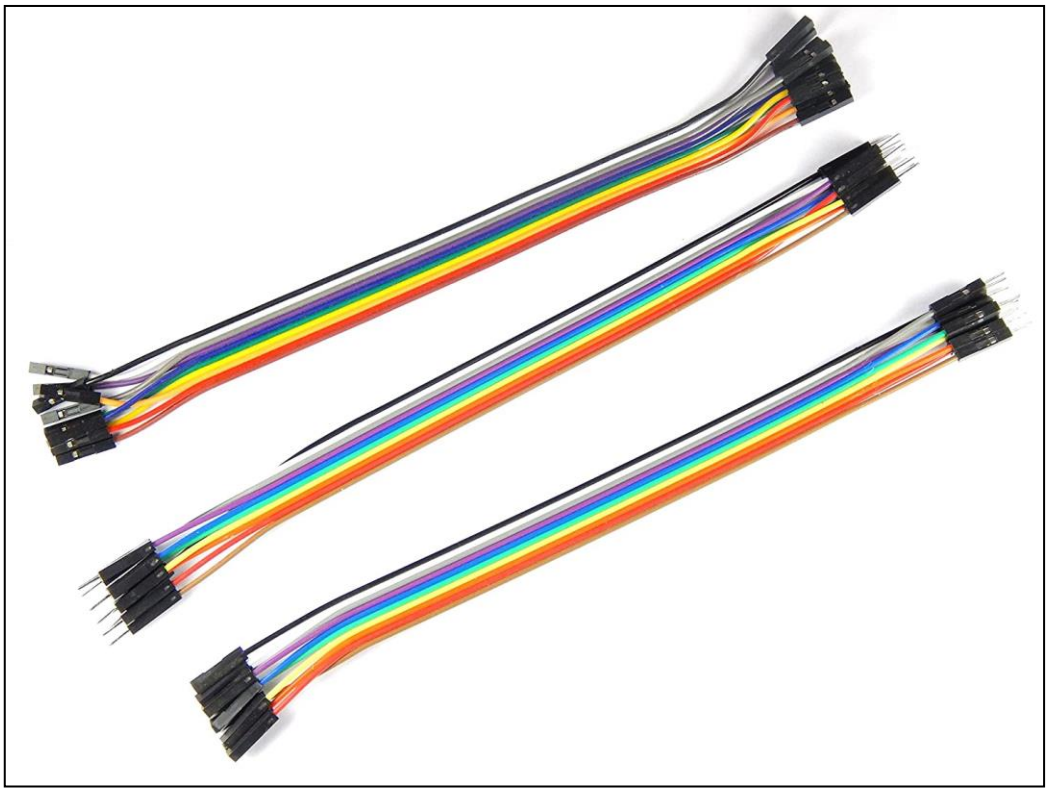

**Figure 5: Jumper Wires**

### 2.4.8 Charging Ports

In this sections, we are going to tell you about different USB cables. USBs are everywhere these days. Smartphones, tablets, music players, and smartwatches, even though they all work differently and serve different purposes, all have one thing in common- USB cables. It is not easy to decide which cable is suitable for your device, but you don't always have to use the one that comes with it. There are multiple options available in the market. They allow a computer to connect to various peripherals like mice, keyboards, flash drives, etc. And now they are also used for charging various devices like smartphones, smartwatches, tablets, earphones, and whatnot.

### 2.4.9 Functions of USB

- Connect devices to a computer to plug and play.
- Transfer data between devices.
- Storing data.
- Device charging.
- Portability

### 2.4.10 Ultrasonic Sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target). In order to calculate the distance between the sensor and the object, the sensor measures the time it takes between the emissions of the sound by the transmitter to its contact with the receiver. The formula for this calculation is **D = ½ T x C** (where **D** is the distance, **T** is the time, and **C** is the speed of sound **~ 343** meters/second). Ultrasonic sensors are used primarily as proximity sensors. They can be found in automobile self-parking technology and anti-collision safety systems. Ultrasonic sensors are also used in robotic obstacle detection systems, as well as manufacturing technology. In comparison to infrared (IR) sensors in proximity sensing applications, ultrasonic sensors are not as susceptible to interference of smoke, gas, and other airborne particles (though the physical components are still affected by variables such as heat). Ultrasonic sensors are also used as level sensors to detect, monitor, and regulate liquid levels in closed containers (such as vats in chemical factories).Most notably, ultrasonic technology has enabled the medical industry to produce images of internal organs.

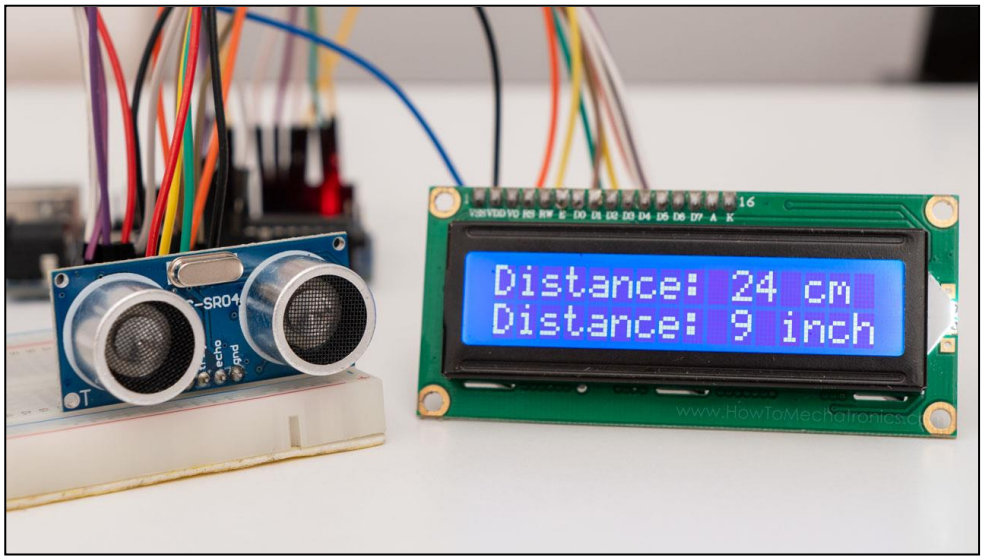


**Figure 6: Ultrasonic Sensor**

# Chapter 3:
# Requirement Analysis

# Chapter 3: Requirement Analysis

## 3.1 Introduction

This chapter covers the requirement of our project. In our proposed system, we'll use two different types of approaches to make the existing system autonomous and smart. Firstly, an ultrasonic sensor. The sensor will detect the level of waste that has been dumped into the container, and if it exceeds a specific level, it will send a notification to the user who control the garbage robot. We are using the reading of ultrasonic sensor to measure how much the garbage bin is filled up. The system helps in saving a lot of time and manpower due to this automated alert from the bins and all the waste collectors have to do is collect the waste from the bins only that are full.

## 3.2 Functional Requirements

Functional requirements define what a software system should do. It defines a function of a software system or its module. Functionality is measured as a set of inputs to the system under test to the output from the system. There are different types of functional requirements.

- Garbage detection
- Low power notification
- Obstacle Detection
- Manual control from mobile app
- WiFi connection Data Processing

### 3.2.1 Garbage detection

It detects the level of the garbage filled within the bin of boat.

### 3.2.2 Low power notification

It gives us a notification through the ESP32 module, when the power of the boat is less than 30%.

### 3.2.3 Obstacle detection

An obstacle detection system uses ultrasonic sensors mounted on the front of boat. When it detect the obstacle it will change its direction. These sensor can measure the distance between the boat and nearby obstacle.

### 3.2.4 Manual control from mobile app

You can control the boat manually from the mobile app

### 3.2.5 WiFi connection and data Processing

It will communicate through WiFi module.

## 3.4 Non Functional Requirements

The non-functional requirement says about “what a system should be” rather than “what a system should do” (functional requirement). They are mostly derived from functional requirements based on input from the customer and other stakeholders. There are many kind of non-functional requirements.

## 3.5 Types of Non-functional Requirements

- Performance
- Availability
- Usability
- Maintainability
- Supportability
- Compatibility
- Operability
- Security

### 3.5.1 Performance

A performance attribute type of non-functional requirement measures system performance.

### 3.5.2 Availability

The availability is the numeral factor that can be calculated. It requires the ability of the system to fully commit to its recommended performance of some time. Availably describes how likely the system is accessible to a user at a given point in time.

### 3.5.3 Usability

Usability measures the usability of the software system being developed.

### 3.5.4 Maintainability

Maintainability of a software system is the ease with which the system can be maintained.

### 3.5.5 Supportability

Serviceability is possible if the system is developed to facilitate serviceability.

### 3.3.6 Compatibility

The system will be compatible with all kinds of browsers.

### 3.3.7 Operability

To make the system more operable, automated as well as manual functional handling is added. In case of any crash of main module, a user can manually add details of subject. This helps in better handling of the system and it increases the factor of availability.

### 3.3.8 Security

Security is a non-functional requirement assuring all data inside the system or its part will be protected against malware attacks or unauthorized access.

# Chapter 4:
# System Design

# Chapter 4: System Design

## 4.1 Introduction

Design is a meaningful engineering representation of something that is to be built. It is the most crucial phase in the developments of a system. Software design is a process through which the requirements are translated into a representation of software. Design is a place where design is fostered in software Engineering. Based on the user requirements and the detailed analysis of the existing system, the new system must be designed. This is the phase of system designing. Design is the perfect way to accurately translate a customer's requirement in the finished software product. Design creates a representation or model, provides details about software data structure, architecture, interfaces and components that are necessary to implement a system. The logical system design arrived at as a result of systems analysis is converted into physical system design.

## 4.2 Architectural Design

The garbage collector system design was achieved basing on the collected User requirements, and a detailed analysis of the existing methods of waste monitoring. These Requirements and the results of the analysis were synthesized to come up with a structured system design of the proposed prototype. The Structured system design was employed and its aim was to obtain a blueprint of the system being developed. In this stage the study employed use of workflow diagram, use case diagrams, sequence diagram, Data Flow diagrams and Class Diagrams. The Hardware components include Arduino UNO, sensors and a wireless module for data communication. The development was done on a windows environment using the Arduino IDE employing C language of development.

## 4.3 Detailed Design

Unified Modeling Language (UML) was used to design the diagrams based on Object Oriented concepts. To elaborate the functionalities of the system, diagrams such as use case diagrams, activity diagrams, sequence diagrams had been used. Such design diagrams are useful to capture requirements and to ensure that the system meets those requirements. Detailed design is the phase where the design is refined and plans, specifications and estimates are created. Detailed design will include outputs such as 2D

and 3D models, P & ID's, cost build up estimates, procurement plans etc. This phase is where the full cost of the project is identified.

## 4.4 Data Flow Diagram

DFD or Data Flow Diagram is the representation of the data flowing throughout the system. DFD includes data inputs and outputs, data stores, and the various sub-processes the data movement. DFDs are represented using standardized symbols and notation to describe various entities and their relationships. The workflow design depicts the flow of data and information through the system. It caters for the logical developer design options and defines actions of given decisions and information process flows. DFD are categorized by many different levels. Most basic level is level 0. The diagram get gradually complex and elaborated as the level increases. Level 0 is called as context diagram. It provides broad to be easily understandable.

### 4.4.1 Level 0

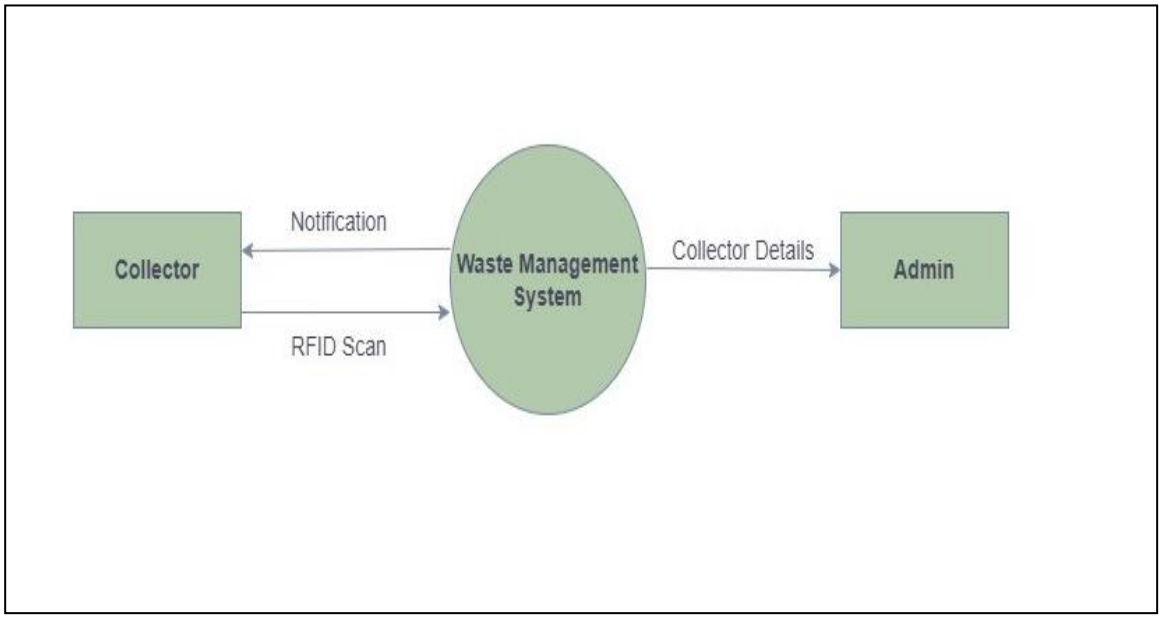


**Figure 7: Level 0**

### 4.4.2 Level 1

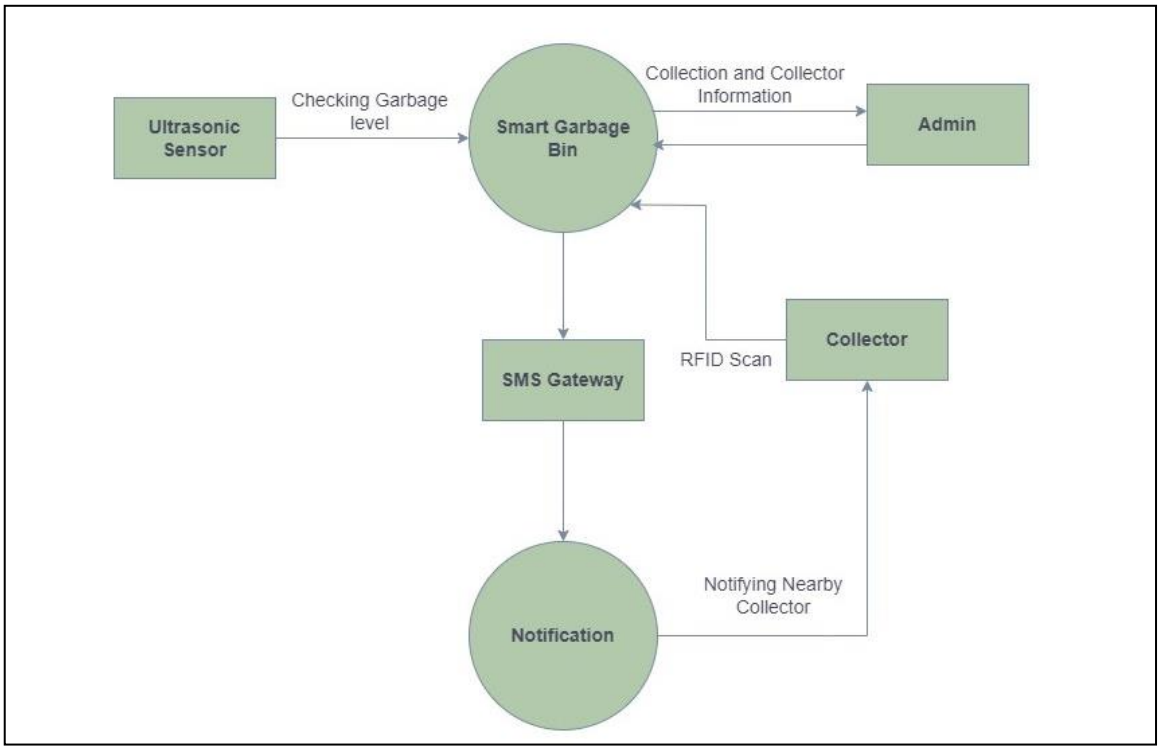


**Figure 8: Level 1**

## 4.5 Use Case Diagram

In the Unified Modeling Language (UML), a use case diagram can summarize the details of your system's users (also known as actors) and their interactions with the system. To build one, you'll use a set of specialized symbols and connectors. Using a case diagram is very important for any project or system as it describes and visually tells how the external user can interact with the system and who has the access or rights to which module of the system. This type of UML diagram should provide an overall overview of the relationship between actors and systems, making it a great tool for explaining the system to non-technical audiences. Application services are consumed by actors or other application services and the application use case diagram provides added richness in describing application functionality by illustrating how and when that functionality is used. It illustrates the activities performed by the users of the System that is the functional requirements from a user's perspective.

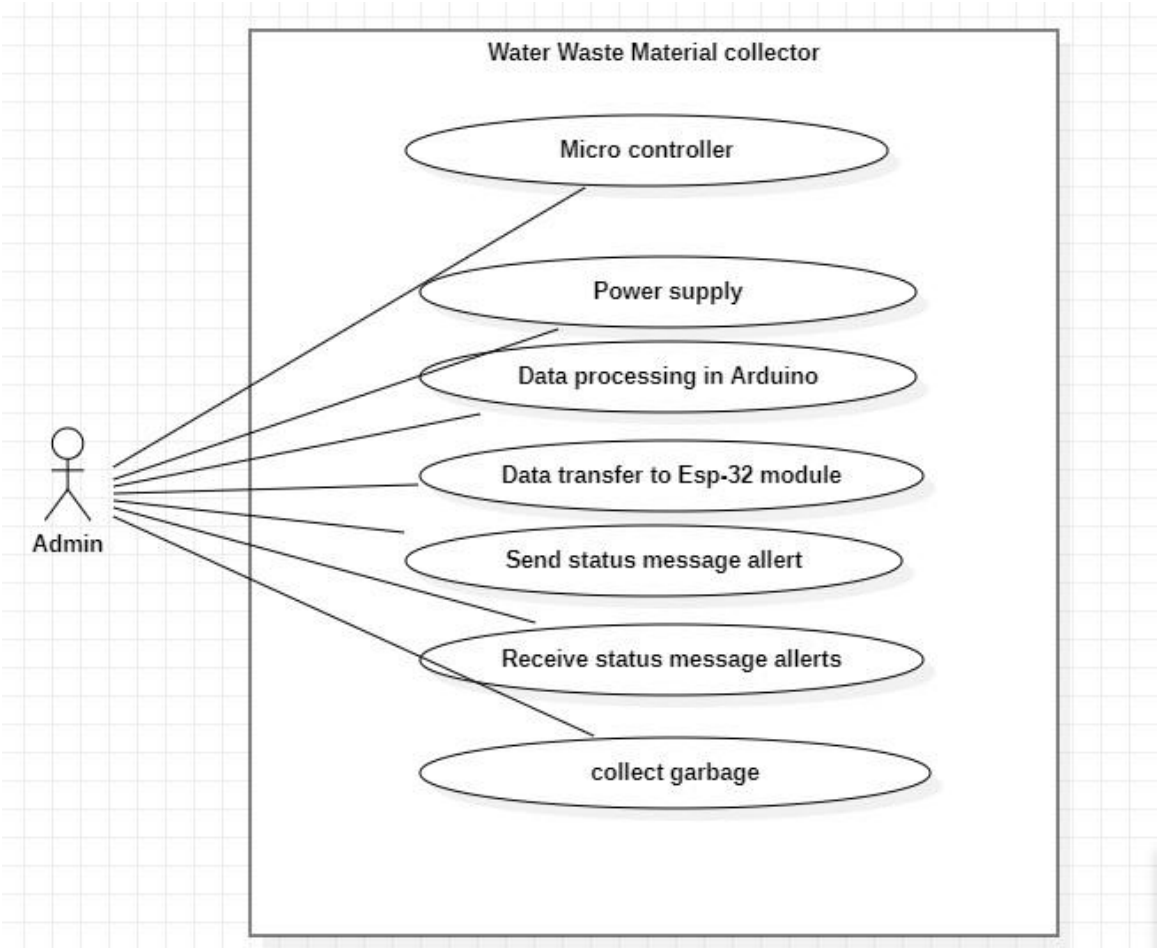


**Figure 9: Use Case Diagram**

## 4.6 Activity Diagram

Activity diagram is another important behavioral diagram in UML diagram to describe dynamic aspects of the system. An activity diagram visually presents a series of actions or flow of control in a system. Activity diagrams are often used in business process modeling. Activities modeled can be sequential and concurrent. In both cases an activity diagram will have a beginning **(an initial state)** and an end **(a final state)**. User actions were grasped by the activity diagrams. The activity diagram in describes the trash collection request process. Further describes hand over garbage use case, which is initiated by bin full notification sent by the trash bin. A small filled circle followed by an arrow represents the initial action state or the start point for any activity diagram. Activity diagram is essentially an advanced version of flow chart.

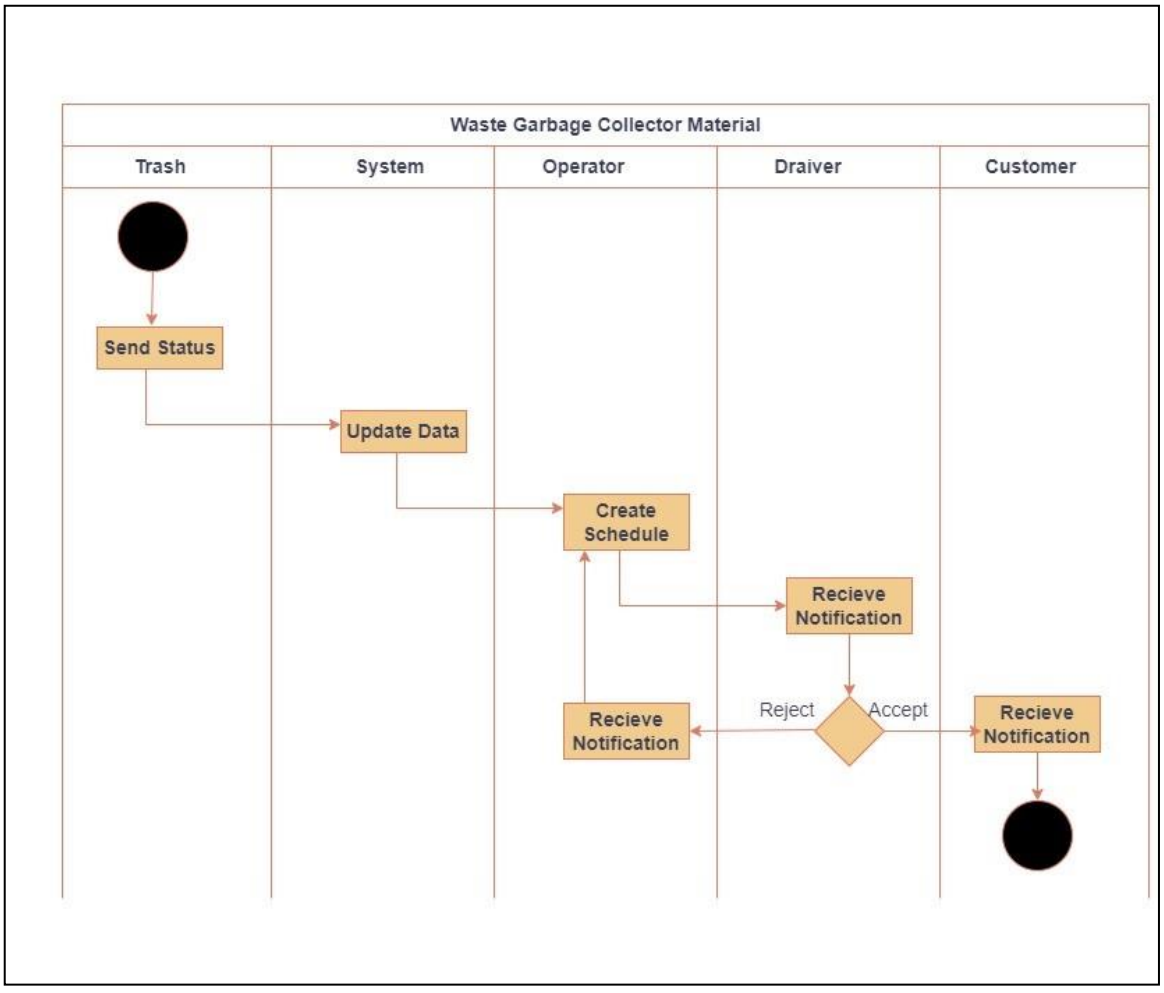


**Figure 10: Activity Diagram**

## 4.7 Sequence Diagram

A sequence diagram, also known as an event diagram or an event scenario, represents the order in which objects interact. UML Sequence Diagrams are interaction diagrams that detail how operations are carried out. They capture the interaction between objects in the context of a collaboration. Sequence Diagrams are time focus and they show the order of the interaction visually by using the vertical axis of the diagram to represent time. One can visually represent simple runtime in this manner. The ESP-32 module informs the collector of the level of garbage, and an ultrasonic sensor checks the waste level. When the collector arrives, he scans the tag, which is attached with the garbage container. The RFID reader tells the system to send SMS notification to the user and the server when collector arrives and is collected. High-level interactions between user of the system and the system, between the system and other systems, or between subsystems (sometimes known as system sequence diagrams).

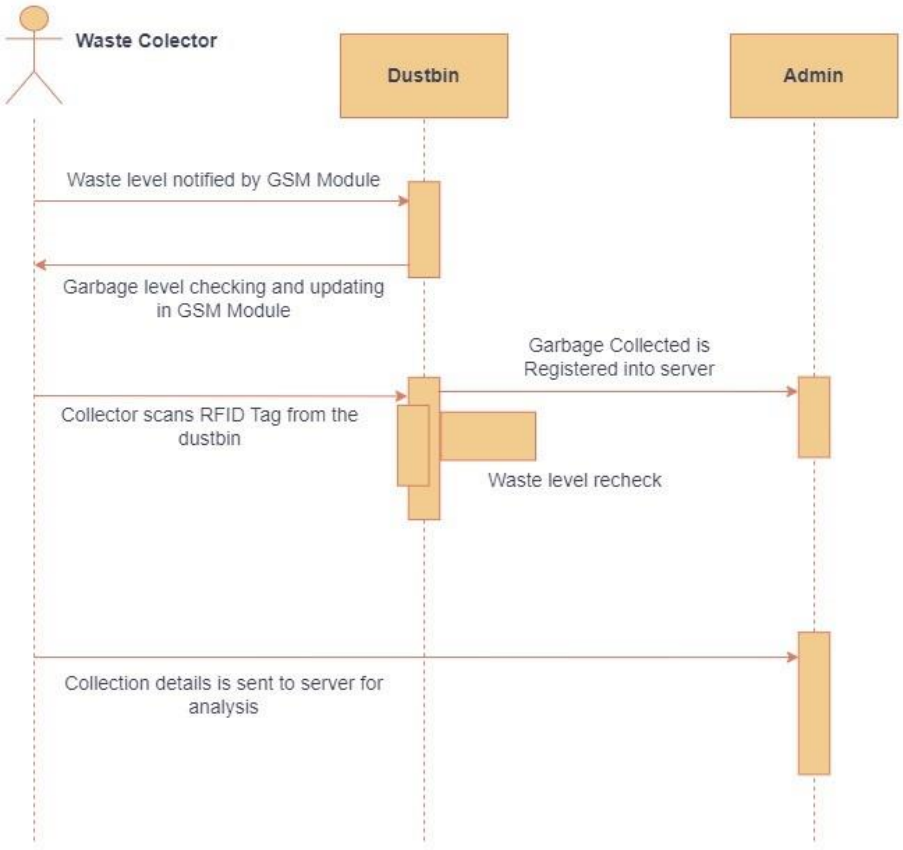


**Figure 11: Sequence Diagram**

## 4.8 Class Diagram

Class diagram is a static diagram. It represents the static view of an application. Class diagram is not only used for visualizing, describing, and documenting different aspects of a system but also for constructing executable code of the software application. These are representations that are used to show hierarchical relationships. A class diagram is also used to show other relationships like whole/part 'has a' relationship using aggregation and composite connectors , interaction 'uses' relationships with dependency arrows, or associations with connecting lines. Class diagrams are one of the most useful types of diagrams in UML as they clearly map out the structure of a particular system by modeling its classes, attributes, operations, and relationships between objects. Class diagrams are type of structure diagram what must be present in the system being modeled.

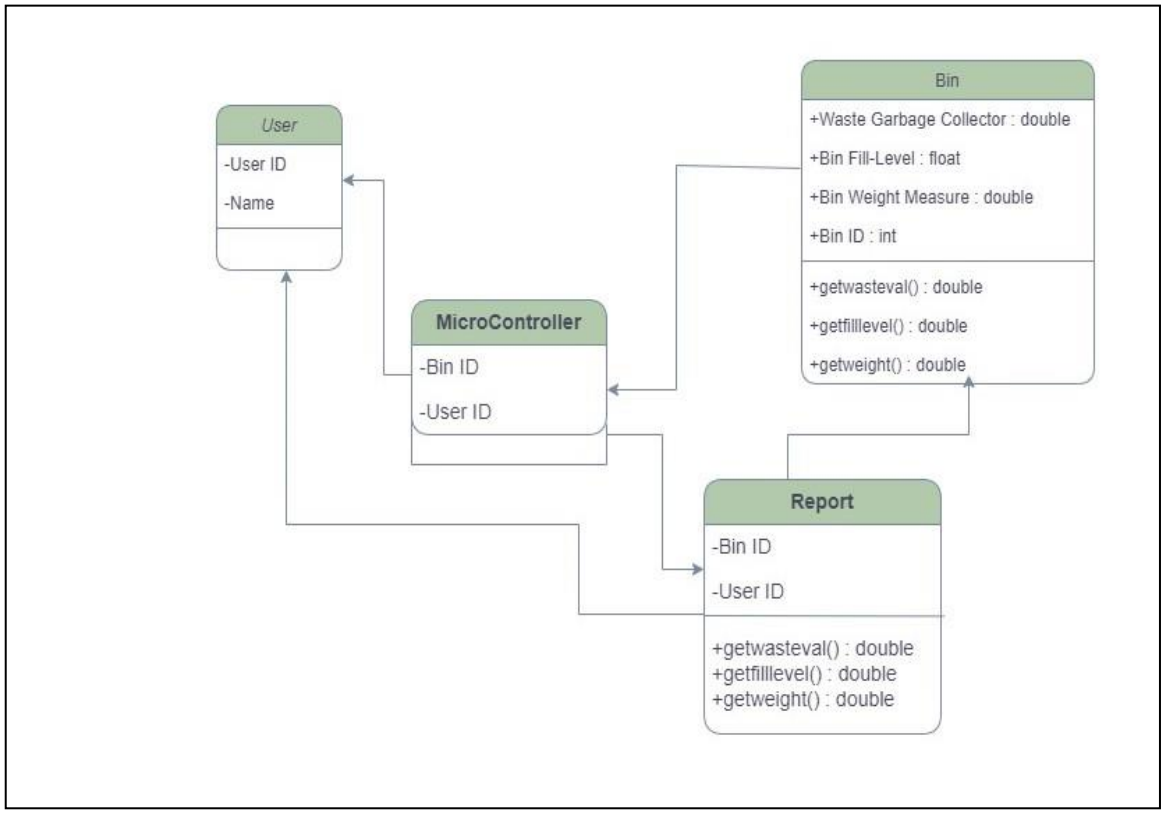


**Figure 12: Class Diagram**

### 4.9 Block Diagram

A block diagram is a drawing illustration of a system whose major parts or components are represented by blocks. These blocks are joined by lines to display the relationship between subsequent blocks. A block diagram is a specialized, high-level flowchart used in engineering. It is used to design new systems or to describe and improve existing ones. Its structure provides a high-level overview of major system components, key process participants, and important working relationships. We use block diagrams to visualize the functional view of a system. It uses blocks connected with lines to represent components of a system. With a block diagram, you can easily illustrate the essential parts of a software design or engineering system and depict the data flow in a process flow chart. You can learn everything about a block diagram, including its uses and types. Check out some of its most used examples and learn how to create your block diagram. Being simple and easy to understand, Block Diagrams are used in most industries to illustrate functional processes in respective fields. Next, we will look at three most areas that make use of block diagrams.

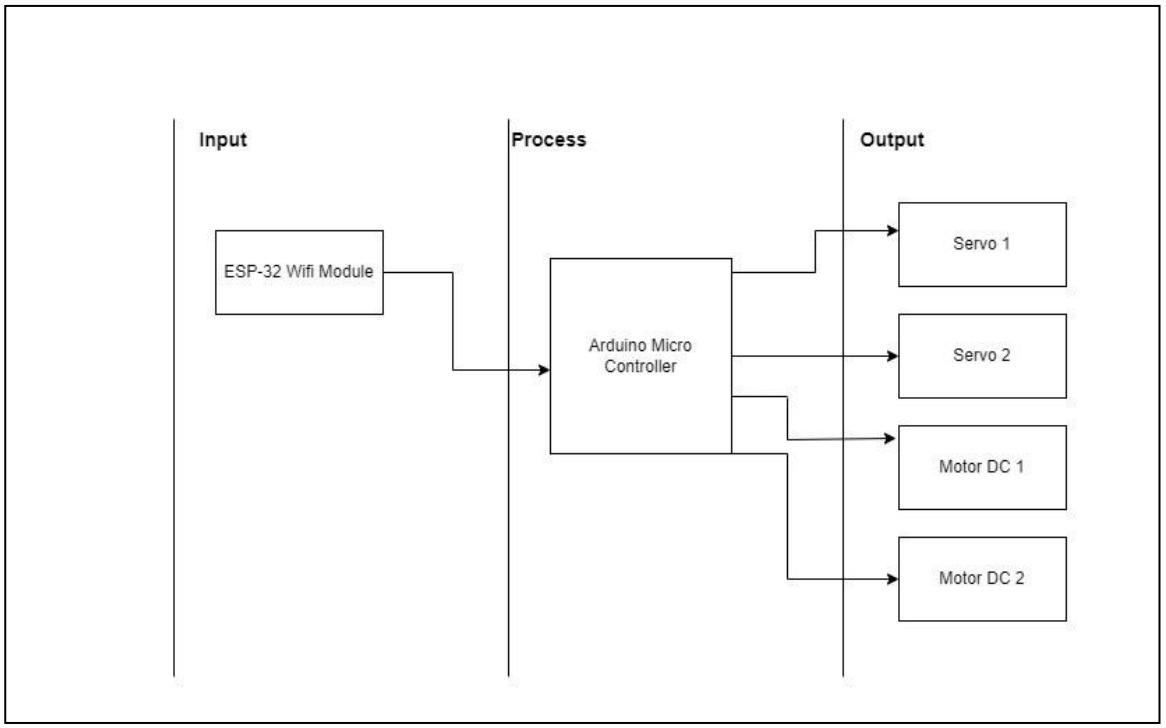


**Figure 13: Block Diagram**

# Chapter 5: Implementations

# Chapter 5: Implementation

## 5.1 Flow control

To implement flow control for a water waste material collector using an ESP32 WiFi cam project, you would typically need additional hardware components such as flow sensors and valves, along with the ESP32 board. Here's a general outline of the flow control process:

### 5.1.1 Hardware setup

Connect the flow sensor(s) to the ESP32 board. Flow sensors usually have separate pins for power, ground, and signal.

### 5.1.2 Software development

- Install the programming tools and libraries on the ESP32 board. For ESP32 development, Platform and the Arduino IDE are frequently employed.
- Create the code necessary to set up the WiFi connection and camera features on the ESP32.

### 5.1.3 Alert and notification

It will generate notification on mobile app when the bin within the boat is empty and full. Mobile app will also show the button to operate the ship like (forward, backward, left, right) directions. Mobile app also have button to on and off the conveyor belt.

### 5.1.4 Remote monitoring and control

Access the IoT platform through a web or mobile application to remotely monitor the ship and control the flow control mechanisms. This enables the user to collect the waste material from the water automatically rather than manually. The user continuously monitor the ship through mobile app.

## 5.2 Pseudo Codes

Pseudocode is a simplified, high-level description of a program's logic or algorithm that uses natural language instead of specific programming syntax. It helps in planning and understanding the flow of a program without focusing on the exact syntax or implementation details. Some of the screenshots of our project code are as follow:

### 5.2.1 ESP-32 WiFi module coding

There are some screenshots of the Esp-32 wifi module.

```
#include <dummy.h>

/*

  This is a simple MJPEG streaming webserver implemented for AI-Thinker ESP32-CAM and
  ESP32-EYE modules.
  This is tested to work with VLC and Blynk video widget.

  Inspired by and based on this Instructable: $9 RTSP Video Streamer Using the ESP32-CAM Board
  (https://www.instructables.com/id/9-RTSP-Video-Streamer-
  Using-the-ESP32-CAM-Board/)

  Board: AI-Thinker ESP32-CAM

*/

#include "src/OV2640.h"
#include <WiFi.h>
#include <WebServer.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include <Arduino.h>
#include <driver/adc.h>
// Select camera model
//#define CAMERA_MODEL_WROVER_KIT
//#define CAMERA_MODEL_ESP_EYE
//#define CAMERA_MODEL_M5STACK_PSRAM
//#define CAMERA_MODEL_M5STACK_WIDE
#define CAMERA_MODEL_AI_THINKER
#define BLYNK_PRINT Serial
#define BLYNK_TEMPLATE_ID "TMPL6pPQY1Q8Q"
#define BLYNK_TEMPLATE_NAME "ESP32 CAM AI THINKER"
#define BLYNK_AUTH_TOKEN "NybBdMV4vu8TR7uT4R3t0TmGIYqgDZTB"
#include "camera_pins.h"
```

Ln 295, Col 13

```
/*
Next one is an include with wifi credentials.
This is what you need to do:

1. Create a file called "home_wifi_multi.h" in the same folder   OR   under a separate subfolder of the "libraries" folder of Arduino IDE. (You are creating a "fake"
library really - I called it "MySettings").
2. Place the following text in the file:
3. Save.

Should work then
*/
#define SSID1 "ali"
#define PWD1 "12345678"
// #include "home_wifi_multi.h"
int previousValueX = 0;
int previousValueY = 0;
#define SERIAL_RX_BUFFER_SIZE 64

OV2640 cam;

WebServer server(80);

const char HEADER[] = "HTTP/1.1 200 OK\r\n" \
                      "Access-Control-Allow-Origin: *\r\n" \
                      "Content-Type: multipart/x-mixed-replace; boundary=123456789000000000000987654321\r\n";
const char BOUNDARY[] = "\r\n--123456789000000000000987654321\r\n";
const char CTNTTYPE[] = "Content-Type: image/jpeg\r\nContent-Length: ";
const int hdrLen = strlen(HEADER);
const int bdrLen = strlen(BOUNDARY);
const int cntLen = strlen(CTNTTYPE);
int LEFT = 0;
int RIGHT = 0;
int FORWARD = 0;
int BACKWARD = 0;
```

```
BLYNK_WRITE(V1) {
  int pinValue = param.asInt();
  if (pinValue == 1) {
    digitalWrite(4, HIGH);
  } else {
    digitalWrite(4, LOW);
  }
}
BLYNK_WRITE(V14) {
  int pinValue = param.asInt();
  Serial.println(pinValue);
}
BLYNK_WRITE(V10) {
  int pinValue = param.asInt();
  Serial.println(pinValue);

  if (pinValue == 1) {
    FORWARD = 1;
  } else {
    FORWARD = 0;
  }
}
BLYNK_WRITE(V11) {
  int pinValue = param.asInt();
  Serial.println(pinValue);

  if (pinValue == 1) {
    RIGHT = 1;
  } else {
    RIGHT = 0;
  }
}
BLYNK_WRITE(V12) {
```

Ln 47, Col 6

```
}
BLYNK_WRITE(V12) {
  int pinValue = param.asInt();
  Serial.println(pinValue);

  if (pinValue == 1) {
    BACKWARD = 1;
  } else {
    BACKWARD = 0;
  }
}
BLYNK_WRITE(V13) {
  int pinValue = param.asInt();
  Serial.println(pinValue);

  if (pinValue == 1) {
    LEFT = 1;
  } else {
    LEFT = 0;
  }
}



void print(int value, char axis){
    if (axis == 'x' && previousValueX != value){
      if(value == 1){
        Serial.println("R");
      }else if(value == -1){
        Serial.println("L");
      }else if(value == 0){
        Serial.println("S");
      }
      previousValueX = value;
```

```
    }
}

void handle_jpg_stream(void)
{
  char buf[32];
  int s;

  WiFiClient client = server.client();

  client.write(HEADER, hdrLen);
  client.write(BOUNDARY, bdrLen);

  while (true)
  {
    if (!client.connected()) break;
    cam.run();
    s = cam.getSize();
    client.write(CTNTTYPE, cntLen);
    sprintf( buf, "%d\r\n\r\n", s );
    client.write(buf, strlen(buf));
    client.write((char *)cam.getfb(), s);
    client.write(BOUNDARY, bdrLen);
  }
}

const char JHEADER[] = "HTTP/1.1 200 OK\r\n" \
                       "Content-disposition: inline; filename=capture.jpg\r\n" \
                       "Content-type: image/jpeg\r\n\r\n";
const int jhdLen = strlen(JHEADER);

void handle_jpg(void)
{
  WiFiClient client = server.client();
```

## 5.2.2 Arduino Uno code

```
// Starting of Program
// MOTOR 1
int m1a = 2;
int m1p = 3;
int m1b = 4;
// MOTOR 2
int m2a = 5;
int m2p = 6;
int m2b = 7;

// Belt Pin
int beltPin = 8;
const float minVoltage = 7.0;
const float maxVoltage = 7.8;
//Battery Percetage Pin
int batteryPin = A0;
char val;

void setup()
{
pinMode(m1a, OUTPUT);  // Digital pin 10 set as output Pin
pinMode(m1p, OUTPUT);  // Digital pin 11 set as output Pin
pinMode(m1b, OUTPUT);  // Digital pin 11 set as output Pin
pinMode(m2a, OUTPUT);  // Digital pin 12 set as output Pin
pinMode(m2b, OUTPUT);  // Digital pin 13 set as output Pin
pinMode(m2p, OUTPUT);  // Digital pin 13 set as output Pin
pinMode(beltPin, OUTPUT);
pinMode(11, OUTPUT);
Serial.begin(9600);
}

void loop()
{
  int batteryValue = analogRead(A0);
```

```
  int batteryValue = analogRead(A0);
  // Map the voltage to percentage
  float batteryVoltage = (batteryValue * 7.4) / 1023.0;
  float batteryPercentage = ((batteryVoltage - 6.0) / (8.4 - 6.0)) * 100;
  // Serial.println(batteryVoltage);
  Serial.println(batteryPercentage);
  // Serial.println(voltage);
  digitalWrite(11, HIGH);
  while (Serial.available() > 0)
  {
  val = Serial.read();
  Serial.println(val);
  }

  if( val == 'F') // Forward
    {
      digitalWrite(m1a, LOW);
      digitalWrite(m1b, HIGH);
      digitalWrite(m1p, 100);
      digitalWrite(m2a, HIGH);
      digitalWrite(m2p, 100);
      digitalWrite(m2b, LOW);
    }
  else if(val == 'B') // Backward
    {
      digitalWrite(m1a, HIGH);
      digitalWrite(m1b, LOW);
      digitalWrite(m1p, 100);
      digitalWrite(m2a, LOW);
      digitalWrite(m2p, 100);
      digitalWrite(m2b, HIGH);
    }

    else if(val == 'L') //Left
    {
```

```
    else if(val == 'L') //Left
    {
      digitalWrite(m1a, LOW);
      digitalWrite(m1b, HIGH);
      digitalWrite(m1p, 100);
      digitalWrite(m2a, LOW);
      digitalWrite(m2p, 100);
      digitalWrite(m2b, HIGH);
    }
    else if(val == 'R') //Right
    {
      digitalWrite(m1a, HIGH);
      digitalWrite(m1b, LOW);
      digitalWrite(m1p, 100);
      digitalWrite(m2a, HIGH);
      digitalWrite(m2p, 100);
      digitalWrite(m2b, LOW);
    }

  else if(val == 'S') //Stop
    {
    digitalWrite(m1a, LOW);
    digitalWrite(m1b, LOW);
    digitalWrite(m1p, 0);
    digitalWrite(m2a, LOW);
    digitalWrite(m2b, LOW);
    digitalWrite(m2p, 0);
  }
  else if(val == '1')
  {
    digitalWrite(8, HIGH);
  }
  else if(val == '0')
  {
    digitalWrite(8, LOW);
```

```
      digitalWrite(m1a, LOW);
      digitalWrite(m1b, HIGH);
      digitalWrite(m1p, 100);
      digitalWrite(m2a, LOW);
      digitalWrite(m2p, 100);
      digitalWrite(m2b, HIGH);
    }
    else if(val == 'R') //Right
    {
      digitalWrite(m1a, HIGH);
      digitalWrite(m1b, LOW);
      digitalWrite(m1p, 100);
      digitalWrite(m2a, HIGH);
      digitalWrite(m2p, 100);
      digitalWrite(m2b, LOW);
    }

  else if(val == 'S') //Stop
    {
    digitalWrite(m1a, LOW);
    digitalWrite(m1b, LOW);
    digitalWrite(m1p, 0);
    digitalWrite(m2a, LOW);
    digitalWrite(m2b, LOW);
    digitalWrite(m2p, 0);
  }
  else if(val == '1')
  {
    digitalWrite(8, HIGH);
  }
  else if(val == '0')
  {
    digitalWrite(8, LOW);
  }
}
```

## 5.3 Components, Libraries, Web services and Stubs

### 5.3.1 Components

Following are the components that are used in our projects.

**DC to DC Buck converter**

A DC-to-DC converter called the Buck Converter is made to step-down convert applied DC input. A buck converter's output voltage is always smaller than its input voltage because the fixed dc input is lowered to a particular dc output voltage when it is applied. Therefore, the Buck converter is sometimes referred to as a step-up chopper or a step-down converter.

Bulk converters' effective power conversion increases battery life and decreases heat production. Therefore, it is mostly favored for the manufacturing of tiny devices. It has a ton of awesome uses. It is frequently used in switched-mode power supplies, or SMPS, where the needed output dc voltage is lower than the input dc voltage.

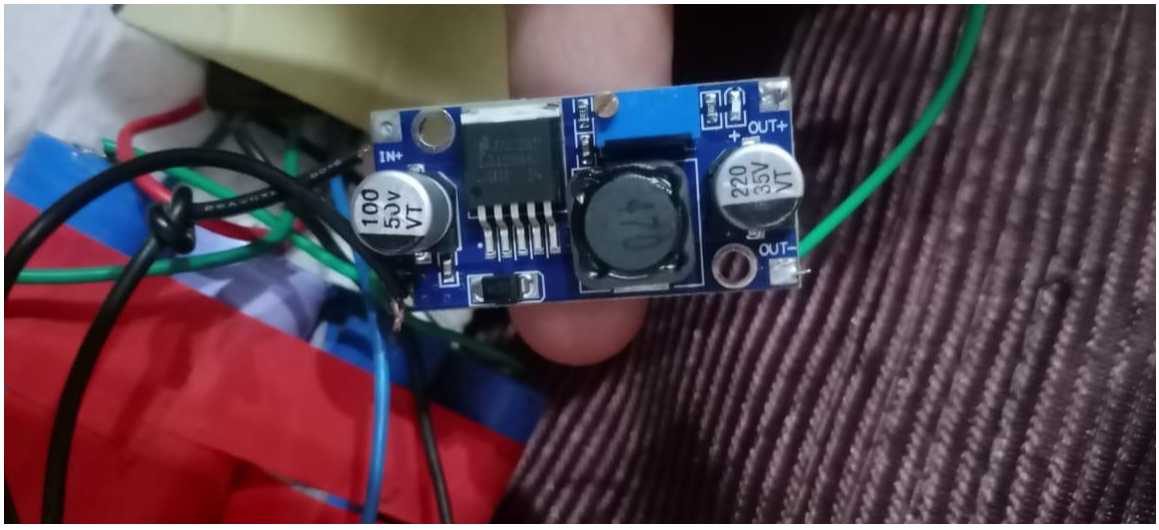


**Figure 14: DC to DC Buck converter**

**Arduino UNO**

A microcontroller board called Arduino UNO is based on the ATmega328P. It contains 6 analogue inputs, a 16 MHz ceramic resonator, 14 digital input/output pins (six of which can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button. It comes with everything needed to support the microcontroller; to get started, just plug in a USB cable, an AC-to-DC adapter, or a battery. You can experiment with your UNO without being overly concerned that you'll make a mistake; in the worst case, you can replace the chip for a few dollars and start over. The Arduino programming language is based on a very simple hardware programming language called processing, which is similar to the C language.

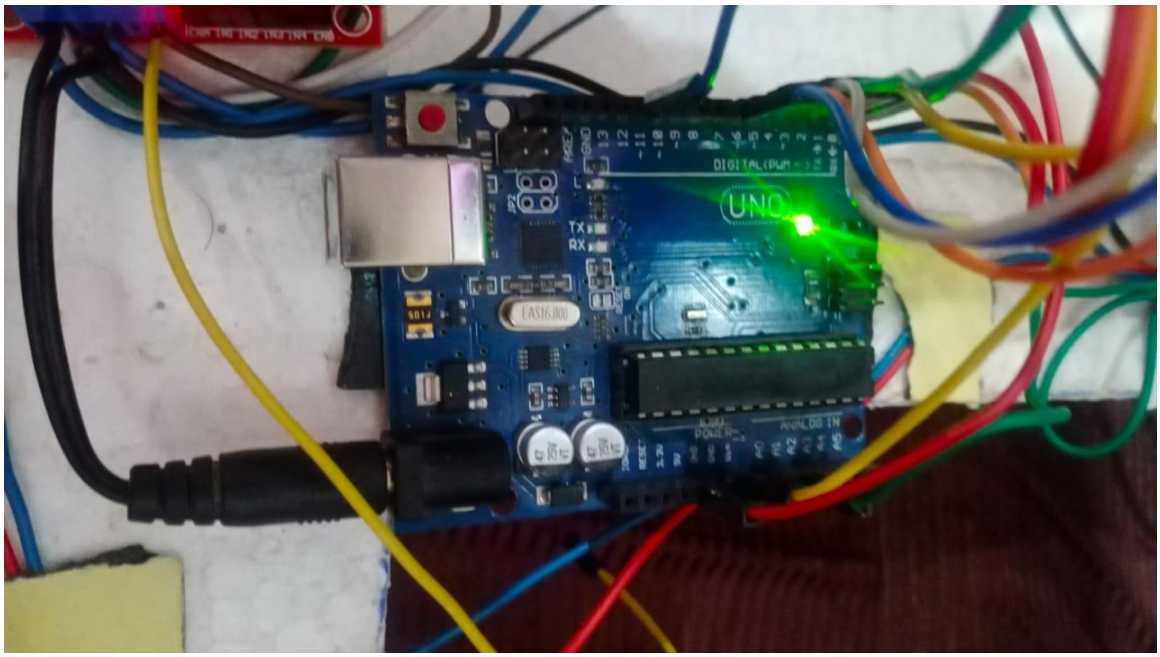


**Figure 15: Arduino**

**Resistance**

The obstruction to current flow in an electrical circuit is measured by resistance. The Greek letter omega () represents the unit of measurement for resistance, known as ohms. Georg Simon Ohm (1784–1854), a German physicist who investigated the connection between voltage, current, and resistance, is the name given to the unit of resistance.

**Figure 16: Resistance**

## Cell

The basic cell of a battery uses two pieces of different metal – known as the cathode (positive) and the anode (negative). Internally, they are kept separate, but both are in contact with the same electrolyte where chemical reactions take place which create the electrical charge.

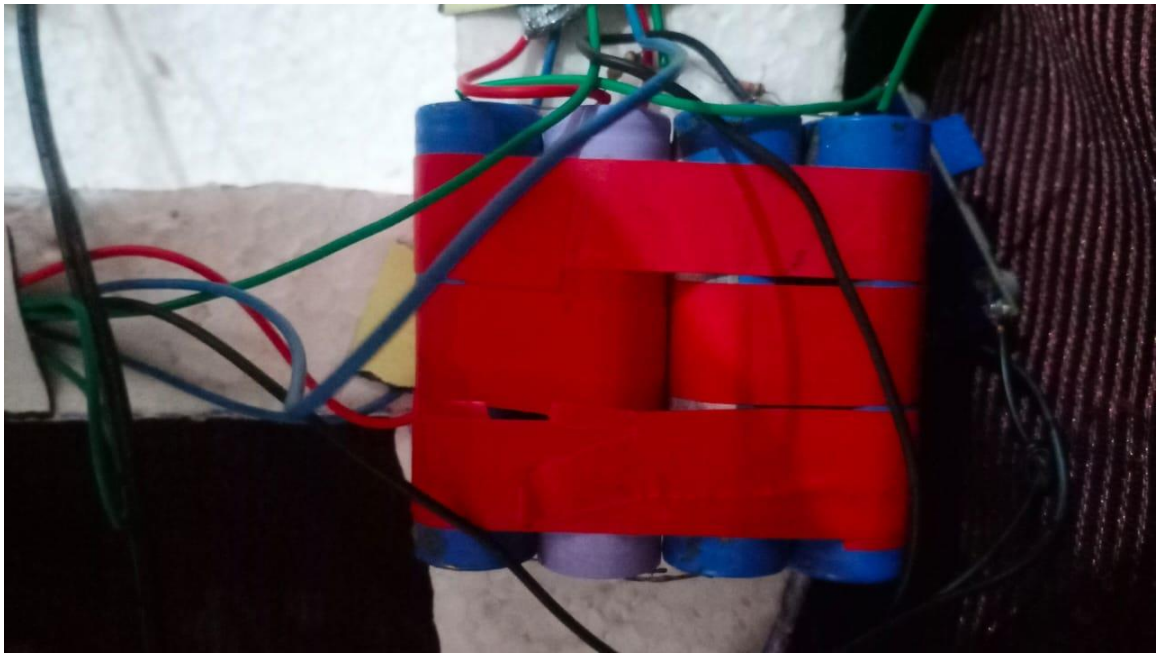

**Figure 17: Cell**

## Prototype Images

**Figure 18: Prototype Pic1**

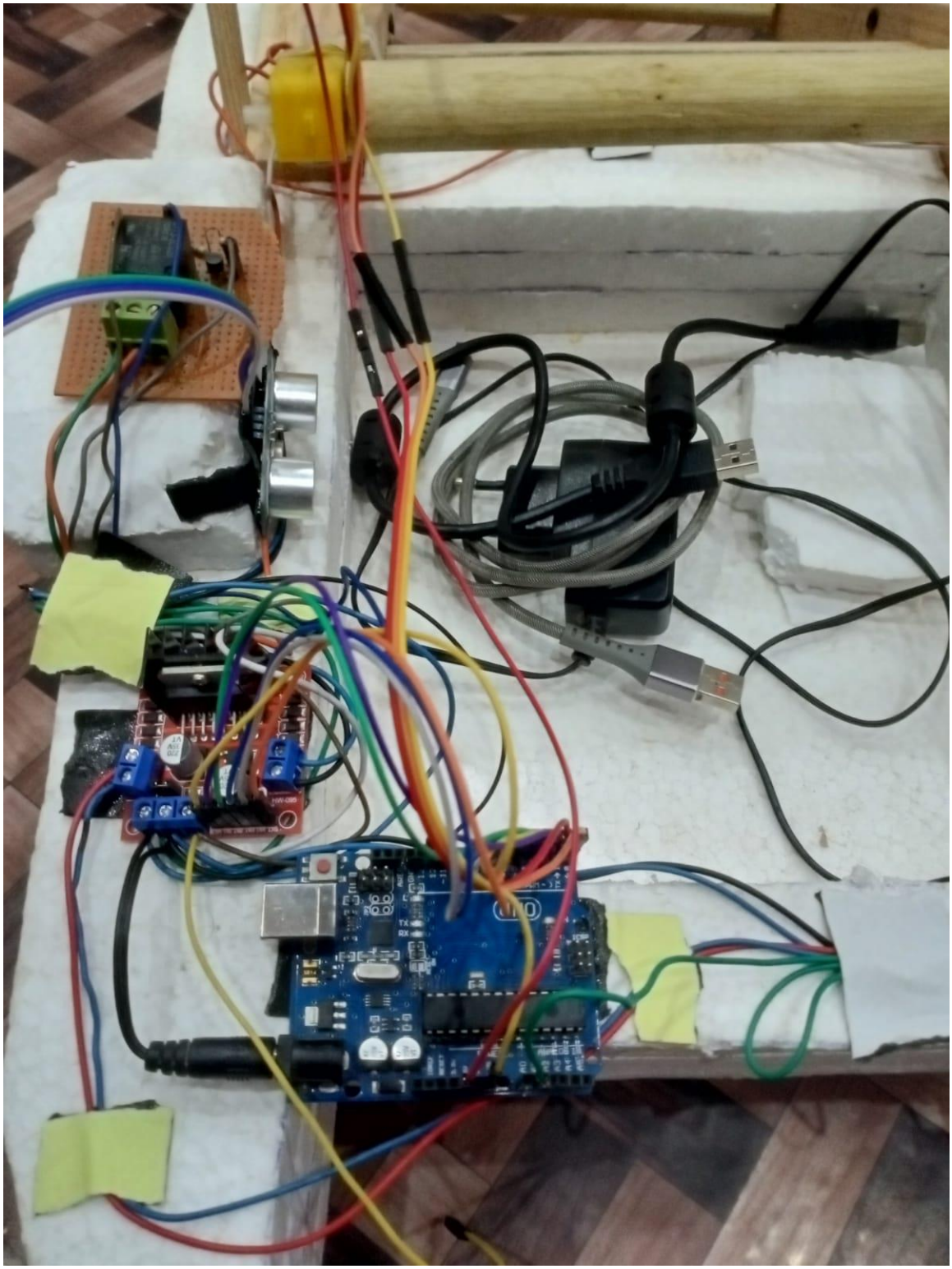

**Figure 19: Prototype Pic2**

### 5.3.2 Web Services / Mobile App

We create mobile applications using the Blynk platform to manage and control our hardware projects. It offers a drag-and-drop interface so users don't need to have a deep understanding of coding to create personalized mobile apps. You may build engaging and responsive apps using the wide range of widgets and functionality provided by Blynk. You may link your hardware, including ESP32, Arduino, Raspberry Pi, and other devices, to the Blynk cloud server using Blynk. Your hardware and the cloud server are connected by the Blynk app. Through the Blynk app, which is available for iOS and Android smartphones, you can then remotely manage and keep an eye on your hardware.

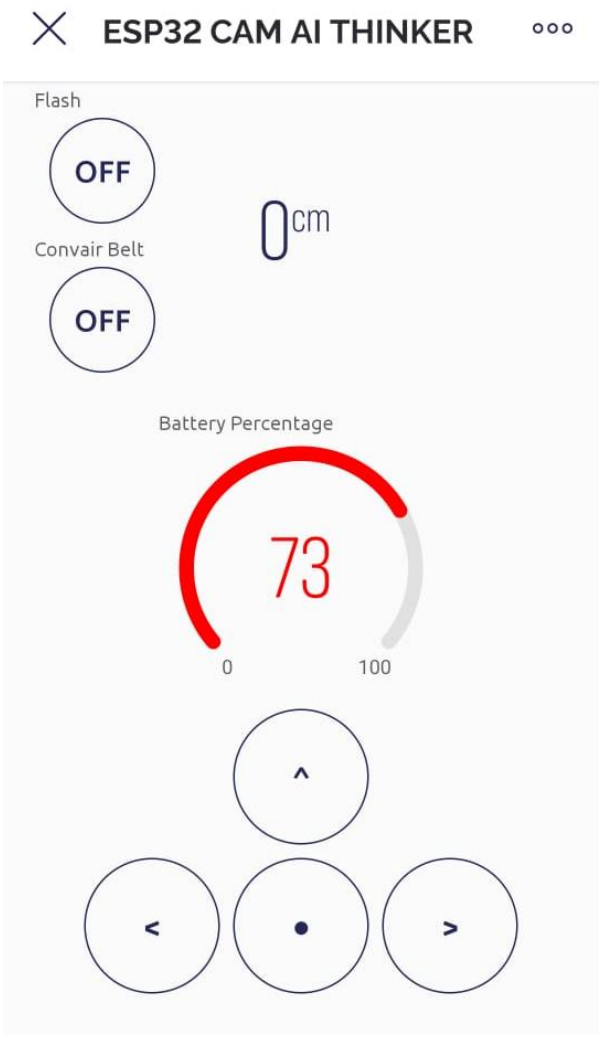


**Figure 20: Mobile App**

## 5.4 Code Layer

### 5.4.1 Presentation layer

Following are the elements that can be considered as a part of presentation layer.

**HTTP Responses:**

The code uses the server.send() function to send HTTP responses with appropriate content types and messages. For example, in the handleNotFound() function, it constructs a message indicating the server status and sends it as a response to the client.

**Image Streaming:**

The code includes functions such as handle_jpg_stream() and handle_jpg() that are responsible for serving image data to clients over HTTP. These functions use specific HTTP headers and send the image data to the client, enabling the presentation of the video stream or individual images.

**Serial Output:**

The code uses Serial.println() to output debug messages or control signals over the serial connection. These messages can be viewed in the serial monitor, providing a form of text-based presentation for debugging and monitoring purposes.

### 5.4.2 Business logic layer

In our code, the business logic layer is responsible for controlling the motors, monitoring the battery voltage, and responding to user commands received through the serial interface. The following parts can be considered as the business logic layer:

- Motor Control Logic
- Battery Monitoring Logic
- User Input Handling

**Motor Control Logic:**

The code contains conditional statements (if and else if) that determine the behavior of the motors based on the value of Val received from the user. It sets the appropriate values for the motor control pins (m1a, m1b, m1p, m2a, m2b, m2p) to control the direction and speed of the motors.

**Battery Monitoring Logic:**

The code reads the analog value from battery Pin to measure the battery voltage. It then maps the voltage to a percentage using a formula. This logic calculates the battery voltage and percentage to monitor the battery level.

**User Input Handling:**

The code checks for available data in the serial buffer (Serial.available()) and reads the value (Val) from the serial interface. Based on the received value, it executes the corresponding motor control logic.

### 5.4.3 Data Management/Access Layer

Following are the elements that can be considered as part of the data management or access management layer. These elements include:

**Variable Declarations:**

The code declares and initializes various variables (m1a, m1p, m1b, m2a, m2p, m2b, beltPin, minVoltage, maxVoltage, batteryPin, val) to store and manage data related to motor control, battery voltage, and user input.

**Pin Mode Configuration:**

The code uses the pinMode() function to configure the I/O pins (m1a, m1p, m1b, m2a, m2b, m2p, beltPin, 11) as output or input pins, enabling data transfer between the microcontroller and external components such as motors and sensors.

**Serial Communication:**

The code utilizes the Serial object and the Serial.begin() function to establish serial communication with an external device (e.g., computer, smartphone). This enables the transmission and reception of data between the microcontroller and the external device.

# Chapter 6:
# Testing and Evaluation

# Chapter 6: Testing and Evaluation

## 6.1 Introduction

Testing is a technique to make sure that the final product is defect-free and that it actually complies with expectations. It entails the human or automatic execution of software, system components in order to evaluate one or more interesting properties. In contrast to actual requirements, testing's goal is to find flaws, gaps, or missing requirements.

## 6.2 List of test scenarios

There are three types of test scenarios that we conduct to gather the functionality of our project.

- Ship's bin test scenarios
- Ship's battery test scenarios
- Mobile app test scenarios

### 6.2.1 Ship's bin test scenarios

Following are the test scenerios that can be performed by the prototype.

| Step | Test case description | Input | Requirements | Testcase status |
|---|---|---|---|---|
| **1** | Sends an allert message and display on the mobile app as garbage bin is empty. | Null | Ship bin should not have waste in it. | pass |
| **2** | Sends an allert message and display on the mobile app as garbage bin is medium. | Filling | Ship bin should be filled to its intermediate level. | pass |
| **3** | Sends an allert message and display on the mobile app as garbage bin is full. | Filled | Ship bin should be filled to maximum level. | pass |

**Table 1: Bin test scenarios**

These are the test that we perform to check the performance of our project. An ultrasonic sensor will detect the level of garbage within the bin of the boat. Ultrasonic sensor will generate a notification when the bin of the boat is empity and full.

### 6.2.2 Prototype battery test scenerios

| Step | Test case description | Input | Requirements | Testcase status |
|---|---|---|---|---|
| **1** | Sends an allert message and display on mobile app as ship's battery is full. | Full | Battery is full | pass |
| **2** | Sends an allert message and display on mobile app as ship's battery is low. | Low | When battery is less than 25% | pass |

**Table 2: Battery Test**

### 6.2.3 Mobile app test scenario

Table 3 show the test case for mobile app. Following test are performed to check mobile app functinality.

| Step | Test case description | Expected result | Testcase status |
|---|---|---|---|
| **1** | User clicks "power" button | Ship start | pass |
| **2** | User clicks "forward" button | Ship move forward | pass |
| **3** | User clicks "backward" button | Ship move backward | pass |
| **4** | User clicks "left" button | Ship move left | pass |
| **5** | User clicks "right" button | Ship move right | pass |
| **6** | User clicks "ON" button | Camera of the ship start | pass |
| **7** | User clicks "start" button | Conveyer belt start | pass |

**Table 3: Mobile App**

## 6.3 Performance and Evaluation

### 6.3.1 Functional testing

Functional testing is a type of software testing that focuses on verifying that the system or application under test (AUT) functions correctly and meets the specified functional requirements. It is concerned with testing the behavior and functionality of the software, ensuring that it performs as intended and meets the user's expectations. The purpose of functional testing is to validate that the individual functions or features of the software work as expected and produce the correct outputs or outcomes. It involves testing various inputs and conditions to verify if the system behaves correctly, produces the desired results, and handles different scenarios appropriately.

Functional testing can be performed at various levels, such as unit testing (testing individual components or modules), integration testing (testing the interaction between multiple components), and system testing (testing the entire system as a whole).

- Camera functionality testing
- Real-time Monitoring and Feedback Testing
- Sensor Integration Testing
- User Interface Testing
- Power Management Testing
- Environmental Testing

- **Camera functionality testing**
  To make sure the ESP32 WiFi camera module can effectively record photos or movies, test its fundamental operation. Make sure the camera module is properly installed, connected, and configured, and that it can take pictures of the desired resolution and quality.
- **Real-time Monitoring and Feedback Testing**
  This involve verifying the transmission of live video streams, displaying real-time data or alerts, and ensuring timely notifications or feedback to the user.

- **Sensor integration testing**

  Test the integration and operation of sensors that the water waste material collection may have, such as proximity sensors and ultrasonic sensor. Ensure that sensor data is accurately recorded and used to prompt the right decisions or actions.

- **User interface testing**

  Test the features of the system's user interface such as, a mobile app. To provide a seamless and simple user experience, test user activities such as taking pictures, starting actions, changing settings, and viewing real-time data.

- **Power management testing**

  Test the power management capabilities of the ESP32 module. Verify that the system operates efficiently and conserves power when not actively capturing or transmitting data. Check the effectiveness of sleep modes, power-saving configurations, and battery life.

- **Environmental Testing**

  Test the water waste material collector under various environmental situations that it might experience. For the system to operate consistently in various locations, this includes varied lighting conditions, temperature ranges, humidity levels, and potential interference elements.

- **Alert and notification system**

  Test the system’s ability to generate alerts and notifications based on predefined threshold or abnormal condition, such as notifying users about low battery and garbage bin level.

### 6.3.2 Non-functional testing

When conducting non-functional testing for a water waste material collector using an ESP32 WiFi cam, we focus on evaluating the system's performance and other non-functional aspects. Here are some non-functional testing types that we can consider:

- Performance Testing
- Usability Testing

- Compatibility Testing
- Reliability Testing
- Scalability Testing
- Interoperability Testing

- **Performance Testing**

  Evaluate the system's performance under different conditions, such as varying loads or network speeds. Measure response times, throughput, and resource utilization to ensure the system meets performance expectations.
- **Usability Testing**

  By evaluating the system's usability, intuitiveness, and user satisfaction, determine how user-friendly it is. This testing may entail asking prospective consumers for input, conducting usability tests, and conducting user surveys.
- **Compatibility Testing**

  To make sure the system works properly in a variety of settings, test its compatibility with various hardware, browsers, and platforms. This involves evaluating the device's compatibility with various computers, tablets, and smartphones.
- **Reliability Testing**

  Test the system's capacity to regularly do its intended tasks without failing in order to confirm its dependability. This involves testing for system instability, error handling, and crash detection.
- **Scalability Testing**

  Determine the system's ability to handle increasing workloads and a growing number of connected devices. This ensures that the system can accommodate future expansion and usage demands.
- **Interoperability Testing**

  Test the ability of the system to interact and integrate with other systems or components. This ensures that the water waste material collector can effectively communicate with other devices, such as central servers or databases.

# Chapter 7:
# Conclusion and Outlook

# Chapter 7: Conclusion and Outlook

## 7.1 Introduction

One of the biggest issues produced by humanity in the world is water waste. The biggest threats to both wildlife and people is polluted water, which endangers both health and lives. Therefore, it is crucial to conduct more research on water waste reduction. The aim of this project is to propose a method for collecting floating garbage that helps reduce water waste.

## 7.2 Achievements and Improvements

### 7.2.1 Achievements

This prototype have several potential achievements. Some of them are follow:

- Efficient waste collection
- Real-time monitoring
- Automated alert system
- Environmental impact

#### 7.2.1 Real-time monitoring

Water bodies can be continuously monitored with the ESP32 WiFi camera. It can assist authorities or individuals in keeping track of the garbage accumulation and taking prompt action by delivering live video feed or photos to a central monitoring system or a mobile app.

#### 7.2.2 Automated alert system

The ESP32 WiFi cam can be integrated with an alert system that automatically sends notifications or alerts when a certain threshold of waste accumulation is reached. This feature can help prompt clean-up efforts or preventive measures.

#### 7.2.3 Environmental impact

The overall environmental impact can be minimized by successfully deploying a water waste material collector using the ESP32 WiFi cam. The amount of waste items

collected, the number of pollution incidents avoided, or the improvement in the water quality of the monitored area can all be used to quantify this accomplishment.

#### 7.2.4 Efficient waste collection

The ESP32 WiFi cam is programmed to gather specific types of waste materials, such as plastics or debris, in water bodies. Achieving a high accuracy in waste collection can be considered a significant achievement.

Improvements.

## 7.2.2 Improvements

There are several possible improvements in water waste material collector project. Few of them are follow:

- Enhanced camera functionality
- Real time monitoring and alerts
- Remote control and automation
- Cloud connectivity
- Energy efficiency

#### 7.2.2.1 Enhanced waste detection

A higher resolution camera module or other functions like night vision are upgradeable for the ESP32 Wi-Fi cam. This would make it possible to identify and monitor water waste materials more effectively.

#### 7.2.2.2 Rael time monitoring and alerts

Real-time monitoring of the gathered waste materials might be added to the project. The system may identify critical levels of garbage accumulation or detect particular types of waste by integrating sensors or image recognition algorithms. The necessary staff can then receive alerts or notifications to take prompt action.

#### 7.2.2.3 Remote control and automation

The collection can be remotely operated or automated by fusing the ESP32 with actuators or motorized parts. It might be configured, for instance, to empty itself when the waste

capacity reaches a given point or to start cleaning processes. This will assure effective waste management and lessen the need for physical intervention.

#### 7.2.2.4 Cloud connectivity

The ESP32 can store, process, and analyze gathered data by connecting to a cloud platform. Additionally, via mobile devices or online interfaces, it enables remote access to and operation of the waste material collection from any location.

#### 7.2.2.5 Energy efficiency

The battery life or energy requirements of the ESP32 and related components can be increased or decreased by optimizing their power consumption. Implementing sleep modes, utilizing low-power components, or incorporating renewable energy sources like solar panels are a few examples of how to do this.

### 7.2.3 Critical review

- Accuracy of Waste Detection
- Reliability and Durability
- Connectivity and Data Transmission
- Data Storage and Management

#### 7.2.3.1 Accuracy of Waste Detection

It is essential that the project be able to reliably detect and identify various waste products. Any restrictions or errors in the identification algorithms or image processing methods could lead to inadequate or incorrect waste data, which would result in poor waste management decisions.

#### 7.2.3.2 Reliability and durability

Important factors to take into account are the waste material collector system's dependability and longevity. It ought to be built to resist a range of environmental factors and long durations of continuous use. The overall reliability of the system may be impacted by design flaws or component weaknesses that frequently cause faults or breakdowns.

#### 7.2.3.3 Connectivity and data transmission

The project may face difficulties due to its dependency on Wi-Fi connectivity for data transmission. The system's capacity to successfully transfer data may be impacted by problems including signal interference, network outages, or insufficient Wi-Fi coverage. It is crucial to evaluate the project's ability to sustain a connection and guarantee uninterrupted data transmission.

#### 7.2.3.4 Data storage and management

A water waste material collecting project requires effective data management and storage technologies. Data storage capacity, data retention policies, data retrieval methods, and backup plans should all be covered by the project. Effective data management ensures that important waste data is accessible and available for analysis and decision-making.

## 7.4 Future recommendation

- Automated Sorting and Recycling
- Energy Harvesting and Efficiency
- Enhanced User Interface and Experience
- Advanced Waste Detection and Classification

### 7.4.1 Automated Sorting and Recycling

Create systems for the collector system's automated garbage sorting and recycling. Use robotic arms or actuators to distinguish between recyclable and non-recyclable items, increasing the effectiveness and efficiency of waste separation.

### 7.4.2 Energy Harvesting and Efficiency

To power the ESP32 Wi-Fi camera and lessen reliance on batteries, look at the use of energy collecting devices such as solar panels or kinetic energy converters. In order to maximize environmental protection and prolong battery life, continue to optimize power use.

### 7.4.3 Enhanced User Interface and Experience

Continually enhance the user interface to make it more accessible, simple to use, and intuitive. Include features that improve user experience and promote simpler data

understanding, such as interactive dashboards, adjustable settings, and data visualization tools.

### 7.4.4 Advance waste detection and classification

To increase the accuracy of trash identification and classification, look into integrating cutting-edge technology like artificial intelligence and machine learning. This can entail using deep learning algorithms for more accurate identification or training models to recognize particular waste items.

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