Environment Friendly Semi-automated Robotic Lake Surface Cleaner for Enhancing Aquatic Life: A Bangladesh's Perspective

Md. Asif Imtiyaj Chowdhury

ID: 2019-3-60-115

Mridul Ranjan Karmakar

ID: 2018-3-60-021

Shafika Sikander

ID: 2019-3-60-057

Prianka Sarker

ID: 2019-3-60-076

A Capstone project report submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering

Department of Computer Science and Engineering
East West University
Dhaka-1212, Bangladesh

November 2023

Declaration

We, **Md. Asif Imtiyaj Chowdhury, Mridul Ranjan Karmakar, Shafika Sikander, and Prianka Sarker,** hereby declare that the work presented in this capstone project report is the outcome of the investigation performed by us under the supervision of **Dr. Md. Hasanul Ferdaus**, Assistant Professor, Department of Computer Science and Engineering, East West University. I/we also declare that no part of this project has been or is being submitted elsewhere for the award of any degree or diploma, except for publication.

Countersigned

. . . . . .

Dr. Md. Hasanul Ferdaus

Supervisor

Signature

. . . . . .

Md. Asif Imtiyaj Chowdhury

(2019-3-60-115)

Signature

. . . . . .

Mridul Ranjan Karmakar

(2018-3-60-021)

Signature

. . . . . .

Shafika Sikander

(2019–3–60–057)

Signature

. . . . . .

Prianka Sarker

(2019-3-60-076)

Signature

Letter of Acceptance

The capstone project report entitled " Environment Friendly Semi-automated Robotic Lake Surface Cleaner for Enhancing Aquatic Life: A Bangladesh's Perspective" submitted by Md. Asif Imtiyaj Chowdhury, Mridul Ranjan Karmakar, Shafika Sikander, and Prianka Sarker to the Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh, is accepted for the partial fulfillment of the requirement for the degree of Bachelor of Science in Computer Science and Engineering on (07/11/2023).

Board of Examiners

1. _____

Dr. Md. Hasanul Ferdaus (Capstone Project Supervisor)

Assistant Professor
Department of Computer Science and Engineering,
East West University

2. _____

Dr Maheen Islam (Chairperson)

Chairperson & Associate Professor
Department of Computer Science and Engineering,
East West University

Abstract

Currently In Bangladesh, the deterioration of water bodies, especially lakes, poses a significant threat to aquatic life and ecosystem health. This study introduces an innovative solution aimed at improving water quality and restoring the balance of aquatic ecosystems. We have developed a semi-automated robotic lake surface cleaner equipped with infrared (IR) sensors and a trash bin collector. This robotic system effectively targets and removes floating debris and pollutants from the lake's surface, preventing the accumulation of harmful substances and enhancing water quality.

The IR sensors enable the robot to navigate autonomously while avoiding obstacles, ensuring efficient coverage of the entire lake surface. The collected waste is stored in a dedicated trash bin, which can be easily emptied, minimizing human intervention. This technology presents a sustainable and eco-friendly approach to lake maintenance, reducing the need for manual labor and the use of harmful chemicals. In Bangladesh's context, this innovation holds the potential to revitalize deteriorating lakes and promote the well-being of aquatic life, benefiting both the environment and local communities.

Acknowledgments

We would like to express our deepest appreciation and gratitude to all those who have supported us in completing our project titled **" Environment Friendly Semi-automated Robotic Lake Surface Cleaner for Enhancing Aquatic Life: A Bangladesh's Perspective."**

We wish to express our sincere gratitude to Dr. Md. Hasanul Ferdaus, our esteemed project supervisor, whose indispensable direction, assistance, and motivation have been integral throughout the duration of this project. Dr. Md. Hasanul Ferdaus's profound erudition, adeptness, and unwavering commitment to the subject have profoundly contributed to our comprehension of the intricacies inherent in the subject matter, thereby furnishing us with invaluable perspectives for the realization of a triumphant project outcome. We extend our heartfelt appreciation for his sagacious mentorship and judicious counsel, steadfastly provided during the entire trajectory of this endeavor.

We would also like to express our gratitude to our fellow colleagues, Md. Asif Imtiyaj Chowdhury, Mridul Ranjan Karmakar, Shafika Sikander, and Prianka Sarker, for our contributions and collaboration throughout the project. Their hard work, dedication, and commitment to the project have been instrumental in its success. We are fortunate to have worked with such a talented and hardworking team.

Furthermore, we extend our acknowledgement to the individuals whose active engagement facilitated the process of data acquisition integral to our study. Their invaluable contributions stand as an indispensable cornerstone, without which the realization of this project would have remained unattainable. The allocation of their time, diligent exertions, and collaborative disposition in furnishing us with the essential dataset merits our profound esteem, as it substantively facilitated the execution of our investigative pursuits.

Additionally, we would like to thank the developers of the open-source tools and libraries we used in this project. Their hard work, dedication, and contribution to the development of these tools have made our work easier and more efficient.

Finally, we would like to thank our friends and family for their continuous support and encouragement throughout our academic journey. Their unwavering support and encouragement

have been a source of motivation for us, and we are grateful for their support.

In closing, our profound gratitude extends to our parents, whose ceaseless backing, inspiration, and supplications have been unwavering. A multitude of other individuals have similarly exhibited steadfast support and companionship in diverse manners, intricately interwoven with our scholastic journey, either through direct or indirect means. Their enduring presence shall be enshrined within our hearts, and we anticipate identifying a more fitting avenue to accord them due recognition in subsequent endeavors.

In conclusion, we would like to thank everyone who has contributed to this project in one way or another. Your support, guidance, and contribution have been invaluable, and we are grateful for your support.

Md. Asif Imtiyaj Chowdhury
November 2023

Mridul Ranjan Karmakar
November 2023

Shafika Sikander
November 2023

Prianka Sarker
November 2023

Table of Contents

List of Figures

List of Tables

List of Algorithms

1. Yolo V8
2. Ultrasonic sensor with DC motor
3. Trash level detection
4. Wi-fi controlled navigation

List of Acronyms

MP	Microplastic
IoT	Internet of Thing

Chapter 1

Introduction

In this modern era, digital devices, whether automated, semi-automated robots are very much needed and useful from different perspectives and in various environments. This kind of modern technology devices are used to do such work that humans cannot do it so easily. Manual cleaning of water garbage is inefficient, time consuming, laborious, and expensive. Besides, manual cleaning laborers are facing health and hygiene issues that have become severely affected. Health impacts also include musculoskeletal, intestinal and vector borne diseases in addition to injuries caused as a result of work-related accidents. Instead of manual cleaning, semi-automated and automated devices are less time consuming and can-do critical work more safely. This waterproof designed machine can easily be used for cleaning the water surface, and it can help to the lives of the water from plastic and pollution. To less the water pollution, this kind of semi-automated water surface garbage collector device has the characteristic of floating in the water surface and moving on the surface. and can classify the garbage based on whether it is plastic bottle or not, collect the classified garbage from the water surface and load that garbage to its trash box. In an agricultural country, this device can be used in many fisheries, swimming pools and ponds, or any chilled water area. So, developing and using such a device will not only for time efficient and reduce health issues; it will also help to maintain the ecological balance of water through modern technology.

1.1 Background

Water is a precious natural resource that is essential for all life on Earth. Despite having an abundance of water, water contamination is a major problem in many regions. In many ways, water bodies are being polluted by various floating items such as garbage, weeds, debris plastic, sewage, effluents, and toxic materials from industries around us. In developing nations, water contamination by floating debris is a significant problem that

requires rapid response. The management and enhancement of lake/river waterbodies depend on accurate quantification. Thus, effective planning and management of water resources are urgently needed. To do this, we must guarantee that watershed resources are used sustainably. Models that are accurate and trustworthy could help with this.

The majority of Bangladesh now has access to clean drinking water from technically sophisticated sources of water in 98 percent of cases. Nevertheless, the water is of poor quality. 80 percent of private piped water taps studied nationwide contained E. coli bacteria, which is comparable to the prevalence of the bacterium in pond water [1]. Moreover, one-third of Bangladesh's young children are truncated, which hinders their capacity to study and grow. Bangladesh has made significant progress in increasing access to water, and by concentrating on improving the standard of water and sanitation, it can build on this success. People are additionally impacted by preexisting arsenic in groundwater because 13 percent of the nation's water sources have arsenic levels that are above Bangladesh's limit. The divisions in Chittagong and Sylhet are especially affected by arsenic exposure. The frequency and severity of natural catastrophes that affect water and sanitation systems are rising due to climate change. A quarter of residents in high-risk regions of the country migrate to contaminated, subpar water sources during disasters. The poor are most impacted by the saline intrusion that coastal areas are experiencing. Open defecation has been successfully eradicated in Bangladesh. Even still, only 28% of toilets have soap and water, and around 50 million individuals use shared, primitive restrooms. Slums in metropolitan settings have limited access to sanitary facilities and clean water. Slums in large cities have the highest incidence of adolescent undernourishment in the nation and five times less access to improved sanitation [1].

Figure 1: Buriganga River water in the dry season

Over the past few years, water contamination in bodies of water has significantly increased. The water quality index further asserts that the river water is unsafe for drinking, bathing, or fishing. Cleaning water bodies manually is ineffective, time-consuming, exhausting, and expensive. Moreover, in developing nations, water contamination by floating debris is a significant problem that requires rapid response. In contrast to impairments brought on by work-related accidents, health implications also include musculoskeletal, digestive, and vector-borne infections. This necessitates methods for automating the current river surface cleaning infrastructure at low cost with basic hardware used by laypeople and the general public.

The origin of life is water. Almost 71% of the surface of the world is covered by oceans and rivers, which are perfect habitats for billions of marine environments [2]. Humanity, however, does not handle the aquatic environment well. Human irresponsibility has been leading to an increase in water pollution for many years. Dredge, industrial waste, sewage, radioactive contaminants, and plastic rubbish make up the debris in the water [3]. The WHO estimates that 97% of the people of Bangladesh have access to water and only 40% have proper sanitation. With a staggering 60% of the population that has to endure unsafe drinking water, the nation is in danger. The availability of this water

greatly fluctuates throughout the year as the warmer season brings massive amounts of water in frequent monsoons and the cooler season brings drought. The infrastructure cannot adequately deal with the barrage of water in monsoon season, so the water is not saved for the drier months. Of the available water, over 80 percent is used for agriculture [4].

Figure 2: Major sources of water pollution in Bangladesh [5]

The percentage of people using drinking water from an improved source that is accessible on premises, available when needed, and free from faucal and priority chemical contamination Improved water sources include piped water, boreholes, or tube wells, protected dug wells, protected springs, and packaged or delivered water [6].

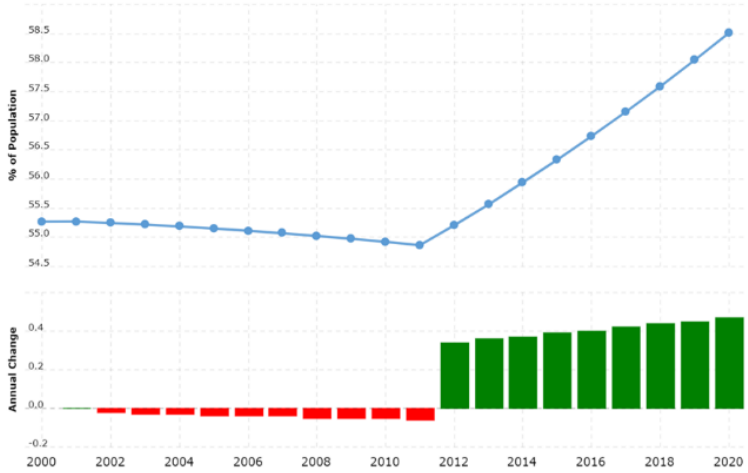

Figure 3: Statistics of Clean Water of Bangladesh [6]

Figure 3 represents the four years between 2017 and 2020. The provided data gives information on the percentage of Bangladeshis who have access to clean water. The information shows the percentage of the population who have access to safe and clean drinking water each year, as well as the percentage growth in access to clean water from the year before. Bangladesh reportedly has 57.15 percent access to clean water in 2017. This indicates that about 57.15 percent of the population had access to safe, high-quality drinking water. According to the data, access to clean water has increased by 0.42% since 2016 as well. In 2018, Bangladesh had 57.59% access to clean water. With a 0.44% rise in access to clean water from 2017, this shows a minor improvement over the previous year. Even if the growth is only slight, it shows that the population's access to clean water is getting wider.

Bangladesh's availability to clean water in 2019 increased to 58.04%. This represented a 0.45% rise over 2018 and indicated a continuance of the trend in favor of increasing access to clean water. Access to clean water in Bangladesh reached 58.51% in 2020. This was an increase of 0.47% from 2019 and maintained the rising trend in access to clean water over the preceding four years. For four years, from 2017 to 2020, the data demonstrate a steady and progressive improvement in Bangladesh's access to clean water. The proportion of the population who have access to clean water has been rising steadily each year, however slowly. In the context of a country with a high population density and limited resources like Bangladesh, the rate of improvement may appear modest, yet these small adjustments are substantial.

Out of its population of 165 million people, 68 million people (41% of the population) lack access to a reliable, safely managed source of water, and 100 million people (61%) lack access to safely managed household sanitation facilities. Garbage dumping and the occupation of rivers is one of the major problems in the country. Due to occupation, the width of the rivers is decreasing and due to excessive garbage being dumped into the river, the river bottom is filled with garbage. As a result, the river is losing its navigability and fish are also dying. [6].

Figure 4: Floating plastics and polythene in lake

Both natural and artificial sources can pollute water [7]. Yet, the preponderance of water sources, especially surface water bodies, are polluted as a result of urbanization, rapid industrialization, and human-made issues. In Bangladesh, the main contributors to surface water pollution are sewage, solid waste, industrial waste, and effluents. A predicted 35 to 77 million people in Bangladesh have been subjected to arsenic in their drinking water on a long-term basis due to groundwater poisoning, which is disastrous.

Figure 5: Floating Plastic Bottles

In Bangladesh's urban area, surface water contamination is primarily caused by industrial emissions. Just approximately 40% of industries have ETPs, according to a 2009 industry assessment by the Bangladesh Center for Advanced Studies (BCAS). ETPs were being built in 10% of businesses at the time, while 50% of industries lacked ETP establishments [8].

In both rich and emerging nations, water contamination has worsened, endangering the physical and environmental health of millions of people worldwide [9]. Each year, diseases associated with water, such as cholera, typhoid, polio, ascariasis, cryptosporidiosis, and diarrheal illnesses, claim the lives of about 3.4 million individuals around the globe [10].

1.2 Problem Statement and Analysis

Bangladesh is a riverine country with approximately 700 large and small rivers and channels, including tributaries and canals. Most rivers in Bangladesh that flow through major cities have become polluted due to a variety of anthropogenic pollution, with plastic being one of the most prevalent issues. The Surma River, a sub-basin of the Bengal Basin, runs through the northeastern part of Bangladesh. The main cause of this is poor waste management in city's water bodies. As a result, it has been established that microplastic (MP) pollution in freshwater systems is a global issue [21]. So Microplastics are regarded as a global issue due to their pestilential effects on fish and humans. Contamination of fish by MPs is a major hazard that requires special focus. MPs can cause tissue damage, oxidative stress, and changes in immune-related gene expression as well as antioxidant status in fish [22]. And Bangladesh only treats 6% of human waste. We discovered that the wastage was not properly treated when we analyzed the treated water. The remaining 94% of this waste is directed through the city's drains and eventually flows into the rivers like Buriganga, Turag, Balu, and others [23]. That is why if we hire workers to clean the waste carried in water, workers cannot clean so many rivers, tributaries, and lakes. There's also the issue of time schedule and hiring the

workers which will be costly and it can be seen that the workers suffer from various waterborne diseases. So, if we use a semi-automated boat for solving the problem, we will be able to clean the polluted effluents from the rivers and canals in a relatively short period.

That's why plastic pollution is now recognized as a major environmental issue. Hopefully, with the new proposed design and work methodology, it could help to scale down the amount of plastic waste.

1.3 Project Objectives

The objectives of this study are given below:

- To identify and selection of the removal floating garbage in a lake.
- To construct the hardware components of the IoT device.
- To develop the software modules of the IoT device.
- To collect the identified floating garbage.
- To analyze the device performance for the future improvements.

The aim of this project is to study the current state of floating wastes in water bodies and its problems, research potential solution approaches, design and construct an IoT-based semi-automated lake surface cleaning robot as a solution for clean aquatic life and evaluate the performance of the device.

1.4 Focus

Over 700 rivers (including tributaries) pass through Bangladesh, which is a riverine nation. The main river bordering Dhaka city is the Buriganga River. Due to time constraints and resources, it is not possible to explore every lake in Bangladesh to find out which lake is polluted with floating plastics and polythene. So, we are focusing on Dhanmondi Lake/Gulshan Lake of Dhaka Bangladesh, and we are developing an IoT device that can be used as a cleaner of floating garbage. We want to evaluate the

performance of our device so that soon we can improve/upgrade the device and it can be used in every lake in Bangladesh to clean the garbage for enhancing aquatic life. During the study, we are focusing on collecting floating plastics and polyethylene from Dhanmondi Lake/Gulshan Lake of Dhaka using semi-automatic IoT devices.

1.5 Project Outlines

The title of our project is “Environment-Friendly Semi-Automated Robotic Lake Surface Cleaner for Enhancing Aquatic Life: A Bangladesh Perspective” aim of this project is to study the current state of floating wastes in water bodies and its problems, research potential solution approaches, design and construct an IoT-based semi-automated lake surface cleaning robot as a solution for clean aquatic life and evaluate the performance of the device. Our project outline given bellow:

1. Introduction:

- Background: Describe the increasing issue of floating waste in water bodies and its impact on aquatic life in Bangladesh.
- Objectives: Highlight the goals of the study, including research, design, construction and evaluation.

2. Literature Review:

- Survey the existing literature on water pollution, waste accumulation, and robotic solutions for cleaning water surfaces.

3. Problem Statement:

- Define the specific challenges related to waste accumulation in Bangladesh's water bodies.

4. Methodology:

- Detailed explanation of the proposed methodology: The work system of the device.
- Workflow Diagram.
- Device components List.

5. Technologies Used:

- IoT Integration: Explain how Internet of Things (IoT) technologies are incorporated into the robot.

6. Robot Features:

- Describe the key features of the robot cleaner, such as sensors, navigation system, and waste collection mechanism.

7. Performance Evaluation:

- Discuss the criteria and methods used to assess the robot's effectiveness in cleaning water surfaces.

8. Results and Findings:

- Present the outcomes of the project, including data on waste removal efficiency and environmental impact.

9. Conclusion:

- Summarize the project's significance and its contribution to enhancing aquatic life in Bangladesh.

10. Future Work:

- Suggest potential improvements and future research directions for the robotic cleaner.

11. References:

- Cite all the sources and references used throughout the project.

This project aims to address a critical environmental issue in Bangladesh by developing a technologically advanced solution that can significantly contribute to the preservation of aquatic ecosystems and enhance the overall environmental quality of water bodies in a region.

Chapter 2

Related Works

2.1 Survey of the State-of-the-art

In this modern era, many researchers and scientists are working for making such fully autonomous and semi-autonomous robotic devices that can detect waste and garbage and collect them from water surfaces with the help of various new technologies and algorithms, and components. Some works such as

[11]S. Arun Kumar, S. Sasikala works for a lake cleaning robot that uses an ultrasonic sensor for object detection, an IR sensor, and DC motors with GPIO Broadcom mode with Raspberry Pi for distance measurement and movement of the robot and also used DC motors for movement of the gripper to pick the object and put it to the trash bin.

[12] In this paper, Shobhit Khandare et. all's designed and implemented a robot for garbage collection. In their work, they used Ultrasonic sensors and IR sensors are used to avoid obstacles in the robot's moving path. The 10rpm motors are made to rotate based on the pre-programmed instructions in Raspberry Pi. The desired object is identified by image processing (Faster R-CNNs, "You Only Look Once "(YOLO), "And single Shot Detectors (SSDs). 3 mechanical movements can do the robot by its arm for trash collection.

In this paper, a fully autonomous water surface-cleaning robot is implemented. This robot can move on any particular path by its implemented AI. The water surface region is uploaded with a home point by any mobile phone or iPad etc. Then the data will upload to the cloud server. From the cloud, the data will Load to SMURF. Then the robot works within the path by the WSCPP algorithm (Coverage Path Planning method) & then back to the home point [13].

[14] In this study, Ketan H. Pakhmode et al. design a solar-powered water surface cleaning device. It stores power during the day and then works at night. A mobile app operates the device by Bluetooth module. Bluetooth module operates signal to the Arduino Nano 3.0 (ATmega328P) micro-controller and it has two sensors (HC-05, version2.08 module, ultrasonic sensor) for trash level and other detect garbage. It works with a belt motor for collecting garbage.

[15] In This paper O. Djekoune, Krim .A & R.Toumi addresses a complete navigation method for a mobile robot that moves in an unknown environment with the help of DVFF, combining the Virtual Force Field (VFF) obstacle avoidance approach and global path planning based on D* algorithm.

[16] Huihai Cui, Yan Li, and Jinze Liu proposed a dynamic filtering-based obstacle detection algorithm that can navigate & control an autonomous land vehicle. The algorithm detects the obstacles using sequential sonar data from dual sonar sensors.

Kamarudin, N.A.S et All's designed a garbage collector robot for small cleaning lakes, narrow rivers, etc. The navigation of the robot is controlled using Arduino UNO & DC Motor drive-L2989 & wireless Bluetooth communication from a smartphone application. The performance of this device in terms of control efficiency and garbage collection, load capacity was tested and evaluated. It managed to float and navigate on the Panchor River within Bluetooth network range [17].

To collect trash in bodies of water, an autonomous robot was created. The AT-MEGA 16 microcontroller was used to create a robot with DC and servo motors as well as sensors. All of the modules were tested to determine the viability of the suggested robot [18].

It was suggested to automate garbage removal in companies using a metallic waste pickup robot. With the help of an Arduino Mega microcontroller connected to sensors and actuators, a complete robotic system was created. The robot moves around on its chassis, wheels, motors, and grippers. Infrared and ultrasonic sensors are used for object detection and sensing [18].

Leveraging image processing, an automatic garbage segregation robot was created to sort waste into biodegradable and degradable categories before depositing the waste into the appropriate container. The robot's software is implemented using MATLAB, and the PIC microcontroller, which is supported by motors, relay circuits, and sensors, is used to operate the robot [11]

Radio Frequency (RF) transmitter and receiver modules are used in conjunction with relays, switches, motors, and a metallic casing configuration to create an embedded system that uses a remote controller to clean sewage [19].

In [20] a mechanical cleaning mechanism for drainage systems is described, including belt drives, cleaners, propellers, and pans. To assess the performance of the created system, tests were conducted on wet days in three separate months. In every test scenario that may have existed, the system functioned admirably.

Describes a pedal-powered boat that is used to remove rubbish and debris from the surface. The system comprises a pedal-operated boat with a waste-collection conveyer belt and propellers mounted to the shaft. Also included is a prototype model with design guidelines [20].

2.2 Summary

This paper provides a comprehensive overview of innovative approaches and technologies in the development of autonomous and semi-autonomous robotic devices for waste and garbage collection, particularly in aquatic environments. Various studies and projects are discussed, showcasing a range of methodologies and components used in these systems. Researchers have employed ultrasonic and IR sensors, image processing techniques like faster R-CNNs, YOLO, and SSDs for object detection, and AI-based algorithms for path planning. Some designs incorporate solar power and mobile app control for efficient operation. Additionally, there are mentions of obstacle avoidance approaches such as Virtual Force Field (VFF) and dynamic filtering-based obstacle detection. These advancements cater to diverse applications, from cleaning lakes and rivers to sewage removal. The integration of sensors, microcontrollers, and actuators in these systems highlights the interdisciplinary nature of robotics in addressing environmental challenges. These innovative solutions demonstrate the

potential for improved waste management and environmental conservation.

`

Chapter 3
Materials and Method

- **Materials**
  - **Dataset Collection**

In our project, we focused on the development of an environment friendly semi-automated robot for cleaning lake surfaces to enhance the aquatic life in Bangladesh. We acquired a substantial dataset consisting of 10,000 images of plastic bottles. This dataset was sourced from Kaggle, roboflow and played a crucial role in training our machine learning models. This image processing and object detection to detect plastic bottles and polythene's in water surface level with the help of YOLO (You Only Look Once) v7 is the future work. The algorithm for the object detection and classification is still in working state.

○ Method

■ Proposed Model

The designed device is controlled with Wi-Fi signal for navigation in every direction with the help of an android mobile application. The device uses two dc motors, one nodemcu esp-8266 and few jumper wires for connection and the nodemcu esp-8266 generates its own Wi-Fi signal. Connect the Wi-Fi in android mobile application and it will integrate with the application and with the device. Our device has a feature of object detection and classify the waste (plastic wastes) using OpenCV, Python and ESP32camera module and Arduino uno-R3. The collection process is achieved by semi-automatic procedure. With the help of ultrasonic sensor and DC Motor conveyor belt. When any floating waste comes near to the device within a certain range, the sensor activates its sensing area and then the conveyor belt automatically start and collect the waste. After picking up the waste, the conveyor belt will automatically stop when the waste is dumped into the trash collection bin inside of our device. After operating, while collecting waste from lake surface, when the garbage reach to a certain level of trash bin, the IR sensor will detect its peak level, then it will give a buzzer noise (beep) while notifying that the trash bin is full and needed attention to remove the waste it collected while operating in a lake.

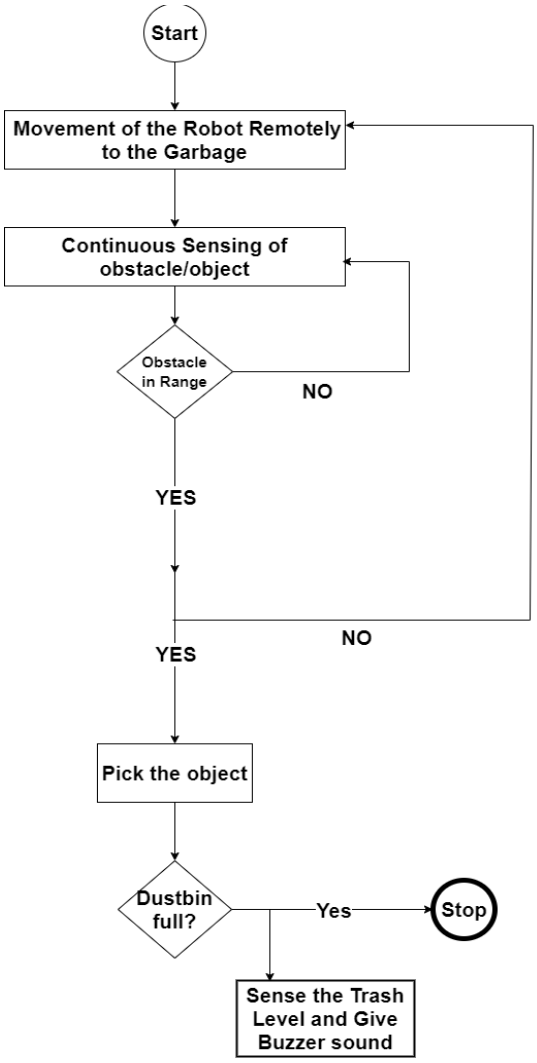

Figure 6: Workflow Diagram of Our Device

Hardware Components:

- 2 Arduino Uno R3
- 1 Breadboard
- 1 Ultrasonic Sensor
- 4 DC geared motors (180rpm dual shaft, 6V)
- 1 IR sensor
- 1 ESP-32 Camera Module
- 1 NodeMCU ESP8266
- 2 Motor Driver (L298N motor driver)
- 10 Power Supply Batteries (18650 7800 mAh, 3.7V each)
- 3 Battery Holders
- 1 Buzzer
- 2-Power on/off Switch

- 2 Propellers
- 1 Conveyor Belt
- 100 Jumper wires
- 3 ft copper wires
- 1 Trash bin
- PVC board (5mm board each)
- Cocksheets
- 1 Barrell Jack

■ Design/Framework

Figure 6 shows the work methodology of our study. Firstly, our device will collect distance data using an ultrasonic sensor. Figure 7 will give an idea of what our prototype device looks like.

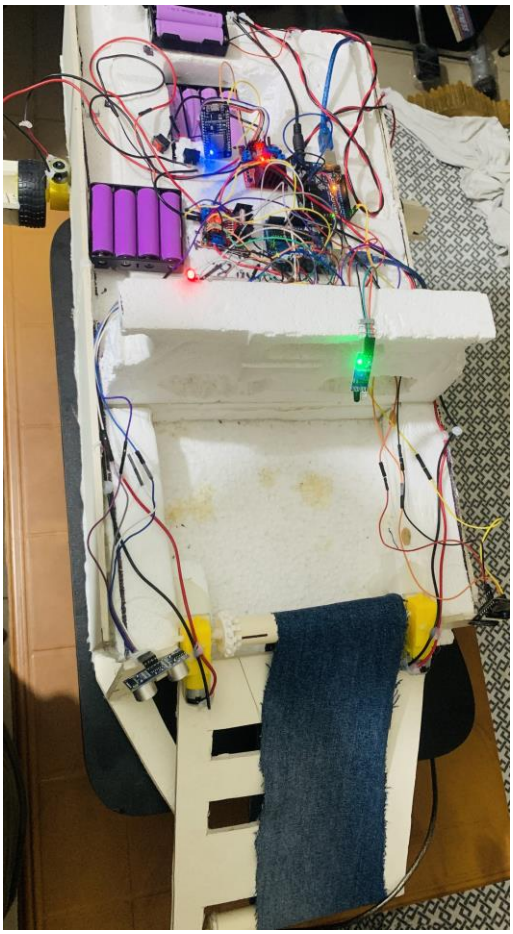

Figure 7: Design Prototype of Device

Table 1. Device Specification

Design parameters	Value
Dimensions	Length: 3 ft Width: 12inchs
Net weight (only robot)	4 kg
Maximum weight (with load)	5-6 kg
Average battery while cleaning	Minimum 30 minutes
Propeller type	Five blade two propellers
Control system	Manual (remote control)
Drive motors	Motor Driver L298N
Waste Collection system	Conveyer Belt

Implementation Method

Dhaka is yet a small city, but the population is increasing day by day. Due to overpopulation of Bangladesh, our surroundings are getting dirty and unhygienic. The lake cleaning robot is designed to effectively navigate and clean the lakes of Dhaka city. It is equipped with appropriate sensors and cleaning mechanisms suitable for the lake environment. The design ensures the robot's stability, buoyancy, and resistance to environmental factors such as waves, wind. The robot is capable of efficiently removing pollutants such as plastic and polyethene. The cleaning robots working mechanisms includes Wi-Fi signal-based android application for smooth navigation with in Wi-Fi range, semi-automatic floating waste collection technique, conveyer belt for collection systems, smart IR sensor-based trash level detection depending on the specific cleaning requirements. Lake cleaning robot has a reliable and sustainable power source to operate effectively. Depending on the size and scope of the lake, the robot is powered by li-on batteries. Efficient energy management systems are crucial to optimize the robot's operational time and reduce the need for frequent recharging or maintenance.

- **Material and Devices**

Techniques: During our study, we developed an IoT-based semi-automated device that can collect floating waste from the lakes of Dhaka city. To develop this IoT-based device the heart of our device is arduino uno r3 to control everything. The ultrasonic sensor is used to measure and sensing that if there is any obstacle ahead of the device and pick it up to the trash bean.

Skills: The design of our project is done on Diagrams.net. For the code writing segment, we used C language and wrote the code into arduino IDE, to run code in Arduino Uno along with a few other libraries such as esp32, esp8266, wi-fi state, etc.

Modern Engineering and IT Tools: During our study, we used Arduino IDE to run all the necessary codes in arduino which was connected with other necessary hardware components such as ultrasonic sensor, breadboard, IR sensor, geared dc motor, power supply and L298N motor drivers. The files filled up almost 100MB SSD storage, 8GB RAM along with CPU and GPU for 35 hours per week.

1. Semi-automated Waste Collection System Using Ultrasonic sensor, DC motor, Motor Driver

Ultrasonic sensors, in contrary to photoelectric sensors, can distinguish an object without being altered by its color. For instance, if two items have the same shape, they can both be recognized using the same parameters, even if one is transparent like glass and the other is gloomy plastic. Figure 8 shows how Ultrasonic transmission and reception are accomplished by the use of piezoelectric ceramics [24].

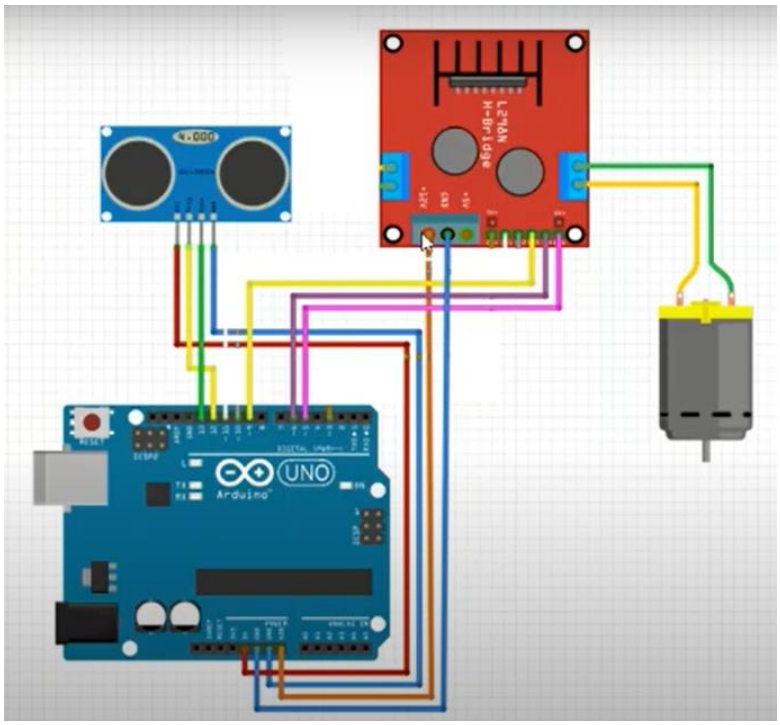

Figure 8: Ultrasonic for collecting waste using dc motor and Arduino uno r3

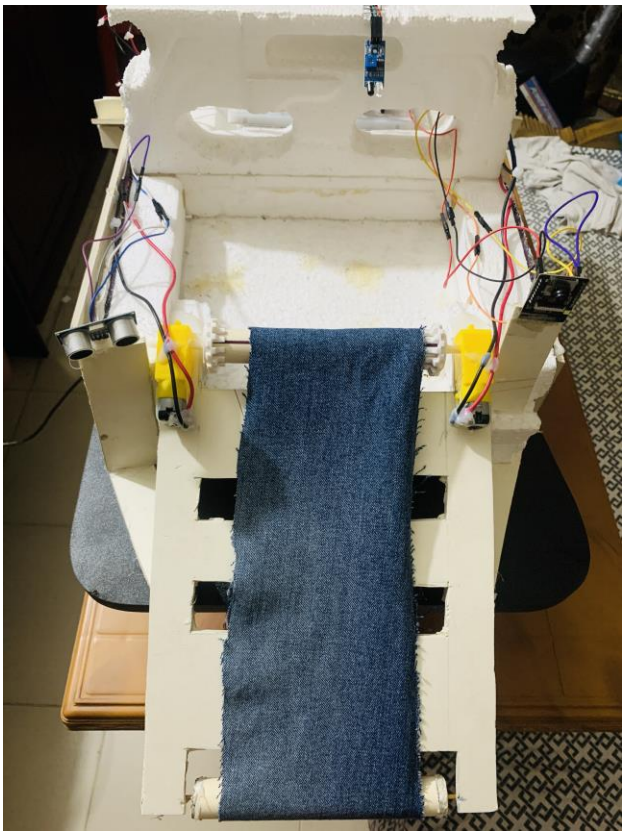

Figure 9: Conveyer belt with semi-automated waste collection system

An ultrasonic sensor is a device that detects things and measures distances using sound waves. It is made up of two primary parts: a transmitter and a receiver. Ultrasonic sensors used in Arduino determine distances by producing high-frequency sound waves and detecting their reflections. When incorporated into a trash cleaning boat on a river, the Arduino triggers the sensor to produce an ultrasonic pulse that travels through the air and collides with items such as floating debris. The sensor detects the reflected pulse and determines the distance based on the time it took to traverse. This distance information aids the boat's navigation and collection of trash. The Arduino code calculates the distance using the formula Distance = (Speed of Sound Time) / 2. Here are the Components:

- Ultrasonic sensor
- Arduino board
- Jumper Wires

Connect the ultrasonic sensor to the Arduino with the jumper wires described below:

- Connect the ultrasonic sensor's black wire (GND) to any GND pin on the Arduino.
- Connect the ultrasonic sensor's red wire (VCC) to the Arduino's 5V pin.
- Connect the ultrasonic sensor's yellow or orange wire (Trig) to digital pin 8 on the Arduino.
- Connect the ultrasonic sensor's green wire (Echo) to digital pin 7 on the Arduino.

Pseudocode in the Arduino IDE:

Import the Mouse library

Define the constant trigpin as 8

Define the constant echopin as 7

Declare a variable named duration as long

Declare a variable named distance as integer

Setup:

Set the trigpin as an output pin

Set the echopin as an input pin

Begin serial communication at a baud rate of 9600

Loop:

Set trigpin to HIGH

Delay for 10 microseconds

Set trigpin to LOW

Measure the duration of the pulse on echopin while it is HIGH and store it in the duration variable Calculate the distance using the formula: distance = duration * 0.034 / 2

Initialize Condition with distance for motor controlling

End of the loop

End of program

We can only have full control over a DC motor if we can control its speed and spinning direction. The IN1 and IN2 pins control the spinning direction of motor A; While IN3 and IN4 control the spinning direction of motor B. PWM – to control speed H-Bridge – to control the spinning direction. The speed control pins ENA and ENB are used to turn on and off the motors and control their speed. If you have 12V motors, then your motor supply voltage should be 14V. Considering a voltage drop of 2 volts, if you are using 5-volt motors, you will need to provide 7 volts at the motor power supply terminal. The speed of a DC motor can be controlled by changing its input voltage. Wiring the motor power supply will be the first step. We're employing "TT" motors, sometimes known as DC gearbox motors, in our experiment because they're frequently used in two-wheel-drive robots. They have a 3 to 12V rating. So, we'll join a 12V external power supply to the VS terminal. The motors will receive 10V and spin at a somewhat lower RPM because L298N has a voltage drop of roughly 2V. But it's all right. Next, we must supply 5V to the L298N's logic circuits. Keep the 5V-EN jumper in place because we'll be using the onboard 5V regulator to take 5V from the motor power source. The six Arduino digital output pins (9, 8, 7, 5, 4, and 3) should now be connected to the input and enable pins (ENA, IN1, IN2, IN3, IN4, and ENB) of the L298N module. Be aware that the PWM function is enabled on both Arduino output pins 9 and 3. Finally, connect one motor to terminal A (OUT1 and OUT2) and the other to terminal B (OUT3 and OUT4). Change the connections on your motor. There isn't a correct way or an inaccurate way, technically.

The ultrasonic sensor receives a trigger signal from the Arduino. This signal is typically a brief pulse of high voltage (about 10 microseconds). When the ultrasonic sensor gets the trigger signal, it produces a brief ultrasonic pulse. The pulse is made up of high-frequency sound waves (usually approximately 40 kHz) that are inaudible to humans. Reflection occurs when an ultrasonic pulse travels through the air and strikes an item in its path. When the pulse comes into contact with an

item, it is reflected toward the sensor. The receiver of the ultrasonic sensor detects the reflected pulse and converts it into an electrical signal. And The Arduino measures the time it takes for the pulse to travel from the sensor to the object and vice versa. It does this by recording the time the trigger signal was sent and the time it received the reflected signal. Knowing the speed of sound in the air the Arduino can calculate the distance to the object using the formula: Distance = (Speed of Sound × Time) / 2.

Then we can see the measured distance in centimeters shown on the Processing window after uploading the code to the Arduino.

2. W-Fi Controlled Seamless Navigation

Robotics, automation, and electronics projects all frequently use DC motors in their varied applications. They provide rotational motion, which is necessary for activities like moving items, propelling wheels, or controlling mechanical systems. With the L298N motor driver acting as an interface, the Arduino Uno can precisely control the speed and direction of the DC motors. For DC motors to function effectively, the supply of voltage and current must be suitable. The responsibility of controlling the voltage and current given to the motors is handled by the L298N motor driver. It can handle larger input voltages (such as 12V or 24V) and makes sure the motors get the right amount of voltage and current without going overboard.

The DC motors can be controlled in both directions by the L298N motor driver. Two motors are given independent control, allowing them to rotate both forward and backward. You may direct the motion of the motors by modifying the signals that the Arduino Uno sends to the motor driver. The L298N motor driver includes the ability for pulse width modulation (PWM). PWM quickly turns the power on and off to give the DC motors exact control over their speed. The speed of the motors can be controlled by changing the average voltage provided to them by varying the duty cycle of the PWM signals produced by the Arduino Uno. Table 2 will provide knowledge of the technical specifications.

Table 2: Technical Specification of L298N Driver

Motor output voltage	**5V-35V**
Motor output voltage (Recommended)	**7V – 12V**
Logic input voltage	**5V – 7V**
Continuous current per channel	**2A**
Max Power Dissipation	**25W**

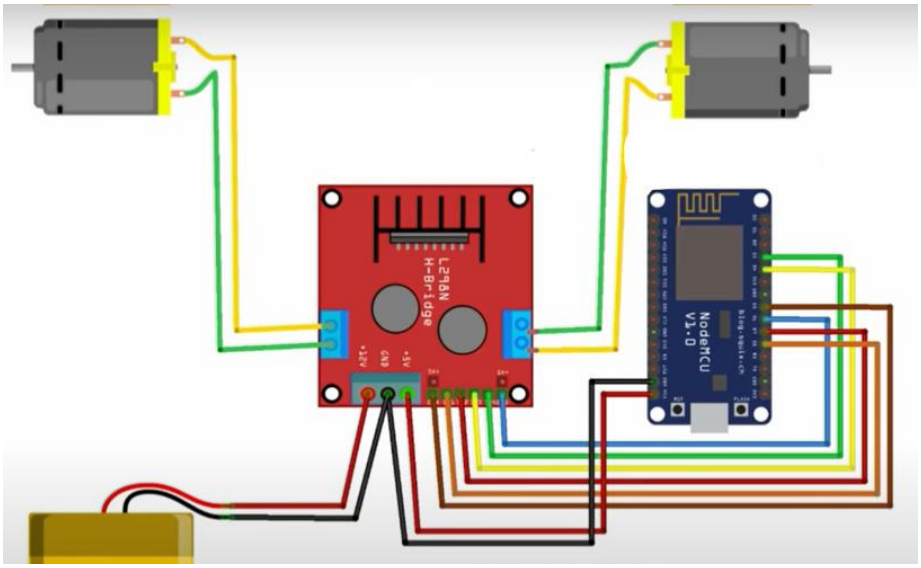

Figure 9: The assembled circuit of the L298N motor driver, DC motors, and Arduino Uno R3 with 14.3V power supply.

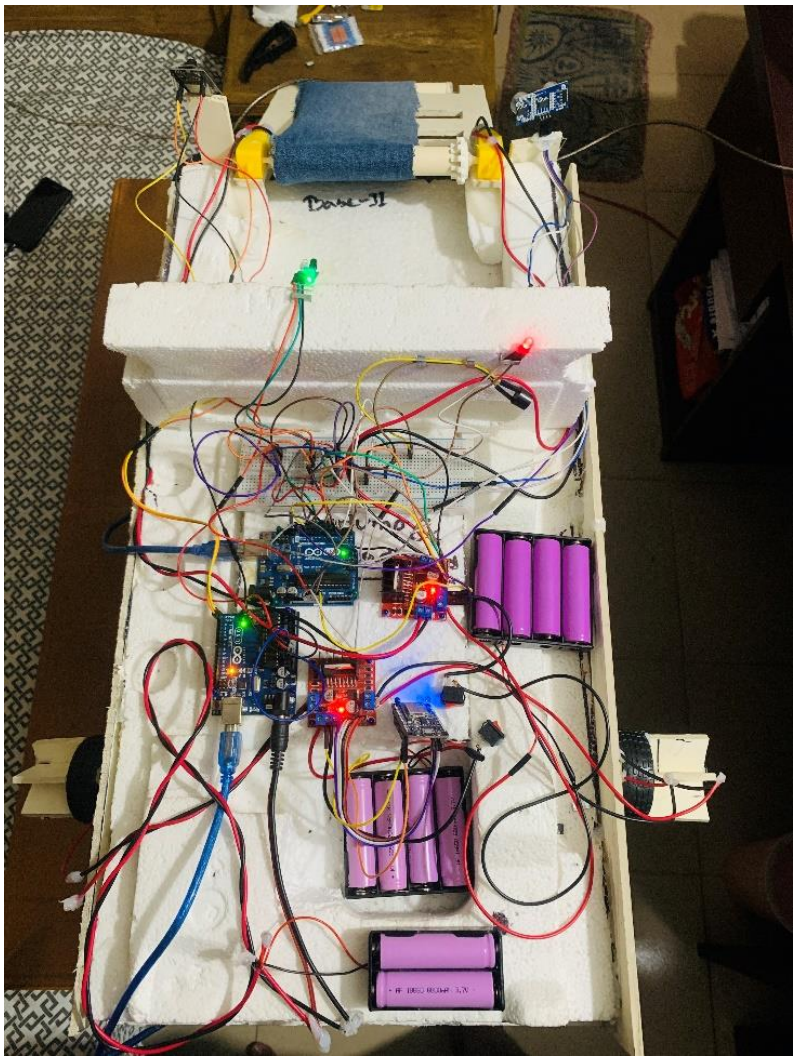

Figure: Navigation Assembly

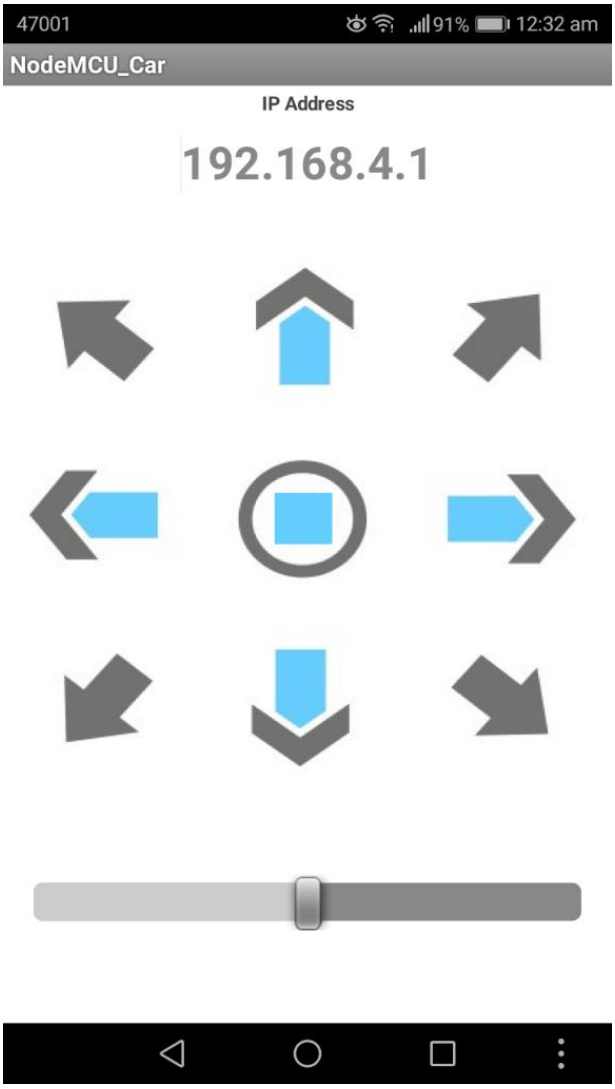

Figure: Mobile app for navigation

Pseudo Code:

```
# Define pin numbers for motor control

ENA = 14    # Enable/speed motors Right

ENB = 12    # Enable/speed motors Left

IN_1 = 15   # L298N in1 motors Right

IN_2 = 13   # L298N in2 motors Right

IN_3 = 2    # L298N in3 motors Left

IN_4 = 0    # L298N in4 motors Left


# Include required libraries

Include the "ESP8266WiFi" library

Include the "WiFiClient" library

Include the "ESP8266WebServer" library


# Initialize variables

command = ""          # String to store app command state

speedCar = 800        # Speed for the motors (400 - 1023)

speed_Coeff = 3       # Speed coefficient


ssid = "NodeMCU Car"  # WiFi SSID
```

```
# Initialize the web server
server = ESP8266WebServer(80)

# Setup function
def setup():
    Initialize the GPIO pins:
    - ENA, ENB, IN_1, IN_2, IN_3, IN_4

    Initialize the Serial communication at 115200 baud

    Connect to WiFi in Access Point (AP) mode with the provided SSID

    Get the IP address of the AP and print it

    Start the web server with route handlers for root and not found

# Function to move the car forward
def goAhead():
    Set the motors to move forward
```

```
# Function to move the car backward
def goBack():
    Set the motors to move backward

# Function to turn the car right
def goRight():
    Set the motors to turn right

# Function to turn the car left
def goLeft():
    Set the motors to turn left

# Function to move the car ahead and right
def goAheadRight():
    Set the motors to move forward and turn right with reduced speed

# Function to move the car ahead and left
def goAheadLeft():
    Set the motors to move forward and turn left with reduced speed
```

```
# Function to move the car backward and right
def goBackRight():
    Set the motors to move backward and turn right with reduced speed

# Function to move the car backward and left
def goBackLeft():
    Set the motors to move backward and turn left with reduced speed

# Function to stop the robot
def stopRobot():
    Stop both motors

# Main loop
def loop():
    Handle client requests from the web server

    Get the "State" parameter from the request

    Depending on the "State" parameter, perform the corresponding action:
```

- "F": Move forward

- "B": Move backward

- "L": Turn left

- "R": Turn right

- "I": Move ahead and right

- "G": Move ahead and left

- "J": Move backward and right

- "H": Move backward and left

- "0" to "9": Set the speed of the car

- "S": Stop the robot

Handle root route

def HTTP_handleRoot():

If the request has a "State" parameter, print it

Send a response with HTTP status 200 and an empty HTML page

End program.

Protection features like overcurrent and overtemperature protection are available with the L298N motor driver. In the event of an excessive current or high temperature, these safety measures aid in preventing damage to the motors and the driver. This ensures the motor control system's durability and dependability. The Arduino Uno microcontroller board and the L298N motor driver are intended to operate in perfect harmony. It is simple to connect the two parts since motor control signals are

sent using digital pins on the Arduino Uno. To execute programming logic and produce the necessary control signals for precise motor control, use the Arduino Uno.

All things considered, the combination of DC motors, the L298N motor driver, and the Arduino Uno offers a flexible and dependable solution for controlling motors in a variety of applications. Fine-grained control over motor speed, direction, and power is made possible by it, enabling the creation of complicated and dynamic motions in a variety of applications.

3. IR Sensor For Trash Level Detection

The IR sensor module contains an infrared detector (usually a photodiode) that is sensitive to infrared radiation. It detects the intensity of the reflected infrared light. The detector converts the detected infrared light into an electrical signal. The output of the IR sensor module can be either analog or digital, depending on the specific sensor module. In the case of a digital output sensor, the module typically includes built-in signal processing circuitry. It compares the detected infrared intensity with a predefined threshold and generates a digital signal (HIGH or LOW) based on whether the threshold is crossed.

The output of the IR sensor module can be connected to an Arduino board. The Arduino can read the sensor's output value using a digital pin set as an input. Based on the sensor output, the Arduino can perform various actions, such as activating an LED, triggering an alarm, or controlling other devices.

Hardware required:

- Arduino
- Breadboard
- Jumper wires
- IR sensor module
- LED
- Resistor

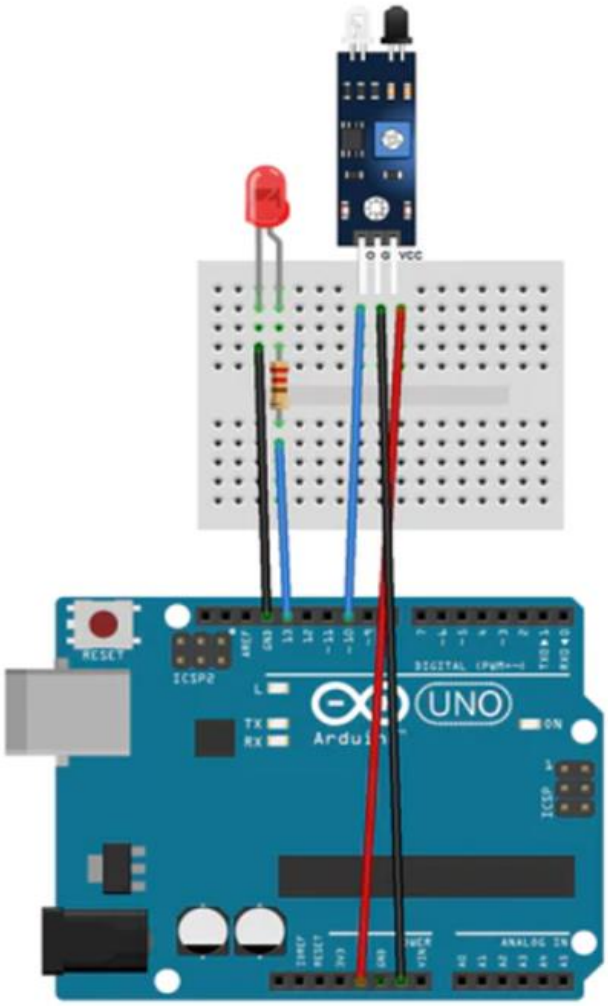

Figure 10: Building circuit of IR sensor and Arduin**o**

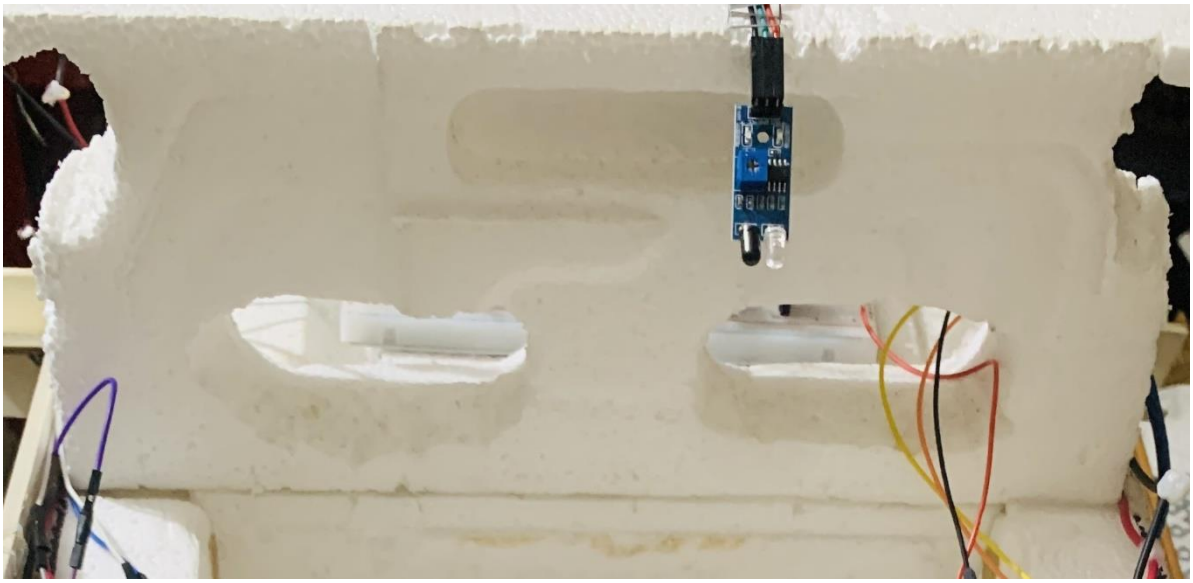

Figure: IR sensor for trash level detection

Pseudo Code:

Initialization:

Initialize robot's sensors, actuators, and communication modules.

Calibrate and configure sensor parameters.

Set initial robot position and orientation.

While True: // Main control loop

Read Sensor Data:

Read data from water quality sensors (pH, dissolved oxygen, turbidity, etc.).

Read data from obstacle detection sensors (sonar, LIDAR, etc.).

Analyze Sensor Data:

Determine water pollution levels and identify polluted areas based on sensor readings.

Identify obstacles and determine the safe path for navigation.

Navigation:

Plan a safe and efficient path to reach the polluted areas while avoiding obstacles.

Move the robot to the next position along the planned path using the robot's motors.

Cleaning Operation:

Activate the cleaning mechanism (e.g., robotic conveyor Belt, suction pump, or filtration system) when reaching a polluted area.

Collect floating debris or scoop sediment as required.

Use water quality sensors to assess the effectiveness of the cleaning operation.

Data Logging and Communication:

Log sensor readings, cleaning operations, and any relevant data for analysis.

Communicate real-time data or status updates to a control station or monitoring system.

Termination Condition:

Check for any termination conditions (e.g., low battery, completion of cleaning tasks, or user intervention).

If a termination condition is met, break the control loop and stop the robot.

End

4. Operating Time

The battery’s capacity, which is commonly expressed in milliampere-hours (mAh) or ampere-hours (Ah), indicates how much charge it can store. Thus, we have four 3.7-volt batteries, we may have to calculate the total voltage of the set by multiplying 4 by 3.7, which is 14.8 volts. The total voltage is unaffected by the battery capacity, as we may have seen. If the power consumption is given in watts, you can calculate the current by dividing the power consumption by the combined battery voltage. For example, if the power consumption is 5W and the combined battery voltage is 14.8V, the current would be 5W / 14.8V = 0.34A (340mA). Multiply the device's current usage by the overall battery capacity. You can estimate the operation time using this. For instance, if the gadget uses 340mA from the total battery capacity of 8000mAh (or 8Ah), the working duration would be around 8Ah / 0.34A = 23.53 hours.

It's essential to keep in mind that this computation just serves as an estimate and may not take battery efficiency, power consumption changes, or battery discharge rate into account. Also, the actual functioning time may change based on the unique qualities of the batteries and the powered gadget.

5. ESP32: Object Detection using OpenCV with python

ESP32 is a series of low-cost, low-power system on a chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth. Stream real-time video footage using ESP-32 camera module. View live video in any browser with the generated public IP address The objective of this study is to present an innovative approach using OpenCV and Python for the development of an environmentally friendly, semi-automated robotic lake surface cleaner designed to enhance aquatic life in the context of Bangladesh. The primary goals of this research are:

To design and develop a semi-automated robotic system capable of cleaning lake surfaces efficiently. This system utilizes computer vision techniques, particularly OpenCV, to identify and address pollution and waste on the water surface. To evaluate the environmental impact of the robotic cleaner by assessing its ability to remove pollutants, debris, and floating waste from water bodies in Bangladesh, with a focus on improving water quality and supporting aquatic ecosystems. To investigate the level of automation achieved through the integration of computer vision technologies and machine learning for object detection, classification, and autonomous decision-making. This includes enhancing the efficiency of the cleaning process and reducing the need for human intervention. To discuss the adaptability of OpenCV and Python in the context of Bangladeshi lakes and waters, considering the local environmental challenges and conditions. This includes addressing the specific requirements of the region. To assess the sustainability and cost-

effectiveness of the proposed robotic cleaner, exploring how it can be economically viable and suitable for long-term usage in maintaining the cleanliness of water bodies in Bangladesh. To measure the impact of the robotic lake cleaner on the enhancement of aquatic life in Bangladeshi lakes, focusing on the improvement of water quality, reduction of pollutants, and the support of a healthier ecosystem. By achieving these objectives, this research aims to contribute to the development of environmentally sustainable solutions for preserving aquatic life in Bangladesh and addressing the challenges posed by pollution and waste on lake surfaces. The study leverages OpenCV and Python's capabilities to create an efficient and adaptable robotic system that can serve as a valuable tool for environmental preservation and restoration.

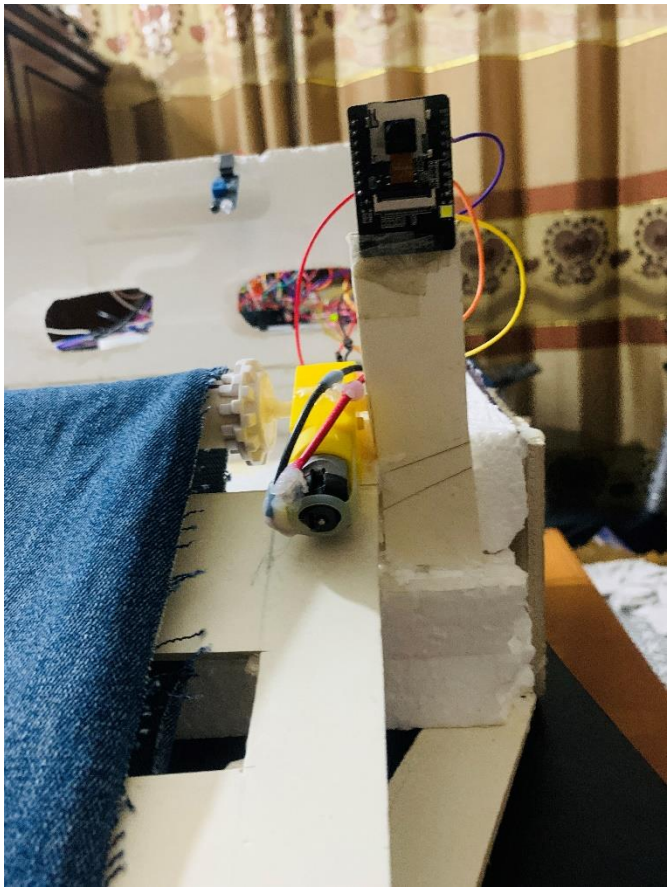

Figure: ESP32 camera module for real-time footage

Pseudocode:

```
# Import necessary libraries

Import cv2

Import matplotlib.pyplot as plt

Import cvlib as cv

Import urllib.request

Import numpy as np

From cvlib.object_detection import draw_bbox

Import concurrent.futures



# Set the URL for the camera feed

url = 'http://192.168.0.110//cam-hi.jpg'

im = None



# Function to display the live transmission

Function run1():

    Create a named window for live transmission with an automatic window size

    While True:

        Retrieve the image response from the specified URL

        Convert the image response into a NumPy array of unsigned integers
```

Decode the image using cv2

Show the decoded image in the 'live transmission' window

Wait for a key press with a delay of 5 milliseconds

If the key is 'q', break out of the loop

Close the 'live transmission' window

Function to perform object detection and display it

Function run2():

Create a named window for detection with an automatic window size

While True:

Retrieve the image response from the specified URL

Convert the image response into a NumPy array of unsigned integers

Decode the image using cv2

Perform object detection using cvlib

Draw bounding boxes around detected objects

Show the annotated image in the 'detection' window

Wait for a key press with a delay of 5 milliseconds

If the key is 'q', break out of the loop

Close the 'detection' window

Main program entry point

If this script is being executed directly:

Print "started"

Create a ProcessPoolExecutor using concurrent.futures

Submit the run1 function for execution in a separate process and store the future object as f1

Submit the run2 function for execution in a separate process and store the future object as f2

Integrating real-time object tracking and routing algorithms with YOLO to optimize the cleaning process can improve boat efficiency. By continuously tracking detected debris, the boat can navigate efficiently, prioritize the collection of larger or dangerous items and avoid obstructions. Object tracking algorithms such as Kalman filters or deep learning-based methods such as Deep SORT (Deep Simple Online Realtime Tracking) can be used for this purpose.[27][28]

In addition to object detection, implementing a deep learning-based garbage classification system will improve the boat's efficiency in identifying different types of garbage. By training a neural network on a diverse dataset of junk, the boat will be able to distinguish between plastic and polyethylene. This feature allows boats to perform targeted cleaning actions. B. Only collect plastic waste for recycling or to identify potentially hazardous items.[29]

Chapter 4
Discussion

4.1 Discussion

In the context of our research, we have developed an environment-friendly semi-automated lake surface cleaning robot with the aim of enhancing aquatic life in Bangladesh. This device is remotely controlled through a dedicated android mobile application and incorporates several key features to effectively clean lake surfaces. One of the pivotal components of this system is its object detection and classification capability, which is achieved using OpenCV and Python. The device is built on a foundation of arduino uno for seamless integration of hardware and software components. Specifically, we have focused on identifying and categorizing plastic bottle garbage within the water (the work is under process and it will be dealt as future work). This technology is pivotal for ensuring that only harmful materials are collected while preserving other elements of the aquatic environment. The device employs an ultrasonic sensor and a DC motor-driven conveyor belt for semi-automatic garbage collection. When plastic garbage, such as plastic bottles or any floating waste, enters in the sensor's detection area, the conveyor belt automatically activates to pick up the waste from water surface. This semi-automatic approach ensures efficient and precise collection, reducing the reliance on manual labor. This feature enhances the convenience and flexibility of managing lake surface cleaning activities, allowing users to direct the robot to specific areas of concern.

Our research is rooted in the perspective of Bangladesh, where aquatic ecosystems face increasing threats from pollution and waste. By implementing this innovative robot cleaner, we aim to significantly improve water quality and support the enhancement of aquatic life. The focus on plastic waste specifically addresses a prevalent environmental issue in the region.

4.2 Summary

The "Environment-Friendly Semi-automated Robotic Lake Surface Cleaner for Enhancing Aquatic Life: A Bangladesh’s Perspective" represents a novel and innovative approach to addressing the ecological challenges faced by Dhaka city lakes in Bangladesh. This research combines advanced technology, including OpenCV, Python, ESP32CAM, NodeMCU ESP8266 and Arduino Uno, to create a semi-automatic robot system with a specific focus on plastic waste detection and removal from water surface. The system is remotely controlled and monitored, allowing for precise and efficient cleaning of lake surfaces. Its object detection and classification capabilities enable it to distinguish plastic bottle garbage from other elements in the water, ensuring that only harmful materials are collected. The semi-automated garbage collection process, facilitated by an ultrasonic sensor and conveyor belt, reduces the need for manual intervention and enhances the effectiveness of the cleaning process.

Overall, this research has significant implications for the preservation and enhancement of aquatic life in Bangladesh. By addressing the critical issue of pollution and waste in lakes, the system aims to contribute to cleaner and healthier aquatic ecosystems. It offers a promising solution for maintaining water quality and supporting the biodiversity of Bangladesh's lakes, demonstrating the potential for similar technologies to be deployed in other regions facing similar environmental challenges.

Chapter 5

Conclusion

5.1 Overall Contributions

In our project, "Environment Friendly Semi-automated Robotic Lake Surface Cleaner for Enhancing Aquatic Life: A Bangladesh’s Perspective" each team member played a pivotal role during the study:

- Conceptualization and Design: Led by Md. Asif Imtiyaj Chowdhury, Mridul Ranjan Karmakar, Shafika Sikander and Prianka Sarker formulated the project's foundation.
- Inception Architecture: Md. Asif Imtiyaj Chowdhury, Mridul Ranjan Karmakar integrated the complex model with finesse.
- User Interface: Md. Asif Imtiyaj Chowdhury created a seamless interaction platform.
- Presentation and Dissemination: Shafika Sikander and Prianka Sarker presented perfectly.
- Resource Management: Led by Md. Asif Imtiyaj Chowdhury, Mridul Ranjan Karmakar, Shafika Sikander and Prianka Sarker collected and managed all the required resources.
- Documentation: All research members contributed to thorough documentation, ensuring transparency.
- Team Collaboration: Active participation from everyone fostered dynamic brainstorming and improvement.

Our collective efforts successfully realized the "Environment Friendly Semi-automated Robotic Lake Surface Cleaner for Enhancing Aquatic Life: A Bangladesh’s Perspective", is a success.

5.2 Limitations and Future Works

Water surface is not always steady. When the device operates, the propeller rotates to move in any direction there will be current in the water surface. For this reason, the ultrasonic sensors sensing an object with in a range and it is difficult because of the wave current that is generated by the propeller rotation may affect in ultrasonic sensors sensing ability. During the study, we have faced many difficulties in hardware connectivity. We cannot ensure the quality of the hardware components we acquired for this study. Jumper wire connectivity and copper connectivity is very crucial for proper voltage supply. It is recommended to collect a multimeter to check whether the device is getting sufficient voltage for its operation. If there is a lack of sufficient voltage supply then it will create a great time consumption to find out where the actual problem is. Lastly, the wire management is also a part of our limitation. Object detection in Arduino uno with ESP32 cam module is hold into future work. For this reason, the object detection and image processing are held in future work. In near future the device navigation can be done with the camera and ultrasonic sensor and the integration. Gripper to collect floating waste would be a great improvement to add in future development.

Bibliography

[1] “Bangladesh: Access to Clean Water Will Reduce Poverty Faster.” https://www.worldbank.org/en/news/press-release/2018/10/11/bangladesh-access-to-clean-water-will-reduce-poverty-faster (accessed Feb. 20, 2023).

[2] J. R. Jambeck et al., “Plastic waste inputs from land into the ocean,” Science (1979), vol. 347, no. 6223, pp. 768–771, Feb. 2015, doi: 10.1126/SCIENCE.1260352/SUPPL_FILE/JAMBECK.SM.PDF.

[3] L. C. M. Lebreton, J. Van Der Zwet, J. W. Damsteeg, B. Slat, A. Andrady, and J. Reisser, “River plastic emissions to the world’s oceans,” Nat Commun, vol. 8, Jun. 2017, doi: 10.1038/ncomms15611.

[4] “Water In Crisis - Spotlight Banglasdesh.” https://thewaterproject.org/water-crisis/water-in-crisis-bangladesh (accessed Mar. 12, 2023).

[5] M. J. Uddin and Y. K. Jeong, “Urban river pollution in Bangladesh during last 40 years: potential public health and ecological risk, present policy, and future prospects toward smart water management,” Heliyon, vol. 7, no. 2. Elsevier Ltd, Feb. 01, 2021. doi: 10.1016/j.heliyon.2021.e06107.

[6] “Bangladesh Clean Water Access 2000-2023 | MacroTrends.” https://www.macrotrends.net/countries/BGD/bangladesh/clean-water-access-statistics (accessed Mar. 12, 2023).

[7] “Pollution: Causes, Effects and Control - Google Books.” https://books.google.com.bd/books?hl=en&lr=&id=1kFbRYQUqcAC&oi=fnd&pg=PA1&ots=NzpbFL8iof&sig=9Dn0zRlRTq2UfqkVZf9oAzJY8xs&redir_esc=y#v=onepage&q&f=false (accessed Mar. 14, 2023).

[8] “Water Pollution Of Most Of The Water Sources In Bangladesh - FAIR.” https://fairbd.net/water-pollution-of-most-of-the-water-sources-in-bangladesh/ (accessed Mar. 14, 2023).

[9] “Javier: Water Pollution from Agriculture: a Global... - Google Scholar.” https://scholar.google.com/scholar_lookup?title=Water%20Pollution%20from%20Agriculture%3A%20a%20Global%20Review.%20Rome%2C%20Colombo%3A%20the%20Food%20and%20Agriculture%20Organization%20of%20the%20United%20Nations%2C%20International%20Water%20Management%20Institute%20on%20Behalf%20of&author=M.-S.%20Javier&publication_year=2017 (accessed Mar. 14, 2023).

[10] “A Snapshot of the World’s Water Quality: Towards a global assessment.” [Online]. Available:

www.unep.org

[11] S. A. kumar* and S. Sasikala, “Effective Aquatic Waste Removal through Lake Cleaning Robot for Smart city Environment,” International Journal of Innovative Technology and Exploring Engineering, vol. 9, no. 4, pp. 2831–2835, Feb. 2020, doi: 10.35940/IJITEE.C8905.029420.

[12] S. Journal and U. Journal, “International Journal of Innovative Technology and Exploring Engineering (IJITEE),” 2020, doi: 10.35940/ijitee.C8905.029420.

[13] J. Zhu, Y. Yang, and Y. Cheng, “SMURF: A Fully Autonomous Water Surface Cleaning Robot with A Novel Coverage Path Planning Method,” J Mar Sci Eng, vol. 10, no. 11, Nov. 2022, doi: 10.3390/JMSE10111620.

[14] R. Kamath, D. D. Salvankar, D. D. Salvankar, and A. D. Shetty, “WATER GARBAGE COLLECTOR USING ANDROID”, Accessed: Mar. 15, 2023. [Online]. Available: www.irjmets.com

[15] A. O. Djekoune, K. Achour, and R. Toum, “A sensor based navigation algorithm for a mobile robot using the DVFF approach,” Int J Adv Robot Syst, vol. 6, no. 2, pp. 97–108, 2009, doi: 10.5772/6797.

[16] H. Cui, Y. Li, and J. Liu, “An Obstacle Detection Algorithm Based on Ultrasonic Sensors for Autonomous Land Vehicle,” 2016, doi: 10.2991/MCAE-16.2016.35.

[17] N. A. S. Kamarudin, I. N. A. M. Nordin, D. Misman, N. Khamis, M. R. M. Razif, and F. H. M. Noh, “Development of Water Surface Mobile Garbage Collector Robot,” Alinteri Journal of Agriculture Sciences, vol. 36, no. 1, pp. 534–540, Jun. 2021, doi: 10.47059/ALINTERI/V36I1/AJAS21076.

[18] O. Nurlansa, D. Anisa Istiqomah, and M. Astu Sanggha Pawitra, “AGATOR (Automatic Garbage Collector) as Automatic Garbage Collector Robot Model,” International Journal of Future Computer and Communication, vol. 3, no. 5, pp. 367–371, Oct. 2014, doi: 10.7763/ijfcc.2014.v3.329.

[19] M. M. Idhris, M. E. parthi, C. M. Kumar, N. N. vathy, K. S. waran, and S. A. kumar, “Design and fabrication of remote controlled sewage cleaning machine,” International Journal of Engineering Trends and Technology, vol. 45, no. 2, pp. 63–65, Mar. 2017, doi: 10.14445/22315381/IJETT-V45P214.

[20] N. C. Daniels, “Drainage System Cleaner A Solution to Environmental Hazards,” 2014. [Online]. Available: www.irjes.com

[21] G. W. Chowdhury et al., “Plastic pollution in aquatic systems in Bangladesh: A review of current knowledge,” Science of the Total Environment, vol. 761, Mar. 2021, doi: 10.1016/J.SCITOTENV.2020.143285.

[22] M. S. Bhuyan, “Effects of Microplastics on Fish and in Human Health,” Front Environ Sci, vol. 10, p.

250, Mar. 2022, doi: 10.3389/FENVS.2022.827289/BIBTEX.

[23] "'We will have the rivers cleaned by March 2023': NRCC Chairman | River Pollution in Bangladesh." https://www.tbsnews.net/features/panorama/repeat-offenders-who-pollute-rivers-should-be-jailed-nrcc-chairman-520134 (accessed Mar. 14, 2023).

[24] "Technical Explanation for Ultrasonic Sensors".Zhang, X., Wu, X., & Zhu, J. (2020). Deep Multispectral Fusion Object Detection in Marine Environment. IEEE

Access, 8, 5319-5328.

[25] Zhang, X., Wu, X., & Zhu, J. (2020). Deep Multispectral Fusion Object Detection in Marine Environment. IEEE Access, 8, 5319-5328.

[26] He, Y., Lu, J., & Wu, J. (2019). Deep Watershed Transform with Discriminative Network for Underwater Object Detection. IEEE International Conference on Image Processing (ICIP), 3025-3029.

[27] Bewley, A., Ge, Z., Ott, L., Ramos, F., & Upcroft, B.(2016). Simple Online and Realtime Tracking with a Deep Association Metric. IEEE International Conference

on Image Processing (ICIP), 3647-3651.

[28] Arulampalam, S., Maskell, S., Gordon, N., & Clapp, T. (2002). A Tutorial on Particle Filters for Online Nonlinear/Non-Gaussian Bayesian Tracking. IEEE Transactions on Signal Processing, 50(2), 174-188.

[29] Li, X., Zhang, X., Hu, Q., & Zhang, L. (2021). Garbage Classification by Deep Learning for Automatic Ocean Garbage Collection. IEEE Access, 9, 45019-

45029.

[30] Redmon, J., Divvala, S., Girshick, R., & Farhadi, A. (2016). You Only Look Once: Unified, Real-Time Object Detection. IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 779-788.

[31] Ronneberger, O., Fischer, P., & Brox, T. (2015). U-Net: Convolutional Networks for Biomedical Image Segmentation. International Conference on Medical Image Computing and Computer-Assisted Intervention

(MICCAI), 234-241.

[32] Guo, X., Zhang, J., Li, L., & Yang, C. (2021). Underwater Garbage Detection Based on Dual-channel Network with LiDAR and Camera. Journal of Physics: Conference Series, 1869(1), 012175.

[33] Deniz, O., Durusu, A., Sahin, E., & Temizel, A. (2018). 3D Underwater Object Detection with Sonar

Images Using Convolutional Neural Networks. IEEE International Conference on Robotics and Automation

(ICRA), 1-6.

[34] Zhou, Z., Siddiquie, B., & Shuai, H. (2019). Improving Object Detection With Selective Feature

Sharing and Interactive Learning. IEEE Transactions on Multimedia, 21(1), 75-86.

[35] Sheng, L., Li, Y., & Zhang, L. (2020). Multi- Source Deep Active Learning for Remote Sensing Object Detection.

[36] Kempton, W., & Tomiak, T. (2005). Vehicle-to- grid power implementation: From stabilizing the grid to supporting large-scale renewable energy. Journal of

Power Sources, 144(1), 280-294. doi:

10.1016/j.jpowsour.2004.12.022

[37] Ellegaard, O., & Christensen, T. H. (2001). Environmental assessment of solid waste systems and

technologies: EASEWASTE. Waste Management & Research, 19(6), 465-475. doi:10.1177/0734242x0101900603

[38] Chen, C. H., & Yang, Y. C. (2014). Safety analysis of offshore wind farm installation using a fault

tree approach. Safety Science, 65, 61-71. doi: 10.1016/j.ssci.2013.12.003 Legal Impacts:

[39] Bhaduri, S., & Hota, S. (2019). Smart city as aliving lab: The intersection of smart technology, policy,

and urban planning. In A. Agarwal, S. Singh, & M. S. Sodhi (Eds.), Handbook of Research on Smart Urban

Development and Advancement in the 21st Century (pp. 1-23). IGI Global. doi: 10.4018/978-1-5225-7305-0.ch001

[40] Wei, Y., Huang, Y., & Hu, G. (2020). Cultural intelligence and host country nationals' knowledge

sharing: The moderating role of cultural similarity. Journal of Business Research, 109, 124-135. doi:

10.1016/j.jbusres.2019.12.031

[41] Li, Q., Liu, B., & Ren, H. (2019). Environment- friendly research and development investment and

corporate environmental responsibility. Journal of Cleaner Production, 230, 422-433. doi: 10.1016/j.jclepro.2019.05.160

[*The in-text citations and list of references, in IEEE or Harvard, referencing style – but consistently within that style. Use of citation and reference management software/tools/services are highly recommended. Citations of textbooks should be used very rarely and citations to web pages should be avoided. All cited papers should be referenced within the text of the report.*]

Appendix A

Mapping of Course and Program Outcomes

CSE400-A

Program Outcomes:

PO1 (Engineering Knowledge): We decided to take on a project that would allow us to apply our knowledge in Computer Science and Engineering. We carefully chose a project that addresses a current issue in medical science and utilized our existing and newly acquired knowledge to solve it. To tackle this problem, we leveraged various technologies such as Machine Learning, Deep Learning, programming languages, and Data Science concepts. By utilizing these technologies, we were able to develop a solution that effectively addresses the problem of detection of lung cancer.

PO4 (Investigation): Gaining knowledge about previous work in a project is crucial in order to identify potential limitations and solutions. Through extensive research and reading of numerous papers related to our work, we were able to gain valuable insights into the tools, methods, and techniques used by others to achieve similar goals. This helped us to better understand the nuances of the problem we were trying to solve and allowed us to leverage the best practices and learnings from previous works to enhance the effectiveness of our project.

CO	Details	Knowledge Profile (K)	Engineering problem (EP)

CO1	To tackle a real-life complex problem, we have accumulated knowledge from various domains such as Machine Learning, Deep Learning, and Data Science. Our capstone project aims to address a significant issue that has the potential to solve various other related problems. Through this project, we aim to utilize our acquired knowledge and apply it to a real-world problem, which will benefit society.	**(i) Identify a real-life problem [K1, K2, K3, K4]** **K1: Theory-based natural Sciences:** To effectively work on our project, we have relied on our knowledge of machine learning, deep learning, statistical tools, and data science. Our previous courses have provided us with both theoretical and practical knowledge in these fields. To deepen our understanding, we have also studied linear algebra and statistical tools in depth. These foundational concepts are essential for developing and implementing our project	**(i) Identify a real-life problem [EP1, EP2, EP3, EP4, EP5, EP6, EP7]** **EP1: Depth of knowledge required**: The main aim of this project was to implement our engineering knowledge, design skills and practical experience to achieve the desired outcome. **EP2: Range of conflicting requirements**: The main aim of this project was to implement our engineering knowledge, design skills and practical experience to achieve the desired outcome. **EP3: Depth of analysis**

		successfully. **K2: Conceptually-based mathematics, numerical analysis, statistics, and formal aspects of computer and information science**: To carry out our capstone project, we have chosen the field of machine learning and deep	**required**: Due to the absence of a definite solution to the problem, we have experimented with multiple approaches and implemented them to discover the optimal solution for the problem. **EP4: Familiarity of issues**: Although collecting a large amount

		learning. Consequently, mathematical concepts such as linear algebra, calculus, and statistical analysis are essential to understanding the models and algorithms involved. In addition, data science is another crucial area that we need to have a solid grasp on to be able to preprocess and manipulate data effectively. All of these concepts require proficiency in numerical analysis and programming languages. **K3: Theory-based engineering fundamentals**: As we are building our project based on machine learning and deep learning algorithms, a clear understanding of programming languages and their fundamentals is crucial. We need to be proficient in programming languages such as Python to implement our algorithms effectively. We must ensure that our code is clean, efficient, and	of dataset was a challenge, we were able to collect a substantial amount of data from the internet resource without difficulty. **EP5: Extent of applicable codes**: We utilized machine learning and deep learning models to address this issue while adhering to engineering standards. Coding expertise and implementation skills were required to construct this project. **EP6: Extent of stakeholder involvement and conflicting requirements**: The perspectives and interests of stakeholders have been taken into consideration for this project. **EP7: Interdependence**: This project involved solving complex and high-level problems.

		well-organized, and our project is developed following standard software development principles. **K4: Forefront engineering specialist knowledge for practice**: Our team comprises experts in the field of engineering with specialized knowledge in Python, Machine Learning, and Deep Learning techniques and software engineering.	
CO2	Our project intends to address the detection for cancerous cells from the CT-scan image of the lung. We aim to build a solution which can detect whether a patient has a cancerous cell in their lung. Early detection of lung cancer can save the patient's time and suffering as well as can work as the second opinion of a doctor.	**(i) Define the problems [K8]** **K8: Research Literature**: We have extensively studied research papers on identifying the methods to detect lung cancer and have acquired significant knowledge on various machine learning and deep learning models, as well as software tools that can be applied to our project. We are certain that this understanding will assist us in addressing the problem effectively.	**(i) Define the problems [EP1, EP2, EP3, EP4, EP5, EP6, EP7]** **[Same as (CO1)]**

CSE400-B

Program Outcomes:

PO2 (Problem Analysis): Our current project centers around creating a deep learning model for the early detection of lung cancer using CT-scan images. This endeavor addresses a critical medical challenge that requires accurate and efficient solutions. To tackle this, we undertook an extensive analysis of the problem, dissecting its core elements. Concurrently, we delved into pertinent research papers to expand our understanding of the issue. Drawing from this research, we pinpointed the shortcomings in existing approaches and are actively striving to surmount them. Our ultimate aim is to devise a resilient solution that excels at identifying signs of lung cancer in CT-scan images, contributing significantly to improved healthcare outcomes.

PO3 (Design/Development of Solutions): We began our project by devising a solution to the problem we selected. We conducted a series of experiments to determine the most effective solution. Our focus is to ensure the safety and well-being of the general public. Our solution is not influenced by any cultural, societal, or environmental factors.

PO5 (Modern Tool Usage): Our approach to detecting cancerous cells in lung that involves the use of advanced IT tools such as Python, as well as machine learning and deep learning techniques. We have carefully selected these tools based on their effectiveness in addressing our problem. By utilizing these tools, we are confident that we can develop a solution that is highly accurate and reliable in detecting whether patient’s contain cancerous cells or not.

PO6 (The Engineer and Society): Our project is dedicated to creating a deep learning model that detects lung cancer through the analysis of CT-scan images. Our focus is on providing a robust solution to a critical medical challenge. Through extensive problem analysis, we have identified the core aspects of the issue. By reviewing pertinent research papers, we have enhanced our understanding of the problem's nuances. Our project aims to overcome the limitations of current methods and deliver a dependable tool for identifying lung cancer indications in CT-scan images, contributing significantly to healthcare improvement.

CO	Details	Knowledge Profile (K)	Engineering Problem (EP)
CO3		**i) Problem Analysis [K1, K2, K3, K4]** **K1: Theory-based natural Sciences:** CNN used to classify images. **K2: Conceptually-based mathematics, numerical analysis, statistics, and formal aspects of computer and information science:** Linear algebra and statistics for neural networks and optimizing loss. **K3: Theory-based engineering fundamentals:** Fundamental knowledge of Artificial Intelligence, Machine Learning, deep learning, image processing. **K4: Forefront engineering specialist knowledge for practice:** ANN, CNN, different architecture of CNN, transfer learning.	**(i) Problem Analysis [EP1, EP2, EP3, EP6, EP7]** **EP1: Depth of knowledge required:** ANN and CNN models have been built and fine-tuned. **EP2: Range of conflicting requirements:** Based on the range of conflicting engineering requirements, here we face a different output from our predicted and the actual one. **EP3: Depth of analysis required:** A number of models have been trained to find the model with the highest accuracy. **EP6: Extent of stakeholder involvement and conflicting requirements:** Lung Cancer detection can be used by doctors for a double check, and normal people. **EP7: Interdependence:** Several machine learning models have been built for lung cancer classification models that can classify between malignant and normal.

CO4		**(i) Design and Implementation [K5]** **K5: Engineering design:** For our engineering design we generate machine learning model from dataset and use some python libraries like numpy, tensorflow, keras, SGD, classification_report, seaborn, matplotlib, pandas.ModelCheckPoint etc. To resize objects,detect objects and cancel noise we use ANN, CNN. To compare performance of the classification between the train and the test data we use a confusion matrix.	**(i)Design and Implementation [EP1, EP2, EP4, EP5, EP6, EP7]** **EP1: Depth of knowledge required:** We come to have depth of knowledge in software design where we implement machine learning models for generating datasets, some python libraries, CNN for detecting images[K5] **EP2: Range of conflicting requirements:** Based on the range of conflicting engineering requirements, we have faced that CT images are noisy and how to process a CT image **EP4: Familiarity of issues:** Collecting dataset of different kinds of cancerous images. **EP5: Extent of applicable codes:** Extent of applicable codes from various types of methods are observed here. The majority of them applied to professional engineering standards. **EP7: Interdependence:**

			For creating the cancer detection model, we had to first preprocess our dataset, then we had to create the CNN model.All these problems are interdependent
CO5		**(i) Materials and Devices [K6]** **K6: Engineering Practice (technology):** We have applied our understanding of machine learning and deep learning by utilizing the programming language Python.	**(i) Materials and Devices [EP1, EP2, EP4, EP5]** **EP1: Depth of knowledge required:** Knowledge about technologies like Keras, and TensorFlow related to train deep learning models. **EP2: Range of conflicting requirements:** Dataset Images and captured are from online resources. So, we preprocess every image when it is captured. **EP4: Familiarity of issues:** Kaggle offers 12 hours of session and 40 hours of GPU for free use. After 12 hours, the saved files are deleted from the working directory of Kaggle. **EP5: Extent of applicable codes:** Modern Tools have been used to develop the Project. Standard

			Design.

CO6		**(i) Social and Environmental Impact of Engineering [K7]** **K7: Comprehension of engineering in society:** Does not show any harmful activities economically, socially, ecologically, or culturally.	**(i) Social and Environmental Impact of Engineering [EP2, EP5, EP6]** **EP2: Range of conflicting requirements:** Tools that are used to develop the project have been selected considering the age, gender, cultural, legal, environmental and societal impacts to develop user friendly mobile applications so that farmers can easily use the application. **EP5: Extent of applicable codes:** Modern Tools, Standard Project Management and Development Practice is used for project management. **EP6: Extent of stakeholder involvement and conflicting requirements:** Stakeholder means farmers and developers can change their needs considering societal, health safety, and cultural issues.

CSE400-C

Program Outcomes:

PO7 (Environment and Sustainability): The project team has taken into consideration the impact on the field of medical imaging, as it can detect the cancerous region without any doctors consultant. Moreover it can reassure the doctor and can act as a second opinion of the doctor. The project demonstrates the team's commitment to sustainability by developing a solution that can contribute in the medical field.

PO8 (Ethics): The project team has considered ethical implications such as privacy and data security in the development of their Android application. The project demonstrates the team's commitment to ethical principles in engineering and their ability to develop solutions that adhere to ethical guidelines

PO9 (Individual Work and Teamwork): The project team has demonstrated effective teamwork by collaborating on the development of the solution, sharing responsibilities, and communicating effectively. The project demonstrates the team's ability to work both independently and collaboratively, highlighting their individual strengths and the collective abilities of the team

P10 (Communication): The project team has effectively communicated their solution by developing an Android app that is user-friendly and provides the result of the cancer condition to the user. The project demonstrates the team's ability to communicate complex engineering concepts in a clear and concise manner, and to develop solutions that meet the needs of the end users.

P11 (Project Management and Finance): The project team has effectively managed the project by establishing clear goals, timelines, and milestones, and by using project management tools to monitor progress and ensure timely completion. The project demonstrates the team's ability to manage project resources effectively, including time, budget, and personnel, and to develop solutions that meet project requirements within these constraints.

P12 (Life-Long Learning): The project team has demonstrated a commitment to lifelong learning by continuously updating their knowledge of emerging technologies, including machine learning, deep learning, image processing and incorporating these into their solution. The project demonstrates the team's ability to adapt to changing

circumstances, to identify and address knowledge gaps, and to develop innovative solutions that push the boundaries of their current knowledge and skills.

CO	Details	Knowledge Profile (K)	Engineering Problem (EP)
CO7	Analyze and interpret data and develop insights about CT-scan images.	**(i) Societal and environmental contexts [K7]** **K7: Comprehension of engineering in society**: The team has considered the impact of their project on society and the environment and developed a solution that promotes sustainability and social responsibility.	**(i) Societal and environmental contexts [EP2, EP5, EP6]** **EP2: Range of conflicting requirements**: The team has considered the impact of their project on society and the environment and developed a solution that promotes sustainability and social responsibility. **EP5: Extent of applicable codes:** The project team has demonstrated a strong understanding of applicable codes and regulations related to road safety and mobile application development.

			EP6: Extent of stakeholder involvement and conflicting requirements:
			The team will consider and address conflicting requirements, and develop appropriate strategies to manage stakeholder expectations and ensure project success.
CO8	Demonstrating an understanding of professionalism and ethical behavior by adhering to professional standards and codes of conduct, and conducting themselves with integrity throughout the project	**(i) Ethical principle and practices [K7]** **K7: Comprehension of engineering in society**: The team will recognize the impact of the project on the medical field and the user can use the platform which can be beneficial for the society as well.	

C09	Involves the ability to apply critical thinking and problem-solving skills to identify and evaluate potential solutions, as well as to use relevant technologies and tools to implement and test these solutions		
CO10	Ability to integrate image preprocessing		
	techniques and machine learning technologies to develop innovative solutions for enhancing the medical assistance technology.		
CO11	Ability to apply modern tools and technologies for developing a solution to a real-world problem		
CO12	Ability to apply knowledge and skills to solve complex engineering problems		

Appendix B
List of Publications

International Journal Papers (Scopus/WoS/SCI-indexed)

International Conference Papers (Proceedings/Lecture Notes)