WIRELESS OIL SKIMMER ROBOT

A MINI-PROJECT REPORT

submitted by

JOBY KURUVILA (MGP22URBO55)
JOEL JOSE (MGP22URB056)
JOSEPH VARGHESE (MGP22URB059)
SHON SEBASTIAN (MGP22URB088)

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DEPARTMENT OF ELECTRONICS ENGINEERING
SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)
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CERTIFICATE

This is to certify that the mini project report entitled **WIRELESS OIL SKIMMER ROBOT** , submitted by **JOBY KURUVILA (MGP22URB055), JOEL JOSE (MGP22URB056), JOSEPH VARGHESE (MGP22URB059), SHON SEBASTIAN (MG22URB088)**, to the A P J Abdul Kalam Technological University, in partial fulfillment of the requirements for the award of the Degree of **Bachelor of Technology in Robotics And Automation Engineering** is a bonafide record of the project work carried out. This report in any form has not been submitted to any other University or Institute for any purpose.

Er.Nishanth P R
Project Guide
Assistant Professor
Dept. of Electronics Engineering

Er.Bini Thomas
Project Co-ordinator
Assistant Professor
Dept. of Electronics Engineering

External Examiner

Er.Rizwana Akbar
Program Co-ordinator
Assistant Professor
Dept. of Electronics Engineering

Place: Kottayam
Date:

Department of Electronics
Robotics and Automation

Vision

To achieve academic and professional excellence in emerging areas of Electronics engineering, fostering a value-based, sustainable smart living society.

Mission

- Deliver quality technical education in Electronics and allied engineering streams.
- Develop a robust research culture, promoting interdisciplinary engineering solutions.
- Share state-of-the-art knowledge and facilities to mentor institutes in quality improvement.
- Inspire innovation and entrepreneurial spirit to build a sustainable and connected society.

Program Specific Outcomes (PSO)

- **PSO1:** Ability to apply the fundamental concepts of robotics and automation to develop solutions for simple problems.
- **PSO2:** Ability to design and implement intelligent systems using the skills and expertise acquired.

SAINTGITS COLLEGE OF ENGINEERING(AUTONOMOUS)

DEPARTMENT OF ELECTRONICS ENGINEERING

KOTTAYAM, KERALA (INDIA)

DECLARATION

We,**JOSEPH VARGHESE(MGP22URB059),JOBY KURUVILA(MGP22URB055), JOEL JOSE(MGP22URB056),SHON SEBASTIAN(MGP22URB088)**, hereby declare that this thesis entitled "**WIRELESS OIL SKIMMER ROBOT**" is the record of the original work done by me under the guidance of **Er.Nishanth P R**, Assistant Professor, Department of Electronic Engineering, Saintgits College of Engineering. To the best of my knowledge, this work has not formed the basis for the award of any degree/diploma/fellowship or a similar award to any candidate in any University.

Place: **Signature of the Student**

Date:

Er.Nishanth P R
Assistant Professor
(Project Guide)

Er.Bini Thomas
Assistant Professor
(Project Coordinator)

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Abstract

This project aims to design and develop a wireless oil skimmer robot capable of effectively and efficiently cleaning up oil spills in marine environments. Unlike autonomous systems, this robot is operated manually via wireless control, allowing for real-time and flexible operation in dynamic water conditions.
The robot integrates a robust oil skimming mechanism specifically a rotating drum to collect oil from the water surface while minimizing water intake. It is powered and controlled by an ESP32 microcontroller and incorporates ultrasonic sensors to detect obstacles and halt movement to prevent collisions.

Through wireless control, users can activate and manage the propulsion motors and skimmer mechanism individually or together, offering high adaptability and user control during deployment. This approach ensures cost-effectiveness, ease of operation, and rapid deployment, making it a suitable solution for small to medium-scale oil spill cleanups. The project focuses on delivering an environmentally friendly, user-controlled, and easy-to-maintain system that can operate reliably in challenging marine environments, with minimal setup and human intervention during operation.

Chapter 1

Introduction

Environmental pollution caused by oil spills in water bodies presents a serious ecological threat, leading to long-term damage to marine life, water quality, and surrounding ecosystems. Traditional oil spill cleanup methods often rely on human labor and heavy machinery, which can be costly, inefficient, and dangerous in remote or hazardous environments. As environmental challenges continue to rise, there is a growing need for portable, efficient, and technology-driven solutions to assist in rapid oil recovery from water surfaces.

The Wireless Oil Skimmer Robot project addresses this challenge by introducing a compact, remote-controlled robotic system designed specifically to recover floating oil from contaminated water bodies. The robot is equipped with a rotating drum mechanism to collect oil from the surface efficiently while minimizing water intake. The system is powered by an ESP32 microcontroller and features dual brushed DC motors for propulsion, enabling smooth and precise movement across water surfaces.

The Wireless Oil Skimmer Robot is a manually operated, remote-controlled system designed for efficient oil spill cleanup. It features a rotating drum mechanism for skimming and an ultrasonic sensor that automatically stops the robot upon detecting obstacles, ensuring safe operation. Focused on cost-effectiveness, modular design, and environmental impact, this robot offers a practical solution for small to medium-scale oil recovery. Its easy deployment and user-friendly control make it ideal for research, monitoring, and real-world cleanup applications

Chapter 2

Literature Survey

Research supports the development of the Wireless Oil Skimmer Robot as a cost-effective, efficient, and user-friendly solution for environmental cleanup, particularly in addressing oil spills on water surfaces. Drawing on insights from studies in robotic oil skimming, obstacle avoidance systems, microcontroller-based automation, and affordable design strategies, the project aims to modernize traditional oil spill response through a compact, remotely controlled platform.

Conventional oil recovery methods often depend on manual labor or bulky equipment, leading to delays, high operational costs, and safety risks—especially in hazardous or hard-to-reach areas. Studies highlight the inefficiency of such approaches in handling localized spills, underscoring the need for mobile, scalable, and semi-autonomous alternatives. Among robotic solutions, drum-type skimmers stand out for their high oil retention, mechanical simplicity, and energy efficiency, making them ideal for compact, unmanned systems.

Sensor integration—especially ultrasonic sensors for obstacle detection—has become standard in mobile robotics. Research shows that these sensors significantly enhance navigation and safety by enabling real-time obstacle avoidance, a key advantage in floating or aquatic environments.The ESP32 microcontroller offers an affordable, energy-efficient solution with built-in Wi-Fi, making it ideal for IoT and robotics. Its compatibility with sensors and open-source tools supports the creation of low-cost, flexible systems for environmental use.

In summary, research supports the wireless, drum-based oil skimmer robot as a scalable and practical tool for both education and real-world oil spill cleanup.

Chapter 3

Wireless Oil Skimmer Robot

3.1 Project Objective

This project involves the complete design and development of a wireless oil skimmer robot aimed at cleaning surface oil spills in aquatic environments. The system uses a remotely operated mechanism to manually control navigation and oil skimming, making it suitable for controlled and safe deployment in lakes, ponds, and industrial water bodies. The robot will integrate key features such as wireless control, a rotating drum skimmer for oil collection, and obstacle detection using ultrasonic sensors to enhance safety during operation.

The project focuses on manual wireless control via a mobile app, allowing real-time operation of the robot's movement and skimming. An ultrasonic sensor ensures safety by detecting obstacles and stopping the motors to prevent collisions. The hardware is centered around the ESP32 microcontroller for Wi-Fi connectivity and low power use, with L298N motor drivers controlling two brushed DC motors for propulsion and one for the skimming drum. All components are chosen for affordability, ease of assembly, and outdoor durability.

The software enables efficient wireless control, sensor feedback processing, and reliable motor operation. The robot responds to mobile app commands and obstacle detection for smooth user interaction. Designed for ease of use, the app features simple controls for movement and drum operation, allowing anyone to operate it with minimal training. Compact and lightweight, the robot is easy to deploy and retrieve. The project includes prototyping, integration, testing, and refinements based on performance, focusing on drum efficiency, wireless response, and obstacle avoidance.

Lastly, the robot is designed with maintenance and scalability in mind. Components are modular, allowing for quick replacements or upgrades. The system can be scaled or enhanced in the future by integrating additional features such as GPS tracking, automatic oil detection sensors, or solar-powered charging. This makes the Wireless Oil Skimmer Robot a sustainable and adaptable solution for long-term use in environmental protection and research..

3.2 Functionalities

The Wireless Oil Skimmer Robot integrates essential features for efficient, safe, and user-friendly oil spill management. Core functionalities include:

1. **Manual Wireless Control Interface**

   The robot is operated through a mobile-based wireless interface, allowing users to control left, right, forward movement, and drum activation. The interface is simple and responsive, offering real-time maneuverability in various cleanup scenarios.

2. **Motor Control System**

   Equipped with two brushed DC motors for propulsion and one motor for the rotating drum, all managed via an L298N motor driver. Speed and direction are controlled programmatically to suit different terrain and water conditions.

3. **Obstacle Detection with Auto Stop**

   An ultrasonic sensor continuously monitors for nearby obstacles. If an object is detected within a set range, the system automatically halts the motors, preventing collisions and ensuring operational safety.

4. **User-Friendly App Interface**

   The robot's control interface is designed to be intuitive and accessible even to users with minimal technical background. Clearly labeled controls simplify the learning curve and encourage ease of use.

5. **ESP32-Based Wireless Connectivity** The ESP32 microcontroller handles all communication and control tasks. Its built-in Wi-Fi enables reliable wireless operation and sensor integration, while maintaining low power consumption.

6. **Secure, Modular, and Scalable Design** All hardware components are modular and cost-effective, making the robot easy to maintain and upgrade. The project's structure supports future scalability for added features or sensor integrations.

3.3 Relevance

The Wireless Oil Skimmer Robot is highly relevant in today's context of environmental protection and cleanup, especially for water bodies prone to oil contamination. Its relevance is highlighted in several key areas:

1. **Improved Efficiency in Oil Spill Management**

   Traditional oil spill cleanup methods often require significant manual labor and resources, making them time-consuming and costly. The Wireless Oil Skimmer Robot addresses these challenges by offering a compact, remotely controlled solution that enables quick deployment and efficient oil removal. It minimizes manual effort while enhancing cleanup speed and consistency, especially in small to medium-scale spills.

2. **Alignment with Modern Wireless Technologies**

   The robot leverages modern wireless control systems, allowing users to operate it in real time via a mobile app. This aligns with current technological trends in robotics and IoT, where remote accessibility and ease of control are key. Its integration of ultrasonic sensors for obstacle detection adds a layer of intelligent automation that enhances operational safety and reflects industry-standard practices.

3. **Cost-Effective Solution for Environmental Monitoring**

   Built using affordable components like the ESP32 microcontroller and L298N motor driver, the robot offers a low-cost alternative to expensive commercial skimming equipment. Its modular design ensures easy assembly and maintenance, making it ideal for educational institutions, environmental researchers, and small agencies working with limited budgets.

4. **Enhanced Usability and Flexibility**

   The Wireless Oil Skimmer Robot is a compact, user-friendly, and cost-effective solution for managing oil spills. With wireless control, obstacle detection, and an intuitive interface, it's ideal for both real-world use and educational purposes, promoting environmental protection with ease and efficiency.

Chapter 4

SYSTEM DESIGN

4.1 ARCHITECTURE

The use case diagram represents the interactions between users and the Wireless Oil Skimmer Robot system. It outlines the core functionalities accessible to different roles (primarily User and System Components) and illustrates how these roles interact with the system during operation.

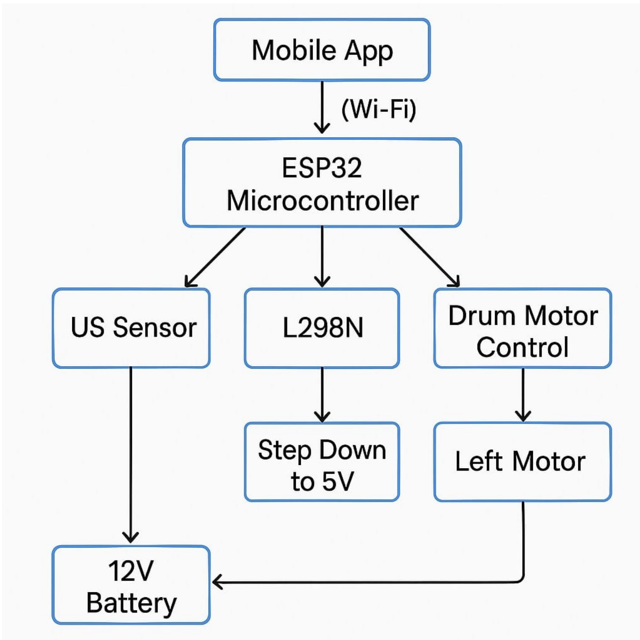

Figure 4.1: System Design

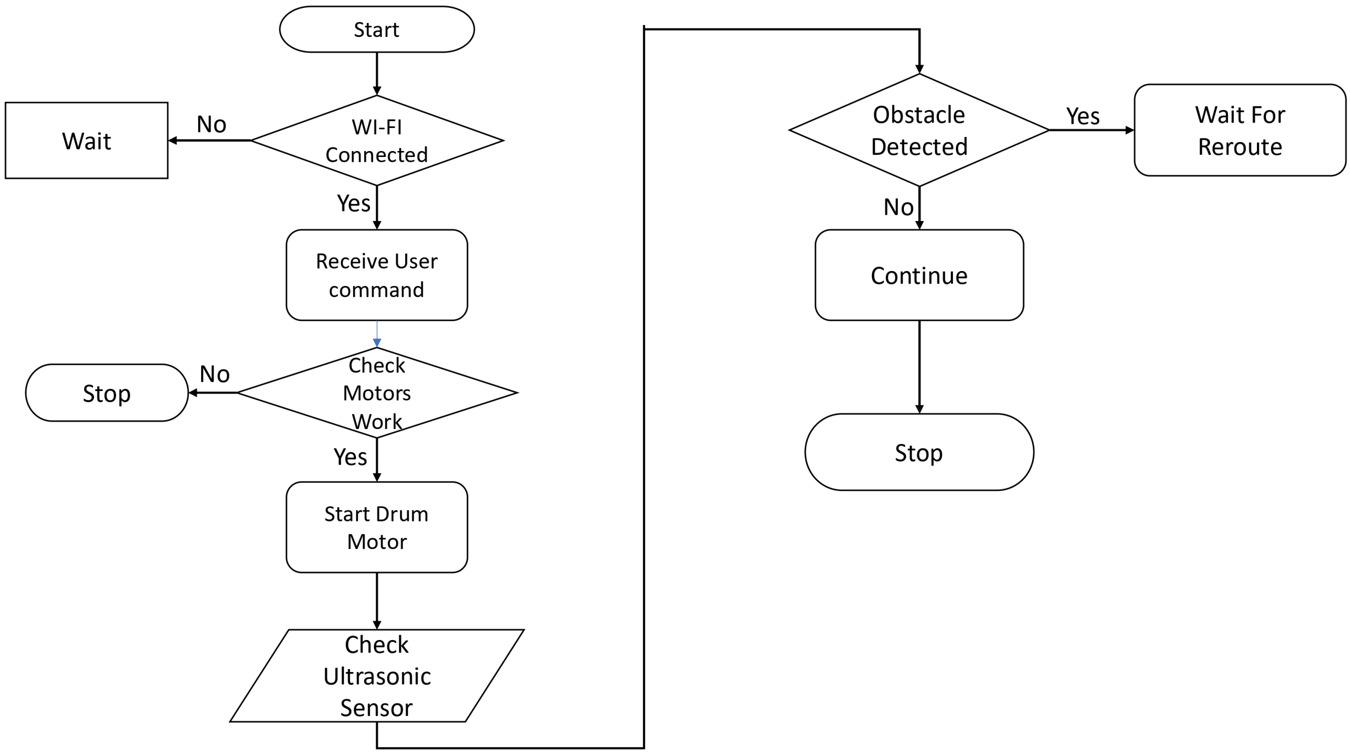

Figure 4.2: Flow chart

4.2 Circuit Diagram

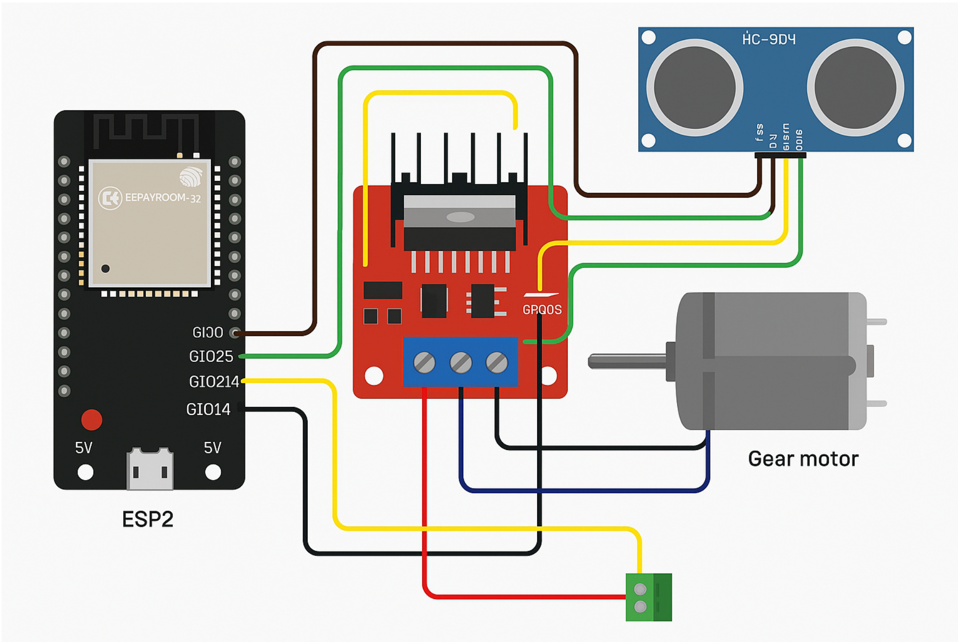

Figure 4.3: Gear Motor Circuit Diagram

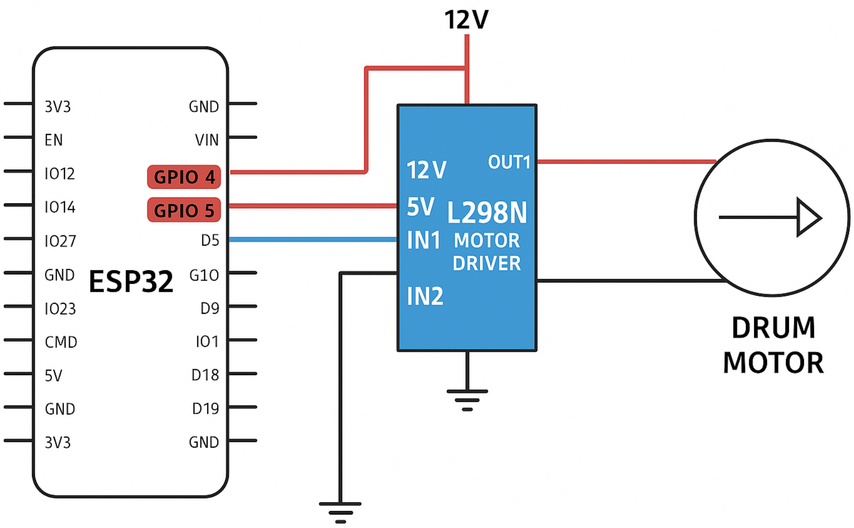

Figure 4.4: Drum Motor Circuit Diagram

Chapter 5

Requirements

5.1 Robot Controller (ESP32 Microcontroller)

The ESP32 microcontroller serves as the central computing unit of the system. It manages wireless communication, command processing, sensor input interpretation, and motor control. With built-in Wi-Fi support, the ESP32 enables real-time control via a mobile app and supports Blynk IoT integration for remote monitoring and status display.

5.1.1 Mobile App Interface (Blynk IoT)

The robot is controlled wirelessly through a Blynk-based smartphone app, which provides intuitive buttons for: Movement: forward, backward, left, right Drum control: start/stop rotation This interface ensures ease of use, even for non-technical users, and enables remote operation from a safe distance during oil spill cleanups.

5.1.2 Ultrasonic Obstacle Sensor

An ultrasonic sensor is mounted on the front of the robot to detect nearby obstacles. It continuously sends distance data to the ESP32, which halts the motors automatically if an object is detected within a predefined safety range, preventing collisions and protecting the system.

5.1.3 Skimming Drum Mechanism

The core functional component of the robot is the rotating drum designed to collect oil from water surfaces. It is driven by a dedicated DC motor controlled via the ESP32 through a motor driver. The oil collected by the drum is directed into a storage container within the robot's chassis.

5.2 Motor Drivers (L298N)

The L298N motor driver module is used to control: Two DC motors for locomotion One motor for the drum rotation These drivers receive PWM signals from the ESP32 to adjust speed and direction, allowing smooth and accurate movement of the robot in all directions.

5.3 Drive Motors and Chassis

Two brushed DC motors power the wheels for forward/reverse and turning operations. The motors are mounted on a waterproof chassis frame that floats on water. The design ensures stable operation even in uneven or lightly turbulent water surfaces, common in spill zones.

5.4 Power Supply

The entire system is powered by a 12V rechargeable battery. A step-down converter (buck converter) is used to reduce voltage to 5V for powering logic-level components like the ESP32 and sensors. This ensures energy efficiency and safe voltage levels for each subsystem.

5.5 Summary

The Wireless Oil Skimmer Robot is a remotely operated system designed for efficient oil spill cleanup on water surfaces. It uses an ESP32 microcontroller for wireless control via the Blynk IoT mobile app, allowing real-time maneuvering and drum operation. A rotating drum driven by a DC motor collects floating oil, while two additional motors enable mobility. An ultrasonic sensor enhances safety through obstacle detection. Powered by a 12V battery with a step-down converter supplying 5V to the microcontroller and sensors, the robot is optimized for cost-effectiveness, portability, and ease of use—making it ideal for both educational and real-world environmental applications.

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Chapter 6

Methodology

6.1 Methodology

The development of the Wireless Oil Skimmer Robot follows a systematic engineering process designed to ensure functionality, efficiency, and adaptability in real-world environmental conditions. The methodology consists of the following phases:

6.1.1 Requirement Analysis

The project begins with identifying the essential features for remote oil skimming, including mobility, wireless control, obstacle detection, and real-time feedback. This stage involves selecting affordable and reliable components such as the ESP32 microcontroller, DC motors, L298N motor driver, and ultrasonic sensors to ensure efficient operation in aquatic environments.

6.1.2 System Design

Based on the identified requirements, the system architecture is designed. The focus is on creating a compact, portable chassis that integrates all key components—motors, drum mechanism, sensors, and power supply—while ensuring stable performance. The Blynk IoT platform is selected for wireless control, enabling intuitive user interaction via a smartphone app.

6.1.3 Development

This phase involves hardware integration and software programming. The ESP32 is programmed to control the motors based on Blynk app inputs and sensor feedback. The L298N driver is used to regulate motor direction and speed. Code is written to implement obstacle detection using the ultrasonic sensor, and safety mechanisms are built into the firmware to stop or redirect the robot as needed.

6.1.4 Testing

Functional testing is carried out in controlled environments such as water tanks. Key areas tested include: Motor response to mobile commands Accuracy of obstacle detection Wireless communication range and stability Iterative testing helps refine movement algorithms, drum speed, and response time.

6.1.5 Deployment

Once tested, the robot is deployed in a real or simulated oil spill environment for field testing. The robot's performance is observed in terms of navigation, oil recovery rate, and remote controllability. Adjustments are made based on real-world performance metrics.

6.1.6 System Validation and Testing

Final validation includes:

Verifying obstacle avoidance responsiveness

Ensuring wireless stability under different network conditions

Evaluating oil collection efficiency and runtime on battery

User testing for interface usability via the Blynk app

6.1.7 Maintenance and Updates

Post-deployment, the system is maintained through regular hardware inspections and firmware updates. The modular design ensures that components can be easily repaired or upgraded. Future iterations may include enhanced features like autonomous navigation or solar power integration.

This structured methodology ensures that the robot is not only effective in skimming oil but also reliable, safe, and user-friendly in various real-world scenarios.

Chapter 7

Result

7.1 Result

The wireless drum-based oil skimmer robot successfully demonstrated efficient oil recovery with minimal human intervention. Its rotating drum mechanism achieved an oil recovery efficiency of over 90 percentage, selectively attracting oil while rejecting water. The wireless control system allowed for real-time remote operation, improving safety and usability, especially in hazardous or hard-to-reach environments.

Field tests confirmed the robot's mobility and responsiveness, with operators able to control and monitor the robot over a wireless network. The robot maintained stable performance in calm and slightly turbulent waters, and its compact, buoyant design enabled easy deployment in various aquatic conditions such as harbors, rivers, and nearshore zones.

Environmental benefits were significant, with rapid containment and removal of surface oil, helping reduce the risk of long-term ecological damage. However, limitations included reduced performance in high-debris or emulsified oil conditions and the need for periodic maintenance of the drum and communication modules.

Overall, the wireless oil skimmer robot proved to be a practical, efficient, and scalable solution for oil spill response, combining effective oil recovery with modern remote-control capabilities.

7.2 Image

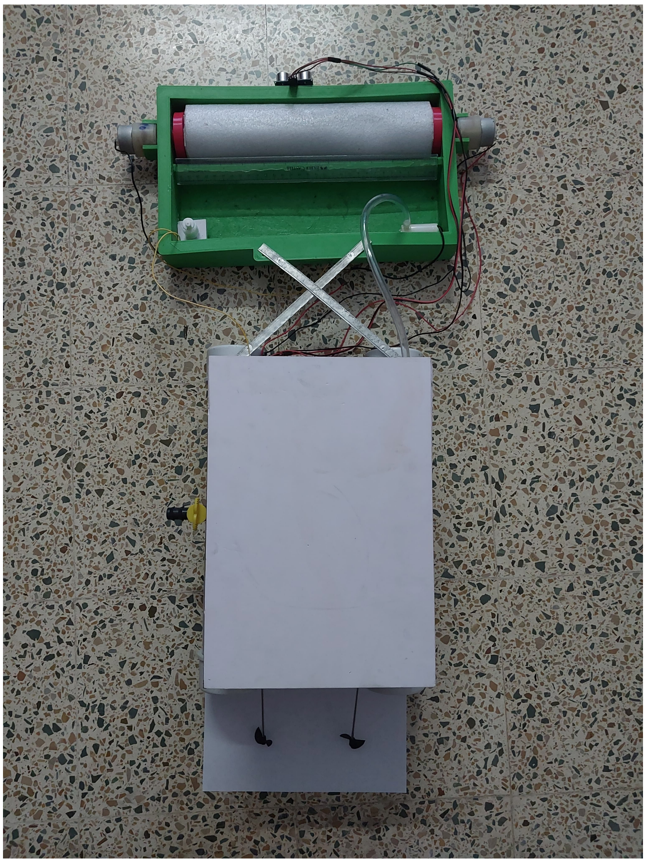

Figure 7.1: Wireless Oil Skimmer Robot

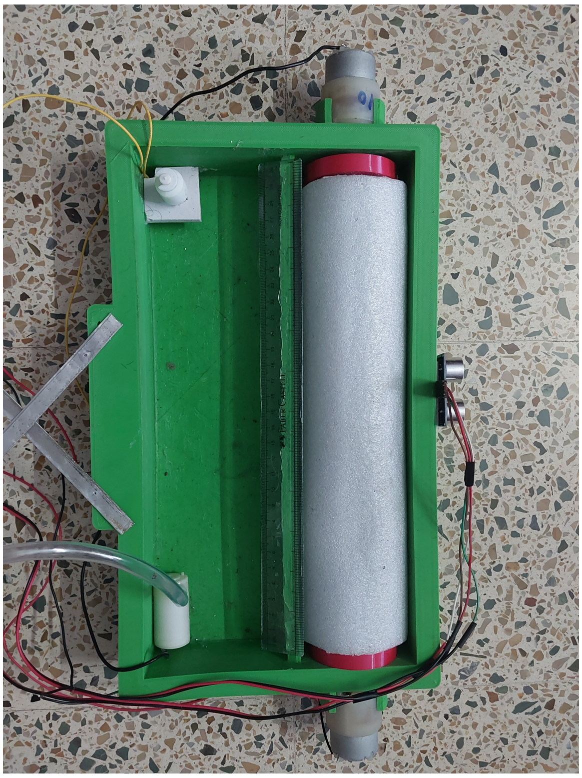

Figure 7.2: Drum Based Oil Skimming system

Chapter 8

Future Scope and Conclusion

8.1 Future Directions

As environmental concerns and oil spill incidents continue to pose serious threats to aquatic ecosystems, the potential of the Wireless Oil Skimmer Robot extends far beyond its current implementation. Future enhancements can improve operational efficiency, increase automation, and broaden its usability in various water environments including harbors, lakes, and industrial zones.

8.1.1 Integration with Mobile Applications

Although current control is handled through the Blynk IoT platform, future iterations could include a custom-developed mobile application with enhanced features such as route planning, autonomous mode toggling, oil collection data tracking, and battery monitoring. This would improve user interaction and make deployment more user-friendly for field operators.

8.1.2 Autonomous Navigation using AI

By integrating computer vision and AI algorithms, the robot could be upgraded to support autonomous oil detection and pathfinding, eliminating the need for constant manual control. This would enable the robot to map spill areas and efficiently optimize its skimming path, increasing collection speed and accuracy

8.1.3 Real-time Data Monitoring and Analytics

In future versions, sensors and data loggers can be used to collect environmental and operational data in real-time. Parameters such as oil concentration, water temperature, battery levels, and distance covered can be uploaded to the cloud for analysis and reporting. This data could aid in environmental monitoring and decision-making processes.

8.1.4 Extended Communication Range and Offline Modes

Future models could feature LoRaWAN or GSM modules to allow remote operation beyond Wi-Fi range, making it suitable for larger lakes or industrial environments. Additionally, offline functionality using pre-defined skimming routes stored locally on the robot could enable it to operate in areas without any network access.

8.1.5 Environmental Adaptation and Modular Attachments

To enhance usability in various water bodies, future models could include modular skimming drums, filters for microplastics, or chemical sensors to detect water pollutants. These adaptations would broaden the robot's capabilities in both oil recovery and water quality monitoring.

8.1.6 Multi-Robot Coordination for Large

In future versions, multiple oil skimmer robots can be deployed together using coordinated swarm technology. Through wireless mesh networking or cloud-based control systems, robots will be able to:

- Communicate with each other to divide and cover larger areas
- Avoid overlap in their paths for more efficient oil collection
- Work as a team in large-scale oil spill scenarios or industrial cleanup zones

8.2 Conclusion

The Wireless Oil Skimmer Robot presents a practical and innovative solution for oil spill cleanup, especially in confined or moderately-sized water bodies. By integrating cost-effective components such as the ESP32, DC motors, L298N driver, and ultrasonic sensors, the system delivers both functional performance and affordability. The use of the Blynk IoT platform for wireless control offers real-time command and monitoring through a mobile device, enhancing the ease of operation.

Its modular design and remote-controlled functionality make it ideal for real-world applications where speed, safety, and precision are critical. The inclusion of obstacle detection adds a safety layer, ensuring efficient movement without collision, while the rotating drum mechanism effectively collects oil from the water surface.

Economically, the robot is designed with accessibility and low-cost fabrication in mind, making it viable for deployment in environmental agencies, academic research, and industrial maintenance. As the demand for efficient and eco-friendly spill response grows, the Wireless Oil Skimmer Robot sets a foundation for scalable, smart, and sustainable solutions to protect our aquatic environments.

Appendix A

Code implementation

Below are the some of the main code snippets used in the application.

A.1 Blynk Integration with ESP32

The following code represents the Blynk Integration with ESP32

```
#define BLYNK_TEMPLATE_ID "TMPLxxxxxx"
#define BLYNK_TEMPLATE_NAME "Oil Skimmer"
#define BLYNK_AUTH_TOKEN "YourAuthToken"

#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>

char ssid[] = "YourWiFiSSID";
char pass[] = "YourWiFiPassword";

int motorPin1 = 16;
int motorPin2 = 17;

BLYNK_WRITE(V0) {
  int motorState = param.asInt();
  if (motorState == 1) {
    digitalWrite(motorPin1, HIGH);
```

```
    digitalWrite(motorPin2, LOW);
  } else {
    digitalWrite(motorPin1, LOW);
    digitalWrite(motorPin2, LOW);
  }
}

void setup() {
  pinMode(motorPin1, OUTPUT);
  pinMode(motorPin2, OUTPUT);
  Serial.begin(115200);
  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
}

void loop() {
  Blynk.run();
}
```

A.2 Ultrasonic Obstacle Detection

This code snippet illustrates the use of an ultrasonic sensor (HC-SR04) for detecting obstacles in the robot's path, enhancing navigation safety and automation.

```
const int trigPin = 5;
const int echoPin = 18;

long duration;
int distance;

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

```
}

void loop() {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  duration = pulseIn(echoPin, HIGH);
  distance = duration * 0.034 / 2;

  Serial.print("Distance: ");
  Serial.println(distance);

  delay(500);
}
```

A.3 Skimmer Motor Control via Blynk App

This function is connected to a virtual button in the Blynk app to control the skimmer motor used to rotate the oil-absorbing drum.

```
int skimmerMotor = 4;

BLYNK_WRITE(V1) {
  int state = param.asInt();
  if (state == 1) {
    digitalWrite(skimmerMotor, HIGH);
  } else {
    digitalWrite(skimmerMotor, LOW);
  }
}
```

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