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Oil Hunter Remote Controlled Marine Robot

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Abstract: ***Oil spills pose a serious threat to marine ecosystems, coastal industries, and public health. Conventional oil spill cleanup methods are slow, labor-intensive, and often inefficient in large water bodies. This paper presents the design and implementation of an*** *Oil Hunter Remote Controlled Marine Robot* ***that can detect, collect, and store oil from the water surface using a manually operated wireless control system.***
Unlike autonomous systems, the proposed robot is remotely controlled using a wireless controller, allowing the operator to navigate the robot precisely toward oil spill locations. The robot integrates a propulsion system, oil collection mechanism, oil–water separation unit, onboard storage tank, and a wireless communication interface. The system is built using cost-effective components such as ESP32, motor drivers, DC motors, relay modules, and a dual-shock controller.
Keywords: Oil spill cleanup, remote controlled marine robot, ESP32, oil skimmer, wireless control, environmental protection.

I. INTRODUCTION

Oil spills in oceans, rivers, and ports cause severe environmental damage and threaten aquatic life. Traditional cleanup techniques such as manual skimming and chemical treatment are slow and require significant human effort.
To overcome these limitations, robotic systems can be used to collect oil efficiently. This project presents a **remote controlled marine robot** that can be operated by a human using a wireless controller. The robot moves on the water surface, collects floating oil using a rotating drum/skimmer mechanism, separates oil from water, and stores the collected oil in an onboard tank.
The remote control approach provides better safety, real-time monitoring, and precise navigation compared to manual cleanup methods.

II. PROBLEM STATEMENT

Oil spills in small water bodies often go untreated due to the lack of affordable and efficient cleanup technologies. Manual cleanup methods are labor-intensive and expose workers to harmful chemicals. Additionally, conventional oil skimmers are bulky and require manual deployment, making them unsuitable for narrow or shallow water bodies.
Another major challenge is the absence of reusable oil recovery mechanisms in low-cost systems. Many existing solutions focus only on oil absorption rather than recovery, leading to secondary waste generation. Furthermore, autonomous robotic systems, although effective, are expensive and complex, requiring advanced sensors, GPS modules, and machine learning algorithms, which increases the overall cost and reduces accessibility for educational and small-scale applications.
Therefore, there is a need for a compact, low-cost, and remotely operated robotic system that can navigate on water, collect floating oil efficiently, separate oil from water, and store the recovered oil for reuse or safe disposal.

III. LITERATURE REVIEW

Several research efforts have been made in the field of oil spill remediation using mechanical, chemical, and robotic techniques. Mechanical oil skimmers such as rotating drum and belt skimmers are widely used in industrial applications due to their high oil recovery efficiency. However, these systems are typically large, expensive, and require manual operation, limiting their use in small water bodies.

A. Mechanical Oil Skimming Systems

Mechanical oil skimmers such as rotating drum, belt, and disc skimmers are widely used in industrial oil recovery applications. These systems rely on the adhesion properties of oil to collect it from the water surface. While they provide high oil recovery efficiency, they are typically large, expensive, and require manual operation, limiting their use in small water bodies.

B. Remote Operated Surface Robots

Remote controlled surface vehicles have been developed for surveillance, water sampling, and environmental monitoring. These robots use wireless communication for navigation and control but generally lack integrated oil collection and separation mechanisms, making them unsuitable for direct oil spill remediation.

C. Autonomous Oil Spill Robots

Autonomous robots equipped with sensors and computer vision algorithms have been proposed for oil spill detection and cleanup. Although these systems offer advanced capabilities, they are complex and costly, making them impractical for small-scale and educational applications.

D. Limitations of Existing Systems

From the reviewed literature, it is evident that most systems suffer from one or more of the following limitations: high cost, complex control systems, lack of compact oil storage, and limited suitability for confined water bodies.

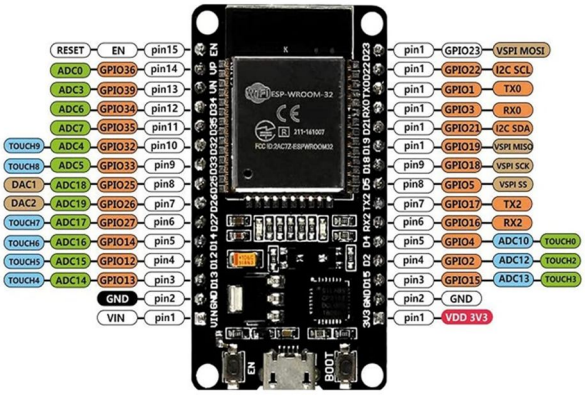
E. Justification for Proposed System

The proposed system combines remote navigation, a mechanical oil skimmer, and an onboard oil–water separation unit in a compact and low-cost platform. This approach provides an effective balance between functionality, cost, and ease of operation, making it suitable for small-scale environmental cleanup tasks.

IV. HARDWARE DESCRIPTION

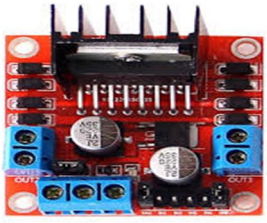
A. ESP32 Microcontroller

The ESP32 microcontroller serves as the central control unit of the robot. It is responsible for receiving wireless commands from the remote controller and generating control signals for the motor driver and relay module. The ESP32 was selected due to its low power consumption, high processing capability, and built-in wireless communication features. Its multiple GPIO pins allow easy interfacing with motor drivers, relays, and other peripherals.



B. Motor Driver – L298N

The L298N dual H-bridge motor driver is used to control the propulsion motors of the robot. It enables bidirectional control of DC motors, allowing the robot to move forward, backward, left, and right. The motor driver also supports PWM-based speed control, ensuring smooth and stable navigation on the water



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C. Propulsion Motors

The robot uses four metal gear motors to provide sufficient torque for movement on the water surface. The use of multiple motors improves maneuverability and stability, especially when carrying the oil storage tank and battery.

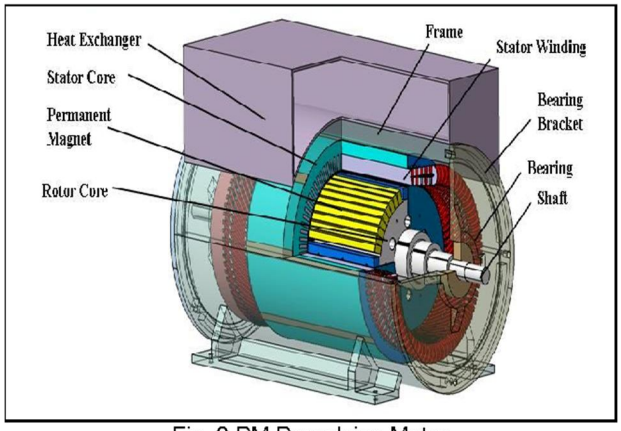


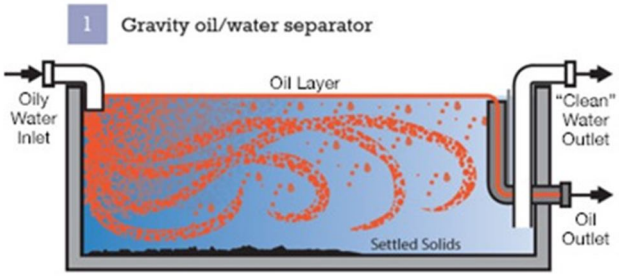
Fig. 2 PM Propulsion Motor

D. Oil Skimmer Motor and Pulley Mechanism

A high-torque 30 V DC motor is used to drive the rotating drum skimmer. The motor is connected to the drum through a 4 cm pulley with a 6 cm diameter, which ensures efficient torque transmission and controlled rotation speed. The rotating drum collects oil from the water surface due to adhesion, and a scraper mechanism directs the collected oil into the storage chamber.

E. Oil–Water Separation Unit

The collected mixture of oil and water is passed through a gravity-based separator. Since oil has a lower density than water, it floats on the surface and is directed into the storage tank, while water is discharged back into the environment. This mechanism ensures efficient oil recovery and minimizes secondary pollution.



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F. Relay Module

A 4-channel low-trigger relay module is used to control the high-power 30 V skimmer motor. The relay acts as an electrical switch that allows the ESP32 to safely control the motor without exposing the microcontroller to high voltage.

G. Power Supply

The robot is powered by a 12 V battery that provides sufficient energy for propulsion motors, control electronics, and the skimmer mechanism. A 7805 voltage regulator with a heat sink is used to provide a stable 5 V supply to the ESP32 and relay module.

H. Floating Structure

The mechanical structure of the robot is built using an aluminium frame for corrosion resistance and thermocol foam for buoyancy. This combination provides a lightweight yet stable floating platform capable of supporting all components.

V. BLOCK DIAGRAM

The block diagram of the system consists of a wireless remote controller that sends commands to the ESP32 microcontroller. The ESP32 processes these commands and controls the propulsion motors through the L298N motor driver. The skimmer motor is activated through a relay module. The power supply unit distributes regulated voltage to all components. The oil skimmer collects oil and directs it to the separator, where oil is stored and water is released.6. Working of the Project:

A. Overview

The block diagram of the Oil Hunter Remote Controlled Marine Robot represents the overall architecture of the system and explains how different hardware modules interact with each other to perform oil spill detection, navigation, oil collection, and storage. The block diagram mainly consists of five major sections: remote control unit, control unit, motor driving unit, oil skimming mechanism, and power supply system. Each of these blocks performs a specific function, and together they ensure efficient operation of the robotic oil recovery system.

B. Step-by-Step Working

Overview

The system operates as a remote controlled oil spill cleanup robot. The operator navigates the robot toward the oil spill using a wireless controller and activates the skimmer mechanism when required.

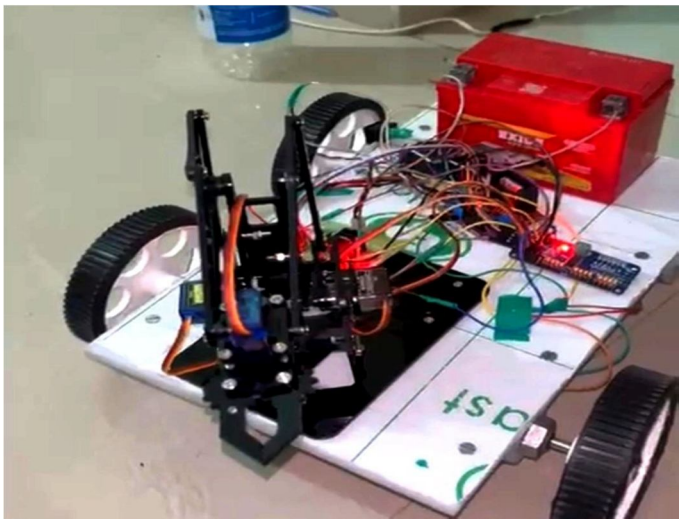
Step-by-Step Operation

1) Power Initialization: When the system is powered on, the ESP32 initializes and establishes communication with the remote controller. The propulsion motors and control circuits receive power from the battery.
2) Remote Navigation: The operator uses the dual-shock controller to move the robot forward, backward, left, and right. The ESP32 processes these commands and controls the motors via the L298N driver.
3) Oil Collection Activation: When the robot reaches the oil spill, the operator activates the skimmer mechanism. The relay module switches on the 30 V DC motor, which rotates the drum through the pulley system.
4) Oil Adhesion and Scraping: Oil adheres to the rotating drum surface and is scraped into the collection chamber. The collected mixture is directed into the separator.
5) Oil–Water Separation: The separator allows oil to float and be stored in the tank while water is discharged back into the environment.
6) Storage and Return: Once the storage tank is filled, the robot is navigated back to the base station for oil removal.

C. Example Scenarios

1) Oil Spill Detection and Collection

- The robot is deployed on the water surface and remotely controlled by the operator using a wireless controller. • The operator navigates the robot toward the oil spill region.
- Once the robot reaches the contaminated area, the skimmer motor is activated.
- The rotating drum collects oil from the water surface and transfers it to the oil collection tank through the separation chamber.



2) Navigation Through Clean Water Area

- When the robot moves in regions where no oil spill is present, only the propulsion motors are used for movement.
- The skimmer mechanism remains turned off to conservepower.
- The operator navigates the robot across the water body until the oil spill area is located.

3) Operation in Confined Water Bodies

• The robot can operate efficiently in narrow water regions such as ponds, small lakes, or drainage channels.
• Due to its compact structure and remote control system, the operator can precisely maneuver the robot in limited spaces.
• The oil skimmer mechanism collects oil from these confined areas effectively.

4) Oil Storage Tank Full Condition

- During continuous operation, the oil collection tank gradually fills with recovered oil.
- When the tank reaches its maximum capacity, the operator stops the skimmer motor.
- The robot is then navigated back to the base station for oil removal from the storage tank.

5) Obstacle Encounter During Operation

- While operating in water bodies, the robot may encounter floating debris or obstacles.
- In such situations, the operator can immediately stop the skimmer mechanism using the controller.
- The robot is then carefully navigated away from the obstacle before resuming oil collection operations.

VI. CONCLUSION

The Oil Hunter Remote Controlled Marine Robot is designed to provide a practical and cost-effective solution for collecting oil spills from water surfaces. Oil pollution in rivers, lakes, and industrial water bodies is a serious environmental issue that affects aquatic life and water quality. Conventional cleanup methods require manual effort and can be slow and unsafe. The proposed system uses a remotely controlled robotic platform that can move across the water surface and collect oil efficiently without direct human involvement.

The robot operates using a wireless control system that allows the operator to guide it toward the contaminated area. The propulsion motors enable smooth navigation on water, while the rotating drum skimmer mechanism driven by a DC motor collects floating oil from the surface. The collected oil is then directed into a separation chamber and stored in a collection tank. The use of lightweight materials such as aluminium sheets and thermocol foam provides sufficient buoyancy and stability during operation.

The project demonstrates that a simple robotic system can effectively assist in small-scale oil spill cleanup operations. It reduces human exposure to polluted water and improves the efficiency of oil collection. The system is also economical and easy to operate, making it suitable for small water bodies, ports, ponds, and industrial wastewater areas.

In the future, the system can be improved by adding cameras for real-time monitoring, sensors for automatic oil detection, and GPS technology for better navigation. Such improvements can further enhance the efficiency and capability of the robot for environmental protection applications..

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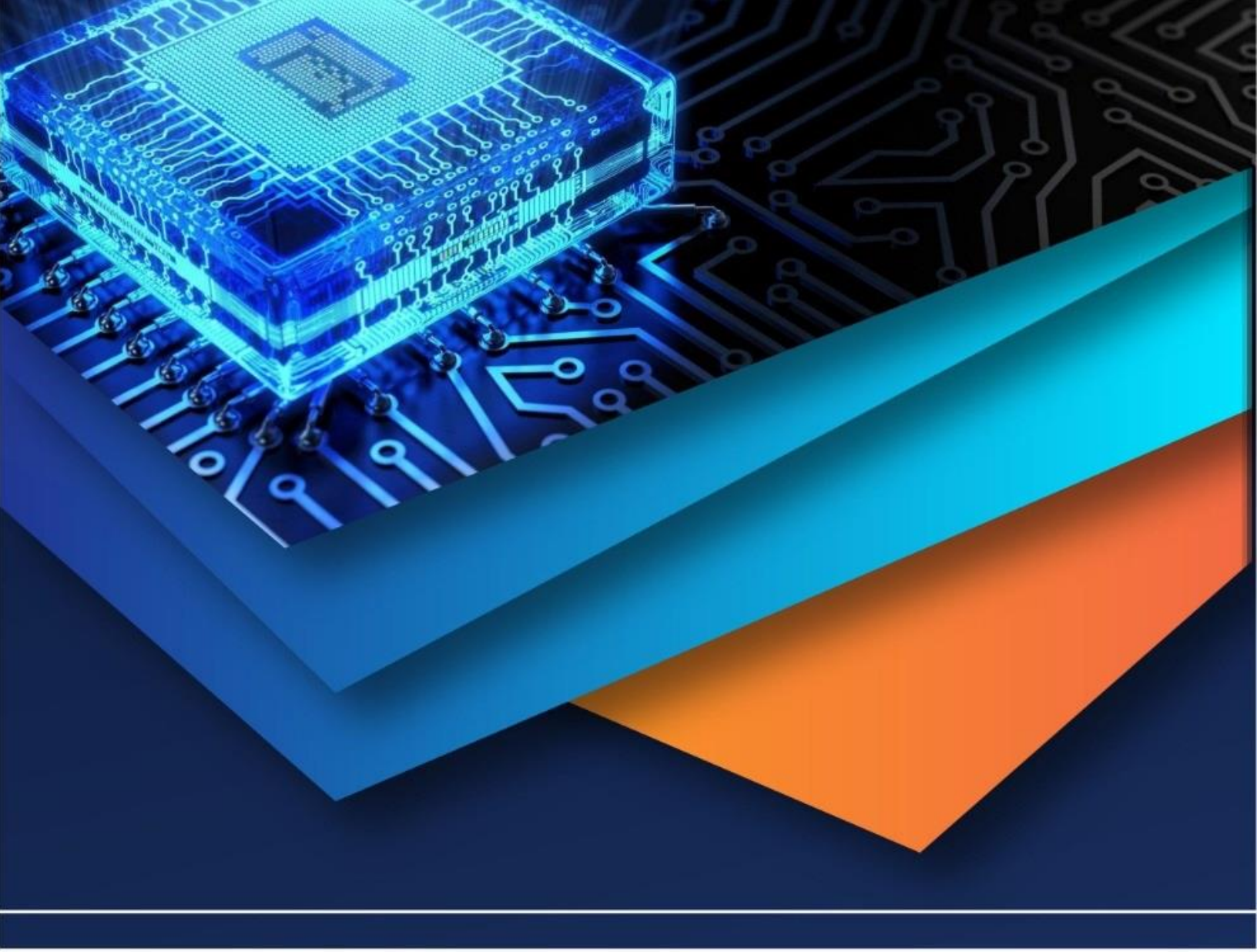

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