Journal of Electronics and Informatics (ISSN: 2582-3825)
www.irojournals.com/iroei/

Internet of Things Enhanced Maritime Robot for Ocean Waste Cleanup

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Abstract

Plastic pollution is a major environmental concern, particularly in aquatic habitats. The accumulation of floating debris in water bodies caused by plastic pollution negatively impacts ecosystems, aquatic life, and water quality. The objective of this proposed study is to develop a remote-controlled boat equipped with sensors for measuring water quality and an efficient waste collection system. These sensors provide important information about the environmental conditions of the water body by measuring important factors like pH, dissolved oxygen, and turbidity. The data on water quality helps identify the regions that require immediate attention to prevent and manage pollution, as well as assess the overall health of the ecosystem. The primary goal of the research is to significantly reduce the plastic waste in marine areas, promote sustainable practices, and raise public awareness about the need to address marine pollution, ultimately enhancing a healthier marine ecosystem.

Keywords: Marine pollution, Ocean waste collection, Remote controlled boat, IoT-Data Collection, Water quality monitoring, PH-sensor

1. Introduction

Variety of waste material originating on land are either carried or dumped into the water, resulting in marine pollution. This contamination endangers the life of sea creatures and harms the environment [6]. The two primary factors that cause marine pollution are debris and chemical pollution. Nutrient pollution, a type of chemical pollution, poses significant risks to

DOI: https://doi.org/10.36548/jei.2024.3.006
Received: 08.07.2024, received in revised form: 06.08.2024, accepted: 23.08.2024, published: 02.09.2024

long-term economic viability, environment integrity and public health. Nutrient pollution is caused by the fertilizers that are used in agriculture to increase the plant growth and yield in the agriculture. This fertilizer releases chemicals into the water bodies, that eventually reach the ocean and lead to contamination. According to the survey on marine pollution by the National Ocean Services, eighty percentage of the pollution on the marine environment originates from land. The primary source that causes the pollution is the nonpoint source pollution, which results from runoff. Examples of nonpoint source pollution are farms, forest areas, ranches, cars, trucks, septic tanks etc [12]. Another major source of pollution is debris carried by the wind to the ocean, which is often caused by littering. This includes the single use plastics, Styrofoam containers and more [11].

Marine pollution is a significant environmental issue that poses a serious threat to the health and the well-being of the planet and has many consequences that either directly or indirectly affects the humans and the marine life.

The proposed study aims to address this issue by developing a remote-controlled boat equipped with sensors to identify the wastes in the marine and collect it. The research is still under development and currently focuses on waste collection using a mobile app developed using Android Studio. The water quality monitoring capability of the device is still under development and would be carried out in the future work of the research.

1.1 Objective

1. **Efficient Ocean Cleanup**: The robot is designed to semi-autonomously collect and remove ocean waste, such as plastic debris, from the water. The use of IoT enables real-time monitoring and control, ensuring more efficient and targeted cleanup operations.
2. **Data Collection and Monitoring**: The robot is equipped with IoT sensors to gather data on ocean conditions, types of waste, and pollution hotspots. This data can be analysed to optimize future cleanup efforts and contribute to environmental research.

These objectives highlight the robot's role in both cleaning the ocean and providing valuable data for better understanding and addressing ocean pollution.

2. Related Work

As waste leakage has adverse impacts on both human health and aquatic environments, it has become a major global concern. It becomes essential to manage the waste by identifying

the key approaches, technologies to have an efficient waste management strategy [1]. This paves way for the integration of innovative technology such as IoT, for environmental monitoring. enhancing environmental sustainability by continuously tracking the change in the environment using the sensors and connected devices [2,5]. IoT (internet of things) has revolutionized various application including the marine waste collection, which poses a serious threat to the environment and the marine life [8,9]. The researchers have come up with many innovative concepts, such as autonomous and semi-autonomous robots [3,4,7] to address these issues. Studies have also explored essential requirements, compared protocols for marine cleanup systems, and developed smart technologies to monitor and tackle the degradation of air and water resources. [10].

3. Proposed Work

The proposed system is a remote-controlled boat equipped with the sensors, to identify and collect the waste in the ocean. The device is controlled remotely by the mobile application developed using the android studio.

3.1 System Architecture

The robot's dual hull structure equipped with chambers keeps it afloat. DC geared motors with propellers enable the robot to achieve various movements, including turning left, right, backward, forward, and combinations like left backward, right backward, left forward, and right forward, by adjusting the polarity of the DC motors.

The mobile application communicates with the robot through a wireless communication medium (Wi Fi) and controls its movements with commands such as STOP, LEFT, RIGHT, FORWARD, and REVERSE. The inputs from the mobile application are sent to ESP32, which processes the commands and sends controls signals to the DC motors through the DC motor drivers (L298N), which manages the speed and the direction of the motors.

The ultrasonic sensor is used for detecting the obstacles in the water, while the relay is used to control high-power components and manage power distribution. The solar panel and the battery system provides power for the continuous operation of the system. Additionally, the proposed device is equipped with pH sensors to monitor the water quality, which is still under the development. Figure 1 illustrates the block diagram of the proposed remote-controlled boat.

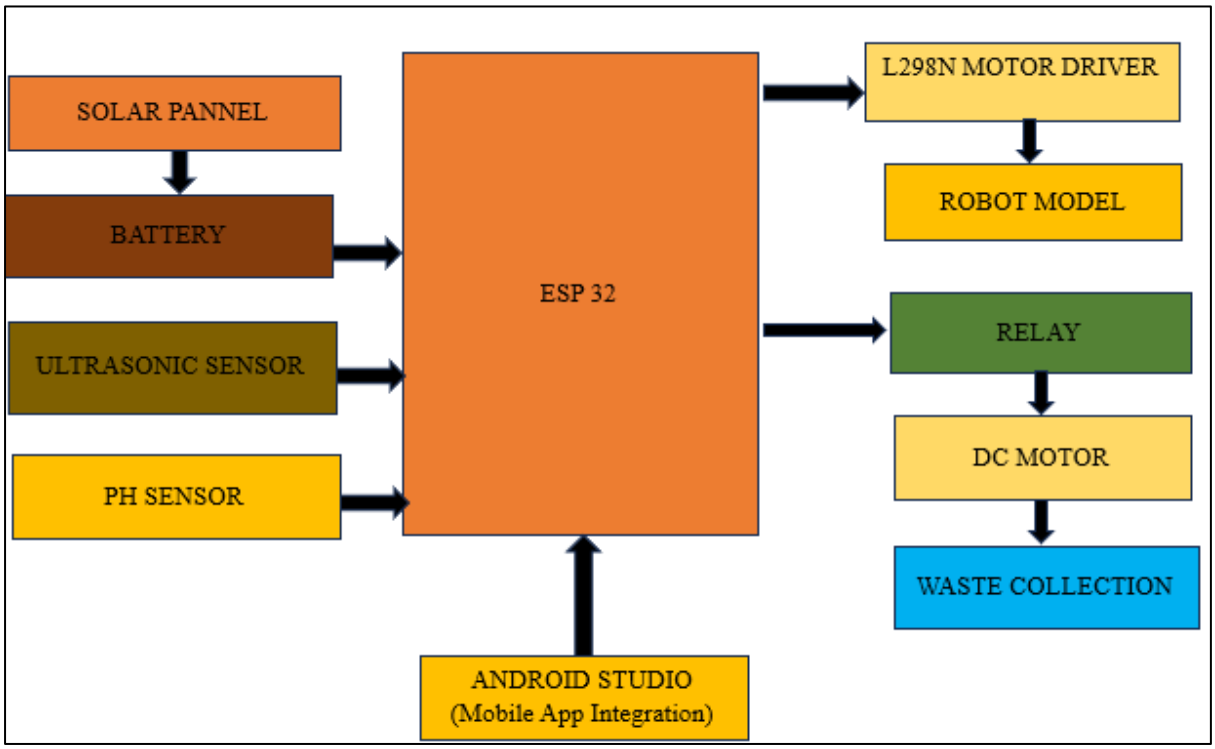

Figure 1. Block Diagram

Table 1. Hardware and Software Components Used

S.No	Hardware Components	Uses
1.	Esp32	It serves as the main control unit of the waste collection robot. It can process sensor data, control motors, and manage the robot's operations.
2.	Ultrasonic Sensor	It particularly designed for navigating complex environments like oceans. These sensors help the robot detect obstacles, measure distances, and ensure safe and efficient operation.
3.	Relay	A relay serves as an electrically operated switch.
4.	PH Sensor	It monitors the acidity or alkalinity of the water.
5.	L298N Motor Driver	It allows for precise control of the speed and direction of the motors, enabling the robot to navigate through water efficiently and adjust its path as needed for optimal garbage collection.

6.	Solar Panel and Battery	It acts as a power source for this sector.
S.No	**Software Components**	**Uses**
1.	Language – Embedded C	The Arduino program code written in Embedded C will continuously read sensor data using appropriate libraries.
2.	Android Studio	Android Studio is the official integrated development environment (IDE) for Android application development.

The Table.1 illustrates the hardware and the software components used in developing the robot.

4. Result

Figure 2 shows the prototype of the remote-controlled robot, which is constructed on a heavy plastic base to ensure it floats in the water. The design includes a plastic tray that serves as a waste collector, an 18V 5W solar panel, and a conveyor belt made of mesh to gather floating objects. The prototype is developed at a small scale and is currently designed to handle a limited amount of waste, specifically up to 5 kg. The conveyor belt has a capacity of less than 6-7 kg and features dimensions of 8 x 48 mm in width and a length of 450 mm, with a roller diameter of 10 mm [13].

Figure 2. Prototype Model

The Figure 3-5 shows the waste collection process of the proposed system.

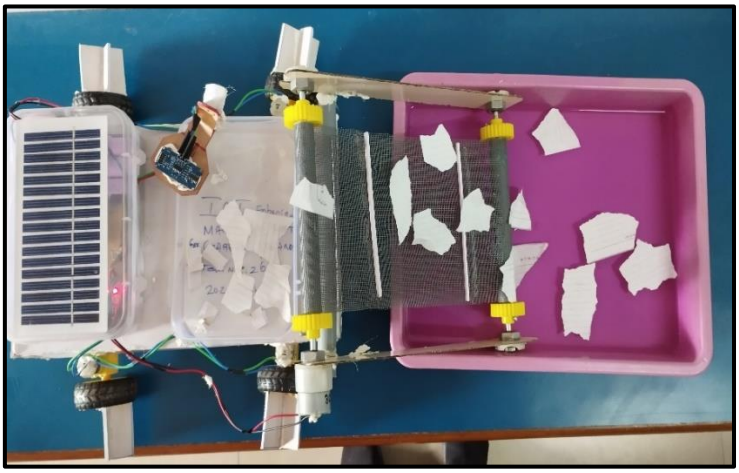

Figure 3. Dust Absorber with Solar Panel

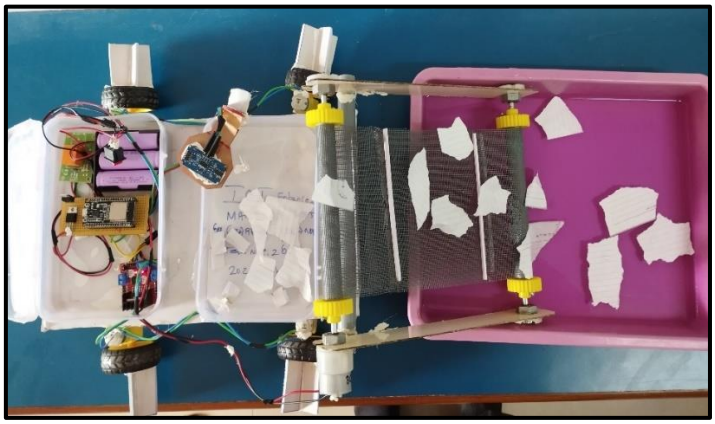

Figure 4. Dust Collector from Water

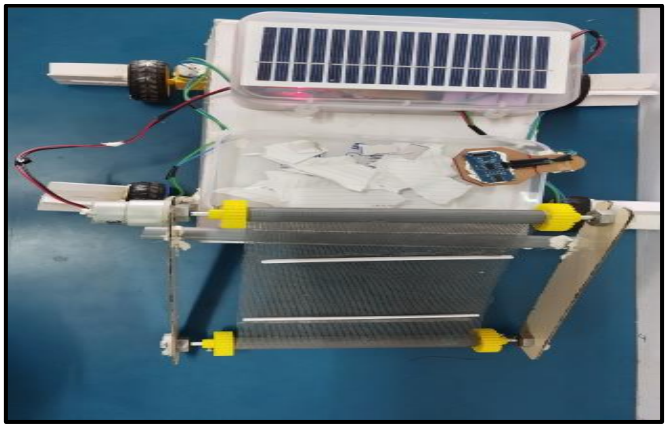

Figure 5. Dust Collector Indication and Separation

Figure 6 shows the mobile application developed by the Android Studio to control robot movements remotely.

Figure 6. Mobile Application

5. Conclusion

The research demonstrates a prototype IOT-based water waste collector that gathers wastes on the water, floats, and can be partially submerged in the water's surface. Though multiple test configurations utilising a smartphone application, remote navigation control of the water waste collector's forward, reverse, and left and right turns has been successful. The water waste collector may eventually be developed with a waste detection system and the ability to drive autonomously without the need for a human operator. By upgrading the collector body with materials of exceptional strength, the risk of flooding can be eliminated. Additionally, incorporating a self-sustaining solar panel could enhance performance by enabling higher speed and torque in the DC motors. The future work will focus on successful completion of the work integrating a water quality sensor, and developing a machine learning model to analyse the collected data to identify the regions that need immediate attention.

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