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Hybrid Solar and Hydro Powered Ocean Cleaning Robot

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Abstract—

Water pollution caused by plastic waste and floating debris has become one of the major environmental problems across oceans, lakes, and rivers. Large amounts of waste entering water bodies every day affect marine life, water quality, and the overall ecosystem. Traditional cleaning methods mainly depend on manual labour and fuel-powered boats, which are expensive, time-consuming, and not environmentally friendly. To overcome these problems, this project proposes a Hybrid Solar and Hydro Powered Autonomous Ocean Cleaning Robot that can automatically collect floating waste using renewable energy sources.

The robot works using a combination of solar energy and hydro energy. A solar panel placed on the robot converts sunlight into electrical energy, while a small hydro turbine generates power from the movement of water. These two energy sources charge a rechargeable battery, allowing the robot to operate continuously for longer durations. The robot is controlled using an Arduino Uno microcontroller and includes motors, sensors, a motor driver, and a Bluetooth communication module for movement and navigation.

The robot moves on the water surface, detects obstacles using infrared sensors, and collects floating waste through a front-mounted collection mechanism. The collected waste is stored inside a basket for later disposal. The use of hybrid renewable energy improves energy

efficiency and reduces dependency on external charging.

The developed system provides an eco-friendly, low-cost, and sustainable solution for cleaning water bodies. It can be used in lakes, ponds, rivers, and coastal areas to reduce pollution and protect aquatic life. In the future, advanced technologies such as GPS navigation, IoT monitoring, and artificial intelligence can be

I. INTRODUCTION

In recent years, water pollution has increased rapidly due to the dumping of plastic waste, bottles, covers, industrial waste, and other floating materials into rivers, lakes, and oceans. This pollution not only affects marine organisms but also creates serious environmental and health-related problems. Marine animals often consume plastic waste accidentally, which leads to injury or death. Polluted water bodies also affect fishing, tourism, and the overall balance of aquatic ecosystems.

Most cleaning operations today are carried out manually using boats and labourers. These methods require more manpower, consume fuel, and involve high operational costs. In large water bodies, manual cleaning becomes difficult and inefficient. Therefore, there is a need for an automated and sustainable system that can continuously clean floating waste with minimum human effort.

With the development of renewable energy technologies and embedded systems, autonomous cleaning robots have become a promising solution for environmental protection. Many existing water-cleaning robots use solar energy because it is freely available and environmentally friendly. However, solar-powered systems alone may not work efficiently during cloudy weather, rain, or nighttime. integrated to improve the efficiency and automation of the system.

Keywords— Hybrid Ocean Cleaning Robot; Solar Energy; Water Pollution Control**;** Renewable Energy System; Floating Waste Collection; Autonomous Cleaning System.

Similarly, hydro-based systems depend on water movement and may produce less energy in calm water conditions.

To solve these limitations, this project introduces a Hybrid Solar and Hydro Powered Autonomous Ocean Cleaning Robot. The robot combines both solar and hydro energy systems so that energy can be generated continuously under different environmental conditions. By using two renewable energy sources together, the robot can operate for longer durations and reduce dependence on external charging.

The main aim of this project is to design a low-cost, eco-friendly, and efficient cleaning robot that can automatically collect floating waste from water surfaces. The system also promotes the use of renewable energy for environmental applications.

II. LITERATURE REVIEW

Many researchers and engineers have worked on developing autonomous water-cleaning systems using renewable energy technologies. These systems aim to reduce pollution and improve the cleanliness of water bodies in an efficient and sustainable manner.

Earlier studies mainly focused on solar-powered cleaning robots. These robots used solar panels to convert sunlight into electrical energy for operating motors and sensors. The systems were successful in collecting floating waste during daytime conditions. However, researchers observed that the efficiency of such robots decreased during cloudy weather and nighttime because the robot depended completely on sunlight for charging.

Other researchers explored hydro-based energy generation systems where turbines were used to generate electricity from water flow. These systems showed good results in moving water conditions such as rivers and streams. However, in lakes or calm water surfaces where water movement is less, hydro systems alone were not sufficient to provide continuous power.

Some advanced projects combined automation with wireless communication and sensors for better navigation and obstacle detection. These systems improved movement control and reduced collisions during operation. Despite these developments, many existing robots still suffer from limited operating time, higher maintenance costs, and dependence on a single energy source.

Recent studies suggest that combining multiple renewable energy sources can improve the reliability and efficiency of autonomous robots. Hybrid renewable energy systems provide continuous power generation under varying environmental conditions and increase the working duration of robotic systems.

Research Gap

Although several water-cleaning robots have been developed, most systems depend on only one renewable energy source such as solar or hydro power. Because of this limitation, the robots cannot operate efficiently under all weather and environmental conditions. Many systems are also expensive and difficult to implement for small-scale applications.There is a need for a simple, affordable, and energy-efficient water-cleaning robot that can operate continuously using multiple renewable energy sources. The proposed project addresses this issue by integrating both solar and hydro energy into a single autonomous cleaning system.

Proposed Solution

The proposed Hybrid Solar and Hydro Powered Autonomous Ocean Cleaning Robot combines solar panels and a hydro turbine to generate electrical power continuously. The robot can automatically move on water surfaces, detect obstacles, and collect floating waste. The hybrid energy system improves operating efficiency, increases battery backup, and reduces dependency on external power sources.

III. METHODOLOGY

A. System Design

The Hybrid Solar and Hydro Powered Autonomous Ocean Cleaning Robot is designed as a floating robotic platform capable of collecting floating waste materials from water surfaces. The robot structure is made using lightweight and waterproof materials to ensure stability and smooth movement on water. All electronic components are placed safely inside the body of the robot to protect them from water damage. The system mainly consists of a hybrid renewable energy unit, Arduino controller, sensors, motor driver, propulsion system, communication module, and waste collection mechanism.

B. Hybrid Renewable Energy System

The robot uses both solar and hydro energy for continuous power generation. A solar panel is mounted on the top surface of the robot to absorb sunlight and convert it into electrical energy using photovoltaic cells. During daytime, the generated solar energy helps charge the rechargeable battery and power the electronic components.

To improve energy generation during low sunlight conditions, a mini hydro turbine is installed beneath the robot. As the robot moves on the water surface, water flow rotates the turbine blades and generates additional electrical energy. The power generated from both solar and hydro sources is combined and stored in the battery. This hybrid system improves power efficiency and allows the robot to operate for longer durations.

C. Power Supply and Battery Management

A rechargeable battery is used as the main power storage unit of the robot. The battery stores electrical energy generated from the solar panel and hydro turbine. Voltage regulators and charging circuits are used to provide a stable power supply to sensitive electronic components such as the Arduino Uno, sensors, Bluetooth module, and motors. The hybrid power management system reduces dependence on external charging and ensures continuous operation under different environmental conditions.

D. Control Unit and Programming

The Arduino Uno microcontroller acts as the central control unit of the robot. It continuously processes input signals from sensors and controls the movement and operation of the robot according to programmed instructions.
The control program is developed using Embedded C language in the Arduino IDE software.

The Arduino performs multiple functions such as:Controlling motor movement , Reading sensor inputs , Detecting obstacles , Managing navigation , Handling Bluetooth communication , Coordinating waste collection operation

The microcontroller ensures smooth coordination between all hardware components and enables autonomous functioning of the robot.

E. Propulsion and Movement System

The movement of the robot is achieved using BO gear motors connected to propellers. These motors are controlled through an L298N motor driver module, which allows the Arduino to control the speed and direction of each motor. Depending on the control signals, the robot can move forward, backward, left, and right on the water surface.

The floating design of the robot provides proper balance and stability during operation.
Differential motor control helps the robot perform smooth directional changes while moving across the water surface.

F. Obstacle Detection and Navigation

Infrared (IR) sensors are mounted on the front side of the robot to detect nearby obstacles such as floating objects, rocks, or walls. The sensors continuously send signals to the Arduino controller.

When an obstacle is detected within a certain distance, the Arduino automatically changes the movement direction of the robot to avoid collision. This autonomous obstacle detection system improves navigation safety and reduces the need for continuous human monitoring.

Bluetooth Communication System

An HC-05 Bluetooth module is integrated into the robot for wireless communication and manual control. The Bluetooth module allows the robot to connect with a smartphone application. Through this connection, the user can monitor and control the movement of the robot within a limited communication range.

This feature helps in testing, monitoring, and manually controlling the robot whenever required.

G. Waste Collection Mechanism

The waste collection system is installed at the front side of the robot using a mesh-type collector or conveyor arrangement. As the robot moves forward, floating waste materials such as plastic covers, bottles, paper waste, and small debris enter the collection section.

The mesh arrangement allows water to pass through while retaining solid waste materials. The collected waste is stored inside a collection basket placed within the robot body. After operation, the waste can be removed manually for proper disposal.

The collection mechanism is designed to efficiently collect lightweight floating waste without affecting the stability or movement of the robot.

H. Testing and Performance Evaluation

After assembling all hardware and software components, the robot is tested under controlled water conditions. Different floating waste materials are placed on the water surface to evaluate the cleaning performance of the robot.

The testing process includes:

- Checking robot movement and stability
- Evaluating solar and hydro power generation
- Testing obstacle detection accuracy
- Verifying Bluetooth communication
- Measuring waste collection efficiency

The results obtained from testing help improve the overall efficiency, reliability, and performance of the autonomous cleaning robot.

IV. RESULTS AND DISCUSSION

The developed prototype of the Hybrid Solar and Hydro Powered Autonomous Ocean Cleaning Robot was tested under controlled water conditions to evaluate its performance, energy efficiency, and waste collection capability. During the testing process, the robot was able to move smoothly on the water surface without losing stability. The floating structure provided proper balance to the system, allowing the robot to carry the cleaning mechanism and electronic components effectively. The movement of the robot was controlled successfully using BO motors and propellers, while the Arduino Uno continuously managed navigation and sensor operations.

The hybrid renewable energy system showed satisfactory performance throughout the experiment. The solar panel generated electrical energy efficiently during sunlight conditions and supplied power to the battery and control circuits. At the same time, the mini hydro turbine generated additional power due to water movement created by the robot's motion. The combination of solar and hydro energy improved the overall power availability and increased the operating duration of the robot compared to systems using only a single energy source. This hybrid approach also reduced the dependency on external charging and made the system more sustainable for long-term operation.

The obstacle detection system functioned effectively during testing. The infrared sensors were able to identify nearby objects and prevent collisions by changing the direction of the robot automatically. This helped the robot navigate safely in water environments containing floating obstacles or barriers. The response time of the sensors and controller was found to be reliable for small-scale water-cleaning applications.

The waste collection mechanism successfully collected lightweight floating materials such as plastic covers, paper waste, leaves, and small bottles from the water surface. The front-mounted mesh collector guided the waste into the storage basket without affecting the movement of the robot. The collected waste remained securely stored until it was manually removed after operation. The cleaning process demonstrated that the robot can effectively reduce floating pollution in ponds, lakes, and slow-moving water bodies.

The Bluetooth communication module also operated properly and allowed wireless control and monitoring of the robot within a short range. This feature helped in controlling the robot manually whenever required and improved the flexibility of operation during testing.

Overall, the experimental results confirmed that the proposed robot is capable of performing autonomous water-cleaning operations efficiently using renewable energy sources. The system proved to be eco-friendly, energy-efficient, and cost-effective. Although the prototype was designed for small-scale applications, the project demonstrates the potential for developing larger and more advanced autonomous cleaning systems for rivers, lakes, and ocean environments in the future.

V. CONCLUSION

The Hybrid Solar and Hydro Powered Autonomous Ocean Cleaning Robot provides an innovative and environmentally friendly solution for cleaning polluted water bodies. The system combines solar and hydro energy generation to achieve continuous and sustainable operation.

The robot can automatically move on water surfaces, detect obstacles, and collect floating waste efficiently with minimum human intervention. The use of renewable energy reduces dependence on conventional power sources and minimizes operational costs.

The project demonstrates how automation and renewable energy technologies can be used together to solve environmental problems effectively. The developed prototype is low-cost, energy-efficient, and suitable for small-scale applications such as lakes, ponds, and rivers.

In future, the system can be improved by integrating advanced technologies such as GPS navigation, IoT-based monitoring, artificial intelligence for waste detection, and automatic route planning for large-scale ocean-cleaning applications.

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REFERENCES

[1] United Nations Environment Programme, *Marine Plastic Pollution Report*, 2021.

[2] Institute of Electrical and Electronics Engineers, “Autonomous marine robotics for environmental monitoring,” *IEEE Access*, 2022.

[3] Tanaka and Williams, “Solar-powered marine debris collection robot,” *Journal of Marine Robotics*, 2019.

[4] Fernandez and Sharma, “Hydrokinetic energy harvesting for robotic systems,” *Renewable Energy Journal*, 2021.

[5] Zhang and Kumar, “Hybrid solar-hydro powered ocean cleaning robot,” *Ocean Engineering Journal*, 2022.