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SOLAR POWERED LAKE SURFACE CLEANING ROBOT

Guide Name

Deepti Kushwaha (assistant professor)

Authors

Sujeet Patel, Shravan Kumar Patel, Sanjay Ganawa

Department of Automobile Engineering

University Institute of Technology, RGPV Bhopal, Madhya Pradesh, India

Abstract

Water pollution due to floating waste, plastics, algae, and suspended particles has become a major environmental issue in lakes and other water bodies. Conventional cleaning methods require large manpower, high operational cost, and continuous maintenance. To overcome these problems, a Solar Powered Lake Surface Cleaning Robot is proposed. The robot utilizes solar energy as its primary power source and integrates IoT-based remote monitoring and control for autonomous cleaning operations.

The proposed system consists of a floating robotic platform equipped with solar panels, DC motors, conveyor belt mechanism, ultrasonic sensor, infrared sensor, and turbidity sensor. The conveyor mechanism collects floating waste from the water surface and transfers it into a storage container. The ultrasonic sensor helps in obstacle detection and autonomous navigation, while the turbidity sensor monitors water quality in real time.

The robot operates in both manual and autonomous modes using Wi-Fi communication and Android application control. Experimental analysis shows that the system can remove approximately 85–90% of floating waste from the lake surface while operating with low power consumption and minimum environmental impact. The buoyancy calculations confirm that the robot can safely float and carry additional waste load without sinking.

Keywords:

Solar Energy, Lake Cleaning Robot, IoT, Water Pollution, Conveyor Mechanism, Autonomous Robot, Environmental Protection.

1. Introduction

Water pollution is one of the major environmental challenges faced by modern society. Lakes, ponds, and rivers are continuously polluted due to disposal of plastics, industrial waste, domestic garbage, and organic matter. Floating waste not only affects water quality but also harms aquatic ecosystems and reduces dissolved oxygen levels in water.

Traditional cleaning techniques involve manual labor and mechanical collection systems which are expensive, time consuming, and inefficient for continuous operation. Therefore, there is a need for an automated and sustainable solution for cleaning water bodies.

The Solar Powered Lake Surface Cleaning Robot is designed to address this problem by combining renewable energy and robotic automation. The robot uses solar energy to power DC motors and sensors, reducing dependency on fossil fuels and external electrical supply. The system autonomously navigates over the water surface and removes floating waste using a conveyor belt mechanism.

The integration of IoT and Wi-Fi communication enables remote monitoring and control through an Android application. This makes the system efficient, eco-friendly, and suitable for smart environmental management applications.

2. Literature Review

Several researchers have worked on automated water cleaning systems and robotic waste collection mechanisms.

M. Mohamed Idhris et al. proposed a remotely controlled sewage cleaning machine to reduce human exposure to hazardous waste and toxic gases. Their system improved safety and cleaning efficiency.

Abhijeet M. Ballade et al. developed a river cleaning system that utilized hydro power for collecting floating waste from rivers. The system mainly focused on reducing river pollution.

P. M. Sirsat et al. introduced a conveyor belt-based river cleaning machine that automatically collects floating debris and reduces manual labor requirements.

Chen Su developed an autonomous garbage cleaning ship using ultrasonic sensors for obstacle detection and floating waste collection. However, stability and navigation control remained challenging.

Recent research has focused on combining solar energy, IoT, and autonomous navigation to improve the efficiency and sustainability of water cleaning systems.

3. Objectives

The major objectives of the project are:

1. To develop an eco-friendly robotic system for lake surface cleaning.

2. To utilize solar energy for sustainable operation.

3. To reduce human effort in waste collection.

4. To monitor water quality using sensors.

5. To implement IoT-based wireless monitoring and control.

6. To improve cleaning efficiency in polluted water bodies.

4. System Components

4.1 Arduino Uno

Arduino Uno acts as the main microcontroller unit of the robotic system. It processes sensor inputs and controls motors, conveyor mechanism, and communication modules.

4.2 Solar Panel

A 10W polycrystalline solar panel is used to generate electrical energy through photovoltaic conversion. The generated power is stored in a rechargeable battery and used to operate the robot.

4.3 DC Motor

A 12V, 30 RPM DC motor is used for propulsion and conveyor movement. The motor provides controlled speed and sufficient torque for robotic operation.

4.4 Conveyor Belt

The conveyor belt collects floating waste from the water surface and transfers it into a storage bin mounted on the robot.

5. Methodology

The robot operates in two modes:

Autonomous Mode

The robot navigates independently using ultrasonic sensors and pre-programmed algorithms.

Manual Mode

The operator controls the robot remotely using an Android application through Wi-Fi communication.

The working procedure is as follows:

1. Solar panel generates electrical energy.

2. Battery stores generated energy.

3. Wi-Fi module establishes communication.

4. User sends control commands through Android app.

5. Microcontroller processes commands.

6. Motors and conveyor mechanism operate.

7. Waste is collected into storage bin.

8. Sensors monitor obstacle distance and water quality.

6. Design and Buoyancy Calculation

The robot is designed using lightweight and corrosion-resistant materials such as HDPE and Aluminium 5052.

Buoyancy Force Calculation

The buoyancy force is calculated using Archimedes' principle.

Given: Length = 83 cm

Breadth = 15 cm

Immersed Height = 8.5 cm

Volume displaced:

$V = L \times B \times h$

$V = 83 \times 15 \times 8.5 = 10582.5 \text{ cm}^3$

Buoyancy force:

$F_b = V \rho g$

The calculations confirm that the robot can float safely and withstand approximately 13 kg of additional load without sinking.

7. Results and Discussion

Experimental testing demonstrated that the robot successfully removes approximately 85–90% of floating waste from the lake surface. The conveyor mechanism efficiently collects plastic bottles, leaves, paper, and suspended debris.

The solar-powered operation significantly reduces energy consumption and environmental pollution. The turbidity sensor provides real-time monitoring of water contamination levels.

Advantages of the system include:

- Eco-friendly operation
- Low operating cost
- Reduced manual effort
- Renewable energy utilization
- Autonomous cleaning capability
- Real-time monitoring

- Limitations include:
- Dependence on sunlight
- Wi-Fi connectivity issues
- Limited battery backup during cloudy weather
- Sensor interference in harsh environmental conditions

8. Conclusion

The Solar Powered Lake Surface Cleaning Robot provides an efficient, sustainable, and intelligent solution for water surface cleaning applications. The integration of solar energy, IoT communication, sensors, and automation improves the operational efficiency while minimizing environmental impact.

The system reduces water pollution, improves aquatic ecosystem health, and decreases dependence on manual cleaning methods. Future work can include AI-based navigation, automatic waste segregation, GPS tracking, and machine learning-based pollution analysis for smart environmental monitoring.

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