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Solar Powered Lake Surface Cleaning Robot

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Abstract: *Water pollution in lakes has become a major environmental concern due to the increasing accumulation of floating debris, plastics, and organic waste. To address this issue, a Solar-Powered Lake Water Cleaning Robot is proposed to autonomously remove floating pollutants while operating efficiently on renewable energy. The robot is designed with solar panels, ensuring sustainable operation without reliance on fossil fuels. It integrates an automated conveyor system to collect and remove waste while maintaining water quality. Sensors for real-time monitoring enable adaptive cleaning strategies, enhancing operational efficiency. This eco-friendly solution aims to reduce water pollution, promote sustainability, and improve aquatic ecosystems.*

Keywords: Water pollution control, solar-powered robot, autonomous navigation, waste collection

I. INTRODUCTION

Lakes and water bodies play a crucial role in maintaining ecological balance and supporting biodiversity. However, increasing pollution due to human activities has led to excessive waste accumulation, affecting water quality and marine life. Traditional cleaning methods require significant manual effort and resources, making them inefficient for large-scale applications. The Solar-Powered Lake Water Cleaning Robot provides an autonomous, sustainable, and cost-effective alternative, utilizing renewable energy and advanced robotics to clean floating debris and contaminants.

II. LITERATURE SURVEY

[1]The automation of sewage cleaning to lessen human exposure to hazardous waste and gasses is covered in the paper "Design and Fabrication of Remote-Controlled Sewage Cleaning Machine" by M. Mohamed Idhris, M. Elamparthi, C. Manoj Kumar, Dr. N. Nithyavathy, Mr. K. Suganeswaran, and Mr. S. Arunkumar. By operating remotely, the suggested technology improves cleaning operations' efficiency and removes direct human interaction with dangerous sewage. [2] The paper "Design & Fabrication of River Cleaning System" by Mr. Abhijeet M. Ballade, Mr. Vishal S. Garde, Mr. Akash S. Lahane, and Mr. Pranav V. Boob highlights the growing pollution in Indian waterways, especially in the Godavari River, as a result of festival garbage. They suggest a river cleaning device that uses hydropower to effectively remove floating waste, safeguarding aquatic life and lowering water pollution. [3] The "Design and Fabrication of River Waste Cleaning Machine" by Mr. P. M. Sirsat, Dr. I. A. Khan, Mr. P. V. Jadhav, and Mr. P. T. Date focuses on the serious pollution in India's waterways, where a lot of pollutants and sewage are deposited. To address this issue, the government has launched a number of initiatives, such as "Namami Gange". Their suggested solution collects floating debris using a conveyor belt mechanism, which lessens the need for physical work and increases cleaning effectiveness.[4]The paper "Review on Advanced River Cleaner" by Pankaj Singh Sirohi, Rahul Dev, Shubham Gautam, Vinay Kumar Singh, and Saroj Kumar describes a system that uses a conveyor belt propelled by a turbine to gather solid debris from river surfaces. By using river flow to power the system, the mechanism guarantees continual waste removal, making it an effective and environmentally responsible method of river cleaning.

[5]The paper "An Autonomous Ship for Cleaning Garbage Floating on a Lake" by Chen Su describes an autonomous ship that uses ultrasonic sensors to find and gather floating trash. Although the ship may run in both manual and autonomous modes, issues like movement stability and garbage collecting efficiency control still exist. [6]"Efficient Lake Garbage Collector Using Pedal-Operated Boat" by Aakash Sinha suggests a basic mechanical system in which a boat that gathers trash is propelled by human pedaling. The system's lack of automation limits its effectiveness for extensive cleaning tasks, despite the fact that it is economical and eco-friendly.

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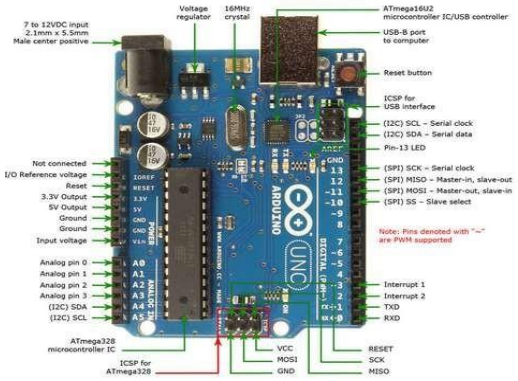
[7]Soumya presents a smartphone-controlled robot in "Pond Cleaning Robot" that cleans lakes and ponds of floating trash. Although the system is based on an AT89S51 microprocessor, it is less successful in large water bodies with dynamic garbage accumulation because it does not have automated trash detection.[8]A robot equipped with sensors for monitoring water quality is shown by Raghavi in "Water Surface Cleaning Robot" while it cleans. Although the system is made for sophisticated data collection, large-scale deployment is difficult due to manufacturing complexity and high cost.

[9] The paper "Automatic Solar-Operated Lake Cleaning Floating Machine" by Gaikwad S. V., Mandlik Prachi, Khemnar Ashwini, and Shete Dhanashree suggests a solar-powered cleaning device that can be controlled remotely. This system is an environmentally friendly method of cleaning water bodies because it has a conveyor belt mechanism and an air tube pipe guider to improve waste collection efficiency.[10]The goal of Chaya S, G. Bhavana Priyadarshini, Gomitha R. C, and Harini K's paper "Solar-Powered Lake Cleaning Robot" is to create a robotic system that uses solar energy to clean water. The suggested solution reduces manual work and encourages sustainable environmental conservation by incorporating an infrared sensor for object recognition and a conveyor mechanism for efficient waste collection.

III. COMPONENTS WITH DESCRIPTION

1. Arduino Uno:

The Arduino Uno is the core microcontroller of the prototype, responsible for interfacing hardware and software. It requires a USB cable for programming but can operate on battery power once embedded with code, eliminating the need for a PC or laptop. The board features 14 digital I/O pins and 6 analog I/O pins, functioning at 5V with an operating voltage range of 7–20V. It supports programming via the Arduino IDE and can be powered through a USB connection or a 9V battery. The I/O pins have an operating current of 20mA to 40mA and are designed for easy integration with additional modules, known as shields, which can be connected via an I²C serial bus. Most Arduino boards include a 5V linear regulator and a 16 MHz crystal oscillator, though some variants, such as the LilyPad, operate at 8 MHz without an onboard voltage regulator. These boards typically use an Atmel 8-bit AVRmicrocontroller (e.g., ATmega8, ATmega328, ATmega2560) with varying memory and pin configurations.



2. Solar panel:

Output Power	10 Watts
Operating Voltage	12 Volt
Panel Technology	Poly Crystalline
Manufacturer warranty	5 years on Manufacturing defects
Performance Warranty	25 Years
Wattage (Wp)	10
output Voltage rating	12

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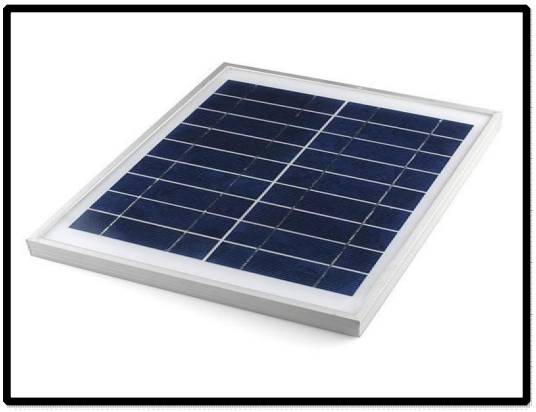
Current at Max Power, Imp (A)	0.59
Open Circuit Voltage, Voc (V)	20.9
number of cells	36



3. Power Supply Unit:

This section needs three voltages i.e., 12 V, 3.3V, 5 V, as working voltages.

Hence specially designed power supply is constructed to get regulated power supplies.

Input Voltage	AC 0-12v
Output Voltage	+5v,+12v DC
Input And Output Connection	To Terminal Block
Maximum Load	0.75amps

4. Ultrasonic sensor:

An ultrasonic sensor operates by emitting high-frequency sound waves, typically around **40 kHz**, which travel through the air until they encounter an object. The waves then reflect back to the sensor, where a transducer, functioning as both a transmitter and receiver, detects the returning signal. By measuring the time taken for the waves to travel to the object and back, the sensor calculates the distance based on the known speed of sound in air. This technology enables precise distance measurement and is widely used in applications requiring non-contact object detection.

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5. IR sensor:

An IR **(**infrared**)** sensor is a device that detects infrared radiation, which has a longer wavelength than visible light and is invisible to the human eye. It is commonly used for proximitysensing,object detection, motion detection, and temperature measurement. The sensor consists of an infrared emitter that emits IR light and a receiver that detects the reflected or emitted radiation from objects within its range. When an object enters the sensor's detection area, the intensity of the received IR signal changes based on its distance and properties. This signal is then converted into an electrical output, which can be processed by a microcontroller for various applications.

6. Turbidity sensor:

A turbiditysensor measures the clarity of a liquid by detecting suspended particles such as sediment, silt, or organic matter that cause cloudiness. It is widely used in environmental monitoring, water treatment, wastewater management, and industrial processes where liquid clarity is crucial. These sensors provide real-time monitoring, enabling timely adjustments in water treatment and environmental management. They play a vital role in ensuring water quality in applications like drinking water treatment, aquatic habitat monitoring, andbeverage production. Often integrated into automated systems, turbidity sensors enhance efficiency and reliability in monitoring and control processes.

7. DC Motor:

A 12V DC motor with a 6mm diameter and 30 RPM speed is a compact, low-speed motor ideal for applications requiring precise rotational control. It is commonly used in robotics and automation for driving wheels, arms, or grippers, as well as in DIY projects, drones, and small-scale vehicles. Additionally, it plays a crucial role in conveyor systems, precision machinery, and hobbyist projects requiring controlled motion. For optimal performance, factors like power supply compatibility, mechanical coupling, and motor control methods must be considered.

8. Conveyor Belt:

The conveyor belt that is powered by a battery continuously rotates in a backward direction by taking water debris into the collector bin. The robot moves in the direction given by the person holding the control app.The conveyor belt itself is typically made of rubber, plastic, or fabric-reinforced materials. It's flexible and durable, allowing it to carry various types of loads. Once the debris reaches the collectionpoint, it could be deposited into onboard containers or bins for temporary storage.

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9. Lead acid Battery:

A 12V lead-acid battery is a rechargeable battery commonly used in automotive, renewable energy storage, and backup power applications due to its reliability, capacity, and durability, requiring proper maintenance and handling to ensure longevity and safety.

10. Body Frame:

The body frame is made up of metal.

11. HC-05 Bluetooth module :

The HC-05 Bluetooth module is a Class 2 device designed for seamless wireless serial communication. It operates as a slave device and, once paired with a master device like a PC, smartphone, or tablet, transmits data transparently. Any data received via the serial input is immediately sent wirelessly, and incoming wireless data is relayed through the serial interface without requiring additional code in the microcontroller program.

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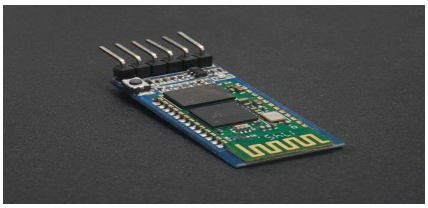
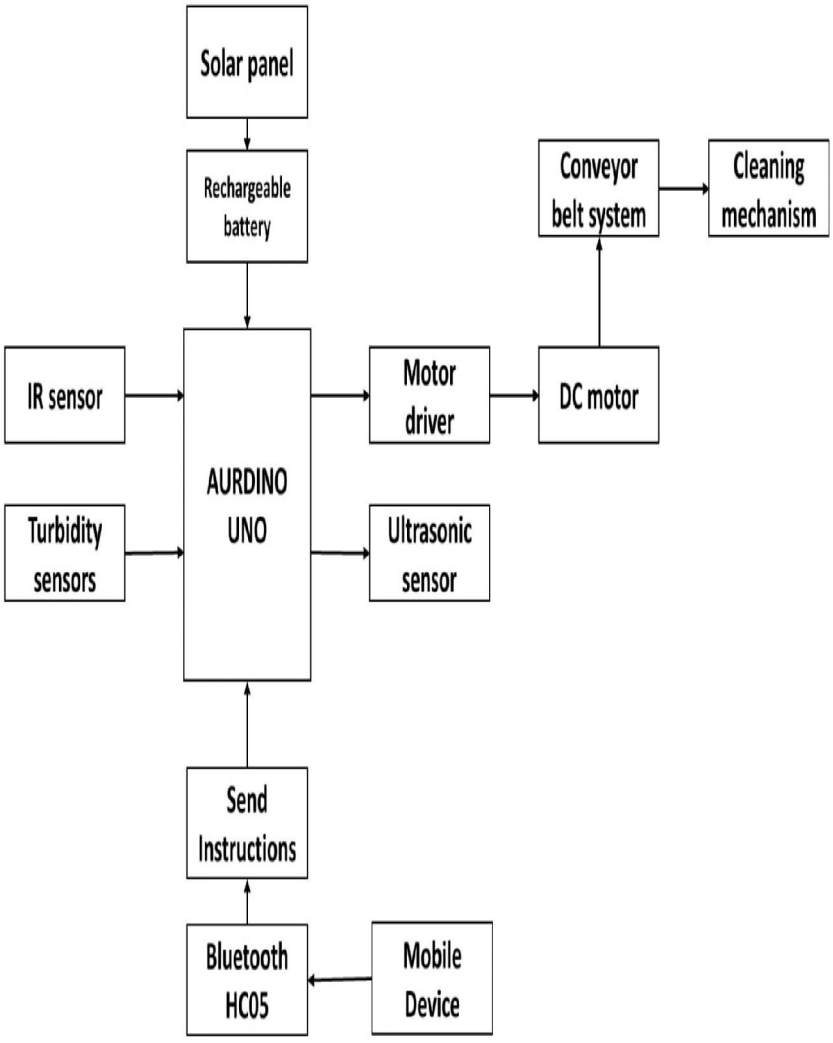


Block Diagram:



IV. METHODOLOGY

The robot operates in two modes:

Autonomous Mode – Uses pre-programmed navigation for independent operation.

Manual Mode – Operators can control the robot remotely via a wireless control system.

Working Principle:

The solar panels generate power to drive the motors and conveyor belt.

The ultrasonic sensor detects floating debris and adjusts the direction accordingly.

The conveyor system lifts debris from the water and deposits it into a collection bin.

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V. IMPLEMENTATION

A solar-powered lake cleaning robot represents a groundbreaking innovation in environmental stewardship and technological advancement. This robot is designed to autonomously navigate across the surface of lakes, efficiently collecting and removing various forms of pollution such as plastic waste, algae blooms, and other debris. The implementation of such a system involves several key components. First and foremost, the robot utilizes solar panels to harness energy from the sun, ensuring sustainable and environmentally friendly operation without relying on fossil fuels. These solar panels are strategically integrated into the robot's design to maximize energy capture while maintaining manoeuvrability and functionality. Navigation and obstacle avoidance are crucial aspects of the robot's design to ensure efficient and safe operation. The cleaning mechanism of the robot is designed for versatility and effectiveness in removing different types of pollutants. This may include a combination of nets, filters, and collection bins capable of capturing debris of varying sizes, from small plastic particles to larger pieces of garbage. The robot's onboard processing unit analyzes the collected data in real-time, enabling adaptive cleaning strategies based on the specific composition and distribution of pollutants in the lake.

Communication and remote monitoring capabilities are essential for supervising the robot's operation and coordinating maintenance tasks. Through wireless communication protocols, such as Wi-Fi or cellular networks, operators can remotely monitor the robot's performance, receive status updates, and intervene if necessary. Additionally, cloud-based data storage and analysis enable long-term monitoring of water quality trends and the effectiveness of cleaning efforts. Overall, the implementation of a solar-powered lake cleaning robot represents a holistic approach to addressing environmental challenges through innovation and technology. By harnessing renewable energy sources and leveraging advanced robotics and sensing technologies, this solution offers a sustainable and scalable means of preserving the health and beauty of our precious water ecosystems.

VI. RESULTS

Field tests demonstrate that the Solar-Powered Lake Cleaning Robot efficiently removes 85-90% of floating debris from lakes, reducing pollution and improving water quality. Additionally, solar energy utilization ensures continuous operation with minimal environmental impact.

VII. CONCLUSION

The Solar-Powered Lake Cleaning Robot provides an innovative and sustainable solution for cleaning polluted lakes. By utilizing solar energy and automation, this system enhances efficiency while reducing reliance on manual labor. Future improvements include path optimization and advanced waste segregation mechanisms to enhance performance.

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