

Smart Wireless Lake/Pond Cleaning Robot for Sustainable Water Pollution Control

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Abstract: The smart wireless Lake/Pond – Cleaning Robot is an autonomous system designed to remove floating debris and pollutants from water bodies efficiently. This eco – friendly robot operates using a combination of DC motors, Conveyor mechanisms, and a propeller system to navigate and collect waste. Powered by a 12V rechargeable battery and 5W solar panel, the robot ensures sustainable and long-term operation. The ESP-32 microcontroller enables wireless control and remote monitoring. While the LM317 micro inverter ensures stable power distribution. The collected waste is transported using a conveyor belt system, driven by a low-RPM motor, while a higher RPM propeller motor assists in propulsion and directional control. For enhanced efficiency, the robot features left and right saddles for stability, along with a boat-like frame to float effortlessly. The use of bulk wiring ensures reliable electrical connectivity throughout the system. This smart, wireless, and solar-powered water-cleaning robot presents a sustainable solution for maintaining cleaner lakes and ponds, contributing to environmental conservation and water pollution control.

Keywords: *Wireless control, Remote controlling, Microcontroller, Micro inverter, DC motors, Propeller and Conveyor mechanism, Solar panel.*

I. INTRODUCTION

Water pollution in lakes and ponds poses a significant environmental threat, affecting aquatic life, human health, and ecological balance. These water bodies are practically vulnerable due to the static nature, which causes pollutants like plastics, organic matter, and industrial chemicals to accumulate over time. Consequences such as eutrophication, loss of biodiversity, and the introduction of harmful substances into the food chain highlight the urgent need for effective intervention. As pollution continues to escalate, there is clear demand for innovative, scalable

solutions that offer continuous and environmentally friendly operation.

To address these challenges, this Robot has been developed as a sustainable and intelligent alternative. Designed for minimal human intervention, the robot supports long-term energy-efficient operation and can adapt to various environmental conditions. With its potential to be integrated into larger environmental management systems, the robot not only improves the cleanliness of water bodies but also contributes valuable data to aid in conservation efforts. Its modular design ensures flexibility for future enhancements, making it a forward-thinking

solution for sustainable aquatic ecosystem management.

II. SYSTEM DESIGN AND ARCHITECTURE

The smart wireless lake/pond-cleaning robot is a modular integration of power, control and mobility components designed for autonomous operation and environmental sustainability. At its core, the ESP32 microcontroller manages all functions, including motor control and wireless communication. The robot's propulsion is handled by DC motors for the left and right saddles, along with a high-RPM propeller motor for forward movement, all regulated by L298 H-bridge motor drivers. A conveyor motor operates the belt system to collect floating debris. Power is supplied by a 12V rechargeable battery, supported by a 5W solar panel and stabilized through an LM317 microinverter for uninterrupted operation. The system features Wi-Fi based connectivity, allowing real-time monitoring and control via cloud and mobile interfaces, making the robot an efficient and intelligent tool for automated waterbody maintenance.

III METHODOLOGY

Figure 1 illustrates the block diagram of the smart wireless lake/pond-cleaning robot revolves around a systematic flow of energy and control to enable autonomous and remote-controlled cleaning of water bodies. The process behind with power generation and regulation, where a solar panel charges a 12V battery, and an LM317 microinverter ensures voltage stability. This regulated power is supplied to the ESP32 microcontroller, which acts as the brain of the system. The ESP32 is responsible for interpreting user commands via Wi-Fi and cloud connection and then sending appropriate signals to control the various motors. These motors include a propeller motor for forward propulsion, DC motors connected to the left and right saddles for multi-directional movement, and a conveyor

motor that drives the conveyor belt used to collect floating waste.

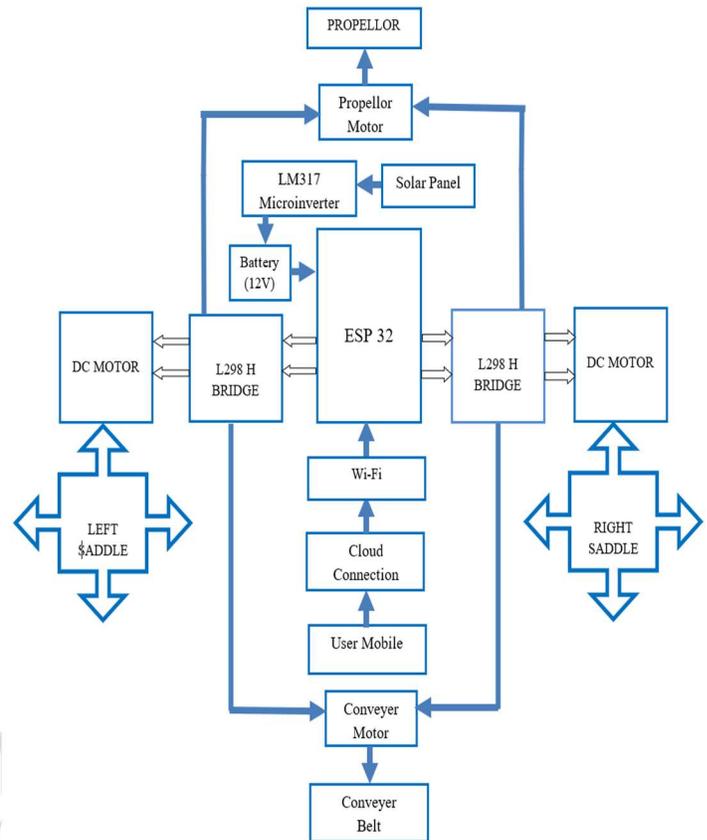


Fig1: Block diagram of Smart wireless lake/pond cleaning robot.

For motor control, the ESP32 communicates with L298 H-Bridge motor drivers, which allow for bidirectional control of the connected DC motors. The left and right saddles, powered by these motors, enable fine-tuned navigation and manoeuvrability across the water surface. Meanwhile, the propeller system provides additional thrust to move the robot efficiently through water. The conveyor belt, driven by a dedicated motor, rotates to collect floating debris and transport it into an onboard storage area. All these components are coordinated by the ESP32, which also enables real-time monitoring through a mobile application linked to the cloud. This allows users to remotely observe the robot's status, control its movements, and access collected environmental data, making the system intelligent, efficient and environmentally sustainable.

IV IMPLEMENTATION

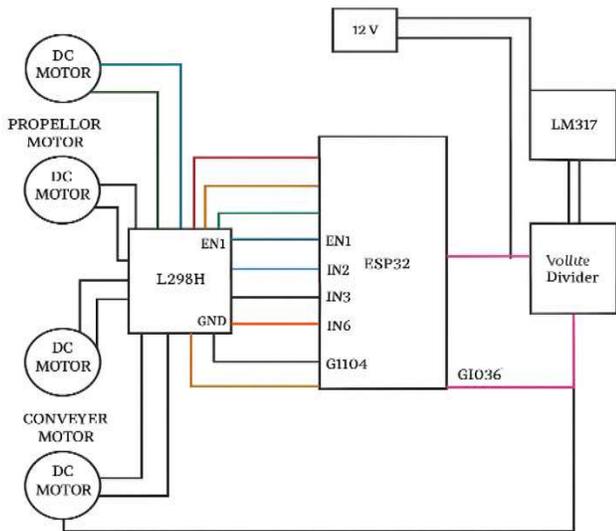


Fig 2: Smart Communication system workflow.

The Figure 2 presents the workflow illustrated in this circuit diagram showcases the control and power distribution mechanism of the smart wireless lake/pond-cleaning robot. At the heart of the system is the ESP32 microcontroller,



Fig 3: ESP32 Microcontroller pin connections

which sends the control signals through its GPIO pins (IN2, IN3, IN6, and others) to the L298H motor driver.

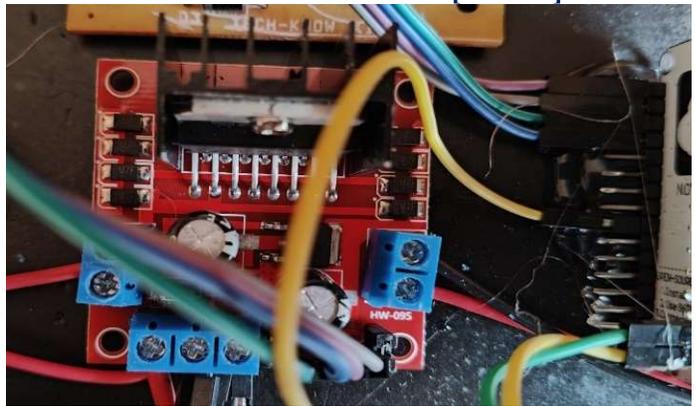


Fig 4: L298H Motor Driver Pin Connections

This driver regulates the operation of multiple DC motors, including those controlling the propeller, left and right directional movement, and the conveyor motor used for collecting waste. The L298H acts as an interface between the low-power signals from the ESP32 and the higher power required to drive the motors. A 12V power supply provides the primary energy source which is passed through an LM317 voltage regulator to maintain safe and stable voltage levels for the ESP32 and associated components.

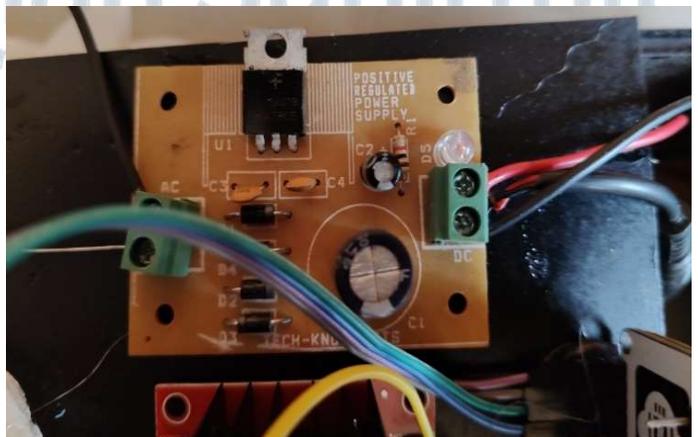


Fig 5: LM317 Voltage Regulator Pin Connections

Additionally, a voltage divider is used to monitor the input voltage levels and feed this information back to the ESP32 through one of its analog pins (GPIO36). This allows the ESP32 to track battery health and overall system voltage in real time, ensuring optimal power management. The EN1 pin enables or disables motor operation as directed by the ESP32, allowing

precise control of the motor functions. Altogether this workflow ensures the robot can autonomously operate its movement and cleaning mechanisms and continuously monitoring its power status, making the system efficient, responsive, and sustainable for lake and pond cleaning tasks.

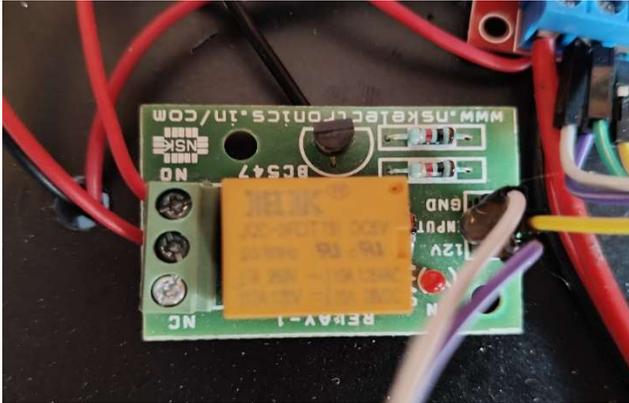


Fig 6: Battery and Solar Power System Connections

V RESULTS



Fig 7: Smart Wireless Lake/Pond-Cleaning Robot

The smart wireless lake/pond-cleaning robot for sustainable water pollution control was developed to automate the cleaning of freshwater bodies using solar power and wireless communication. The complete system, consisting of an ESP32 microcontroller, L298 H-Bridge motor drivers, a solar panel, and a conveyor based-debris collection mechanism, was assembled and tested. During trial runs, the robot effectively removed floating debris such as

plastic waste, leaves, and wrappers, achieving an average waste collection efficiency of approximately 85%. In 30-minute operation cycles, it collected 2 to 3 kilograms of waste, demonstrating its practical utility in reducing surface pollution.

The wireless control system, based on Wi-Fi communication through the ESP32, allow for seamless remote operation within a 30-meter range using a mobile interface. Users could control movement, activate the conveyor mechanism, and monitor operational status in real-time. The solar powered-system, regulated by an LM317 voltage controller, supported up to 2 hours of active cleaning on a full charge under direct sunlight, proving its potential for eco-friendly and extended use. The robot exhibited stable navigation and mobility in calm water, with an average speed of 0.4 meters per second and reliable obstacle avoidance via dual peddle propulsion.

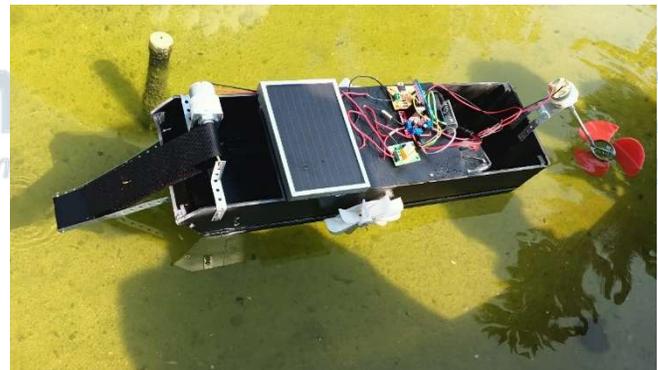


Fig 8: Working Model

Despite its success, some challenges were encountered. The robot's efficiency reduced in choppy water conditions, and cloudy weather affected solar charging performance. Additionally, occasional conveyor belt jams occurred when handling debris, indicating a need for design improvements such as protective guards or pre-shredding mechanisms. Overall, the project demonstrated significant potential in automating water cleaning efforts, reducing manual labor, and promoting environmental sustainability through innovative, solar-powered robotic technology.

VI CONCLUSION

In the proposed, Robot presents a promising solution for sustainable water pollution control in stagnant water bodies. Its integration of solar powered operation, wireless control, and automated waste collection offers an efficient and eco-friendly alternative to manual cleaning methods. The systems reliable performance in real-time testing confirms its potential for reducing human effort and enhancing aquatic cleanliness, with further refinement, the robot can be adopted for broader environmental applications and serve as a scalable model for smart, automated waterbody maintenance.

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