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Autonomous Water Cleaning Robot

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***Abstract*— Worldwide freshwater bodies face a pollution crisis due to industrialization, urbanization, and improper waste disposal. Current river-cleaning techniques depend on labor manual operations and large machinery. This paper presents a design and proper solution for the problem, which is a Smart Remote River Cleaning Device that has an ESP32-based embedded system with multi-sensor water quality monitoring, real-time IoT cloud, and automatic surface waste collection. The device has a motorized conveyor-net assembled to capture floating waste and debris. It also has water quality sensors which are pH, turbidity, and TDS, with GPS modules streaming the data to the cloud. It also has Solar photovoltaic panels connected to lithium polymer (Li-Po) battery to provide efficiency. The proposed device offers a low-cost, sustainable solution for water pollution.**

***Keywords*— Autonomous water cleaning robot, Microcontroller, IOT water-quality Monitoring, river-cleaning robot, solar-powered robotics, water pollution, Conveyor Mechanism**.

I. Introduction

Rivers and other fresh waters are very polluted due to industrialization and lack of proper waste disposal. Regular methods of cleaning the river require more workforce and Large machines, which are too expensive and extremely dangerous for humans, take the risk of life. So that for this problem, a Smart Remote River Cleaning Device (SRRCD) has been developed. This device uses an ESP32 controller, PH, TDS, turbidity, and GPS sensors. These sensors check the water quality and send the information to the cloud.

II. Related Work

This section contains Research information about the Autonomous water surface cleaning robot has grown rapidly, focusing on debris collection from surface, the robot will understand its goal of waste detection and collection, based on water quality monitoring.

A. Surface waste gathering many researchers have manual filtration and cruising ideas to remove debris. A Different way is using an Arduino, Microcontroller, a conveyor belt, and propellers controlled by a Bluetooth Application successfully showing floating garbage collection in the water bodies. But this configuration was not enough for functions like Real-time water Quality check, GPS tracking, and IoT cloud connectivity.

To attain self-determination, IoT cloud and computing services are added, for instance. A Raspberry Pi-system utilizing Navigation, BLDC motor, and computer vision can show accurate and autonomous routing for debris collection. Even after its accuracy, the total implementation cost is higher and after this adding solar panels and water quality could make it even Costlier.

B. Energy Integration in Water Cleaning Systems

Viability becomes a main concern in Latest USV design. A reliable solar energy water surface cleaning robot uses solar panels, DC motor, and a mechanical collection bucket successfully ensures it usability of constant work on the water surface, solar power. However, this prototype did not contain GPS Cruising, IoT Cloud, and Real time water Quality check.

C. Research Gap

This literature shows Perpetual balancing act between surface cleaning ability and Bioinstrumentation. While various platforms effectively collect floating debris or depend on computer vision, the mostly ignore the parallel degradation of water PH. This project focuses on these clear Architectural Gaps by creating a balance between cost, renewable energy, and fully automation of robot operation. This separately combines Automation of surface debris collection with the PH, TDS, and turbidity sensor's gather input to the IoT cloud platform.

III. Proposed System

The Smart Water Cleaning Robot is designed as an autonomous water cleaning robot that should be capable of collecting floating waste from the water surface. The Robot combines the embedded control, waste collection, wireless communication to improve its efficiency

The ESP32 microcontroller is the main brain or central controller of the system, which collects all the data from the sensor and controls all mechanical operations. Two DC motors navigate the robot towards the floating waste. An ultrasonic sensor continuously measures the distance between the robot, and the obstacles present near the robot. When any obstacle is detected within the predefined range, the controller changes the direction automatically that prevents collisions.

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Conveyor Belt, which is present at the front of the robot, rotates continuously. Floating plastic bottles, paper, leaves, and similar waste are lifted from the surface of water, and it goes into the storage container. The storage container is empty after cleaning is done.

Esp32 enables Wi-Fi connectivity, allowing the robot to send all the data to an IoT platform for monitoring. The proposed system provides a solution that reduces manual labor cost while maintaining efficient cleaning work.

TABLE I
PRIMARY FEATURES

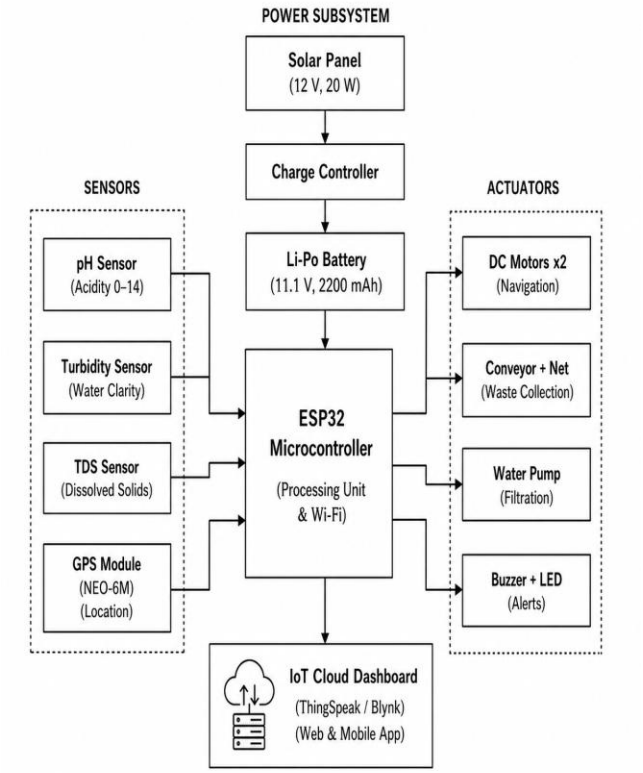
Ref.	***Primary Feature***	***Power Source***
[1]	Coverage path planning	Battery
[2]	Vision-based detection	Battery
[3]	Low-cost build	Battery
[4]	Ultrasonic-obstacle avoidance	Battery
[5]	Solar-assisted operation	Solar + Battery
SRCU	Multi-sensor IoT monitoring + collection	Solar + Li-Po

IV. System Architecture And Hardware Design

ESP 32 is used in this device that acts as the brain of this project. It gathers inputs from sensors and other components; it sends the output data to the Cloud platform that was created or database attached.

The user gets to know the quality of the water. The collected data is studied to analyze water is consumable or not therefore this robot helps both practical and theoretical implementation

This Robot Heavily Relies on Sensor Accuracy. This requires peak output from sensors. Also, the sensors are prone to work accurately under water and overall surfaces.



V. IOT Cloud Architecture

On the Cloud virtual machine, the Sensor data is published using MQTT protocol over Wi-Fi in the ESP32 module. The dashboard presents water quality parameters, GPS-based debris contamination, and time series charts to alert thresholds. Users get to notify over telegram bot API when thresholds trigger. All the data water collected, and water contamination sends to cloud

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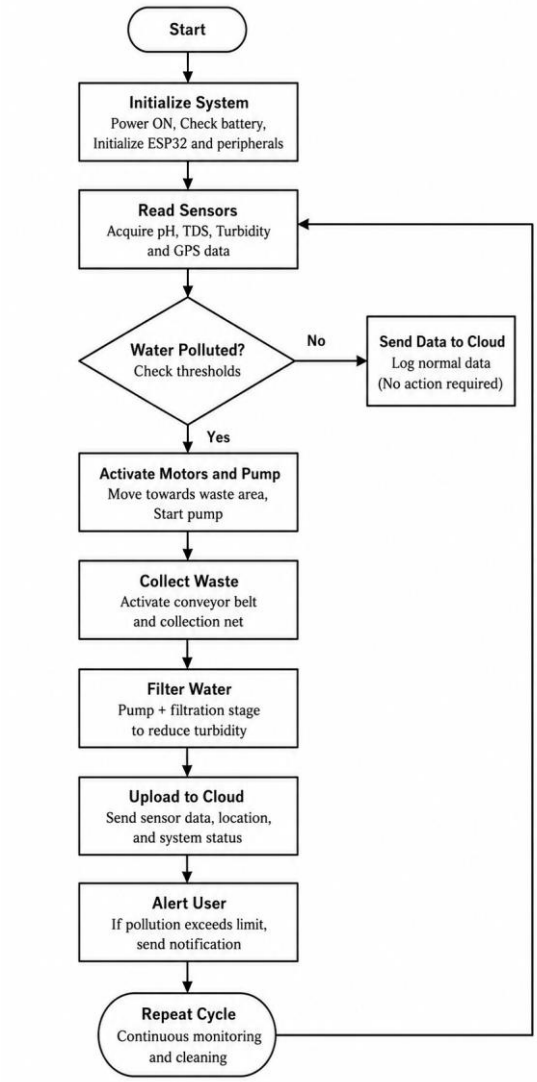

VI. Experimental Results And Discussion

Mental evaluation was done in two phases: In the lab test and small pond on the university campus. Experimental evaluation was done in two phases: In the lab test and small pond on the university campus. Field trials were conducted across five sessions assess environmental variability

Working of Sensors

1. Sensors collect the real time data from the water
2. secondly microcontroller process the data
3. Wi-Fi or gsm model send the data to the cloud platform
4. then cloud platform stores the data and analyzes the data
5. User can monitor the data from the website or mobile app

Features of Sensors.

1. Sensors have high accuracy like it can provide us the accurate water Quality.
2. Real-time monitoring – sensors are always active they keep on checking and sending the data to the users which users can save.

TABLE II
PARAMETERS

Parameter	Reference Range	Mean SRRCD Value	MAPE (%)	Std. Dev.
pH	6.2 – 8.4	6.3 – 8.6	2.8	±0.11 pH units
TDS (ppm)	120 – 680	123 – 702	3.2	±18.4 ppm
Turbidity (NTU)	45 – 820	46 – 847	3.1	±22.7 NTU
GPS Accuracy (m)	Reference GPS	±2.5 CEP	N/A	±0.8 m

VII. Conclusion

In this project, we have developed a Smart Remote River Cleaning Device (SRRCD). This solar powered device collects floating waste from the river and monitors water quality. And this paper provides information regarding the device's design, fabrication process, and testing.

In this system it integrates microcontroller which is esp32 and a multistage conveyor net. Also, four sensors for sensing the environment like ph. level turbidity and gaps and a cloud connected IoT dashboard. For battery management, it has 20 W solar panels and a Li-Po battery for backup.

We plan to do several new features for this project in the future. Cameras could be used to identify and automatically collect waste. Multiple robots could work together to clean large rivers. New sensors will be installed to monitor water quality more efficiently. The device's size can be reduced so that it can also be used in smaller drains and canals. And more, the project's design and software will be made publicly available, enabling others including individuals and organizations to utilize and improve the system

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