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CLEANBOT: IOT WATER SURFACE ROBOT

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ABSTRACT

This paper describes the design of a robot for cleaning floating debris on the water surface. Three important issues for designing the aquatic robots are cost-effective solution along with robustness and durability. The Water Cleaning Robot, utilizing the ESP32 CAM module, represents a significant advancement in automated water purification systems. This robot is designed to efficiently clean water by integrating waste collection and purification features into a single, autonomous unit. Equipped with a camera module for real-time monitoring, the robot navigates through water bodies to collect debris and contaminants, depositing them into an onboard waste tank. The purification system, embedded within the robot, employs advanced filtration techniques to treat the collected water, ensuring its quality. The ESP32 CAM module facilitates live streaming and remote-control capabilities, allowing operators to monitor the cleaning process and adjust settings as needed. This innovative solution addresses the growing need for efficient water management in various environments, from residential to industrial settings, by combining waste collection and water purification into a seamless, automated process.

Keywords: ESP32, Wi-Fi Control, Remote Monitoring.

I. INTRODUCTION

Water is vital for all forms of life on Earth, covering more than 70% of the planet's surface. However, only around 3% of this vast resource is freshwater that can be used for drinking and other essential purposes. Due to its unique property as a universal solvent, water can dissolve a wide range of substances, including harmful contaminants such as industrial chemicals, sewage, and waste products. Unfortunately, human activities have led to significant water pollution, posing serious threats to both the environment and public health. Water pollution happens when foreign substances—often toxic—enter natural water bodies like rivers, lakes, and oceans. These contaminants can make the water not safe for human use and disrupt aquatic ecosystems. Major sources of this pollution include the improper disposal of sewage, discharge of industrial effluents, and household waste, all of which contribute to the degradation of water quality.[1]

In India, the Ganga River is a lifeline for millions, providing water to roughly 500 million people across 11 states. Despite its significance, the Ganga has suffered from severe pollution over the years. In 2017, it was ranked as the second most polluted river in the world, underscoring the urgent need for intervention.[2]

To address this environmental challenge, the Government of India launched 'Namami Gange' mission in 2014. With a budget of ₹20,000 crore, this ambitious program aims to clean and restore the Ganga by reducing pollution and promoting sustainable river management practices.[3]

II. METHODOLOGY

The Water Surface Cleaning Robot was developed by first collecting and testing components like ESP8266, ESP32CAM, motors, and relays. These were connected to form the circuit, enabling wireless control and real-time video streaming. The ESP8266 handled robot movement and communication, while the ESP32-CAM captured images for waste detection. A mobile app was created for remote control and monitoring. The conveyor belt mechanism was integrated for waste collection, triggered by image processing. Power optimization was implemented using a 18650 battery. Finally, the system was tested in real-world conditions to validate functionality and efficiency.

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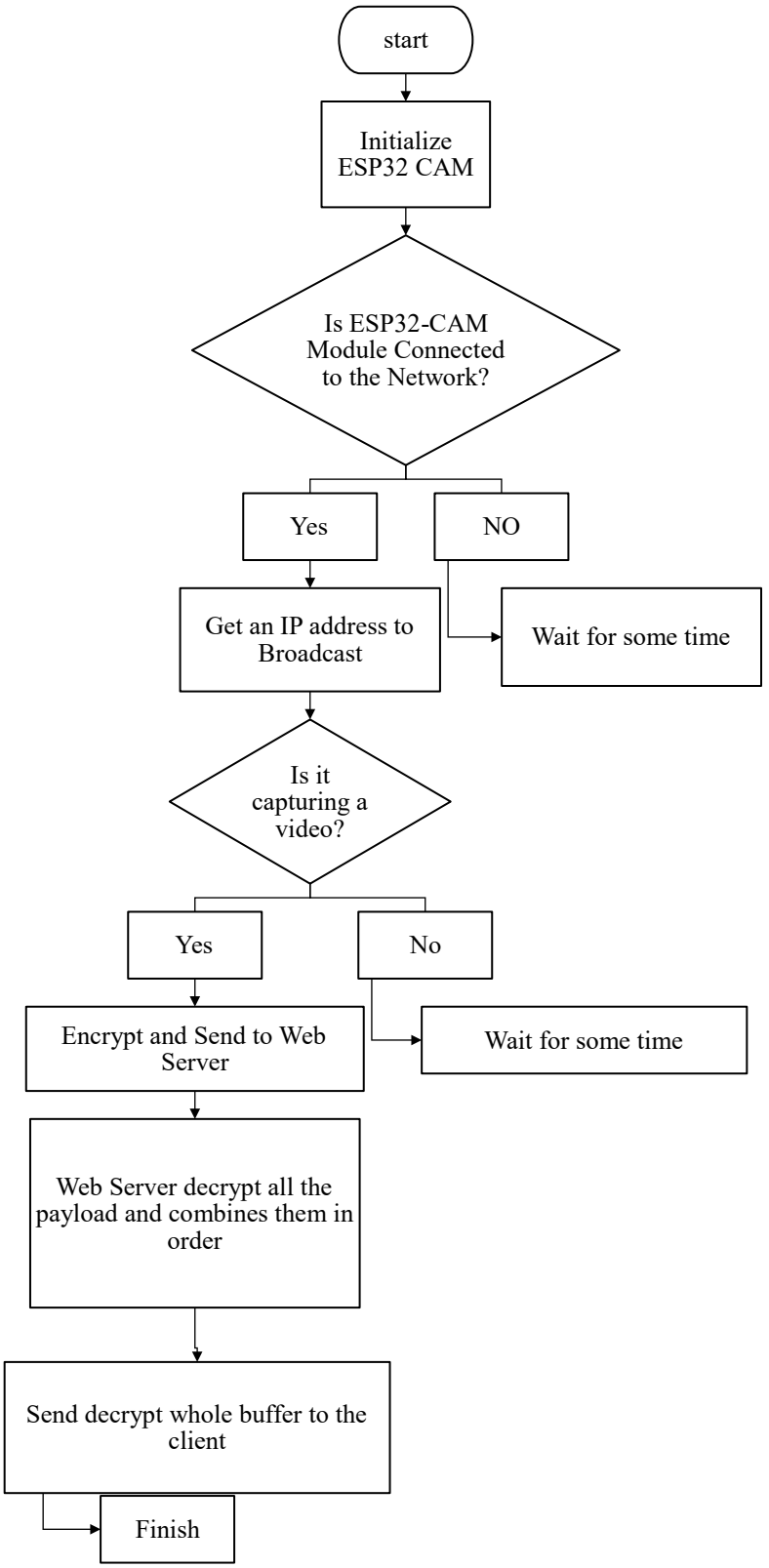
Flowchart



Working

The Water Surface Cleaning Robot operates in three main phases: initialization, operation, and termination. In the initialization phase, the ESP32 CAM module is activated, establishing a Wi-Fi connection for remote control, while the motor control unit and RC transmitter/receiver setup enable movement via a mobile or web interface.

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During the operation phase, the robot connects to a designated Wi-Fi network, starts live video streaming, and navigates through water bodies using underwater thrusters to detect and collect floating debris with a conveyor belt or suction system. The robot processes remote control commands for movement, waste collection. In the termination phase, the system disconnects from Wi-Fi, stops the video stream, and powers down motors and peripherals to conserve battery. The collected waste is manually removed before the next cleaning cycle. This structured process ensures efficient and sustainable water surface cleaning.

III. MODELING AND ANALYSIS

The Water Surface Cleaning Robot was modeled as a floating, mobile unit equipped with a conveyor mechanism and real-time image processing. The system architecture includes key modules: motion control (via L298N and Bo motors), waste detection (via ESP32-CAM), and wireless communication (via ESP8266).

Modeling:

Mechanical Model: Designed for buoyancy and stability in water with a frame supporting the conveyor and electronics.

Control Model:

Integrated ESP8266 as the central controller managing motor operations, data flow, and relay switching.

Vision Model:

Utilized ESP32-CAM with image processing algorithms to detect floating waste and guide navigation.

Analysis:

Performance Analysis: Focused on waste detection accuracy, real-time response, and cleaning coverage.

Power Analysis: Evaluated energy efficiency and battery life using 18650 cells.

Connectivity Analysis: Tested Wi-Fi signal strength and latency during remote control.

Navigation Efficiency: Analyzed robot movement and obstacle avoidance in varying water conditions.

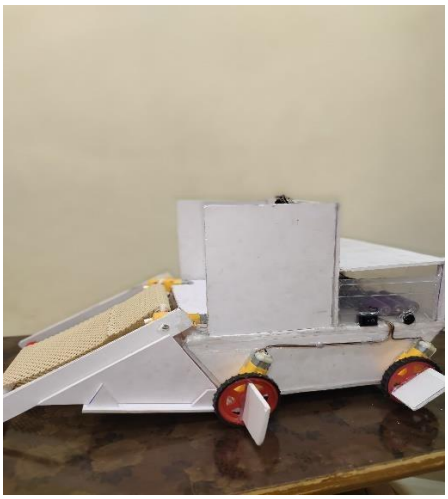

Figure 1: Actual image of project

IV. RESULTS AND DISCUSSION

The Water Surface Cleaning Robot successfully performed autonomous and remote-controlled cleaning operations on water surfaces. Key results include: Effective Waste Detection: The ESP32-CAM accurately identified and tracked floating debris using real-time image processing. Smooth Navigation: The robot moved reliably in all directions and adjusted its path based on waste location. Efficient Waste Collection: The conveyor mechanism consistently collected floating waste into the storage bin. Remote Monitoring: Live video streaming and control via the mobile app functioned smoothly within Wi-Fi range. Power Efficiency: The system operated effectively for extended periods using an 18650 batteries, supporting multiple cleaning cycles.

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Table 1. Comparative Analysis With Previous Projects

Feature	Previous Projects	This Project	Improvem-ent Achieved
Remote Monitoring	Limited	Real-Time Video streaming via ESP32 CAM	Allows Live Supervision & control
Motor System	Basic DC motor	BO motors with L298N Driver	Enhanced Precision & Efficiency
User Interface	None /Limited	Web-based With ESP32 CAM	Easy to use/ Accessible UI
Speed Control	Fixed Speed	Dynamic Speed Control	Smoother & Adjustable Movement
Environmental Impact	Low Sustainabili ty	Uses Rechargea ble Batteries	Eco-friendly approach

V. CONCLUSION

The Water Surface Cleaning Robot is an innovative solution for efficiently removing waste from water bodies. By integrating real-time image processing, it enhances the precision and effectiveness of waste detection and collection. The system is designed for remote operation through a mobile application, ensuring user-friendly control and monitoring. The incorporation of a conveyor belt mechanism streamlines the waste collection process, making it more systematic and efficient. This project contributes to environmental sustainability by providing an automated and technology-driven approach to water surface cleaning, reducing manual effort and improving overall cleanliness in aquatic environments.

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