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Surface Water Cleaning Robot (SWCR) for Sustainable Environmental Protection

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Abstract- The emphasis of the project is centered upon the designing and advanced construction of an ecological water cleaning system that has wireless control features which integrates advanced environmental monitoring and robotics that is operated remotely towards achieving environmental sustainability. Consequently, due to the growing concern of water pollution, there is an increasing demand of deploying an easy system which will eliminate the waste and pollutants from the water bodies in an efficient manner. The system consists of a and a rotary bracket which consists of a substantial floating platform mounted on a 12V battery, four 500 RPM DC motors and L298N motor driver for river surface navigation. The operation of this device centers around the use of an ESP32- CAM module which acts as a camera that streams real time images to the operator for effective monitoring of the device and waste collection process. This system solves the problem of debris reduction in water bodies and enhances water reclamation curbing the risks of cash intensive manual cleaning. If the technology comes into practice it is going to improve environmental protection by introducing a new approach to environmental management and promoting sustainability strategies in the protection of water bodies.

Index Terms- ESP32-CAM module, 500 RPM motors, L298N motor driver, 12V rechargeable battery, Real-time images, Servo Motors, SWCR.

I. INTRODUCTION

Plastic and floating waste in water release harmful chemicals, disrupt water quality, and promote the growth of toxic bacteria and algae. This contamination makes water treatment difficult and can lead to health issues like endocrine disruption. Consuming contaminated seafood can cause inflammation and organ damage, posing serious long-term risks to human health and well-being. The growing issue of water pollution is addressed in [1] and proposes the intelligent water surface cleaner robot (IWSCR) that utilizes a vision module, motion control module, and grasping module to autonomously detect and collect garbage. The need for an advanced path planning system for autonomous vehicles, specifically for cleaning floating garbage in aquatic environments has been discussed in [2] and introduces the Fast-Marching method (FM*).

A remote-operated river cleaning machine has been designed in [3] to address the limitations of previous methods, offering an effective, efficient, and eco-friendly solution for river surface cleaning. The introduction of foreign materials into water bodies results in water-borne diseases and threatens aquatic life which makes necessary innovative solutions for cleaning polluted water [4],[5] proposes a robotic water boat designed to detect and remove garbage from water bodies, aiming to mitigate the impact of pollution. Introduces remote-controlled water cleaning robot integrates waste collection and water quality monitoring in [6] that addresses the limitations of existing systems. unlike previous designs that only used cameras for monitoring, this system employs an additional pH sensor to assess water quality, particularly in industrially polluted areas.

Aims to optimize resource usage, reduce labor intensity, and demonstrate practical value in maintaining water cleanliness in real-world scenarios has discussed in [7]. A robot is designed in [8] to operate in both autonomous and tele-operated modes, utilizing a floating platform for stability and efficiency. A water surface cleaning robot called SMURF is introduced in [9] which achieves high-efficiency cleaning without human operation in various water bodies. To reduce the aquatic pollution and contamination using WATERBIN is proposed in [10] which is a Remote-controlled robot for water surface cleaning.

A multi-function unmanned surface vehicle (MF-USV) is developed in [11] for obstacle avoidance and water quality monitoring and water surface cleaning. A double-hull water surface cleaning robot is designed by using Raspberry Pi in

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[12] which is Suitable for complex water environments with high efficiency. The critical issue of water pollution caused by human activities is addressed in [13] and proposes a solar-powered boat designed to collect garbage from water bodies, which operates autonomously at night to avoid crowds and reduce costs.

Water pollution has drawn much attention as one of the critical environmental concerns at present. The worsening situation is primarily caused due to human behavior that leads to the dumping of plastic waste, chemicals and other forms of waste into water bodies such as ponds, rivers, lakes, and oceans. Such pollution poses a danger not only to aquatic animals but also to habitats, people's health and the surrounding environment as a whole. Such circumstances call for urgent measures to counteract the adverse impacts and bring equilibrium back to our water systems. One of such measures is an innovative water cleanup gadget that is aimed at addressing the problem of collection of floating rubbish in the water bodies.

The scope of this project is commercialization of the new type of the water cleaning robot which is to be operated via RC technology for the purpose of gathering debris of all kinds, including plastic, polythene or even organic wastes such as leaves and any other watery debris. With the configuration of the robots together with technology, the robots can be used in a self-contained manner as well as by operators and so there is no limitation to using the robots for clearing of waste from any water body.

Water bodies prove to be beneficial for humans and the ecological system as well. They all enhance aquatic life by providing necessary shelter, serve as abundant sources of water for drinking purposes and are also crucial for agricultural irrigation. However, their pollution poses dangers to human health, animals, and the ecosystems of the world.

There has been a growing demand of helping in the cleanup of polluted bodies of water as manual labor and broad based water treatment methods are usually tedious, expensive, and unrealistic particularly in remote areas. The situation calls for taking up the water pollution problem in an effective and efficient manner like with the employment of the water-cleaning robot whose design has there capabilities to scale up.
The construction of the water-cleaning robot contains several functions the performance of which makes the robot work effectively. The Water Cleaning robot uses the ESP32 CAM a cheap camera, wireless and capable of video streaming in real time. This functionality is valuable as it allows an operator to see what is on the surface of water for navigation purposes and to control the movement of the robot as well. Through the ESP32 CAM, the operators are able to carry out operations of the robot from a mobile device connected to a Wi-Fi thus controlling the robot without physically being at the field. This kind of remote controlled capability adds advantages to the robot.

The L298N motor driver module further enhances the robot's movement capabilities by controlling the motors responsible for navigation. This allows the robot to efficiently move across water surfaces, adapting to different conditions, including calm or turbulent waters. The combination of the ESP32 CAM and L298N motor driver modules ensures that the robot can effectively collect waste while maintaining stability and responsiveness, regardless of environmental challenges. In addition to its technical capabilities, the water-cleaning robot brings considerable environmental benefits. By removing plastics and other pollutants from water bodies, it helps improve water quality, which is essential for the health of aquatic ecosystems. Aquatic animals, in particular, are severely impacted by pollution, with many mistaking plastic debris for food, leading to injury or death. The robot's ability to collect waste before it disperses or sinks to the bottom of the water body helps protect these animals and preserves the integrity of aquatic habitats.

Moreover, the robot's capacity to remove organic debris such as leaves can help prevent the accumulation of nutrients that lead to harmful algal blooms. These blooms, which occur when excess nutrients fuel rapid algae growth, can deplete oxygen levels in the water, creating "dead zones" where aquatic life cannot survive. By keeping water surfaces clear of such debris, the robot supports the maintenance of balanced ecosystems and promotes healthier water bodies.

The advanced water-cleaning robot provides a practical, scalable, and efficient solution to the growing problem of water pollution. Through its remote-controlled capabilities and integration of the ESP32 CAM and L298N motor driver modules, the robot is able to remove floating debris from water bodies while offering real-time monitoring and control. This project represents a significant step forward in addressing water pollution and protecting the environment. By improving water quality, the robot contributes to the preservation of aquatic life, ecosystem health, and the overall well-being of our planet.

II. DESCRIPTION OF COMPONENTS

The key components used in this proposed work are discussed in this section as follows.

1. ESP32-CAM MODULE

The ESP32-CAM is a compact development board featuring a dual-core ESP32 processor, a 2MP OV2640 camera, and support for Wi-Fi and Bluetooth. It includes 4 MB Flash memory, GPIO pins, and a microSD card slot for external storage. Ideal for IoT, surveillance, and real-time streaming applications, it can be programmed via the Arduino IDE or

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ESP-IDF. With its versatile connectivity and imaging capabilities, the ESP32-CAM is perfect for innovative projects and remote sensing.

Fig. 1. ESP32-CAM module

2. L298N- Motor Driver

The L298N motor driver is an integrated circuit for controlling DC and stepper motors, featuring dual H-bridge drivers. It operates with motor supply voltages from 5V to 35V and handles up to 2A per channel, with a peak current of 3A.

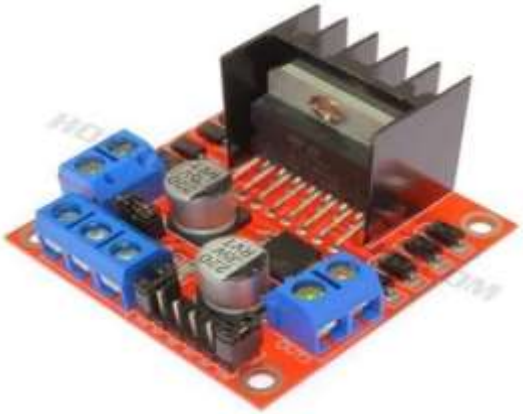

Fig. 2. L298N - Motor Driver

It includes PWM control for speed, and built-in protection against overcurrent and thermal issues. Commonly used in robotics, automation, and DIY projects, it offers robust motor control and versatility, making it ideal for various motor-driven applications.

3. Servo Motors

Servo motors are used for precise control of angular position, velocity, and acceleration in applications like robotics, aerospace, and industrial automation. They feature a motor, control circuit, and feedback device (potentiometer or encoder) that continuously adjusts position.

Fig. 3. Servo Motor module for the rotation of ESP32 CAM Module

The types include standard servos for hobbyists, continuous rotation servos for constant movement, and high- torque servos for heavy-duty tasks. They operate on pulse- width modulation (PWM) signals, ensuring high accuracy and reliability, and are essential for precise and reliable movement control.

4. DC Motor for Propulsion & movement of the Robot

The DC motors operates at 500 revolutions per minute and is used in various applications where moderate speed is required. It operates on voltages typically ranging from 6V to 12V and generates torque that varies with load and speed.

Fig. 4. DC motors for Robot's propulsion and movement

Key components include an armature, commutator, and brushes. Applications span automotive, industrial, consumer electronics, and robotics. The motor's efficiency ranges from 70% to 90%, and it requires regular maintenance, including lubrication and inspection of components.

III. METHODOLOGY

The key components used in this proposed work are discussed in this section as follows.

1. Design and Framework

The water surface cleaning bot is designed with a semi-hemispherical main body made from lightweight PVC material. This unique shape ensures smooth water flow,

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allowing water to pass through the hollow hemisphere while directing floating debris towards the collection net positioned at the rear. To maintain the buoyancy, a PVC pipe with floating frame is constructed in a rectangular shape that attached to the circular shaped pipes, surrounding the main body. This frame is strategically attached besides the hemisphere, providing balance and ensuring that the bot remains afloat. The floating system is designed to support the total weight of the robot, including its motors and any collected trash.

The water flow channels are an essential part of the design, with the front of the hemisphere acting as an inlet to allow water and debris to enter the system. As the water flows through, it passes through a net at the back, which traps the floating waste while clean water exits through designated outlets at the rear or sides. This design facilitates efficient collection of debris while allowing the filtered water to flow back into the water body.

2. Circuit Design

Power Supply

The battery's positive terminal goes to the input of the UBEC/Buck converter. The ground of the battery connects to both the UBEC and the GND of the ESP32-CAM and L298N.

UBEC/Buck Converter

The UBEC converts the 7-12V from the battery to 5V. The 5V output of the UBEC powers the ESP32-CAM and servos.

Connections for DC Motors

Left Motors: Left Motor 1 and Left Motor 2 are connected to OUT3 and OUT4 of the L298N.

Right Motors: Right Motor 1 and Right Motor 2 are connected to OUT1 and OUT2 of the L298N.

Connections for Pan and Tilt Servos

Power Supply for Servos: Both servos get their 5V power from the UBEC. Connect the GND of the UBEC to both servos' ground pins.

Servo Control Lines: Pan Servo: The signal/control pin of the pan servo is connected to GPIO 12 on the ESP32-CAM.

Tilt Servo: The signal/control pin of the tilt servo is connected to GPIO 13 on the ESP32-CAM.

ESP32-CAM to L298N Motor Control Pins

IN1 to GPIO 14 (Right Motor 1 control) IN2 to GPIO 15 (Right Motor 1 control) IN3 to GPIO 2 (Left Motor 1 control) IN4 to GPIO 4 (Left Motor 1 control)

3. Testing of the Integrated module (SWCR)

The integration of ESP32-CAM with an L298N motor driver and a tilt servo motor requires linking up the necessary pins for power, ground, and signal transmission. The ESP32- CAM would control the L298N motor driver to achieve movement through DC motors while at the same time controlling the tilt servo to orient the camera. From the GPIO pins, the ESP32-CAM transmits PWM signals to the motor driver and servo to be able to realize very precise control. After some connections are made, tests are conducted by uploading code that initiates motor and servo functionalities. The communication and responses in terms of motor direction and tilt movement are tested to ascertain whether the system works precisely as desired for real-time applications.

IV. IMPLEMENTATION

The block diagram shows the detailed description of water surface cleaning robot where it promotes the environment health by removing the debris on the water surface.

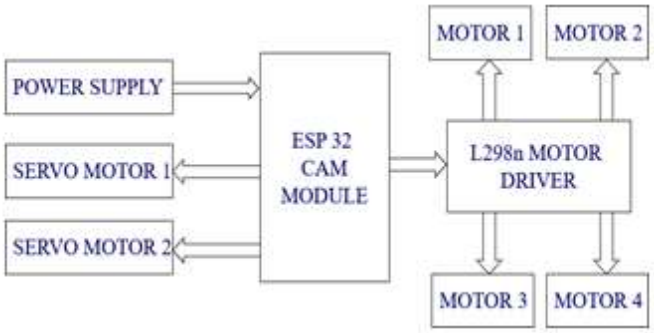

Fig. 5. Implementation block diagram of SWCR system

The ESP32-CAM module of water surface cleaning robot used for surveillance, L298N motor driver for motion control, and servo motors for tilt control of changing orientation through a camera.

Fig. 6. Design of Proposed SWCR system

The ESP32-CAM module acts as the processing core which communicates with every component of hardware, captures the live video feed via Wi-Fi streaming into a mobile app. The remote-control interface of the app manipulates the robot and controls the camera angle for desired navigation. A control

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panel of four DC motors is there which helps the bot move forward, backward, or turn in all directions; it sucks in the floating rubbish with a net attached to its rear side and gathers waste materials efficiently from the surface of the water. It allows the camera to tilt and rotate totally, therefore giving a full view while navigating or monitoring. It is well powered with a stable power supply to ensure an efficient operation. All these parts come together to make the robot autonomously clean water surfaces under the user's control, making it very effective for ponds, lakes, and other surfaces. This is about the synergistic operation of hardware and software, wherein a mobile application can serve as an interface for effective communication and control with an eco- friendly solution for the maintenance of water bodies..

V. CONCLUSION

This paper discusses the design and implementation of a water surface cleaning robot using the ESP32-CAM module for monitoring and control of the system. The ESP32-CAM module along with tilt servo motor, L298N motor driver, and a 12V battery in the proposed system create a robust system that can easily clean any water surface in ponds or swimming pools and aquatic farms effectively. The motivation behind this project is to contribute to environmental conservation by clearing floating debris and pollutants from water bodies at an affordable solution. The developed system successfully demonstrates its operability via a mobile app, which offers real-time monitoring and control. This project offers an innovative approach to cleaning the surface of water, making it worthwhile for reducing manual efforts and creating a relatively cleaner water body. Future developments will be focused toward perfecting the automation, widening the scope of applications, and including more features that make it highly functional and operationally efficient. Overall, this project marks a tremendous stride towards the development of a friendly, environmental solution in terms of keeping the freshness of aqua surroundings clean.

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REFERENCES

1. Kong, Shihan, et al., "IWSCR: An intelligent water surface cleaner robot for collecting floating garbage." IEEE Trans. Syst. Man. Cybern. 51, no. 10 (2020): 6358-6368.
2. S. Kong, Z. et al., "An FM*-Based Comprehensive Path Planning System for Robotic Floating Garbage Cleaning," in IEEE Trans. Intelligent Transportation Systems, vol. 23, no. 12, pp. 23821-23830, Dec. 2022, DOI: 10.1109/TITS.2022.3190278.
3. Sayyad, Saifali, et al., "Design and fabrication of River cleaning machine." Int. Res. J. Engg. Tech., 6, no. 05 (2019).
4. Janai, Siddhanna, et al., "Swachh Hasth-A Water Cleaning Robot." Int. J. Engg. Res. Tech. (IJERT) (2020).
5. Phirke, Shreya, et al., "Design of an autonomous water cleaning bot."Mater. Today 46 (2021): 8742-8747.
6. Satheesh, Jishnu, et al., "Wireless communication-based water surface cleaning boat." In 2020 4th International Conference on Trends in Electronics and Informatics (ICOEI) (48184), pp. 716-720. IEEE, 2020.
7. Gao, Xiaohong, and Xijin Fu. "Miniature water surface garbage cleaning robot." In 2020 International Conference on Computer Engineering and Application (ICCEA), pp. 806-810. IEEE, 2020.
8. Wang, Zhongli, et al., "Design and hydrodynamic modeling of a lake surface cleaning robot." In 2008 IEEE/ASME International Conference on Advanced Intelligent Mechatronics, pp. 1343-1348. IEEE, 2008.
9. Zhu, Jiannan, et al., "SMURF: A fully autonomous water surface cleaning robot with a novel coverage path planning method." J. mar. sci. eng. 10, no. 11 (2022): 1620.
10. Amarnath, M., et al., "WATERBIN–a remote controlled water surface cleaning robot." Int. Res. J. Engg. Tech., 8, no. 06 (2021).
11. Chang, Hsing-Cheng, et al., "Autonomous water quality monitoring and water surface cleaning for unmanned surface vehicle." Sensors 21, no. 4 (2021): 1102.
12. Wang, Pei, et al., "Structure design and simulation analysis of the water surface cleaning robot." In Journal of Physics: Conference Series, vol. 2181, no. 1, p. 012050. IOP Publishing, 2022.
13. Pakhmode, Ketan H., et al. "Solar powered water surface garbage collecting boat." Int. Res. J. Engg. Tech., 6, no. 03 (2019).

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