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AI Based River Cleaning Robot

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Abstract - The Increasing pollution due to floating waste such as plastic bottles leaves and other debris poses a serious threat to aquatic ecosystem and Traditional manual methods for maintaining water quality demand significant human effort and require a considerable amount of time to complete. Often in effective in reaching hazardous are in accessible areas, to addresses this challenge This project focuses on the design and development of a river cleaning robot capable of collecting and removing floating debris from the water surface. The proposed system is an AI-enabled river cleaning robot built using a Raspberry Pi, camera module, and L298N motor driver. The camera continuously captures real-time images of the river, which are analyzed by the Raspberry Pi using artificial intelligence and computer vision algorithms to recognize floating waste materials. Based on the identified waste, control commands are generated to guide the robot movement toward the debris for effective collection

***Key Words*:** Raspberry pi 5, Motor Driver l298N, camera module, Conveyor belt, DC Motor.

1.INTRODUCTION

Water contamination is among the most critical environmental issues faced today. Natural water sources such as rivers and lakes are increasingly polluted by plastic materials, floating waste, and various harmful substances, posing serious risks to both aquatic ecosystems and human well-being. Conventional cleaning approaches rely heavily on manual effort, require significant time, and can expose workers to hazardous condition.

To overcome these challenges, a manually operated river cleaning robot has been developed as an effective and innovative approach. Its compact structure and efficient integration of hardware and software are designed to minimize human involvement, reduce operational costs, and support the maintenance of cleaner and healthier river environments. Floating debris such as plastics, bottles, packaging materials, leaves, and organic waste has become a major environmental concern, blocking river flow, disrupting aquatic life, and contributing to water contamination. Traditional river cleaning methods are labor-intensive time-consuming, and often ineffective due to limited manpower and the continuous inflow of waste. This project combines three key elements: a Raspberry Pi, a vision-based camera system, and an L298N motor driver. The Raspberry Pi serves as the central control unit of the robot, managing advanced tasks such as analyzing visual data from the camera, executing object recognition algorithms, and making intelligent decisions using image processing and artificial intelligence methods.

A dedicated camera module is used to continuously observe the river surface and detect floating waste in real time. Depending on the system requirements, various image-processing and vision techniques such as color-based filtering, shape analysis, motion estimation, or trained deep-learning models like Mobile Net or YOLO can be applied. The visual information obtained enables the robot to accurately move toward debris, avoid obstacles, and maintain stable operation even in flowing water condition.

As rivers continuously collect new waste, an autonomous robotic system can function for long durations, adjust to varying debris conditions, and carry out uninterrupted cleaning operations without experiencing fatigue. A primary goal of this project is to make use of low-cost and readily accessible components. The Raspberry Pi is selected due to its adaptability, strong processing capabilities, and support for open-source frameworks such as Open CV and Tensor Flow Lite. The system is designed to be economical, power-efficient, and scalable, enabling operation with minimal human involvement. By integrating embedded control systems, motor-driving mechanisms, and AI-based visual processing, the proposed robot supports sustainable environmental practices and provides a dependable, environmentally friendly approach to minimizing river pollution. With recent advancements in automation, various technologies have been developed to clean water bodies while requiring very little human involvement. One such robotic system is designed to operate on lakes and reservoirs, where it autonomously navigates the surface to collect floating waste. While the robot performs well in calm and controlled water environments, it does not include real-time water quality monitoring. This limitation prevents the system from evaluating the ecological condition of the water body during the cleaning process.

2. METHODOLOGY

The AI Based river-cleaning robot is built using a raspberry pi, raspberry pi camera module 2, Motor Driver, ultrasonic sensor, four gear motors, and a 32gb microSD card. The raspberry pi acts as the main processing unit and connected to the camera module through the CSI camera port using a camera cable. The microSD card is used to hold the Raspberry Pi operating system along with the Python scripts that perform image analysis and floating waste detection.

During operation, the camera module continuously records real-time video of the river surface, which is analysed by the Raspberry Pi using OpenCV-based image processing or machine-learning algorithms to detect floating debris. The L298N motor driver manages the robot's movement by receiving control commands from the Raspberry Pi and supplying the appropriate power to the motor. The motor driver operates four geared DC motors that support both navigation and waste collection functions. Propeller-driven motors enable forward, reverse, and turning movements on the water surface. At the same time, a conveyor belt system is activated to lift and transfer floating waste into a designated storage compartment once the robot reaches the detected debris. A servo motor provides precise mechanical control, such as adjusting the conveyor belt position or directing collected waste into the bin.

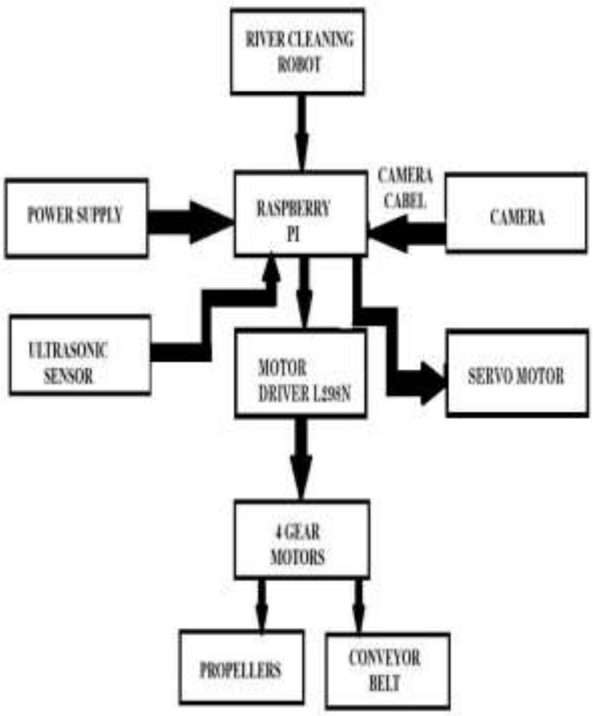

Fig1.Block Diagram of AI Based River Cleaning Robot

The entire methodology operates in a continuous loop sensing the environment, detecting waste, navigating toward it, collecting debris, and resuming scanning. This structured interaction between hardware components and AI-based software enables autonomous operation with minimal human intervention. The proposed approach enables effective waste collection while maintaining an economical, scalable, and environmentally responsible system that is well suited for practical river cleaning applications.

The river cleaning robot project successfully integrates mechanical design, embedded control systems and artificial intelligence to address real world river pollution challenges.

By combining Motor Driver for hardware control, raspberry pi 5 for intelligent processing, and camera-based waste detection, the system offers an efficient manually controlled method for waste removal from rivers. This approach significantly minimizes human effort and operational expenses while supporting a cleaner and safer environment. With continued advancements in technology, such robotic systems have the potential to play a vital role in intelligent environmental management and long-term sustainable development

3. DESIGN

The AI-based River Cleaning Robot is designed as a compact, floating robotic the system is designed to perform its intended functions efficiently. The mechanical structure consists of a lightweight and corrosion-resistant floating platform that provides stability on water. Buoyant materials are used to ensure proper balance while supporting the weight of electronic components, motors, and the waste collection mechanism. The front section of the robot is designed to guide floating debris toward the collection unit, while the rear section houses propulsion components for smooth navigation. The electronic design is centred on the Raspberry Pi, which acts as the main controller for image processing and decision-making. A camera module is mounted at an elevated position to capture a clear view of the river surface. The camera feeds real-time images to the Raspberry Pi, where AI-based algorithms process the data to identify floating waste. Distance measurement is carried out using an ultrasonic sensor, enabling the robot to recognize obstacles and move safely. Control commands produced by the Raspberry Pi are sent to the L298N motor driver, which effectively regulates the speed and direction of multiple motors.

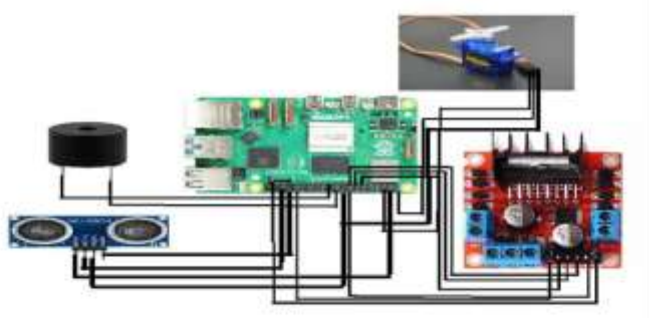

Fig 2. Circuit diagram

The actuation system includes four gear motors connected to propellers and a conveyor belt mechanism. The propellers enable directional movement and speed control, allowing the robot to navigate toward detected waste. The conveyor belt, assisted by a servo motor, lifts and transfers collected debris into a storage compartment. The power supply system is designed to deliver stable voltage to all components, with proper regulation and protection to ensure reliable operation.

4.RESULTS & ANANLYSIS

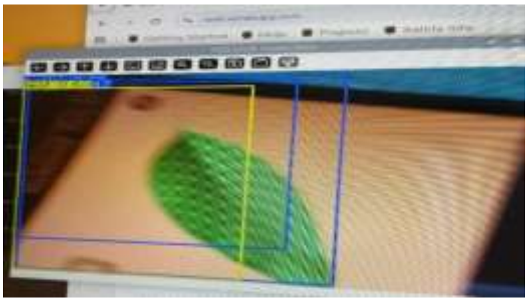

Fig 3: Camera Detecting the Object

The river cleaning robot was designed, implemented, and tested to assess its effectiveness in identifying and collecting floating debris through real-time image processing techniques.

The Raspberry Pi camera module, connected through the CSI ribbon cable, continuously captured live video, and the YOLO-based detection model accurately identified debris such as leaves and small waste objects with clear bounding boxes, as seen in the test outputs. The detection confidence remained stable under normal lighting conditions, demonstrating the reliability of the vision system.

Fig 4. Camera detecting a Bottles

The performance of the robot was evaluated based on detection accuracy, response time, mobility, and collection efficiency. The AI algorithm running on the Raspberry Pi effectively differentiated between water surface patterns and solid waste objects. False detection was minimal when the water surface was calm; however, slight misclassification occurred during heavy reflections or ripples. During testing, the camera module continuously captured live video frames of the water surface. These frames were processed on the Raspberry Pi using an AI-based image processing algorithm to identify floating waste such as plastic bottles, wrappers, debris. Once waste was detected, the robot adjusted its direction automatically and activated the collection mechanism. The L298N motor driver provided reliable control of the propulsion motors, enabling smooth forward movement, turning, and stopping. The robot was able to detect waste objects within an average distance of approximately 1 to 1.5 meters, depending on lighting conditions. Under normal daylight condition, the robot demonstrated high detection accuracy and responded promptly to the presence of floating waste. Its collection mechanism effectively gathered debris and stored it in the onboard container without causing significant disturbance to the water. By minimizing human involvement, the system enhances safety and provides an environmentally friendly solution for maintaining clean water bodies. This project successfully validates the potential of Raspberry Pi-based AI systems for applications in environmental protection.

5. DISCUSSION AND CONCLUSION

The AI-based river cleaning robot demonstrates how intelligent automation can be effectively applied to environmental maintenance tasks. The integration of a Raspberry Pi with a camera module enables real-time visual monitoring of the water surface, allowing the system to identify floating waste without human intervention. This approach reduces dependency on manual labour and improves operational safety, especially in polluted or hazardous water bodies. The use of an AI-based image processing algorithm allows the robot to distinguish waste materials from natural water patterns. Compared to conventional sensor-based systems, camera-based detection offers greater flexibility, as it can adapt to different waste shapes and sizes. The L298N motor driver plays a crucial role in ensuring accurate movement control, enabling the robot to navigate toward detected waste and perform collection operations smoothly. The discussion also highlights the practicality of using Raspberry Pi as the main processing unit. Despite its compact size and low power consumption, it is capable of handling image acquisition, processing, and motor control simultaneously. This makes the system suitable for small-scale river, lake, and pond cleaning applications, particularly in urban and semi-urban areas.

However, the system performance is influenced by environmental factors such as lighting conditions, water reflections, and surface disturbances. Although the AI algorithm performs well under normal conditions, its accuracy decreases when waste is partially submerged or when the water surface is highly reflective. These observations suggest the need for improved algorithms and possibly additional sensors for enhanced robustness.

Fig 5: model of the project

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