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River cleaning robot using Arduino microcontroller

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ABSTRACT

River cleaning robots represent a promising technological solution to address the pervasive issue of water pollution in river systems. These autonomous devices are designed to collect and remove various types of debris from river environments, contributing to improved water quality and ecosystem health. This abstract summarizes the key aspects of river cleaning robots, including their technological advancements, operational mechanisms, and environmental impact. River cleaning robots have evolved significantly from early mechanical designs to sophisticated autonomous systems. Initially, these robots were equipped with basic skimming and collection mechanisms. Recent advancements have incorporated state-of-the-art technologies, including artificial intelligence, machine learning, and advanced sensor systems. Modern river cleaning robots can autonomously navigate complex river environments, detect and classify different types of debris, and operate efficiently with minimal human intervention. The operational capabilities of these robots are enhanced by various design features such as mobility systems, debris collection mechanisms, and renewable power sources. Mobility systems allow robots to maneuver through diverse water conditions, while collection mechanisms like nets, scoops, and suction devices enable effective debris removal. Many robots are powered by renewable energy sources, such as solar panels, which contribute to their sustainability and reduce their environmental footprint.

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1. INTRODUCTION

River pollution poses significant threats to human health, aquatic life, and ecosystems, with floating garbage being a particularly challenging issue to address. Wireless river-cleaning robots offer a promising solution by autonomously detecting and collecting floating waste without requiring human intervention. These robots, equipped with sensors like cameras, ultrasonic devices, and water quality sensors, use image processing to identify garbage, avoid obstacles, and navigate waterways safely. Additionally, a built-in collection system gathers floating debris, while data on the cleaning operations is stored on a website for monitoring. This paper focuses on designing and developing such a wireless robot to reduce water pollution, minimizes environmental impact, and protect aquatic life [1]–[5]. Waterlogging caused by plastic, thermocol, and metal waste leads to health issues like malaria and typhoid. Manual cleaning methods are inefficient and risky due to exposure to infectious microorganisms. This study proposes an effective garbage collection system designed to clean waste from rivers, channels, and lakes. The system targets floating debris, including litter, logs, and tires, and incorporates IoT technology for monitoring and control. The vessel is designed to operate in various environments, including inland waterways, enhancing its utility for cleaning water bodies [6]–[10]. Ocean garbage poses a severe threat to marine life, with rivers being major contributors. Efforts to address this include reducing single-use plastics and transporting waste from rivers. This paper introduces a river-cleaning robot designed to collect surface waste. Equipped with Robot Vision technology, the robot detects and collects trash into a storage tank. The robot operates using Python and includes detailed descriptions of its components and working system. The goal is to help control waste growth and protect the environment [11]–[15]. Water, a vital natural resource, is increasingly polluted by human waste, especially plastic. This research introduces a solar-powered robotic boat designed to collect plastic waste from lakes, rivers, and drains, ensuring cleaner water surfaces. The boat features intelligent sensors, DC motors, and IoT-based control via a mobile app using the ESP32 controller. It efficiently gathers lightweight recyclables like plastic bottles into a storage container and monitors waste levels using an ultrasonic sensor. Tests demonstrated its ability to travel long distances and operate effectively within network range. This portable garbage collector aims to raise awareness of water body conditions and promote environmental sustainability [16]–[20].

This paper introduces an autonomous waste collection robot designed to clean water surfaces efficiently. The robot uses a conveyor system powered by a servo motor to collect debris, garbage, and plastics, while a water wheel driven by a BLDC motor enables movement on water. It features an advanced computer vision system based on the YOLOv5s algorithm and employs sensors like GPS, Compass, and a camera for navigation and waste detection. Key hardware components include a Raspberry Pi, Flight Controller, LiPo Batteries, and Transceivers. Experimental results highlight the robot's effectiveness in autonomous cleaning, contributing to environmental conservation and river pollution management [21]–[25].

2. BLOCK DIAGRAM

The robot block diagram for river cleaning is displayed in Figure 1. In this work, an Arduino-based smart building automation system with programming software is presented. The system has a very useful and convenient cost configuration and supports a variety of sensors. Though it employs technology to create a better place, the design and execution of building management system (BMS) and the completion of many types of green projects today are similar in many aspects. This system helps us to minimize human labor. Our project's major features include an RFID module for gate opening and shutting, common area illumination, a keypad for door opening and closing, and fire detection and main system alerts. For the purpose of testing the system and presenting it in real time, every hardware sensor and Arduino component is assembled into the best possible demonstration model. The intelligent BMS environment is correlated and animated with the aid of these models. The function becomes easily understood. A dependable circuit known as BMS has responsibility for managing the several systems that are employed within it. “Uno” was chosen to commemorate the release of Arduino Software (IDE) 1.0 since it means “one” in Italian. The reference versions of Arduino were the Uno board and version 1.0 of the Arduino Software (IDE), which has since been replaced by more recent versions. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform, for an extensive list of current, past or outdated boards.

Figure 1. Block diagram of river cleaning ROBOT

3. OPERATION OF RIVER CLEANING ROBOT USING BLUETOOTH MODULE

The operation of a river cleaning robot using a Bluetooth module involves a systematic process to remotely control and automate the cleaning of water bodies. The robot is equipped with a microcontroller (e.g., Arduino or ESP32) that acts as the central processing unit, paired with a Bluetooth module (such as

HC-05 or HC-06) for wireless communication. This setup allows the operator to control the robot using a smartphone or other Bluetooth-enabled devices. The robot is typically mounted on a buoyant chassis to ensure it remains afloat while navigating the water surface. The cleaning robot’s movement is managed via DC motors or servo motors that are connected to the microcontroller. Commands such as forward, backward, left, and right are transmitted via Bluetooth from the controlling device. The microcontroller interprets these commands and adjusts the motor operations accordingly. This functionality allows the operator to guide the robot to specific areas in the river or pond where waste is concentrated. Advanced systems may include autonomous navigation, with ultrasonic or infrared sensors detecting obstacles and adjusting the robot’s path.

Table 1 and Figure 2 show the river cleaning robots. For cleaning purposes, the robot is outfitted with a collection mechanism, such as a conveyor belt or a robotic arm, designed to scoop or lift floating debris from the water surface. As the robot moves, waste material is gathered onto the conveyor belt and deposited into an onboard storage compartment. This bin can be emptied manually once the cleaning operation is complete. The system ensures effective removal of pollutants like plastic, leaves, and other floating debris. The Bluetooth module plays a crucial role in simplifying the operation of the river cleaning robot. Enabling wireless communication eliminates the need for physical connections, allowing the operator to maintain a safe distance from the water body. Bluetooth terminal applications or custom-built apps on smartphones are used to send control commands, making the system user-friendly and versatile. Additionally, the robot can be enhanced with sensors to monitor water quality or detect hazardous materials, expanding its utility beyond waste collection. This technology offers a cost-effective and environmentally friendly solution to tackle water pollution. It is particularly suitable for cleaning small- to medium-sized water bodies, such as rivers, lakes, and ponds. By leveraging Bluetooth-controlled robotics, the system provides a scalable, efficient, and easily operable method to address the growing concern of aquatic waste management.

Table 1. River-cleaning robots use a combination of mechanical

Debris Type	Handling Method
Large floating objects	Grippers, arms, or conveyor belts lift and store them
Small plastics	Fine mesh nets or rotating drums trap smaller particles
Organic debris (leaves, twigs)	Separated or filtered out to avoid clogging systems
Mixed waste	Sorting compartments or post-processing at shore stations

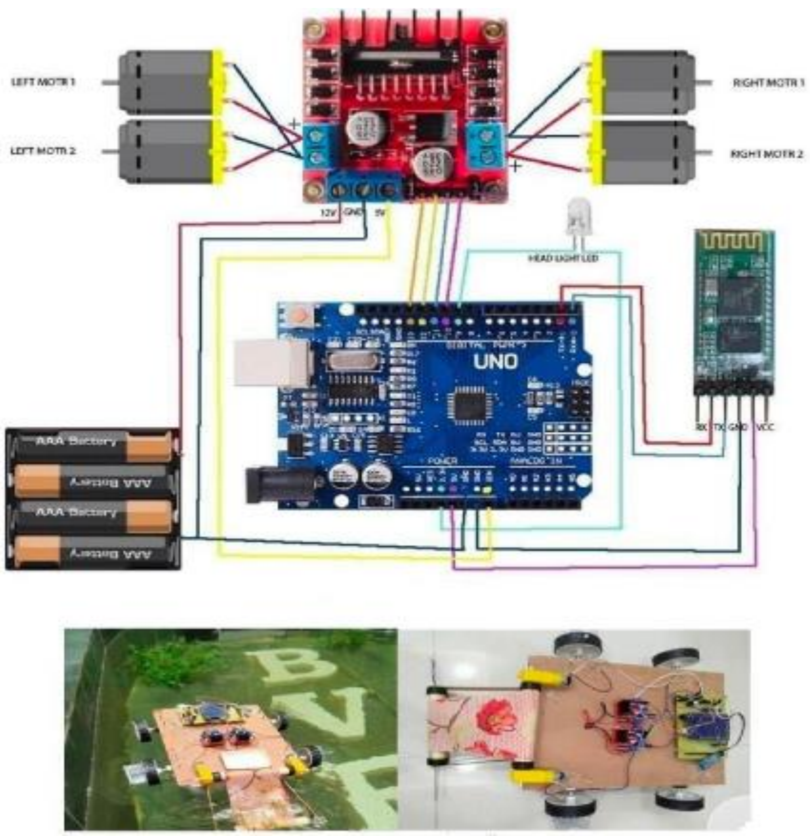

Figure 2. Circuit diagram of river cleaning robot

4. PROTOTYPE RESULTS

The water level sensor's output is displayed in Figure 3. Sensors are used by the suggested system to keep an eye on its surroundings. Table 2 lists the pH values of the different solvents that were determined using the pH sensor. With a value ranging from 0 to 14, the pH sensor determines how acidic and alkaline water and other liquids are. The threshold value for evaluating the water's quality was established using these data. Waves cause the water source's water level to fluctuate constantly. If the water level is within the normal range, it is checked. The administrator or user will be informed of any unusual changes in the rise in water level. The water level sensor's output. The waste collection rate depends on the robot's design, flow conditions, and debris density. For a typical river-cleaning robot prototype: Average collection rate: 20 to 80 kg of waste per hour, factors affecting rate: speed of water current, size and buoyancy of waste, efficiency of the robot's conveyor or collection mechanism, debris density in the target area**.**

Table 2. Comparison: prototype vs. existing river-cleaning methods

Criteria	Robot Prototype	Traditional Methods
Automation	High – autonomous or semi-autonomous	Low – manual labor or controlled machinery
Efficiency	Continuous collection (24/7 operation)	Intermittent, depends on human resources
Waste Collected	20–80 kg/hr (prototype); up to 2000+ kg/hr (full scale)	~100–500 kg/day (manual teams)
Operating Cost	Higher upfront, lower long-term	Low upfront, higher ongoing labor cost
Scalability	Modular, can be deployed in fleets	Hard to scale without proportional manpower
Environmental Impact	Minimal with proper design	Potential damage if not carefully managed

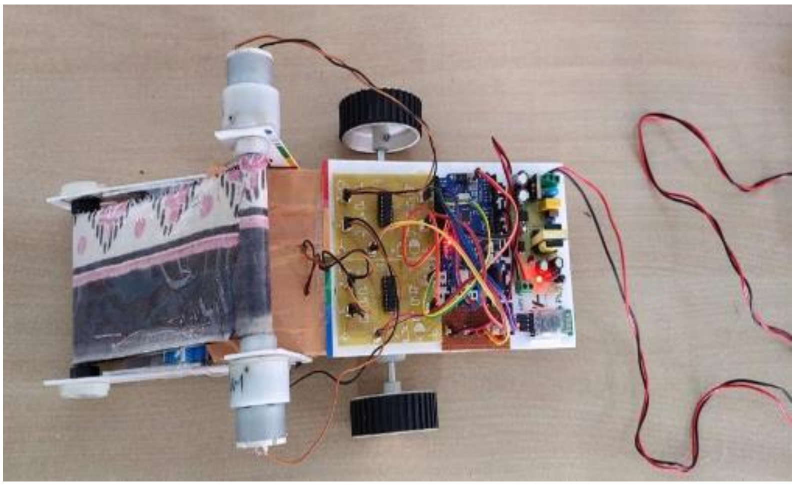

Figure 3. The output of the water level sensor

5. CONCLUSION

The river cleaning robot represents a significant advancement in the field of environmental management, offering a modern solution to the ongoing challenge of maintaining clean and healthy water bodies. Its autonomous capabilities and advanced technologies provide several Enhanced Efficiency: The robot's ability to operate continuously and cover large areas makes it a highly efficient tool for debris removal. This efficiency translates to improved water quality and more effective management of aquatic environments. Cost-Effective Solution: By reducing the need for manual labor and operating with minimal human intervention, river cleaning robots can lower overall cleanup costs and provide sustainable long-term solution. Increased Accessibility: The robot's design allows it to reach areas that are difficult or hazardous for human workers, ensuring comprehensive cleaning of water bodies, including narrow channels and shallow regions. Improved Safety: Handling potentially dangerous tasks, such as cleaning polluted or contaminated waters, reduces risks to human health and safety. Environmental and Educational Impact: Beyond its practical applications, the robot serves as a tool for environmental monitoring and public education, raising awareness about water pollution and showcasing technological innovations in environmental management. However, it is important to consider potential challenges such as high initial costs, maintenance requirements, and operational limitations in adverse conditions. Addressing these challenges through ongoing research, development, and refinement will enhance the effectiveness and reliability of river cleaning robots.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest to disclose

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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