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River Cleaning Robot using IOT based

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Abstract *Rivers are increasingly polluted by floating waste and debris, which threatens aquatic life, water quality, and human health. Cleaning these rivers manually is not only time-consuming but also risky for workers. To overcome these challenges, this project presents an IoT-based River Cleaning Robot designed to automatically collect floating waste and support continuous river monitoring. The robot uses a simple mechanical collection system along with smart sensors to detect obstacles, identify waste, and track its location. In addition, water quality sensors measure parameters such as pH and turbidity to help assess pollution levels. All sensor data is sent to a cloud platform through IoT technology, allowing users to monitor the robot's performance and river conditions in real time. The system can be operated in both autonomous and manual modes, making it flexible for different environments and situations. By reducing the need for human involvement in dangerous conditions, the robot improves safety while lowering operational costs. Overall, the proposed river cleaning robot provides a practical, eco-friendly, and reliable solution for maintaining cleaner rivers and supports environmental protection efforts and smart city initiatives.*
Keywords *- Aquatic life, Autonomous operation, Autonomous Robot, Cloud platform ,Eco- friendly , Environmental protection, Floating waste, Health ,IoT, Ph Sensor, River, River cleaning robot, Smart city, Turbidity sensor ,Technology ,Water pollution monitoring, Water quality sensors.*

I. INTRODUCTION

In addition to maintaining diverse biodiversity, rivers play a crucial role in the global water environment by supplying necessities like drinking water, irrigation, and transportation. However, the buildup of plastic trash, organic debris, and other pollutants has made many of the world's rivers more contaminated in recent decades. In addition to endangering aquatic life, this pollution puts human health and the environment at serious risk. Up to 80% of oceanic plastic garbage is thought to be transported by rivers, which exacerbates the worldwide plastic catastrophe. Effective, sustainable, and scalable solutions are therefore desperately needed to reduce river pollution and safeguard water resources. Conventional techniques for cleaning such garbage include manual labor, which is expensive, time-consuming, and occasionally dangerous because of contaminated water or challenging access to certain places. Semi-automated methods are being developed to overcome these issues and make cleaning less labor-intensive and more efficient. Because of its 360° rotation capability, the robot can navigate and clean in any direction without requiring significant motions. By enabling remote operation and control, wireless technology improves usability and flexibility when keeping an eye on the robot's operations. A mechanical system called the Water Surface Cleaning Robot is used to clear floating debris off water bodies' surfaces. A 12V rechargeable battery powers the system, and for sustainable energy, a solar panel can be added. In addition to lowering reliance on manual cleaning techniques, this robot offers an affordable, environmentally responsible, and scalable way to deal with surface water contamination. It provides an illustration of how IoT and robotics technologies might be applied to environmental preservation.

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II. LITERATURE REVIEW

Research on automated cleaning systems is being prompted by the growing environmental issue of river pollution caused by floating garbage.

1) Title:- A Review on Wall-Climbing Robots: Locomotion, Adhesion, and Applications
Name of Author:- D. P. P. B. Liyanage, et al.
Year:- 2024
This review paper provides an in-depth analysis of wall-climbing robots (WCRs), emphasizing locomotion and adhesion technologies. It categorizes locomotion methods into wheel-based, legged, and hybrid designs, and compares adhesion techniques such as vacuum, magnetic, adhesive, and gripping mechanisms. The study evaluates each approach's suitability for different surfaces and operational conditions. Additionally, it explores WCR applications in inspection, maintenance, and surveillance of hazardous or hard-to-reach areas. The paper concludes by identifying key challenges such as energy efficiency, adaptability, and reliability—and outlines future research directions for developing more capable and versatile wall-climbing robotic systems.

2) Title:- Autonomous Swimming Pool Cleaning Robot
Name of Author:- Nur Ahmad Al-Maahi Bin Noorazman, A. I. Ibrahim
Year:- 2022
The paper "Autonomous Swimming Pool Cleaning Robot" by Nur Ahmad Al-Maahi Bin Noorazman and A. I. Ibrahim focuses on designing and developing an autonomous robot capable of cleaning swimming pool floors to achieve up to 80% hygiene efficiency. It highlights the importance of regular cleaning for maintaining safe and healthy aquatic environments and proposes an autonomous underwater rover as a practical solution. The study emphasizes the robot's ability to navigate the pool bottom independently, collect debris, and ensure consistent cleaning performance, ultimately reducing manual labor and improving the effectiveness of pool maintenance operations.

3) Title:- An Amphibious Climbing Soft Robot with Bio-inspired Suction Adhesion
Name of Author:- Jian Tang, et al.
Year:- 2023
This paper presents an innovative amphibious climbing soft robot inspired by tree frogs and starfishes, designed for strong adhesion on both wet and dry surfaces. It features a bio-inspired suction system composed of multiple soft suction cups with an internal vacuum mechanism, allowing it to conform to irregular surfaces for stable attachment. The robot's modular, flexible body enables vertical climbing on materials like glass, tile, and concrete without causing damage. Experimental evaluations confirm its high adaptability and performance across varied environments, highlighting its potential for inspection, maintenance, and monitoring in complex and unstructured terrains.

4) Title:- Energy-Efficient Water Cleaning Devices
Name of Author:- Elsevier
Year:- 2019
This paper focuses on developing an energy-efficient water cleaning device through key design optimizations. It examines motor efficiency to minimize power consumption and introduces an improved brush design that enhances cleaning performance while reducing torque requirements. Additionally, the study explores methods for minimizing water usage using advanced nozzle designs and precise flow control systems. Experimental evaluations show significant reductions in both energy and water consumption compared to traditional cleaning devices. The results validate the proposed approach as an effective, sustainable, and cost-efficient solution for modern water cleaning applications focused on environmental and operational efficiency.

5) Title of Paper: Robotic Surface Cleaners for Hygiene Maintenance
Name of Author: Rajesh Kannan Megalingam
Year: 2018
This paper reviews the rapid automation trends transforming hygiene maintenance, particularly in public and commercial environments. It focuses on the deployment of autonomous robotic surface cleaners equipped with advanced navigation systems and specialized cleaning tools. The core finding is that these systems significantly enhance facility management operations and standards. Specifically, the review demonstrates substantial improvements in worker safety by reducing human exposure to contaminants and hazardous cleaning agents. Furthermore, the robots boost cleaning efficiency through optimized, systematic coverage and scheduling, leading to notable maintenance cost reduction by minimizing reliance on manual labor. The paper emphasizes the growing role of autonomous cleaners in maintaining high hygiene standards across critical infrastructure.

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III. METHODOLOGY

The development of the River Cleaning Robot aimed to create an autonomous system capable of efficiently removing floating debris from water bodies such as lakes, rivers, and ponds. The methodology was structured into key phases: design and system integration, prototype development, testing and evaluation, and iterative refinement.

1. Design and System Integration

The design of the River Cleaning Robot focused on selecting key components to enable effective navigation, debris detection, and collection. The primary design goal was autonomy, efficiency, and adaptability to different water environments.

- **Navigation System:** The robot was equipped with a combination of paddle wheels and thrusters. The paddle wheels provided stability and movement across calm water surfaces, while thrusters allowed for precise navigation in more turbulent conditions. This dual-propulsion system ensured robust mobility in various water bodies, including those with currents or waves.
- **Debris Detection and Sensing:** To efficiently locate and collect debris, the River Cleaning Robot incorporated a suite of sensors, including:
  - **Ultrasonic sensors** for distance measurement and obstacle avoidance.
  - **Infrared sensors** for detecting changes in water temperature, which could indicate the presence of debris.
- **Debris Collection Mechanism:** The robot featured a mechanical system that could extend and retract depending on the size and type of debris. The system was designed to collect materials like plastic waste, wood, and organic debris. The collected waste was stored in an on board compartment, which could be emptied manually once full.
- **Power Supply:** The River Cleaning Robot was powered by a combination of rechargeable batteries and solar panels. The batteries powered the robot's motors and sensors, while the solar panels helped recharge the batteries during operation, extending the robot's autonomous runtime.
- **Communication and Control:** The robot was designed with wireless communication capabilities, allowing remote control and monitoring. Operators could track the robot's location, monitor its performance, and adjust its path if needed through a mobile application or dedicated interface.

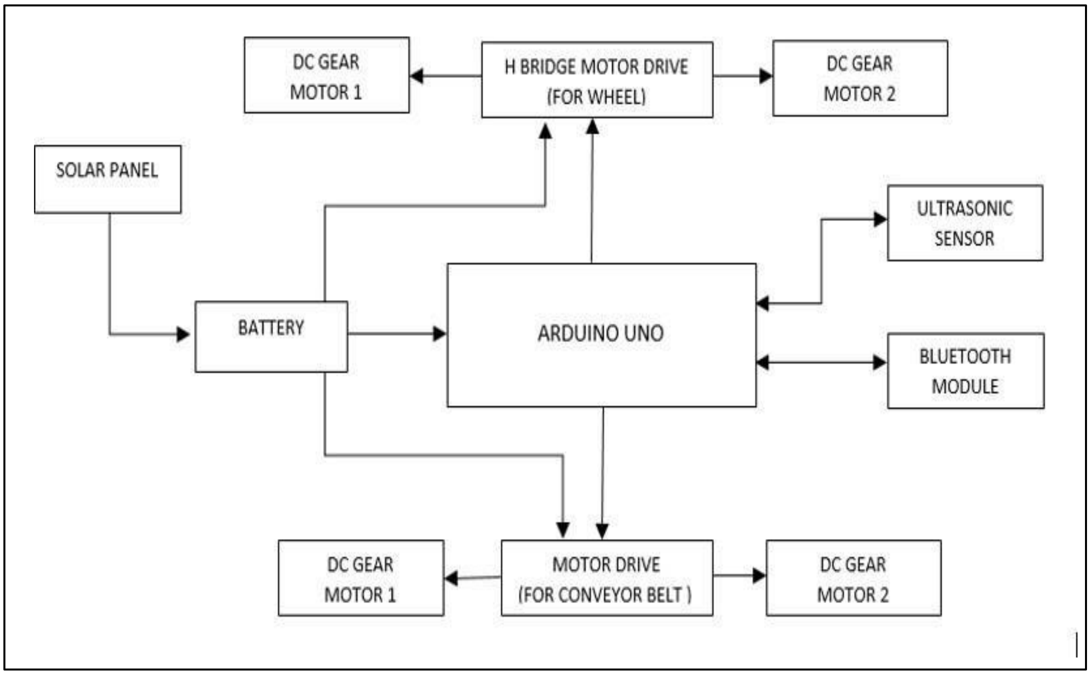

Figure 1Block Diagram of IoT-Based River Cleaning Robot

2. Prototype Development

After completing the design phase, a prototype was built with lightweight, durable materials. The frame was made of waterproofed plastic and aluminum to ensure buoyancy and prevent corrosion. All electronic components, including sensors and motors, were sealed to prevent water ingress, ensuring the longevity and reliability of the robot.

3. <u>Testing and Evaluation</u>

Testing was carried out in both controlled laboratory conditions and real-world water environments. Initial tests were conducted in a water tank to evaluate the robot's basic functionality, such as:

- Navigation performance, including obstacle avoidance and ability to follow a designated path.
- Sensor accuracy in detecting and locating debris.
- The efficiency of the debris collection mechanism.

Subsequent field tests took place in natural water bodies, such as lakes and rivers, where the robot was subjected to dynamic conditions like varying water currents, debris types, and environmental factors (e.g., wind and rain).

Field testing focused on:

- **Navigation and maneuverability:** Assessing the robot's ability to navigate through complex water environments, including avoiding plants and rocks.
- **Debris removal efficiency:** Measuring the quantity and types of debris collected during each operation.
- **Energy efficiency:** Evaluating how long the robot could operate autonomously using solar power and batteries.

4. <u>Future Work</u>

Future development will focus on scaling the River Cleaning Robot for larger water bodies, improving its energy efficiency, and enhancing its ability to operate in more polluted or industrial water environments. Additionally, further optimization of the robot's path planning algorithms and autonomous decision-making processes will be pursued to ensure optimal performance in complex, dynamic environments.

5. <u>Mathematical Calculations:</u>-

1. Power Requirement Calculation

Used to determine the energy needed to operate motors, sensors, and controllers.

$$P=V\times I \quad \text{………Equation 1}$$

If each DC motor draws 0.5A at 12V, and there are 4 motors:

$P=12\times(4\times0.5)=24$ W

If Arduino + Bluetooth + Sensors ≈ 6W,

then Total Power = 30W .

2. Battery Capacity Calculation

Used to find how long the robot can operate on one charge

$$\text{Battery Capacity (Ah)}=\text{Total Load (A)}\times\text{Operating Time (h)}/\text{Efficiency}$$

If load = 2.5A, time = 3h, and efficiency = 0.85:

$C=2.5\times3/0.85=8.82$Ah

So, use a **12V 9Ah battery**.

3.Solar Panel Output Calculation

If a solar panel recharges the battery:

$$\text{Power Output}=V\times I$$

and

$$\text{Charging Time (hours)}=\text{Battery Capacity (Wh)}/\text{Panel Power (W)}$$

12V, 9Ah battery → 108Wh

20W solar panel →

Charging Time=108÷20=5.4h

4. Torque Calculation for Motors

To ensure the motors can move the robot and the waste load.

$$T=F\times r$$

Where:

- T= Torque (Nm)
- F= Force (N)
- r = Wheel radius (m)

If the robot mass = 3kg, and friction coefficient = 0.1:

$F=m\times g\times\mu=3\times9.81\times0.1=2.94$N

For r =0.05mr

$T=2.94\times0.05=0.147$ N

5. Speed of Robot

$v=\omega\times r$

Where:

ω= Angular speed (rad/s)

r= Wheel radius (m)

If motor speed = 100 RPM $\rightarrow\omega=2\pi\times100/60=10.47$ rad/s .Then, $v=10.47\times0.05=0.52$ m/ s

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IV. RESULTS

The successful design, construction, and testing of the IoT-Based River Cleaning Robot prototype showed how the suggested idea might be put into practice. The prototype successfully detected and gathered floating trash, including plastic bottles, wrappers, and light organic debris, while operating independently on the water's surface. The robot's stability and mobility were unaffected by the garbage collection mechanism's seamless operation, which moved the gathered rubbish into the onboard storage container.

The prototype was able to avoid collisions and continue operating continuously because to the integrated sensors' accurate obstacle detection and dependable navigation. By sending real-time data, such as waste status, battery level, and operating parameters, the IoT module functioned as planned. When predetermined criteria were achieved, alerts were sent to support prompt maintenance and action. The prototype's running time was increased and its reliance on external charging was decreased with the addition of a solar-assisted power system. Overall, the prototype findings confirm the IoT-Based River Cleaning Robot's efficacy, dependability, and scalability, demonstrating its potential for practical use in rivers and other aquatic environments.

V. CONCLUSION

In order to combat the growing issue of water pollution in rivers and other aquatic ecosystems, the IoT-Based River Cleaning Robot provides a smart, effective, and sustainable solution. The robot can detect, gather, and handle floating waste with little assistance from humans because to the integration of autonomous navigation, sophisticated sensors, and Internet of Things-based communication. Continuous monitoring of the robot's performance, garbage collecting status, and environmental conditions is made possible via real-time data transmission, which guarantees prompt decision-making and enhanced operational control. Long-term operation in contaminated or difficult-to-reach water bodies is made possible by this automation, which also greatly decreases manual labor and improves safety.

The robot's sturdy and modular construction guarantees dependable operation in a variety of aquatic conditions, including currents and waves. The use of solar energy as the main power source lowers long-term operating costs, encourages environmentally responsible operation, and lessens reliance on conventional energy sources. The technology is appropriate for both small-scale and large-scale cleanup activities because of its scalable architecture, which enables numerous robots to collaborate. All things considered, the suggested IoT-Based River Cleaning Robot supports smart water management programs, promotes environmental sustainability, and offers an affordable, flexible, and cutting-edge way to preserve healthier and cleaner aquatic environments.

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