IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 4, April 2026

DOI: 10.17148/IJARCCE.2026.154122

Design and Development of Intelligent system for Water cleaning Robot using IoT

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Abstract: Water bodies in urban and rural areas are increasingly polluted due to plastic waste, floating, debris, and other solid pollutants. Manual cleaning of lakes, ponds, and rivers is time consuming, unsafe, and not be efficient for continuous monitoring. This project presents the Design and Development of an Intelligent Water Cleaning Robot using IoT that focuses on automated waste collection from water surfaces. The system uses an Arduino-based control unit integrated with IoT and Bluetooth communication and to operate a floating robot equipped with a rotor-based harvesting mechanism for collecting waste. The robot can be remotely controlled, while sensors and connectivity allow monitoring of operation status. Collected waste is stored onboard, reducing human effort and exposure to polluted water. This system improves the water cleanliness by providing an efficient, low-cost, and intelligent solution for continuous water surface waste removal. This intelligent system reduces human effort, enhances cleaning efficiency, and provides continuous environmental monitoring. The project contributes to sustainable water resource management and supports smart environmental protection systems.

Keywords: Efficient Waste Collection, Cost-Effective Solution, Environmental Protection, Remote Monitoring.

I. INTRODUCTION

Water is one of the most essential natural resources for human survival, agriculture, and industrial development. However, rapid urbanization, industrialization, and population growth have significantly increased water pollution levels across the world. Lakes, rivers, ponds, and other water bodies are increasingly contaminated with plastic waste, floating debris, domestic sewage, and industrial effluents. These pollutants not only degrade water quality but also harm aquatic life and disturb the ecological balance. Traditional methods of cleaning water bodies mainly rely on manual labor or large mechanical systems, which are expensive, time consuming, and sometimes unsafe for workers. To address these challenges, automation and smart technologies offer an effective and sustainable solution. The Design and Development of an Intelligent Water Cleaning Robot using IoT focuses on creating an autonomous system capable of collecting floating waste while simultaneously monitoring water quality in real time. The integration of robotics and Internet of Things (IoT) technology enables efficient cleaning operations and continuous environmental monitoring without direct human intervention. This intelligent system improves operational efficiency, reduces human effort, lowers maintenance costs, and supports smart city initiatives. By combining automation with environmental monitoring, the project contributes to sustainable water resource management and promotes cleaner and healthier ecosystems.

II. SYSTEM ANALYSIS AND DESIGN

Existing System:

Currently, the cleaning of water bodies such as rivers, lakes, and ponds is mostly carried out using traditional and semi-mechanized methods. These systems have several limitations in terms of efficiency, cost, and monitoring capability.

1. Manual methods involve workers collecting waste using simple tools. These methods require high effort, consume time, and expose workers to health risks.
2. Mechanical cleaning systems use motorized boats to remove debris. Although effective, they are costly and require skilled operators.
3. Water treatment plants focus on purifying water but are not suitable for cleaning surface-level waste. These methods lack automation and real-time monitoring capabilities.

Limitations of Existing Systems:

The existing methods for cleaning water bodies and monitoring water quality have several drawbacks. These limitations highlight the need for an intelligent IoT-based water cleaning robot.

1. High Labor Dependency– Manual cleaning requires a large workforce. It is time-consuming and physically demanding, increasing operational costs and reducing efficiency.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 15, Issue x, Month 2026

DOI: 10.17148/IJARCCE.2026.14xx

2. Safety Risks– Workers are exposed to polluted water, harmful chemicals, sharp objects, and biological contaminants, which may cause health problems.
3. Lack of Automation– Most traditional systems are not fully automated. Continuous monitoring and cleaning require constant human supervision.

Proposed System:

The proposed system is an IoT-based intelligent water cleaning robot designed to operate on the surface of water bodies. It performs automatic waste collection and monitors water quality in real time. Key Features of the Proposed System:

1. Automatic waste removal using a rotating mechanism
2. Water quality sensing (pH, turbidity, temperature, etc.)
3. Microcontroller-based control system
4. Obstacle detection for safe navigation
5. IoT connectivity for remote monitoring via mobile or web applications This system reduces human effort and improves cleaning efficiency.

III. SYSTEM DESCRIPTION

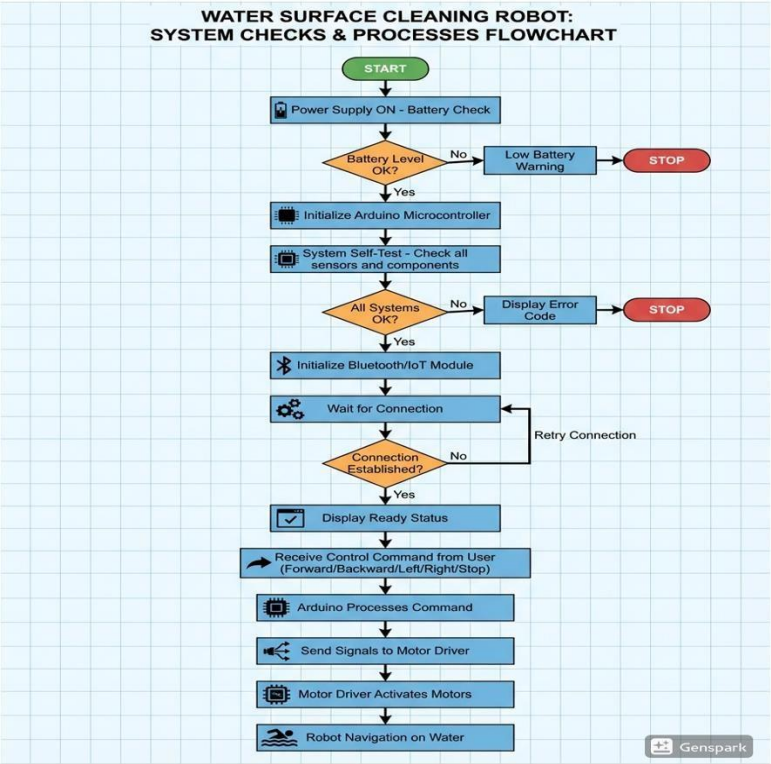

Fig 1: Flow Chart

A. Prototype design

1. Microcontroller Unit:

- Arduino UNO / Arduino Mega or ESP32
- Acts as the central control unit
- Processes sensor data and controls motors
- Manages IoT communication

2. Motor and Drive System:

- DC Motors (2–4 units) – For robot movement
- High Torque DC Motor – For conveyor/waste collection mechanism
- Motor Driver Module (L298N/L293D) – Controls motor speed and direction
- Propellers or Wheels – For navigation in water

3. Waste Collection Mechanism:

- Conveyor belt or rotating drum system
- Metal/plastic mesh for collecting floating waste
- Waste storage container

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4. IoT Communication Module:

- ESP8266 Wi-Fi Module (if using Arduino) OR
- ESP32 (with built-in Wi-Fi & Bluetooth) OR
- GSM Module (SIM800L) for remote areas

5. Obstacle Detection Ultrasonic Sensor (HC-SR04) – Detects obstacles to avoid collision

6. Power Supply System:

- 12V Rechargeable Battery
- Voltage Regulator Module Solar Panel (optional for future enhancement) Additional Components
- Jumper wires Breadboard / PCB
- Switches
- LED indicators
- Connectors

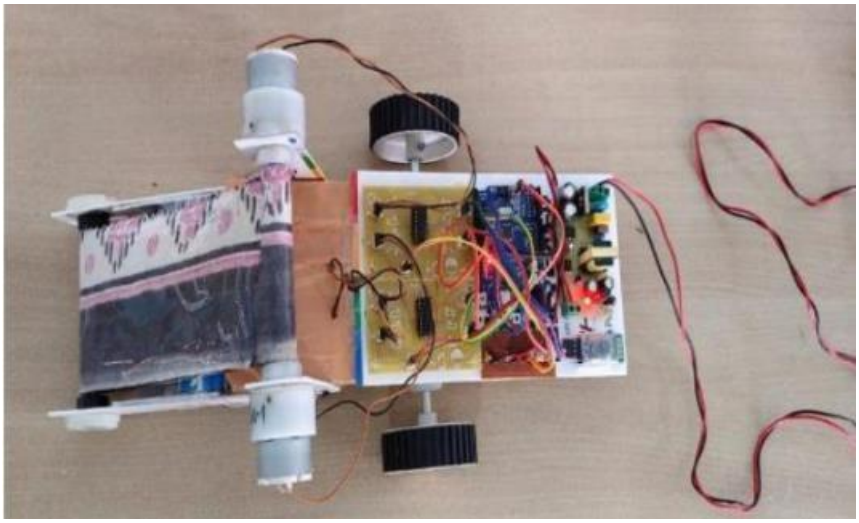

Fig 2: Prototype

IV. RESULTS

Result Table

Test No.	Waste Detected	Collected Successfully	Time Taken (sec)	Bin Status	IoT Update
1	Yes	Yes	12	20% Full	Sent
2	Yes	Yes	15	40% Full	Sent
3	No	No	0	40% Full	Sent
4	Yes	Yes	18	70% Full	Sent
5	Yes	Yes	20	100% Full	Alert Sent

Fig 3: Performance Analysis of IoT-Based Water Cleaning Robot

Fig 3: shows the table illustrates the experimental outcomes of waste detection and collection.

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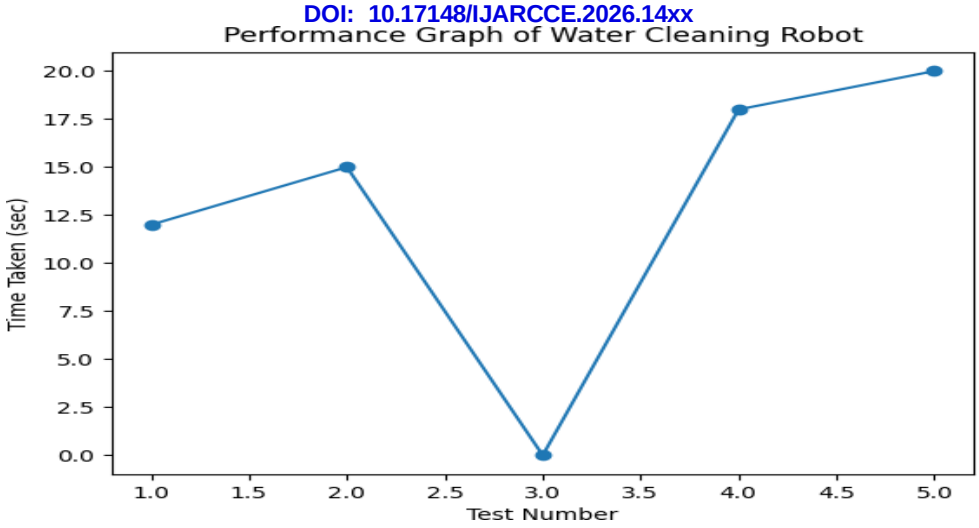

Fig 4: Performance Evaluation of IoT-Based Cleaning System

Fig 4 shows Graphs are used to visually represent the performance of the water cleaning robot over different test cases. Graphical representation helps in understanding the efficiency, time variation, and overall system performance.

V. CONCLUSION

Water pollution has become one of the most serious environmental problems due to the increasing accumulation of floating waste such as plastic bottles, bags, leaves, and other debris in water bodies. Rivers, lakes, ponds, and canals are often polluted because of improper waste disposal and lack of efficient cleaning systems. Traditional cleaning methods mainly depend on manual labor, which is time-consuming, inefficient, and sometimes unsafe for workers. Therefore, there is a need for an automated and intelligent system that can effectively clean water bodies and monitor environmental conditions. The **Design and Development of an Intelligent Water Cleaning Robot using IoT** provides a modern and efficient solution to this problem. The proposed system uses a floating robotic platform equipped with sensors, a waste collection mechanism, and an IoT communication module. The robot is capable of moving across the water surface and collecting floating waste using a conveyor or collection tray mechanism. At the same time, sensors monitor important water quality parameters such as turbidity, temperature, and water level. The microcontroller acts as the central control unit, processing sensor data and controlling the robot's movement and waste collection operations.

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