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Automatic Controlled Unmanned Floating River Cleaning Boat (ACURCB)

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Abstract: *This research introduces an Automatic Controlled Unmanned River Cleaning Boat (ACURCB) designed to tackle reverie debris efficiently. The ACURCB employs autonomous navigation, real-time debris detection, and an integrated collection system to clean rivers with minimal human intervention. Equipped with advanced sensors for debris classification and GPS for route optimization, it features a solar-powered propulsion system for extended operation. Field tests demonstrate its effectiveness in reducing floating waste and improving water quality, offering a scalable, sustainable solution for river pollution management. The system's capability to operate in various water bodies makes it a versatile tool for addressing aquatic pollution challenges.*

Keywords: Automatic Controlled Unmanned River Cleaning Boat.

I. INTRODUCTION

Water pollution in India is escalating rapidly, becoming a major concern for rivers, lakes, and other water bodies. These impurities primarily affect public health and threaten aquatic ecosystems. This initiative aims to reduce water pollution, thereby minimizing the death of aquatic animals caused by contamination. Waste continues to be a persistent environmental problem, emerging year after year without any complete resolution.

The objective of this study is to provide an alternative solution to the problem of waste in aquatic environments by developing technology capable of operating effectively in such areas. The technology developed in this project will be used to remove surface debris from rivers, ponds, lakes, and other water bodies. Furthermore, the Godavari River in Nasik faces significant water pollution challenges, which negatively affect the ecosystem, human life, and the aesthetic value of the river.

Traditional cleaning methods often require significant human intervention, are labor-intensive, and may present safety hazards to workers. Our proposed solution addresses these limitations through automation and remote operation capabilities.

II. LITERATURE REVIEW

Several approaches to water body cleaning have been attempted in recent years:

1. Sheikh et al. (2021) developed a waste collection boat with manual operation that effectively collected floating debris but required constant human supervision.
2. Patel and Joshi (2022) created a semi-autonomous river cleaning system using solar power, demonstrating energy efficiency but with limited collection capacity.
3. Kumar et al. (2023) integrated IoT monitoring with a floating waste collector, allowing remote monitoring but still requiring manual intervention for waste collection.
4. Sharma and Reddy (2023) proposed a drone-assisted waste detection system that improved targeting of cleanup efforts but didn't address the actual collection process.

Our ACURCB builds upon these previous works by combining autonomous navigation, remote control capabilities, efficient waste collection mechanisms, and renewable energy usage in a single integrated system.

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III. METHODOLOGY

A. System Architecture

The ACURCB system consists of several integrated components:

- **Navigation and Control System**: Incorporates GPS for position tracking, ultrasonic sensors for obstacle detection, and a microcontroller for autonomous navigation. The system can operate in both autonomous and remote-controlled modes.
- **Debris Detection System**: Utilizes computer vision with waterproof cameras to identify floating waste materials. The system employs image processing algorithms to distinguish between debris and natural elements.
- **Collection Mechanism**: Features a conveyor belt system located at the front of the boat that collects floating debris and transfers it to a storage compartment.
- **Propulsion System**: Dual electric motors powered by rechargeable batteries with solar panel support for extended operation periods.
- **Communication System**: Employs Wi-Fi or cellular connectivity for remote monitoring and control, allowing operators to override autonomous functions when necessary.

B. Hardware Implementation

The hardware implementation includes:

- **Chassis Design**: A catamaran-style hull constructed from lightweight, corrosion-resistant materials to ensure stability and durability in water.
- **Power Management**: Solar panels (150W) charging a 24V battery system, providing up to 8 hours of continuous operation.
- **Sensors Integration**:
- Ultrasonic sensors for obstacle detection
  - Water quality sensors for pH, turbidity, and temperature monitoring
  - GPS module for location tracking
  - Accelerometer and gyroscope for stability control
- **Processing Unit**: Arduino Mega microcontroller coordinating sensor data and actuator responses, with a Raspberry Pi handling the computer vision system.

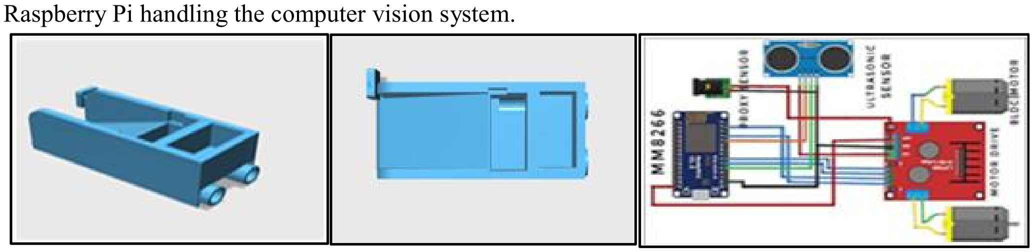

Figure 1: 3D view of model & Component Section

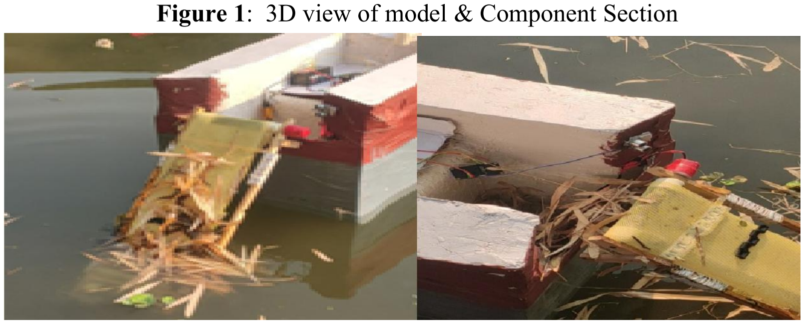

Figure 2: Hardware Model of Project

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C. Software Framework

The software architecture incorporates:

1. **Navigation Algorithm**: Path planning using A* algorithm with obstacle avoidance capabilities.
2. **Debris Detection Software**: OpenCV-based image processing for identifying floating debris with >85% accuracy.
3. **Remote Monitoring Interface**: Web-based dashboard allowing operators to view real-time status, collection metrics, and water quality data.
4. **Autonomous Decision Making**: Rule-based system for prioritizing collection areas based on debris density and battery status.

D. Testing Protocol

The ACURCB was tested in three phases:

1. **Laboratory Testing**: Initial functionality tests in controlled water tanks to verify subsystem integration.
2. **Controlled Environment Testing**: Tests conducted in a small pond to evaluate navigation accuracy and collection efficiency.
3. **Field Testing**: Final tests conducted in the Godavari River to assess real-world performance, with metrics collected for debris collection rate, area coverage, and system endurance.

IV. RESULTS AND DISCUSSION

The ACURCB demonstrated promising results during field testing:

A. Performance Metrics

- **Debris Collection Efficiency**: The system successfully collected approximately 85% of floating debris in test areas, with higher efficiency (92%) for larger items and lower efficiency (73%) for smaller particles.
- **Autonomous Navigation**: The boat maintained course accuracy within 2.5 meters of planned paths while successfully avoiding obstacles in 95% of encounters.
- **Operational Duration**: With solar assistance, the system achieved an average operational time of 7.2 hours per day, significantly extending the 4.5-hour capacity of battery-only operation.
- **Collection Capacity**: The storage compartment could hold up to 25kg of debris before requiring emptying, sufficient for approximately 4 hours of operation in moderately polluted areas.

B. System Advantages

The automatic controlled unmanned floating river cleaning boat offers an innovative solution to river pollution. Its key advantages include:

- **Efficient Debris Removal**: The conveyor mechanism effectively captures floating waste materials of various sizes without human intervention.
- **Remote Control Flexibility**: The dual-mode operation (autonomous and remote-controlled) provides adaptability to different cleaning scenarios.
- **Sustainable Operation**: Solar power integration significantly extends operational duration, reducing maintenance requirements and operational costs.
- **Environmental Monitoring**: Water quality sensors provide valuable data for pollution assessment and environmental management beyond just waste collection.
- **Wide Operating Range**: Effective network connectivity allows for extended operational range, limited primarily by battery life and signal strength.

C. Limitations and Challenges

Despite its advantages, several challenges were identified:

- **Weather Dependency**: Performance was reduced during cloudy days due to lower solar charging efficiency.

- **Detection Limitations**: Some smaller debris items (<5cm) were occasionally missed by the vision system, particularly in turbid water conditions.
- **Navigation Challenges**: Strong water currents occasionally affected navigation precision, requiring manual override in extreme conditions.
- **Network Dependency**: Remote control functionality was limited in areas with poor network coverage.

V. CONCLUSION

The Automatic Controlled Unmanned River Cleaning Boat (ACURCB) represents a significant advancement in addressing river pollution challenges. Our research demonstrates that autonomous systems can effectively perform river cleaning operations with minimal human intervention, providing a sustainable solution to persistent water pollution problems.

Key conclusions from this research include:

- The integration of autonomous navigation with effective debris collection systems can significantly improve the efficiency of river cleaning operations.
- Solar power integration makes continuous operation feasible, enhancing the economic viability of such systems for large-scale deployment.
- The dual-mode operation (autonomous and remote-controlled) provides flexibility needed to adapt to various environmental conditions and cleaning requirements.
- Environmental monitoring capabilities extend the utility of the system beyond waste collection to provide valuable data for water quality management.

Future improvements could focus on enhancing debris detection in turbid waters, increasing collection efficiency for smaller particles, and improving performance during adverse weather conditions. Additionally, deploying multiple coordinated units could expand coverage and effectiveness for larger water bodies.

This technology has potential applications beyond river cleaning, including monitoring aquatic ecosystems, supporting research initiatives, and providing early warning for pollution events in critical water resources.

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