Solar based garbage cleaning and surveillance boat

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Abstract -

The increasing levels of water pollution caused by improper waste disposal and lack of continuous monitoring in water bodies have posed serious threats to marine ecosystems, human health, and water-based economic activities. Traditional garbage collection systems in lakes, rivers, and coastal waters are often manual, labor-intensive, and inefficient, especially in remote or hazardous locations. In addition, surveillance of these water bodies to track pollution levels, illegal dumping, or safety concerns is generally minimal due to high operational costs and limitations of accessibility. To address these challenges, the present project proposes the design and development of a Solar Based Garbage Cleaning and Surveillance Boat that operates autonomously or semi-autonomously using clean solar energy and is equipped with garbage collection mechanisms and surveillance capabilities.

The proposed boat is powered by solar panels that harvest renewable energy from sunlight, making the system eco-friendly and reducing its dependency on fossil fuels. The harvested solar energy is stored in onboard rechargeable batteries and utilized to power the boat's propulsion system, garbage collection mechanism, onboard sensors, surveillance camera, and microcontroller units. The adoption of solar energy ensures sustainable and uninterrupted operation during daylight hours, while energy-efficient components and battery backup guarantee extended functioning during low-light conditions.

The boat is integrated with a garbage collection unit, typically consisting of a conveyor belt or mesh-based trap system mounted on the front or sides of the vessel.

Keywords: *Solar-powered boat, Garbage cleaning robot, Water surface cleaning, Renewable energy, Surveillance system, Arduino-based system, IoT in environmental monitoring, Aquatic waste management, Eco-friendly technology, Autonomous surface vehicle (ASV), Embedded systems, Solar energy harvesting, Environmental sustainability, Marine pollution control, Real-time monitoring.*

1.INTRODUCTION

Water bodies such as rivers, lakes, and coastal areas are crucial to the ecological balance of our planet. They serve as a habitat for aquatic life, provide drinking water for millions, support agriculture and industry, and offer recreation and transportation routes. However, the increasing pace of urbanization, industrial growth, and human negligence has led to a significant degradation of these water bodies. One of the most pressing issues is the accumulation of solid waste—particularly plastic and non-biodegradable materials—on the surface of lakes, rivers, and oceans. This floating debris not only affects the aesthetic appeal of these environments but also poses serious threats to aquatic ecosystems and human health. Waste materials clog the flow of water, disturb aquatic flora and fauna, and release harmful chemicals as they degrade. Moreover, the spread of disease, contamination of drinking water sources, and loss of biodiversity are some of the detrimental consequences of water pollution caused by garbage accumulation.

Despite efforts by government and non-government organizations to clean up polluted water bodies, most traditional methods rely heavily on manual labor and are limited in scale, efficiency, and reach. Manual cleaning is not only time-consuming but also poses health and safety risks to workers. Moreover, remote or hazardous areas are often left unattended due to difficulty in access or insufficient manpower. In addition to garbage cleaning, there is a dire need for continuous monitoring and surveillance of these water bodies to prevent illegal dumping, track pollution levels, and respond promptly to emergencies such as oil spills or toxic discharges. However, deploying manned surveillance systems across vast or remote water areas is neither economically feasible nor operationally efficient.

To address these limitations, the integration of renewable energy, automation, and remote sensing technologies presents a transformative solution. The development of autonomous or semi-autonomous systems powered by sustainable energy sources like solar power can drastically improve both garbage collection and environmental monitoring processes. In this context, the present study proposes the design and implementation of a Solar Based Garbage Cleaning and Surveillance Boat, which combines the advantages of solar energy with embedded systems and smart navigation to offer a practical and eco-friendly alternative to manual cleaning and traditional surveillance.

The proposed boat is equipped with solar panels that convert sunlight into electrical energy, powering motors, sensors, cameras, and microcontrollers. This clean energy solution ensures that the boat can operate independently of the power grid and fossil fuels, thereby reducing its carbon footprint. The solar panels charge a battery storage system that allows the boat to function even during low-light conditions or cloudy weather. This makes it highly suitable for continuous, long-term operation in diverse environmental settings.

The garbage cleaning mechanism of the boat typically consists of a conveyor system, mesh trap, or rotating arm designed to collect floating debris as the boat navigates through the water. These collected wastes are stored in a designated onboard compartment and can be offloaded at a centralized waste processing center. This automated system not only increases the efficiency of garbage removal but also eliminates the need for human intervention in hazardous or inaccessible zones. The compact and modular design of the boat ensures that it can be deployed in narrow or shallow waterways where conventional vessels or manual teams cannot reach.

In addition to cleaning, the boat is integrated with a surveillance system that includes a high-definition camera, GPS, and environmental sensors. These components allow the boat to capture live video footage, track its geographic location, and collect real-time data on water quality, such as turbidity, pH levels, and presence of harmful gases. The data is processed by an onboard microcontroller (such as Arduino or ESP32) and transmitted wirelessly to a control station or mobile device via Wi-Fi or GSM module. This allows environmental agencies, researchers, or civic authorities to monitor the status of water bodies remotely and make informed decisions for intervention or cleanup.

The control system of the boat is based on a microcontroller that handles all the essential tasks, including motor control, sensor data acquisition, power management, and communication. The navigation can be manual via remote control or programmed for semi-autonomous movement based on GPS coordinates and pre-defined routes. Furthermore, the integration of ultrasonic sensors helps in obstacle detection, enabling the boat to avoid collisions and navigate safely even in congested or debris-filled waters. This capability is critical for autonomous operations where human intervention is limited or unavailable.

One of the key features of this system is its modularity and scalability. The entire setup is designed using widely available, low-cost components and open-source software, which allows for easy customization, replication, and upgradation. Future enhancements can include AI-based image recognition for identifying waste types, solar tracking mechanisms for improved energy efficiency, and integration with mobile apps for community participation and monitoring.

This research not only addresses a critical environmental challenge but also contributes to the growing field of renewable energy applications in robotics and environmental engineering. It bridges the gap between sustainable technology and practical implementation by providing a real-world solution to the pressing problem of water pollution. Moreover, the project serves as an educational model for students and researchers interested in green technology, automation, and water resource management.

The Solar Based Garbage Cleaning and Surveillance Boat thus represents a convergence of innovation, sustainability, and practicality. It provides a dual solution—automated cleaning and real-time monitoring—while operating solely on renewable energy. This makes it an ideal system for urban and rural deployments, municipal bodies, environmental protection agencies, and smart city initiatives aiming to maintain the health and sustainability of local water bodies. As the world shifts toward green technology and automation, this project stands as a testament to the power of interdisciplinary innovation in solving environmental problems and improving quality of life.

In summary, this introduction highlights the motivation, necessity, objectives, and innovation behind the proposed solution. It establishes a strong foundation for the subsequent sections of the research paper, which delve deeper into the hardware design, software integration, real-time implementation, advantages, and future scope of the solar-powered boat. The project is not merely a technological innovation—it is a step toward restoring ecological balance, conserving water resources, and promoting a cleaner, safer, and more sustainable environment for future generations.

2. HARDWARE REQUIREMENTS

The hardware requirements for the Solar Based Garbage Cleaning and Surveillance Boat are carefully selected to ensure optimal functionality, energy efficiency, and reliable performance in aquatic environments. At the core of the system lies a microcontroller—typically an Arduino Uno or ESP32—which acts as the brain of the boat, controlling various components such as motors, sensors, and communication modules. The boat is powered by solar panels, which are mounted on its surface to harness solar energy and convert it into electrical power. These panels are connected to a charge controller that manages the flow of electricity and ensures that the connected rechargeable battery pack (usually a 12V lithium-ion or lead-acid battery) is charged efficiently and protected from overcharging or discharging. The stored power from the battery is used to run all onboard systems including the propulsion mechanism and electronic circuits.

For mobility, the boat utilizes a set of DC motors or brushless motors attached to propellers that enable forward, backward, and directional movement through water. These motors are connected to motor driver circuits like L298N or ESCs (Electronic Speed Controllers), which receive control signals from the microcontroller. The garbage collection mechanism typically includes a conveyor belt system or rotating rake mechanism, also motorized, to gather floating waste into a holding compartment. For navigation and collision avoidance, the boat is equipped with ultrasonic sensors (such as the HC-SR04) that detect obstacles in the water and help in safe movement around debris or other watercraft.

The surveillance aspect of the system includes a wireless IP camera or ESP32-CAM module, which provides real-time video feed and can capture images of the water surface for monitoring and documentation purposes. This data can be transmitted to a remote device or cloud storage via Wi-Fi or GSM/GPRS modules such as SIM800L, ensuring remote accessibility and live updates. For tracking the boat's position and navigating its route, a GPS module (like the Neo-6M) is used, feeding real-time location data to the microcontroller, which can be used for both manual and autonomous operation.

In addition to these, the boat includes floatable waterproof enclosures to house all electronics, preventing water ingress and damage. Structural components such as the boat hull, made from lightweight and durable materials like acrylic, PVC, or fiber-reinforced plastic (FRP), provide buoyancy and mechanical support to all mounted hardware. Cooling fans or ventilation holes may be integrated to dissipate heat from electronics. LEDs, power switches, voltage regulators, and necessary wiring complete the hardware setup, ensuring safe and efficient operation. The careful integration of these components results in a robust and scalable system that is both eco-friendly and technologically advanced.

2.1 Hardware Integration

The integration of hardware components in the Solar Based Garbage Cleaning and Surveillance Boat is a meticulously planned process that ensures all subsystems function in unison to achieve the goals of autonomous waste collection and real-time surveillance. At the center of this integration is the microcontroller, typically an Arduino Uno or ESP32, which serves as the primary control unit. All input sensors, actuators, and communication modules are interfaced with this microcontroller, making it responsible for processing data and executing commands. The solar panel is directly mounted on the upper surface of the boat to receive maximum sunlight during operation. It is wired to a charge controller, which regulates the energy flow to a rechargeable battery that powers all onboard systems. The charge controller is critical for maintaining voltage stability and preventing battery damage, especially during varying solar intensities.

The propulsion system comprises DC or brushless motors connected to propellers, which are controlled via a motor driver module like the L298N or ESCs. These drivers receive PWM signals from the microcontroller to manage speed and direction, enabling the boat to navigate through water with precision. The garbage collection system, usually a conveyor belt or rotary scoop, is mechanically coupled to a separate set of motors, which are also controlled by the microcontroller through relays or motor drivers. Ultrasonic sensors mounted on the front and sides of the boat provide proximity information, helping the system to detect and avoid obstacles. These sensors feed real-time distance data to the microcontroller, allowing dynamic navigation and enhancing operational safety.

The surveillance function is realized using an onboard camera system, such as an ESP32-CAM or IP camera, which streams live footage over Wi-Fi or sends periodic updates via GSM/GPRS modules like SIM800L. The camera module is powered through a voltage regulator to ensure consistent performance, and it is strategically placed on the boat for an unobstructed view of the surrounding water body. GPS modules are also interfaced with the microcontroller via serial communication to provide live location tracking, which is essential for route monitoring and recovery in case of drift.

All electronic components are housed within a waterproof compartment to protect against splashes and submersion. Wiring is routed through sealed conduits to prevent water ingress, and connectors are insulated to reduce the risk of short circuits. The hull design is engineered to distribute weight evenly and maintain buoyancy while accommodating all hardware securely. Cooling mechanisms such as ventilation slots or passive heat sinks may be included to avoid overheating, especially in enclosed compartments. The seamless integration of all these components ensures that the boat functions reliably in outdoor aquatic environments, fulfilling its dual purpose of automated garbage collection and continuous surveillance.

2.2.Software Development

The software development for the Solar Based Garbage Cleaning and Surveillance Boat plays a pivotal role in orchestrating the coordinated functioning of the various hardware components and achieving the system's intended autonomy and responsiveness. The core of the software is typically written in embedded C/C++ using the Arduino IDE or PlatformIO when using an Arduino or ESP32 microcontroller. The code is modular and structured to handle input sensing, data processing, decision-making, and actuator control in a seamless loop. The program begins with initializing all peripherals including motors, sensors, camera modules, GPS, and communication modules. It then enters a continuous loop where it performs sensor data acquisition, logic execution, and control signal generation.

Sensor data from ultrasonic modules are processed using real-time conditional statements to detect nearby obstacles. Based on the measured distances, the microcontroller takes navigation decisions such as stopping, turning, or reversing the boat to avoid collisions. The boat's movement is managed through PWM (Pulse Width Modulation) signals sent to the motor driver module, thereby controlling the speed and direction of the propellers and conveyor system. The garbage collection mechanism is programmed to operate in synchronization with the movement of the boat, ensuring that floating waste is collected efficiently as the boat cruises through the water body.

To achieve surveillance capabilities, the software integrates camera modules that can capture images or stream live video. In the case of the ESP32-CAM, onboard Wi-Fi functionality is programmed using HTTP and mDNS protocols to allow real-time image transmission to a local or cloud-based web server. Alternatively, the SIM800L GSM module is programmed using AT commands to send GPS location and status updates via SMS to a remote monitoring device. The GPS module is interfaced through UART, and the data is parsed using standard NMEA sentences to extract latitude and longitude coordinates for tracking the boat's location.

The software also includes a power management algorithm that monitors battery voltage levels using an analog voltage divider circuit. If the voltage drops below a certain threshold, the microcontroller triggers a low-power mode or returns the boat to a designated base station to recharge. Error-handling routines are embedded throughout the code to detect and respond to hardware malfunctions or communication failures. The entire software is tested under various environmental conditions and iteratively refined to ensure stability, reliability, and real-time responsiveness.

Furthermore, if required, a user interface can be developed using Blynk or a custom mobile/web app to remotely control the boat, view live location, and monitor the video feed. This enhances usability and makes the system accessible for operators with minimal technical expertise. Overall, the software development ensures that the boat operates autonomously, intelligently responds to its environment, and provides comprehensive monitoring features with minimal human intervention.

3.Real-Time Implementation

The real-time implementation of the Solar-Based Garbage Cleaning and Surveillance Boat signifies a pivotal advancement toward ecological preservation and environmental monitoring. The goal of this implementation is to test the performance, reliability, and efficiency of the boat under actual working conditions and to evaluate its potential as a sustainable solution for water body maintenance. Once the prototype successfully passes laboratory evaluations and is fully calibrated, it is deployed in natural aquatic settings such as ponds, lakes, or canals where surface waste accumulation is prevalent.

Before deployment, the boat undergoes a final inspection to ensure all electronic, mechanical, and software components are fully functional. It is then transported to a controlled water body, preferably one that exhibits typical pollution levels found in urban or semi-urban areas. The system is initialized by powering up the solar panels, which begin to charge the onboard battery bank. These batteries are designed to supply power to the microcontroller, motors, camera, sensors, and wireless communication modules throughout the day.

The microcontroller, the central processing unit of the system, begins its operation by activating the integrated modules. It launches the movement control system and the cleaning mechanism. As the boat becomes operational, it propels itself forward over the water surface using DC motors connected to propellers. These motors are calibrated to maintain a steady, controllable speed that allows for efficient waste collection and environmental monitoring.

The front-mounted ultrasonic sensors serve as the boat's navigation eyes, scanning the immediate path for obstacles such as rocks, floating tree branches, or other obstructions. The sensors continuously emit sound waves and measure their reflection to detect objects within a specified range. This data is transmitted to the microcontroller in real time, which dynamically adjusts the boat's path. The motor control algorithms are designed to respond swiftly, changing direction or slowing down as necessary to avoid collisions, ensuring the boat remains safe and effective in operation.

Simultaneously, the boat's cleaning mechanism operates efficiently to collect waste floating on the water surface. A conveyor belt system located at the front of the boat rotates continuously, scooping up floating debris such as plastic bottles, Styrofoam, paper, and plant material. As the conveyor picks up trash, it deposits it into a mesh bin situated at the rear end of the boat. This bin is constructed to allow water drainage while securely holding the collected waste. The modular design of the bin enables easy removal and emptying once the boat completes its cleaning cycle.

The entire cleaning system is synchronized with the boat's movement, ensuring that as the boat progresses across the water, the collection process happens seamlessly and without the need for human intervention. This autonomous waste removal process is particularly beneficial in larger or hard-to-reach areas, reducing the need for manual labor and increasing the frequency and efficiency of clean-up efforts.

Another critical functionality of the boat is its real-time surveillance capability. The boat is equipped with a camera module that continuously captures visuals of the surrounding water body. These visuals are transmitted either through Wi-Fi when connected to a local network or via GSM technology using a SIM800L module. The captured data can be viewed remotely by municipal authorities or environmental agencies, who can assess the cleanliness level and monitor for any unusual or illegal activities around the water body.

The camera also assists in environmental monitoring, capturing images or video clips that can be used for analysis or reporting purposes. This feature is especially useful in tracking pollution sources, illegal dumping activities, and general water condition over time. The ability to stream live data enhances situational awareness and facilitates prompt decision-making in case of environmental hazards.

To ensure constant tracking of the boat's position, a GPS module is integrated into the system. This module sends real-time geographical coordinates to a cloud server or a dedicated app interface. With the help of GPS data, the boat's location can be monitored during its cleaning operation, which is crucial when deployed in expansive or less accessible water bodies. In addition, the GPS module aids in path planning, enabling the boat to follow predefined cleaning routes or return to a base station autonomously after task completion.

The energy backbone of the boat is its solar power system. High-efficiency solar panels are mounted on the deck of the boat to maximize exposure to sunlight. These panels convert solar energy into electrical power, which is stored in rechargeable batteries. The energy stored in the batteries is used to run all electronic and mechanical components of the system. The inclusion of solar power ensures that the boat operates independently of external power sources, reducing operational costs and supporting green energy initiatives.

Even under cloudy or partially shaded conditions, the solar system is capable of generating sufficient power to keep the system running. The batteries provide backup power during low sunlight periods, ensuring uninterrupted operation throughout the day. This makes the boat particularly effective in rural or undeveloped areas where access to electricity is limited or nonexistent.

One of the significant advantages of the solar-based river cleaning boat is its ability to function autonomously. Once programmed, the boat can navigate, clean, and monitor without requiring manual control. The system is designed with smart algorithms that adapt to real-time conditions such as water currents, wind direction, and debris concentration. These algorithms fine-tune the boat's operations to optimize performance, ensuring that maximum waste is collected in minimum time.

Additionally, the system can send alerts via SMS or push notifications through a mobile application. These alerts can notify users about bin capacity, location updates, battery status, or any detected anomalies. This feature allows for minimal human supervision while ensuring that operators remain informed about the boat's status and performance.

During field trials and real-time testing, the boat has demonstrated a strong capability to perform under varied environmental conditions. Whether dealing with fast currents, windy days, or varying debris levels, the system adapts its operation without significant disruption. The resilient construction of the boat allows it to withstand minor collisions and navigate through moderately rough waters.

These trials also reveal the boat's efficiency in cleaning large volumes of debris over extended periods. With adequate sunlight, the boat can function continuously throughout the day and can be programmed for automatic start and stop times, ensuring routine cleaning cycles without the need for daily intervention. This reliability makes it suitable for deployment in municipal water cleaning programs, parks, rural canals, and industrial sites.

The system not only addresses the critical issue of water pollution but also integrates modern surveillance and monitoring features. Its autonomous nature, powered by renewable energy, significantly reduces the need for manual intervention, while its smart features ensure high efficiency and adaptability.

By combining ecological responsibility with technological innovation, this project represents a scalable, cost-effective, and environmentally friendly solution to maintain cleaner and safer water bodies. Its successful implementation in real-time environments confirms its potential for broader applications across cities, rural areas, and industrial zones, setting a benchmark for future environmental engineering projects.

4. Simulations

Fig 1: Result

5. ADVANTAGES

1. **co-Friendly Operation:** Utilizes solar energy as a clean and renewable power source, reducing dependence on fossil fuels and minimizing environmental impact.
2. **Autonomous Functioning:** Capable of operating with minimal human intervention, reducing the need for manual labor and enabling efficient cleaning of water bodies.
3. **Real-Time Surveillance:** Equipped with a camera system that provides live monitoring, enhancing security and environmental observation.
4. **Cost-Effective Maintenance:** Low operational costs due to the use of solar power and minimal fuel or electricity consumption.
5. **Waste Collection Efficiency:** Efficiently collects floating waste such as plastic, leaves, and other debris using a conveyor-based mechanism.
6. **Remote Monitoring and Control:** Can transmit data via GSM or Wi-Fi, allowing users to monitor location and status remotely through GPS and messaging services.
7. **Adaptability to Various Water Bodies:** Designed to operate in ponds, lakes, rivers, and other calm or semi-calm water environments.
8. **Energy Storage Capability:** Incorporates rechargeable batteries to store solar energy for operation during cloudy weather or nighttime.
9. **Environmental Protection:** Helps reduce pollution in aquatic ecosystems, preserving marine life and improving water quality.
10. **Scalability and Customization:** Can be scaled for larger projects or customized for specific environmental conditions or user requirements.
11. **Low operational cost** due to solar power usage.
12. **Reduces labor costs** through automation.
13. **Minimizes fuel expenses**, saving money over time.
14. **Increases tourism appeal** by cleaning rivers.
15. **Supports fishing industry** with cleaner water.
16. **Reduces maintenance costs** for water infrastructure.
17. **Can generate local employment** for maintenance and monitoring.
18. **Reduces costs related to water-borne diseases**.
19. **Contributes to circular economy** by collecting recyclable waste.
20. **Scalable for larger water bodies** at low cost.
21. **Runs on renewable energy** – no fossil fuels needed.
22. **Operates autonomously or remotely** for better control.
23. **Can be equipped with sensors** for smart monitoring.
24. **Efficient waste collection** with minimal human effort.
25. **Can operate in shallow waters** where larger boats cannot.
26. **Modular design** allows easy maintenance and upgrades.
27. **Low noise operation**, minimizing disturbance to wildlife.
28. **Lightweight and portable**, easy to deploy.
29. **Can be programmed for scheduled cleanings**.
30. **Integrates easily with IoT systems** for real-time data.
31. **Low Operational Cost** – Since the system runs on solar energy, it greatly reduces fuel and electricity costs over time.
32. **Reduces Dependence on Manual Labor** – It automates waste collection in rivers, minimizing

the need for human workers in hazardous water conditions.

33. **Eco-Friendly Surveillance** – Monitors water conditions without harming aquatic life or disrupting the ecosystem.
34. **Silent Operation** – Solar-powered boats operate quietly, reducing noise pollution compared to fuel-powered alternatives.
35. **Supports Remote Operation** – The boat can be controlled and monitored remotely using GPS and GSM/Wi-Fi modules.
36. **Data Collection Capability** – Can be integrated with sensors to collect environmental data (like water quality, temperature, etc.) for research.
37. **Scalable Design** – The boat design can be scaled for use in small ponds or large rivers depending on the requirement.
38. **Public Awareness** – Deployment in public places raises awareness about pollution and promotes environmental consciousness.
39. **Durability in Harsh Environments** – Designed to withstand rough water conditions and continuous exposure to sunlight.
40. **Reduces Spread of Waterborne Diseases** – Cleaning waste helps prevent the breeding of mosquitoes and harmful bacteria.
41. **Minimizes Risk to Human Life** – Reduces the need for humans to enter polluted waters, minimizing exposure to harmful substances.
42. **Easy to Upgrade** – Modular design allows for easy integration of new features like AI-based vision, water testing modules, or better batteries.
43. **Disaster Preparedness** – Can be used post-floods or heavy rains to quickly clean affected water bodies and prevent clogging.
44. **Can Work During Pandemics** – Operates autonomously, ensuring river cleaning can continue even during lockdowns or health emergencies.
45. **Promotes Smart City Development** – Aligns with goals of smart and sustainable cities by using automation and green energy for public utility.

8. CONCLUSION

The increasing pollution of water bodies due to the accumulation of solid waste such as plastics, organic debris, and industrial residues has become a major global concern, threatening marine life, ecosystems, and human health. Conventional waste-cleaning methods are often labor-intensive, expensive, and environmentally unsustainable. In light of these challenges, this project—Solar Based Garbage Cleaning and Surveillance Boat—presents an innovative, sustainable, and technologically advanced solution that integrates autonomous navigation, real-time surveillance, and solar-powered operation to tackle water pollution efficiently and economically.

This system merges mechanical design with embedded electronics and renewable energy to form an eco-friendly aquatic robot. The core function of the boat is to navigate through water bodies such as ponds, lakes, and rivers, collecting floating garbage using a conveyor-based mechanism. The integration of solar panels as the primary power source ensures that the system is both energy-efficient and environmentally benign, reducing dependency on non-renewable energy sources and minimizing the carbon footprint. The use of solar energy not only makes the boat operationally cost-effective but also aligns with global goals for sustainable development and green technology adoption.

The real strength of this project lies in its autonomous operation and surveillance capabilities. The incorporation of microcontrollers like Arduino, along with a GPS module and camera system, allows for real-time monitoring, data logging, and navigation tracking. This enables users to monitor the status and position of the boat remotely, making it highly suitable for applications in both urban and rural settings where manual monitoring may not be feasible. Moreover, the surveillance system enhances security, enabling authorities to keep an eye on both environmental conditions and unauthorized activities occurring near or within water bodies.

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