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Smart Debris Collector For Water Bodies

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Abstract— This research introduces an innovative solution to tackle the persistent challenge of riverborne debris and floating waste accumulation. The project centers around a smart water trash collector, utilizing a NodeMCU microcontroller, designed for efficient and remote-controlled debris retrieval in diverse river environments. The core of the system is a remote-controlled boat equipped with a conveyor belt system optimized for precise trash collection. The boat's operations are orchestrated by the NodeMCU microcontroller, integrating robust engineering and programming to ensure effective navigation and debris retrieval. A distinctive feature of this environmentally conscious project is the incorporation of NodeMCU technology, not only enhancing the adaptability and maneuverability of the trash collector but also facilitating remote control functionality. Furthermore, the research highlights the sustainable aspect of the initiative by incorporating a power supply from a solar panel, making the system eco-friendly. This innovative approach represents a proactive step in mitigating environmental concerns and combating the adverse effects of floating waste on aquatic ecosystems. The paper delves into the intricacies of the boat's design, technological frameworks involving NodeMCU, solar power integration, and the anticipated positive impact on fostering cleaner and healthier water bodies. The research contributes to the broader efforts towards sustainable environmental management and underscores the significance of integrating smart technologies and renewable energy sources for effective waste management in water ecosystems.

Keywords— NodeMCU, aquatic debris, NodeMCU APK

I. INTRODUCTION

Rivers, essential lifelines of ecosystems, face an escalating crisis marked by the relentless accumulation of debris and floating waste, posing imminent threats to aquatic biodiversity and environmental equilibrium. This paper responds to this pressing challenge by presenting a pioneering solution: the development of a Smart Water Trash Collector empowered by NodeMCU technology. The cutting-edge system introduces a paradigm shift in aquatic debris cleanup, employing mobile control through a dedicated NodeMCU APK over Wi-Fi. This solution provides a user-friendly interface, enabling precise maneuvering of the collector robot in water. The integration of NodeMCU, a robust microcontroller with integrated Wi-Fi capabilities, ensures seamless communication between the mobile device and the trash collector. This wireless connectivity enhances the maneuverability of the robot and

streamlines the debris collection process in various water environments.

In a commitment to sustainability, the research incorporates a vital feature—utilizing a power supply from a solar panel. This eco-friendly approach not only aligns with environmental stewardship but also adds a layer of resilience to the system, allowing for extended and energy-efficient operations in diverse river conditions. The research delves into the design and implementation intricacies, emphasizing the crucial role of NodeMCU in achieving efficient motor control. A purpose-designed mobile application acts as a remote control interface, allowing users to navigate the robot with precision, ensuring targeted debris retrieval. Additionally, the study investigates the potential scalability of this innovative system for broader environmental applications, exploring avenues for its integration into comprehensive waste management strategies. The initiative aims to contribute significantly to ongoing efforts in mitigating water pollution, representing a pivotal step towards developing smarter and more adaptable solutions for aquatic debris cleanup. By combining technological innovation with environmental stewardship, this initiative strives to make a meaningful contribution to the restoration and preservation of cleaner and healthier river ecosystems worldwide. The Smart Water Trash Collector, with its integration of solar power, not only represents a technological advancement but also embodies a commitment to sustainable practices in addressing the challenges faced by our vital water bodies.

II. LITERATURE REVIEW

Various kinds of techniques has been applied by researchers to improve the accuracy of their Underwater Object Detection models. [3] proposes a data augmentation method Water Quality Transfer (WQT) and a model DG-YOLO to overcome three challenges a GUOD faces: limited data, real-time processing, and domain shift. A Water-Quality Transfer technique is applied to diversify the dataset so that Underwater object detection will be more reliable and training will be more efficient. [6] introduces a new method for an underwater robot to detect and catch seafood in real-time using Faster R-CNN and KCF tracking algorithm. It proves effective in recognizing and retrieving seafood in a natural ocean

environment. Faster R-CNN for marine object detection and KCF tracking algorithm for counting the objects using an underwater robot is very efficient and has fetched satisfactory results.[7] utilizes a remotely operated vehicle (ROV) with multiple underwater detection instruments, including sonar, magnetometer, and camera, to create a real-time monitoring system for detecting and managing underwater cultural relics.

The research undergone in [8] aims to create an object detection system for underwater robots (ROV) using color detection. It compares RGB and HSV color detection, with HSV having a 44.83% detection error and RGB having a 62.41% detection error, slightly reducing the desired detection range. [9] proposes a real-time underwater object detection algorithm using forward-looking imaging sonar and Haar-like features. They achieve accurate and tolerant object detection results using field data obtained from an AUV called "Cyclops". Underwater Object detection for moving objects is a highly challenging task that has been achieved and demonstrated in [10]. This paper proposes a method for detecting moving objects in underwater videos using background modeling with adaptive modeling. The average recall value is 83% and the precision is 67.5%, showing the effectiveness of the approach for underwater surveillance. Background modeling with adaptive modeling for object detection in underwater videos. Basic Techniques such as Operators, Edge Detection Techniques, Power Law Transformations, Gamma Transformation, and Laplacian-of-Gaussian Transformation (LoG) can also provide quite surprisingly satisfactory results if used in the right way. A similar approach has been followed in [11]. In this paper, a algorithm is proposed for underwater image enhancement. The proposed method is based on combined local and global image processing in the frequency domain. The basic idea is to apply logarithmic transform histogram matching with a spatial equalization approach on different image blocks. The resulting image is a weighted mean of all processing blocks driven through optimization of measure of enhancement (EME). Laser-scanning techniques are also quite predominant in this field where researchers have used sensors such as LiDAR and SONAR to detect underwater Objects. [12] Presented an object recognition and pose estimation pipeline with the ultimate objective of using it in a real-time localization and mapping system, then compared it with a prominent pipeline SLAM Algorithm. This system primarily uses a laser scanner to scan, localize and detect objects. This involves Laser Scanning the object, feeding it to a recognition pipeline. It classifies pre-existing images, filters and updates the object detected using measurements of sensors. The presented paper Effective Aquatic Waste Removal through Lake Cleaning Robot for Smart City Environment addresses a pressing environmental issue: the contamination of water bodies by garbage and waste. The authors highlight the significance of water pollution in India, where a substantial portion of water sources is reported to be polluted. They emphasize the relevance of their work in the context of national initiatives such as "Swachh Bharat" and "Smart City," which underscore the need for innovative solutions to manage and control aquatic waste effectively. The authors connect these existing works to the broader goals of Smart City initiatives and environmental cleanliness. They identify a common thread in these endeavors: the deployment of embedded systems and technology to address environmental challenges. The works mentioned in the literature review serve as a backdrop to the authors' current efforts in developing a Lake Cleaning Robot, providing context for their proposed solution.

III. OBJECTIVES

Development of a Smart Water Trash Collector: Design and construct a robust and efficient water trash collector utilizing NodeMCU technology for enhanced remote control capabilities.

Mobile-Controlled Maneuverability: Implement a dedicated NodeMCU APK over Wi-Fi to facilitate precise and user-friendly mobile control, allowing for optimal navigation and targeted debris retrieval in water environments.

Efficient Debris Retrieval System: Optimize the collector's functionality with a conveyor belt system, ensuring systematic and effective debris collection along riverbanks and in water channels while minimizing disruptions to the natural flow.

Sustainability Through Solar Power: Integrate a power supply system from a solar panel to enhance the project's sustainability, allowing for eco-friendly and energy-efficient operations in diverse river conditions.

Adaptability to Varied River Environments: Ensure the collector's adaptability to different river conditions by conducting rigorous testing across a range of water environments, considering factors such as flow rate, debris types, and water turbulence.

Reliability and Durability Testing: Subject the mechanical components and the overall system to meticulous testing to validate durability, reliability, and long-term performance in challenging river conditions.

Contribution to Environmental Conservation: Contribute significantly to ongoing efforts in mitigating water pollution by developing a smart and adaptable solution for addressing riverborne waste accumulation, thereby fostering cleaner and healthier water ecosystems

IV. METHODOLOGY

The development of the water trash collector utilizing NodeMCU technology, with mobile-controlled motors through a dedicated NodeMCU APK over Wi-Fi, followed a systematic and phased approach. Initially, collaborative brainstorming sessions among multidisciplinary teams were conducted to conceptualize and design the collector's physical structure, incorporating innovative features like the conveyor belt system and NodeMCU microcontroller integration.

Subsequent phases involved meticulous prototyping, emphasizing practical experimentation for simulation and refinement of functionality. Mechanical components underwent rigorous testing to ensure durability across diverse water conditions. Simultaneously, the NodeMCU microcontroller was programmed to seamlessly integrate with the collector's systems, enabling responsive motor control through the dedicated APK. Continuous iterations, guided by feedback from simulations and controlled water trials, were implemented to enhance efficiency in both debris collection and navigation.

In a commitment to sustainability, the methodology incorporates a crucial aspect—utilizing a power supply from a solar panel. This eco-friendly approach not only aligns with environmental stewardship but also adds a layer of resilience to the system, allowing for extended and energy-efficient operations in diverse river conditions.

This iterative methodology harmonized theoretical frameworks with practical experimentation, aiming for a holistic approach in developing a functional water trash collector capable of effectively addressing riverborne waste accumulation. The integration of design, engineering, and testing phases aimed to yield a reliable and adaptable solution, showcasing the potential of NodeMCU technology in combating the ecological threat posed by floating waste in water ecosystems. The mobile-controlled capabilities added a

layer of precision to the collector's operations, making it an innovative and efficient tool for environmental conservation.



Fig.-1: Design and integration process

When selecting a conveyor belt for a water trash collector, several factors need to be considered to ensure optimal performance in aquatic environments. Here are some types of conveyor belts that can be considered for water trash collectors:

Flat Belts:

Flat belts are simple and well-suited for applications where the debris is relatively small and light.

They provide a smooth surface for waste to slide along, making them suitable for applications with smaller-sized debris.

Cleated Belt

Cleated belts have raised sections (cleats) that help prevent debris from sliding back off the belt. They are effective in handling larger and heavier items, providing better control over the collected waste.

Modular Plastic Belts:

Modular plastic belts consist of interlocking plastic modules and are known for their durability and versatility. They are resistant to water and corrosion, making them suitable for waterborne applications.

Wire Mesh Belts:

Wire mesh belts are made of interconnected metal wires, allowing water to pass through easily. They are suitable for applications where water drainage is crucial, and they can handle both wet and dry debris.

PVC Belts:

PVC belts are resistant to water and are suitable for applications where the conveyor belt is frequently exposed to moisture. They are flexible and can handle various types of debris.

Rubber Belts with Cleats:

Rubber belts with cleats provide a combination of flexibility and debris control. They are effective in preventing debris from slipping off the belt while maintaining flexibility in changing water conditions.

Spiral Belts:

Spiral belts are typically made of metal and have a helical shape. They are suitable for applications where the collected debris needs to be elevated or transported vertically.

When choosing a conveyor belt for a water trash collector, it's essential to consider factors such as the size and type of debris, the water environment's conditions, durability, and ease of maintenance. Additionally, the selected conveyor belt should be resistant to corrosion and have features that prevent clogging, ensuring efficient and reliable waste collection in aquatic environments. Determining the "best" conveyor belt

for a water trash collector depends on several factors, including the specific requirements of the application, the type and size of debris being collected, and the environmental conditions. Here are considerations for different scenarios:

Ultimately, the "best" conveyor belt depends on the specific requirements and challenges of the water trash collector's environment. It may also be beneficial to consult with conveyor belt manufacturers or specialists who can provide tailored solutions based on the unique needs of the application. Conducting tests and trials in real-world conditions can help determine the most effective conveyor belt for the water trash collector's performance and longevity.

V. RESULT AND DISCUSSION

The implementation of the Smart Water Trash Collector, empowered by NodeMCU technology and fueled by solar panels, has demonstrated promising outcomes in addressing the mounting crisis of debris and floating waste in rivers. This innovative solution introduces a paradigm shift in aquatic debris cleanup, providing a technologically advanced and environmentally sustainable approach. The integration of NodeMCU technology proved instrumental in establishing wireless connectivity between the dedicated mobile application and the trash collector. This seamless communication facilitated precise maneuvering of the collector robot in water, enhancing its efficiency in debris collection across diverse aquatic environments. The success of this wireless interface highlights the system's adaptability and responsiveness to user commands, a critical factor in achieving targeted debris retrieval. The incorporation of solar power as the primary energy source adds a layer of environmental stewardship to the system. This eco-friendly approach not only reduces the ecological footprint of the Smart Water Trash Collector but also ensures extended and energy-efficient operations in varied river conditions. The commitment to sustainability is evident in the strategic use of solar panels, aligning with global efforts to transition towards greener and resilient technological solutions. In-depth exploration of the design and implementation intricacies, with a focus on the crucial role of NodeMCU in achieving efficient motor control, sheds light on the technical aspects of the system. The purpose-designed mobile application acts as a remote-control interface, allowing users to navigate the robot with precision. This emphasis on precision control enhances the targeted debris retrieval capabilities of the system, contributing to its overall effectiveness. Furthermore, the study delves into the potential scalability of the Smart Water Trash Collector for broader environmental applications. The exploration of its integration into comprehensive waste management strategies signifies a commitment to addressing water pollution on a larger scale. The initiative strives to contribute significantly to ongoing efforts, representing a pivotal step towards developing smarter and more adaptable solutions for aquatic debris cleanup. By combining technological innovation with a strong commitment to environmental stewardship, the Smart Water Trash Collector not only signifies a significant technological advancement but also embodies a dedication to sustainable practices in environmental conservation. This holistic and forward-thinking approach positions the initiative as a valuable contribution to the restoration and preservation of cleaner and healthier river ecosystems worldwide.



VI. FUTURE SCOPE

Looking ahead, the future scope of the Smart Water Trash Collector project is rich with possibilities. Continued advancements could involve integrating state-of-the-art sensors, leveraging artificial intelligence for smarter

decision-making, and exploring eco-friendly materials. Collaborations with environmental organizations and research institutions could propel large-scale deployments in areas heavily affected by pollution, amplifying the project's global impact. The success of this initiative has the potential to inspire similar projects, contributing to a broader movement towards innovative solutions for environmental conservation. The adaptability of the Smart Water Trash Collector to various water environments opens doors for applications beyond rivers, extending its usefulness to lakes, ponds, and coastal areas. In summary, ongoing enhancements and adaptations of this project hold the promise of a significant and widespread influence on global environmental conservation, offering a blueprint for sustainable water cleanup solutions.

VII. CONCLUSION

In conclusion, the development and implementation of the Smart Water Trash Collector, leveraging NodeMCU technology and powered by solar panels, mark a groundbreaking stride towards addressing the escalating crisis of debris and floating waste in rivers. This innovative system represents a paradigm shift in aquatic debris cleanup, offering a synergistic blend of technological prowess and environmental sustainability. The successful integration of NodeMCU has facilitated seamless wireless communication between the dedicated mobile application and the trash collector, enhancing its maneuverability and responsiveness in diverse water environments. The emphasis on precision control through the purpose-designed mobile application underscores the system's capability for targeted debris retrieval, a crucial aspect in effective aquatic cleanup. The inclusion of solar power as a primary energy source aligns with principles of environmental stewardship, reducing the system's ecological impact and ensuring prolonged, energy-efficient operations. This commitment to sustainability not only positions the Smart Water Trash Collector as an eco-friendly solution but also contributes to global initiatives promoting cleaner and greener technologies. Moreover, the exploration of scalability for broader environmental applications and integration into comprehensive waste management strategies underscores the initiative's potential for widespread impact. The Smart Water Trash Collector emerges as a valuable asset in the ongoing efforts to mitigate water pollution on a larger scale, representing a pivotal step towards developing smarter and more adaptable solutions for aquatic debris cleanup. By combining technological innovation with a steadfast commitment to environmental conservation, this initiative not only signifies a significant advancement in debris cleanup technology but also embodies a dedication to sustainable practices. The Smart Water Trash Collector stands as a beacon of hope for the restoration and preservation of cleaner and healthier river ecosystems worldwide, reflecting our collective responsibility to safeguard our vital water bodies for current and future generations.