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Autonomous Water Guardian (AWG) for Water Waste Management

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Abstract - *Water pollution, a pressing global issue, threatens the sustainability of aquatic ecosystems and human health. Conventional waste management approaches often struggle to address the magnitude of this challenge effectively. To tackle this problem, we propose an innovative solution: the Autonomous Water Guardian (AWG). Leveraging machine learning (ML) and Internet of Things (IoT) technologies, the Autonomous Water Guardian functions as an autonomous boat cleaner, tasked with navigating water bodies and autonomously collecting waste. The Autonomous Water Guardian integrates a suite of sensors to monitor water quality continuously. These sensors provide real-time data, which is transmitted to a cloud server for analysis and storage. Upon detecting contamination, the AWG initiates a cleaning process to restore water quality. Waste collected during cleaning operations is managed in onboard tanks, and notifications are dispatched when these tanks approach full capacity. Key features of the Autonomous Water Guardian (AWG) include its ability to autonomously collects and manages waste, data transmission to municipal authorities is carried out manually, this facilitates rapid response to significant changes in water quality. By automating waste collection and management, the AWG enhances operational efficiency and safety, mitigating the risks associated with manual labor and hazardous waste handling. This interdisciplinary project underscores the synergy between machine learning (ML), IoT technologies and cloud computing in addressing complex environmental challenges. By providing a sustainable solution to water pollution and waste accumulation, the AWG contributes to the preservation of aquatic ecosystems, public health, and resource conservation*

Key Words: *Water pollution, IoT, Autonomous Water Guardian (AWG), Cloud Computing, Waste Management, Environmental Sustainability, Machine Learning, IOT Technologies, Interdisciplinary Solutions*

1.INTRODUCTION

Water pollution poses a significant threat to the sustainability of aquatic ecosystems and human health worldwide. Despite efforts to mitigate this issue, traditional waste management methods often fall short in addressing the complex challenges associated with water contamination and waste accumulation. To address these challenges, we introduce the Autonomous Water Guardian (AWG), A groundbreaking solution empowered by advanced technologies such as machine learning (ML), Internet of Things (IoT), and cloud computing.

The Autonomous Water Guardian represents a paradigm shift in water waste management, offering a comprehensive and efficient approach to monitoring and cleaning water bodies. At the core of the AWG's functionality are a myriad of sensors, including the HX711 and 5kg load cell for precise weighing of waste collected, DHT11 sensor for humidity monitoring, and a pH sensor for real-time water quality assessment. These sensors work in tandem to provide accurate and timely data on water conditions, enabling proactive intervention to prevent contamination and safeguard water resources.

Central to the AWG's operation is its integration with a cloud platform, leveraging the Blynk IoT platform for seamless data transmission and management. Through the Blynk mobile application, users have access to real-time information on water quality, waste levels, and operational status of the AWG. Furthermore, the AWG's intelligent notification system alerts users when the waste bin reaches full capacity, triggering automated collection processes.

A key innovation of the AWG is its waste collection mechanism, facilitated by an elevator-like structure designed to efficiently retrieve and store waste. Equipped with a camera for object detection, the AWG utilizes the YOLO v7 algorithm to identify and classify waste materials, ensuring targeted and effective cleaning operations. Additionally, GPS technology, integrated through the Neo6M module, enables precise navigation of the AWG, ensuring optimal coverage of designated water bodies

Powered by a Raspberry Pi 4 Model B 4GB, the AWG operates autonomously, following predefined routes and efficiently collecting waste up to 5kg in weight. Through meticulous programming and hardware integration, the AWG embodies the convergence of cutting-edge technologies to address pressing environmental challenges

In this paper, we present a comprehensive overview of the design, implementation, and performance evaluation of the AWG. We highlight its innovative features, including sensor integration, cloud connectivity, waste detection, and autonomous navigation. Furthermore, we discuss the environmental impact and potential applications of the AWG, emphasizing its role in promoting sustainability, preserving aquatic ecosystems, and protecting public health.

2. OBJECTIVE AND OVERVIEW

The primary objective of this research is to develop an innovative solution for efficient water waste management through the implementation of the Autonomous Water Guardian (AWG). Leveraging advanced technologies such as ML, IoT, and cloud computing, the AWG aims to monitor water quality, detect contaminants, and autonomously collect waste in water bodies. By addressing the pressing issue of water pollution, the AWG strives to contribute to environmental sustainability and public health preservation.

Key objectives include:

Integration of sensor technologies, including HX711, DHT11, pH sensor, and GPS, to enable real-time monitoring of water quality and waste levels.

Implementation of ML algorithms, such as YOLO v7, for object detection and classification to facilitate targeted waste collection.

Utilization of cloud computing platforms, specifically Blynk IoT, for data transmission, storage, and remote monitoring of the AWG's operation.

Deployment of the AWG in water bodies to autonomously navigate predefined routes, detect contaminants, and collect waste.

Evaluation of the AWG's performance in terms of efficiency, accuracy, and environmental impact, with the ultimate goal of promoting sustainability and mitigating water pollution.

3. PROBLEM STATEMENT

Rapidly accumulating waste and pollutants threaten aquatic ecosystems and human health. Traditional waste management struggles to keep pace. This project addresses this critical challenge by developing the Autonomous Water Guardian, an innovative solution that leverages technology, automation, and sustainability for water waste management

4. TECHNOLOGY USED IN PROJECT AUTONOMOUS WATER GUARDIAN:

1. TensorFlow: -
   Utilized for object detection tasks, providing tools for building and training deep learning models.

2. OpenCV for Image Processing: -
   OpenCV is employed for image processing tasks, analyzing visual data captured by onboard cameras. It enhances waste detection and classification.

3. YOLO v7 Algorithm for Object Detection: -
   YOLO v7 enables real-time detection and classification of waste materials, facilitating targeted cleaning operations.

4. Node-RED for Sensor Integration and Data Processing: Node-RED facilitates sensor integration, data processing, and workflow automation, enhancing system efficiency

5. Firebase: -
   Employed for data storage and synchronization, offering cloud-based databases and storage solutions.

5. IOT DEVICES USED IN PROJECT AUTONOMOUS WATER GUARDIAN (AWG):

1. HX711 Amplifier and 5kg Load Cell
2. NEO6M GPS Module
3. DHT11 Sensor for Humidity and Temperature Monitoring
4. pH Sensor for Water Quality Monitoring
5. Raspberry Pi 4 Model B

6. IMPLEMENTATION

❖ Implementation of Navigation with NEO6M Module:

The navigation of the Autonomous Water Guardian (AWG) is facilitated by the NEO6M GPS module, which provides accurate location data for route planning and navigation. The implementation involves the following steps:

1. Hardware Setup: The NEO6M GPS module is connected to the Raspberry Pi 4 Model B via serial communication (UART). GPIO pins are used to establish the connection, with appropriate wiring and configurations.

2. Software Configuration: The Raspberry Pi is programmed to communicate with the NEO6M module using UART protocol. Python libraries such as `gpsd` are utilized to retrieve GPS data from the module.

3. Data Processing: GPS data obtained from the NEO6M module is processed to extract relevant information such as latitude, longitude, and altitude. This data is then used to calculate the AWG's position and plan navigation routes.

4. Route Planning: Based on the GPS coordinates obtained from the NEO6M module, route planning algorithms are implemented to determine optimal paths for the AWG to navigate water bodies efficiently.

5. Navigation Control: The Raspberry Pi controls the movement of the AWG based on navigation commands

generated from the route planning algorithms. Actuators such as motors or servos are used to adjust the AWG's direction and speed according to the planned route.

❖ Implementation of Waste Detection with OpenCV and YOLO v7 Algorithm:

The detection of waste materials in water bodies is achieved using OpenCV for image processing and the YOLO v7 algorithm for object detection. The implementation involves the following steps:

1. Image Acquisition: Images of the water surface are captured using onboard cameras mounted on the AWG. These images are then processed using OpenCV to enhance quality and clarity.

2. Object Detection: The YOLO v7 algorithm is applied to the processed images to detect and classify waste materials present in the water. YOLO v7 utilizes convolutional neural networks (CNNs) to identify objects of interest with high accuracy and speed.

3. Classification and Localization: Detected waste materials are classified into predefined categories (e.g., plastic bottles, debris) and localized within the image frame. Bounding boxes are drawn around detected objects to visualize their positions.

Fig 1: Waste that can be carried by te AWG for example Empty Water Bottles

4. Decision Making: Based on the detected waste materials, the AWG determines appropriate actions such as initiating cleaning operations or adjusting navigation routes to avoid obstacles.

❖ Implementation of SR04 Distance Sensor, DHT11 Module, and HX711 Module with Node-RED and Blynk:

The integration of the SR04 distance sensor, DHT11 module, and HX711 module with Node-RED and Blynk enables real-time monitoring and control of environmental parameters and waste collection processes. The implementation involves the following steps:

1. SR04 Distance Sensor: The SR04 distance sensor is connected to the Raspberry Pi's GPIO pins, and NodeRED is configured to read distance measurements.

   These measurements are then transmitted to the Blynk mobile app and web dashboard for visualization and monitoring

Fig 2: Node Connection of SR04 in Node Red

2. DHT11 Module: Similarly, the DHT11 module for humidity and temperature monitoring is integrated into the system. Node-RED flows are configured to read sensor data and transmit it to Blynk for visualization on the mobile app and web dashboard. Users can monitor environmental conditions in real-time and receive notifications if temperature or humidity levels exceed specified limits.

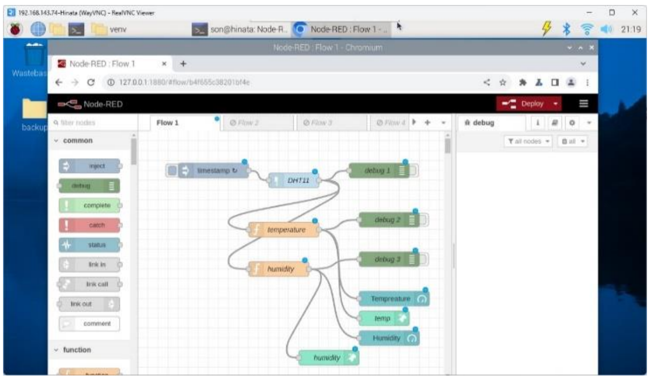

Fig 3: Node Connection of DHT11 in Node Red

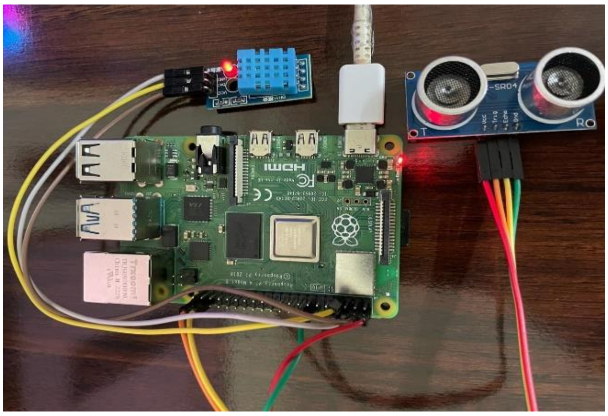

Fig 4: SR04 and DHT11 connection with raspberry pi

3. HX711 Module: The HX711 amplifier and 5kg load cell are connected to the Raspberry Pi for weight measurement. Node-RED is configured to read weight measurements and transmit them to Blynk for visualization and monitoring. Users can track waste bin capacity in real-time and receive notifications when the bin reaches full capacity, prompting them to initiate waste collection processes.

Fig 5: HX711 and weighing module connection with raspberry

By leveraging Blynk's mobile app and web dashboard, users can access real-time data on environmental parameters and waste collection status, facilitating proactive decision-making and ensuring efficient operation of the AWG. Additionally, Blynk's notification feature enhances user engagement by providing timely alerts and updates on system status, contributing to the overall effectiveness and reliability of the AWG implementation.

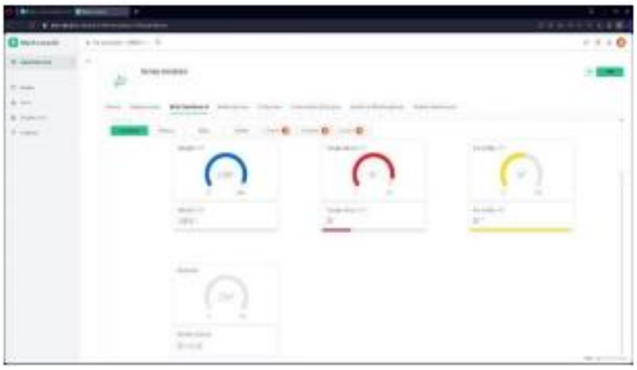

Fig 6: Data visualization Using Blynk 2.0

Brief Information on AWG Model:

The AWG model is designed to autonomously navigate water bodies, detect waste materials, and collect them using onboard actuators. It incorporates advanced technologies such as ML, IoT, and cloud computing to achieve efficient water waste management. The model undergoes iterative testing and refinement to optimize performance and reliability in real-world conditions.

This comprehensive implementation of the AWG encompasses navigation with the NEO6M module, waste detection using OpenCV and YOLO v7, sensor integration with Node-RED and Firebase, and development of a robust AWG model capable of addressing environmental challenges effectively

7. FUTURE SCOPE

1. Autonomous bots can clean large water bodies effectively, reducing manual effort.
2. Multiple bots can work in tandem for large-scale cleaning operations.

8. CONCLUSION

In conclusion, the Autonomous Water Guardian (AWG) presents a groundbreaking solution for efficient water waste management. By leveraging advanced technologies such as ML, IoT, and cloud computing, the AWG demonstrates remarkable capabilities in detecting and collecting waste materials in water bodies. Through the integration of sensors and sophisticated algorithms, the AWG can autonomously navigate water bodies, monitor water quality parameters, and respond proactively to changes in environmental conditions. As a scalable and sustainable solution, the AWG has the potential to address critical environmental challenges and promote public health preservation. Moving forward, further research and development efforts will focus on optimizing the AWG's performance and facilitating its widespread adoption in real-world applications.

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