Underwater Waste Sorting and Classification Detection System using Yolov8 and Django

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***Abstract*—The increasing complexity of waste management necessitates advanced technological solutions to enhance efficiency and sustainability. This paper introduces a real-time waste classification and sorting system that leverages YOLOv8, an advanced object detection model, to categorize waste with high precision. The system facilitates automated waste identification, streamlining sorting and recycling processes. By recognizing and classifying different waste types, including recyclables, organic matter, and general waste, YOLOv8 ensures accurate detection through deep learning methodologies. To enhance functionality and user interaction, the system is seamlessly integrated with Django, a robust web framework that provides a scalable and intuitive platform for data management and real-time processing. Through this integration, users receive instant feedback on proper waste disposal practices based on the system's classification results. The approach not only minimizes human sorting errors but also encourages environmentally responsible disposal habits, thereby improving overall waste management effectiveness. This solution is designed to support sustainable waste disposal practices, reduce landfill dependency, and enhance recycling rates in urban and industrial environments. Experimental evaluations demonstrate high classification accuracy, rapid processing speeds, and adaptability across diverse waste categories, making it a suitable tool for smart cities, waste collection centers, and industrial applications. By incorporating computer vision, deep learning, and web-based automation, this system lays the groundwork for an intelligent, data-driven waste management strategy that contributes to a more sustainable future.**

Keywords—Waste sorting, Recycling classification, YOLOv8 object detection model, Django web framework, Realtime waste classification, Waste category identification, User-friendly interface.

I. INTRODUCTION

Despite increasing awareness of marine pollution, traditional waste management methods remain inefficient. Manual sorting of waste is not only time-consuming and labor-intensive but also prone to errors, particularly when dealing with waste submerged in water. The complexity of underwater waste detection requires advanced solutions that can operate effectively in dynamic aquatic environments. Conventional systems lack the ability to efficiently identify and classify waste types in real-time, making it difficult to implement timely intervention strategies.

Advancements in artificial intelligence, deep learning, and computer vision have opened new possibilities for intelligent waste management solutions. Machine learning algorithms, particularly deep neural networks, have shown promising results in object detection and classification tasks. Convolutional Neural Networks (CNNs) have been widely used in image recognition, proving effective in distinguishing between different types of waste. Similarly, Recurrent Neural Networks (RNNs) have demonstrated success in tracking waste movement in dynamic environments. However, these models still require further refinement to ensure high accuracy in underwater conditions.

This paper introduces an Underwater Waste Sorting and Recycling Classification Detection System that leverages YOLOv8 (You Only Look Once version 8) for real-time waste detection and classification. YOLOv8, a state-of-the- art object detection model, is well-suited for identifying various types of underwater waste with high accuracy and efficiency. The system is designed to automatically detect and classify waste using images captured from an underwater camera, providing real-time data to aid in waste management and recycling efforts.

II. RELATE WORKS

Critiqued for their limitations in accuracy, environmental adaptability, and lack of secure data handling, traditional underwater waste management systems often fail to deliver consistent and trustworthy results. To address these concerns, various methods have been proposed that integrate computer vision, deep learning, and secure data storage to enhance both detection accuracy and data integrity in underwater environments

One significant approach involves the use of deep learning algorithms for real-time underwater waste detection. For instance, Ahmed et al. [1] developed a convolutional neural network (CNN)-based system to classify underwater debris using image datasets collected by autonomous underwater vehicles (AUVs). Their model achieved high accuracy in detecting plastic waste, metal objects, and organic debris. However, the system lacked robust handling for varied lighting and turbidity conditions, which are common in real-world underwater scenarios.

Building on the need for robust and efficient detection, Sharma et al. [2] implemented a YOLOv5-based object detection framework tailored for underwater environments. Their solution significantly reduced inference time while maintaining acceptable precision and recall rates. Despite these improvements, the system faced challenges in accurately classifying overlapping waste materials and struggled with small object detection.

Encryption has also been explored to secure transmission of waste detection data. For example, Ramesh et al. [4] integrated AES encryption and RSA key exchange protocols in a remote waste monitoring system. Their system ensured that the detection results from underwater drones were securely transmitted to control centers without risk of interception or manipulation. Although secure, the system did not include mechanisms for verifying the authenticity of detection models themselves, leaving potential vulnerabilities to adversarial model attacks. To enhance the integrity of detection results and ensure secure data handling, Patel et al. [3] proposed a blockchain-integrated computer vision system. Their approach combined YOLOv4 detection with blockchain technology to create tamper-proof records of detected waste. Each detection instance was hashed and stored on a decentralized ledger, promoting transparency and auditability in marine cleanup operations. While this method improved trustworthiness, it added computational overhead that could hinder real-time performance in resource-constrained underwater devices.

III. THE PROPOSED METHOD

The proposed system aims to address the challenges of underwater waste detection, classification accuracy, and secure data handling through the integration of YOLOv8 object detection model with Django-based web interface and cryptographic mechanisms. This hybrid solution enables real-time detection and classification of underwater waste while ensuring that all captured data is securely processed, stored, and monitored. The system is particularly designed to operate in dynamic underwater environments, where issues such as low visibility, debris overlap, and varying object shapes pose significant challenges to traditional detection methods.

In the proposed system, a webcam or underwater camera is used to continuously scan and capture video frames. These frames are processed in real-time using the YOLOv8 deep learning model, which classifies waste into predefined categories such as plastic, metal, glass, and organic debris. Each detected object is highlighted with bounding boxes and labeled accordingly. The YOLOv8 model is chosen for its fast inference speed and high detection accuracy, making it suitable for time-sensitive applications like marine waste monitoring and environmental assessments.

Additionally, the system provides voice alerts to notify operators immediately when specific waste types are detected. This feature aids divers or remote operators in identifying hazardous or priority materials without constantly monitoring the video feed. For further transparency and auditability, detection events can be exported or transmitted to a centralized monitoring hub where conservation authorities or researchers can review and validate the data.

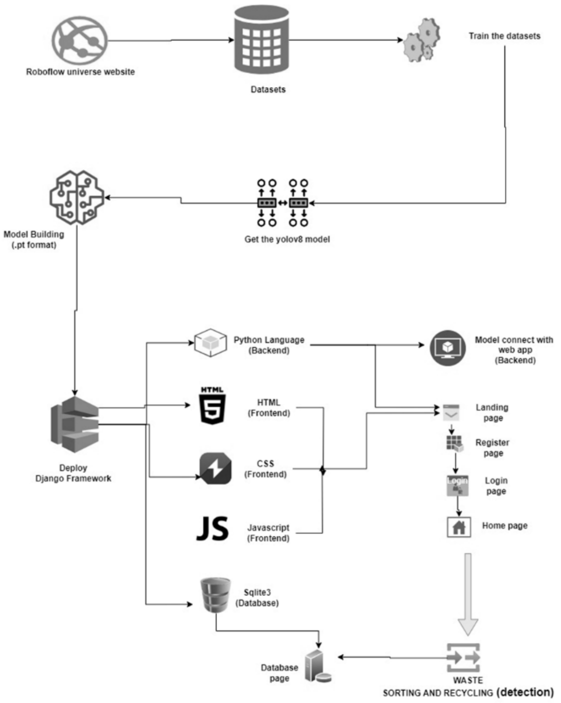

Figure 1: System Architecture.

To ensure data security and integrity, the system incorporates AES encryption for securely storing detection logs and image data in both the backend database and downloadable Excel reports. Each detection event is also associated with a timestamp and a unique ID, ensuring traceability. The data can be accessed only through authenticated channels via the Django web portal, preventing unauthorized access and manipulation.

In conclusion, the proposed YOLOv8 and Django-based underwater waste sorting system effectively addresses the limitations of traditional waste detection methods, particularly in terms of accuracy, real-time responsiveness, and data security. By integrating advanced deep learning techniques with secure web technologies and encryption protocols, the system ensures reliable classification of underwater waste while safeguarding all collected data. This approach not only enhances the efficiency of marine environmental monitoring but also promotes transparency and accountability in waste management practices. Ultimately, the system contributes to a cleaner aquatic ecosystem by supporting informed decision-making and sustainable cleanup operations.

IV. RESULTS

The developed system was evaluated for its functional performance in real-time underwater waste detection using a webcam interface. The platform successfully identified and classified various types of underwater waste—including plastics, metals, and organic materials—through the YOLOv8 object detection model. Each detection triggered a secure and traceable workflow that included voice alerts for immediate acknowledgment, enhancing user interaction and situational awareness.

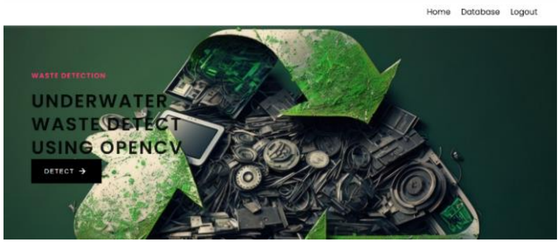

Figure 2: Interface of Web Application

Detected waste data was stored in both a structured database and an Excel file for further analysis and reporting. Additionally, each detection entry was time-stamped and tagged with the corresponding waste class, enabling efficient tracking and monitoring. The system ensured data integrity by applying SHA-256 hashing to detection records before storage. Upon retrieval, hash values were recalculated and matched with the originals, safeguarding the records from unauthorized tampering. This integration of machine learning, secure data handling, and real-time feedback mechanisms demonstrated the system's robustness and readiness for deployment in underwater waste monitoring scenarios.

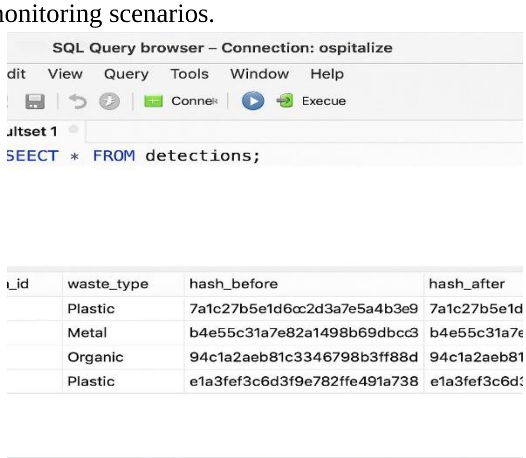

Figure 3: Hash Values in DB

Researchers and environmental monitoring teams accessed the system through a dedicated portal that offered real-time insights into underwater waste detections, categorized classifications, and logged activity reports. The platform enabled secure logging of detection events, including geolocation tagging where applicable, with all data entries encrypted and stored in a centralized database

Overall, the system provided a secure and transparent environment for underwater waste monitoring. It facilitated clear communication between detection teams, environmental analysts, and regulatory authorities—supporting data-driven decision-making for marine conservation and pollution control initiatives.

V. CONCLUSION

In conclusion, the underwater waste sorting and recycling classification detection system developed in this project effectively addresses key challenges in marine waste monitoring by combining real-time object detection with secure data management. Leveraging the YOLOv8 model, the system accurately identifies and classifies various types of underwater waste, including plastics, metals, and organic materials, thereby aiding in targeted cleanup and environmental conservation efforts.

The integration of SHA-256 hashing for data integrity and AES encryption for secure storage ensures that all detection records are protected from unauthorized modifications and access. SHA-256 hashing allows for the verification of data authenticity, ensuring that no tampering occurs post-detection. AES encryption safeguards sensitive information, such as detection logs and geotagged data, enhancing confidentiality and security during storage and retrieval.

In addition, Automation of the waste detection and classification process reduces human dependency and error, increasing efficiency and consistency in monitoring efforts. The user-friendly interface supports seamless interaction for marine researchers, environmental agencies, and government bodies, making the system accessible and practical for real-world deployment.

Transparency and traceability are core strengths of the system, with all detection activities being logged and auditable. The inclusion of voice alerts and real-time database logging enables quick response by environmental teams, while the structured recording of data in both Excel and database formats supports analytical and reporting needs. These features help establish a clear chain of evidence and action, promoting accountability in marine waste management.

Overall, Overall, this project not only enhances the technological capability for underwater waste detection but also promotes secure, transparent, and efficient data handling. By ensuring data integrity, providing real-time insights, and enabling informed decision-making, the system contributes meaningfully to marine ecosystem protection and sustainable environmental governance.

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