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Underwater Garbage Detection Using YOLOv8 Model

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Abstract: Effective machine-learning algorithms are vital for the successful navigation of underwater environments and the intelligent recognition of objects in murky waters. The advancement of modern society has led to increased pollution in marine ecosystems, particularly in oceans, rivers, and lakes, which threatens our precious water resources. Despite existing environmental regulations, solid waste, including refuse and debris, continues to be directly dumped into the ocean, negatively affecting the survival and health of marine life. Consequently, it is imperative to employ suitable methods for the precise detection and analysis of features in these specific environments. In this study, we have utilized the YoloV8 algorithm for underwater waste detection, utilizing a dataset comprising 5096 images from various categories. These categories encompass items such as masks, metal cans, glass bottles, gloves, plastic bags, and tires, captured across a range of distinct underwater settings. This research also tackles the escalating problem of underwater waste in oceans and seas by identifying debris in underwater imagery.

Keywords: Object Detection, Deep Learning, Waste Detection, YOLOv8, Underwater Image, Marine Plastic Waste Detection.

I. INTRODUCTION

The health of marine and freshwater ecosystems faces escalating threats due to the increasing accumulation of waste materials beneath the water's surface. As human activities in coastal and aquatic regions continue to grow— driven by tourism, fishing, transportation, and industrial development—the generation of waste also rises, much of which contributes to the pollution of our oceans, rivers, and lakes. Debris such as plastics, cans, bottles, and fishing nets not only tarnish the natural beauty of aquatic environments but also pose significant risks to aquatic life and disrupt the ecological balance.

Manual methods for detecting and cleaning underwater waste have traditionally been the primary approach to combat pollution. However, these methods are often labor- intensive, time-consuming, costly, and limited in their effectiveness. Challenges such as poor visibility, fluctuating light conditions, and the vastness of underwater areas render manual monitoring inadequate for continuous or large-scale surveillance. These issues highlight the urgent need for a more efficient, automated, and scalable solution.

Recent advancements in artificial intelligence, particularly in deep learning and computer vision, have created new opportunities for automating environmental monitoring. Object detection algorithms, such as the YOLO (You Only Look Once) series, have demonstrated remarkable effectiveness in real-time visual recognition tasks across various fields, including autonomous driving and medical imaging.

The latest version, YOLOv8, provides enhanced accuracy, quicker inference, and optimized performance, making it an ideal candidate for underwater applications. By leveraging the capabilities of YOLOv8, this research aims to develop a robust and real-time underwater waste detection system that can assist in monitoring and preserving aquatic ecosystems with improved efficiency and accuracy.

This research explores the application of YOLOv8 for detecting underwater waste in real time. By training the model on a dataset comprising underwater images of various waste objects, the system learns to identify and localize debris with high accuracy.

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1.1 OVERVIEW
This study presents an underwater waste detection system using the YOLOv8 deep learning model, known for its real-time object detection capabilities. The system processes images or video from underwater drones to identify and locate waste such as bottles, bags, and cans. A custom dataset of annotated underwater images is used for model training. The paper outlines the system architecture, training process, evaluation metrics, and experimental results, demonstrating YOLOv8's effectiveness in underwater monitoring.

1.2 PROBLEM STATEMENT
Underwater waste pollution is a growing environmental issue that affects marine biodiversity, water quality, and ecosystems. Existing monitoring methods are limited in automation, scalability, and real-time analysis, hindering effective waste detection. The lack of an efficient, automated system delays the identification and removal of pollutants, leading to prolonged ecological harm. These challenges highlight the need for a reliable and rapid detection solution. A precise, scalable system is crucial for effective underwater monitoring and environmental protection.

1.3. OBJECTIVE
This research aims to develop an automated underwater waste detection system using the YOLOv8 deep learning model. The system will accurately identify and locate underwater debris such as plastics, bottles, bags, and cans from images or video frames captured by underwater drones or submersible cameras. By utilizing a custom annotated dataset, the study seeks to train the model for real-time detection to facilitate rapid identification and removal of pollutants.

1.4. SCOPE
This research aims to create an automated underwater waste detection system using the YOLOv8 deep learning model. It involves building a specialized dataset of annotated underwater images to train the model for real-time detection of waste like plastics, bottles, and bags. The study will test the system's effectiveness in real underwater environments with drone and submersible camera footage. Additionally, it will explore the system's scalability and potential for use in large-scale environmental monitoring and waste management efforts.

II. EXISTING SYSTEM

Underwater waste detection methods range from manual inspections to advanced AI techniques. Manual methods using divers or ROVs are labor-intensive and unsuitable for large-scale monitoring. Traditional image processing with tools like OpenCV struggles with lighting and complex underwater scenes. Classical machine learning models rely heavily on handcrafted features. Deep learning approaches using CNNs and models like YOLOv4/v5 and Faster R-CNN offer accurate, real-time detection but require large labeled datasets and high computational resources.

III. PROPOSED SYSTEM

The proposed underwater waste detection system leverages YOLOv8 for real-time identification of debris such as plastic bottles, bags, nets, and cans, even under low visibility, turbidity, or cluttered backgrounds. Its optimized architecture ensures high speed and accuracy while remaining computationally efficient. The system runs effectively on standard hardware, including Jetson Nano or Raspberry Pi with accelerators, making it affordable and accessible for small organizations and NGOs. The system merges efficiency, affordability, and adaptability for impactful marine waste detection.

DATASETS
The dataset for underwater garbage detection with YOLOv8 consists of annotated images or video frames featuring debris like plastic bottles, bags, cans, and fishing nets. These images are captured from underwater cameras, ROVs, or drones in real aquatic environments such as rivers, lakes, and oceans. The dataset includes diverse object categories and environmental conditions like low light, turbidity, and varied backgrounds to enhance model robustness.

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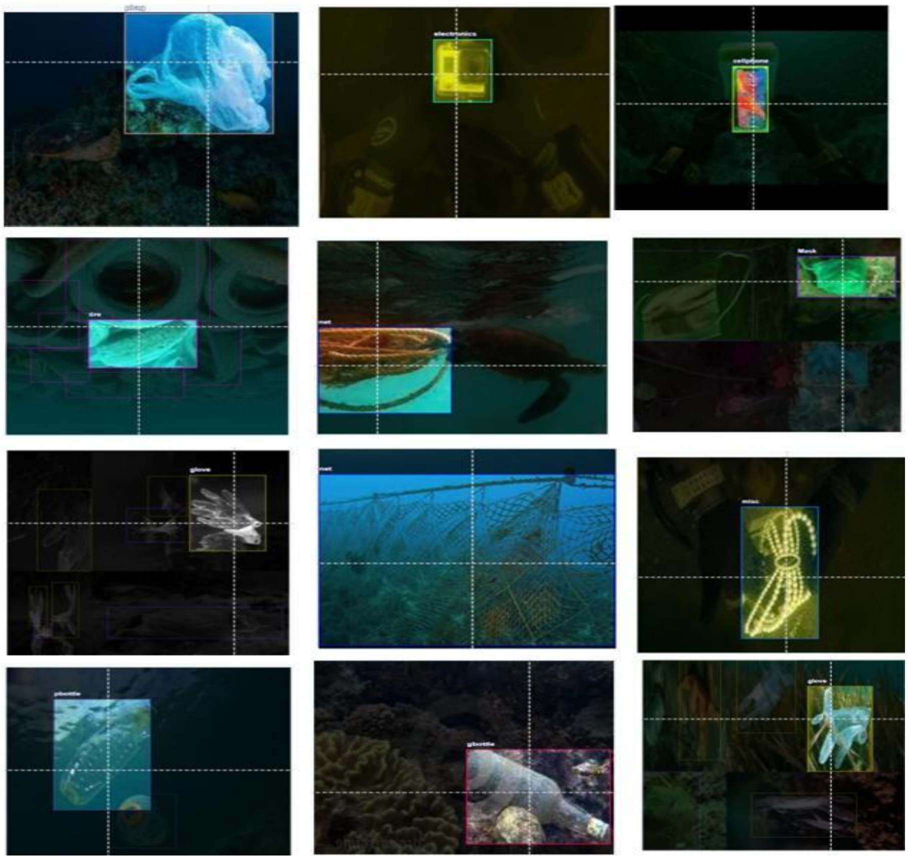

Fig -1: Types of Wastes

IV. METHODOLOGY

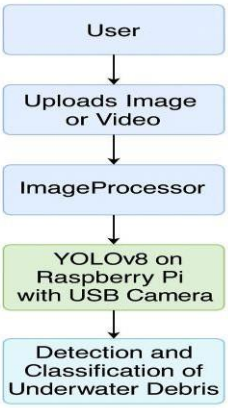

Fig -2: Flowchart of Personality Prediction

1.3 DATA COLLECTION

This phase involves collecting a diverse dataset of underwater images or video frames containing debris like plastic bottles, fishing nets, bags, and cans. The visuals are captured using underwater cameras, drones, or ROVs in natural aquatic environments such as rivers, lakes, and oceans. The dataset includes various conditions like low light, turbidity, and different backgrounds. This ensures the model performs effectively under real-world underwater scenarios.

1.4 DATA PREPROCESSING

n this phase, the collected images are preprocessed by resizing to the required input dimensions, normalizing pixel values, and applying image augmentation techniques like rotation, flipping, and contrast adjustment. Denoising and visibility

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enhancement are also performed to improve image quality in unclear waters. These steps help prepare the images for model training. This process addresses challenges like turbidity and poor lighting conditions.

1.5 FEATURE EXTRACTION

Feature extraction is essential in object detection, converting raw images into meaningful representations by highlighting distinct object features. Traditional methods used hand- crafted techniques like HOG or SIFT to extract edges, shapes, and textures. Modern deep learning models like YOLOv8 automate this process using CNNs that learn hierarchical features from simple to complex. This enables accurate and robust detection of underwater debris in varying environmental conditions.

1.6 MODEL SELECTION

For underwater garbage detection, YOLOv8 (You Only Look Once version 8) is selected due to its advanced real-time object detection capabilities. Unlike traditional or earlier deep learning models, YOLOv8 offers a strong balance between speed and accuracy, making it highly effective for identifying multiple types of debris in a single pass.

1.7 MODEL TRAINING

the YOLOv8 architecture is trained using a labeled dataset containing annotated underwater images of various debris types, such as plastic bottles, cans, and fishing nets. During this process, the model learns to associate visual features with object classes by optimizing its internal parameters through backpropagation and a defined loss function. The training is conducted over multiple epochs, with validation used to monitor generalization and prevent overfitting. This enables the model to achieve accurate and robust real-time detection of underwater debris in diverse and challenging environments.

1.8 MODEL EVALUTION

Evaluation assesses a trained model's performance using metrics like precision, recall, F1-score, mean average precision (mAP), and Intersection over Union (IoU). These metrics measure the accuracy of predictions, the ability to detect relevant objects, and the spatial correctness of bounding boxes. Evaluation on a test dataset helps determine the model's effectiveness. This process also highlights areas for further optimization.

1.9 ACTIVITY DIAGRAM

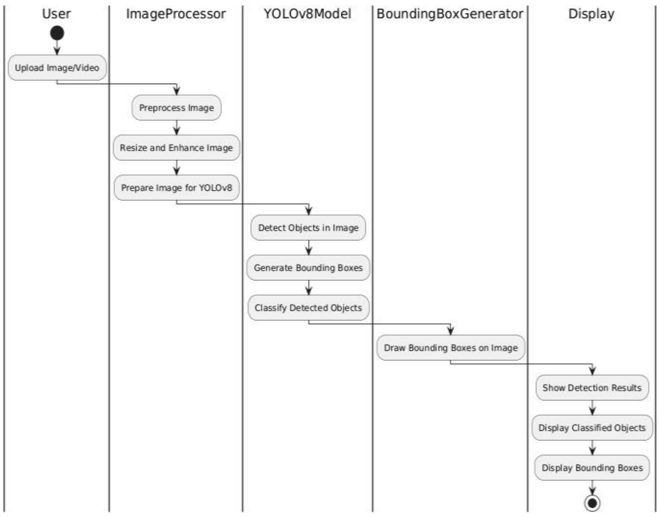

Fig -3: Activity Diagram

The process starts with the user uploading an image or video, which is then passed to the Image Processor. The Image Processor performs tasks such as preprocessing, resizing, and enhancing the image to make it suitable for analysis by the YOLOv8 model.

The YOLOv8 model detects objects in the image, generates bounding boxes around the identified debris, and classifies the objects (e.g., plastic bottles, cans). The Bounding Box Generator takes these bounding box coordinates and draws them on the image.

Finally, the Display component presents the detection results by showing the classified objects and the drawn bounding boxes to the user. This flow ensures that each part of the system functions sequentially to detect and classify underwater

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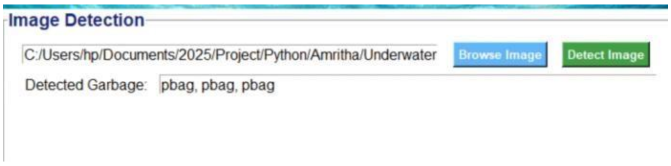
debris. This seamless integration of components ensures accurate detection and classification, providing valuable insights into the underwater environment.

V. RESULT

Fig-4 A sample waste image to predict type of waste



VI. CONCLUSION

This project developed an underwater garbage detection system using YOLOv8 on a Raspberry Pi with a USB camera, aimed at real-time detection and classification of underwater waste. It demonstrated the feasibility of deploying lightweight, deep learning models on resource-constrained devices, achieving good accuracy for common garbage types in clear water. The system performed well in real-time, suitable for monitoring in shallow, moderately clean water. Challenges included reduced accuracy in turbid waters and hardware limitations. Despite these, the project highlights the potential of affordable AI solutions for marine pollution monitoring and opens avenues for future advancements.

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