CS307/367 Artificial Intelligence : Agent Project Report

Kunj Thakkar
Computer Science and Engineering
Email: 202251142@iiitvadodara.ac.in

Nyasha Vasoya
Computer Science and Engineering
Email: 202251155@iiitvadodara.ac.in

Vaibhav Kumar Jonwal
Computer Science and Engineering
Email: 202251150@iiitvadodara.ac.in

Azim Khorajiyay
Computer Science and Engineering
Email: 202251169@iiitvadodara.ac.in

***Abstract*—In the quest for cleaner oceans, the integration of AI in autonomous vehicles has emerged as a game-changer for marine patrolling. This study focuses on the YOLOv11 model for underwater waste detection, aiming to enhance the efficiency and accuracy of marine monitoring systems. By leveraging advanced deep learning techniques, we explore how these state-of-the-art models can revolutionize the identification and classification of underwater debris, contributing to sustainable marine practices. Our findings will not only highlight the strengths and weaknesses of each model but also pave the way for future innovations in autonomous marine vehicles, ensuring a cleaner and safer ocean environment for all.**

I. Literature Review

A. Introduction

The integration of autonomous systems in maritime environments has gained significant attention for tasks such as underwater waste detection. By leveraging advanced AI and robotic technologies, Autonomous Underwater Vehicles (AUVs) and Unmanned Underwater Vehicles (UUVs) enhance the efficiency and scope of maritime operations. This literature review explores the role of AI in addressing environmental challenges, focusing on key advancements, navigation challenges, and future directions.

B. Enhanced Surveillance with AI

Maritime authorities face significant resource gaps in monitoring vast oceanic regions. Studies emphasize the deployment of AUVs and UUVs to address these limitations [1]. The COMPASS2020 project demonstrates how integrating these systems into maritime safety and security operations enhances surveillance capabilities and waste detection [1]. AI-driven AUVs improve situational awareness, enabling authorities to detect waste and respond to environmental threats effectively.

C. Technological Developments

The evolution of deep learning, particularly Convolutional Neural Networks (CNNs), has revolutionized underwater object recognition [**?**]. Model such as YOLOv11 offer real-time processing capabilities, crucial for immediate identification of underwater waste. Additionally, sensors like Synthetic Aperture Sonar (SAS) and Multi-Beam Echo Sounder (MBES) enhance mapping and detection accuracy. [2]

D. Simulation and Real-World Applications

Simulation systems play a crucial role in the development and testing of navigation and obstacle avoidance algorithms. These systems provide a controlled environment for evaluating UUV performance. Real-world applications, such as monitoring pollution incidents and addressing illegal activities, further showcase the potential of AI-enhanced maritime operations. [3]

II. Methodology

This project focuses on detecting underwater waste using the YOLOv11 model, a state-of-the-art detection framework. Below is the detailed methodology involved in preparing, training, and evaluating model.

A. Setting up the environment

To streamline the training processes, we utilized Google Colab, which offers cloud-based GPU support, key libraries include *Ultralytics* and *roboflow* for YOLO and dataset management were used. Using these tools data handling was simplified.

B. Dataset Prepration

The dataset employed here was taken from *Roboflow*, which included annotated images of underwater waste. The dataset was crucial for training the model to detect and classify waste accurately.*Roboflow API* was used to import the dataset directly into *Colab* environment, ensuring efficient integration.

1) Dataset Insights:

- Detected frequent items like tires and bags reliably but struggled with smaller objects like sunglasses.
- Balanced data distribution aided overall performance, though underrepresented classes posed challenges.

C. Model selection and training

Here in this project YOLOv11n was trained. A compact and powerful version of YOLOv11 architecture, designed for high performance with minimal computational overhead which is great for onboard computations for *UUV*. Training involved initializing with pre-trained weights, configuring the dataset, and fine-tuning the hyper-parameters like learning rate and batch size.

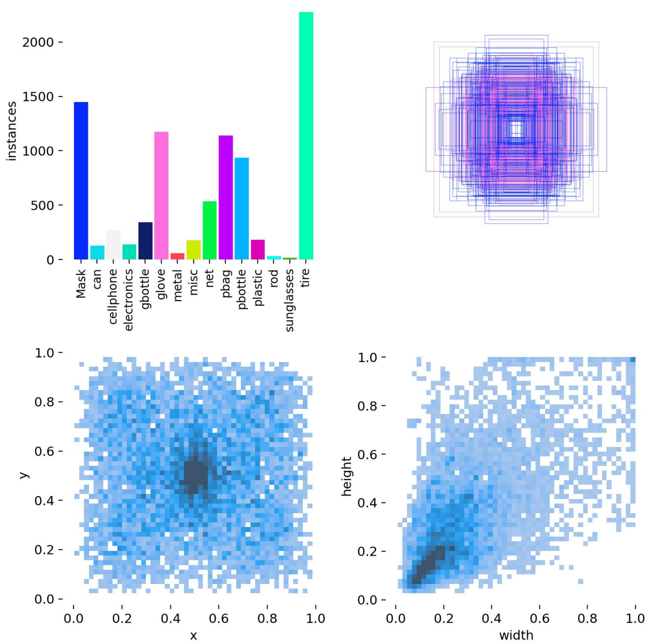

Fig. 1. Labels after training

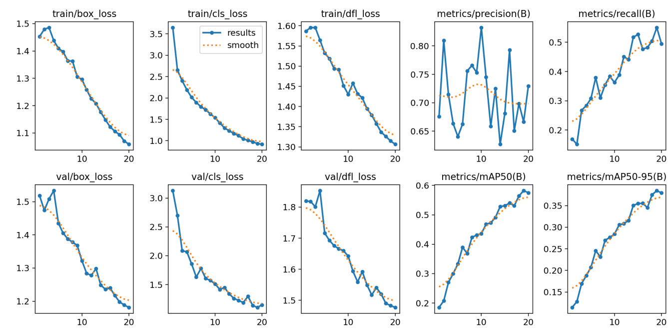

Fig. 2. Training Results

B. Model Performance

- Achieved 80% mAP@0.5 and 35% mAP@0.5-0.95, ensuring reliable detection across IoU thresholds.

C. Visual Observations

- Accurate detection of objects like bags and bottles, even in cluttered or low-visibility conditions.
- Challenges included overlapping objects and partial obstructions, but the model adapted well.

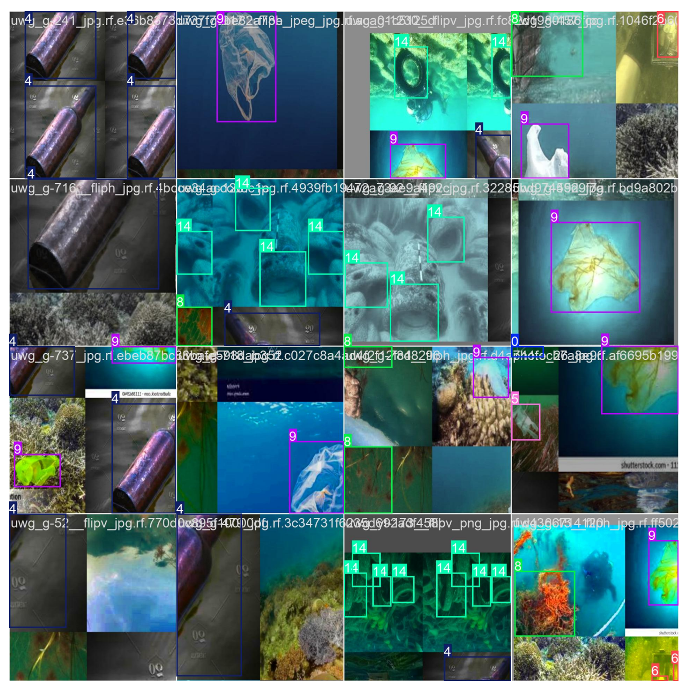

Fig. 3. batch0 after training

D. Evaluation and Inference

Both models were evaluated on validation data using metrics such as precision, recall, and mean Average Precision (mAP). Once validated, their trained weights were employed for inference, enabling accurate detection of underwater waste in new images.

III. Results

This project used the YOLOv11 model to detect underwater waste with the Neural Ocean dataset. Key findings include:

A. Training Metrics

- Losses for box, class, and DFL consistently decreased, improving object localization, classification, and bounding box precision.
- Validation metrics matched training trends, showing strong generalization.

D. Confusion Matrix

- The confusion matrix revealed strong performance for well-represented classes like tires and plastic-bags, with high true positive rates.
- Lower performance was observed for underrepresented classes, such as metal, can and sunglasses, indicating room for improvement in training data diversity.

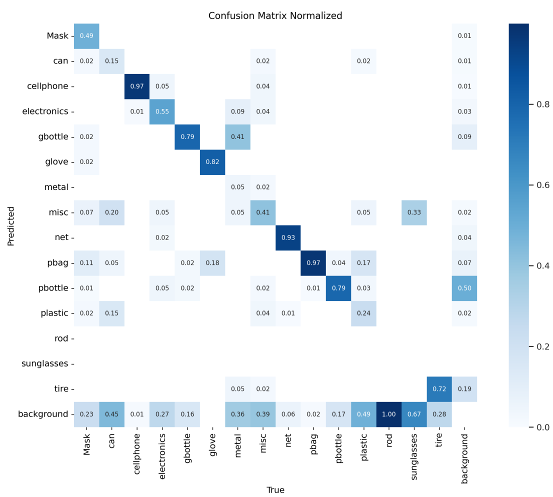

Fig. 4. Enter Caption

IV. Conclusion

YOLOv11 proved effective for underwater waste detection, demonstrating the potential of AI in addressing environmental challenges in complex ecosystems.

V. Future Work

This project remains a work in progress. Future work includes developing a simulation environment to integrate this detection model into autonomous underwater vehicles (UUVs) for seaway patrolling. By simulating real-world conditions, we aim to enhance the model's adaptability and reliability. This step aligns with the overarching goal of deploying UUVs for efficient and autonomous underwater waste management, contributing to cleaner and safer marine ecosystems.

References

[1] Towards Augmenting Maritime Surveillance Capabilities via Deployments of Unmanned Aircrafts and Autonomous Underwater Vehicles
[2] Towards Augmenting Maritime Surveillance Capabilities via Deployments of Unmanned Aircrafts and Autonomous Underwater Vehicles
[3] Autonomous Navigation and Obstacle Avoidance for Small VTOL UAV in Unknown Environments
[4] GitHub repository containing trained model