Micro-Plastic Detection in Marine Bodies (YOLOv5)

Mini Project Presentation

Salman Faris N (80522018)

M.Sc. (Five Year Integrated) in
Computer Science (Artificial Intelligence & Data Science)

29 April 2025

COCHIN UNIVERSITY OF
SCIENCE AND TECHNOLOGY

Agenda

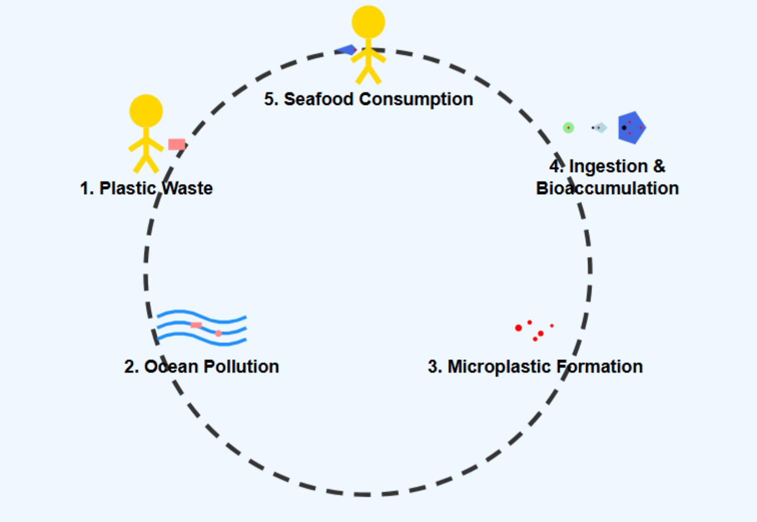
Introduction

This project focuses on detecting microplastics—tiny plastic particles harmful to marine life—using the YOLOv5 object detection model.

Motivation

- The small size of microplastic allows them to be easily ingested by marine organisms, leading to bioaccumulation and posing serious risks to the marine food web and, ultimately, human health.
- Traditional methods rely on manual analysis using microscopes, which is time consuming, labor-intensive, and often inconsistent.
- we strive to develop a scalable and efficient detection system.
- This approach not only reduces manual effort but also enhances accuracy and speed, providing a valuable tool for researchers and environmental monitoring agencies working to combat plastic pollution.

Motivation


5. Seafood Consumption
1. Plastic Waste
4. Ingestion &
Bioaccumulation
2. Ocean Pollution
3. Microplastic Formation

Literature Review

AUTHOR	MODEL	ACCURACY	DATASET
Xiongfei Meng	PCA + RF	99.7%	Pure and mixed microplastics samples
Sun Lanjun	PCA + SVM, PCA + KNN	100% classification	Fluorescence spectral data
Jinhui Liu	Electrochemical Sensors	Not specified	Private Data
Pensiri Akkajit	YOLOv8x	99.0% precision	Augmented dataset
Kalpana Patidar	Comparative assessment	Not specified	Water, sediments
Kai Zhao	YOLOv5 + DeepSORT	97% (lab), 96% (field)	Real-time images(Private Data)
MAB Sarker	YOLOv5 + DeepSORT	Not specified	In-situ images annotated for training

Outcome Of The Survey

- Principal Component Analysis (PCA) with classifiers like Random Forest (RF), SVM, and KNN on spectral datasets results in high accuracy.
- YOLO-based object detection models (YOLOv5, YOLOv8x) along with the DeepSORT algorithm are used for real-time tracking.
- Some studies used private or specialized datasets, highlighting a limitation in dataset availability and a barrier to open reproducibility.

Problem Statement

Develop a Microplastic Detection System using Deep Learning-based Image Analysis

Objectives

- Develop a robust and efficient deep learning-based object detection system for the automatic identification of microplastics in marine environments
- The perfomance of the model was assessed using a range of evaluation metrics.

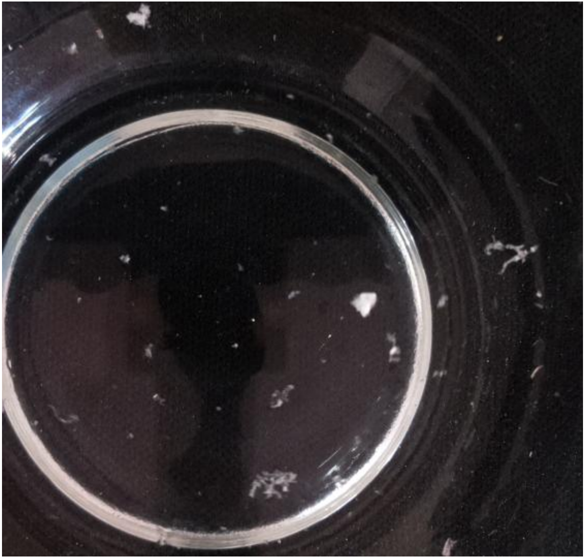
Scope

- The scope encompasses the end-to-end pipeline—from dataset preparation and labeling to model training, evaluation, and refinement.
- It includes working with both lightweight (YOLOv5s) and mid-sized (YOLOv5m)
- The scope is limited to image-based detection of microplastics and does not extend to classification of plastic types, chemical analysis, or detection in other mediums such as sediments or organisms.

Dataset

- The dataset used for this project was downloaded from Kaggle, a popular platform for machine learning datasets and competitions.
- It consists of high-resolution images containing microplastic particles captured under controlled laboratory conditions.
- Each image typically shows a black background (such as a Petri dish or container) with small, scattered white or translucent particles, which represent microplastics.
- The microplastics in the images vary in shape, size, and texture, mimicking real-world contamination samples from marine or freshwater environments.

Dataset



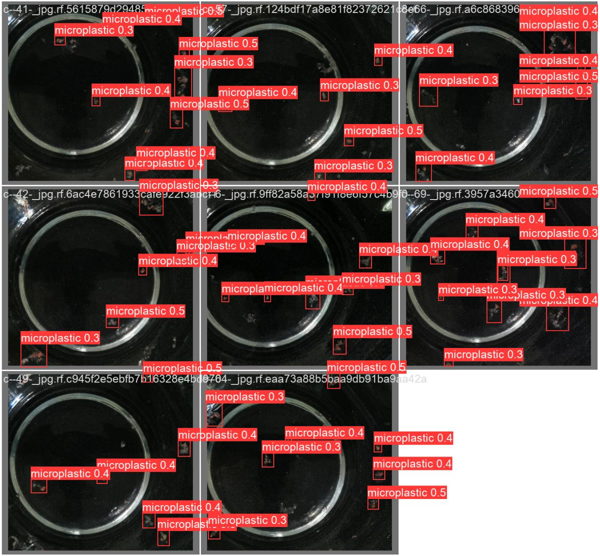
Dataset Structure

- Initially:
  - Raw images in ‘.jpg‘/‘.png‘ format.
  - Annotations provided through a CSV file (bounding boxes and labels).
- Conversion to YOLO format:
  - Created ‘.txt‘ annotation files corresponding to each image.
- Final structure:
  - `images/` folder with raw images.
  - `labels/` folder with YOLO annotations.
  - Split into `train/` and `val/` sets, preserving class distribution.

Pre-processing and Augmentation

- Images were resized to 416$\times$416 pixels for model training to standardize the input size.
- Data augmentation techniques such as Mosaic, flipping, scaling, and color jittering were applied to improve model robustness
- These techniques helped to increase the diversity of the training samples.

Pre-processing and Augmentation



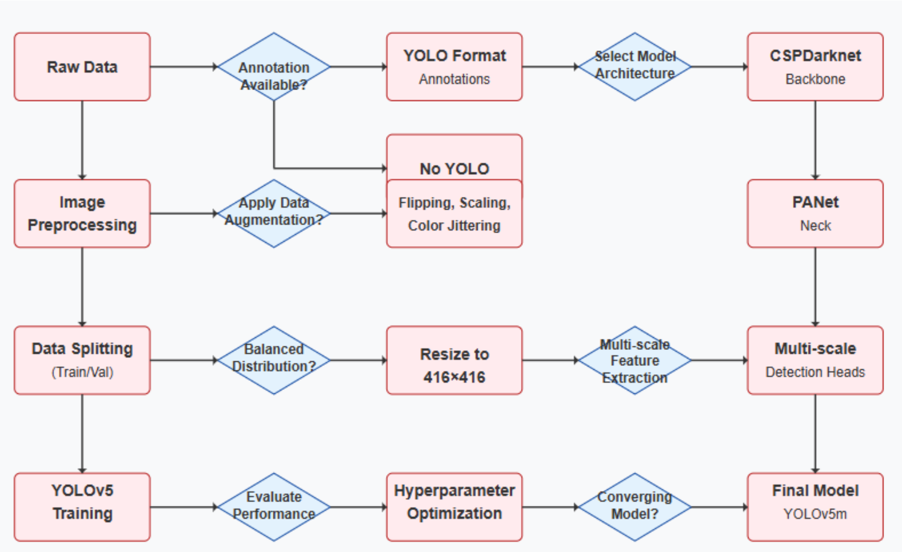
Methodology

- Selected YOLOv5 for object detection due to its speed, accuracy, and lightweight architecture.
- Trained the YOLOv5s model on the prepared dataset.
- Used data augmentation techniques (such as mosaic, flipping, scaling, color jittering) to improve model generalization.
- Monitored loss curves and metrics like mAP (mean Average Precision) during training.

Methodology

- Evaluated model performance on the validation set.
- Fine-tuned hyperparameters such as learning rate, batch size, and number of epochs for optimal results.
- Later migrated to YOLOv5m to achieve better accuracy and improved detection perfomance.
- The model can be used for inference with images of different sizes (like 640×640) even if trained on 416×416.

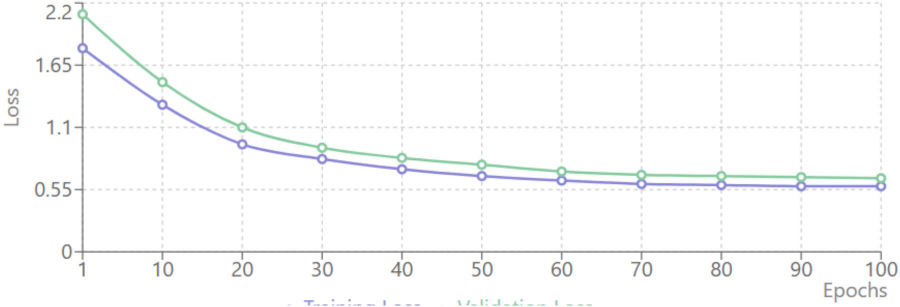
Architecture Diagram



Model Performance

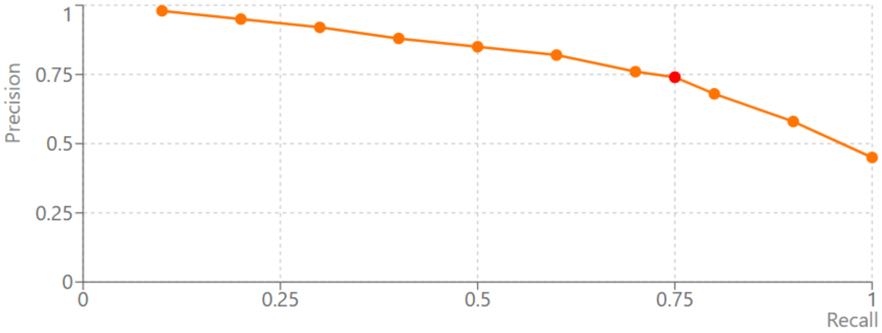
Metric	YOLOv5s	Hyper-Tuned	YOLOv5m
Recall	0.62	0.67	0.75
Precision	0.67	0.62	0.74
mAP@0.5	0.59	0.59	0.62
mAP@0.5:0.95	0.22	0.22	0.48
Training Loss	0.58	0.49	0.28
Validation Loss	0.65	0.51	0.35

Visualizations



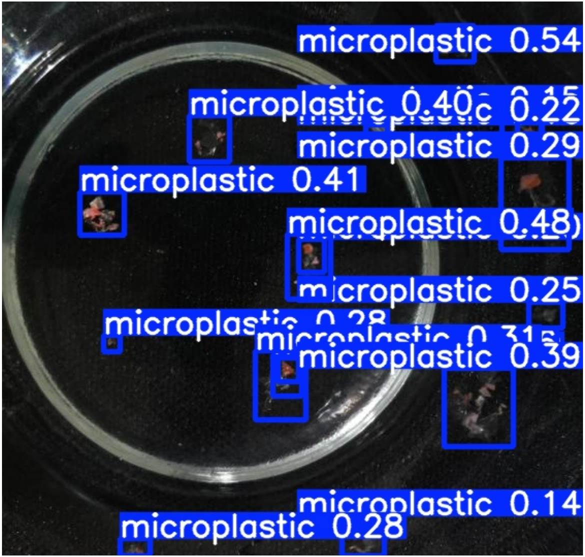
Training Vs Validation Loss

Visualizations



Precision Vs Recall

Visualizations



Sample Output

Conclusion

- The results achieved in this study demonstrate the feasibility of applying object detection models like YOLOv5 for environmental monitoring tasks.
- This system can serve as a valuable tool for marine scientists, environmentalists, and policy-makers aiming to monitor and combat microplastic pollution on a larger scale.
- In conclusion, the project lays a strong foundation for the application of artificial intelligence in environmental protection efforts. It emphasizes that with structured workflows, even limited resources can be effectively leveraged to create meaningful technological solutions addressing some of today's most pressing environmental challenges.

Future Work

- Larger, diverse datasets
- Recent models: YOLOv8, Faster R-CNN
- Extending the system not just to detect microplastics, but also to classify different types (e.g., fibers, fragments, films).

References

- X. Meng, S. Chen, L. Sun, B. Liu, B. Ma, Y. Qu, Y. Song, and D. Li, "Identification of marine microplastics by a combined method of principal component analysis and random forest for fluorescence spectrum processing," Marine Pollution Bulletin, 2025.
- S. Lanjun, L. Zhijian, M. Xiongfei, Z. Yanchao, H. Shuhan, L. Le, and W. Lin, "Rapid identification of marine microplastics by laser-induced fluorescence technique based on pca combined with svm and knn algorithm," Environmental Research, vol. 269, p. 120947, 2025.
- J. Liu, J. Niu, W. Wu, Z. Zhang, Y. Ning, and Q. Zheng, "Recent advances in the detection of microplastics in the aqueous environment by electrochemical sensors: A review," Marine Pollution Bulletin, vol. 214, p. 117695, 2025.
- P. Akkajit, M. E. E. Alahi, and A. Sukkuea, "Enhanced detection and classification of microplastics in marine environments using deep learning," Regional Studies in Marine Science, vol. 80, 2024.

References

- K. Patidar, M. Alshehri, W. Singha, M. Alrasheedi, A. M. Younis, U. C. Dumka, and B. Ambade, "Assessing the microplastic pandemic: Prevalence, detection, and human health impacts in asian aquatic environments," Physics and Chemistry of the Earth, Parts A/B/C, vol. 137, p. 103800, 2025.
- M. A. B. Sarker, M. H. Imtiaz, T. M. Holsen, and A. B. M. Baki, "Real-time detection of microplastics using an ai camera," Sensors, vol. 24, no. 13, 2024.
- M. A. B. Sarker, U. Butt, M. H. Imtiaz, and A. B. Baki, "Automatic detection of microplastics in the aqueous environment," in 2023 IEEE 13th Annual Computing and Communication Workshop and Conference (CCWC)

Thank You

Thank You!