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Automatic Damage Detection in Under Water Constructions

Final Internship Presentation

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AGENDA

- Project Overview
- Dataset Overview
- YOLO Annotation
- Object Tracking
- Data Augmentation
- Model Building
- Object Detection vs Instance Segmentation
- Evaluation Metrics
- Results
- Additional Tasks

PROJECT OVERVIEW

OBJECTIVE

Develop an automatic damage detection system for underwater constructions using machine learning techniques.

METHODOLOGY

Utilize the YOLO (You Only Look Once) model to identify and classify various types of damage

DATASET OVERVIEW

Dataset of underwater videos and images were used. Considered folders are **bridge_86_shimoga, bridge_242_kr_nagar ,krs_dam_ER35-KA-DM-4-2224-27, shirawata_dam_ER31-MA-DM-1-49820CH, sholayer_dam_er40-tn-dm-1-22-23, vani_vilasa_sagar_dam_er38-ka-dm-5-ubp-2022-23-1-20240301T105318Z-001**

→

Some folders already had damage boxes drawn and stored as JSON files.

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I used the **YOLO Label.exe** for additional labeling.

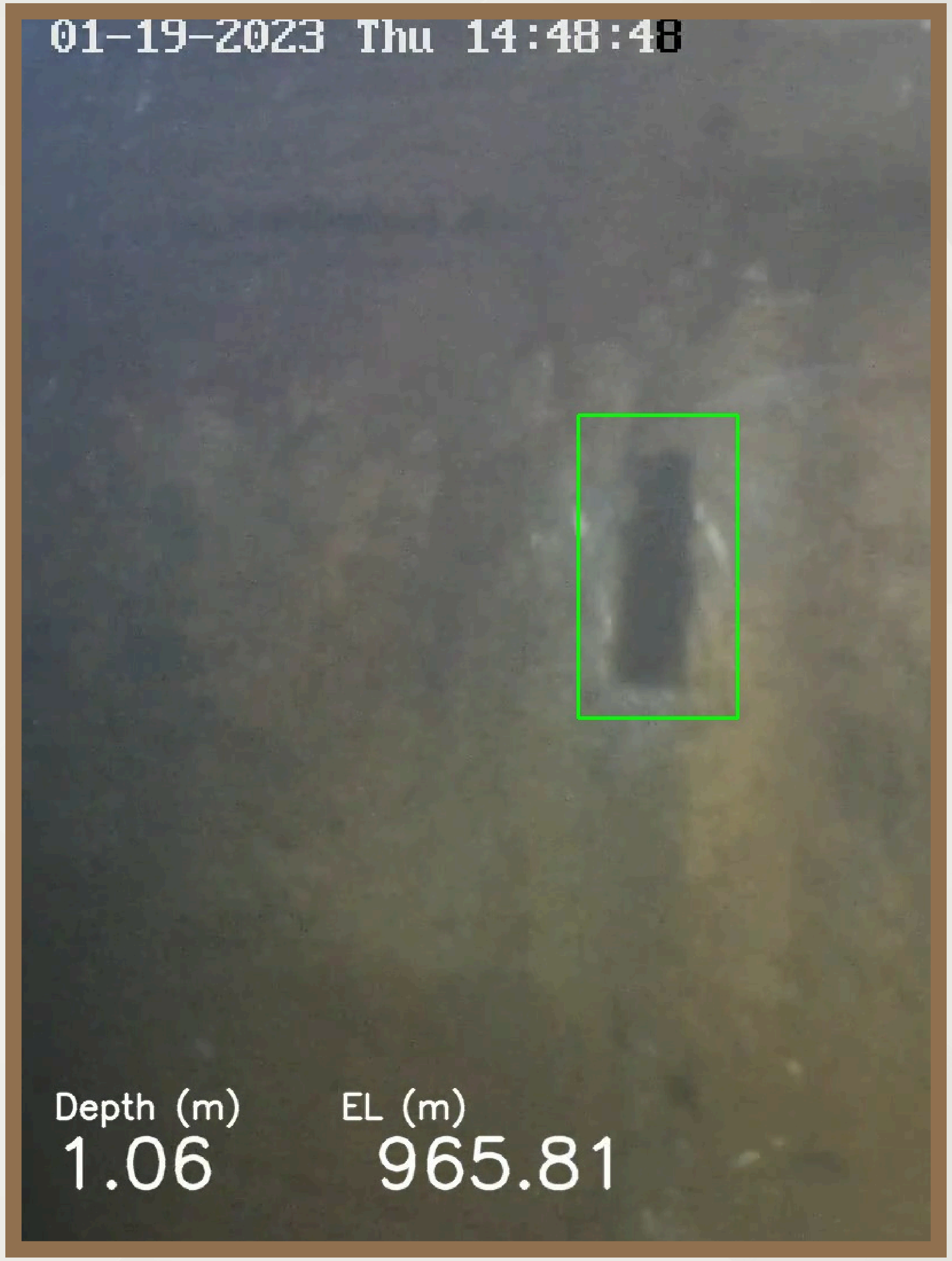
→

Converted JSON files to YOLO format for consistency. **JSON_to_Yolo.py**

YOLO ANNOTATION

- For labelling the dataset 'YoloLabel.exe' was used.
- Anchor boxes around every object is annotated and labelled using the YoloLabel tool.
- YoloLabel stores class and coordinates of each object in a .txt file within the image folder.
- Due to limited data, focused on three classes for better accuracy:

  0: Loss of Pointing Mortar
  1: Cavities
  2: Reinforcement Exposed



OBJECT TRACKING

- Needed more data to train YOLO models effectively as yolo need 1000+ data.
- Extracted additional frames from underwater videos to expand the dataset.
- Selected frames from (t-2) seconds to (t+2) seconds around keyframes in videos.
- Used object tracking to maintain consistent annotations across these frames.
- Improved the diversity and quality of the dataset.
- CODE : **Object_tracking.py** and **Frame_extraction.py**

DATA AUGMENTATION

- Data augmentation involves artificially expanding the size and diversity of a dataset by applying transformations to existing data samples.
- Enhances model generalization and performance by exposing it to a wider range of variations and scenarios.
- Rotating images in various degrees, flipping is done
- Enhanced the dataset's variability and prepared it for training the YOLO model.
- CODE : **augmentation.py**

MODEL BUILDING

- Utilized 3000 images of underwater structures for training.
- Split the dataset into an 80% training set and a 20% validation set.
- Initially employed to detect "Loss of Pointing Mortar." using YOLOv7.
- Transitioned to YOLOv8 for instance segmentation to achieve pixel-level accuracy in identifying "Loss of Pointing Mortar," "Cavities," and "Reinforcement Exposed."
- For Segmentation annotation used Roboflow - Link

DIFFERENCE BETWEEN OBJECT DETECTION AND INSTANCE SEGMENTATION

OBJECT DETECTION

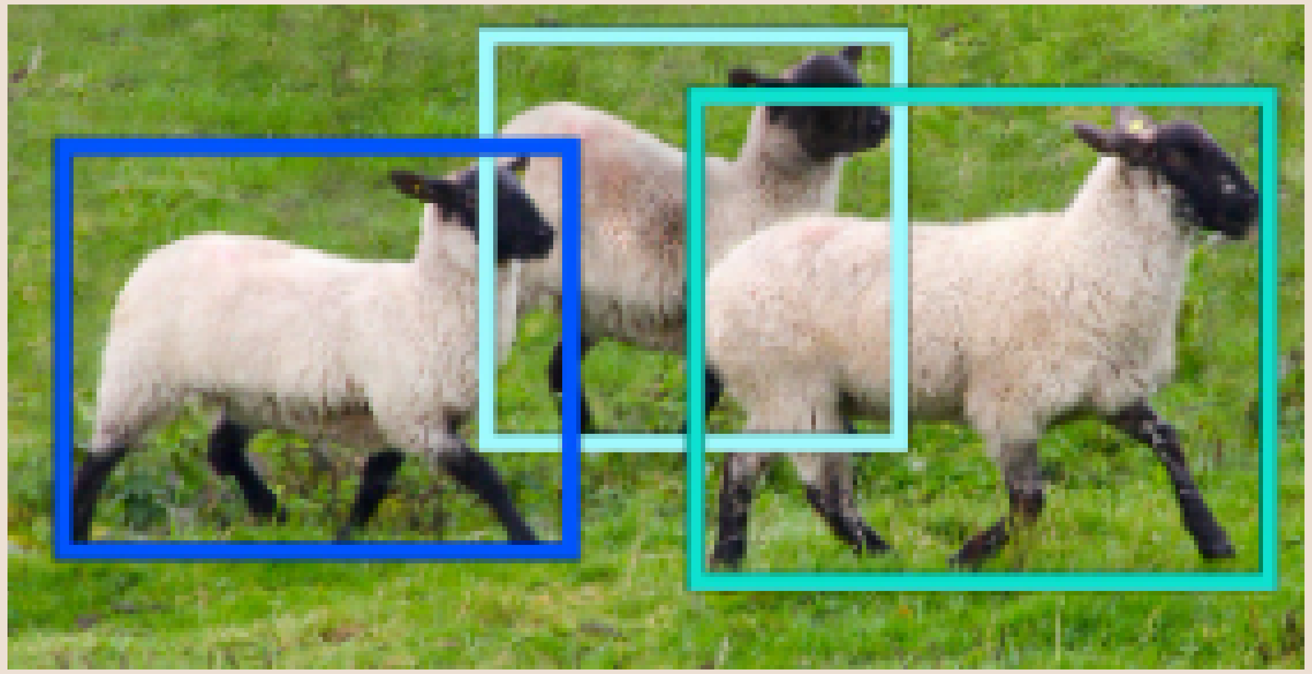
- Identifies and localizes objects within an image, typically by drawing bounding boxes around them.
- Provides bounding boxes that encapsulate the entire object.

INSTANCE SEGMENTATION

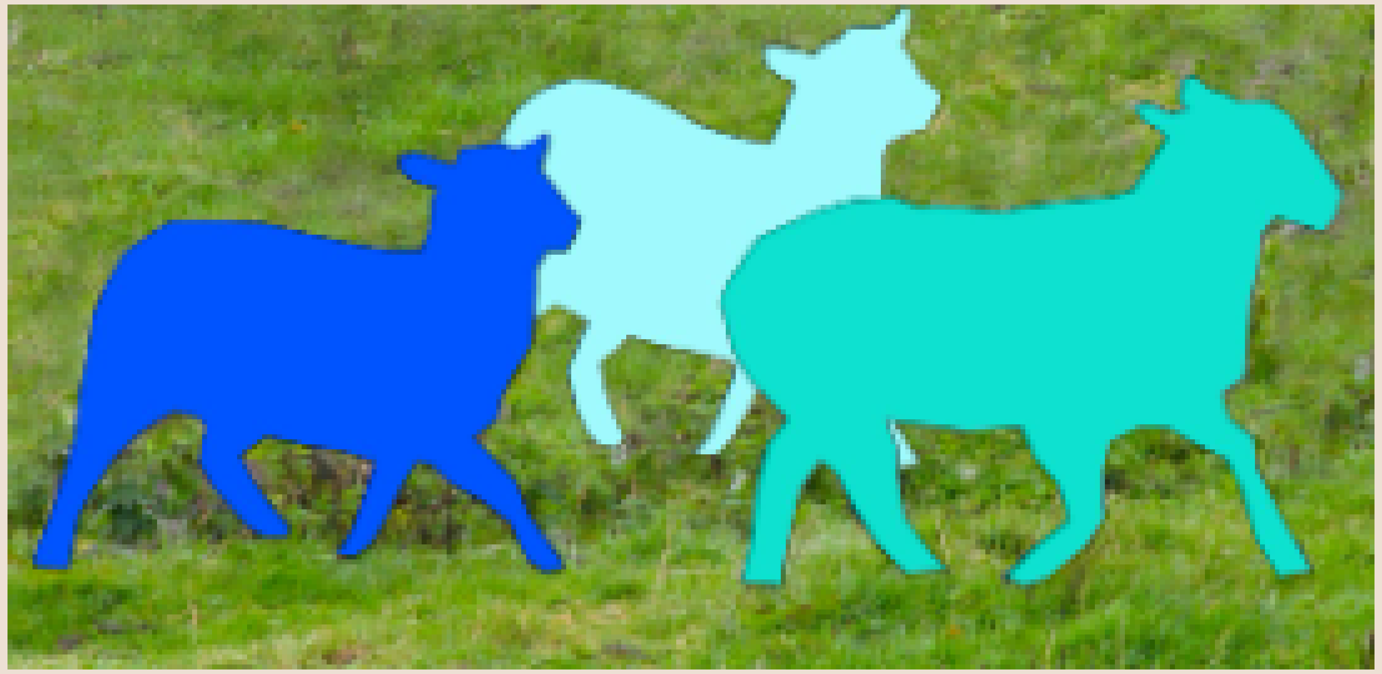
- Identifies and segments individual object instances within an image at the pixel level.
- Provides a detailed mask or segmentation map for each object instance, distinguishing between different instances of the same class.

DIFFERENCE BETWEEN OBJECT DETECTION AND INSTANCE SEGMENTATION

OBJECT DETECTION

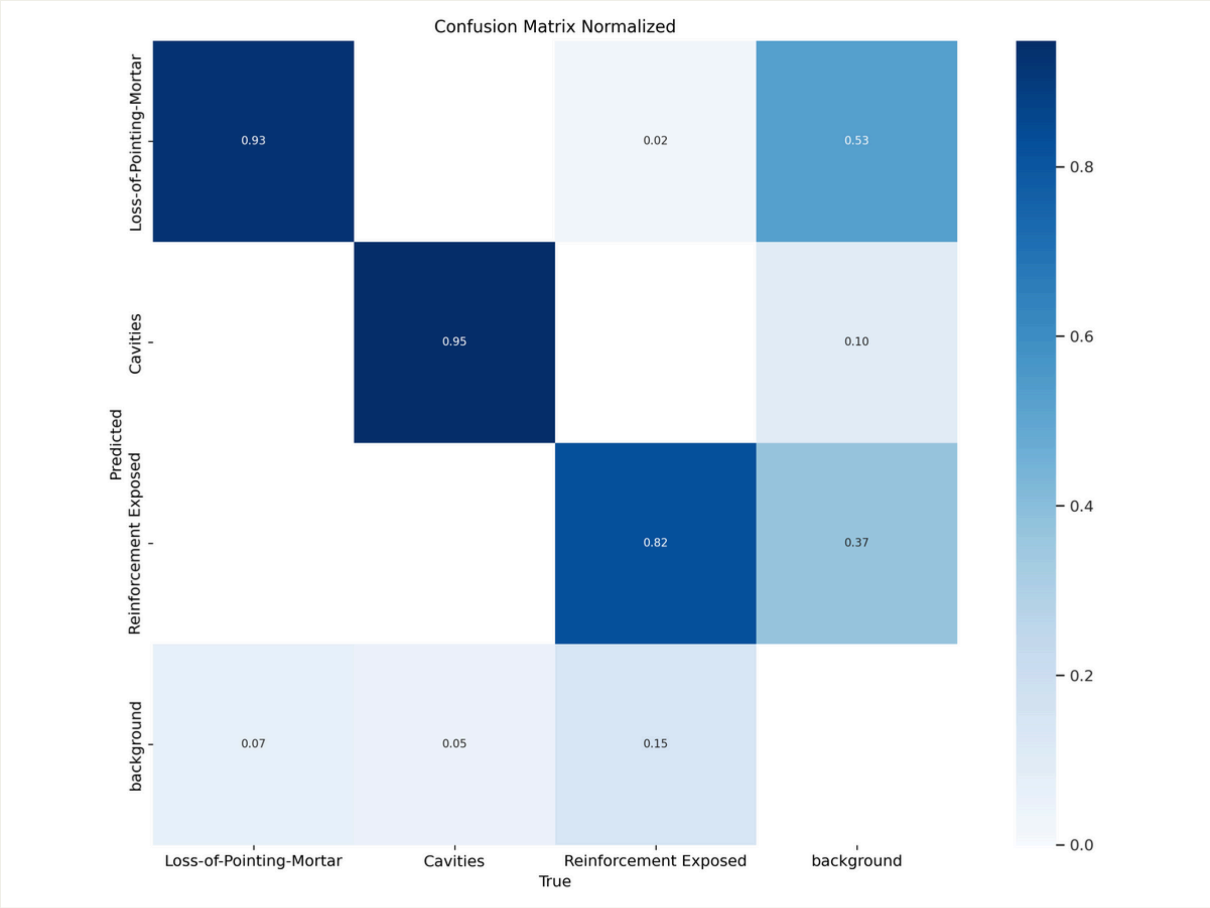


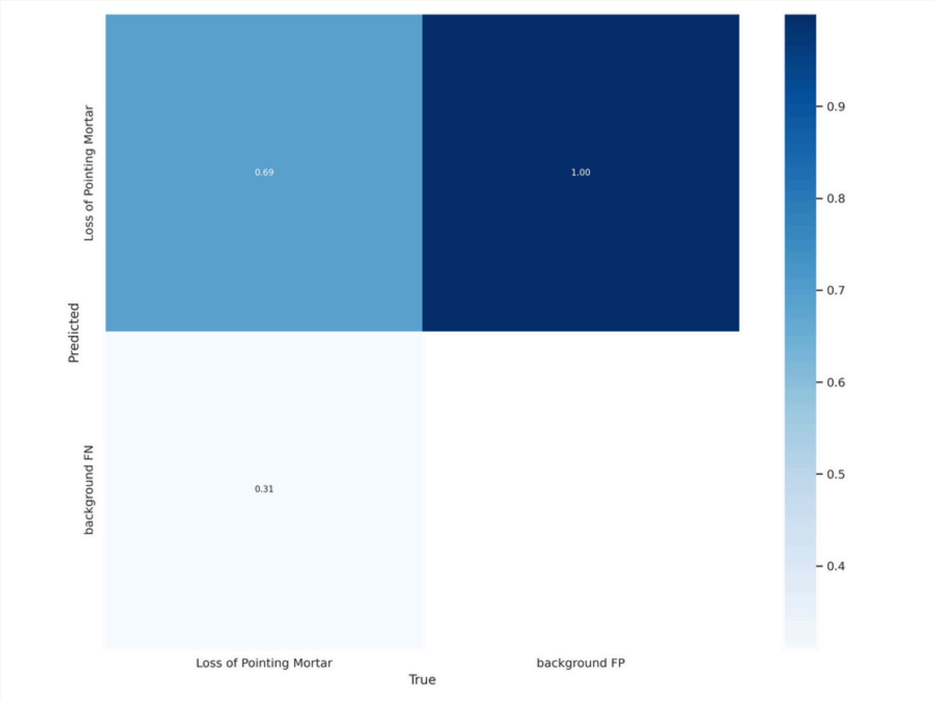
INSTANCE SEGMENTATION



EVALUATION METRICS

- Used to assess the effectiveness and performance of the YOLOv7 model in detecting damages in underwater structures.
- Confusion Matrix provides a detailed breakdown of model predictions compared to actual labels.
- F1 Curve Shows the balance between precision and recall across different thresholds.
- These metrics ensure the model's accuracy and reliability in identifying specific damages in varied underwater environments.





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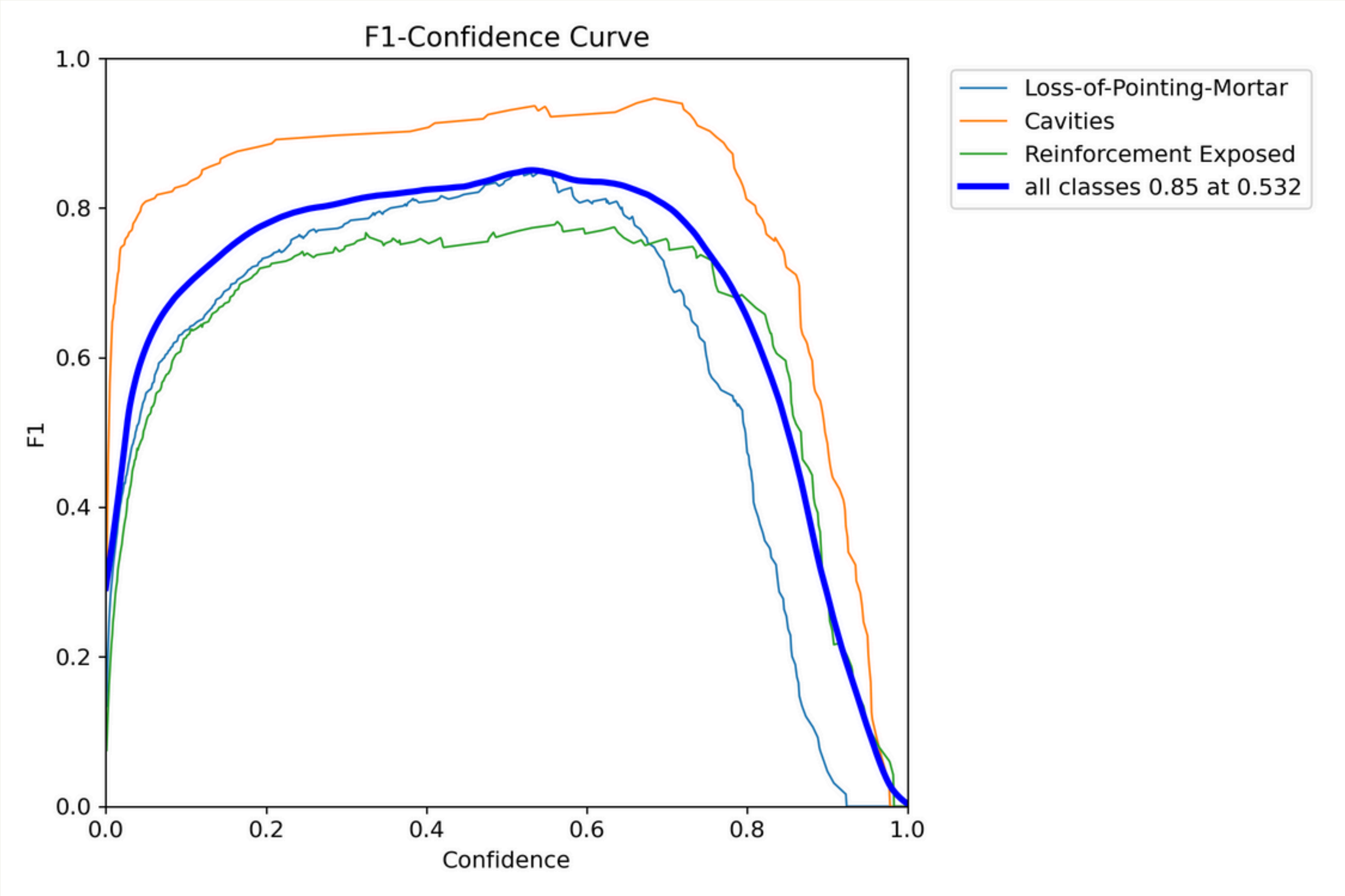

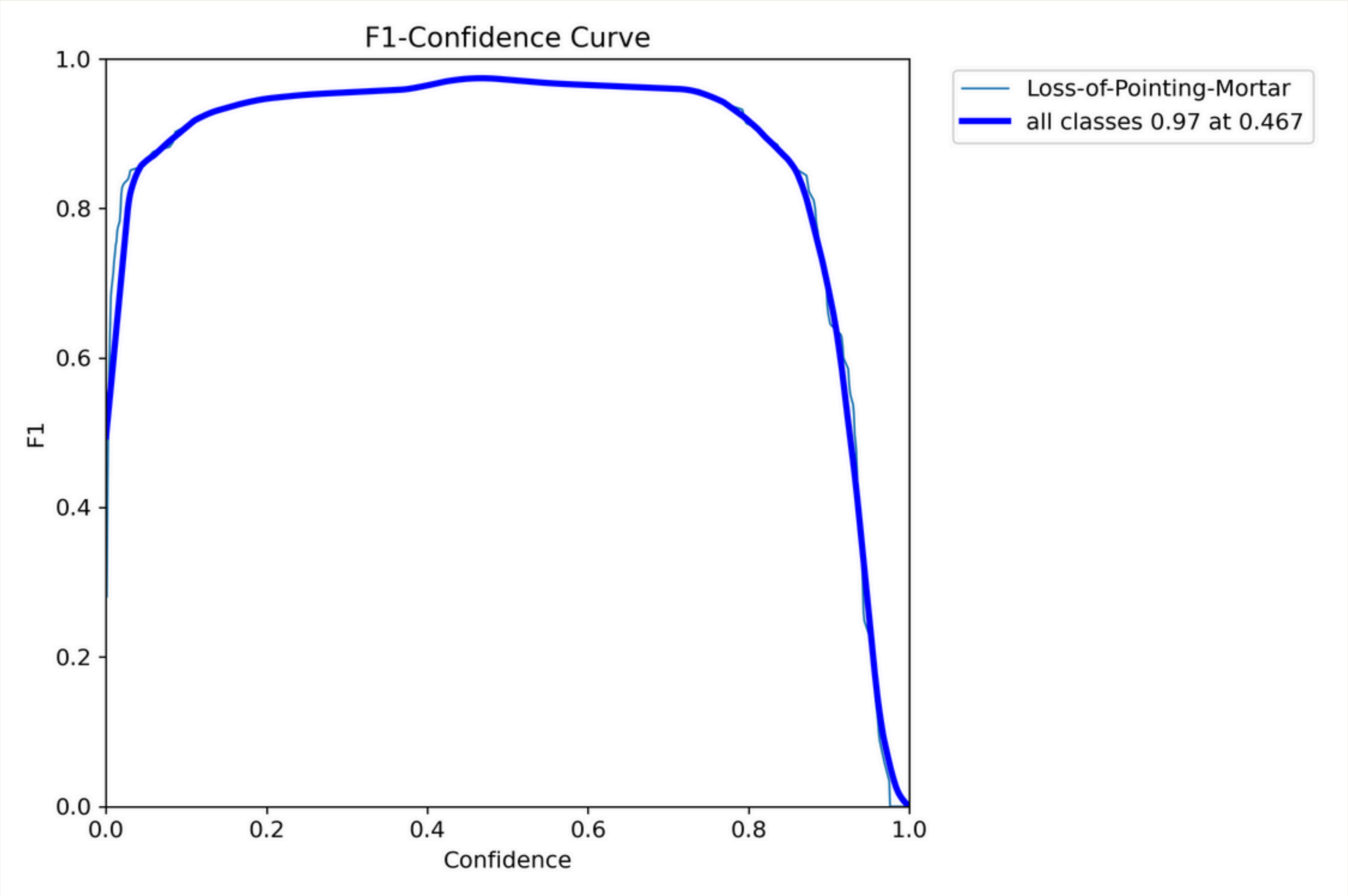

RESULTS

- Utilized evaluation metrics such as Confusion Matrix and F1 Curve
- The model successfully detected 'Loss of Pointing Mortar' in 69% of cases where it was present and correctly identified its absence in all cases, but it showed a 31% false alarm rate. Improvement is needed to reduce false alarms and enhance overall accuracy.
- Achieved high accuracy in detecting damages like Loss of Pointing Mortar (93%), Cavities (95%), and Reinforcement Exposed (82%) for damage detection using Instance Segmentation.
- Background detection indicates areas for enhancement.
- All the projects were uploaded in https://github.com/meerap1
- All practical directions for training and testing the model is uploaded in GithHub

ADDITIONAL TASKS

- Utilized YOLOv7 for detecting fish within standard video footage. (Link)
- Extended YOLOv7 application to fish detection in imaging sonar videos. (Link)
- Implemented YOLOv8 instance segmentation on a Custom Dataset. - (Link)

THANK YOU