Hochschule Ravensburg-Weingarten
University of Applied Sciences

Student Names	Matriculation Numbers	Study Program
1. Yashas Prabhu TS	17141809	MM
2. Aditya Balasaheb Sonawane	20141748	MM

Task 2: Evaluation of an Object Detector

Guided by:
Prof. Dr. Stefan Elser

1 Introduction

Object detection is the process of localizing and classifying objects in an image or a video through computer vision. With the advent of deep learning, convolutional neural networks (CNNs) have become the dominant method for object detection. In this task, the Kitti dataset is used to train the complex YOLO model. The training involves the feeding of large datasets to automatically learn features and patterns for effective object detection. The data set is divided into a training set, a validation set, and a test set (a common split might be 70% for training, 15% for validation, and 15% for testing). The obtained predictions are compared with the ground truth to determine the effectiveness of the object detector in identifying and locating the object. Key parameters considered for the evaluation of the object detector are precision and recall values.

1.1 Goal

- To evaluate the given results of the object detector.
- Provide the BEV images, including the bounding boxes with IoUs.
- Calculate precision and recall for each BEV image.

2 Methodology

The methodology used to evaluate the object detector is as follows:

- The prediction and labels data of bounding boxes are imported.
- The bounding boxes are plotted onto the respective BEV images using the Shapely library and Matplotlib library.
- The IoUs are calculated by matching every ground truth bounding box with the predicted box, and the maximum IoU obtained for every ground truth box is recorded, and the rest is eliminated for every ground truth box.
- Once the maximum IoUs for every ground truth box are obtained, a threshold of 0.5 is set to determine true positive values.

Calculation is done using the following formulas:

1. To calculate IOU:
$$\text{IOU} = \frac{\text{Area of Union}}{\text{Area of Intersection}}$$
2. To calculate Precision:
$$\text{Precision} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Positive}}$$
3. To calculate Recall:
$$\text{Recall} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Negative}}$$

True positive is the ability of the model to correctly predict the positive class when the true class is positive and is obtained by the length of IoUs greater than 0.5 list. False positive is the ability of the model to incorrectly predict the positive class when the true class is negative and is obtained by subtracting True positives from predictions. False Negative is the ability of the model to incorrectly predict the negative class when the true class is positive and is obtained by subtracting the True positive from Ground truth list.

2.1 Flow chart

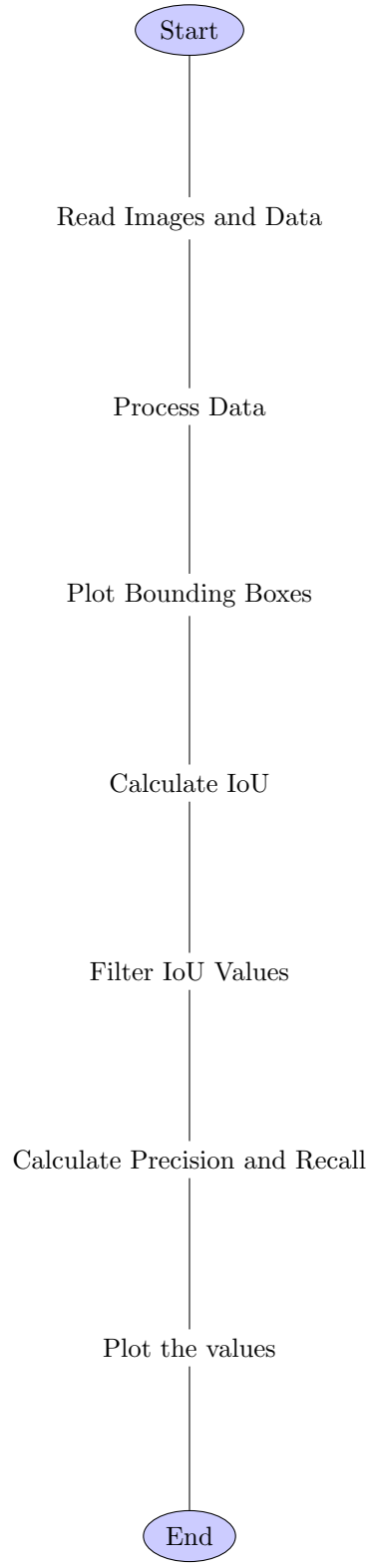
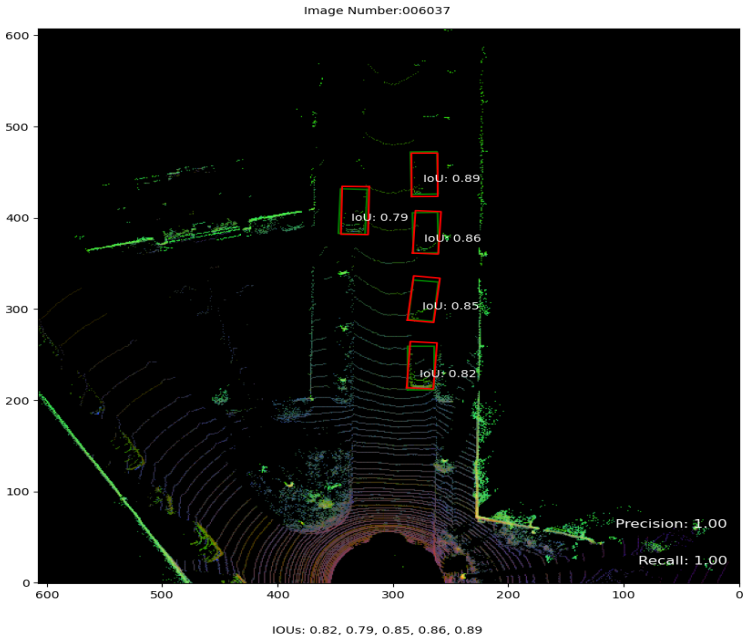


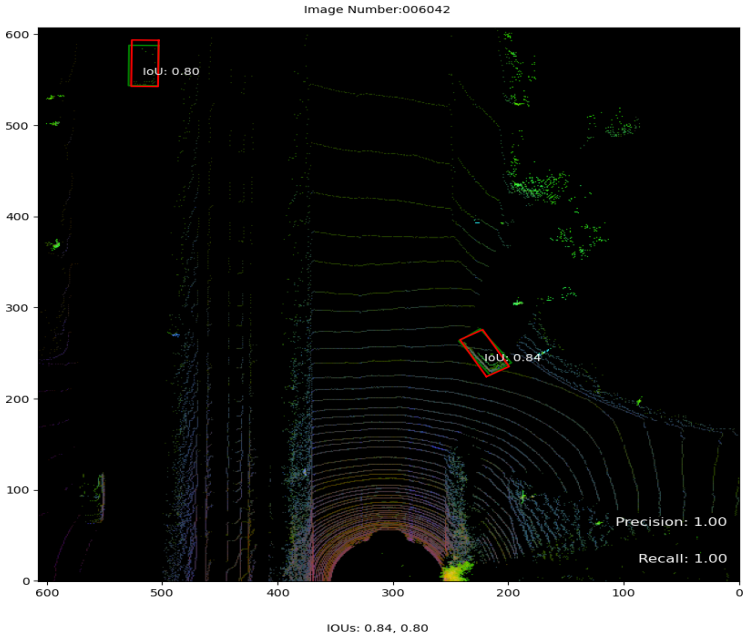
Figure 1: Flowchart of the Code

3 Results

The IoUs,Precision and Recall are plotted for the given predictions dataset for the respective images.Precision measures the ability of the model to avoid false positives. Recall measures the ability of the model to avoid missing positive instances.



IOUs: 0.82, 0.79, 0.85, 0.86, 0.89



IOUs: 0.84, 0.80

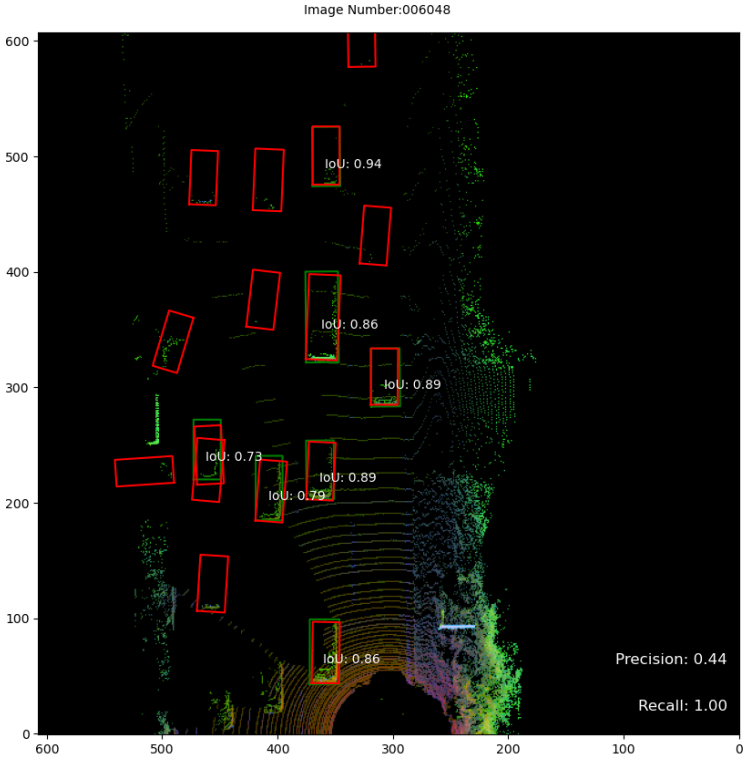


Image Number:006048
IoU: 0.94
IoU: 0.86
IoU: 0.89
IoU: 0.73
IoU: 0.89
IoU: 0.79
IoU: 0.86
Precision: 0.44
Recall: 1.00
IOUs: 0.89, 0.86, 0.79, 0.89, 0.86, 0.94, 0.73

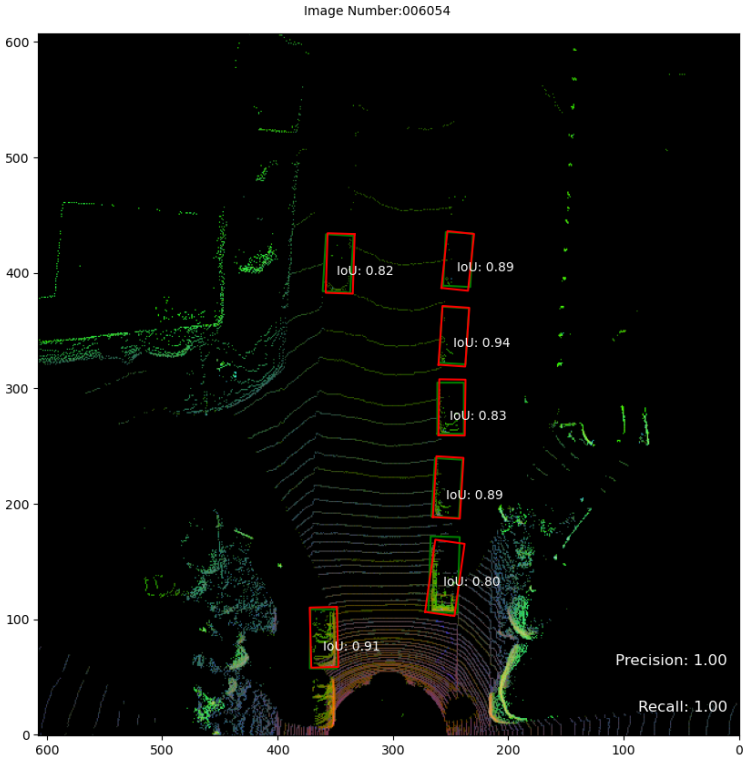
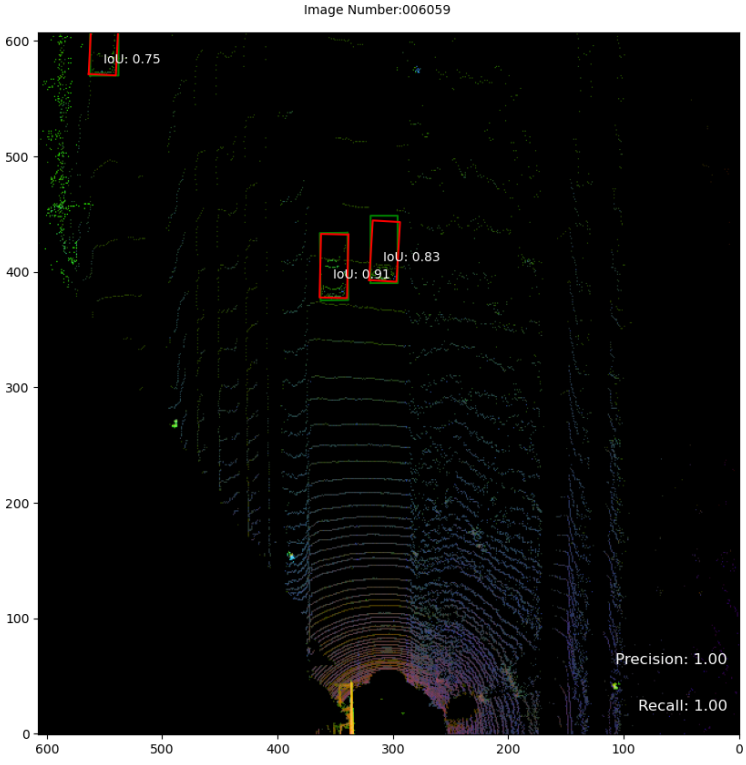
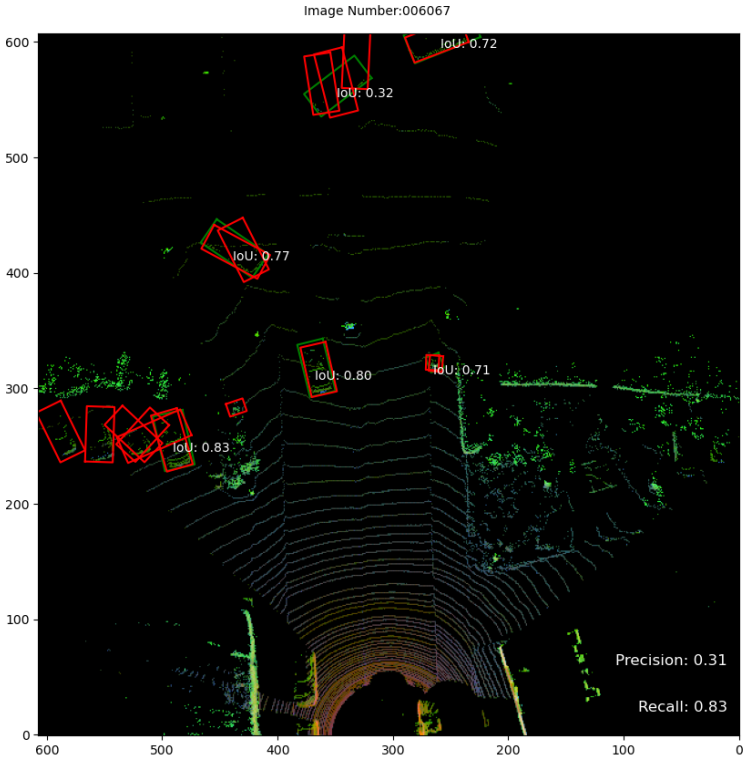


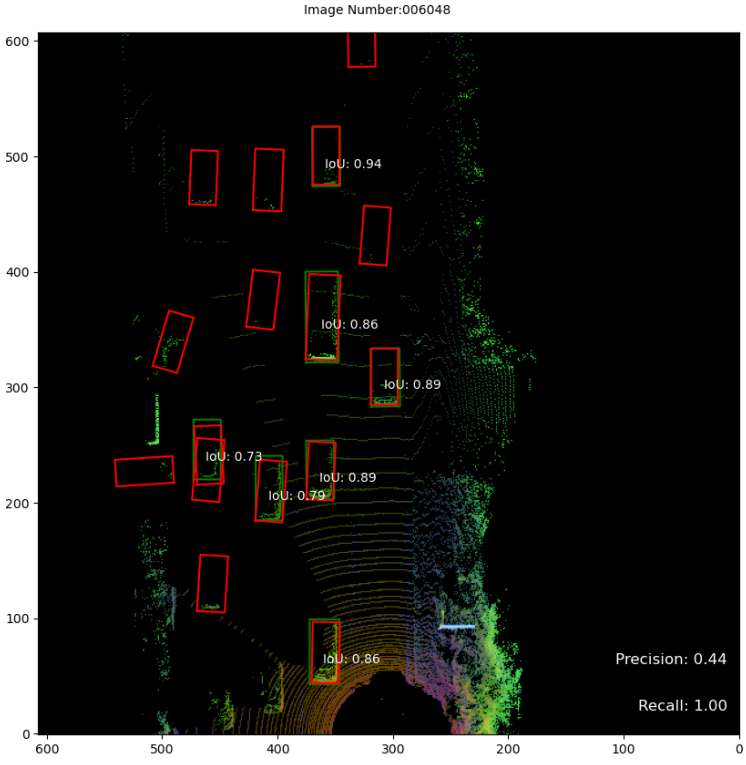
Image Number:006054
IoU: 0.82
IoU: 0.89
IoU: 0.94
IoU: 0.83
IoU: 0.89
IoU: 0.80
IoU: 0.91
Precision: 1.00
Recall: 1.00
IOUs: 0.80, 0.91, 0.82, 0.89, 0.83, 0.94, 0.89



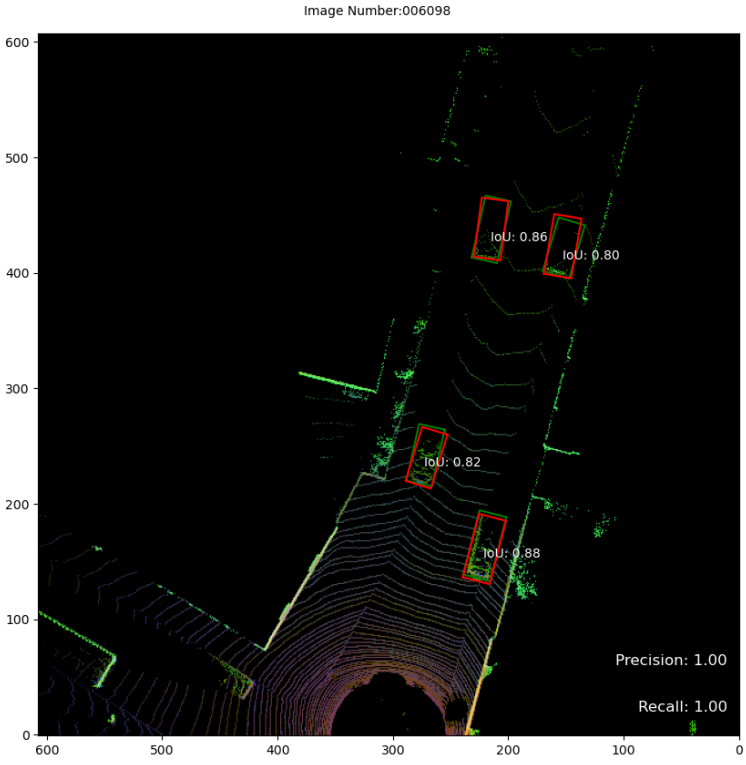
IOUs: 0.91, 0.75, 0.83



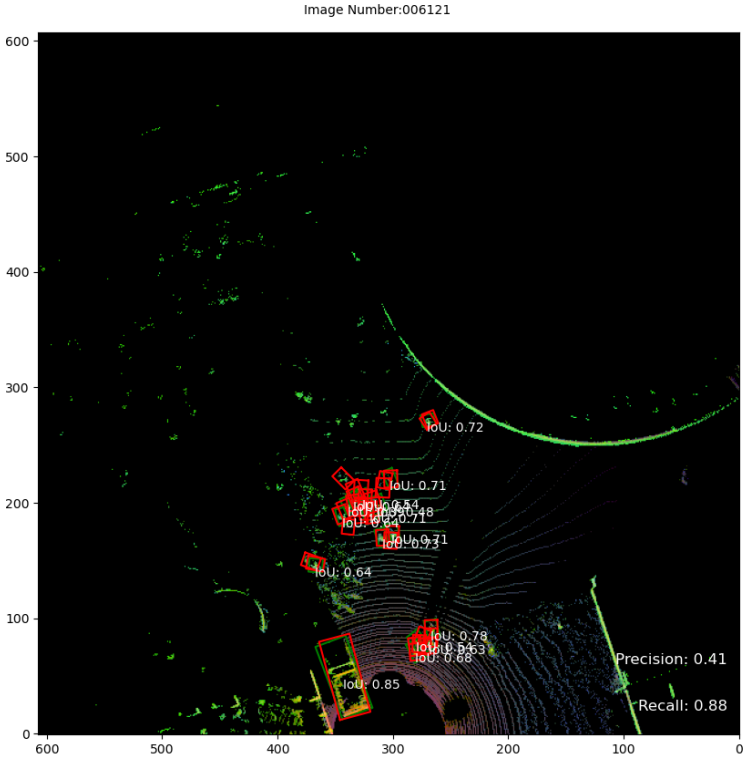
IOUs: 0.80, 0.71, 0.32, 0.77, 0.83, 0.72



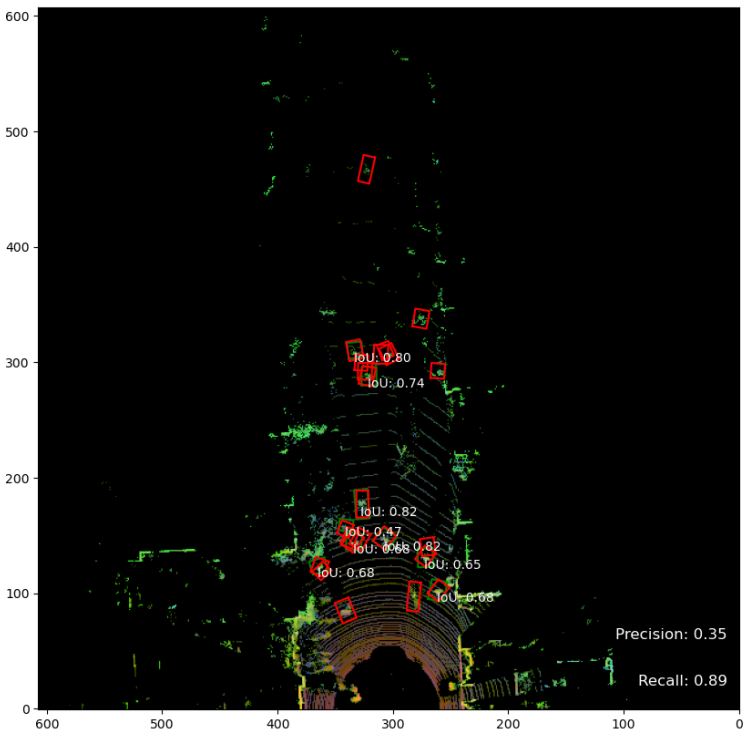
IOUs: 0.89, 0.86, 0.79, 0.89, 0.86, 0.94, 0.73



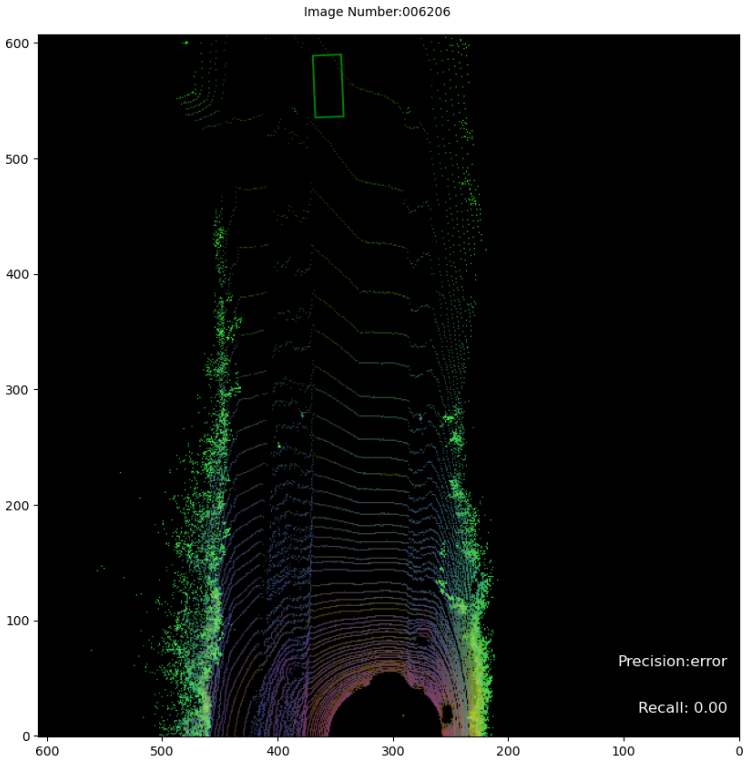
IOUs: 0.88, 0.82, 0.86, 0.80



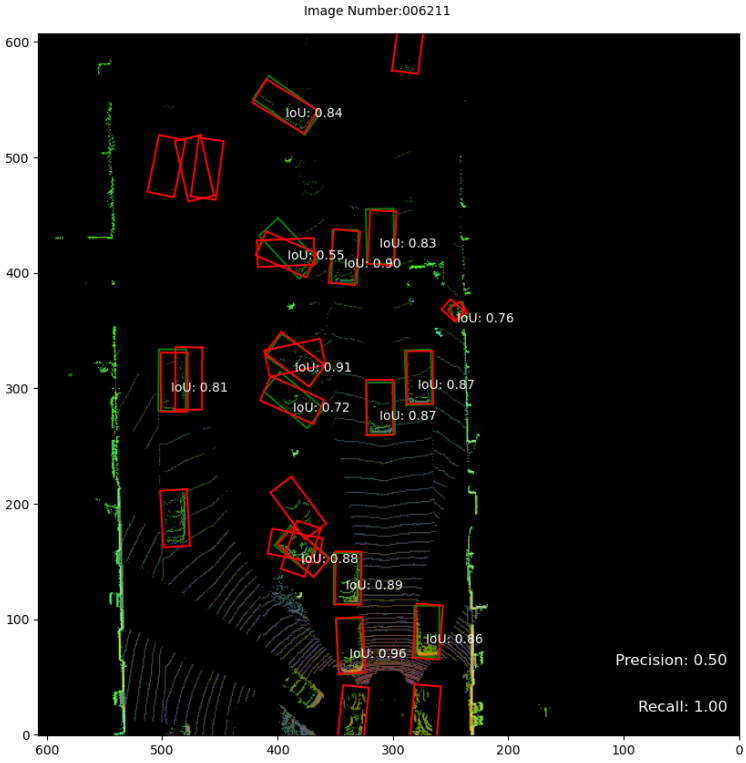
IOUs: 0.72, 0.64, 0.63, 0.78, 0.54, 0.68, 0.73, 0.71, 0.48, 0.71, 0.71, 0.64, 0.39, 0.64, 0.54, 0.85



IOUs: 0.68, 0.82, 0.68, 0.68, 0.65, 0.82, 0.47, 0.74, 0.80



No Predictions data hence unable to calculate IoUs.



IOUs: 0.87, 0.96, 0.89, 0.88, 0.72, 0.91, 0.55, 0.90, 0.84, 0.86, 0.87, 0.76, 0.81, 0.83

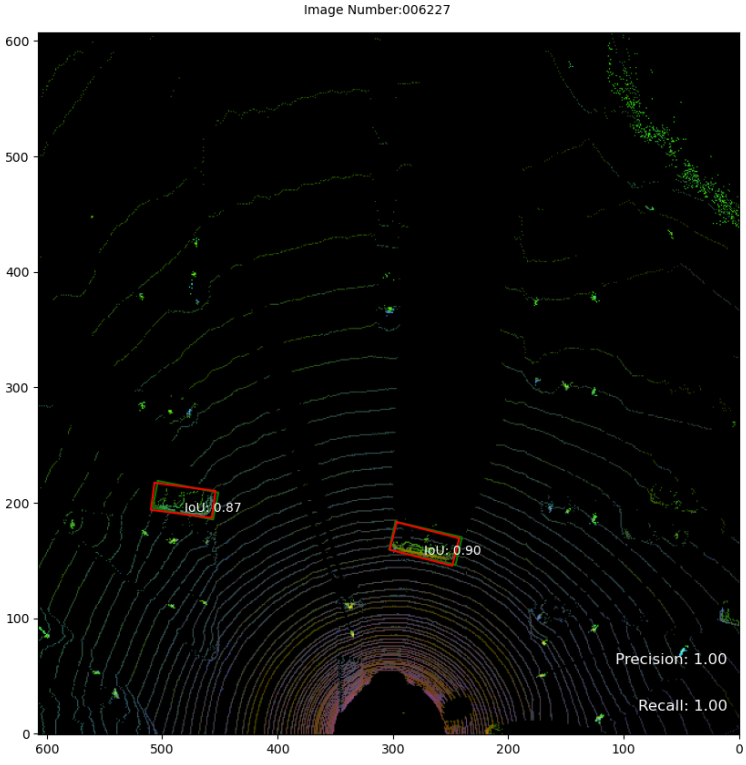


Image Number:006227
IoU: 0.87
IoU: 0.90
Precision: 1.00
Recall: 1.00
IOUs: 0.90, 0.87

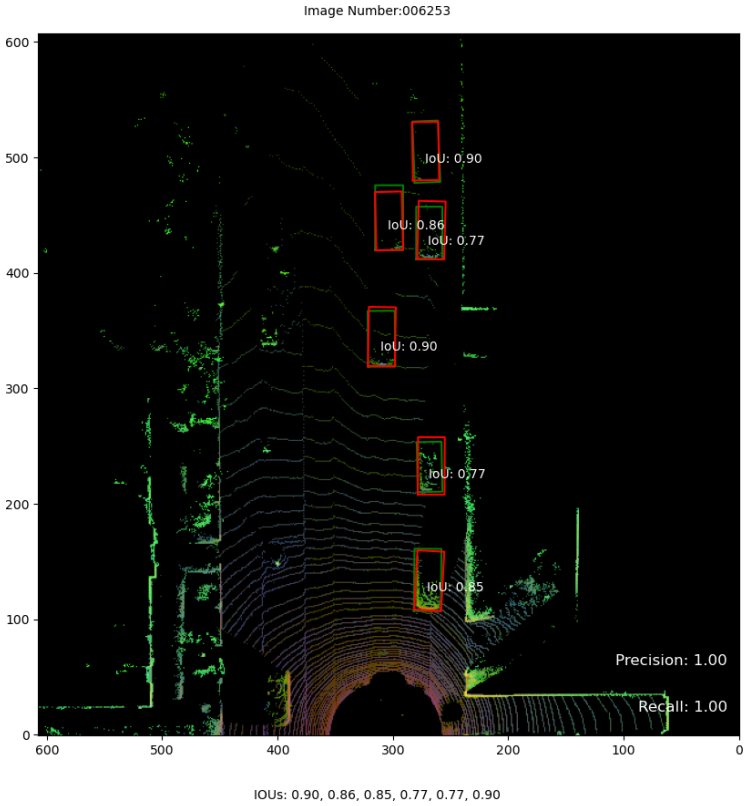
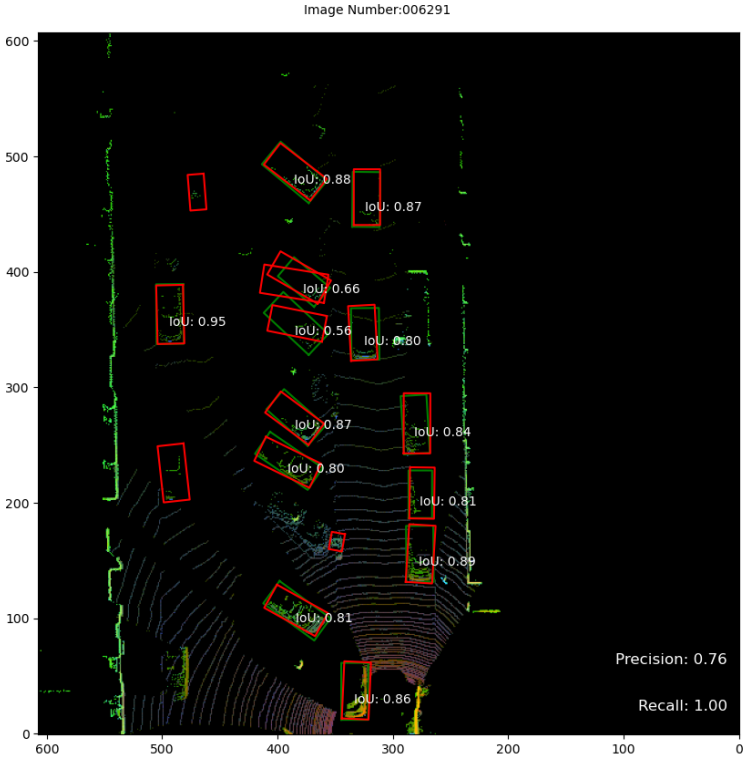
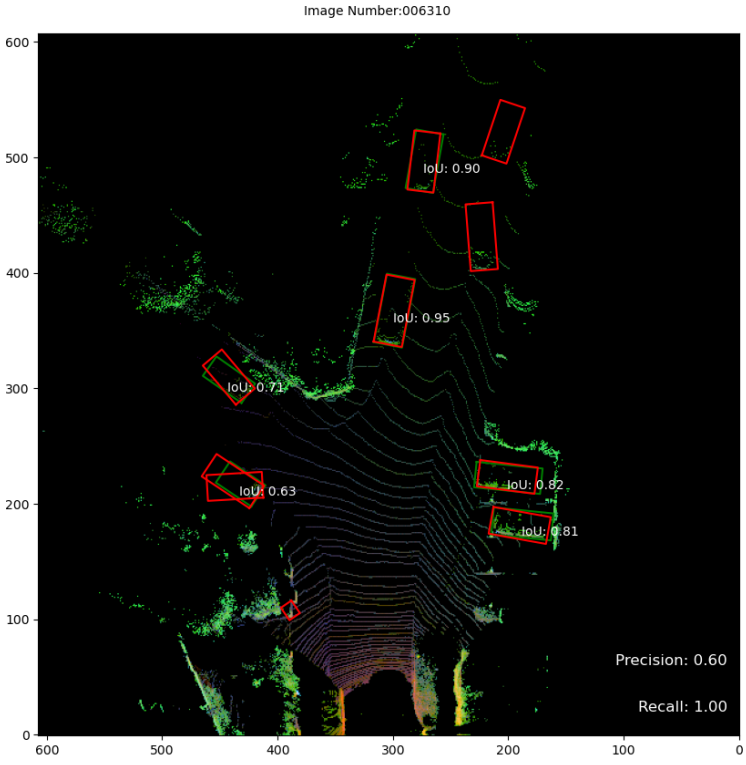


Image Number:006253
IoU: 0.90
IoU: 0.86
IoU: 0.77
IoU: 0.90
IoU: 0.77
IoU: 0.85
Precision: 1.00
Recall: 1.00
IOUs: 0.90, 0.86, 0.85, 0.77, 0.77, 0.90



IOUs: 0.80, 0.86, 0.81, 0.80, 0.87, 0.56, 0.66, 0.88, 0.89, 0.81, 0.84, 0.95, 0.87



IOUs: 0.95, 0.71, 0.63, 0.81, 0.82, 0.90

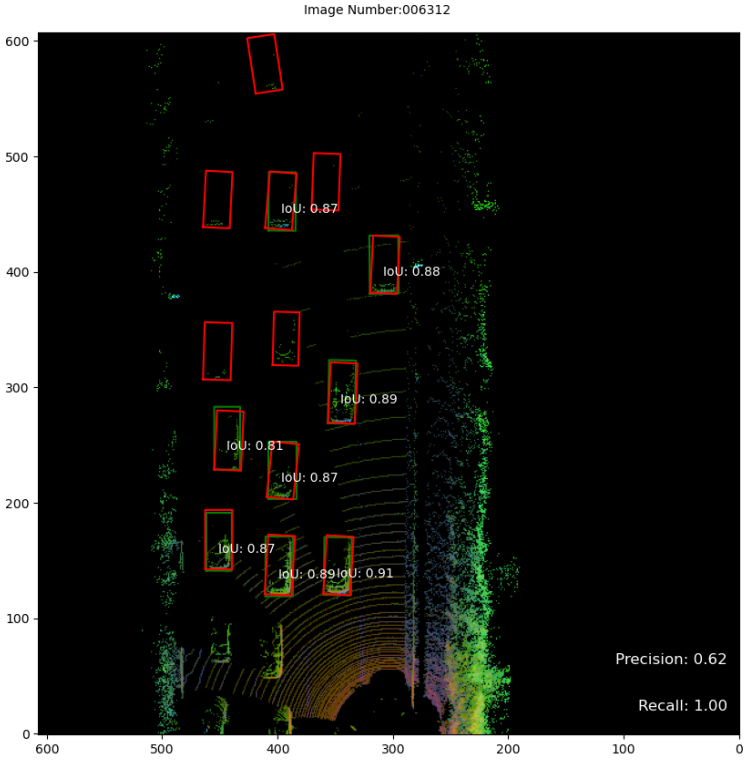


Image Number:006312
IoU: 0.87
IoU: 0.88
IoU: 0.89
IoU: 0.81
IoU: 0.87
IoU: 0.87
IoU: 0.89
IoU: 0.91
Precision: 0.62
Recall: 1.00
IOUs: 0.88, 0.89, 0.91, 0.87, 0.89, 0.87, 0.87, 0.81

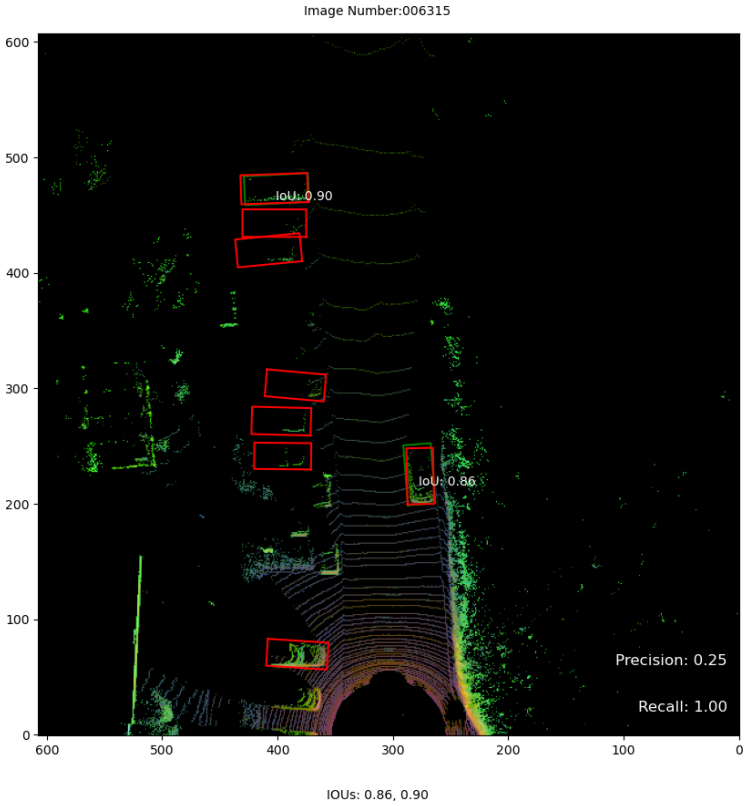


Image Number:006315
IoU: 0.90
IoU: 0.86
Precision: 0.25
Recall: 1.00
IOUs: 0.86, 0.90

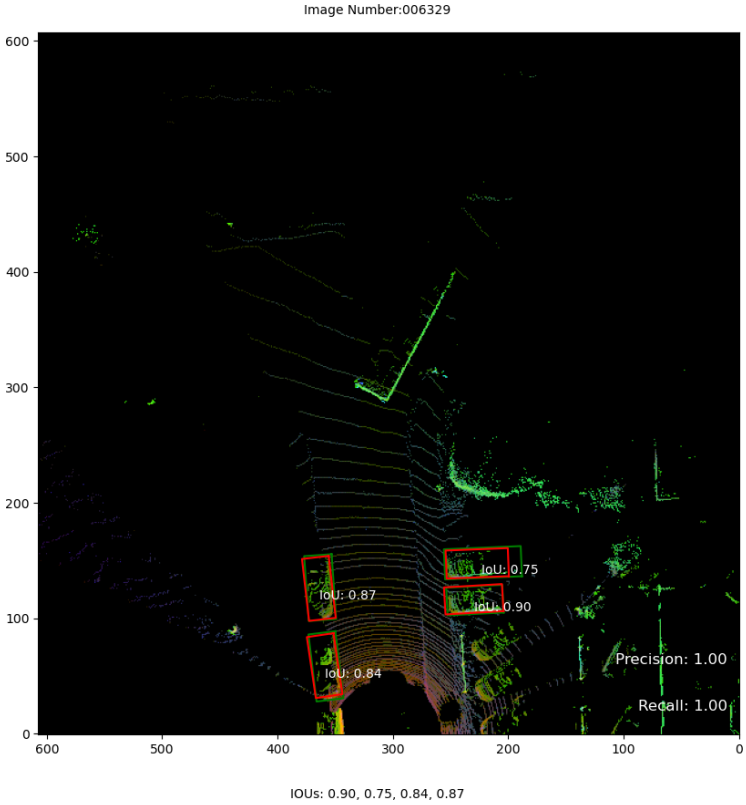


Image Number:006329
IoU: 0.87
IoU: 0.75
IoU: 0.90
IoU: 0.84
Precision: 1.00
Recall: 1.00
IOUs: 0.90, 0.75, 0.84, 0.87

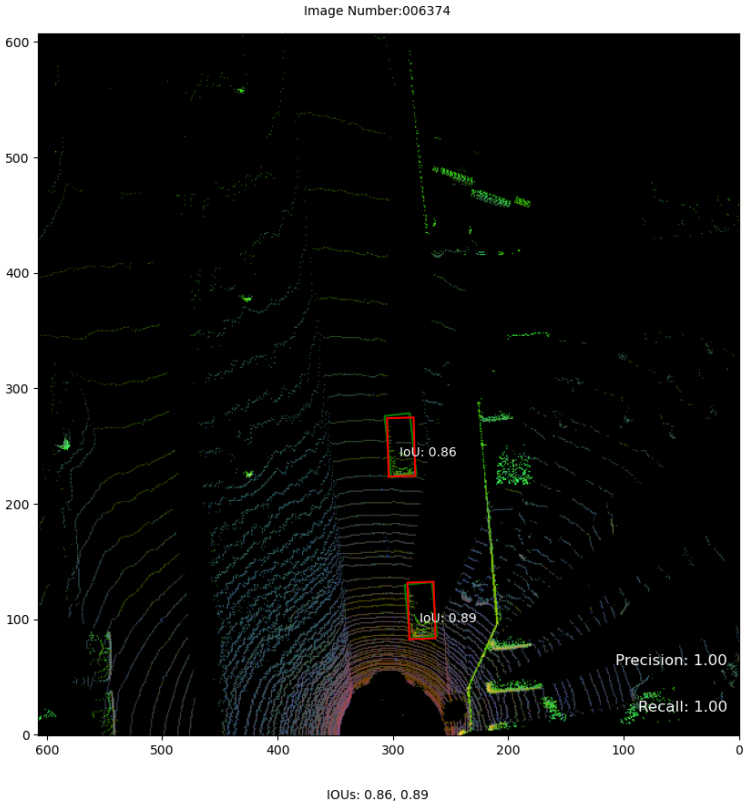


Image Number:006374
IoU: 0.86
IoU: 0.89
Precision: 1.00
Recall: 1.00
IOUs: 0.86, 0.89

4 Conclusion

Image numbers 006048, 006067, 006121, 006130, 006206, 006211, and 006315 have recall and precision values less than 1. Further improvement can be made by training the module on additional data sets and selecting suitable YOLO versions based on the data sets and detection type.

5 Reference

- Felix Berens,RWU Weingarten. Object detection
- Dr.Stefan Elser,RWU Weingarten.LIDAR AND RADAR Systems graded hands on projects.