2D - Multi Vehicle Tracking in Carla Simulator

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Introduction

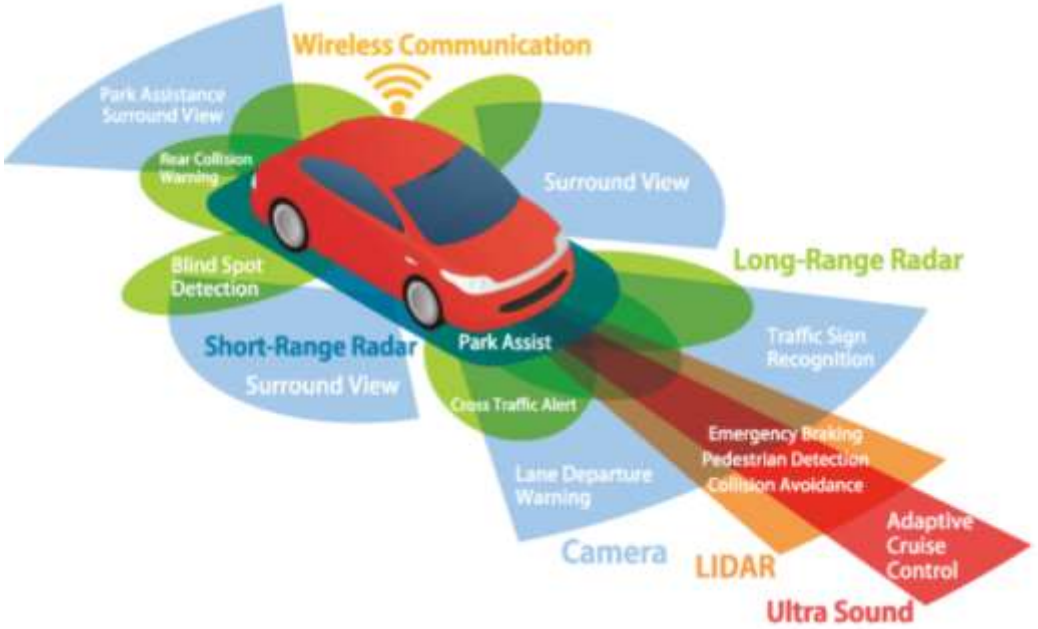
- Autonomous vehicles have become increasingly popular in the transportation industry, facilitating more research on vehicle detection and tracking models. As a crucial component of modular driving systems, multi-vehicle tracking is an active research area in academia.

Backgrounds

Autonomous Vehicles

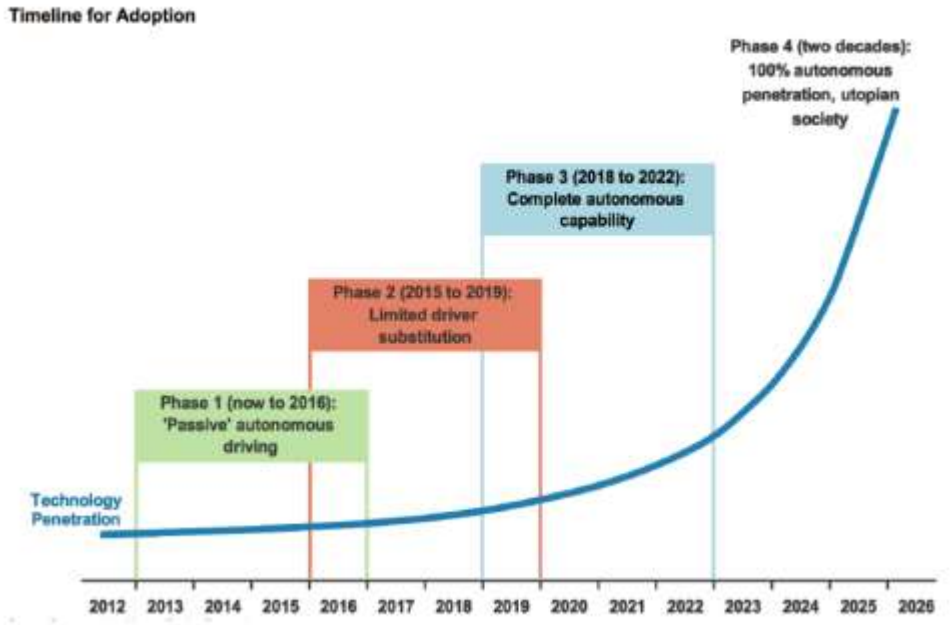
- Self-driving or autonomous vehicles are vehicles that can sense their environment and operating without human intervention.

- This technology can redefine commuting experience , mitigate workplace hazards and optimize industrial processes.



Journey of autonomous vehicles

- Started in 1920’s with radio-controlled experiments.
- Google’s work in 2000’s lead to todays autonomous push , aided by advancements in sensor technology .
- How do they work ?



Carla Simulator (Car Learning to Act)

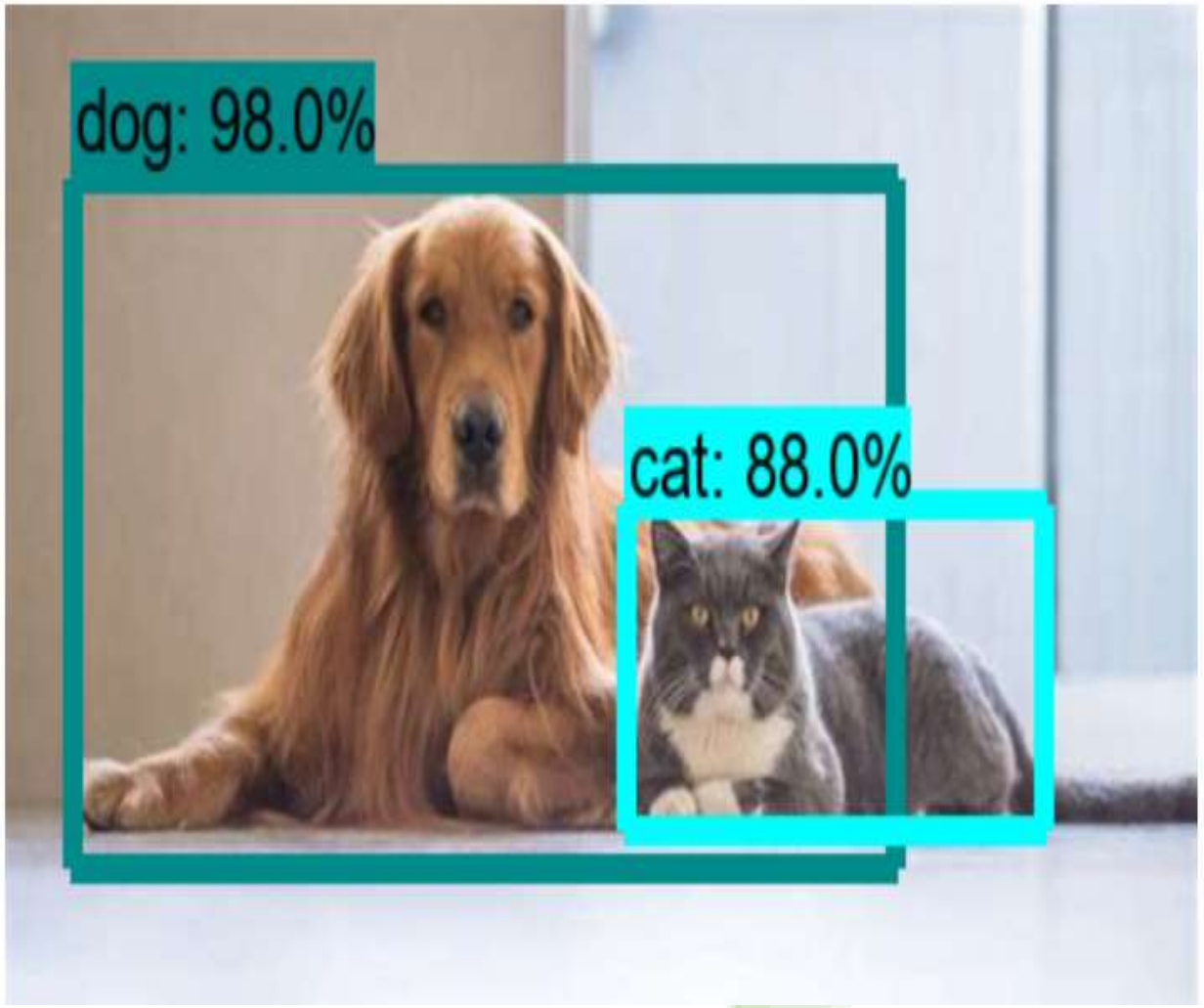
- Open-source simulator to generate realistic simulations.
- Can simulate weather conditions , vehicles , pedestrians and multiple sensors .
- Can be platform for developing , testing and validating autonomous driving algorithms in virtual environment.

More about CARLA

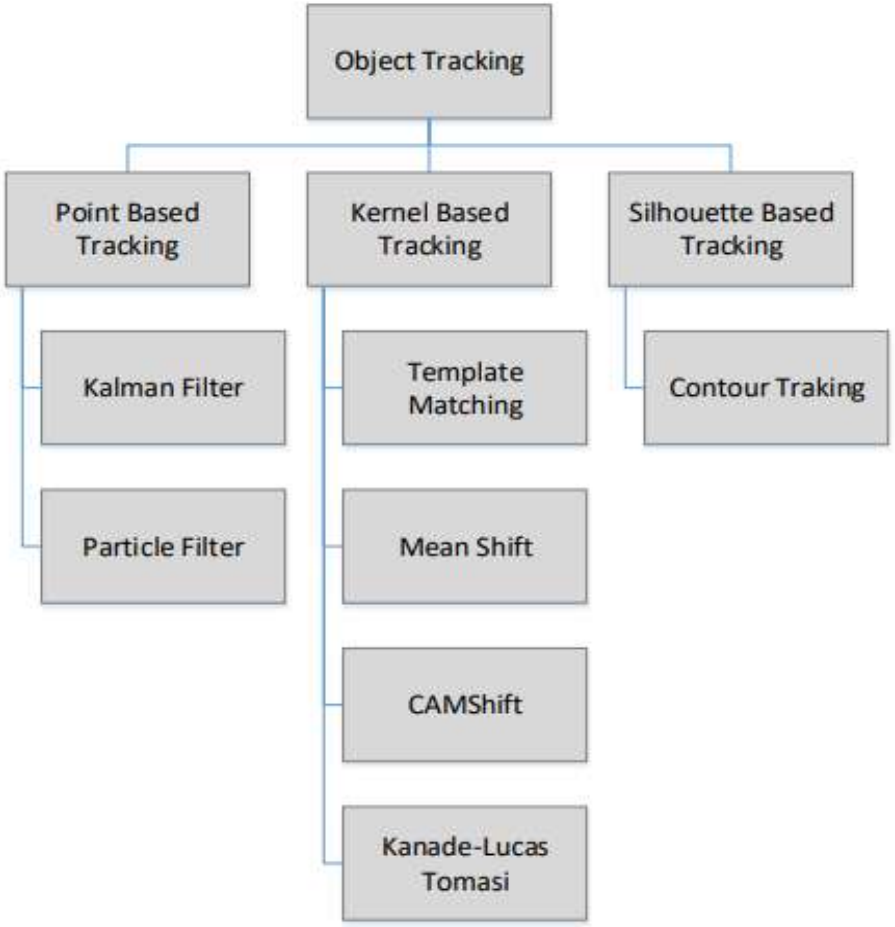
- **Sensors**: Carla offers a range of sensors to simulate like LIDAR , rada, and GPS along with wide range of cameras.
- **Multi object tracking (MOT)** : can implement multiple object tracking.
- **Environment** :The environment is highly customisable and controllable , making it apt for testing in wide range of real scenarios.
- **Ground truth** : Carla provides ground truth data to evaluate models.

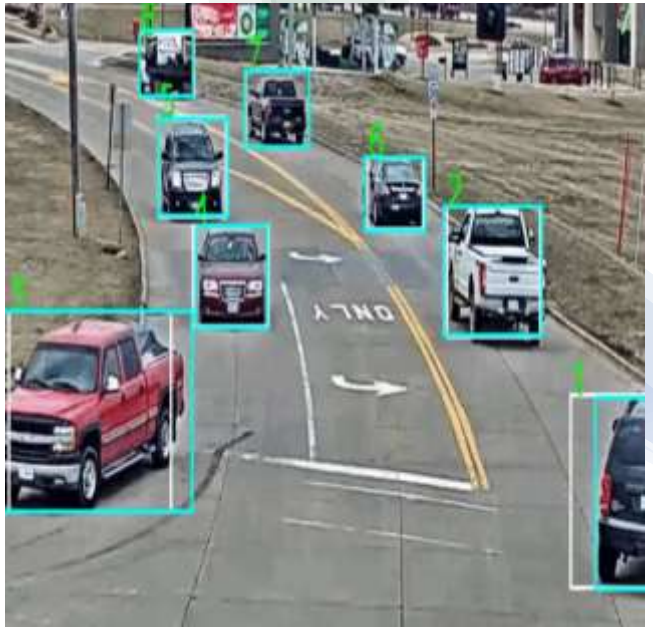
Object Detection

- Computer vision technique to detect objects
- There are one-stage and two stage models



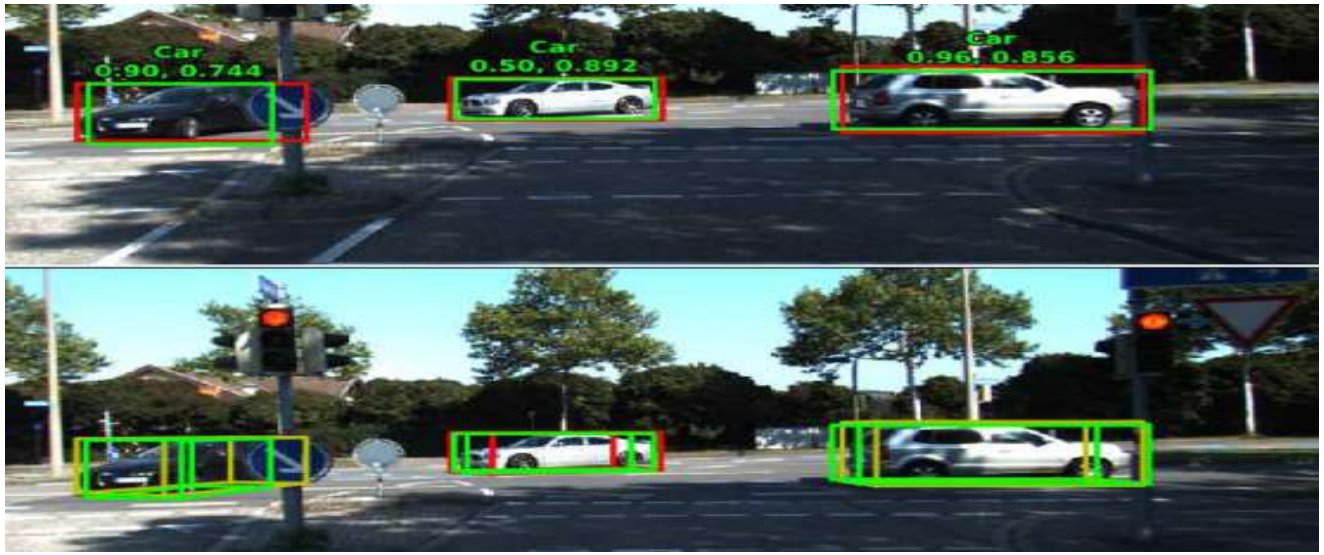
Object Tracking





2D vs 3D Tracking

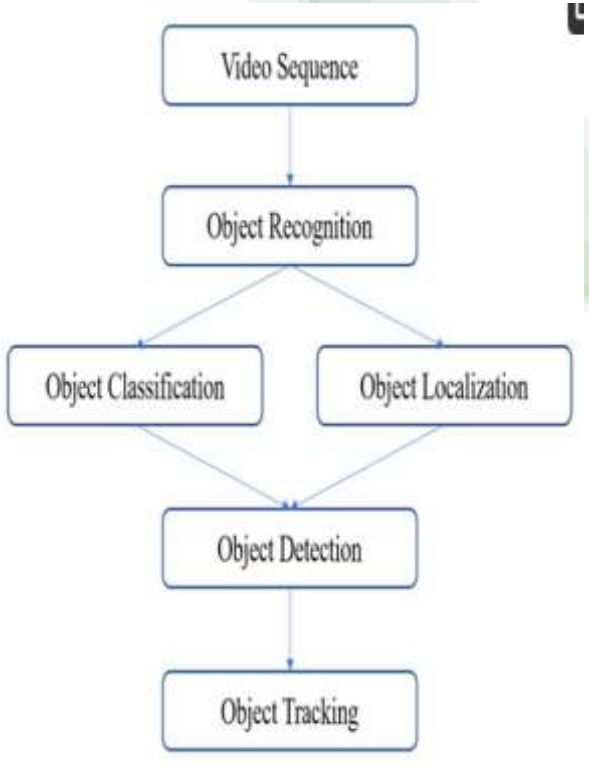
- **2D tracking** :Opting for 2D tracking for its speed and efficiency.
- **Monocular Motion**: utilizing monocular camera is to capture motion of the object . 3D tracking can be done with monocular camera , but at reduced cost of efficiency
- **Depth complexity** :3D tracking required more data like depth and orientation and more sensors like LIDAR , GPS which makes it computationally expensive
- **Robustness**: 2D is more robust when depth data is not reliable .



Aims & objectives

Aim

The goal of this research is to create a real-time vehicle tracking system employing camera image analysis in the Carla simulator using YOLOv8 and Deep Sort .



Objectives

Train the YOLO model on the custom dataset and generate best weights.

We will be using YOLO to extract the features from the raw data followed by Deep Sort to track objects over time.

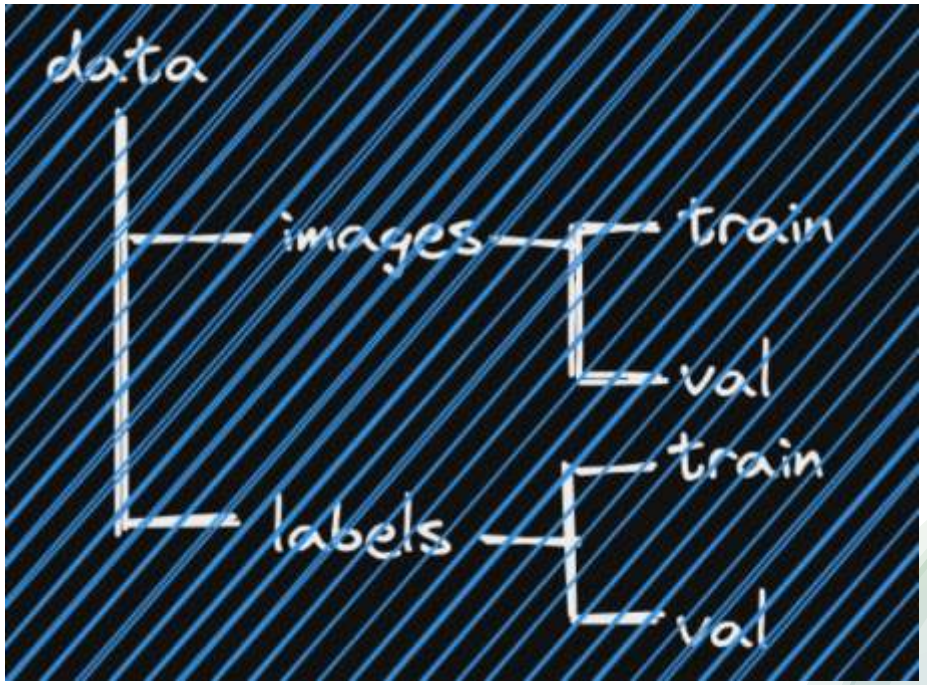
Once the tracking algorithm is developed, we will be integrating the developed model with the Carla simulator to validate model in real time scenarios.

Ground truth generated from CARLA can be used to evaluate the performance of the tracking model.

Technicalities

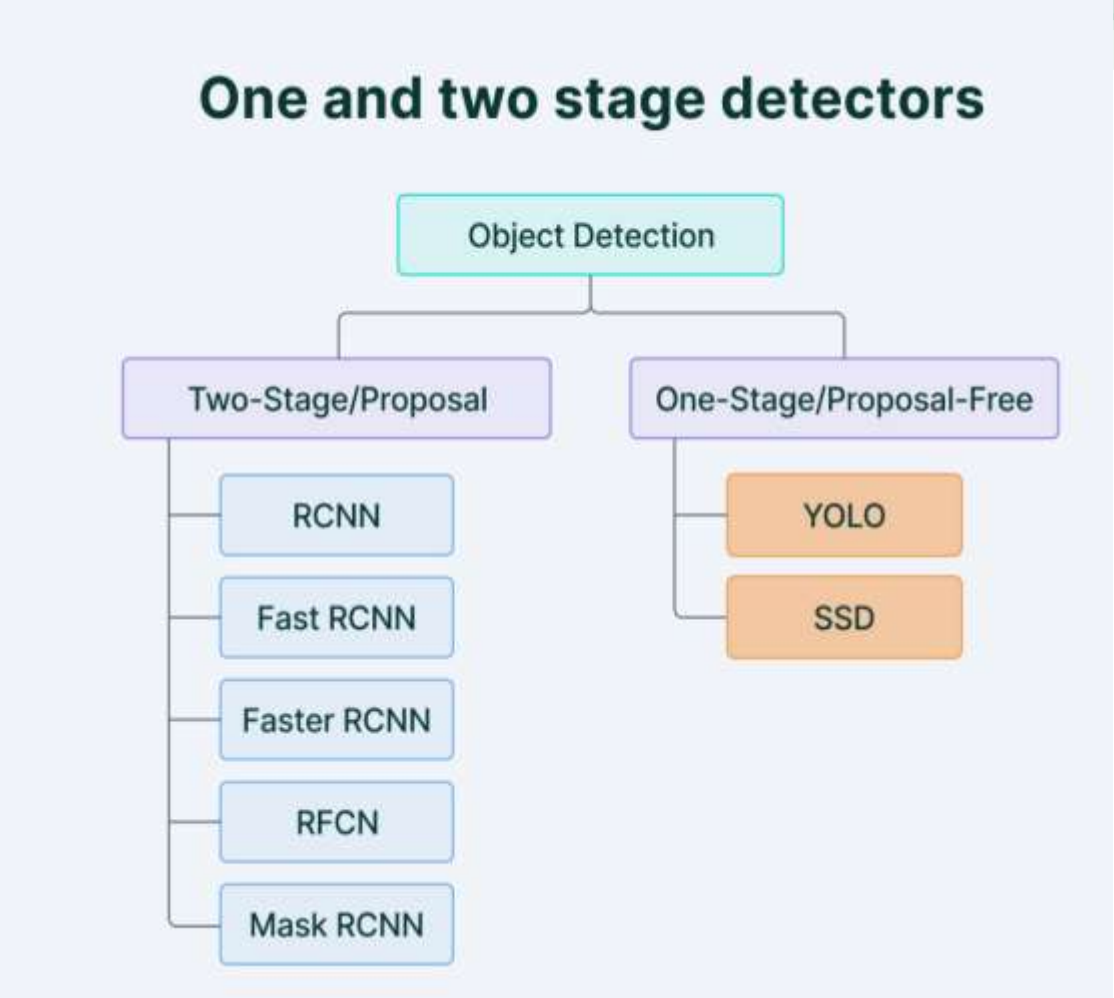
Dataset and processing

- Carla data set from Kaggle , generated by Roboflow.
- 10 different classes to train from like cars, trucks , Bikes, motobikes and more.
- Around 1800 images (train + validation) all the data is modified as per YOLO standards.

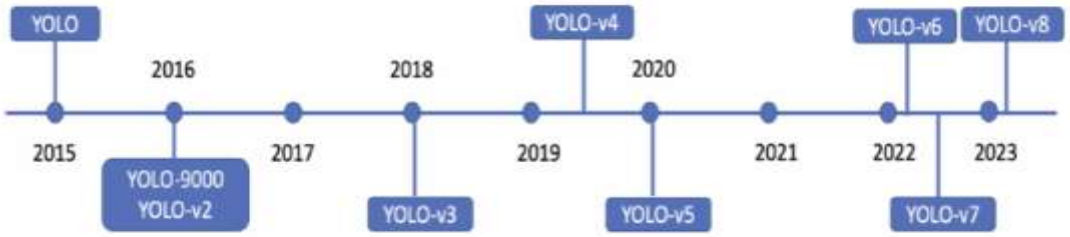


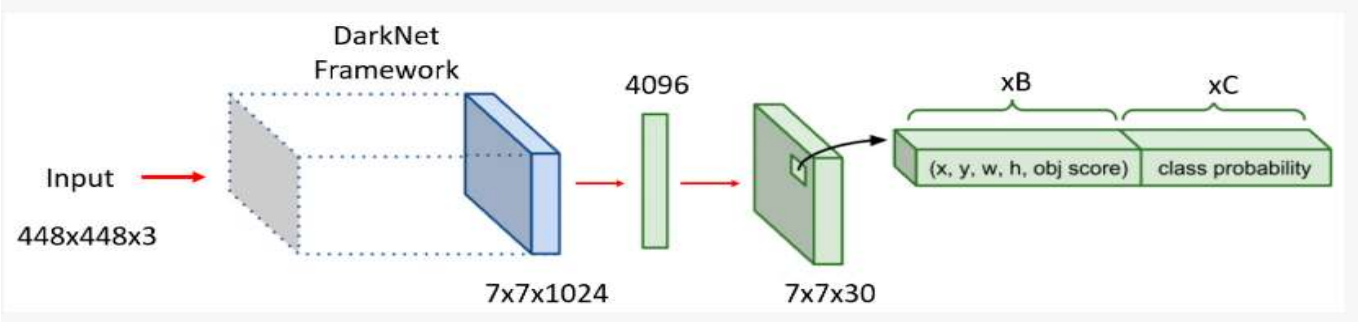
Detection models

- Single stage detection
- Two stage detection
- YOLO ,SSD and Faster RCNN are popular models



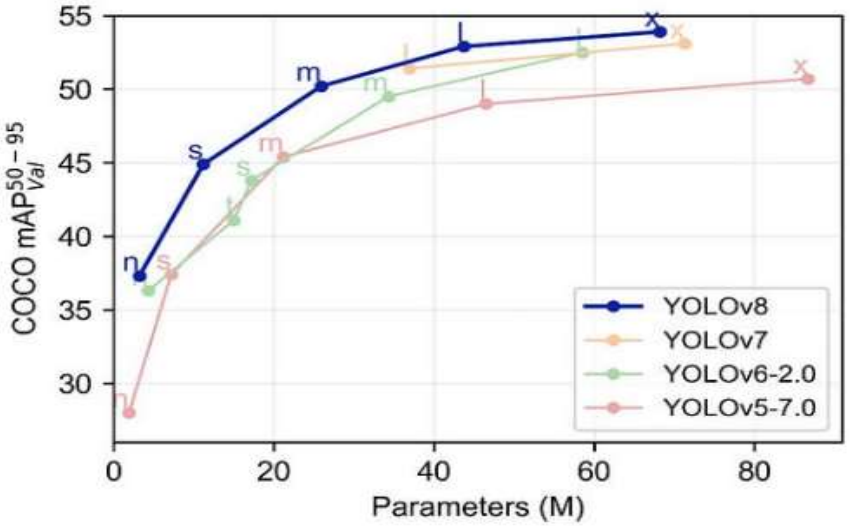
Why YOLO (You Only Look Once)





More about YOLOV8

- Latest Version of Ultralytics YOLO.
- Fast, accurate, and less expensive
- Object detection and tracking, instance segmentation, image classification and pose estimation.



Model	size (pixels)	mAP^{val} 50-95	Speed CPU ONNX (ms)	Speed A100 TensorRT (ms)	params (M)	FLOPs (B)
YOLOv8n	640	37.3	80.4	0.99	3.2	8.7
YOLOv8s	640	44.9	128.4	1.20	11.2	28.6
YOLOv8m	640	50.2	234.7	1.83	25.9	78.9
YOLOv8l	640	52.9	375.2	2.39	43.7	165.2
YOLOv8x	640	53.9	479.1	3.53	68.2	257.8

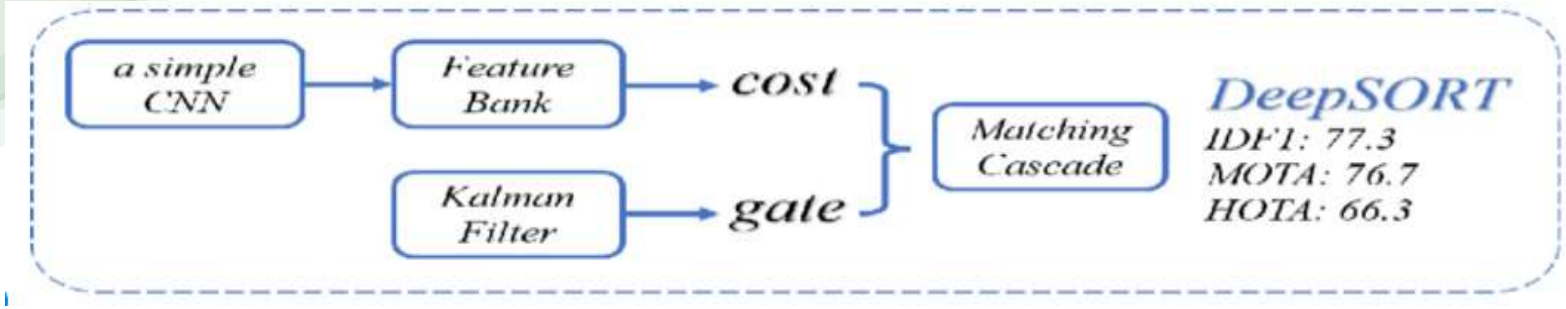
Tracking algorithms

- SORT
- Deep SORT
- Fair MOT
- OC SORT
- Deep OC SORT
- Byte SORT
- Strong SORT
- Strong SORT++

Why DeepSORT

- Extension of original SORT(Simple Online Real time Tracking)
- DeepSORT uses a better association metric that combines both motion and appearance descriptors.
- DeepSORT can be defined as the tracking algorithm which tracks objects not only based on the velocity and motion of the object but also the appearance of the object.

DeepSORT Architecture



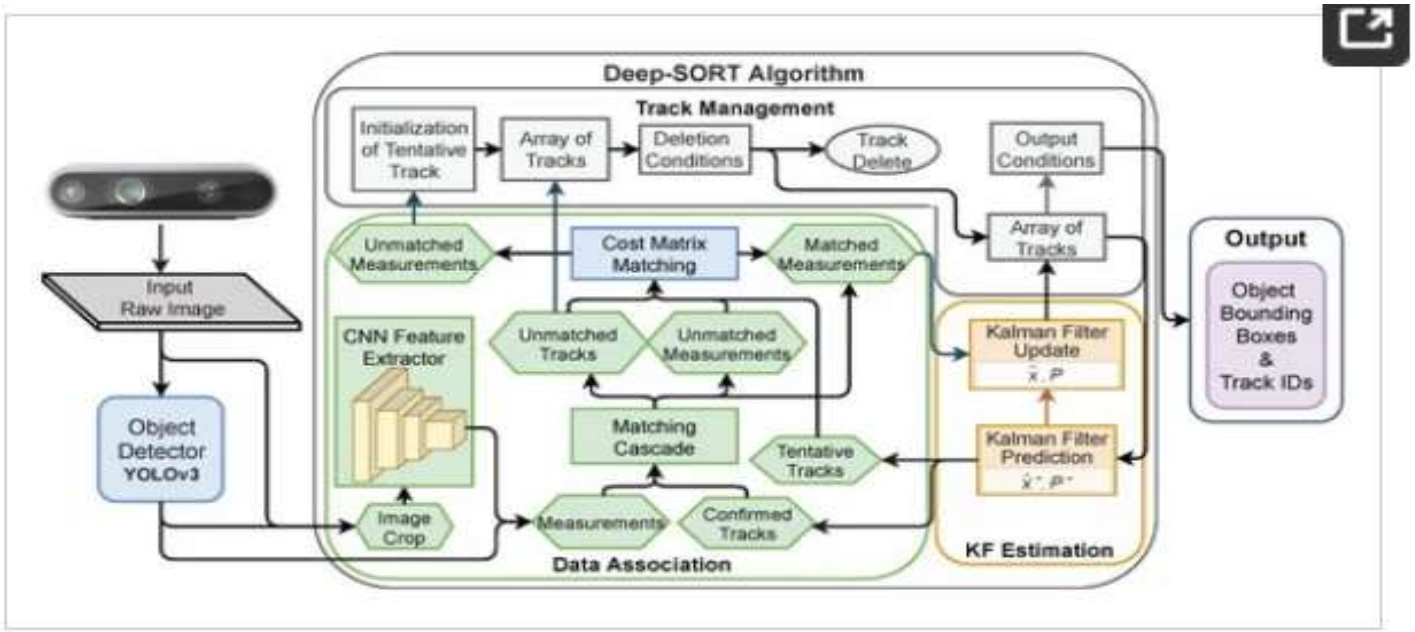
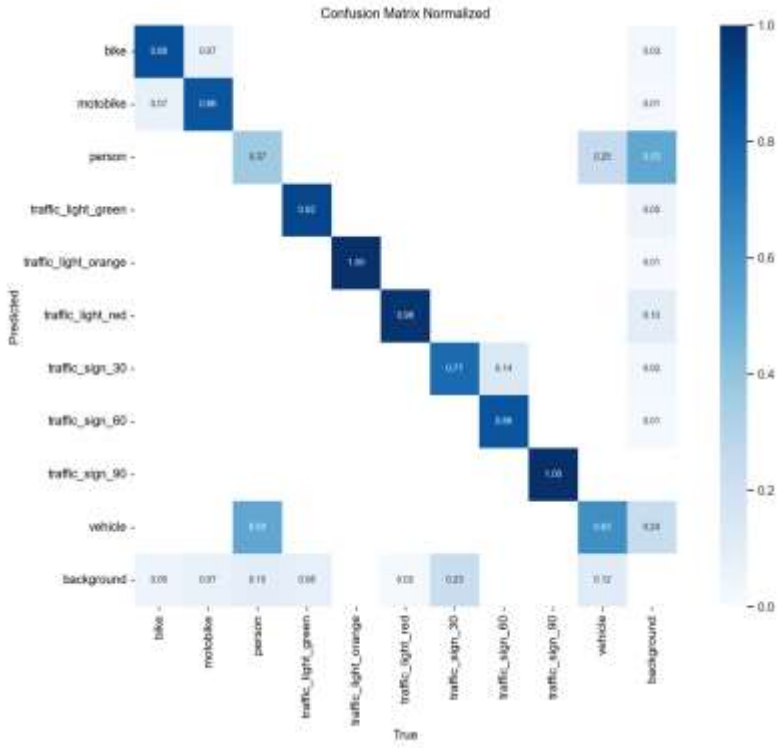
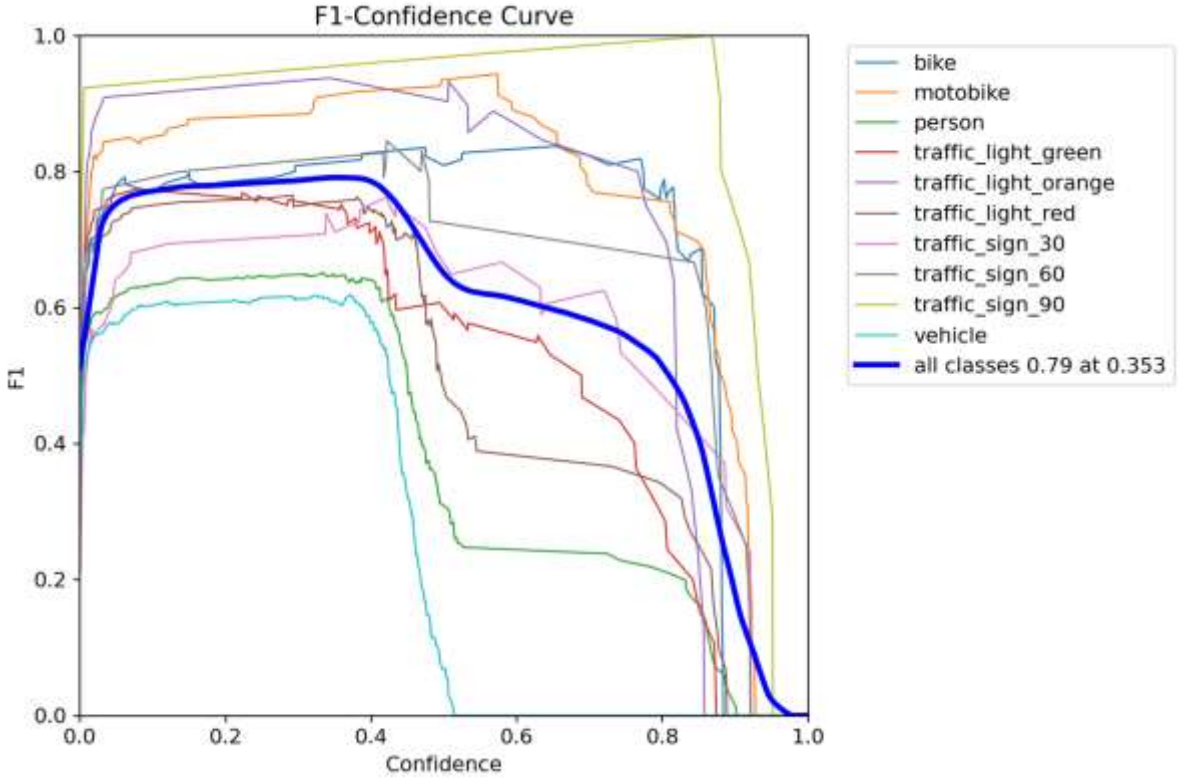


Figure 3. Overview of the object tracking Deep-SORT algorithm.

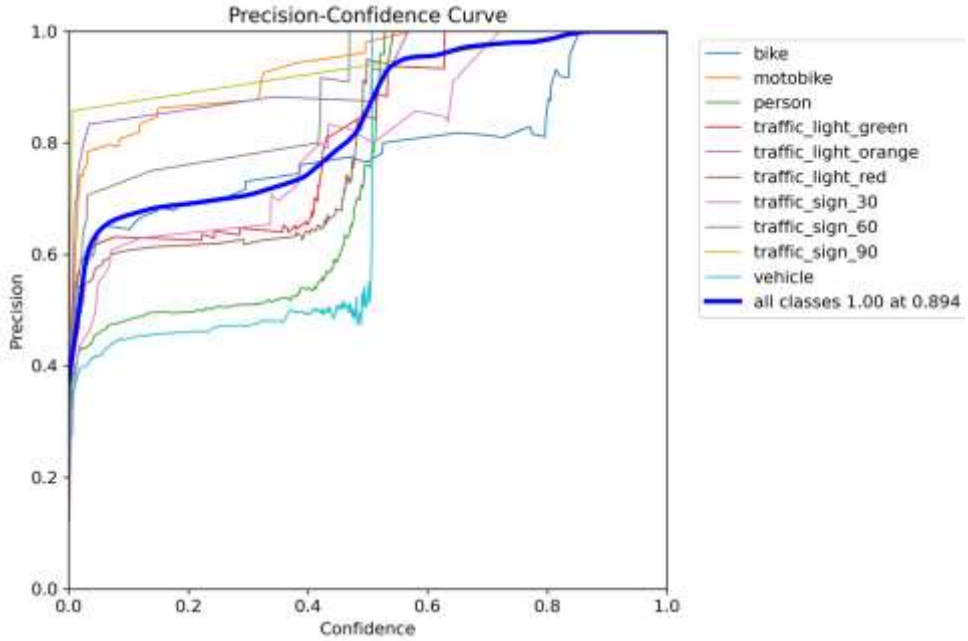
RESULTS

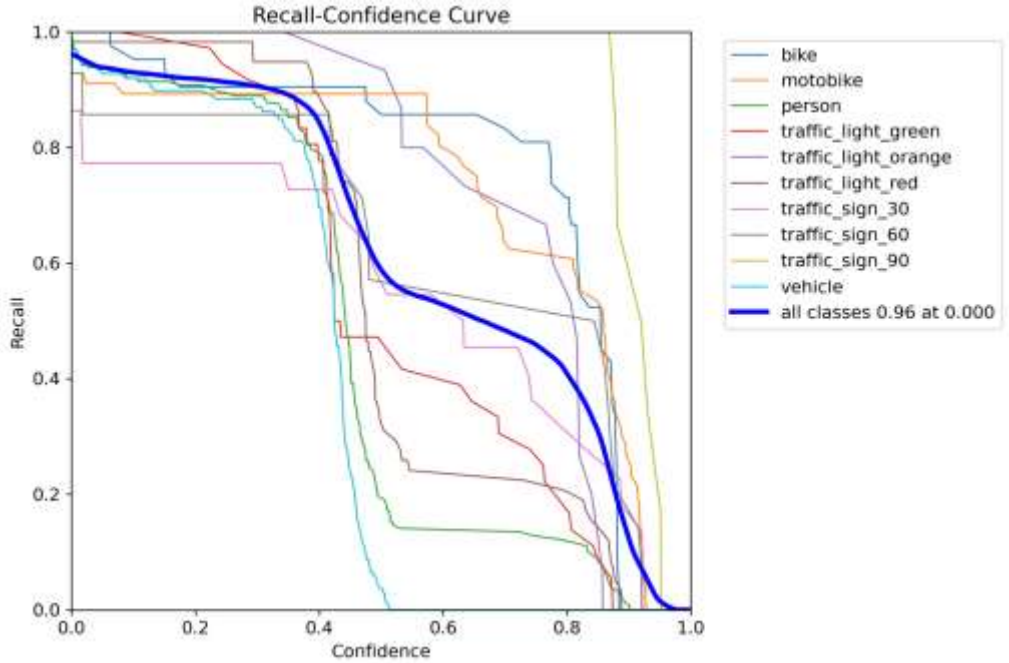
YOLO results from training

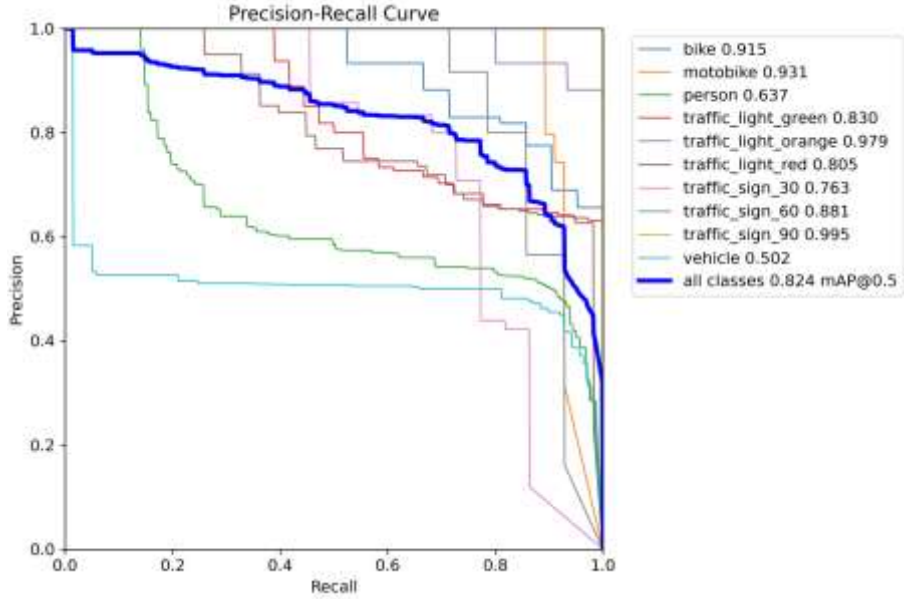




YOLO PLOTS


Precision-Confidence Curve
Precision
Confidence
0.0
0.2
0.4
0.6
0.8
1.0
bike
motobike
person
traffic_light_green
traffic_light_orange
traffic_light_red
traffic_sign_30
traffic_sign_60
traffic_sign_90
vehicle
all classes 1.00 at 0.894


Recall-Confidence Curve
Recall
Confidence
0.0
0.2
0.4
0.6
0.8
1.0
bike
motobike
person
traffic_light_green
traffic_light_orange
traffic_light_red
traffic_sign_30
traffic_sign_60
traffic_sign_90
vehicle
all classes 0.96 at 0.000


Precision-Recall Curve
Precision
Recall
0.0
0.2
0.4
0.6
0.8
1.0
bike 0.915
motobike 0.931
person 0.637
traffic_light_green 0.830
traffic_light_orange 0.979
traffic_light_red 0.805
traffic_sign_30 0.763
traffic_sign_60 0.881
traffic_sign_90 0.995
vehicle 0.502
all classes 0.824 mAP@0.5

YOLO validation images

YOLO on CARLA Simulator

Object label

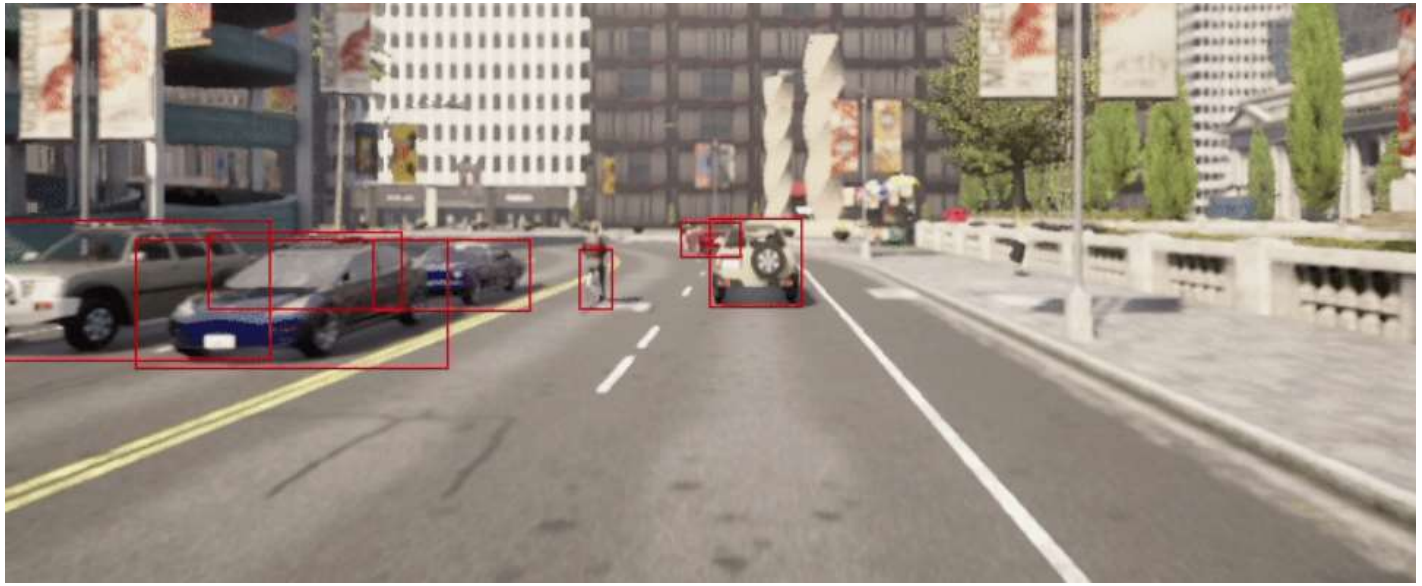
confidence score

Bounding box in xyxy format

Deep SORT Output

In progress

- Ground truth values were generated for tracking model.
- To estimate the performance metrics MOTA and MOTP , need to use the generated ground truth values.



Future Scope

- Faster RCNN + Deep SORT.
- Better model of tracking like StrongSORT ++ or Transformers can be implemented to improve the over performance of the model

Video Link

- Youtube link : https://youtu.be/QvCtighMrE0

- OneDrive

https://universityofexeteruk-my.sharepoint.com/:v:/g/personal/bs571_exeter_ac_uk/EQtj6wPOXC9GlhE6UEFPuT4BIZIjPbe66wsxRvQWeh1wIQ?e=3u2NbF

THANK YOU