3D Object Detection for Autonomous Vehicles

Team 8
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What is the problem and why it is important?

Autonomous Vehicles are the significant part of the future **safe**, **green**, **affordable** and **accessible** transportation.

3 steps to have a level5 AV:

1. Perception
2. Prediction
3. Planning

Dataset:
Lyft Perception dataset kit
Sample dataset (573 MB)
Training dataset (58 GB)
Testing and Validation dataset (58 GB)

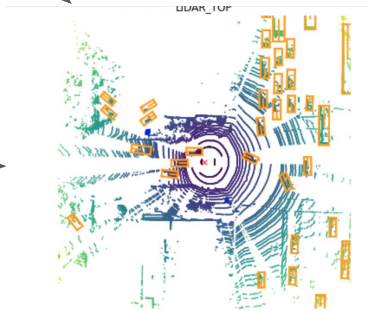
The goal is to build a model to percept objects around an AV and learn more about practical parts of deep learning.

Approach

YOLO (2D)

U-NET (3d point clouds)

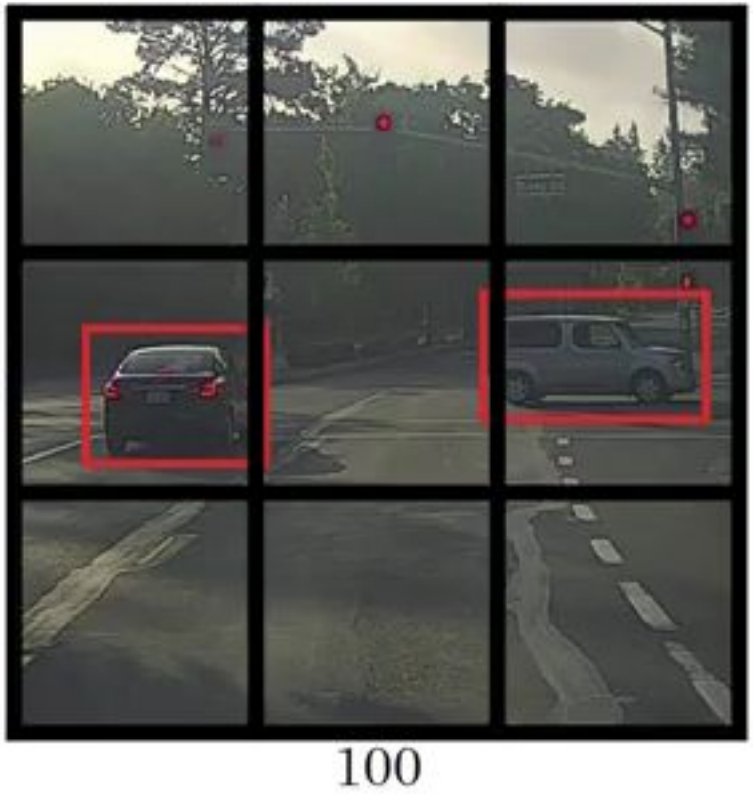
PSPNet-ResNet



YOLO

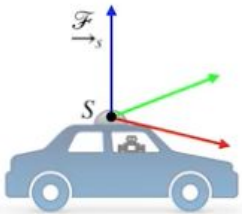
Data captured by camera (2D)

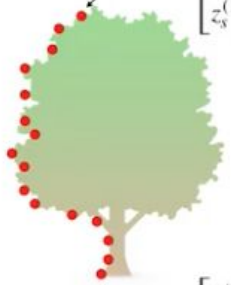
Fast with high accuracy but 2D



Point Clouds
Captured by Lidar

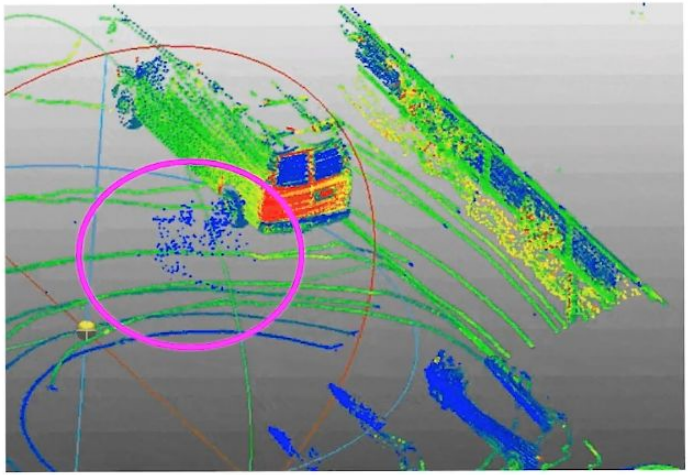
$$\mathbf{P}_s = \begin{bmatrix} \mathbf{p}_s^{(1)} & \mathbf{p}_s^{(2)} & \cdots & \mathbf{p}_s^{(n)} \end{bmatrix} = \begin{bmatrix} x_s^{(1)} & x_s^{(2)} & \cdots & x_s^{(n)} \\ y_s^{(1)} & y_s^{(2)} & \cdots & y_s^{(n)} \\ z_s^{(1)} & z_s^{(2)} & \cdots & z_s^{(n)} \end{bmatrix}$$



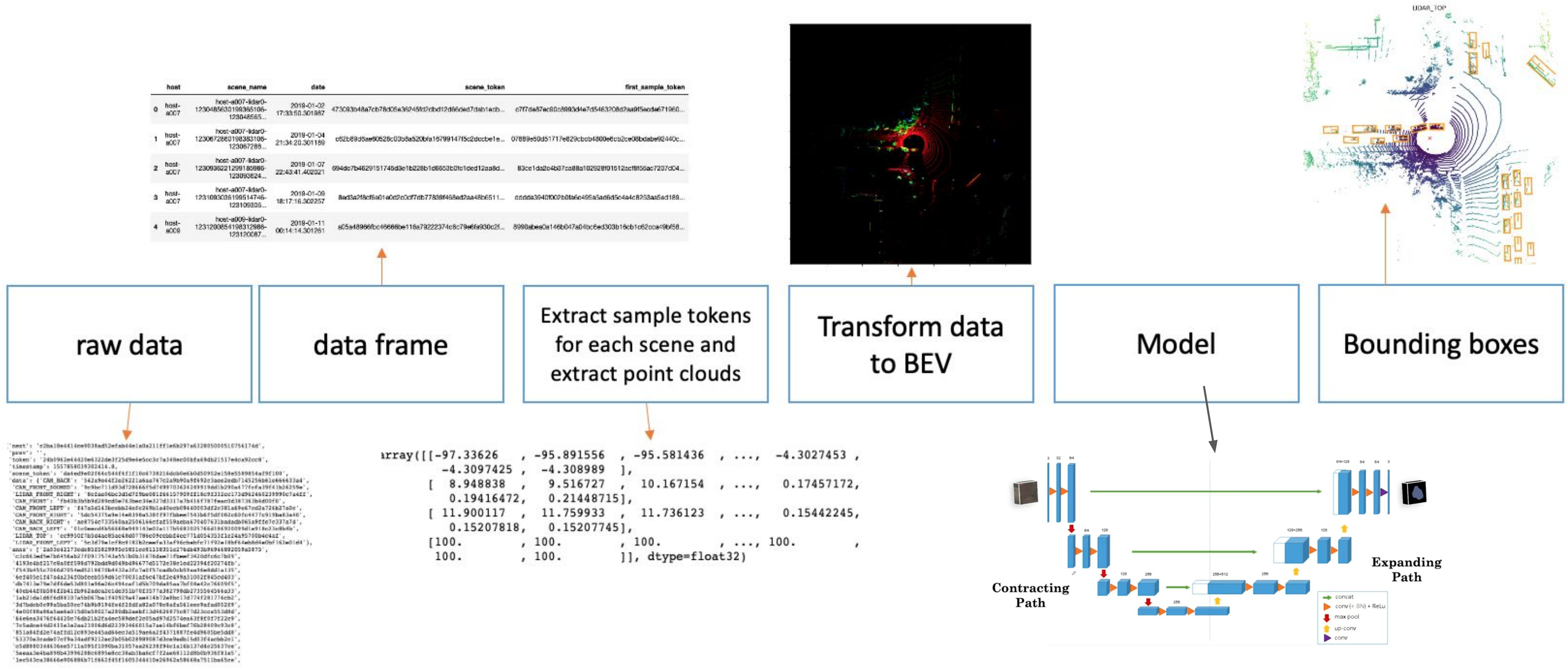


$$\mathbf{p}_s^{(1)} = \begin{bmatrix} x_s^{(1)} \\ y_s^{(1)} \\ z_s^{(1)} \end{bmatrix}$$

$$\mathbf{p}_s^{(n)} = \begin{bmatrix} x_s^{(n)} \\ y_s^{(n)} \\ z_s^{(n)} \end{bmatrix}$$



U-Net


host
scene_name
date
scene_token
first_sample_token
raw data
data frame
Extract sample tokens for each scene and extract point clouds
Transform data to BEV
Model
Bounding boxes
array([[-97.33626 , -95.891556 , -95.581436 , ..., -4.3027453 ,
-4.3097425 , -4.308989],
[8.948838 , 9.516727 , 10.167154 , ..., 0.17457172,
0.19416472, 0.21448715],
[11.900117 , 11.759933 , 11.736123 , ..., 0.15442245,
0.15207818, 0.15207745],
[100. , 100. , 100. , ..., 100. ,
100. , 100.]], dtype=float32)
Contracting Path
Expanding Path

PSPNet-ResNet Model

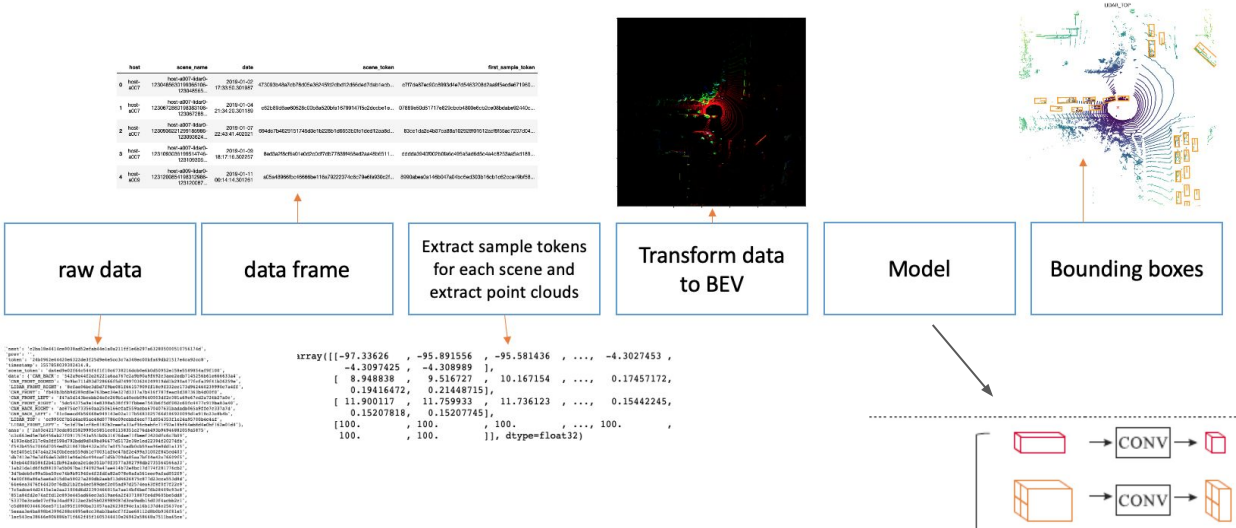
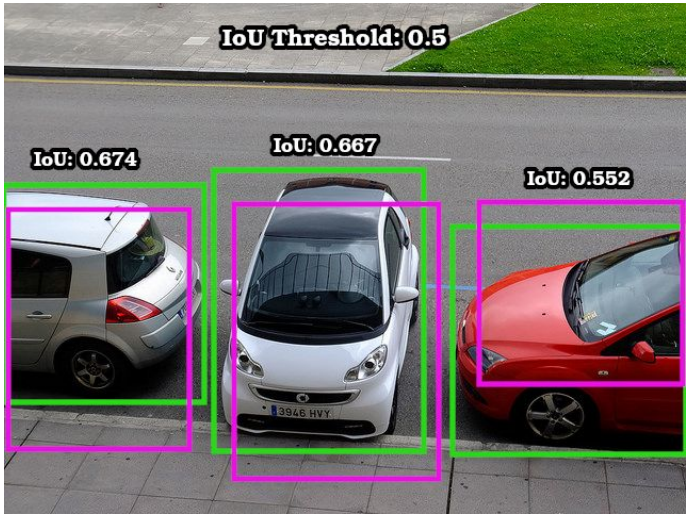


Fig 2. Architecture of Pyramid Scene Parsing Network (PSPNet)[1]

[1] Pyramid Scene Parsing Network by Zhao et al, https://arxiv.org/abs/1612.01105

Evaluation and Findings

Model	Number of Epochs	MAP	MAP - car	MAP - pedestrian	MAP - animal
U-Net	1	0.09	0.46	0.00021	0.0
U-Net	15	0.01	0.50	0.0027	0.0
PSPNet-ResNet	15	0.09	0.71	0.0134	0.0



Conclusions

Cloud points gathered from Lidar sensor are very important in AV 3D object detection:

- They do not get affected by adverse weather conditions
- They do not rely on light for object detection

But:

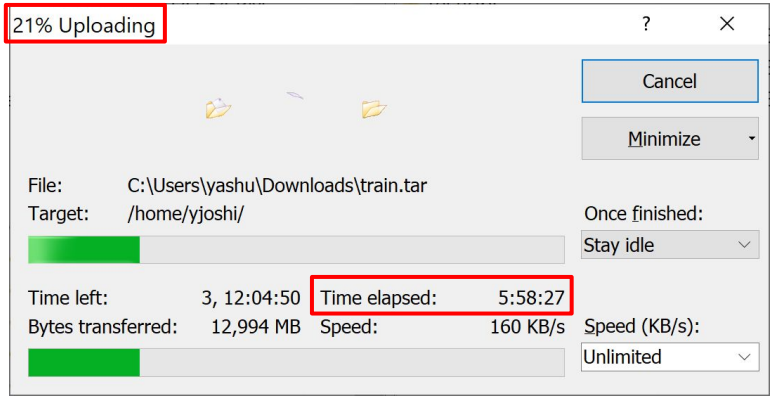
They are not reliable for detecting small objects such as animals, or any smaller class in the training set.

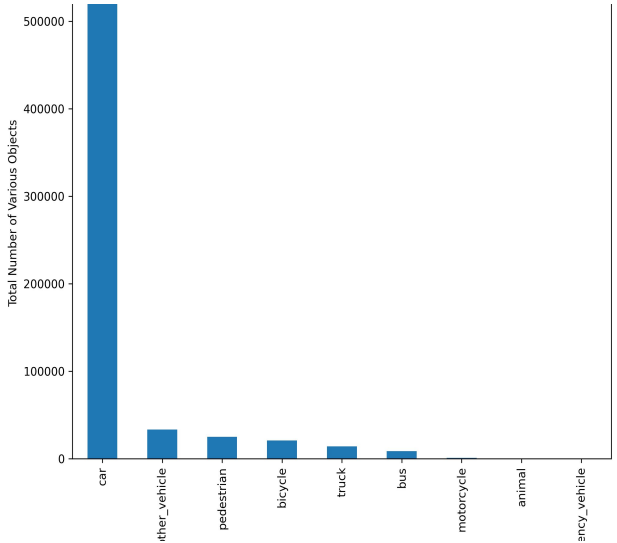
Possible Solutions and Future Works

- Using both images and point clouds to detect objects (They are complementary)
- Having separate pretrained model for each class such as animals, pedestrians,...and fine tune model with autonomous vehicle data
- Training model with more epochs
- Using ensemble models (combination of various trained model) for prediction

Problems

- Related to data:
  - Downloading Dataset
  - Understanding the data
  - Transferring data to GL
  - Installing some of the packages
  - The dataset we have is highly imbalance.





First two scenes of the data: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  'last_sample_token': '5ec01e4634ca91751311eaafb45a9196ba8616bf05edc85593aff158db653a34',
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Information inside one sample


```
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 'timestamp': 1557858039302414.8,
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  'CAM_FRONT_ZOOMED': '9c9bc711d93d728666f5d7499703624249919dd1b290a477fcfa39f41b26259e',
  'LIDAR_FRONT_RIGHT': '8cfae06bc3d5d7f9be081f66157909ff18c9f332cc173d962460239990c7a4ff',
  'CAM_FRONT': 'fb40b3b5b9d289cd0e763bec34e327d3317a7b416f787feac0d387363b4d00f0',
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```

Problems

- Related to models:
  - VoxelNet [2] Implementation
  - Models failed to predict the small objects, for example pedestrians.

Average per class mean average precision = 0.09416772164775028
('animal', 0.0)
('bicycle', 0.0012601587242598114)
('bus', 0.0537961585349724)
('car', 0.5057703547292053)
('motorcycle', 0.0010937927262783702)
('other_vehicle', 0.18122473782388235)
('pedestrian', 0.002728630097923848)
('truck', 0.007467940545480116)

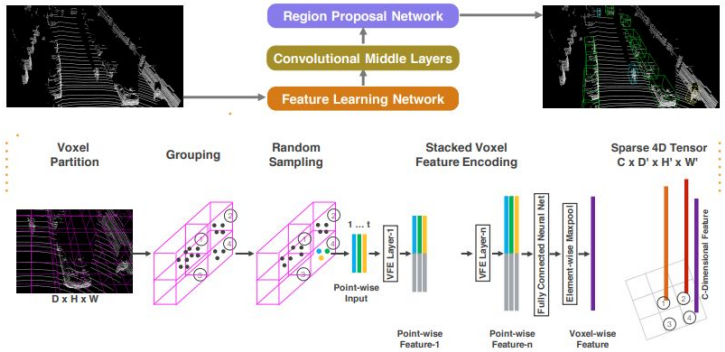


Fig 2. Architecture of VoxelNet[2]

[2] VoxelNet: End-to-End Learning for Point Cloud Based 3D Object Detection by Zhou et al, https://arxiv.org/abs/1711.06396

What we learned
Our Journey...

Object detection using torchvision

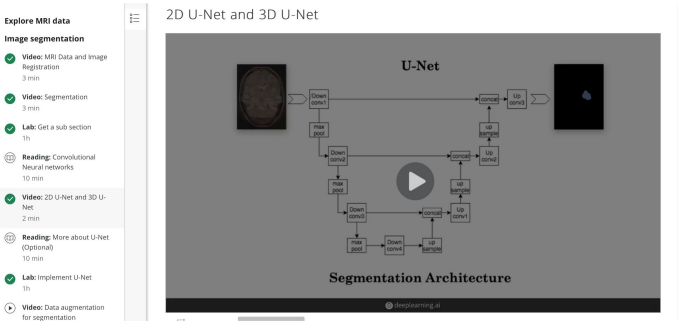
Greg Teichert
CSCAR Consultant

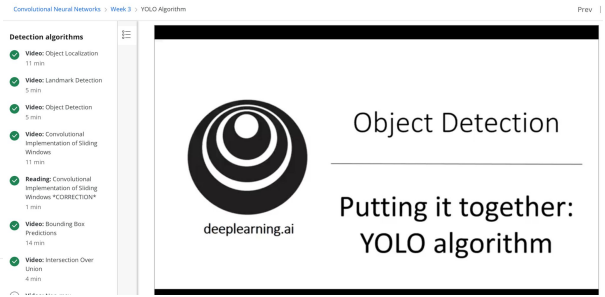
Perform Real-Time Object Detection with YOLOv3

by Coursera Project Network

Congratulations!

You've successfully completed **Perform Real-Time Object Detection with YOLOv3**!





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by DeepLearning.AI

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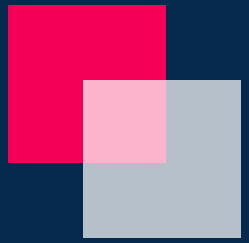

Questions?