

AUTONOMOUS DRIVING PROPELLED BY DEEP LEARNING TECHNIQUES

Real-Time 3D Objects Detection and Segmentation based on Automotive LiDAR Technology

AUTHORS

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POSTGRADUATE COURSE

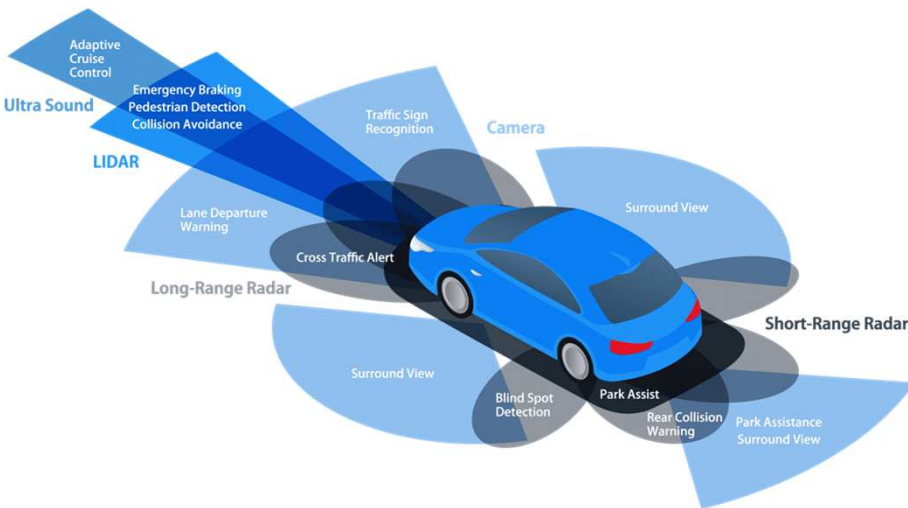
Artificial Intelligence with Deep Learning

Barcelona, 22.03.2023

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<https://github.com/pdymek/Workspace-AD-LiDAR>



github.com/pdymek/Workspace-AD-LiDAR

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main 1 branch 0 tags Go to file Add file Code

pdymek removed old md d224f38 20 minutes ago 194 commits

A0_Configuration	update hparams	22 minutes ago
B0_Dataset	Updated model	2 days ago
C0_Training	update hparams	22 minutes ago
C1_Inference	update hparams	22 minutes ago
D0_Modeling	create new md	yesterday
F0_Visualization	Merge branch 'main' of https://github.com/pdymek/Workspace-AD-LiD...	2 days ago
F1_Documentation	Merge branch 'main' of https://github.com/pdymek/Workspace-AD-LiD...	22 minutes ago
main.py	upd main2	2 days ago
readme.md	update hparams	30 minutes ago
readme.txt	Update readme.txt	2 days ago
requirements.txt	moved all to version 04	last month

readme.md

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UPC - Universitat Politècnica de Catalunya

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OUTLINE

1. MOTIVATION
2. GOAL
3. SETUP
4. PROJECT PLAN
5. DESIGN & DEVELOPMENT
6. EXPERIMENTAL RESULTS
7. CONCLUSIONS
8. REFERENCES



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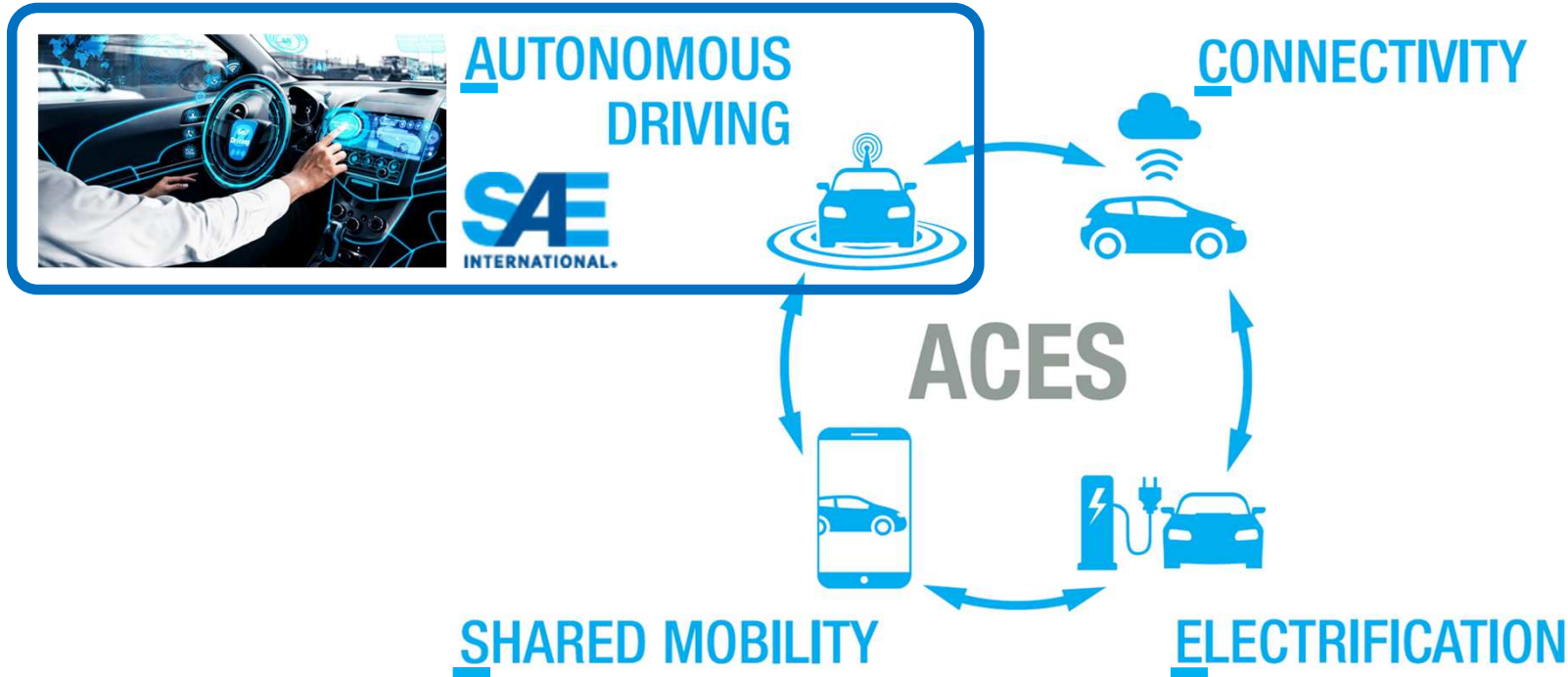
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1. MOTIVATION: AUTOMOTIVE INDUSTRY – THE NEW ERA OF MOBILITY

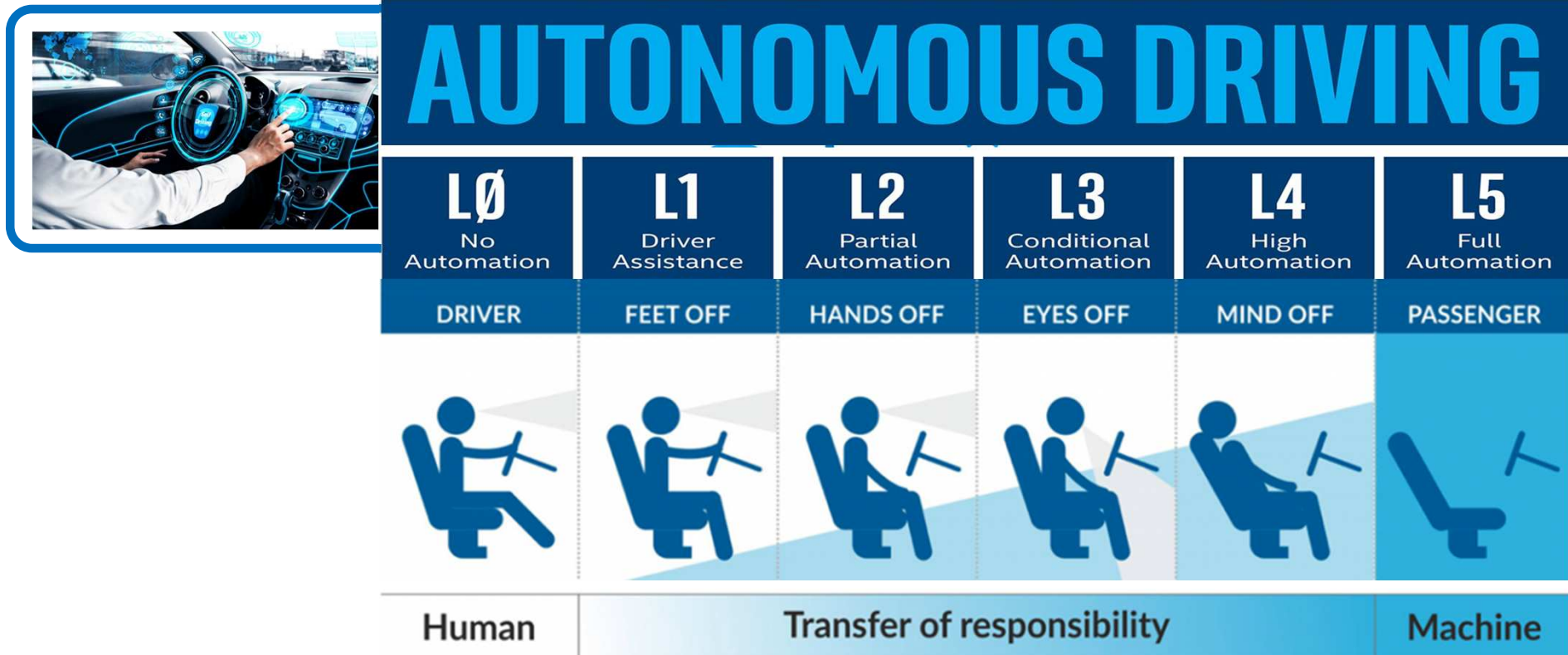
The automotive industry, in big momentum these days, is in the middle of a revolutionary transformation towards the Software Defined Vehicle (SDV). The pace of technological innovation is accelerating at an unprecedented rate by the coexistence of **four megatrends**:



Source: McKinsey&Co.

1. MOTIVATION: AUTOMOTIVE INDUSTRY – THE NEW ERA OF MOBILITY

The automotive industry, in big momentum these days, is in the middle of a revolutionary transformation towards the Software Defined Vehicle (SDV). The pace of technological innovation is accelerating at an unprecedented rate by the coexistence of **four megatrends**:



SAE J3016 defines up to five different levels of automation: from assisted (feet off) to autonomous (driver off). The more autonomy, the more sensors (e.g. RADAR, LiDAR, etc.) required to perceive the driving environment/context.



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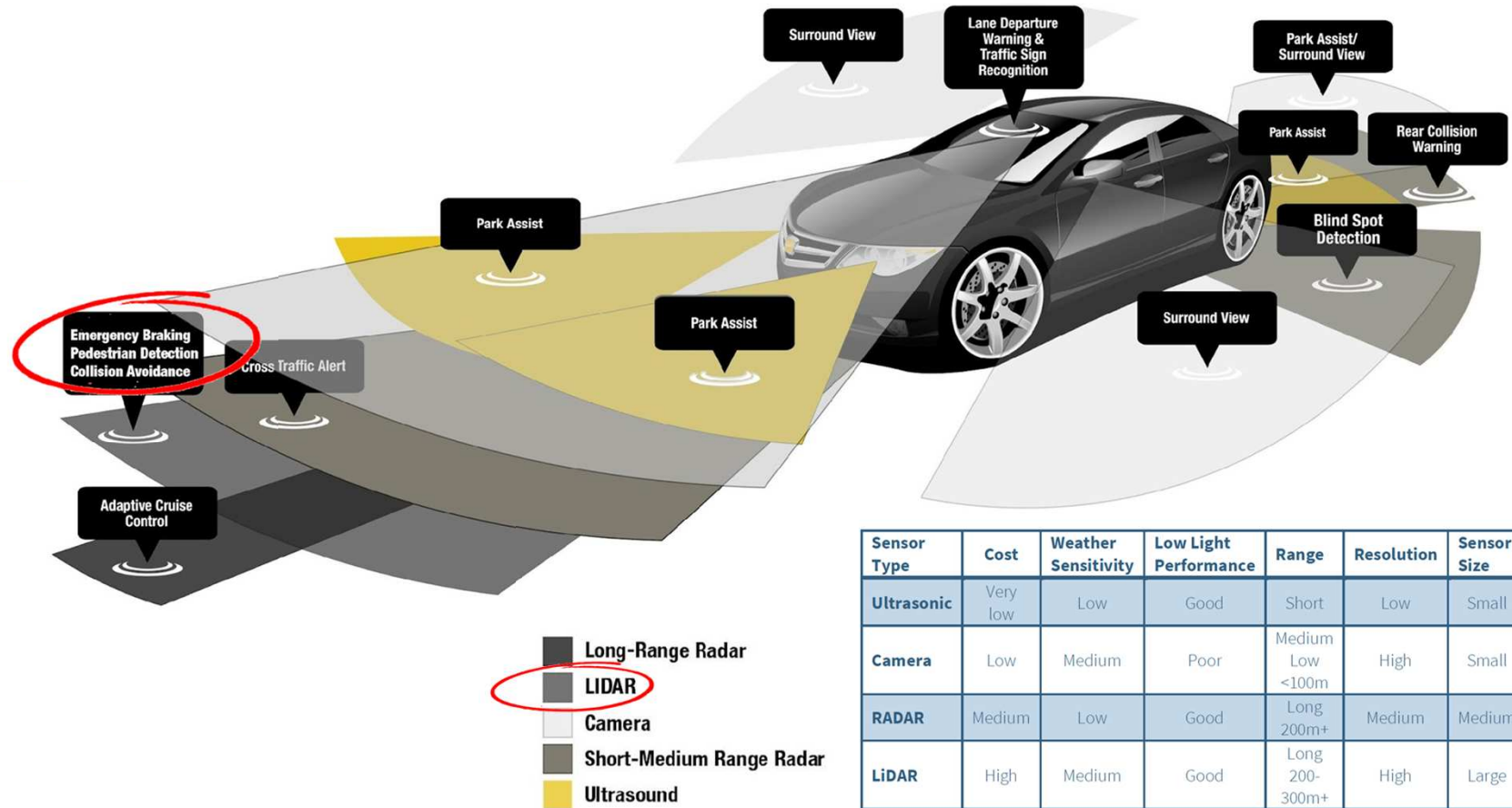
8. REFERENCES

2. GOAL: AUTOMOTIVE AUTONOMOUS DRIVING OBJECTS SEGMENTATION

The objective of the project is to implement a image/video segmentation solution based on LiDAR point cloud data targeting to be embedded in an automotive electronic control unit to support AD/ADAS applications.

AD/ADAS Features

- Traffic Sign Recognition
- Emergency Braking
- Pedestrian Detection
- Collision Avoidance
- Highway Pilot



Source: Strategy Analytics



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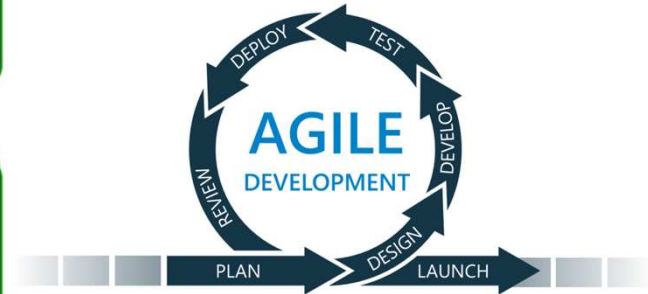
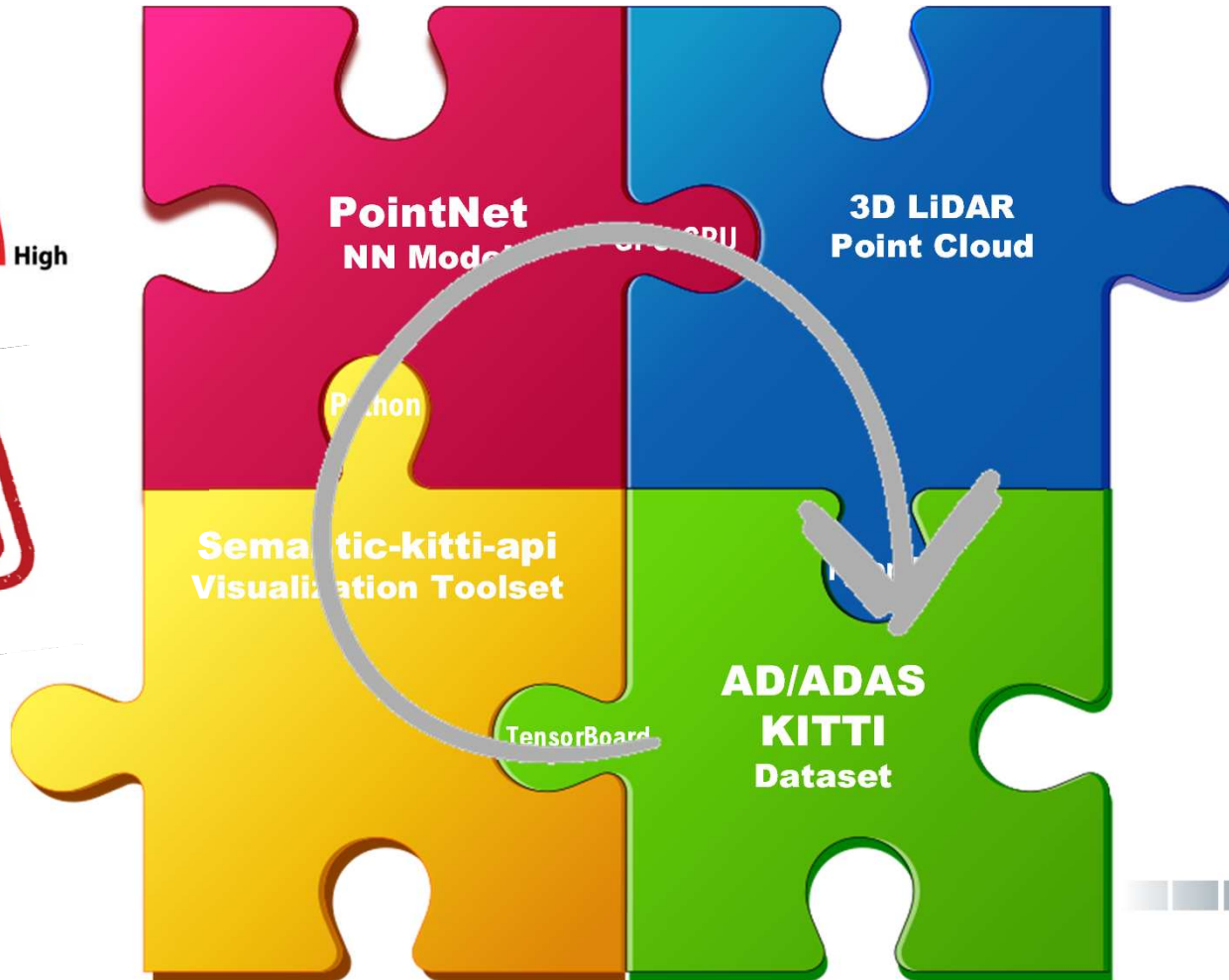
1. MOTIVATION
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3. SETUP: INTEGRATION OF TECHNOLOGIES – OUR BIGGEST CHALLENGE !

Connecting the dots...



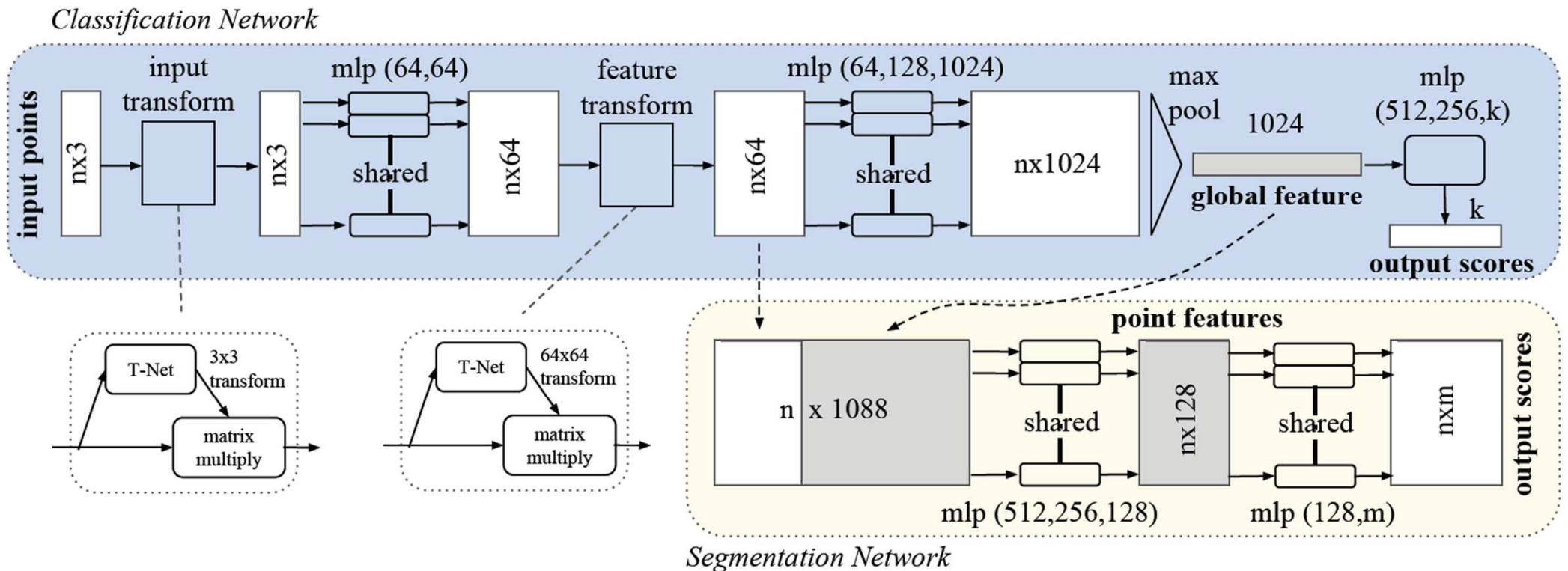
**CHALLENGE
ACCEPTED**



3. SETUP (1004): NEURAL NETWORK POINTNET MODEL

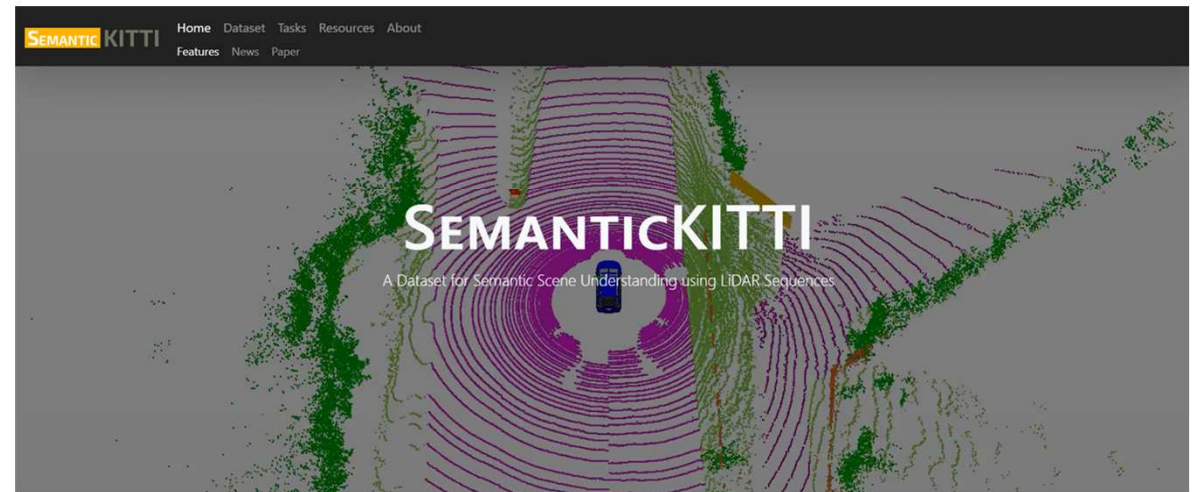
PointNet is one of the most well-know NN models for classification and segmentation based on point cloud.

Architecture



3. SETUP (2004): KITTI/SEMANTICKITTI DATASET

KITTI/SemanticKITTI is probably the most used dataset in autonomous driving research.



3. SETUP (3004): 3D POINT CLOUD LIDAR SENSOR

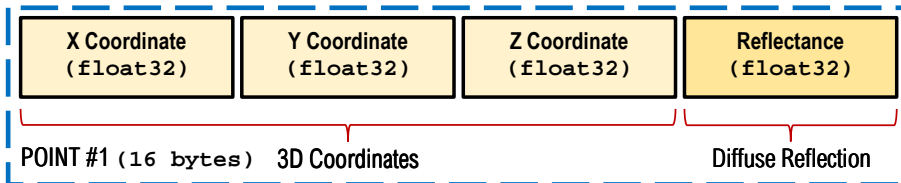
Technical Characteristics

- Velodyne HDL-64E LiDAR sensor
- Point cloud raw data captured at 10 Hz
- Around 120K points per frame

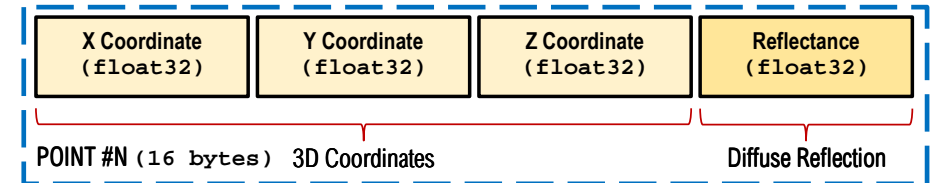


Velodyne Lidar
AN OUSTER COMPANY

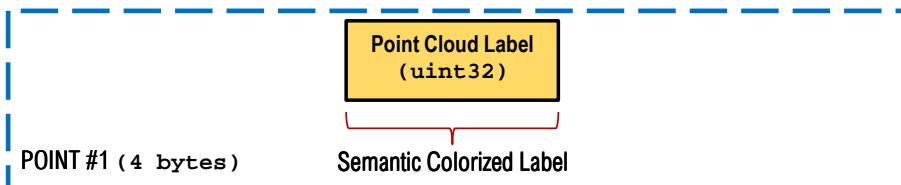
POINT CLOUD DATA FORMAT (.bin file)



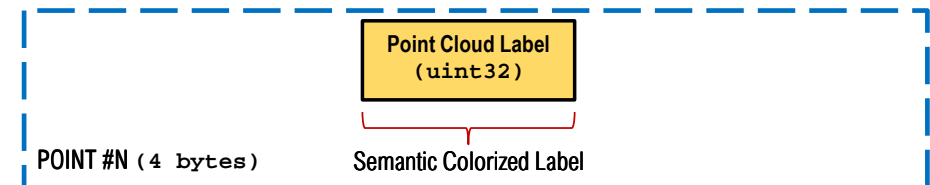
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LABEL & PREDICTION DATA FORMAT (.label file)

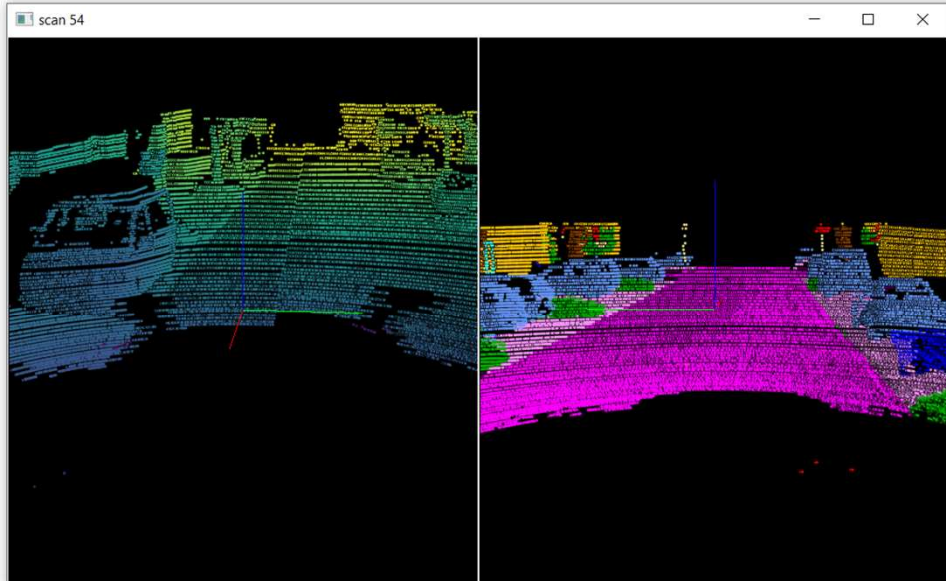
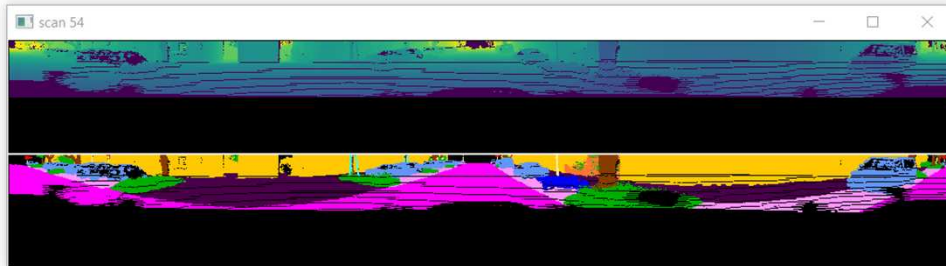


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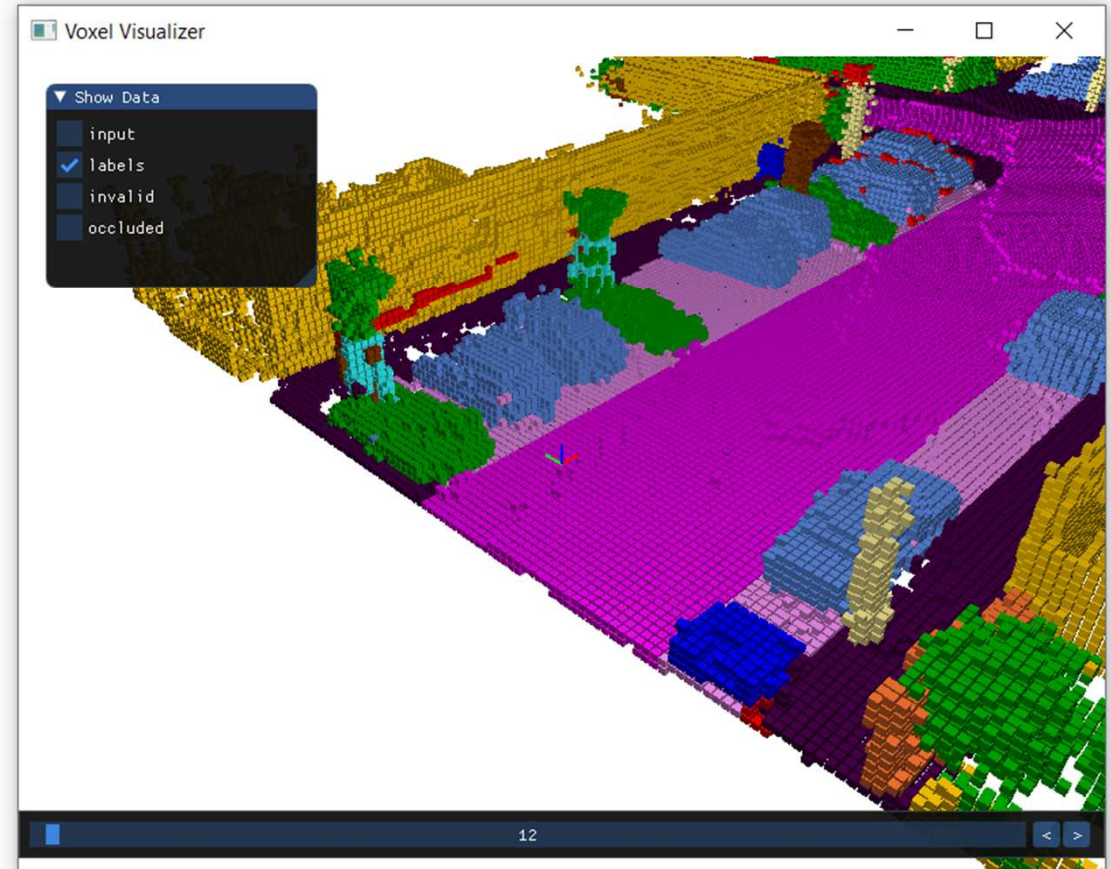


3. SETUP (4oo4): 3D POINT CLOUD VISUALIZATION

semantic-kitti-api toolset



Point Cloud View



Voxels View

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4. PROJECT PLAN – MILESTONES & ACHIEVEMENTS

Our journey...

PROCESS	JANUARY				FEBRUARY				MARCH			
	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
Topic research, goals & business requirements	100%											
Dataset selection & preparation		100%										
Model research & analysis		100%										
System architecture design / reevaluation				70%						30%		
Model development and hyper-parameter tuning					80%							
Model training, evaluation & performance						70%						
Model deployment								100%				
KPI visualisation										100%		
Project documentation & code delivery											100%	



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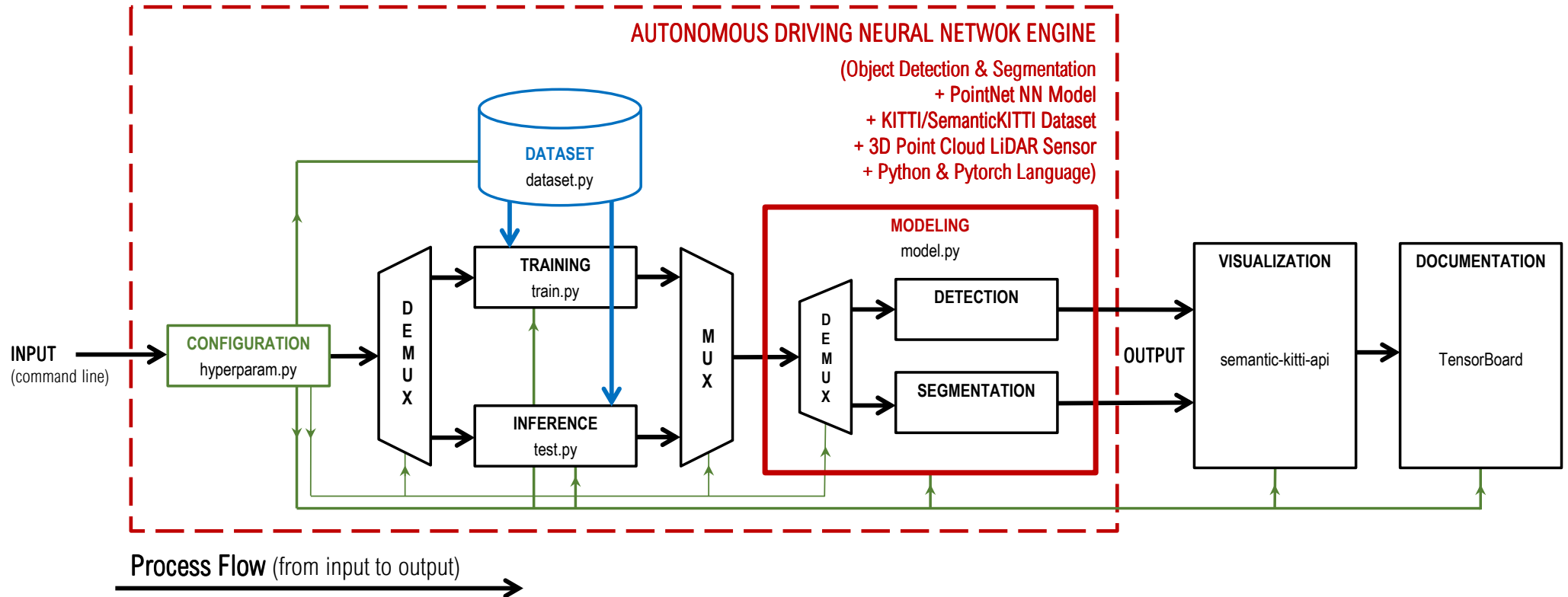
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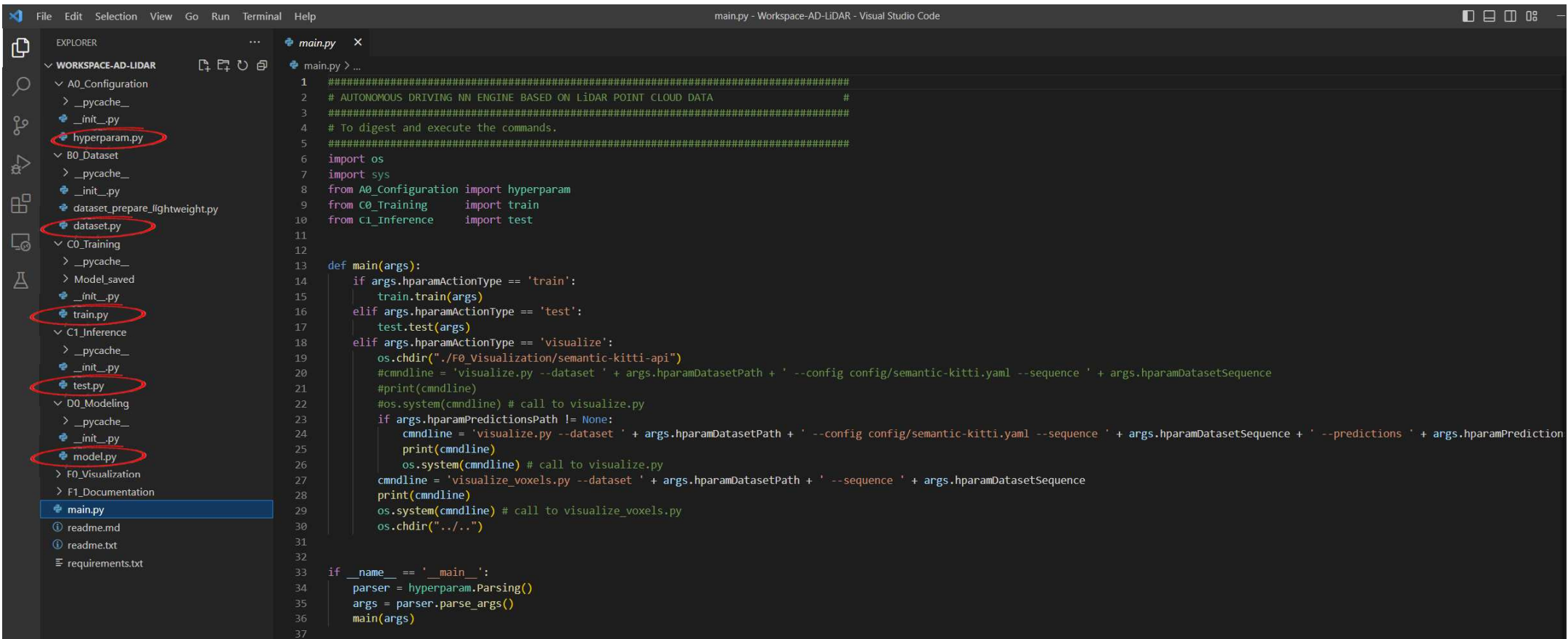
5. DESIGN & DEVELOPMENT (1004): SYSTEM ARCHITECTURE

Modular, flexible and scalable NN concept by design.



5. DESIGN & DEVELOPMENT (2004): SOFTWARE IMPLEMENTATION

The core technology developed is embedded in five key files addressing configuration, data handling, modeling, training and test.



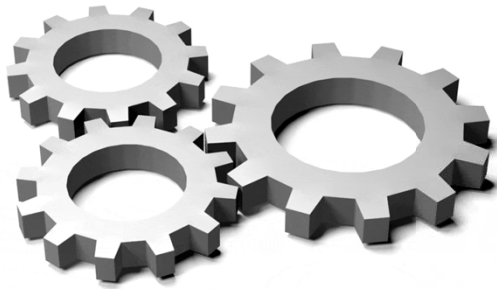
```

1 #####
2 # AUTONOMOUS DRIVING NN ENGINE BASED ON LIDAR POINT CLOUD DATA #
3 #####
4 # To digest and execute the commands.
5 #####
6 import os
7 import sys
8 from A0_Configuration import hyperparam
9 from C0_Training import train
10 from C1_Inference import test
11
12
13 def main(args):
14     if args.hparamActionType == 'train':
15         train.train(args)
16     elif args.hparamActionType == 'test':
17         test.test(args)
18     elif args.hparamActionType == 'visualize':
19         os.chdir("../F0_Visualization/semantic-kitti-api")
20         #cmdline = 'visualize.py --dataset ' + args.hparamDatasetPath + ' --config config/semantic-kitti.yaml --sequence ' + args.hparamDatasetSequence
21         #print(cmdline)
22         #os.system(cmdline) # call to visualize.py
23         if args.hparamPredictionsPath != None:
24             cmdline = 'visualize.py --dataset ' + args.hparamDatasetPath + ' --config config/semantic-kitti.yaml --sequence ' + args.hparamDatasetSequence + ' --predictions ' + args.hparamPredictionPath
25             print(cmdline)
26             os.system(cmdline) # call to visualize.py
27         cmdline = 'visualize_voxels.py --dataset ' + args.hparamDatasetPath + ' --sequence ' + args.hparamDatasetSequence
28         print(cmdline)
29         os.system(cmdline) # call to visualize_voxels.py
30         os.chdir("../..")
31
32
33 if __name__ == '__main__':
34     parser = hyperparam.Parsing()
35     args = parser.parse_args()
36     main(args)
37
  
```

5. DESIGN & DEVELOPMENT (3004): FROM TRAINING TO INFERENCE

The resultant trained model is saved as a **.pth file** to right after be used in the inference.

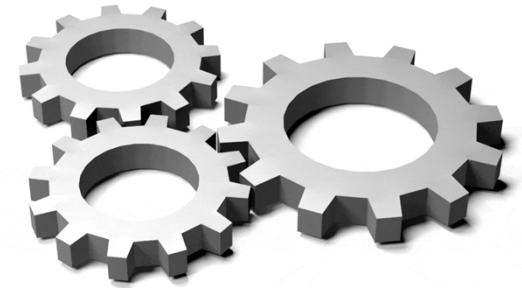
TRAINING & VALIDATION



.pth file (PointNet weights & biases)

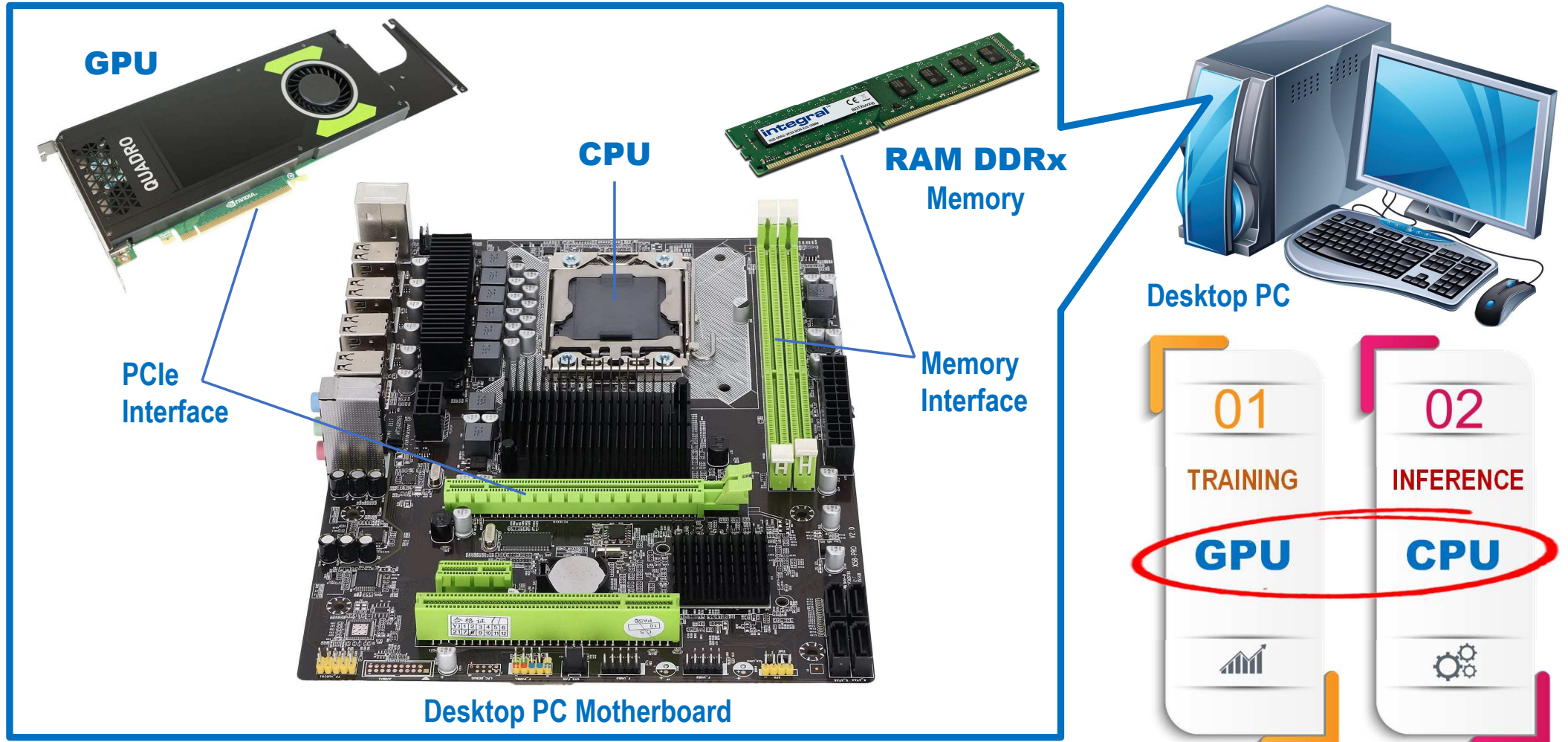


TEST (INFERENCE)



5. DESIGN & DEVELOPMENT (4004): HARDWARE PLATFORM

Three key components: CPU, GPU and RAM.





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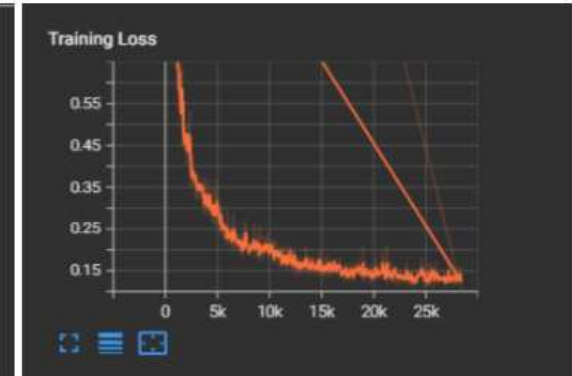
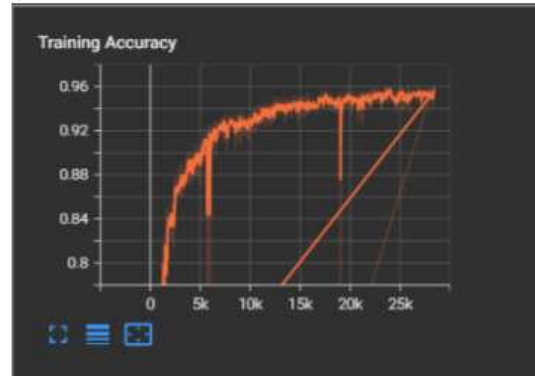
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6. EXPERIMENTAL RESULTS (1003)

Visual analysis and assessment of results supported by the **TensorBoard** tool.

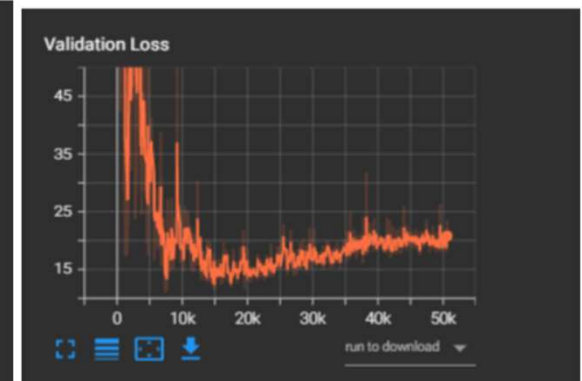
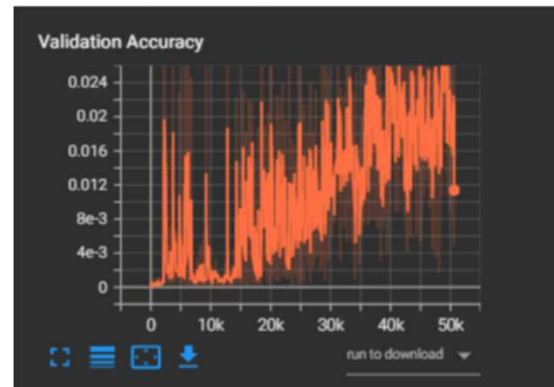
$lr = 0.001$ (Best model in epoch7)
After that the model is overfitting.

Training (Seq_00)



$lr = 0.01$ (Best model epoch 0)
Lw_version of Seq_00

Validation(Seq_08)



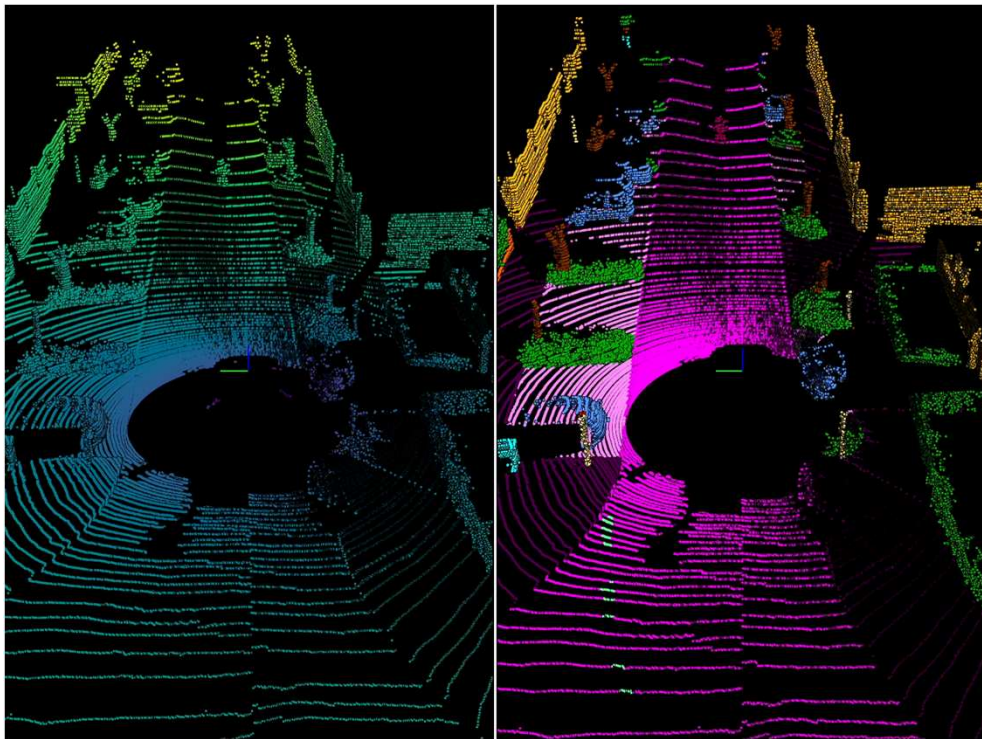
6. EXPERIMENTAL RESULTS (2003)

Visual analysis and assessment of results supported by the **TensorBoard** tool.

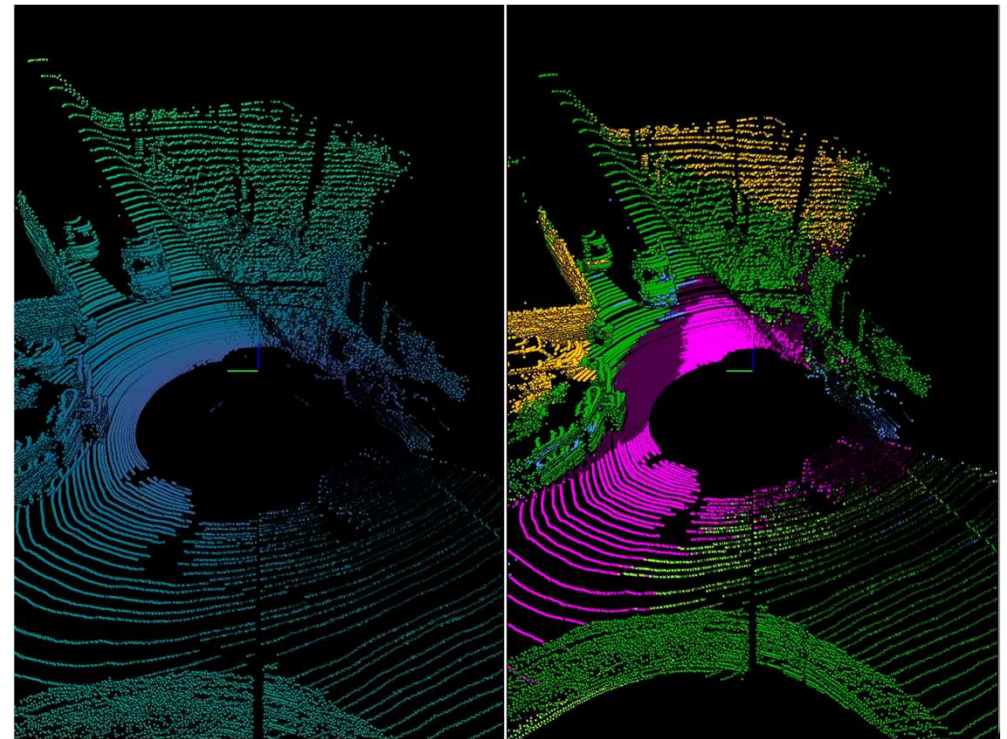
Time for Training (RTX 3060)	Sequence for Training	Sequence for Validation	lr	Accuracy	mIoU
~5h	Seq_00	Seq_08	0.001	0.35	-
~3h	(few Categories) Seq_00	Seq_08	0.001	4.5e-4	-
~2h	(few Categories) Seq_00	(few Categories) Seq_08	0.01	0.46	0.88304
~2h	(few Categories) Seq_00	(few Categories) Seq_08	0.001	0.43	0.87869

6. EXPERIMENTAL RESULTS (3003)

Visualization of results in real-time through **semantic-kitti-api** tool.



Ground Truth (Labeled Data)



Prediction (Inference)



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7. CONCLUSIONS

- Relevant AD/ADAS use case (pain point) explored. Business case with high impact in the automotive industry.
 - The integration of different technologies was the main challenge of the project.
 - Learning by doing. Gaining and absorbing knowledge quickly was our main strength.
 - Our “time-aggressive” development flow: Python program (instead of Colab) and PC with CPU/GPU (instead of cloud).
 - Lesson learned: to balance your AI/DL workload (batch sizes, etc.) with the RAM, CPU and GPU of your platform
 - It is crucial to iterate many times your solution in order to achieve good results.
 - Excellent teamwork of the four team members following agile methodologies.
- Although the start of the project was quite tough, the job was done and delivered on time!





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Neural Network:

- <https://github.com/marionacaros/3D-object-segmentation-light-PointNet>
- <https://github.com/Yvanali/KITTISeq>
- <https://github.com/fxia22/pointnet.pytorch>

Point Cloud Visualization Tool:

- <https://github.com/PRBonn/semantic-kitti-api>

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