

# GEM Final Video

# LiDAR-Based Lane Navigation

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# Motivation / Problem Statement:

When using camera-based lane detection, problems such as lighting conditions, short ranges, and road height change often make it difficult to precisely locate the lanes and adjust the parameters.

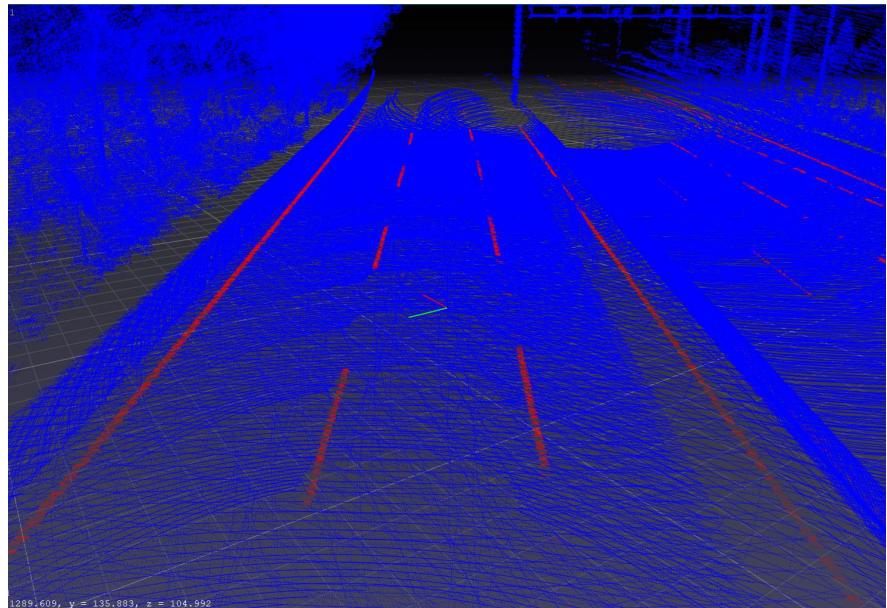


Figure 1. LiDAR Lane Detection

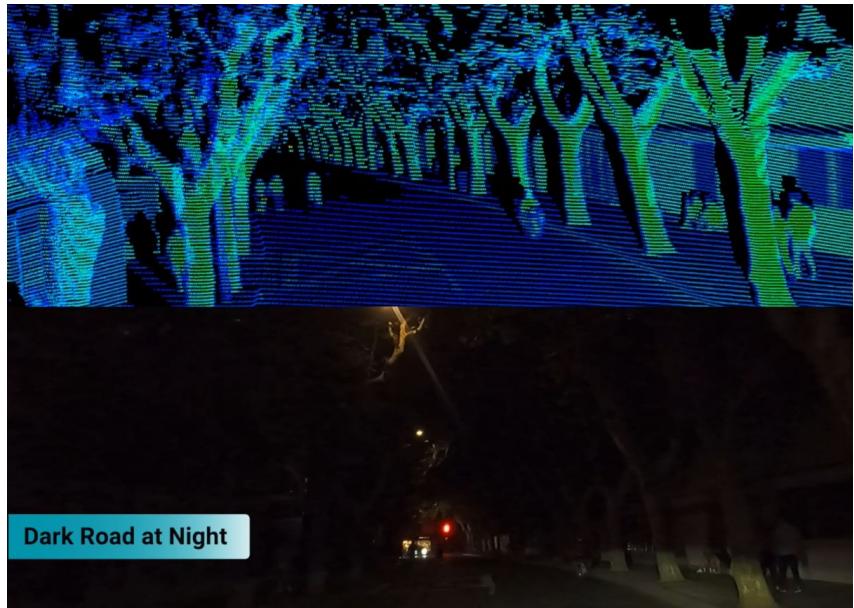
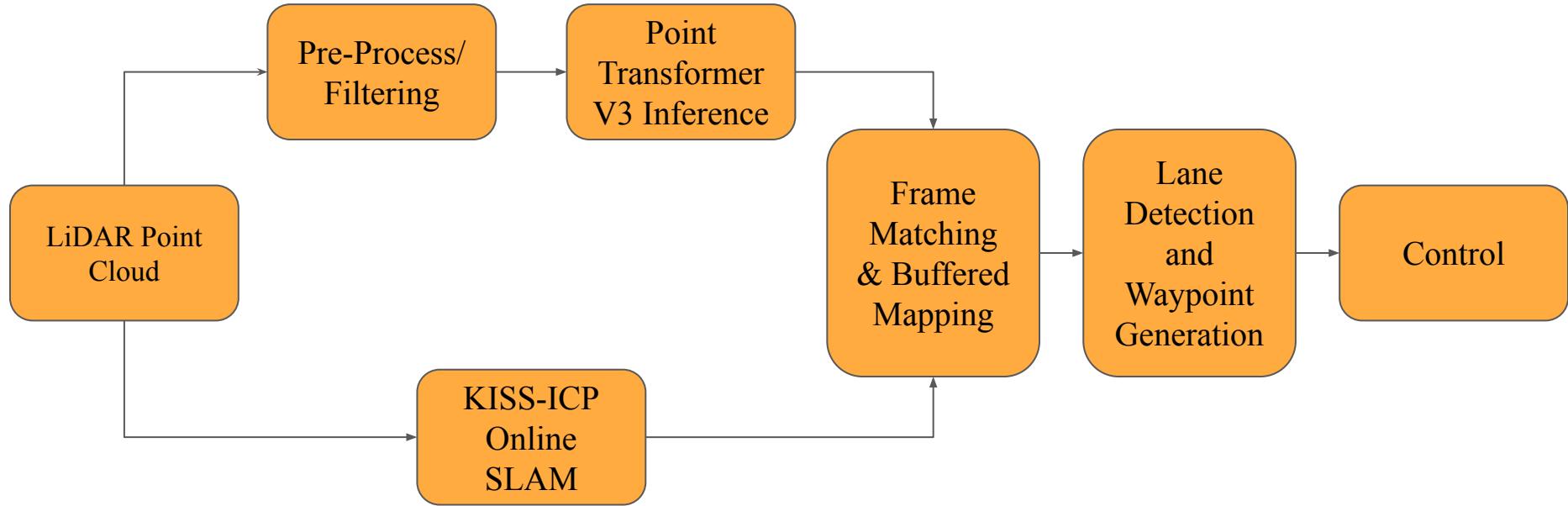
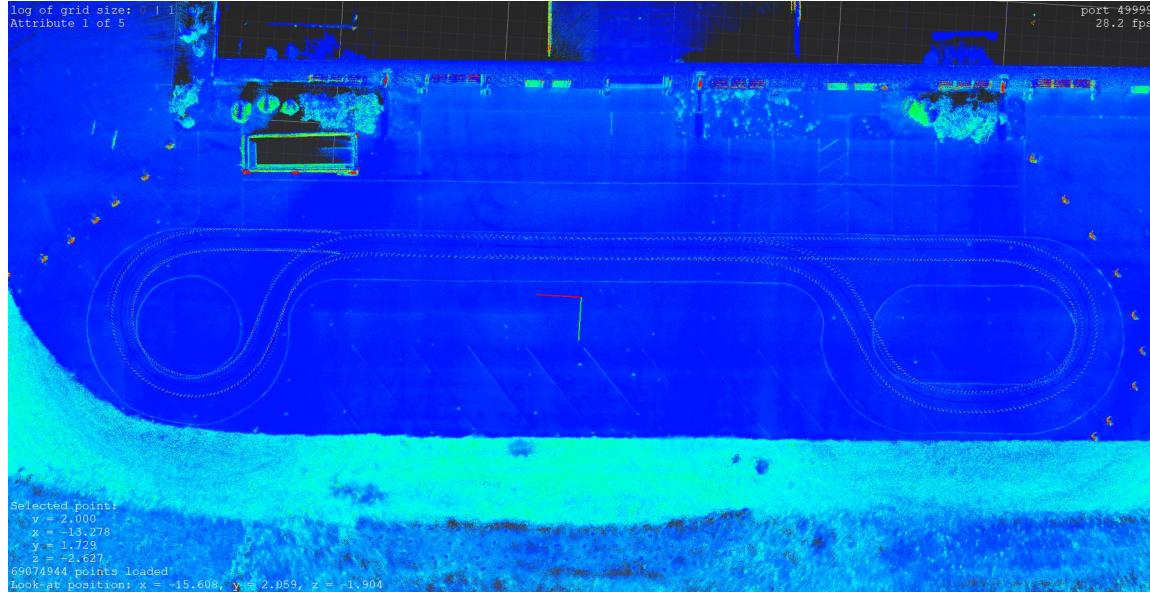


Figure 2. LiDAR vs Camera Vision at Night

# Pipeline



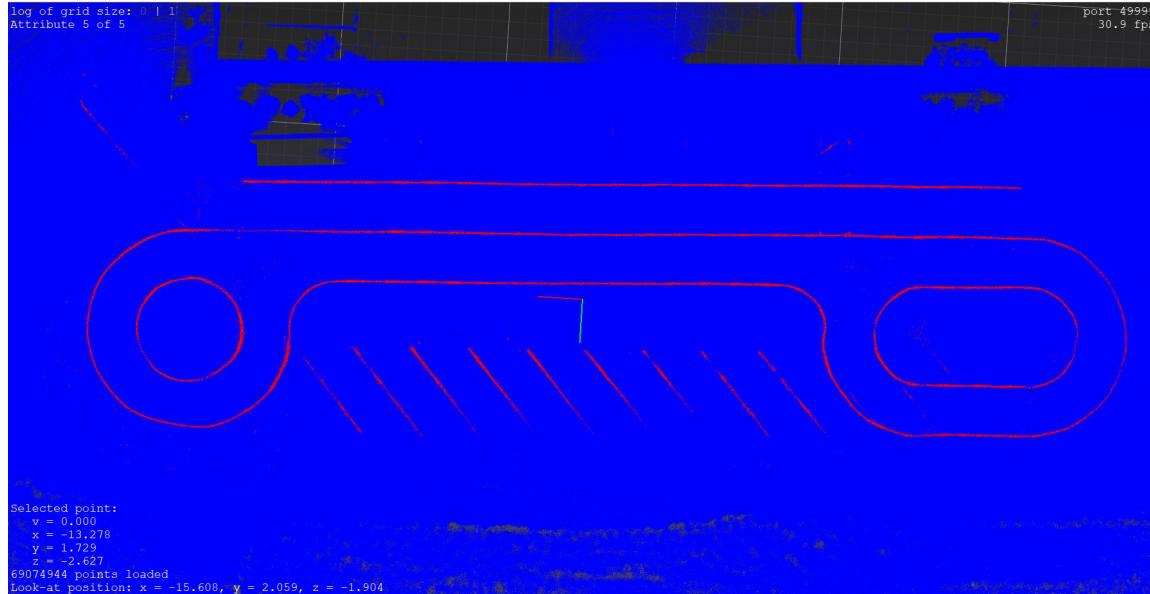
# Point Transformer V3 model Training



Lidar Point Cloud Mapping with Near IR attribute

- ❑ Trained 7 models with first 5 using **near ir** value and the last two with **signal** value
- ❑ Training Data
  - **1504** lidar frames with different lightning conditions

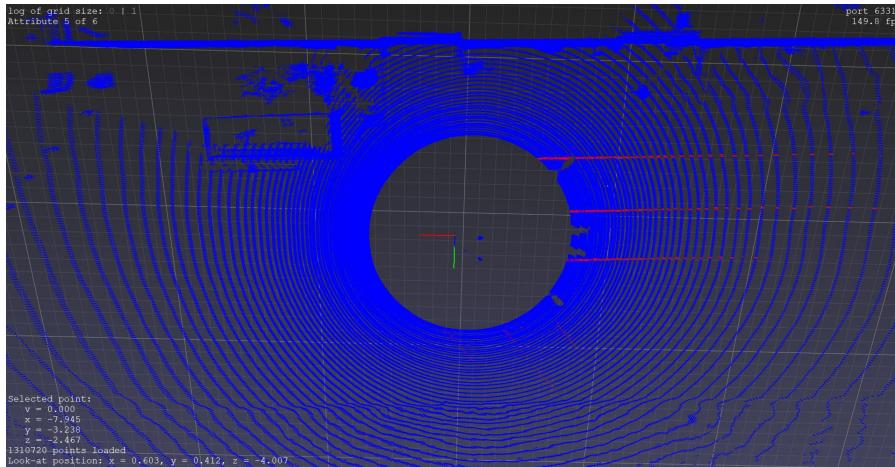
# Point Transformer V3 model Testing



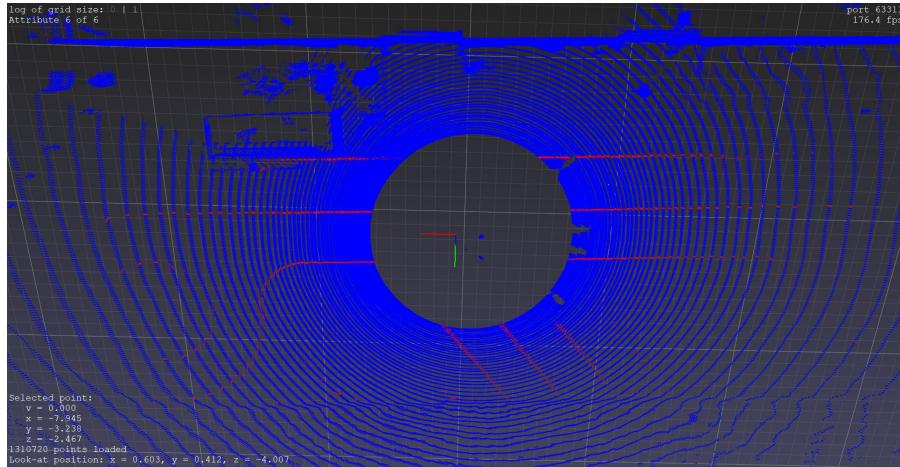
Lane Prediction on High Bay Map

- ❑ Tested on **681** frames using **signal** attribute
  - Precision: 0.62
  - Recall: 0.73

# Point Transformer V3 model testing in daylight environment



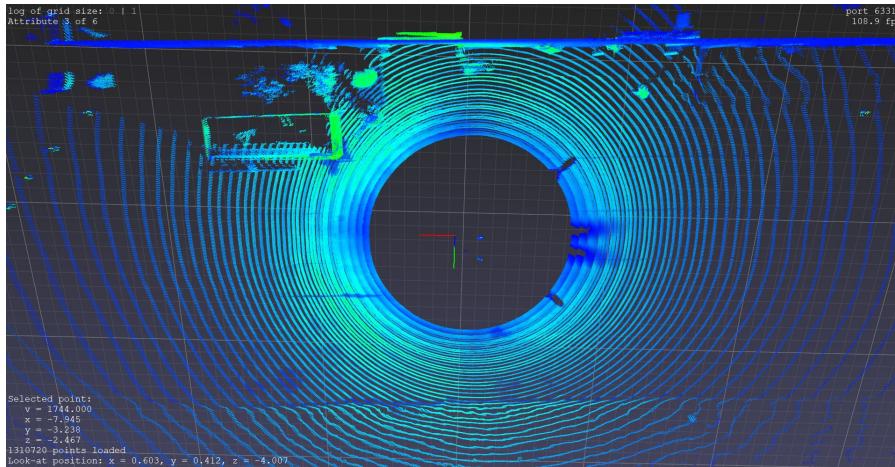
Inference result using **signal** attribute



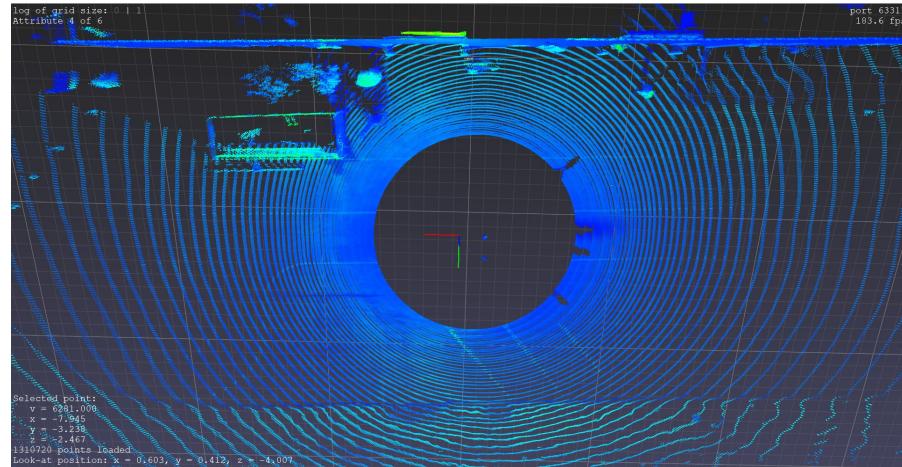
Inference result using **near ir** attribute

**Signal** better in cloudy/low light env, **Near ir** better in sunny

# Point Transformer V3 model testing in daylight environment



Signal on High Bay using 5 frames

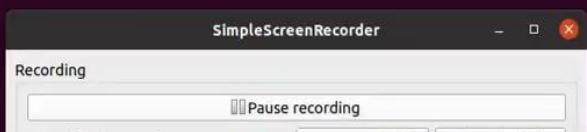


Near ir on High Bay using 5 frames

**Signal** better in cloudy/low light env, **Near ir** better in sunny

# Road Line Inference

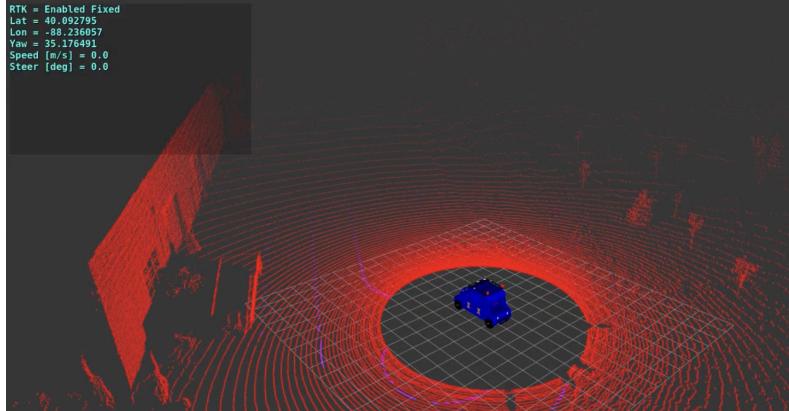
```
for scan #11081.0: 0.350 seconds
for scan #11684.0: 0.410 seconds
for scan #11689.0: 0.349 seconds
for scan #11692.0: 0.408 seconds
for scan #11696.0: 0.341 seconds
for scan #11700.0: 0.420 seconds
for scan #11704.0: 0.346 seconds
for scan #11707.0: 0.448 seconds
for scan #11712.0: 0.362 seconds
for scan #11715.0: 0.423 seconds
for scan #11720.0: 0.429 seconds
for scan #11724.0: 0.345 seconds
for scan #11728.0: 0.343 seconds
for scan #11732.0: 0.413 seconds
for scan #11736.0: 0.342 seconds
for scan #11739.0: 0.409 seconds
for scan #11743.0: 0.346 seconds
for scan #11747.0: 0.410 seconds
for scan #11751.0: 0.416 seconds
for scan #11755.0: 0.349 seconds
for scan #11759.0: 0.351 seconds
for scan #11763.0: 0.412 seconds
for scan #11767.0: 0.354 seconds
for scan #11770.0: 0.412 seconds
for scan #11774.0: 0.349 seconds
for scan #11778.0: 0.410 seconds
for scan #11782.0: 0.409 seconds
for scan #11786.0: 0.344 seconds
for scan #11790.0: 0.345 seconds
for scan #11794.0: 0.410 seconds
for scan #11798.0: 0.347 seconds
for scan #11801.0: 0.409 seconds
for scan #11805.0: 0.360 seconds
for scan #11809.0: 0.421 seconds
for scan #11813.0: 0.436 seconds
for scan #11817.0: 0.358 seconds
for scan #11821.0: 0.363 seconds
for scan #11825.0: 0.431 seconds
for scan #11829.0: 0.353 seconds
for scan #11833.0: 0.423 seconds
for scan #11837.0: 0.357 seconds
for scan #11841.0: 0.416 seconds
```



## Legends

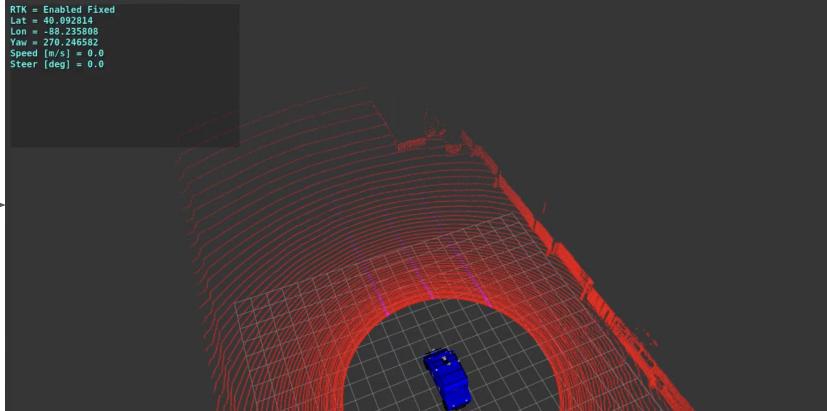
- Lane LiDAR Point
- Non-Lane LiDAR Point

# Pre-Process/Filtering



Reduced from  
130,000 pts to  
40,000 pts

~300ms  
Inference  
Speed-Up



```
[INFO] [1733077858.300351]: Total processing time for scan #9250.0 0.746 seconds
[INFO] [1733077859.113164]: Total processing time for scan #9259.0 0.798 seconds
[INFO] [1733077859.877161]: Total processing time for scan #9266.0 0.750 seconds
[INFO] [1733077860.638231]: Total processing time for scan #9274.0 0.750 seconds
[INFO] [1733077861.394351]: Total processing time for scan #9282.0 0.742 seconds
[INFO] [1733077862.150294]: Total processing time for scan #9289.0 0.740 seconds
[INFO] [1733077862.992708]: Total processing time for scan #9297.0 0.827 seconds
[INFO] [1733077863.794845]: Total processing time for scan #9305.0 0.785 seconds
[INFO] [1733077864.583077]: Total processing time for scan #9312.0 0.770 seconds
[INFO] [1733077865.356912]: Total processing time for scan #9321.0 0.755 seconds
[INFO] [1733077866.191019]: Total processing time for scan #9329.0 0.819 seconds
[INFO] [1733077866.950354]: Total processing time for scan #9337.0 0.744 seconds
[INFO] [1733077867.715549]: Total processing time for scan #9344.0 0.752 seconds
```

```
[INFO] [1733078113.835829]: Total processing time for scan #11817.0 0.358 seconds
[INFO] [1733078114.206686]: Total processing time for scan #11821.0 0.363 seconds
[INFO] [1733078114.646341]: Total processing time for scan #11825.0 0.431 seconds
[INFO] [1733078115.005275]: Total processing time for scan #11829.0 0.353 seconds
[INFO] [1733078115.439606]: Total processing time for scan #11833.0 0.423 seconds
[INFO] [1733078115.803190]: Total processing time for scan #11837.0 0.357 seconds
[INFO] [1733078116.227402]: Total processing time for scan #11841.0 0.416 seconds
[INFO] [1733078116.649516]: Total processing time for scan #11845.0 0.415 seconds
[INFO] [1733078117.006666]: Total processing time for scan #11849.0 0.351 seconds
[INFO] [1733078117.375559]: Total processing time for scan #11853.0 0.363 seconds
[INFO] [1733078117.801448]: Total processing time for scan #11857.0 0.419 seconds
[INFO] [1733078118.166938]: Total processing time for scan #11861.0 0.358 seconds
[INFO] [1733078118.587001]: Total processing time for scan #11864.0 0.414 seconds
```

# KISS-ICP Odometry (Online SLAM)



## Legends

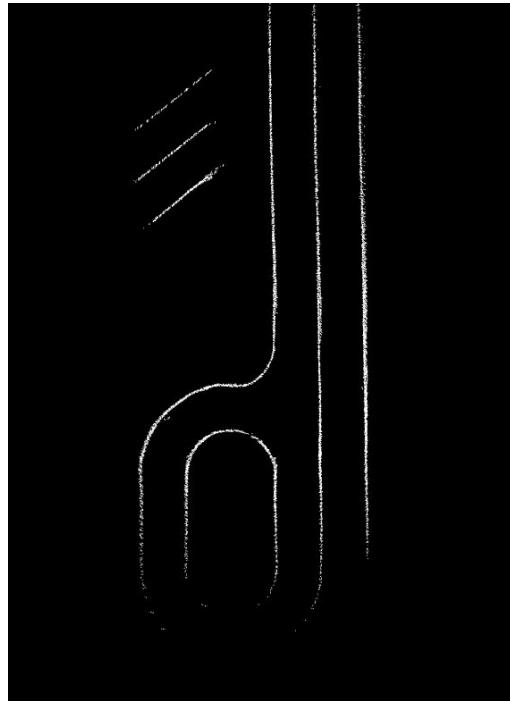
- Lane LiDAR Point
- Vehicle Trajectory

# Frame Matching & Buffered Mapping

Single Frame

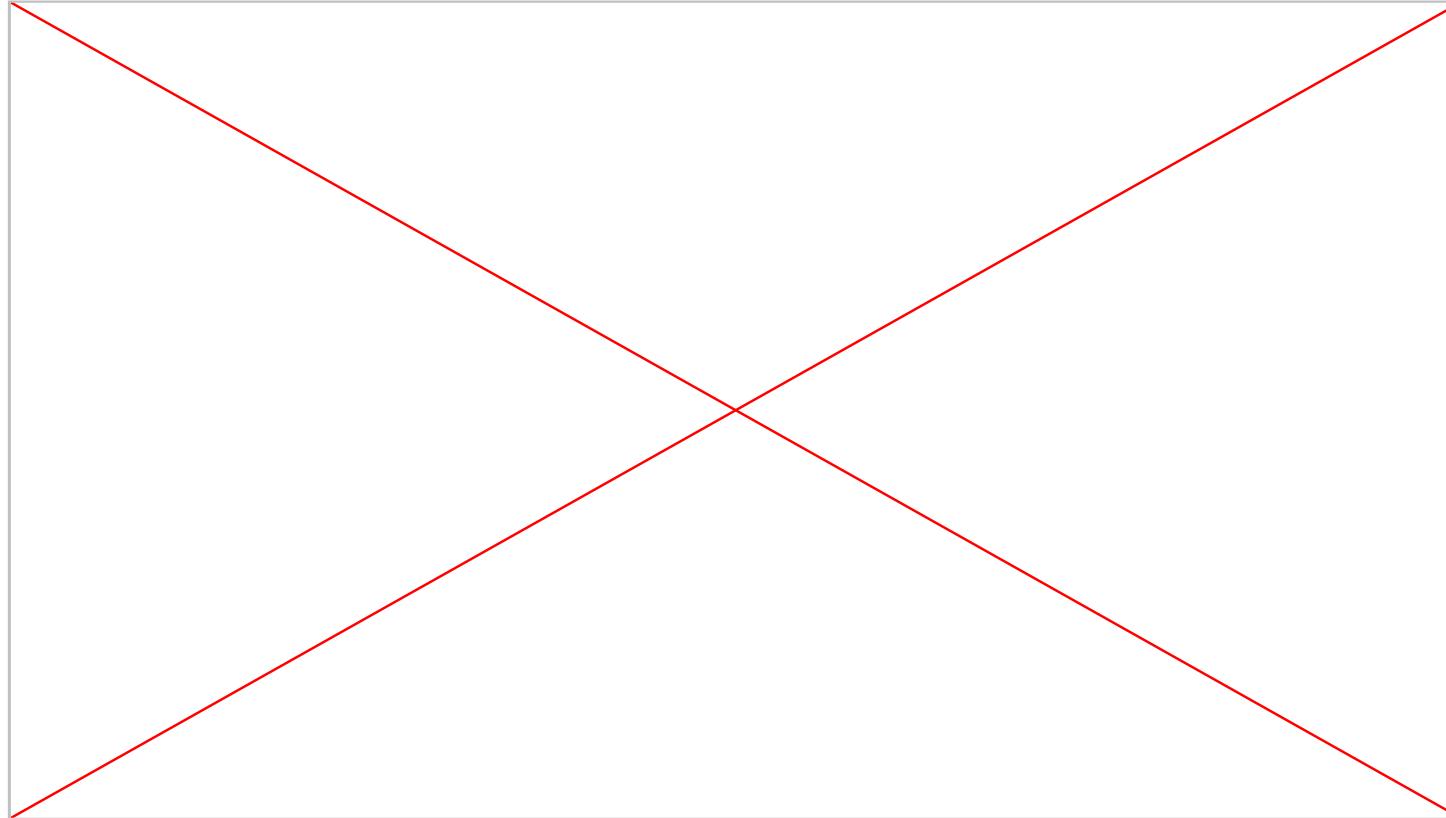


20 Frames Buffer



VS

# Waypoints Generation

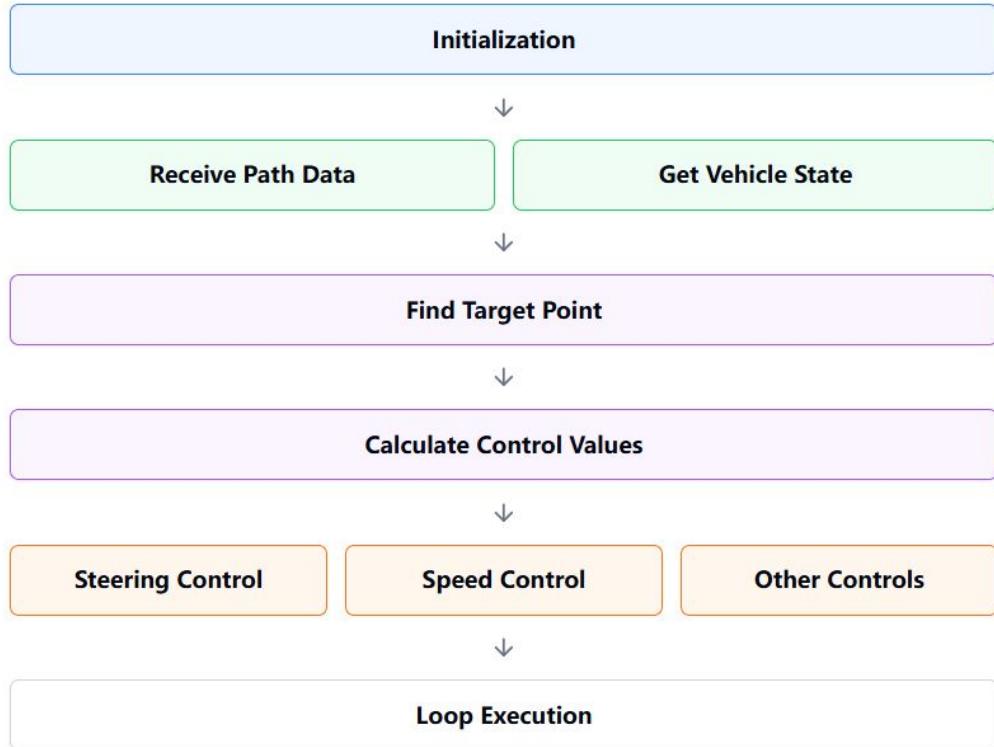


## Legends

- Right Lane Detection
- Generated Waypoints
- Buffered Point Cloud
- Vehicle Trajectory

# Control Pipeline

1. Locate the vehicle position in Lidar frame
2. Planning an ideal trajectory based on the right lane
3. Select several waypoints closest to the vehicle
4. Adjust the steering angle according to the angle of the planning trajectory



# Control in Day-Light Environments

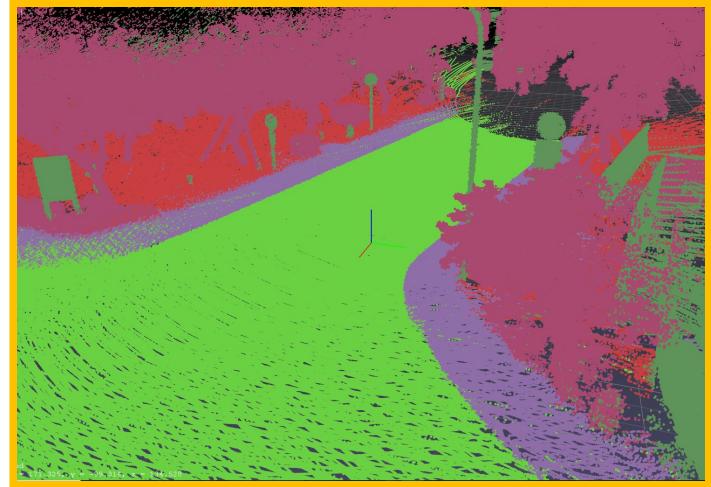


# Control in Low-Light Environments



# Novelty

1. LiDAR
  - Pros: Range / Low Light Performance / Accuracy / Data Size
2. Buffered Mapping (Online SLAM) to increase robustness and blind zone problem
3. Utilize Point Transformer v3 to deal with noisy signal data for lane line detection
4. Extendable pipeline (semantic segmentation)



ITRI lidar point cloud with semantic labeling

# Questions?

# References

- [1] Vizzo, Ignacio, et al. "KISS-ICP: In Defense of Point-to-Point ICP -- Simple, Accurate, and Robust Registration If Done the Right Way." *ArXiv*, 30 Sept. 2022, <https://arxiv.org/abs/2209.15397>. Accessed 4 Dec. 2024.
- [2] Wu, Xiaoyang, et al. "Point Transformer V3: Simpler, Faster, Stronger." *ArXiv*, 2023, <https://arxiv.org/abs/2312.10035>. Accessed 4 Dec. 2024.