KI DELTA LEARNING

Scalable AI for Automated Driving

Final Event | March 09, 2023

Mounting Position based Lidar Domain Gap Analysis

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Motivation

- A domain gap describes the difference in the Input data between two domains
  - Different mounting positions of Lidars have geometric implications on the input domain
  - Two commonly used positions

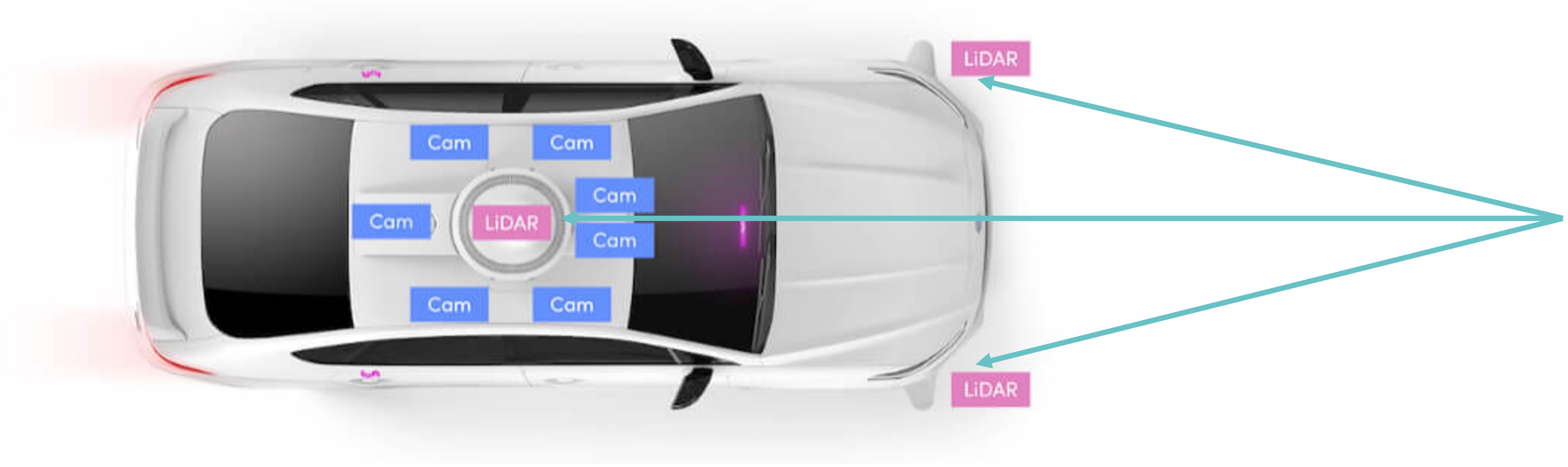
  - An important part is the analysis and identification of the domain shift
  - As well as a quantification of changes in the input data to evaluate procedures for the gap closure

Contribution

- Analysis of the domain gap in LIDAR data cross-sensor domain adaption
  - Focus on change in measurement distribution with respect to sensor position
    - Focused on class based measurement distributions
    - Shared coordinate system measurement accumulation
    - Enable comparative analysis of the gaps
  - Show adaption strategies and the corresponding limitations
  - Provide insights into classical voxel domains

Lidar Data Domain

- We used the Lyft Level 5 data which uses different Lidar sensors in different mounting positions



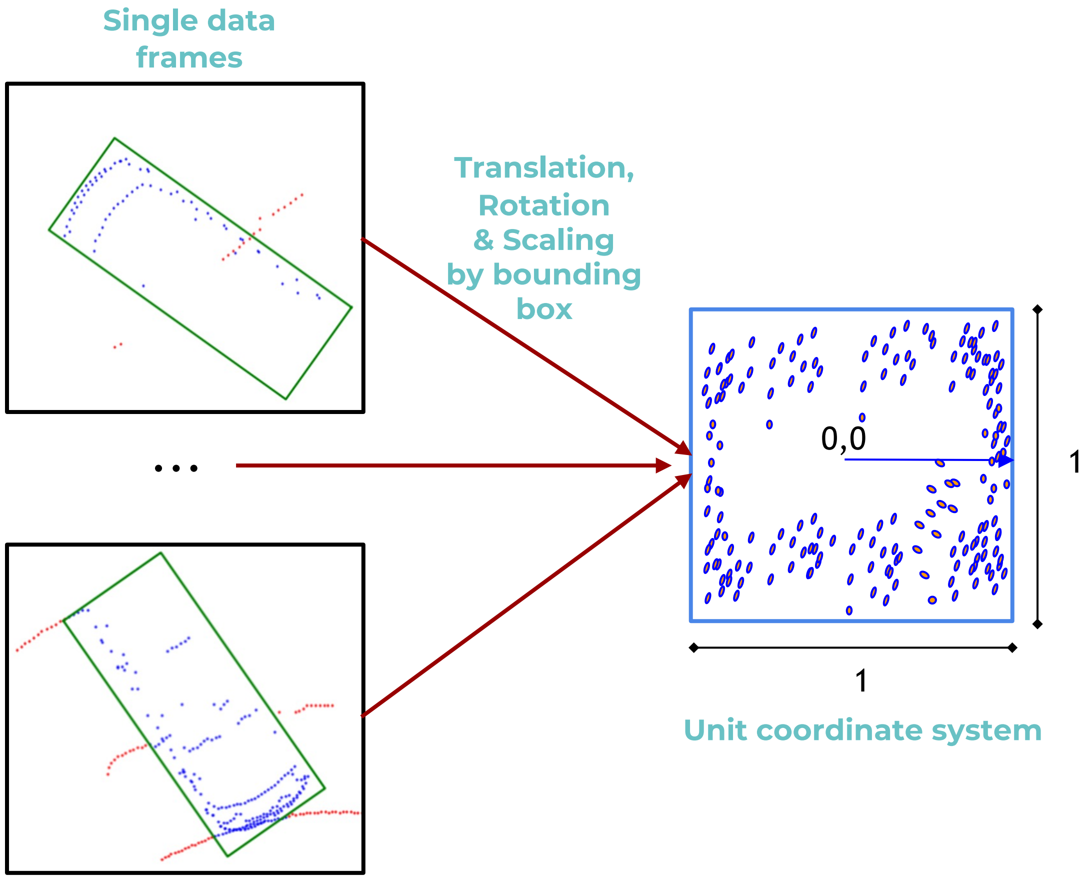
Sensor shift

40 and 64-beam Lidars on the roof and bumper.

R. Kesten, M. Usman, J. Houston, T. Pandya, K. Nadhamuni, A. Ferreira, M. Yuan, B. Low, A. Jain, P. Ondruska, S. Omari, S. Shah, A. Kulkarni, A. Kazakova, C. Tao, L. Platinsky, W. Jiang, and V. Shet. *Lyft level 5 perception dataset 2020.* https://level5.lyft.com/dataset/, 2019.

Data Accumulation

- For a comparative analysis we used a scale invariant coordinate system.
  - Extract points from annotation bounding box using the extra margin 10 cm in all dimensions to provide a common space for all data points to a surrounding rectangle.

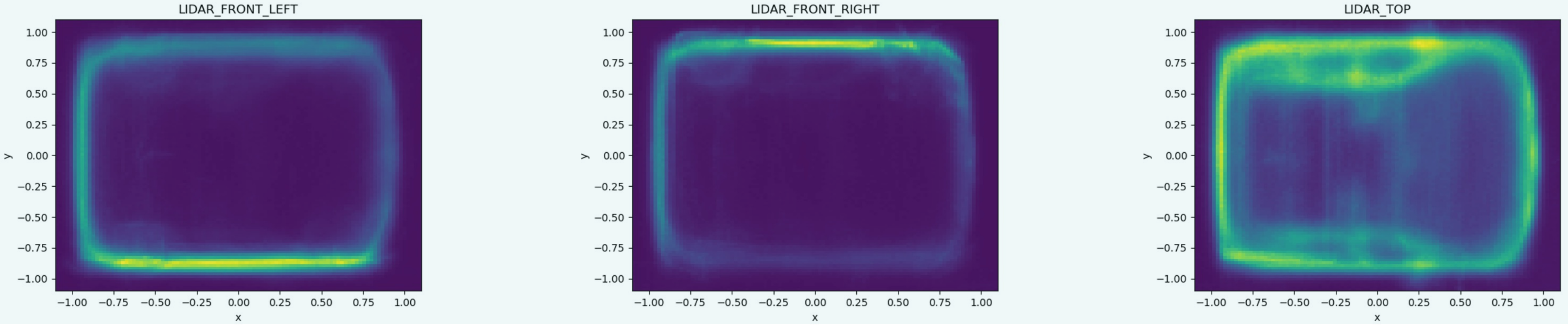


Scheel, Alexander, and Klaus Dietmayer. "Tracking multiple vehicles using a variational radar model." *IEEE Transactions on Intelligent Transportation Systems* 20.10 (2018): 3721-3736.

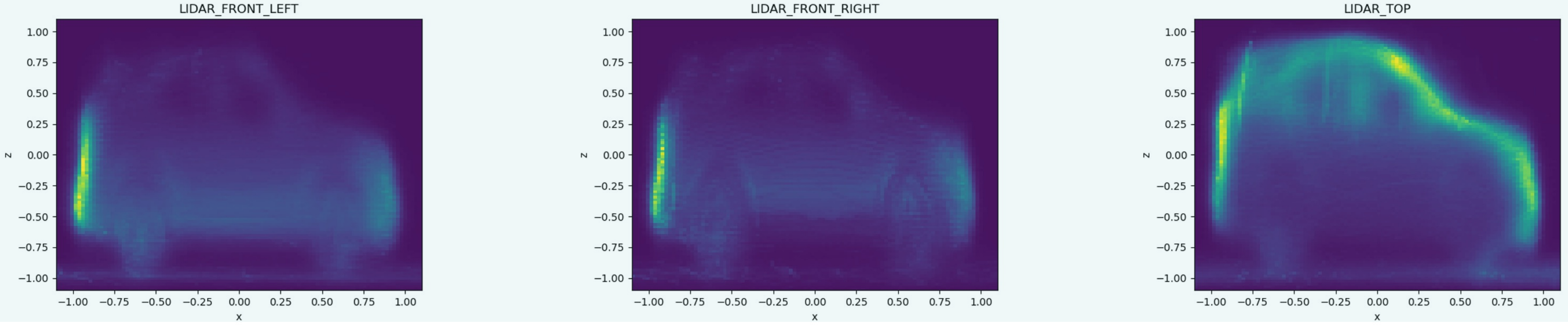
Data Accumulation

- We accumulated Histogram over all annotations of type car perceived by the sensors

Birdseye view

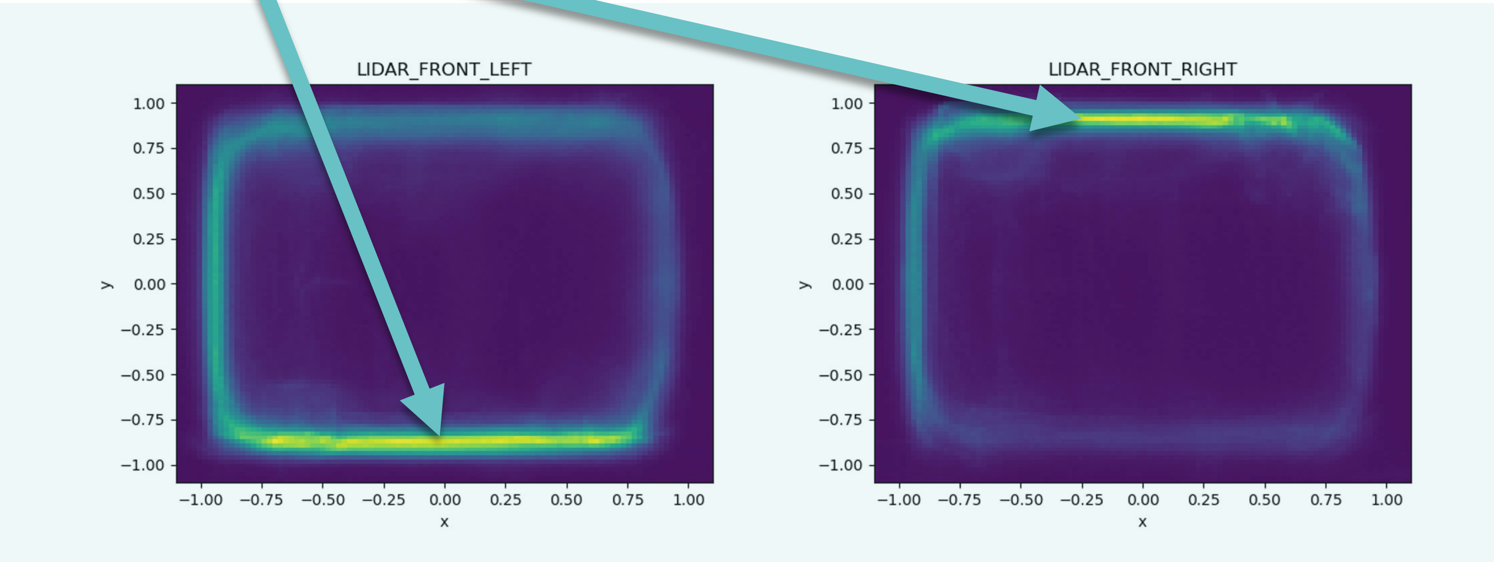


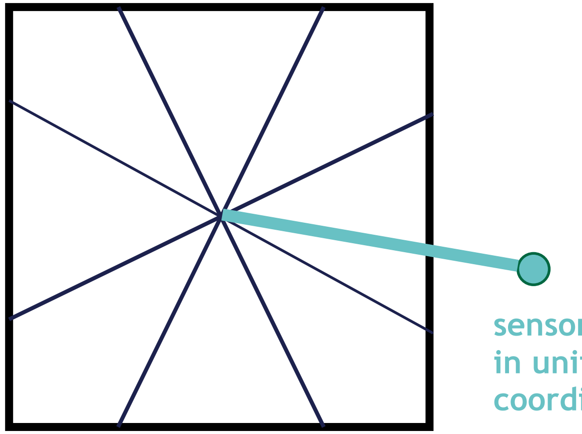
Side view



Data Accumulation

- And found a data bias with respect to the aspect angles and the sensor position



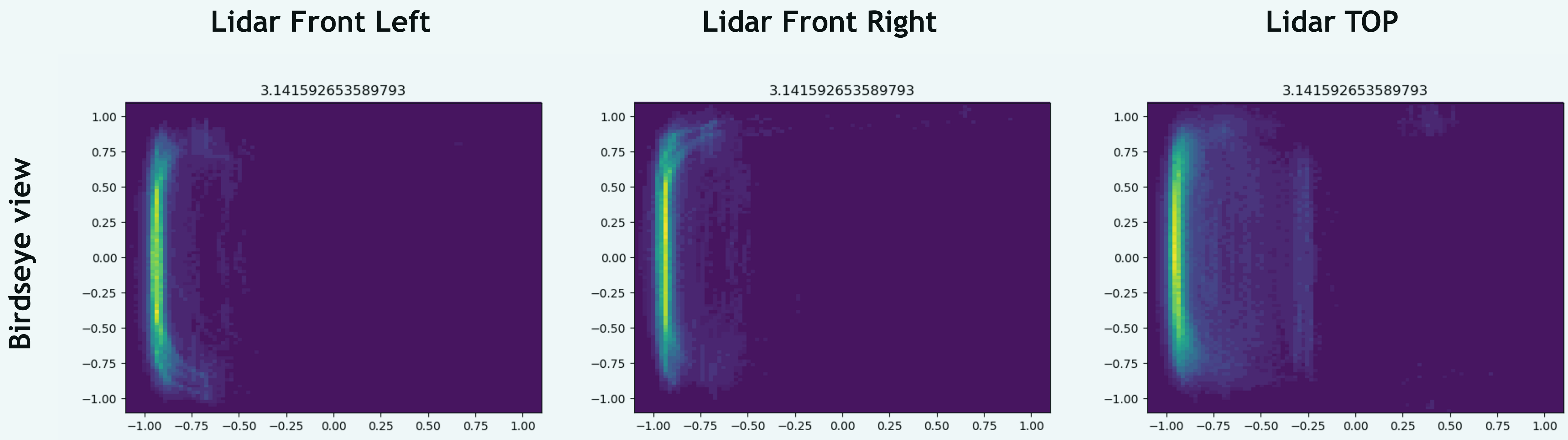


sensor position
in unit
coordinates

- To mitigate this bias conditionals on the aspect angle were generated.

Data Accumulation

- This provides side based measurement distribution



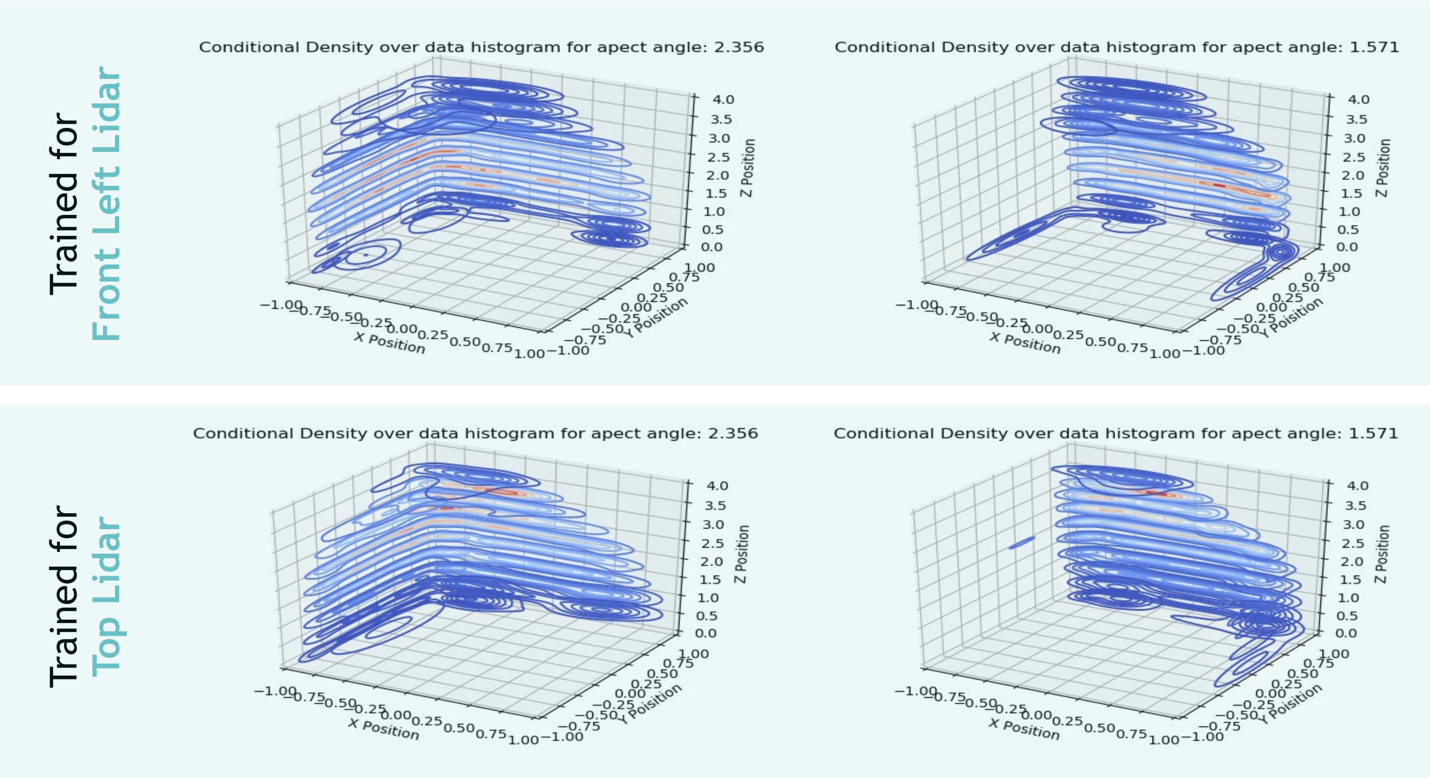
Model Generation

How to use and compare the accumulated data?

- We use the data for the training of a representative distribution model
  - Gaussian mixture
- These models provide a likelihood for new measurements and our assumption is that the likelihood is an indicator that new data was emitted by the respective sensor setup.
- We want to evaluate this hypothesis by comparing the likelihood functions with respect to different sensor data

Model Generation

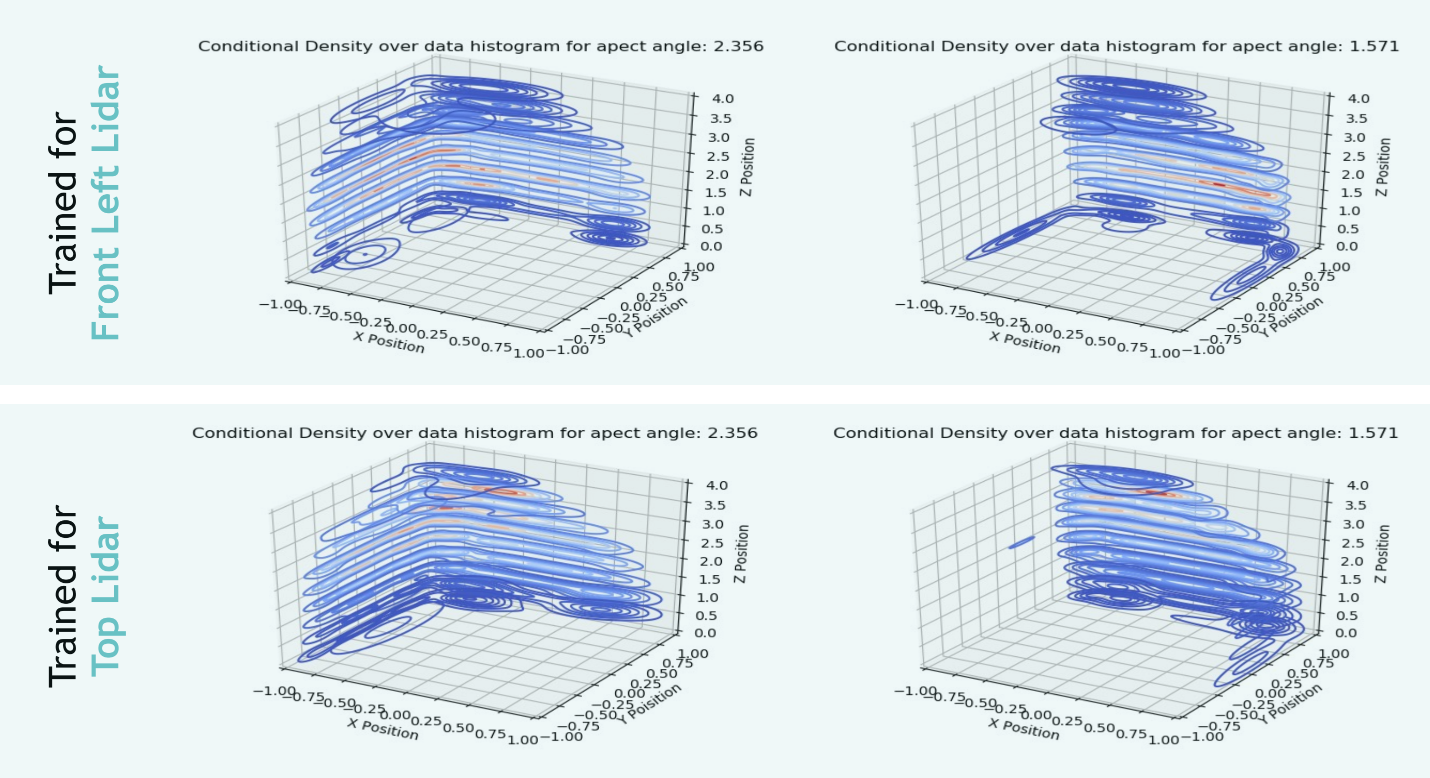
- Mixture models based on for the respective aspect angles



Trained conditional mixture models. Normalized equidistant slices from the 3d mixture
are provided for 2 of the aspect conditionals. Color scale (blue – red)

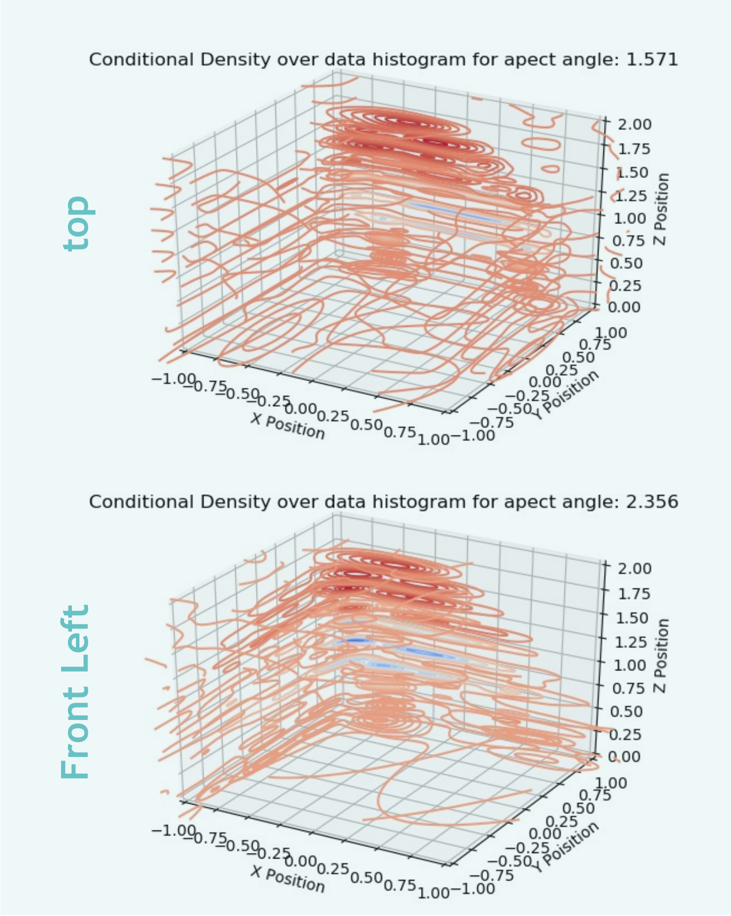
Model Comparision

- Mixture models based on for the respective aspect angles and difference



Trained conditional mixture models. Normalized equidistant slices from the 3d mixture are provided for 2 of the aspect conditionals. Color scale (blue – red)

Likelihood difference

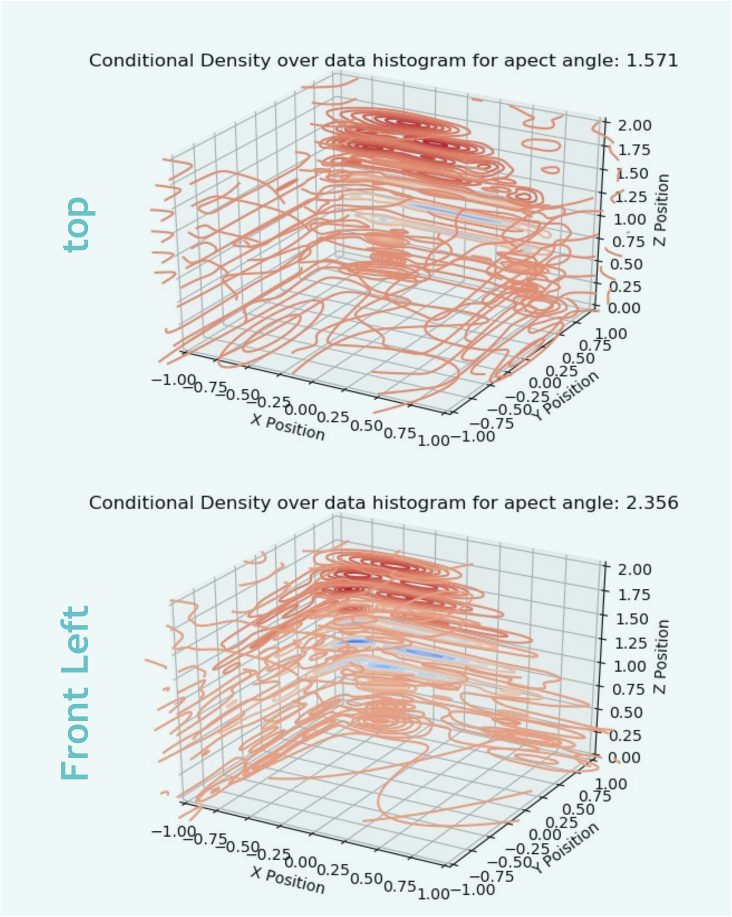


Model Comparision

- The models likelihood provides a measure, that describes measurement distribution and is comparative.

  - The difference in likelihood on a new sample may be used
    - A negative value indicates the low mounted sensor
    - A positive value indicates

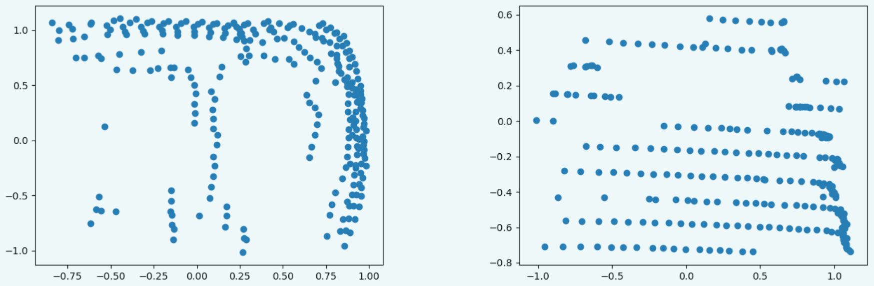
Likelihood difference



Model Comparision

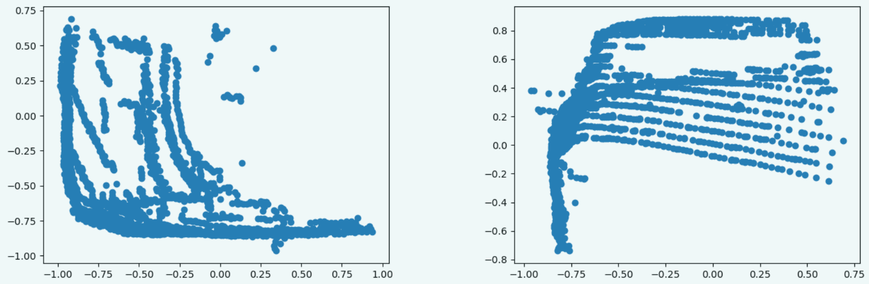
- The model’s likelihood provides a measure for the measurement distribution and is comparative.
  - The difference in likelihood on a new sample may be used
    - A negative value indicates the low mounted sensor
    - A positive value indicates

Lidar_Front_Left data : Top and side view



Likelihood difference -0.121

Lidar_Top data : Top and side view

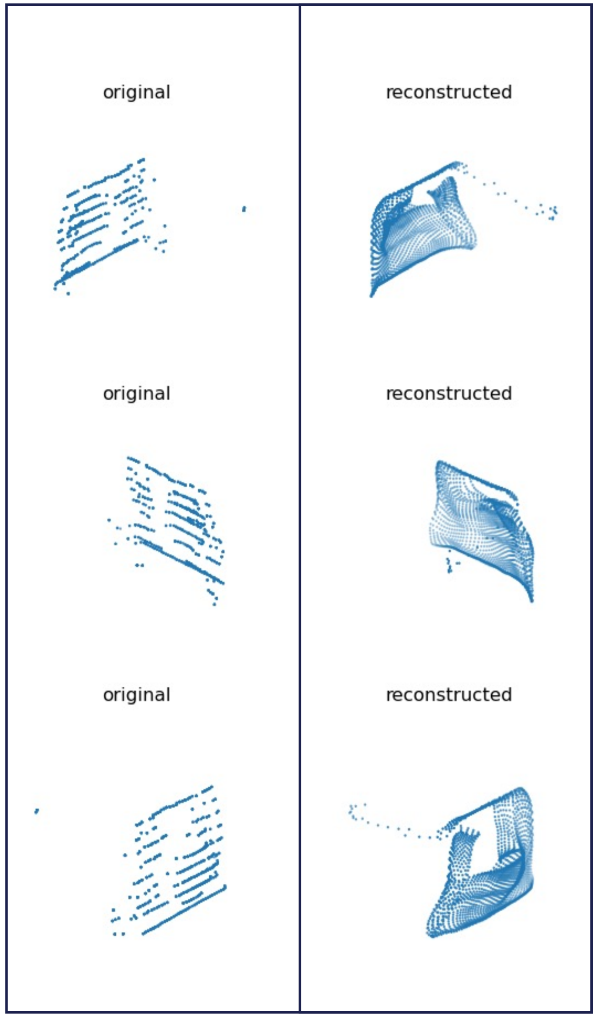


Likelihood difference 0.562

Domain Adaption via Auto-Encoders

- We considered using the GMM as a generative model or use autoencoders
  - This cannot encode scan structure or a concrete number of measurements

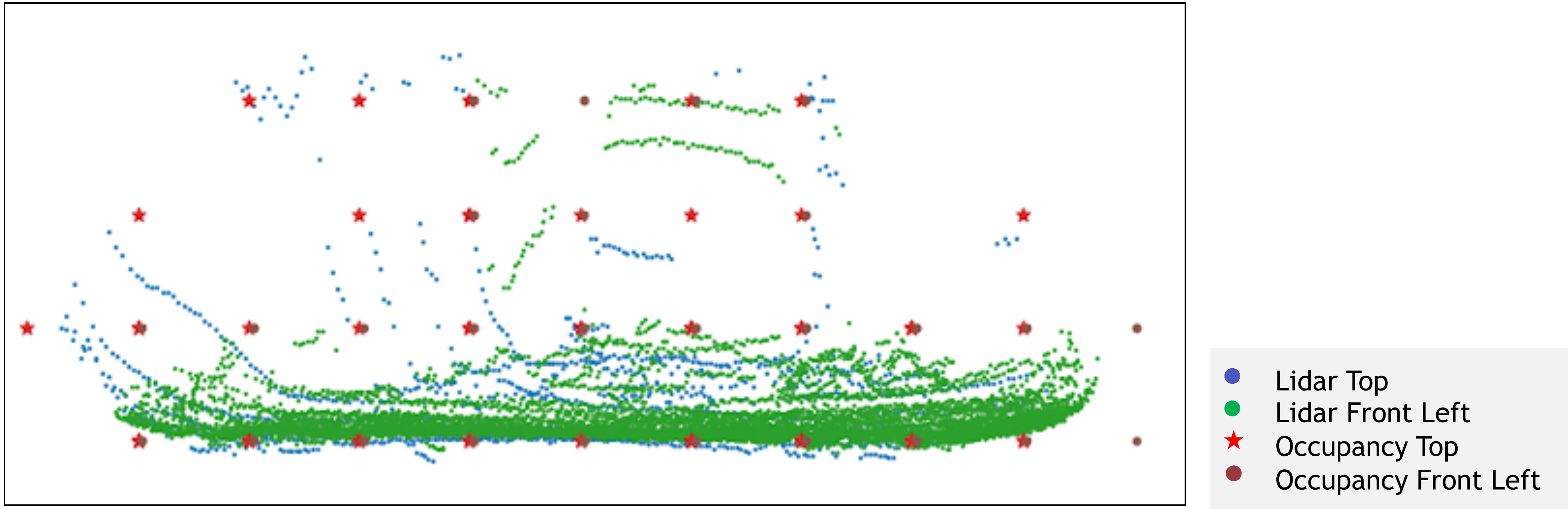
- Leads us to the final question of this talk:
  How different are the domains in the voxel space?
  - The comparison of a high dimensional voxel feature space is complicated
  - As a baseline, we compare the base occupancy of a voxel grid
    - We count the number of cells occupied in one frame in comparison



Yang, Yaoqing, et al. "Foldingnet: Point cloud auto-encoder via deep grid deformation." *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2018.

Voxel Occupancy

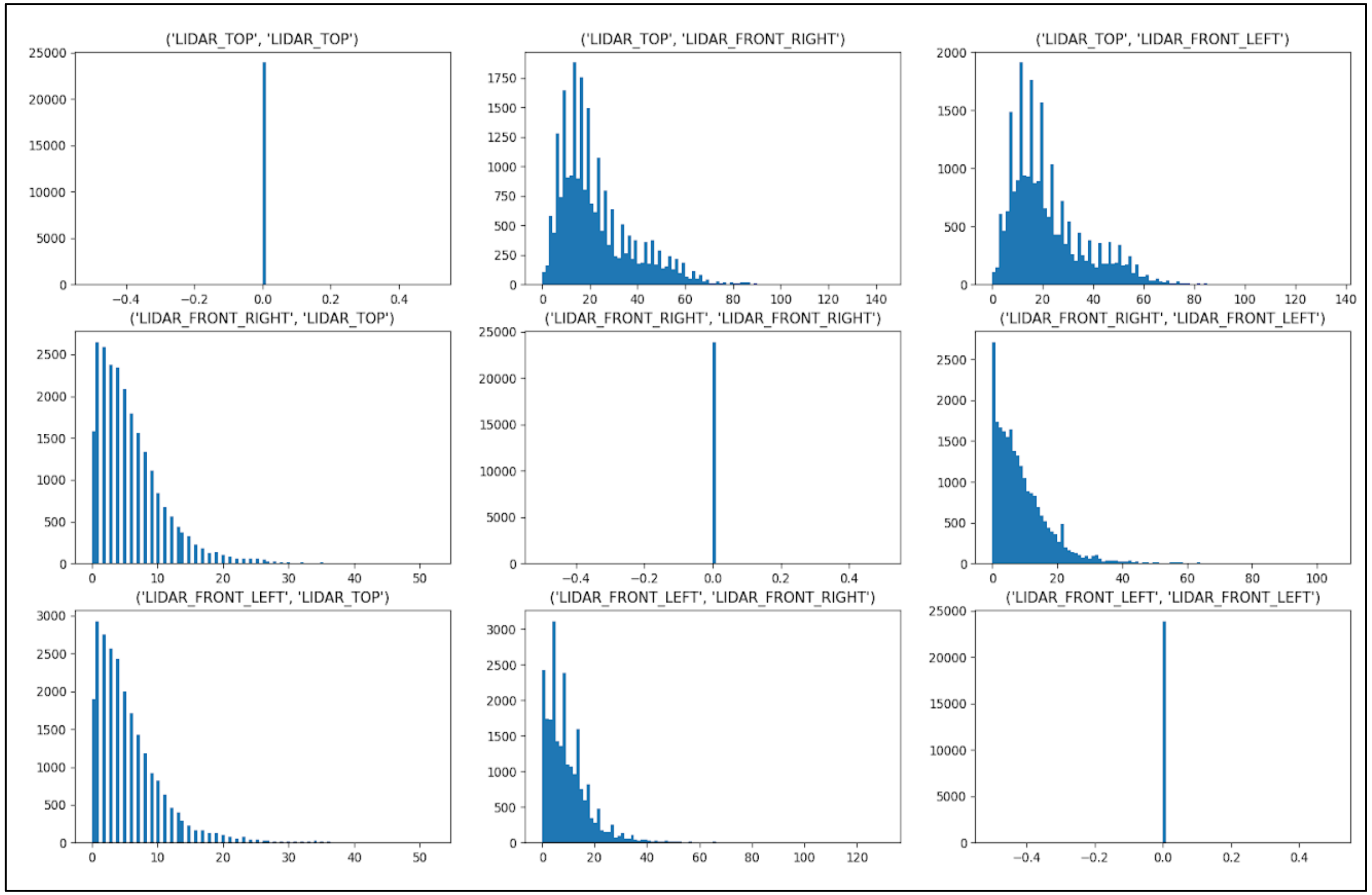
- Consider frame by frame comparison in the data set
- Simple delta per frame: #(occupied(Top) and not occupied(Front Left))



Birdseye view for sensor measurements and sensor occupancy a sensor pair

Voxel Occupancy

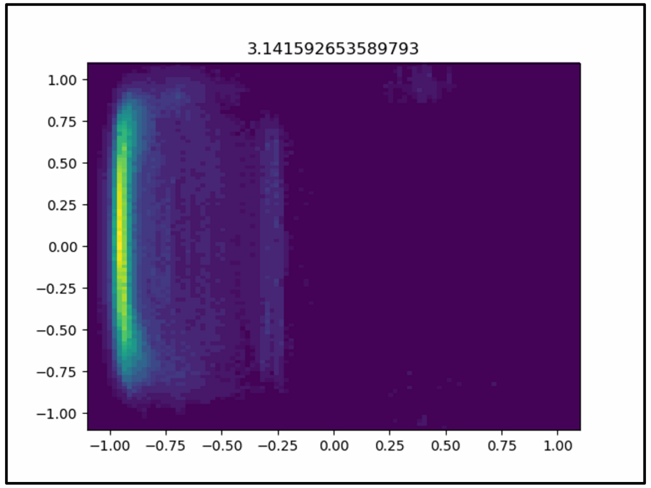
- Resulting distribution as histograms over all frames in which all sensors receive measurements on the target
- Similar distribution between low and high mount
- Distribution as a measure of the delta

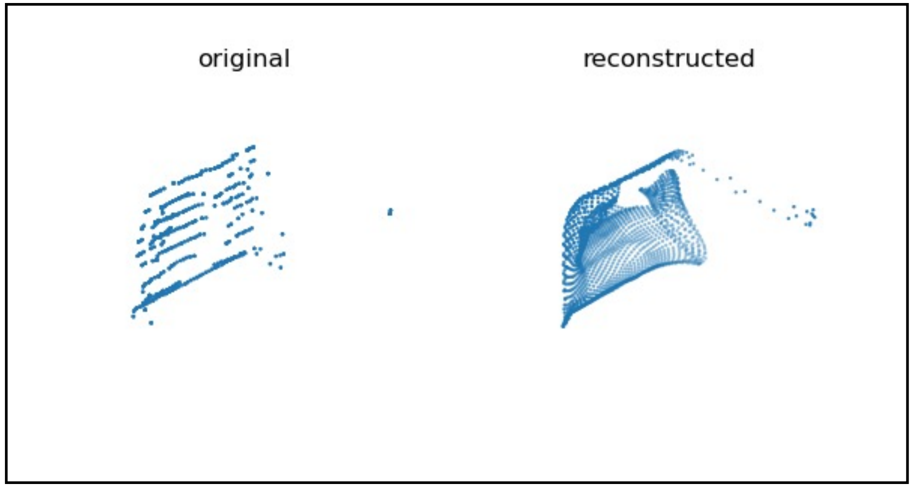


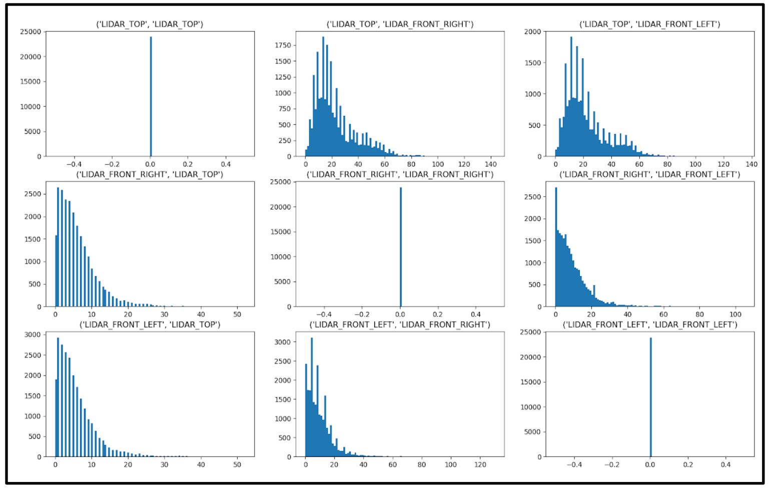
Sensor Sensor Delta Matrix for grid size 0.25m

Summary

- We provided a comparative analysis of the distribution of cars in lidar sensors in different domains
- Investigated the generation of data and found limitations regarding real data
- Looked into discretization effects that a neural network may face when discretising the domain
- All analysis parts provide indicators to use in analysing the plausibility of abstraction methods







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KI FAMILIE

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