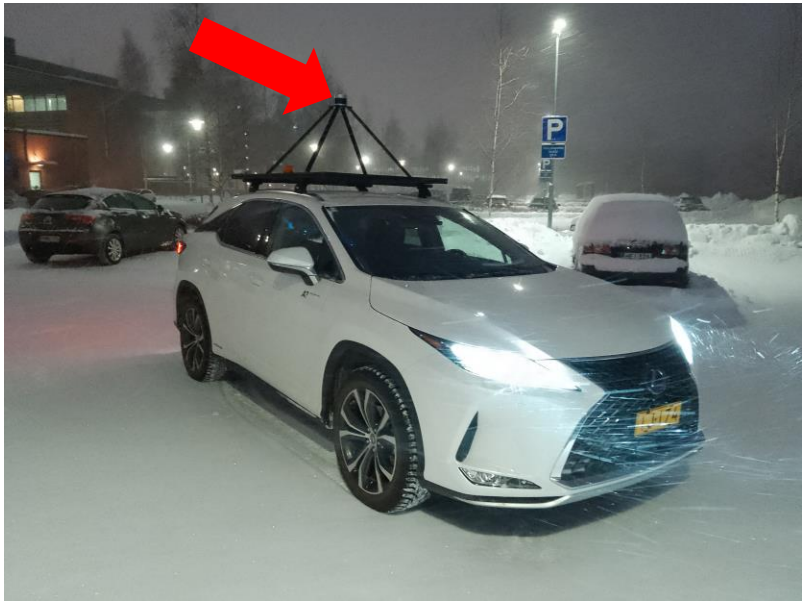
Aalto University

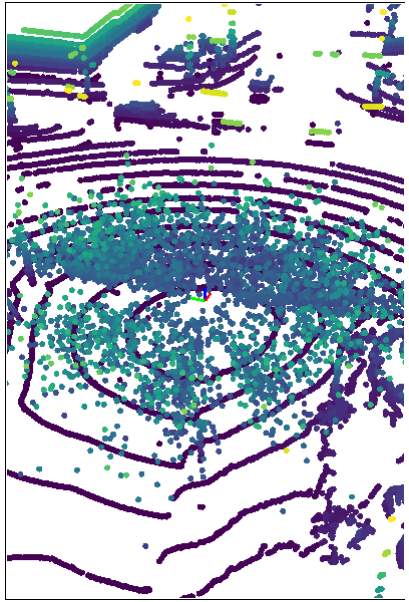
Denoising LiDAR Point Clouds in Snowfall

Alvari Seppänen

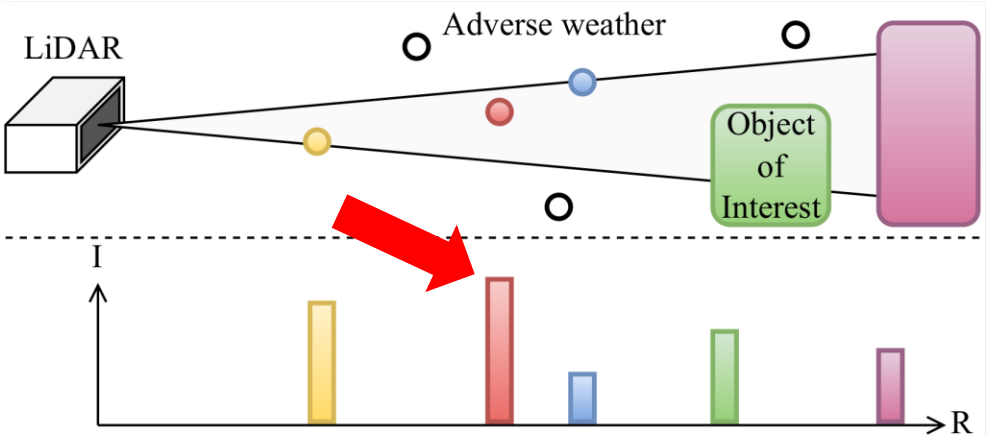
Background

Adverse weather causes noise LiDAR point clouds





Background



Degrades the data, which worsens the performance of down-stream tasks

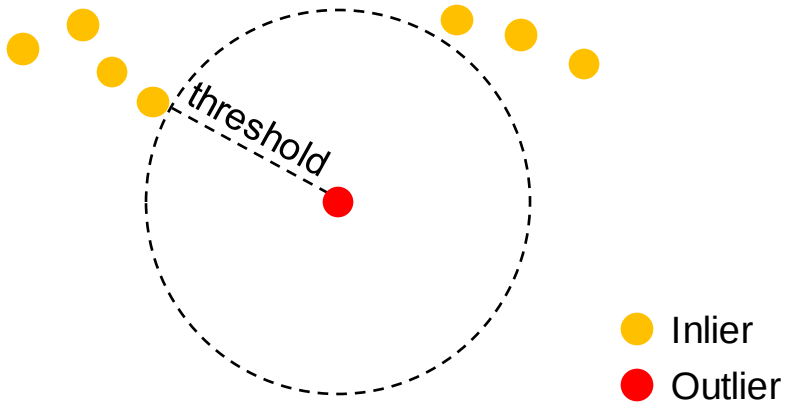
ADAS & mobile robots use LiDAR measurements for defining free space

- Points caused by airborne particles are undesired

Previous work

Classical methods

- Intensity-based threshold
- Density-based threshold



Learned methods

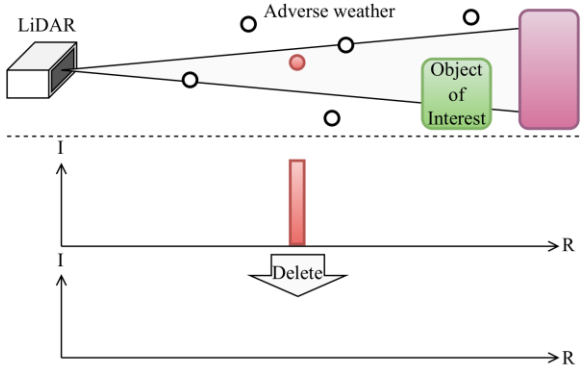
- WeatherNet (Heinzler *et al.* 2020, RA-L)
- 4DenoiseNet (Seppänen *et al.* 2022, RA-L)
- SLiDE (Bae *et al.* 2022, ECCV)

- **This work**

  Multi-echo idea and a new self-supervised approach

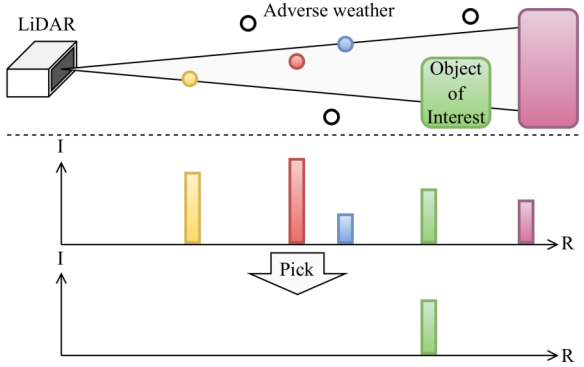
Previous work

Remove points caused by airborne particles



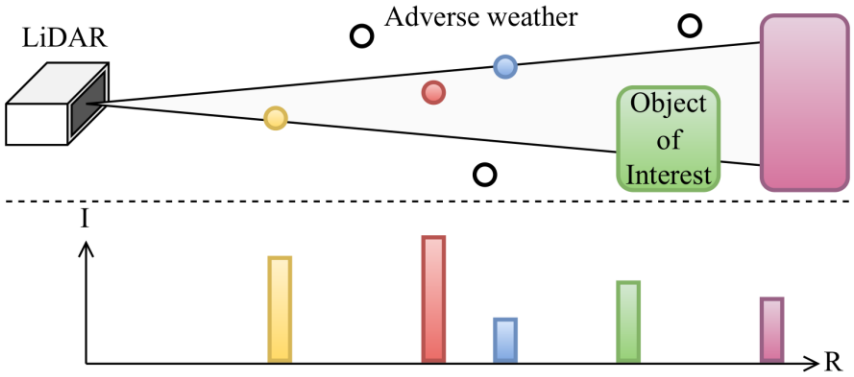
This work

Remove points caused by airborne particles and find substitutes for them from alternative echoes (multi-echo denoising)



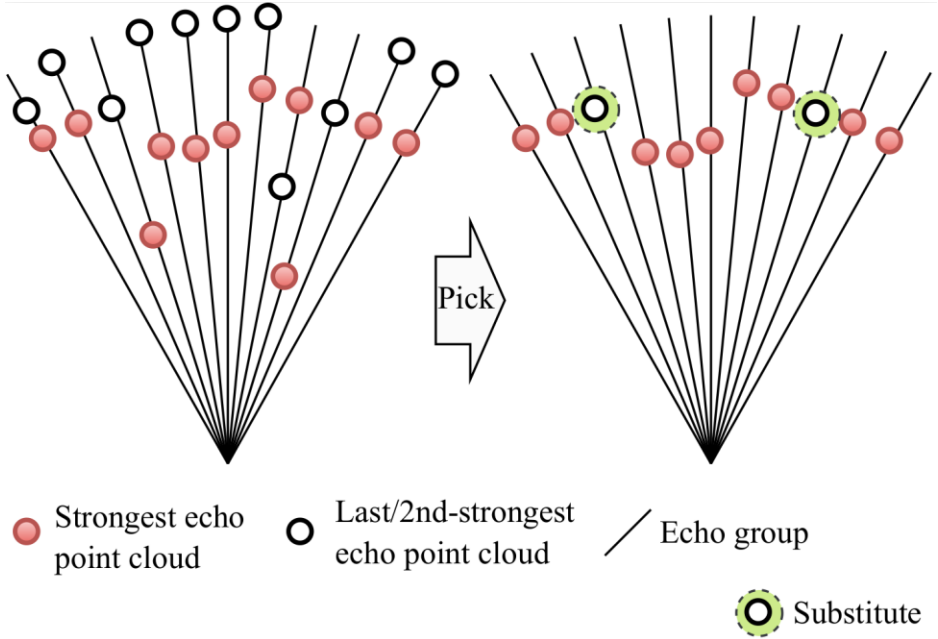
Methods – What is multi-echo denoising?

The goal is to *see through* adverse weather



Methods – Pick an echo

Pick substitutes from alternative echoes



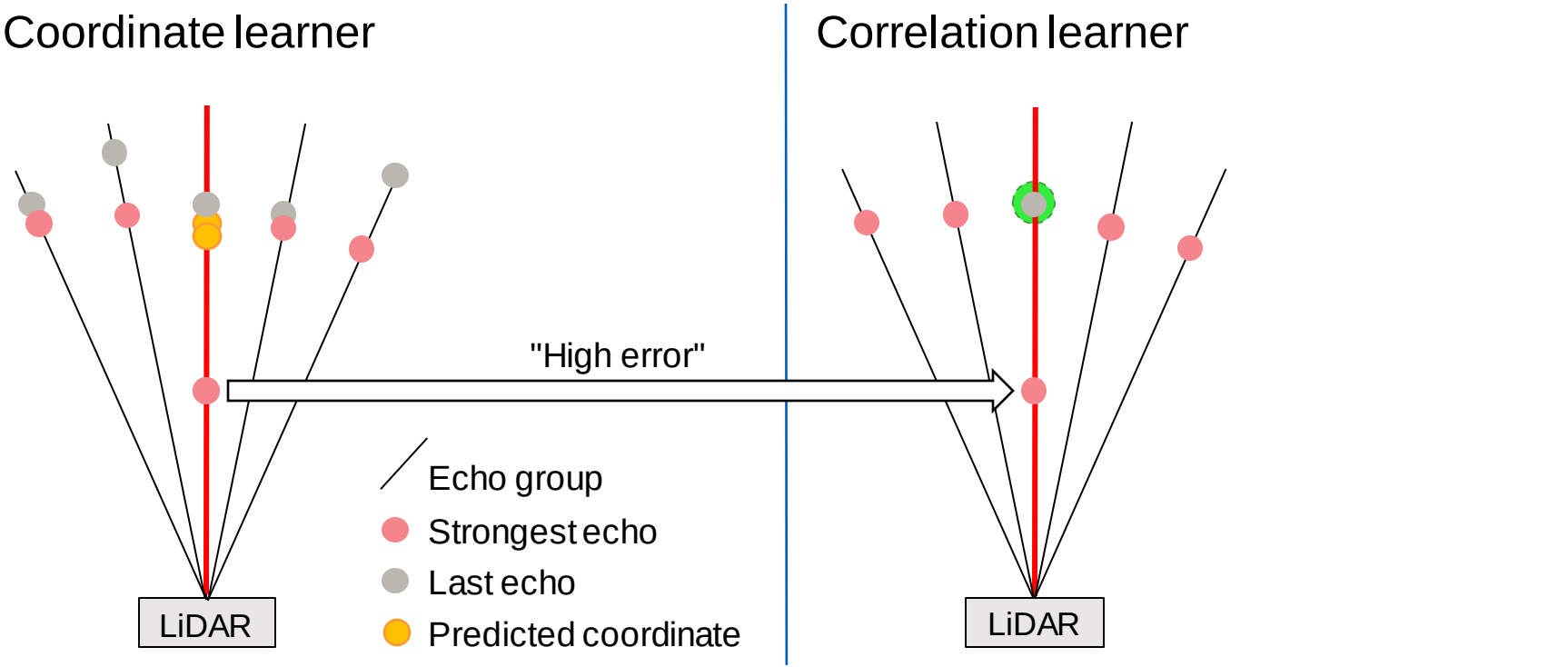
Methods – Self-supervised learning

How to do this without labels (self-supervised)?

Key idea: estimate points correlation to its neighbors

- high correlation ➡ inlier
- low correlation ➡ outlier

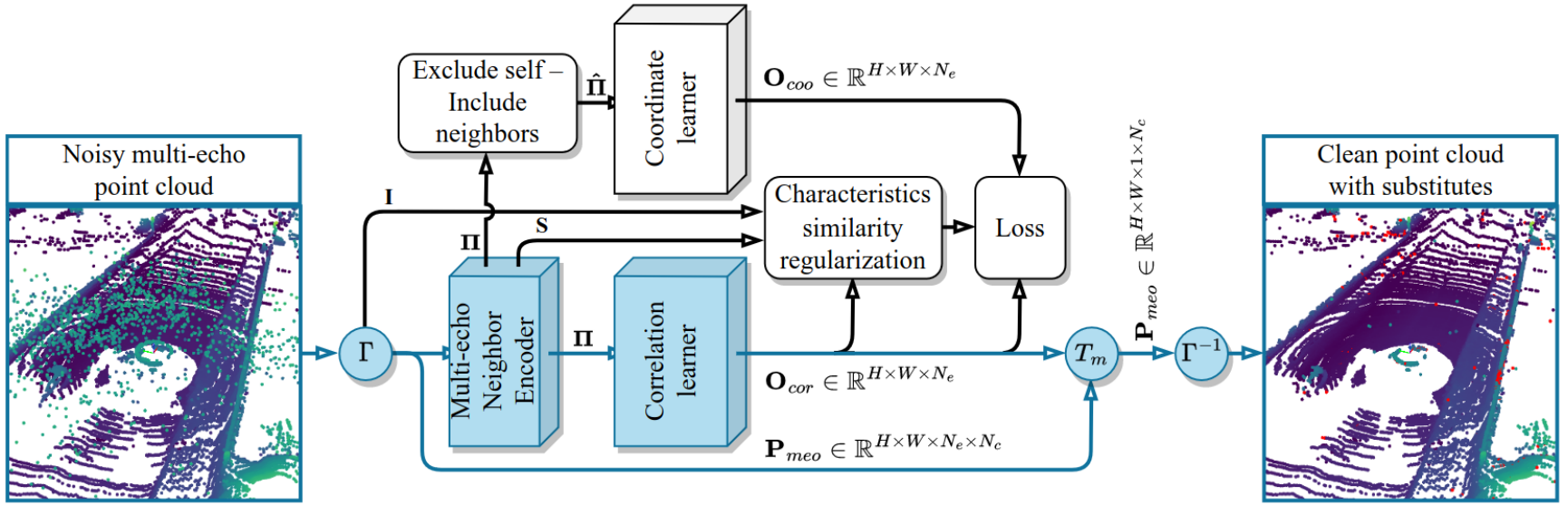
Methods – Dual neural network



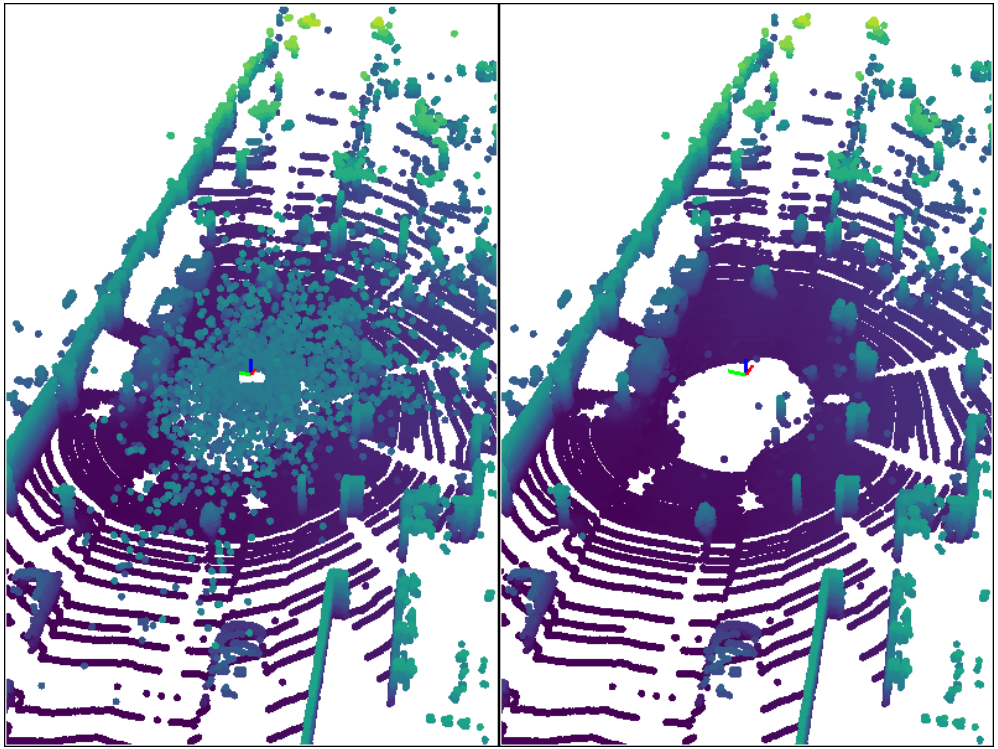
Methods – Architecture

Coordinate learner predicts coordinates given the neighbors

Correlation learner uses this information to learn correlation with neighbors

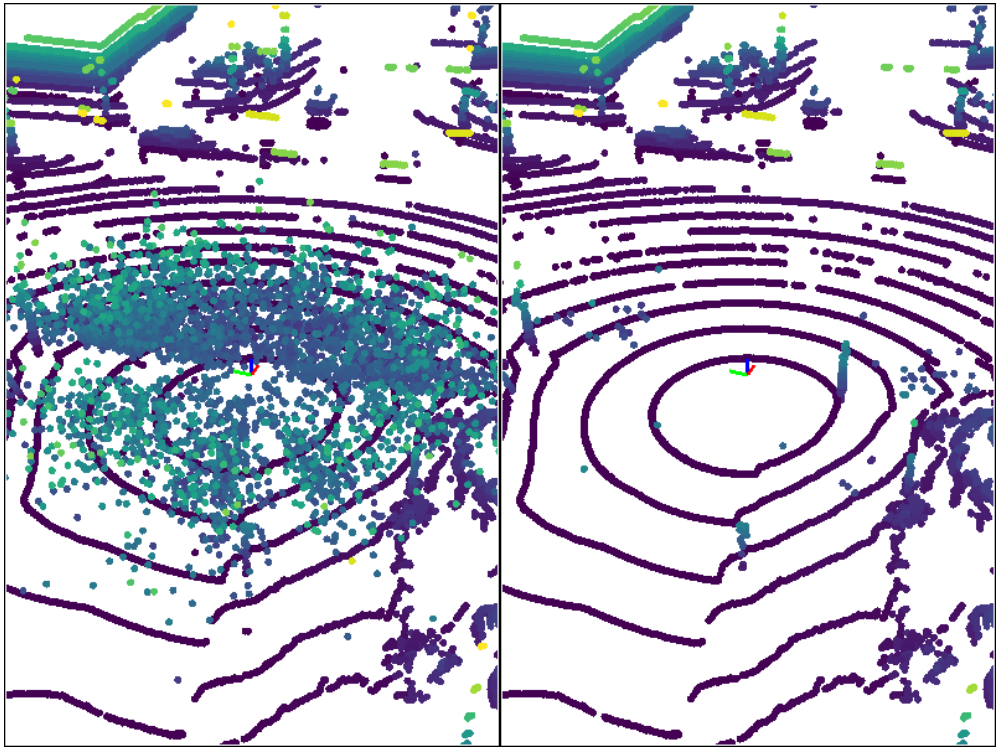


Qualitative results



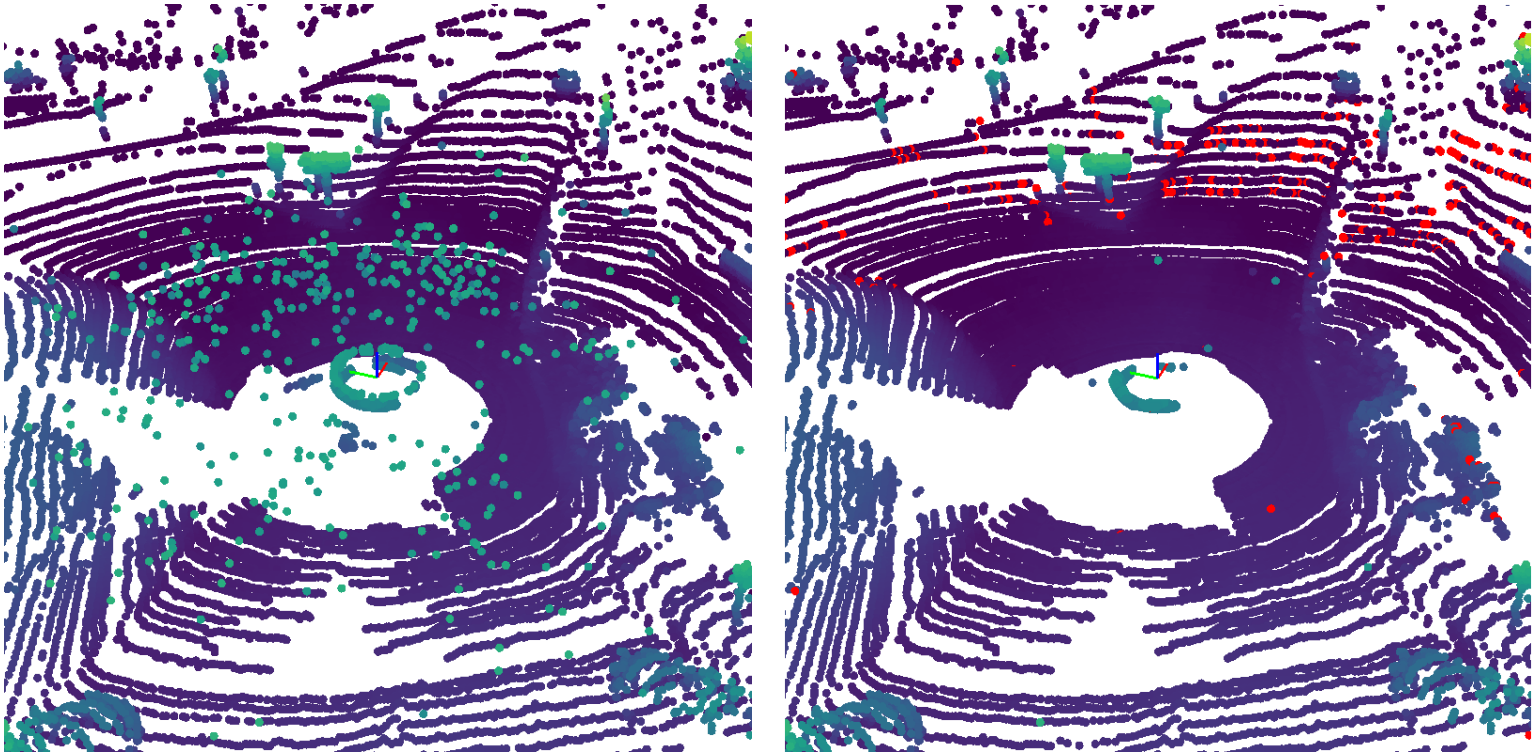
64-channel LiDAR

Qualitative results

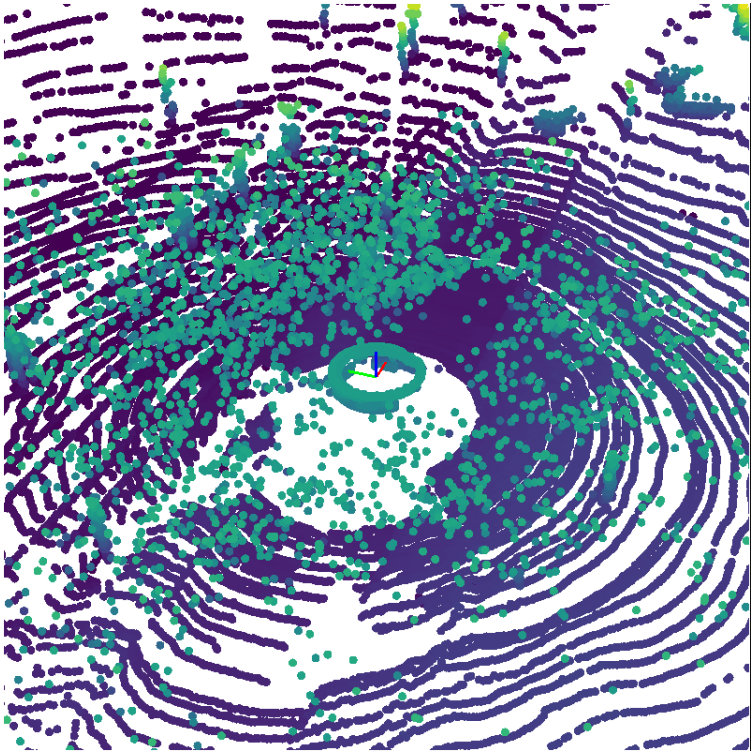


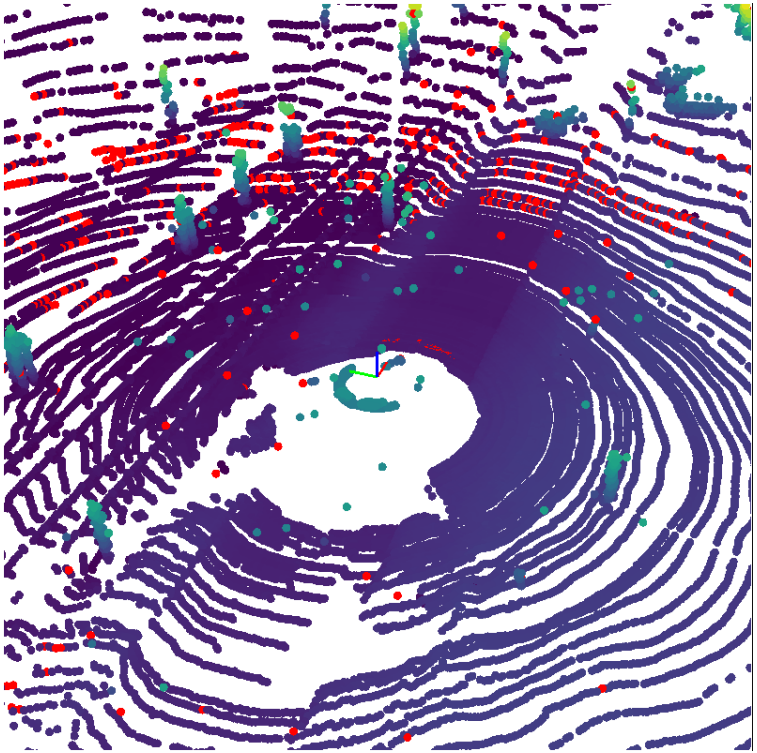
32-channel LiDAR

Qualitative results



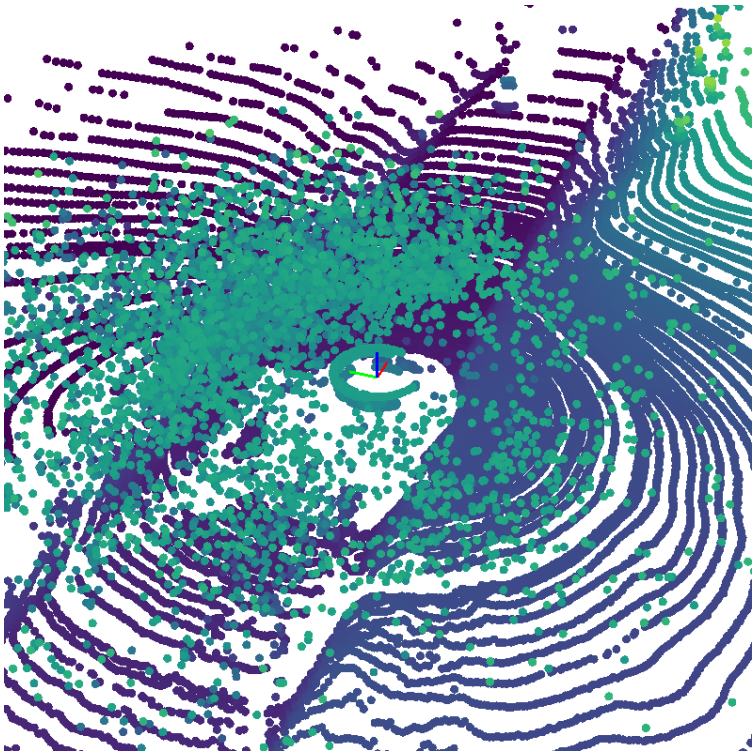
Qualitative results

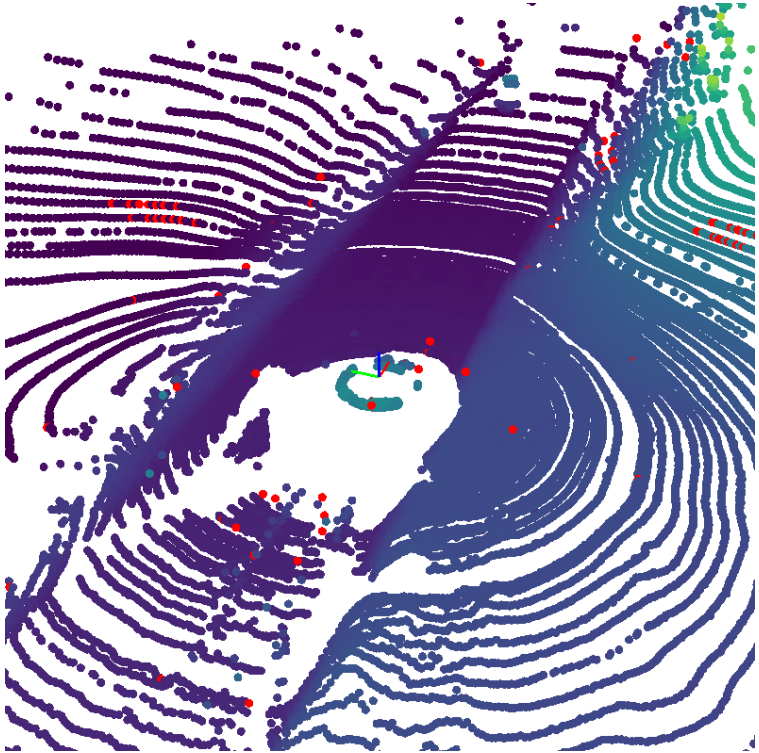




Substitute

Qualitative results





Substitute

Quantitative results

Type	Method	IoU Light	IoU Medium	IoU Heavy	Runtime ms	Param. $\cdot 10^6$
Classical						
Self-supervised						

Summary

Adverse weather such as snowfall can corrupt LiDAR point clouds significantly

Corrupted point clouds can be denoised with multi-echo denoising

A neural network can learn this without labels

- Possibility for continuous learning and adaptation to never-before-seen conditions

The presented method enables LiDAR-based perception to work better in adverse weather conditions

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