University of Stuttgart
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Radar Point Cloud Perception for Robust 3D Object Detection

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Thesis	FA/MA
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Motivation

Reliable environment perception is essential for automated driving and mobile robotics. Compared with camera and LiDAR, 4D mmWave radar is more robust under adverse weather and poor illumination, and additionally provides Doppler velocity for motion-aware sensing [1, 2]. These properties make radar point clouds a strong candidate for robust 3D object detection.

However, radar point clouds are sparse and noisy, and differ significantly from LiDAR measurements. LiDAR-oriented pipelines therefore cannot be transferred directly and may ignore radar-specific cues such as Doppler velocity and radar cross section. This thesis investigates effective radar point cloud perception for 3D object detection, with scope adaptable between radar-only modeling and a lightweight cross-modal extension on public datasets such as View-of-Delft, TJ4DRadSet, K-Radar, and Astyx [3, 2, 4].

Objectives

- Review recent radar point cloud perception methods for 3D object detection, including radar-only, LiDAR-radar, and radar-camera approaches.
- Build a radar point cloud detection pipeline using a public dataset such as View-of-Delft, TJ4DRadSet, K-Radar, or Astyx.
- Investigate radar-specific representations and features, e.g., pillar/voxel encodings, Doppler velocity, radar cross section, temporal aggregation, or sparsity-aware feature extraction.
- Compare a radar-only baseline against one selected extension, such as cross-modal feature fusion, LiDAR-assisted training, camera-assisted supervision, or knowledge distillation.
- Evaluate detection quality, runtime, robustness, and failure cases, and identify when radar-only perception is sufficient and when cross-modal information is beneficial.

Prerequisites

- Motivated to work on research in the field of radar perception
- Good programming skills in Python
- Experience in ML-frameworks (Preferably PyTorch)
- *Optional*: Experience with computer vision, 3D point clouds, or autonomous driving datasets
- *Optional*: Experience with OpenPCDet, MMDetection3D
- *Optional*: Participated in the ISS Deep Learning Lab /Automotive Radar Course

If this topic has sparked your interest, write me an email and we can discuss the proposal in more detail. Please include your current transcript and CV.

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References

[1] Zengyun Liu. *Awesome-3D-Detection-with-4D-Radar*. 2026. URL: https://github.com/liuzengyun/Awesome-3D-Detection-with-4D-Radar (visited on 05/31/2026).

[2] Alexander Musiat et al. *RadarPillars: Efficient Object Detection from 4D Radar Point Clouds*. 2024. DOI: 10.48550/arXiv.2408.05020. arXiv: 2408.05020 [cs.CV].

[3] Andras Palffy et al. "Multi-class Road User Detection with 3+1D Radar in the View-of-Delft Dataset". In: *IEEE Robotics and Automation Letters* 7.2 (2022), pp. 4961–4968. DOI: 10.1109/LRA.2022.3147324.

[4] Patrick Palmer et al. "LEROjD: Lidar Extended Radar-Only Object Detection". In: *Computer Vision – ECCV 2024*. 2024. URL: https://www.ecva.net/papers/eccv_2024/papers_ECCV/papers/07776.pdf.