Karlsruher Institut für Technologie

Applied Informatics and Formal Description Methods
Cooperative Autonomous Systems
Kaiserstraße 89
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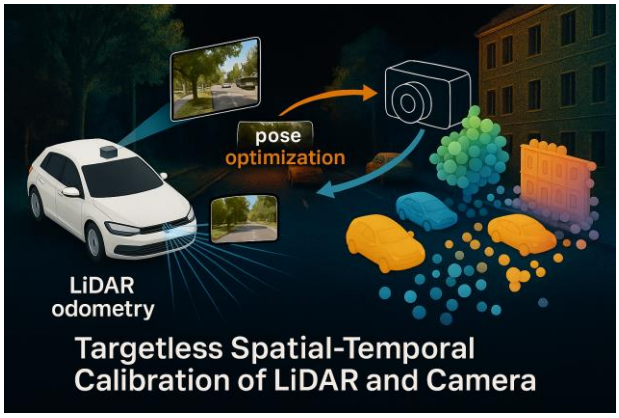
Master Thesis

Targetless Spatial-Temporal Calibration of LiDAR-Camera Systems

Background:



Accurate and robust spatio-temporal calibration between LiDAR and camera sensors is essential for high-quality sensor fusion in autonomous systems. Traditional methods often rely on artificial targets like checkerboards or spheres, which are impractical for large-scale or dynamic environments. Recent research explores targetless, structureless approaches that use natural scene features and continuous motion to estimate spatial and temporal offsets. Methods such as SOAC and TLC-Calib leverage neural scene representations (e.g., NeRF, 3D Gaussian Splatting) for joint scene reconstruction and sensor pose optimization from raw, unlabelled data. These frameworks achieve accurate calibration by combining implicit scene modeling with photometric and geometric consistency. Examples include Park et al. (2020), who use continuous-time optimization with image features and LiDAR odometry, and Jung et al. (2025), who propose a differentiable framework based on anchored 3D Gaussians. Herau et al. (2024) improve robustness through multi-NeRF training. This thesis will investigate and extend such approaches toward a unified, efficient, and targetless calibration framework based on differentiable scene representations and continuous optimization.

Your Tasks:

- Conduct a comprehensive literature review on spatio-temporal LiDAR-camera calibration, with emphasis on targetless and neural field-based methods (e.g., SOAC).
- Reproduce key baseline methods using datasets like KITTI-360, Waymo, and nuScenes.
- Develop a novel calibration pipeline for fast and accurate spatio-temporal calibration.

Your Profile:

- Solid understanding of computer vision, robotics, and sensor fusion.
- Hands-on experience with LiDAR and camera data processing.
- Familiarity with SLAM, NeRF, and 3D Gaussian Splatting.
- Independent, research-oriented mindset and the ability to handle open-ended problems.

Start date: Immediately **Duration:** As per the applicable examination regulations.

If you are interested or have any questions regarding this thesis position, feel free to contact:
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[1] Park, Chanoh, et al. "Spatiotemporal camera-LiDAR calibration: A targetless and structureless approach." IEEE Robotics and Automation Letters 5.2 (2020): 1556-1563.
[2] Jung, Haebeom, et al. "Targetless LiDAR-Camera Calibration with Anchored 3D Gaussians." arXiv preprint arXiv:2504.04597 (2025).
[3] Herau, Quentin, et al. "Soac: Spatio-temporal overlap-aware multi-sensor calibration using neural radiance fields." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2024.