Karlsruher Institut für Technologie

Fakultät für Informatik
Institut für Anthropomatik und Robotik
Lehrstuhl für Intelligente Sensor-Aktor-Systeme (ISAS)
Prof. Dr.-Ing. Uwe D. Hanebeck

Intelligente Sensor-Aktor-Systeme

Praxis der Forschung:
Simultaneous Localization and Mapping based on Directional Estimation

Supervisor: M.Sc. Kailai Li, **Email:** kailai.li@kit.edu
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Simultaneous Localization and Mapping (SLAM) denotes the technique of constructing or updating a map of unknown surroundings (*mapping*) while at the same time estimating an agent's pose (*tracking*). It plays a central role in a variety of application scenarios, such as autonomous driving [1], robotic perception [2], manipulation [3] as well as navigation in unknown environments. However, due to the high nonlinearity and dynamics of rigid body motions, which mathematically belong to the *special Euclidean group* $SE(3)$, the tracking step is still challenging in real-world scenarios. Conventional pose estimation methods include applying the stochastic filters, e.g., from the well-known Kalman filter family, or the Monte Carlo-based particle filters, which lack the necessary probabilistic interpretation of the nonlinearity underlying the manifold of $SE(3)$. In some vision-based scenarios numerical approaches are also applied but they typically have the assumption of small motion between consecutive frames.

Directional statistics [4], a subfield of statistics, specifically deals with uncertain directional variables on nonlinear manifolds such as $SE(2)$, $SE(3)$, $SO(3)$, etc.. Distributions from this subject have been further applied to construct some *directional estimation* approaches for tracking. In this project, a novel pose estimator will be implemented for performing SLAM in real-world scenarios and further get evaluated under challenging circumstances. More specifically, the project is composed of the following work packages.

Work Packages:

- Literature review of existing SLAM work flow, especially the system using visual/LiDAR-inertial sensor suite.
- Investigation of representation methods of rigid body motions and corresponding distributions of directional statistics for modeling their uncertainties.
- Development and implementation of a $SE(3)$-estimator using directional estimation approaches based on sensor fusion.
- Coupling the estimator with existing mapping approaches into a full SLAM system.
- Loop closure detection and constructing a globally consistent map.
- Evaluation using real-world dataset in multiple application scenarios, e.g., autonomous driving, large-scale 3D reconstruction, etc..

Students applying to this project should be highly self-motivated and willing to take on challenges. Solid coding skill with C++ and good mathematical foundations are expected. Pre-knowledge with ROS is a plus. At least one joint publication is planned as one of the goals of the project.

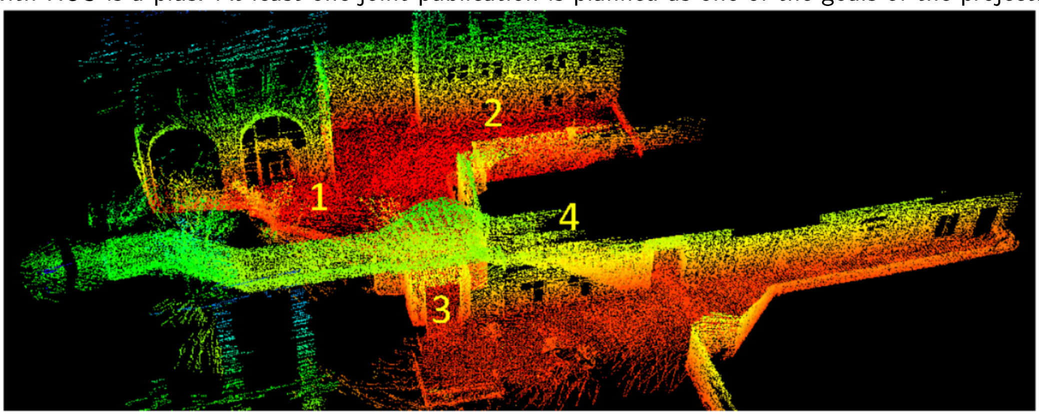

Figure 1: LiDAR odometry [1]

References

[1] J. Zhang and S. Singh, "Visual–inertial combined odometry system for aerial vehicles," *Journal of Field Robotics*, vol. 32, no. 8, pp. 1043–1055, 2015.

[2] T. Laidlow, M. Bloesch, W. Li, and S. Leutenegger, "Dense rgb-d-inertial slam with map deformations," in *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 6741–6748, 2017.

[3] A. Byravan and D. Fox, "Se3-nets: Learning rigid body motion using deep neural networks," in *Robotics and Automation (ICRA), 2017 IEEE International Conference on*, pp. 173–180, IEEE, 2017.

[4] K. V. Mardia and P. E. Jupp, *Directional statistics*, vol. 494. John Wiley & Sons, 2009.