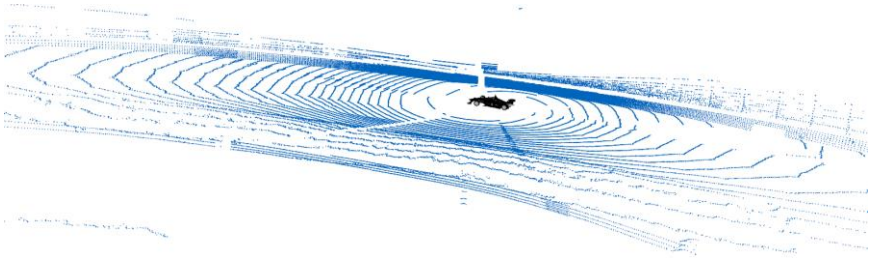
Institute of Automotive Technology
TUM School of Engineering and Design
Technical University of Munich

Master's Thesis

Localization for High Dynamic Autonomous Racing



The Indy Autonomous Challenge (IAC) was the first fully autonomous wheel-to-wheel race in history. Teams from ten international universities implemented individual software stacks and deployed these to identical vehicles to compare software performance. For localization, the vehicles were equipped with two redundant differential GPS receivers. With RTK correction, those systems can reach accuracy at centimeter-level. Due to the strong performance of this system, none of the teams implemented a localization algorithm for GPS-denied environments and high speeds.

The scope of this thesis is to improve the concept of the open-source *KISS-ICP*, an algorithm for LiDAR localization, for high dynamic scenarios on racetracks. The primary objective is to create an algorithm robust against rapid changes in a vehicle's state. External signal sources, such as information from a state estimator or raw sensor signals (e.g., IMU), should be used to leverage the robustness of the developed algorithm. Pre-processing of the data will be a vital part of this thesis. A de-skewing approach for high-frequent vehicle pose changes should be developed to improve the robustness of scan matching. Another important aspect is the computationally efficient processing of the data for low-latency pose estimations, as resources of the racecar are limited. The anticipated outcome of this research is an advanced localization system that enables accurate and reliable positioning for autonomous racing vehicles, contributing to the development of safe and high-performance autonomous driving in high-speed environments.

The following work packages are part of the student research project:

- Familiarization and literature review for the current state of the art in localization for high dynamic applications
- Development of a map-based LiDAR-Localization algorithm with focus on robust scan matching in high dynamic scenarios
- Incorporation of external signal sources from state estimators and sensors
- Application and evaluation on the Indy Autonomous Challenge Racecar of the TUM
- Evaluation, discussion, and documentation of the results in a written form
- Filing and documentation of the developed software in the FTM Gitlab

Qualifications:
You should be able to independently familiarize yourself with the topic and the tools and have a structured way of working. Ideally, you have programming experience in Python and C++ and knowledge of the ROS2 framework. *There are no hard requirements, as everything can be learned if you are willing to put in the extra effort.*

Contact:
If you are interested in this project or have your own ideas on this topic, send your CV and transcript of records with a few sentences about your motivation or idea to:

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