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Feature-based Localization for Autonomous Vehicles

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Ever since the DARPA Challenges, which took place from 2004 to 2007, the development of autonomous vehicles has received broad attention in the scientific community. DISAL is currently working on an autonomous vehicle in collaboration with Peugeot Citroen.

This semester project explores means of localizing an autonomous vehicle. In particular, the focus is on fine grained localization on the street. Based on the experience represented by previous work in the field, this is achieved by detecting the curb using a laser range finder.

In order to make use of the car setup that is currently available with DISAL's test platform, and in order to explore a sensor setup that differs from previous work, a generic laser range finder is simulated at the front bumper of the autonomous vehicle, facing down.

Front bumper-mounted laser range finder

The project has been conducted entirely in simulation for practical reasons. A major portion of the time dedicated to the project has been spent on enhancements of the simulated environment, such as the generation of smooth street and curb models based on data from Open Street Map. In order to limit difficulties in this proof of concept work, a uniform and exaggerated curb dimension of 30cm has been modeled. The simulated environment consists solely of the car, the street with curb and some buildings.

Three levels of sophistication of the localization have been implemented and compared:

1. Using only GPS and odometry.
2. Beam-model based laser range state estimation in addition to level 1.
3. Feature-based estimation instead of beam-model based estimation

The difference between the latter two estimation methods is that while beam-model based estimation compares the measured sensor values to predictions of a sophisticated (yet typically incomplete) model, feature-based estimation first looks for features in the sensor data and only uses those for a comparison with a simplified model.

A feature extraction algorithm has been developed that is adapted to the particular sensor setup of this project, making use of the closeness to the road.

An improvement of the localization error from about 0.5m using level 1 to about 0.3m using levels 2 or 3 has been observed, with slightly better results with level 2. Qualitatively, the error transversal to the street has been reduced in particular.

Localization improvement from level 1 to level 2

The slightly better results in level 2 don't need to lead to the conclusion that it performs better than level 3. In fact, the clean environment of a simulation gives level 2 an advantage it would not necessarily have in practice. Besides, there has not been enough time to properly fine-tune parameters of the algorithm (e.g. with a PSO), nor to make properly extensive measurements. This would be interesting future work for the project.

Overall, however, the results of previous work could be reproduced qualitatively in simulation. could be reproduced qualitatively in simulation.