University Research Group:	Systems Control and Optimization Laboratory
Company Research Group:	Bosch Corporate Research, Future Systems Consumer Goods
Project Type:	Master Thesis in Robotics (30 ECTS-Credits, 6 months)

Master Thesis Proposal

Path and Trajectory Optimization for Nonholonomic Systems

The generation of natural and safe motions in dynamic environments for non-holonomic robotics systems is still an open challenge. Very recently different optimization based approaches have been presented to generate a smooth path that locally avoids obstacles: e.g. CHOMP [1] a gradient descent based approach, TrajOpt [2] - a SQP based approach, KOMO [3] - a k-order Newton optimization method. Unfortunately, a clear understanding of their functionalities on nonholonomic systems has never been presented.

With this thesis we aim to study, implement and compare recent optimization techniques (e.g. SQP, KOMO, CHOMP) for nonholonomic systems (e.g. car, differential drive, truck and trailer) in cluttered environments described by occupancy grids.

The implemented algorithms will be compared in terms of efficiency and path quality, in different simulated environments and then tested on a real robot.

A good knowledge of `C++` is requested. The software will be mostly developed using `ACADO` and `Casadi` as `ROS` nodes. We aim to use as simulator the `Gazebo` environment.

There will be regular meetings with the project supervisors at times/dates to be defined. Bosch Corporate Research offices are located in Renningen (near Stuttgart).

The candidate judgment will be based on the achievement of the described goals and whether she/he met the following criteria: motivation, autonomy, understanding of the topic, creativity, theoretical soundness, implementation quality, report and presentation.

To express your interest or for any questions feel free to send an email to:
robin.verschueren@imtek.uni-freiburg.de or Luigi.Palmieri@de.bosch.com.

References

[1] Matt Zucker et al. Chomp: Covariant hamiltonian optimization for motion planning. *The International Journal of Robotics Research*, 32(9-10):1164–1193, 2013.

[2] John Schulman et al. Motion planning with sequential convex optimization and convex collision checking. *The International Journal of Robotics Research*, 33(9):1251–1270, 2014.

[3] Marc Toussaint. A tutorial on newton methods for constrained trajectory optimization and relations to slam, gaussian process smoothing, optimal control, and probabilistic inference. 2016.