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M A S T E R ' S T H E S I S

Gaussian Processes based Model Predictive Control of Overtaking Maneuvers for Autonomous Vehicles

Problem description:

In the field of autonomous driving, performing overtaking maneuvers poses a major challenge and has received significant attention recently [5]. A common approach for trajectory planning in autonomous driving is Model Predictive Control (MPC), which requires a precise model of the ego vehicle, as well as surrounding vehicles and their behavior.
Gaussian processes have become increasingly popular in the context of MPC [1, 3], due to their ability to provide accurate modeling. Learning MPC has shown promise for racing applications [4], while so far, Gaussian process based MPC has been employed to control a single miniature racing car [2]. However, for racing or everyday traffic it is inevitable to deal with the behavior of other vehicles while overtaking.
The goal of the thesis is to employ Gaussian processes and MPC to learn the behavior of other vehicles during overtaking maneuvers and use this knowledge to safely and efficiently plan ego vehicle trajectories.

Tasks:

- Literature research - Gaussian process based MPC and overtaking maneuvers for autonomous vehicles
- Implementation of MPC law for overtaking maneuvers
- Extension of MPC law to include Gaussian process based learning feature

Bibliography:

[1] Gang Cao, Edmund M-K Lai, and Fakhrul Alam. Gaussian process model predictive control of an unmanned quadrotor. *Journal of Intelligent & Robotic Systems*, 88(1):147–162, 2017.
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[3] Torsten Koller, Felix Berkenkamp, Matteo Turchetta, and Andreas Krause. Learning-based model predictive control for safe exploration and reinforcement learning. *arXiv preprint arXiv:1803.08287*, 2018.
[4] Ugo Rosolia and Francesco Borrelli. Learning model predictive control for iterative tasks. a data-driven control framework. *IEEE Transactions on Automatic Control*, 63(7):1883–1896, July 2018.
[5] Eun Sang Cha, Kee-Eung Kim, Stefano Longo, and Ankur Mehta. Op-cas: Collision avoidance with overtaking maneuvers. pages 1715–1720, 11 2018.

Supervisor:	M. Sc. Alexandre Capone, M. Sc. Tim Brdigam
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(S. Hirche)
Univ.-Professor