Dimensionality Reduction for Real-time Iteration in Nonlinear Model Predictive Control

TECHNISCHE UNIVERSITÄT DARMSTADT

Project Seminar (3-4 Students)

In the optimal control of nonlinear systems, model predictive control (MPC) is a popular choice due to its ability to consider state and input constraints. During MPC runtime, the optimal control problem (OCP) needs to be solved repeatedly. However, the necessity for this online solution to the OCP often renders it impractical in real-time critical applications. Therefore, specialized dimensionality reduction techniques designed for OCPs have been proposed to address this issue [1].

In this project, you will first familiarize yourself with and investigate a specific MPC algorithm, where the nonlinear OCP is replaced by its quadratic approximation [2]. Then, the project aims to combine the dimensionality reduction methods from [1] with the algorithm from [2] to facilitate the efficient solution of the OCP of an example MPC implementation. After that, the baseline and the reduced MPC scheme will be compared regarding performance and resource efficiency.

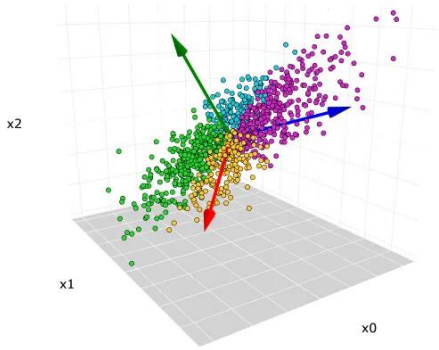
Depending on the rate of progress, the method is tested on a real system in our lab. Your tasks include:

- Understanding the main ideas in [1] and [2].
- Development of a reduced MPC scheme and its implementation.
- Closed-loop simulations and comparison of the results, with a special focus on suboptimality and computation times.

Knowledge of control theory and optimization is required. A firm grasp of programming in MatLab/Python is highly recommended. Creativity is desirable. Please do not hesitate to contact us if you have any further questions!

[1] Pan, Guanru, and Timm Faulwasser. "NMPC in active subspaces: Dimensionality reduction with recursive feasibility guarantees." *Automatica* 147 (2023): 110708.

[2] Gros, Sébastien, et al. "From linear to nonlinear MPC: bridging the gap via the real-time iteration." *International Journal of Control* 93.1 (2020): 62-80.



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