TECHNISCHE UNIVERSITÄT MÜNCHEN
LEHRSTUHL FÜR STEUERUNGS- UND REGELUNGSTECHNIK
UNIV.-PROF. DR.-ING./UNIV. TOKIO HABIL. MARTIN BUSS
DR.-ING. MARION LEIBOLD

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MASTER'S THESIS

Nonlinear Model Predictive Control Using Higher Order Numerical Integration and Generalized Hold Elements

Problem description:

Model Predictive Control (MPC) is a widely applied control strategy that finds great success in complex industrial processes due to its capability of directly considering performance criteria and constraints on system variables [1]. For the application of MPC on continuous-time systems, usually discrete-time models issued from forward Euler integration in conjunction with piecewise constant inputs (i.e., zero-order hold) are used.
For the sampled control of nonlinear systems, the use of higher order numerical integration schemes for the discrete-time modeling and control implementation has shown improved control performance in practice, e.g., on a magnetic levitation system [2]. Regarding MPC, the results of a first study on a simple linear system suggest that the use of models based on higher-order numerical integration, with possibly higher-order hold elements, can be beneficial in terms of accuracy, control performance, and efficiency of computations.
The goal of this work is to study nonlinear MPC and to analyze whether the use of more sophisticated discrete-time models brings advantages concerning the numerical efficiency to achieve a certain accuracy. The experimental evaluation of the developed MPC scheme will be conducted on a magnetic levitation system available at the Chair of Automatic Control in Garching.

Tasks:

- Literature review on the use of higher-order (collocation) models as the basis of MPC
- Familiarization with nonlinear MPC and its implementation
- Familiarization with the experimental setup and application of the developed approach
- Studies concerning the above-mentioned criteria under different integration schemes with different hold mechanisms

Requirements:

- Good knowledge in control theory, especially optimal control
- Good experience in MATLAB & Simulink
- Passed the following courses with distinction:
  → *EI students:* Dynamical Systems, Optimal Control and Decision Making
  → *MW students:* Advanced Control, Nonlinear Control

Bibliography:

[1] Lars Grüne and Jürgen Pannek. Nonlinear model predictive control. In *Nonlinear model predictive control*, pages 45–69. Springer, 2017.
[2] Paul Kotyczka, Christian J. Martens, and Laurent Lefèvre. High order discrete-time control based on Gauss-Legendre collocation. *IFAC-PapersOnLine*, 54(19):237–242, 2021.

Supervisor:	M.Sc. Johannes Teutsch
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(M. Leibold)
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