Chair of
Automatic Control

FAU

Announcement for Research Project/ Master Thesis

Benchmarking of NMPC algorithms for robots

Motivation

The control of complex and highly dynamic robot systems using Nonlinear Model Predictive Control (NMPC) is a promising approach [1, 2]. MPC solves an optimal control problem (OCP) with a receding horizon to achieve optimal control while explicitly enforcing state and input constraints.

Recently, MPC methods for whole-body rigid dynamics with contacts have been proposed. These are mostly used for humanoid or other legged robot systems [3, 4]. However, promising results for classical robotics can be expected [2]. In this work, existing NMPC-based algorithms are to be examined and evaluated for the case of one- and two-arm robot manipulation.

Task

First, a literature review of state-of-the-art MPC methods for use in robotics applications should be performed, with a focus on serial-link torque-controlled robots using the fully dynamic model. Building on this, the main goal of the work will be to compare different MPC solvers and toolkits in different simulation scenarios. The performance of these solvers will be evaluated in terms of their accuracy, computational efficiency, and robustness to external disturbances.

Requirements

A solid background in robotics and knowledge of programming languages such as C++ or Python are required. Knowledge of numerical optimization techniques and familiarity with MPC algorithms would be an advantage.

References

[1] A. Völz and K. Graichen, "Gradient-based nonlinear model predictive control for systems with state-dependent mass matrix," 2021 60th CDC, Austin, TX, USA, 2021, pp. 1012-1017.

[2] S. Kleff, et. al., "High-Frequency Nonlinear Model Predictive Control of a Manipulator," 2021 ICRA, Xi'an, China, 2021, pp. 7330-7336.

[3] Mastalli, Carlos, et al. "Crocoddyl: An efficient and versatile framework for multi-contact optimal control." 2020 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2020.

[4] Katayama, Sotaro, and Toshiyuki Ohtsuka. "Efficient solution method based on inverse dynamics for optimal control problems of rigid body systems." 2021 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2021.

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