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BACHELOR THESIS

Nonlinear Model Predictive Control in the Application of Constrained Manipulator Control

Problem description:

In the practical cases, a manipulator is required to perform tasks, usually end-effector position and orientation control, along with various inequality constraints, i.e., joint limits, joint velocity limits, torque limits, obstacle avoidance, etc. There have been several approaches to integrate such constraints into the manipulator control architechture based on different ideas such as gradient projection, potential field, weighted least norm, and optimization technique. Among them, a variant of the optimization technique is the nonlinear model predictive control (NMPC) that has been used succesfully for the process control in the industry. Thanks to the development of the computing power, the NMPC has been a promising candidate to solve inequality constrant problem for the robotic applications but still there are several difficulties related to the theoritical and practical aspects, for example, it's hard to prove stability and to implement for the real-time application.
In this thesis, the Linear/Nonlinear model predictive control will be studied from the fundamental theory to the practical implementation but will be more focused on the literature study of [3]. A student is required to read, understand, summerize, and test methods listed in [3] on the robotic applications that could be mobile robots or robotic manipulators. To implement algorithms, robot kinematics also needs to be studied. The final goal is to apply the NMPC for the 7-DOFs manipulator with joint limits, joint velicity limits, and obstacle avoidance.

Tasks:

- Literature study for the nonlinear model predictive control related to the robotic applications
- Implementation of the NMPC with various examples using Matlab or C++
- Simulation of 7-DOFs manipulator with joint limits, joint velocity limits, and obstacle avoidance

Bibliography:

[1] Anthony A. Maciejewski and Charles A. Klein Obstacle Avoidance for Kinematically Redundant Manipulators in Dynamically Varying Environment, In *International Journal of Robotics Research*, 1985
[2] Poignet Ph. and Gautier M. Nonlinear Model Predictive Control of a Robot Manipulator, In *International Workshop on Advanced Motion Control*, 2000
[3] Camacho, Eduardo F and Alba, Carlos Bordons *Model Predictive Control*, Springer, 2013

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