TECHNISCHE UNIVERSITÄT MÜNCHEN
LEHRSTUHL FÜR INFORMATIONSTECHNISCHE REGELUNG
ORDINARIA: UNIV.-PROF. DR.-ING. SANDRA HIRCHE

MASTER'S THESIS

Trajectory Optimization and Control in Maximal Coordinates

Problem description:

Minimal coordinates (also called generalized or joint coordinates) have historically dominated robotic simulation and control, possibly due to the perception that they lead to greater computational efficiency. However, rigid body dynamics in maximal coordinates can be computed with similar efficiency as dynamics in minimal coordinates [2]. Additionally, recent findings indicate superior performance of maximal-coordinate control over minimal-coordinate control for linearized systems [1].
A relatively simple yet powerful tool for the control of linear and linearized systems is the Linear-Quadratic Regulator (LQR). It can also be extended to trajectory optimization, for example with the iterative-LQR algorithm (iLQR), or to online control, for example with model-predictive control schemes (MPC) based on LQR. Since the classical LQR has been derived for maximal coordinate robotic systems, the extension to more advanced concepts such as iLQR and MPC is a logical next step. Especially the optimization through physical constraints such as joints or environment contact poses interesting research questions.
The aim of this master thesis is to derive advanced trajectory optimization and control algorithms for systems described in maximal coordinates. Afterwards, the performance of the derived control methods can be evaluated in a simulation of a controlled and constrained systems.

Tasks:

- Literature research on maximal coordinates, trajectory optimization and control
- Derivation of iLQR and MPC based on maximal-coordinate LQR
- Evaluation of performance and applicability to constrained dynamical systems

Bibliography:

[1] J. Brüdigam and Z. Manchester. Constrained Linear-Quadratic Optimal Control in Maximal Coordinates (submitted). *IEEE Robotics and Automation Letters*, 2020.
[2] J. Brüdigam and Z. Manchester. Linear-Time Variational Integrators in Maximal Coordinates (accepted). In *Workshop on the Algorithmic Foundations of Robotics (WAFR)*, 2020.

Supervisor:	M. Sc. Jan Brüdigam
Start:	As soon as possible
Intermediate Report:	After 3 months
Delivery:	After 6 months

(S. Hirche)
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