Numerical Methods for Embedded Optimisation and their Implementation within the ACADO Toolkit

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Abstract

When nonlinear dynamic systems shall be controlled to perform certain tasks optimally, nonlinear optimal control problems have to be solved. Often it is even desired to solve such problems in real-time, possibly on embedded hardware. This occurs most prominently in the framework of model predictive control (MPC) of fast systems, e.g. in mechatronics or automotive engineering. We briefly review the state-of-the-art in nonlinear dynamic optimisation and point out the differences between direct approaches based on Sequential Quadratic Programming (SQP) and Interior-Point (IP) methods. We then review algorithmic ideas for embedded nonlinear optimisation, in particular the so-called real-time iteration.

These methods are recently implemented in the ACADO Toolkit, an open-source software environment and algorithm collection for Automatic Control and Dynamic Optimisation. The ACADO Toolkit provides a general framework for using a variety of algorithms for direct optimal control, including in particular embedded optimisation in form of model predictive control (MPC) as well as moving horizon estimation (MHE).ACADO Toolkit is implemented as self-contained C++ code whose object-oriented design allows for convenient coupling of existing optimisation packages and for extending it with user written optimisation routines.

We finally present simulation results using ACADO Toolkit for a challenging test problem, namely nonlinear MPC of power generating kite systems.