Efficient Numerical Methods for Solving Inverse Optimal Control Problems and Recent Computational Results for Modeling Human Locomotion

K. Hatz[1], J. P. Schlöder[1], and H. G. Bock[1]

Abstract: We present efficient numerical methods for hierarchical dynamic optimization problems, which are also called inverse optimal control problems. The problem setting is a complex bi-level optimization problem: A regression objective on the upper level and a nonlinear optimal control problem (OCP) in ordinary differential equations with discontinuities and mixed path-control constraints on the lower level. The OCP can be considered as a model (a so-called optimal control model (OCM)) that describes optimal processes in nature, such as human gait. However, the optimal control model includes unknown parameters that have to be determined by fitting the OCM to measurements, which is done in the upper level optimization. We present mathematical and numerical approaches for solving this new class of problems. We furthermore use our efficient direct all-at-once approach for hierarchical dynamic optimization to derive optimal control models for the gait of cerebral palsy patients from real-world motion capture data that has been provided by the Motion Lab of the Orthopaedic University Hospital Heidelberg.

[1] IWR, University of Heidelberg
Im Neuenheimer Feld 368, 69120 Heidelberg, Germany
kathrin.hatz@iwr.uni-heidelberg.de, schloeder@iwr.uni-heidelberg.de, bock@iwr.uni-heidelberg.de