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Inverse Optimal Control Problems and Applications to Modeling the Gait of Cerebral Palsy Patients

Abstract: We present numerical methods solving inverse optimal control problems as complex bi-level dynamic optimization problems: a nonlinear approximation problem on the upper level and a nonlinear optimal control problem (OCP) with discontinuities and mixed path-control constraints on the lower level. The OCP solution can be considered as a model that describes autonomous optimal processes in nature such as human gait. However, the optimal control model includes unknown parameters that need to be determined by fitting its solution to measurements in the upper level optimization. We develop a direct mathematical all-at-once approach for solving this relatively new class of problems, and apply this to identify biomechanical optimal control models for the gait of cerebral palsy patients from real-world motion capture data obtained by the Motion Lab of the Orthopedic University Hospital Heidelberg.