Discrete Mechanics and Optimal Control

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The optimal control of physical processes is of crucial importance in all modern technological sciences. In general, one is interested in prescribing the motion of a dynamical system in such a way that a certain optimality criterion is achieved. Typical challenges are the determination of a time-minimal path in vehicle dynamics, an energy-efficient trajectory in space mission design, or optimal motion sequences in robotics and biomechanics.

In order to solve optimal control problems for mechanical systems, this thesis links the theory of optimal control with concepts from variational mechanics. The application of discrete variational principles allows for the construction of an optimization algorithm that enables the discrete solution to inherit characteristic structural properties from the continuous problem.

The numerical performance of the developed method and its relationship to other existing optimal control methods are investigated. This is done by means of theoretical considerations as well as with the help of numerical examples arising in problems from trajectory planning and space mission design.

The development of efficient approaches for exploiting the mechanical system's structures reduce for example the computational effort. In addition, the optimal control framework is extended to mechanical systems with constraints in multi-body dynamics and applied to robotical and biomechanical problems.