Geometric Methods for Fast and Feasible Hybrid Trajectory Optimization

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Abstract

Designing dynamically feasible trajectories for robotic systems is especially challenging when both high-dimensional dynamics and hybrid contact behaviors must be addressed. This talk presents two complementary advances in trajectory generation. First, I describe a Riemannian optimization framework for trajectory optimization of rigid bodies evolving as a hybrid dynamical system. By formulating discrete rigid body dynamics with Lie Group Variational Integrators and deriving closed-form Riemannian derivatives, the method enables a Riemannian Interior Point optimization algorithm that respects the topology of the rotation group and achieves linear complexity in both horizon length and degrees of freedom. This allows for the principled handling of impacts and mode switches while preserving computational efficiency. Second, I present ongoing theoretical work on generalizing the Affine Geometric Heat Flow (AGHF) method to mechanical systems undergoing contact. This formulation provides a pathway toward efficient trajectory synthesis in systems where continuous dynamics and discrete contact constraints are tightly coupled. Together, these results represent progress toward scalable, structure-preserving algorithms for planning and control of complex robotic systems.

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