Bringing the Heat: Swift Trajectory Planning with Spatial-Pseudospectral Techniques

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Abstract

Planning and generating trajectories for high-dimensional robotic systems efficiently, while adhering to the constraints of robot dynamics, presents significant challenges. Typically, this involves either solving a nonlinear, non-convex optimization problem or converting the issue into a high-dimensional nonlinear Partial Differential Equation (PDE). However, the optimization-based approach often entails solving a large nonlinear program that is computationally demanding for high-dimensional systems. Conversely, the memory required for the PDE approach scales exponentially with the model's dimension, making it impractical for robotic systems with a large number of degrees of freedom. To overcome these obstacles, this talk introduces a novel algorithm for trajectory generation that utilizes the Affine Geometric Heat Flow PDE. This method enhances computational speed without sacrificing the dynamic feasibility of motion planning while still being able to integrate path constraints. The proposed approach utilizes a pseudospectral method coupled with spatial vector algebra to efficiently solve the Affine Geometric Heat Flow. The efficacy of this approach is demonstrated through various comparisons with real robotic systems, including the 16-degrees-of-freedom bipedal robot, Digit, where the proposed trajectory synthesis across a variety of tasks is always completed in under approximately five seconds.

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