Geometric Motion Planning for Inertial Systems

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Abstract

In order to enable better visualization and understanding of the effect of the robot's geometry and inertia on the robot's trajectories, this dissertation proposes to use geometric mechanics to bridge the gap between the physical motion of a robot and its mathematical structure. The main focus of this research is to investigate the system geometry and inertia and their relationship with the curves and acceleration that produce the most efficient trajectories or gaits. This dissertation 's approach has an advantage over the state-of-the-art method, which uses numerical forward dynamic simulations. Such numerical simulations are computationally expensive and dependent on starting parameters. The proposed geometric motion planning framework allows the user to design a trajectory with respect to the requirements without any need for forward simulation. Furthermore, the proposed framework enables the user to understand the system's movement from its mathematical model rather than computing the results and exploring the outputs. Unlike previous works that were focusing on the system geometry to gain insight about the system's movement, this dissertation uses the geometry and inertia to describe the system's movement. This is achieved using two tools to gain insight into the underlying locomotion: constructing geodesics and constructing metric fields. The geodesic illustrates the robots geometric structure of the natural dynamic path which is defined as the straightest path. The metric field in mechanical systems is obtained from the system's inertia which illustrates where it is easier to move in parameterized space.

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