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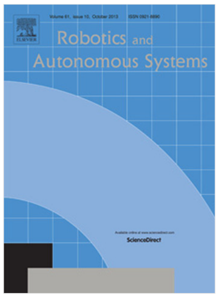

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Completeness of Randomized Kinodynamic Planners with State-based Steering

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Abstract

Probabilistic completeness is an important property in motion planning. Although it has been established with clear assumptions for geometric planners, the panorama of completeness results for *kinodynamic* planners is still incomplete, as most existing proofs rely on strong assumptions that are difficult, if not impossible, to verify on practical systems. In this paper, we focus on an important class of kinodynamic planners, namely those that interpolate trajectories in the state space. We provide a proof of probabilistic completeness for such planners under assumptions that can be readily verified from the system's equations of motion and the user-defined interpolation function. Our proof relies crucially on a property of interpolated trajectories, termed *second-order continuity* (SOC), which we show is tightly related to the ability of a planner to benefit from denser sampling. We analyze the impact of this property in simulations on a low-torque pendulum. Our results show that a simple RRT using a second-order continuous interpolation swiftly finds solution, while it is impossible for the same planner using standard Bezier curves (which are not SOC) to find any solution.[1]

Keywords: kinodynamic planning, probabilistic completeness

1. Introduction

A deterministic motion planner is said to be *complete* if it returns a solution whenever one exists [2]. A *randomized* planner is said to be *probabilistically complete* if the probability of returning a solution, when there is one, tends to one as execution time goes to infinity [3]. Although these two notions might seem theoretical, they are of notable practical interest, as proving completeness requires one to formalize the problem by hypotheses on the robot, the environment, etc. While

[1] This paper is a revised and expanded version of [1], which was presented at the *International Conference on Robotics and Automation*, 2014. The proof (Section 3) has been rewritten using Landau notation for easier reading, and a new evaluation on the low-torque pendulum has been appended, including a proof of incompleteness for fixed-time Bezier interpolation and empirical evaluation in simulations (Section 4).