Beyond Basic Path Planning in C-Spaces

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Substantial progress has been made for the basic problem of computing a collision-free path for a robot among known obstacles. Fundamental complexity and sampling issues are well understood and several successful path planning algorithms are in widespread use across academia and industry. However, deficiencies in the problem formulation itself and the demand of engineering challenges in the design of autonomous systems raise important open questions and topics for future research.

This presentation identifies three important areas for growth in motion planning. In these areas, the current demand for solutions is high, but the level of progress is far behind that of basic path planning in configuration spaces.

1. Planning under differential constraints

Mechanical systems must satisfy differential equations of motion due to kinematics and dynamics. Rather than plan and transform the computed path, it is perhaps best to directly compute paths through the C-space that directly account for the differential constraints, or even better to compute collision-free trajectories through the phase space.

2. Feedback motion planning

Robot environments are unpredictable. Our motion models are completely accurate. Therefore, it is usually impossible to execute a preplanned path. Tracking a computed path often solves this problem; however, it should be better to directly compute a plan (or policy) over most or all of the free space, commanding the robot in a direction that makes progress, regardless of where it goes.

3. Planning with sensing uncertainty

In many settings, it is too costly or even impossible to extract complete, correct descriptions of the environment. It is therefore crucial to determine what information is actually necessary to solve the given task. This amounts to identifying an appropriate information space, designing sensors and filters to induce transitions in the information space, and then computing a plan that uses information feedback to determine each action during execution.