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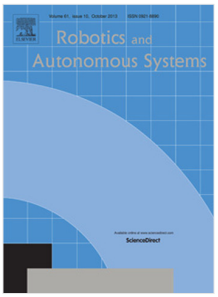

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Motion Planning in Irreducible Path Spaces

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Abstract

The motion of a mechanical system can be defined as a path through its configuration space. Computing such a path has a computational complexity scaling exponentially with the dimensionality of the configuration space. We propose to reduce the dimensionality of the configuration space by introducing the irreducible path — a path having a minimal swept volume. The paper consists of three parts: In part I, we define the space of all irreducible paths and show that planning a path in the irreducible path space preserves completeness of any motion planning algorithm. In part II, we construct an approximation to the irreducible path space of a serial kinematic chain under certain assumptions. In part III, we conduct motion planning using the irreducible path space for a mechanical snake in a turbine environment, for a mechanical octopus with eight arms in a pipe system and for the sideways motion of a humanoid robot moving through a room with doors and through a hole in a wall. We demonstrate that the concept of an irreducible path can be applied to any motion planning algorithm taking curvature constraints into account.

Keywords: Motion Planning, Irreducible Paths, Serial Kinematic Chain, Swept Volume

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