Practical exact motion planning of a class of robots with three degrees of freedom

Francis Avnaim Jean Daniel Boissonnat

INRIA Centre de Sophia-Antipolis
Route des lucioles 06565 Valbonne

Abstract

We propose a retraction method to solve the motion planning problem for a class of robots with three degrees of freedom moving amidst polygonal obstacles. A robot of this class is a planar manipulator with two arms that carries a polygonal object in its hand, free to rotate around the wrist. The set FP of free configurations of the robot that avoid collision with the obstacles is three dimensionnal. Its boundary consists of adjacent portions of analytic surfaces. More precisely, each portion of surface is a set of positions for which the robot keeps one given contact with the obstacles.

The main idea consists in computing, for each contact between the robot and the obstacles, the free space associated to the two degrees of freedom resulting system. Each of these free space is a portion of analytic surface bounded by curves of double contact. Next, we compute the adjacency relationships between the portions of surfaces using the double contact labelling. We obtain a complete and exact representation of the boundary of free space as an adjacency graph of patches of analytic surfaces. This representation allow us to compute free motions of the robot.

Constructing FP takes $O(n^3 \log n)$ time and computing a motion takes $O(n^3)$ time in the worst-case, where n is the size of the polygonal obstacles. These complexities can be reduced to, respectively, $O(n \log n)$ and $O(n)$ for typical practical situations.