Measuring Motion Planning Strategies

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Abstract

This paper proposes a new metric for the performance of motion planning heuristics.

There have been several studies of the problem of finding a minimal length path for a robot to move from a source to a destination in a field of obstacles. A typical aim of the research is to reduce the complexity of finding a shortest path.

In many circumstances, however, two practical considerations limit this research. Firstly, very little time is required to compute the shortest path in comparison to the time to actually move the robot. Secondly, the robot is often unsure of its environment, and cannot perceive obstacles beyond a certain proximity of its current position. This kind of robot cannot compute a global shortest path.

Lumelsky and Stepanov ["Path-Planning Strategies for a Point Mobile Automaton Moving Amidst Obstacles of Arbitrary Shape", *Algorithmica* 2 (1987), 403-430)] study a robot which can only perceive an obstacle by "bumping" into it. With an appropriate strategy this robot can produce a short, but not shortest, path. Worst case guarantees for the length h of the path traveled by the robot are used as a measure for various strategies.

We extend the Lumelsky-Stepanov idea: we suggest that algorithms for robots with limited perception can be measured effectively by the ratio $\rho = h/\omega$, where ω is the length of the (globally) shortest path. This ratio is motivated by the intuition that a high value of h is not meaningful for an input with a high value for ω. Further, ρ can be used for measuring the degree by which the perception of the robot limits its performance.

The metric is similar to the "performance guarantee" metric for problems in Combinatorial Optimization where an optimal solution is unobtainable for complexity reasons. It is also reminiscent of the amortized analysis of some self adjusting data structures.

We support the suggested metric with an example in two dimensional motion planning problem with rectilinear barriers. Upper and lower bounds on ρ are given for the performance of the Lumelsky-Stepanov "bumping" automaton. Two other kinds of robot are considered: a more perceptive robot which can "see" a short distance, and a very perceptive robot which can "see" any distance, but cannot "see through" barriers.