Abstract

Robotic motion planning aspires to match the ease and efficiency with which humans move through and interact with their environment. Yet state of the art robotic planners fall short of human abilities; they are slower in computation, and the results are often of lower quality. One stumbling block in traditional motion planning is that points and paths are often considered in isolation. Many planners fail to recognize that substantial shared information exists among path alternatives. Exploitation of the geometric and topological relationships among path alternatives can therefore lead to increased efficiency and competency. These benefits include: better-informed path sampling, dramatically faster collision checking, and a deeper understanding of the trade-offs in path selection.

In path sampling, the principle of locality is introduced as a basis for constructing an adaptive, probabilistic, geometric model to influence the selection of paths for collision test. Recognizing that collision testing consumes a sizable majority of planning time and that only collision-free paths provide value in selecting a path to execute on the robot, this model provides a significant increase in efficiency by circumventing collision testing paths that can be predicted to collide with obstacles.

In the area of collision testing, an equivalence relation termed local path equivalence, is employed to discover when the work of testing a path has been previously performed. The swept volumes of adjoining path alternatives frequently overlap, implying that a continuum of intermediate paths exists as well. By recognizing that such neighboring paths with related shapes and outcomes, up to 90% of paths may be tested implicitly, bypassing the traditional, expensive collision test and delivering a net 300% boost in collision test performance. Local path equivalence may also be applied to the path selection problem in order to recognize higher-level navigation options and make smarter choices. This thesis presents theoretical and experimental results in each of these three areas, as well as inspiration on the connections to how humans reason about moving through spaces.