Research

Research
Papers
Software
Teaching
Resume
Gallery
Contact

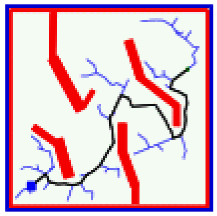
Classical Path Planning with RRTs

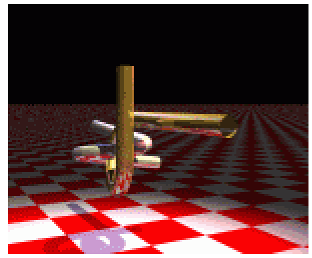
Overview

RRT-Connect is a simple and efficient algorithm for solving single-query path planning problems in high-dimensional configuration spaces. Inspired by classical AI bidirectional search, the method works by incrementally building two Rapidly-exploring Random Trees (RRTs) rooted at the start and the goal configurations. The trees each explore space around them and also advance towards each other through the us of a greedy heuristic. *(See algorithm animations)*

The algorithm was designed to be both general and practi and has been successfully applied to a variety of challenging planning problems. Some of the key advantages of RRT-Conne include:

- No preprocessing of the environment.
- The free configuration space is explored in a greedy fashion, yet high-dimensional local minima are gracefully overcome.
- Computation time scales with problem difficulty (i.e. simple queries will be solved very efficiently).
- Easy to implement effectively (no complicated parameter tuning is required).
- Proven to ultimately converge to uniform coverage o any non-convex space (provided the sampling distribution in uniform).


Algorithm Description


Computed Examples


Software


Other Relat Info

Path Planning

Path planning problems arise in such diverse fields as robotics, assembly analysis, virtual prototyping, pharmaceutical drug design, manufacturing, and computer animation. Path planning problems generally involve comput a continuous sequence ("a path") of configurations (generalized coordinates) between an initial configuration (start) and a final configuration (goal) while respecting certain constraints.

The *"basic path planning problem"* involves computing a collision-free path between two configurations in a static environment of known obstacles. In this case, the constraints on the solution path arise from the geometry both the obstacles and the "robot" (the object for which a path is being computed). If the robot can be represented a single 3D rigid object that rotates and translates in a 3D environment, then the problem is sometimes referred to a *"the piano-mover's problem"*.

"Path Planning" vs. "Motion Planning"

The term *"motion planning"* is usually distinguished from *"path planning"* in that the computed path is parameterize by time (i.e. *a trajectory*). The consideration of "time" or "system dynamics" (physics) is often important for proble requiring time-parameterized solution trajectories.

Rapidly-exploring Random Trees (RRTs) were initially designed to pl open-loop trajectories for systems with nonholonomic constraints induced by system dynamics("kinodynamic plannin

Subsequently, RRT-Connect was developed to efficiently solve instances of the "basic path planning problem" involving holonomic systems. It was first used for automatically generating collision-free object manipulation moti for animated characters in interactive 3D virtual environments. Since then, the algorithm has been refined and applied to broad class of interesting and challenging planning problems.

References and Further Information

- ***NEW - Available soon:*** **Improved RRT-Connect algorithm:** Revisec journal version. [Computed Examples] [Software]
- Motion Planning for Humanoid Robots using various adaptations of RRT-Connect.
- **RRT-Connect algorithm with preliminary analysis:** J.J. Kuffner and LaValle. RRT-Connect: An efficient approach to single-query path plann In *Proc. IEEE Int'l Conf. on Robotics and Automation (ICRA'2000)*, San Francisco, CA, April 2000. [Abstract] [PDF] [Computed Examples]
- **Movie clip of Computed Examples:** J.J. Kuffner and S.M. LaValle. RR Connect: An efficient approach to single-query path planning. Video Pro IEEE Int'l Conf. on Robotics and Automation (ICRA'2000), April 2000. [MoreInfo]
- **Kinodynamic Planning with RRTs:** S.M. LaValle and J.J. Kuffner. Randomized kinodynamic planning. *International Journal of Robotics Research*, 20(5):378-400, May 2001. [Abstract] [PDF] [MoreInfo]
- **Overview of RRTs for path and trajectory planning:** S.M. LaValle a J.J Kuffner. Rapidly-exploring random trees: Progress and prospects. Ir *Robotics: The Algorithmic Perspective. 4th Int'l Workshop on the Algori Foundations of Robotics.*, Hanover, NH, 2000. A. K. Peters. [Abstract] [[MoreInfo]
- **Original Holonomic RRT-Connect algorithm (Chapter 5):** J.J. Kuffi Jr. *Autonomous Agents for Real-time Animation*. PhD thesis, Stanford University, Stanford, CA, December 1999. [Abstract] [PDF] [MoreInfo]
- **Original Kinodynamic RRT Paper:** S.M. LaValle and J.J Kuffner. Randomized kinodynamic planning. In *Proc. IEEE Int'l Conf. on Robotics Automation (ICRA'99)*, Detroit, MI, May 1999. [Abstract] [PDF] [MoreIr
- The RRT Page at UIUC (contains many links to papers, presentations, a free software).
