A Benchmark Suite for Motion Planning Algorithms

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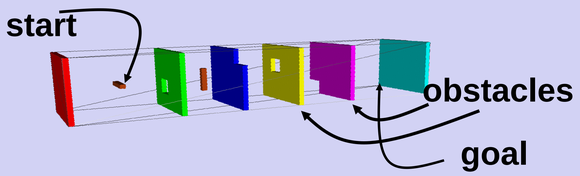
What is Motion Planning?

Given: a start and goal configuration of robot in an environment
Find: a valid path from start to the goal.

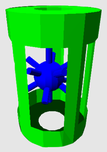


Applications

Robot Navigation, Automation, Robot Surgery, Protein Folding

Difficulties

- Narrow Passage
  - Unlikely to sample region
  - Disconnected region results
- Cluttered Environments
  - Hard to connect samples



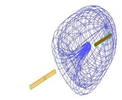
Metrics

[M. Morales 2007]

- Ways to measure performance.
  - Time
  - Number of collision detection calls.
  - Samples needed to solve a set of queries.

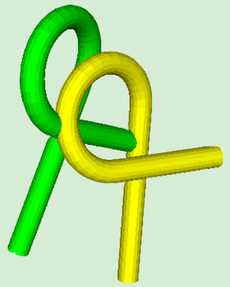
Why Benchmarks?

- A benchmark is a standard hard problem used to compare different solving techniques.
- Benchmarks allow for comparison of different algorithms.
- The Parasol Motion Planning Benchmarks Suite can be used to compare motion planning algorithms.



Example Benchmarks

Alpha Puzzle



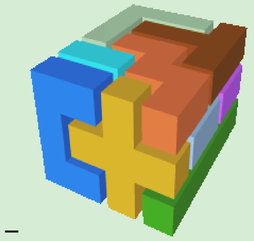
What's hard?
- Complex translation & orientation movement

What algorithm does well?
- RRT – good for solving this problem with such a narrow passage

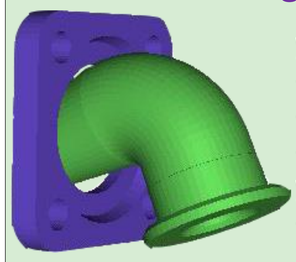
Pentomino Puzzle

What's hard?
- Consists of twelve pieces
- Pieces are combined in several ways to fit a 3x4x5 container.
- Goal: disassemble the puzzle

What algorithm does well?
- Obstacle Based-PRM(OBPRM) – allows disassembly problem to be solved using probabilistic motion planning methods.

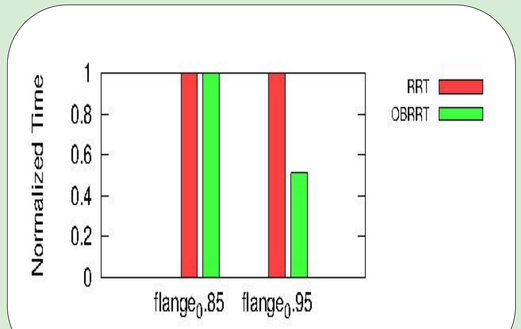


Flange Problem



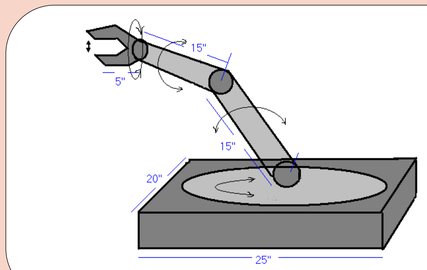
What's hard?
- Requires sliding motion
- Obstacle and robot are nearly touching
- Robot twisted into or out of the obstacle.

What algorithm does well?
- RRT – good for solving a local problem such as a pipe with narrow space to move through a hole.



Configuration Space (C-Space)

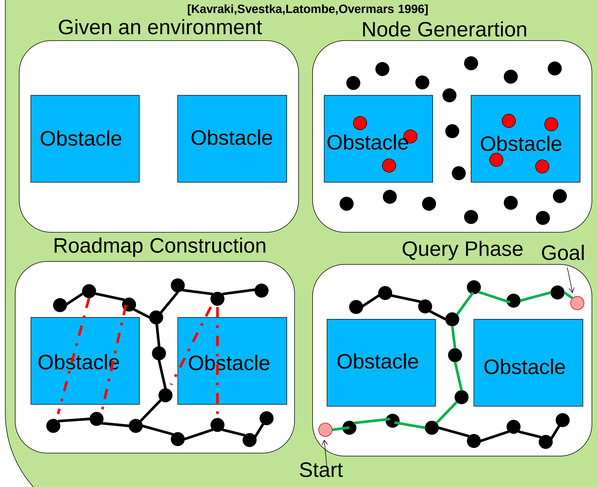
- The Degrees of Freedom (DoF) are the number of parameters that define it's configuration.
- Set of configurations that in which the robot collides with an obstacle is called Obstacle Space
- Each point in the C-Space represents a different configuration of the robot.
- Set of configurations that avoids collisions with obstacles are called Free Space.



Basic Motion Planning Algorithms

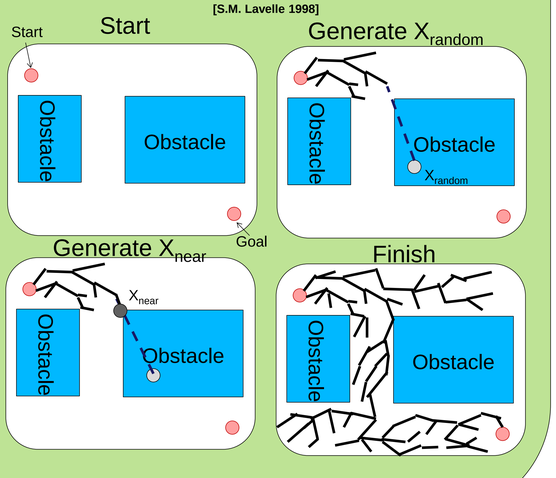
Probabilistic Roadmap (PRM)

[Kavraki,Svestka,Latombe,Overmars 1996]



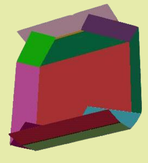
Rapidly Exploring Random Tree (RRT)

[S.M. Lavelle 1998]



Conclusions / Future Work

- Basic motion planning problem is to produce a path from start to goal configuration.
- Motion planning is used in several applications such as automation, robot surgery, etc.
- A configuration describes the pose of the robot, and the configuration space is the set of all possible configurations.



References

- **Probabilistic roadmaps for path planning in high-dimensional configurations spaces,** L. Kavraki, P. Svestka, J. Latombe, and M. Overmars, *IEEE International Conference on Robotics and Automation*, 566-580, 1996.
- **Rapidly-exploring random trees: A new tool for path planning,** S.M. Lavalle. TR 98-11, Computer Science Dept.,Iowa State University, October 1998.
- **Metrics for Sampling-Based Motion Planning**, Marco A. Morales, Ph.D Thesis, Parasol Laboratory, Department of Computer Science, Texas A&M Univeristy, College Station, Texas, Dec. 2007.