Lecture 22
Motion Planning II

Katie DC
Modern Robotics Ch 10.2-10.5
Admin

• No office hours (unless by appointment) or homework parties during fall break

• Final Projects
  • “Presentations” are the week after break
  • Videos due Monday 12/2 at midnight
  • Final report Monday 12/16 at midnight

• No class on Tuesday 12/10

• Quiz 4: decision-making, planning, and final
  • Required: Thu Dec 5 to Sat Dec 7
  • Re-take: Mon Dec 9 to Wed Dec 11
  • Practice Exam will be posted soon
Who is Nancy Amato?

- Head of the CS department and expert in motion planning
- Her paper on probabilistic planning is one of the most important papers in PRM, the first to not use uniform sampling in the configuration space
- She wrote a seminal paper with one of her students that shows how robot planning can be applied to protein motions (folding)
  - This line of work started a new research area in computational biology
Motion Planning Review
Graphs and Trees
Graphs and Trees
Graph Search Methods

A* search algorithm.
Graph Search Methods

A* search algorithm.

Dijkstra’s algorithm.

Credit: Subh83 on Wikipedia
Grid-World Example
A simple roadmap: visibility graph
A simple roadmap: visibility graph
Sampling Based Planners: Probabilistic Roadmaps
Reachability Tree for Dubin’s Car

Credit: Steven LaValle, Planning Algorithms
Algorithm 10.3 RRT algorithm.

1: initialize search tree $T$ with $x_{\text{start}}$
2: while $T$ is less than the maximum tree size do
3:   $x_{\text{samp}} \leftarrow$ sample from $\mathcal{X}$
4:   $x_{\text{nearest}} \leftarrow$ nearest node in $T$ to $x_{\text{samp}}$
5:   employ a local planner to find a motion from $x_{\text{nearest}}$ to $x_{\text{new}}$ in the direction of $x_{\text{samp}}$
6:   if the motion is collision-free then
7:       add $x_{\text{new}}$ to $T$ with an edge from $x_{\text{nearest}}$ to $x_{\text{new}}$
8:       if $x_{\text{new}}$ is in $\mathcal{X}_{\text{goal}}$ then
9:           return SUCCESS and the motion to $x_{\text{new}}$
10:      end if
11:   end if
12: end while
13: return FAILURE
Rapidly Exploring Random Trees (RRT)

**Algorithm 10.3** RRT algorithm.

1. initialize search tree $T$ with $x_{start}$
2. while $T$ is less than the maximum tree size do
3.     $x_{samp} \leftarrow$ sample from $X$
4.     $x_{nearest} \leftarrow$ nearest node in $T$ to $x_{samp}$
5.     employ a local planner to find a motion from $x_{nearest}$ to $x_{new}$ in the direction of $x_{samp}$
6.     if the motion is collision-free then
7.     add $x_{new}$ to $T$ with an edge from $x_{nearest}$ to $x_{new}$
8.      if $x_{new}$ is in $X_{goal}$ then
9.         **return** SUCCESS and the motion to $x_{new}$
10.    end if
11.   end if
12. end while
13. **return** FAILURE
RRT: Lunar Lander

Check out Steven Lavalle’s RRT Gallery: http://msl.cs.uiuc.edu/rrt/gallery.html
Summary

• Given an initial state and a desired final state, motion planning provides us with tools to find a time horizon and a sequence of actions to find a trajectory that reaches the goal without collisions.

• A roadmap path planner uses a graph representation of free space, which can then provide a trajectory using search algorithms.

• The basic RRT algorithm is a sampling-based method that grows a single search tree from start to find a motion to goal:
  • Uses a local planner to find a motion from the nearest node to the sampled node.
Course Recap

- **Weeks 01-03**: Perception + State Estimation
- **Weeks 04-11**: Kinematics + Control
- **Weeks 12-13**: Planning + Decision-Making
- **Weeks 14-15**: Projects
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