Feasible Motion Planning

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0.0/20.0 points (graded)

This question will test your understanding of A^* planning and Rapidly Exploring Randomized Trees (RRTs) with a series of short questions. **Unless mentioned otherwise, all the planning problems considered here are in continuous state and action spaces.**

(a) Suppose we have a bounded environment where there is **no** collision free path from the start to the goal. Which of the following is true?

- [ ] The RRT algorithm will terminate in finite time.
- [ ] The A^* algorithm (with a fixed grid resolution) will terminate in finite time. ✔

Explanation

The first choice is incorrect since the RRT algorithm will keep going if it doesn't find a feasible path. The only guarantee we can make for the RRT is that it is probabilistically complete, i.e., that if there is a feasible path, the probability that one is found approaches 1 as time approaches infinity.

The second choice is correct since with a fixed resolution the planning problem is finite and thus the A^* will terminate in finite time.

(b) Which of the following statements about RRTs are true in general? Select all that apply. (Here, you may assume that the obstacle set and free space are "nice". In particular, we assume that the obstacle set is a closed set in the topological sense).

- [ ] The algorithm is complete (i.e., the algorithm will always terminate in finite time. Further, it will return a feasible path if and only if one exists).

- [ ] The algorithm is probabilistically complete (i.e., if there is a feasible path, the probability that one is found approaches 1 as time approaches infinity). ✔

- [ ] Assume that a feasible motion plan exists. Then there exists a $T \in \mathbb{R}$ such that the probability that a feasible path is found within time T is 1.

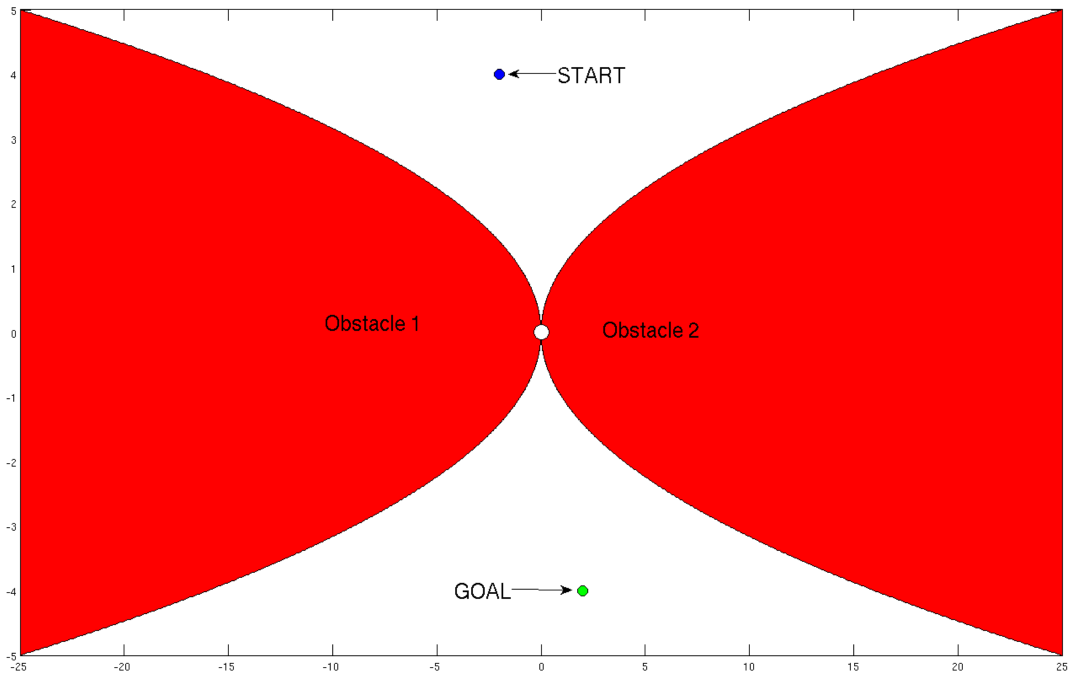
- [ ] As time approaches infinity, the probability that an **optimal** path is found approaches 1 (here "optimal" means shortest path).

- [ ] Assume that a feasible motion plan exists. As time approaches infinity, the probability that a feasible path is found is bounded above by a constant $c < 1$.

Explanation

All choices except the second one are incorrect. The only guarantee we can make for the RRT is that if there is a feasible path, the probability that one is found approaches 1 as time approaches infinity.

(c) Suppose we have a planning problem in $\mathbb{R}^2$ where there are two obstacles. The first obstacle is the set $\{(x, y) \mid (x, y) \neq (0,0), x \leq -y^2\}$ and the second obstacle is the set $\{(x, y) \mid (x, y) \neq (0,0), x \geq y^2\}$. These obstacles are shown in the figure below, as are the start and goal positions. Notice that this motion planning problem is feasible (i.e., there exists a collision free path from start to goal).



Suppose we use the RRT algorithm to solve this planning problem. As time goes to infinity, which of the following is true?

- The probability that a feasible path is found approaches 0. ✔
- The probability that a feasible path is found approaches some number in the open interval $(0, 1)$.
- The probability that a feasible path is found approaches 1.

Explanation

The first choice is correct. In other words, the RRT algorithm will fail for this problem. This is because in order to successfully find a feasible path, the algorithm must sample a point on the line $x = 0$ and then perform the "extend operation" vertically downwards (with no margin for error). The probability that this occurs is 0.

(d) In this question, we will consider the planning problem on a uniform two dimensional grid (here "uniform" means that the grid cells are squares). Suppose we are given a number of obstacles along with start and goal cells. The actions available are "up", "down", "left" and "right". Which of the following are *admissible heuristics* in general for the A* algorithm (recall that an admissible heuristic is one that lower bounds the true cost)?

- [ ] Euclidean distance in $\mathbb{R}^2$. ✔
- [ ] Euclidean distance squared.
- [ ] L_1 distance (also known as the "taxicab distance". The distance between points p and q in two dimensions is given by $L_1\left(p,q\right)=\sum_{i=1}^{2}\left|p_i-q_i\right|$.). ✔
- [ ] L_∞ distance (sometimes known as the "Chebyshev distance". The distance between points p and q in two dimensions is given by $L_\infty\left(p,q\right)=\max\{\left|p_1-q_1\right|,\left|p_2-q_2\right|\}$.). ✔
- [ ] The heuristic that is identically equal to 0. ✔
- [ ] The heuristic that is identically equal to 100.

Explanation

An admissible heuristic must underestimate the optimal distance. This is not the case for the square of the Euclidean distance (e.g., if the distance is very large). This is also not true for the heuristic that returns a non-zero constant (e.g., 100). All other choices are admissible heuristics.

Submit You have used 0 of 1 attempt

Answers are displayed within the problem