

Homework 2

Introduction to Robotics
ncorrell@colorado.edu

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1. You want to find a driving route that minimizes the number of turns between two locations in Boulder.
 - (a) Would you rather employ a sampling-based or a discrete algorithm such as Dijkstra or A* for doing this and why? (1pt)
 - (b) Provide a possible cost function that encodes both path length l and the number of turns t . (1pt)
2. Assuming points are sampled uniformly at random in a randomized planning algorithm. Calculate the limiting behaviour of the following ratio (number of points in tree)/(number of points sampled) as the number of points sampled goes to infinity. Assume the total area A_{total} and the area of free space A_{free} within are known. (1pt)
3. Assuming a k-d-tree is used as a nearest-neighbour data structure to store a RRT data structure, and points are sampled uniformly at random, calculate the run-time of inserting a point into a tree of size N . Use “big-Oh” notation, e.g. $\mathcal{O}(N)$. (1pt)
4. Why does the bandwidth of a Ultra-sound based distance sensor decrease significantly when increasing its dynamic range, but that of a laser range scanner does not for typical operation? (2pt)
5. You are designing an autonomous electric car to transport goods on campus. As you are worried about cost, you are thinking about whether to use a laser scanner or an ultra-sound sensor for detecting obstacles. As you drive rather slow, you are required to sense up to 15 meters. The laser scanner you are considering can sense up to this range and has a bandwidth of 10Hz. Assume 300m/s for the speed of sound in the following.

- (a) Calculate the time it takes until you hear back from the US sensor when detecting an obstacle 15m away. Assume that the robot is not moving at this point. Use $c = 300m/s$ for the speed of sound. (1pt)
 - (b) Calculate the time it takes until you hear back from the laser scanner. Hint: you don't need the speed of light to answer this question. (1pt)
6. A Global Positioning System sensor provides position estimates within a circle of approximately 3m diameter. Every now and then the satellites on the horizon change and the center of this circle moves elsewhere, approximately staying within a 30 meter radius of the true location of the receiver.
- (a) Provide an estimate for both the accuracy and the precision of this sensor. (1pt)
 - (b) The sensor provides 18000 readings per hour. What is its bandwidth?