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HW 2

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 continuous algorithm or a discrete algorithm such as Dijkstra or A* for doing this and why?

       I would rather employ a discrete algorithm than a sampling-based continuous algorithm because we are trying to use the driving route to get two locations in Boulder which relates to using a discrete graph. To add on, within the discrete algorithm, I would use Dijkstra or A* since it is known for using to solve the shortest distance problems.

    b. Provide a possible cost function that encodes both path length l and number of turns t between two states that heavily prioritizes not making turns if possible. You may assume that you are given l and t for any given pair of states (e.g., through the functions distance(s1, s2) and num_turns(s1, s2), respectively). NB: A cost function is a function c(s1, s2) that takes in a pair of states and returns a realvalued cost. Provide a mathematical equation for this. c: $S \rightarrow \mathbb{R}$

       *c = l + (l * t) //* I believe this cost function is trying prioritizes to make least turns as possible where *l* is length of the path and *t* is the number of turns. The first *l* is mainly for the case of driving without making any turns such as high way. To exemplify, if the distance is 4 miles and there are 15 turns, the cost will be 64 but if the distance is 15 miles and there are only 2 turns, the cost will be 45.

2. Assume that points are sampled uniformly at random in a randomized planning algorithm. Calculate the limiting behavior of the following ratio as the number of points sampled goes to infinity: (number of unique points in tree)/(number of points sampled). Assume the total area $Atotal$ (including free space and obstacles) and the area of free space $Afree$ (no obstacles) within are known

   $$\frac{A_{free}}{A_{total}}$$

   With this ratio, this should approach for an infinite number of samples, and the tree should only grow in free space as we sample the entire area.

3. Assuming a k-d-tree (e.g., quadtree, octree, etc.) is used as a nearest-neighbor data structure to store a run of RRT's output graph and points are sampled uniformly at random, calculate the expected run-time of inserting a point into a tree of size N. Use "big-O" notation, e.g. O(N)

   O(log N)

4. Why does the bandwidth of an Ultrasound-based distance sensor decrease significantly when increasing its dynamic range, but that of a laser range scanner does not for typical operation? [Hint: what is the limiting factor in an ultrasonic sensor? What about a laser scanner?]

   With ultrasound-based distance sensor, since it needs to travel there and back, increasing its dynamic range would decrease significantly and it would take longer to read. For laser range scanner, it travels a lot faster so it doesn't take as much time anyway even though it increased its dynamic range.

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 30 meters. The laser scanner you are considering can sense up to this range and has a bandwidth of 5Hz

   a. Calculate the time it takes until you hear back from the ultrasonic sensor when detecting an obstacle 30m away. Assume that the robot is not moving at this point. Use c = 300m/s for the speed of sound

      distance / speed of sound
      2 * 30m / (300 m/s) = 0.2 seconds
      Since it needs to travel there and back, the distance would be 60m and it would take 0.2 seconds

   b. Calculate the time it takes until you get a reading from the laser scanner. [Hint: You do not need the speed of light to answer this question]

      $\mathrm{Hz} = \frac{1}{sec}$, in other words $\sec = \frac{1}{Hz}$
      $\frac{1}{5\ Hz} = 0.2$ seconds
      Therefore it would take 0.2 seconds

6. A GPS sensor provides position estimates within a circle of approximately 3m in diameter. Every now and then the satellites on the horizon change and the center of this circle moves elsewhere, approximately staying within a 30m radius of the true location of the receiver

a. Given the error data above, which value corresponds to accuracy and which to precision?

Accuracy is 30m and precision is 3m

b. The sensor provides 18000 readings per hour. What is its bandwidth?

$$\frac{18000\ reading}{hour} * \frac{hour}{3600\ sec} = \frac{5\ reading}{sec}$$

5 reading per second means 5 cycles per second which concludes 5 Hz for bandwidth