MAE 145: Planning and Estimation
Homework #4

Assigned Jan 29. Due on Feb 5, at 10:30am

Notice:

Please upload 1 file for this homework (there are no programming assignment this week). In your assignment include the names of the other students you have collaborated with to do the homework problems. The Collaboration Policy for this course is detailed in the syllabus.

Homework exercises:

1. E3.1 from the Lecture Notes on Robotics Planning and Kinematics.
2. Suppose we build a new robot by placing and interconnecting a fixed-base Scara robot (see Lecture Notes, figure 315) on top of a flat disk robot (such as a roomba). What is the configuration space of this new robot?
3. Consider the configuration space of the SCARA manipulator, represented as the square $[-\pi, \pi] \times [-\pi, \pi]$, with appropriate point identifications to define a torus. Define a graph using the following nodes given in coordinates of the square: $n_1 = (-\pi, -\pi)$, $n_2 = (-\pi, -\frac{\pi}{2})$, $n_3 = (-\pi, 0)$, $n_4 = (-\pi, \frac{\pi}{2})$, $n_5 = (-\pi, \pi)$, $n_6 = (-\frac{\pi}{2}, -\pi)$, $n_7 = (-\frac{\pi}{2}, -\frac{\pi}{2})$, $n_8 = (-\frac{\pi}{2}, 0)$, $n_9 = (-\frac{\pi}{2}, \frac{\pi}{2})$, $n_{10} = (-\frac{\pi}{2}, -\pi)$, $n_{11} = (-\frac{\pi}{2}, \pi)$, $n_{12} = (0, -\pi)$, $n_{13} = (0, -\frac{\pi}{2})$, $n_{14} = (0, 0)$, $n_{15} = (0, \frac{\pi}{2})$, $n_{16} = (0, \pi)$, $n_{17} = (\frac{\pi}{2}, -\pi)$, $n_{18} = (\frac{\pi}{2}, -\frac{\pi}{2})$, $n_{19} = (\frac{\pi}{2}, 0)$, $n_{20} = (\frac{\pi}{2}, \frac{\pi}{2})$, $n_{21} = (\frac{\pi}{2}, \pi)$, $n_{22} = (\pi, -\pi)$, $n_{23} = (\pi, -\frac{\pi}{2})$, $n = (\pi, 0)$, $n_{24} = (\pi, \frac{\pi}{2})$, $n_{25} = (\pi, \pi)$.
   (a) Which nodes of the above represent the same point on the torus?
   (b) What is the shortest path between the points n_7 and n_{19}? (Draw it in a square representing the torus)
   (c) Now define a graph over the previous set of points, $\{n_1, \ldots, n_{24}\}$ where edges are defined as follows: Given $n_i = (a, b)$ and $n_j = (c, d)$, there is a connection between them if and only if $|a - c| + |b - d| \leq \frac{\pi}{2}$. List the set of edges of the graph and draw the graph edges and nodes over a square.
   (d) What are the neighbors of node n_1? and of n_{22}?
   (e) Implement a BFS algorithm by hand over the previous graph starting from n_7. Indicate in your drawing the layers of nodes (layer 0, layer 1, layer 2, ...) and the edges chosen by the BFS.