ECE4560 - Homework #8
Due: Oct. 23, 2017

Problem 1. (20 pts) Consider the three-link planar manipulator discussed in class and depicted in Figure 1. Modify the `scara_r2.m` code so that it can plot the reachable workspace and the complete workspace for the system. Also plot in the plane the dextrous workspace limits (inner and outer rings); it can be the same plot, or on another one. Call it `planar_r3.m`. Let the link lengths be 1.5, 1.0, and 0.3 inches from base to end-effector, respectively.

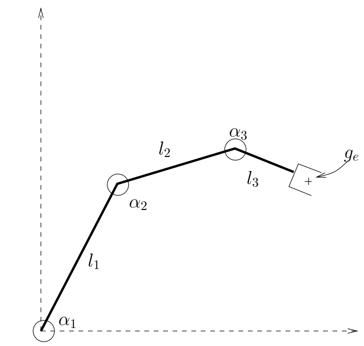

Figure 1: 3R Planar manipulator.

Problem 2. (20 pts) Consider the wristless Armatron manipulator of Figure 2. It is not possible to achieve an arbitrary configuration without the wrist, so let's consider the reachable workspace, e.g., the set of reachable positions of the end-effector.

Supposing that the link lengths were $l_0 = 1$, $l_1 = 3/4$, $l_2 = 1/2$:

(a) What are the forward kinematics for position? Use any technique you'd like.

(b) Assuming that the joint limits were $\alpha_1 \in [-\pi/2, \pi/2]$, $\alpha_2 \in [-\pi/3, \pi/3]$, and $\alpha_3 \in [-\pi/2, \pi/2]$, show a plot of the reachable workspace. You should be able to modify the `scara_r2.m` or thr `planar_r3.m` code for this.

(c) What is the end-effector configuration for $\alpha = (\pi/3, \pi/3, -\pi/4)^T$?

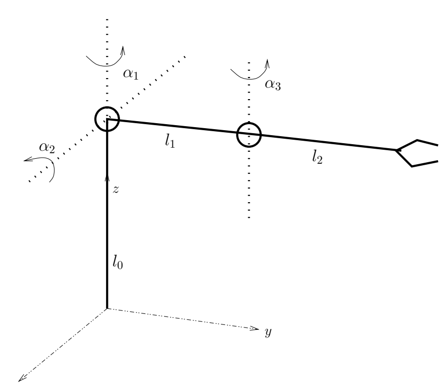

Figure 2: Wristless Armatron.

Problem 3. (20 pts) The Lynxmotion L6 is a small manipulator meant to replicate commonly found industrial manipulators in terms of its joint degrees of freedom. Unlike most industrial manipulators, which have six degrees of freedom, this one has only 5 degrees of freedom. A sketch of it is depicted below in Figure 3 with a straight-up reference configuration. Us the product of Lie groups method. You can leave the solution in symbolic form, meaning that it is sufficient to define the individual $g_i(\alpha_i)$ matrices and the final transformation to the end-effector. I do want, however, for you to give me the translation part $d_e(\alpha)$. The example from class should be a good guide as to how to proceed. Suppose for now that the link lengths are: $l_0 = 4.35$, $l_1 = 4.72$, $l_2 = 4.72$, $l_3 = 5.12$, and $l_4 = 0.79$ given in inches. Whereas l_3 go to roughly the hand area of the end-effector, the extra length l_4 goes a bit further to what would be the fingertips of the gripper (the length is not depicted in the figure). Its inclusion in the forward kinematics is optional.

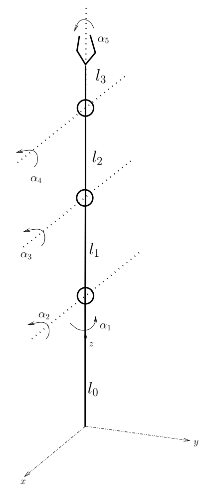

Figure 3: Lynxmotion L6 manipulator.

Problem 4. (30 pts) Time to test out the forward and inverse kinematics that has been coded up for the Piktul manipulator. Does it work or not? The test will be using the traditional pick and place routine. The code should specify where to perform the pick and where the place will be, then execute it. Some info is in the Module 1, Adventures bullets 1 and 3.

The particular details are:

a) For the repetitive case, use the forward kinematics to predict the pick configuration of the object and the place configuration of the object, then execute. The joint angles for pick and place are:

$$\alpha_{\text{pick}} = \begin{bmatrix} 0.75 & 30 & -20 & -40 & 0.75 \end{bmatrix}^T \quad \text{and} \quad \alpha_{\text{place}} = \begin{bmatrix} 0.75 & -20 & -45 & -25 & 0.75 \end{bmatrix}^T$$

b) For the arbitrary case, the pick and place end-effector configurations are specified, and you should solve for the joint angles, then execute. The pick and place configurations will be:

$$g_{\text{pick}} = \left[\begin{array}{cc|c} 0.707 & 0.707 & 6.893 \\ -0.707 & 0.707 & -3.447 \\ \hline \multicolumn{2}{c|}{0} & 1 \end{array}\right] \quad \text{and} \quad g_{\text{place}} = \left[\begin{array}{cc|c} 0.500 & -0.866 & 6.468 \\ 0.866 & 0.500 & 5.314 \\ \hline \multicolumn{2}{c|}{0} & 1 \end{array}\right]$$

In both cases, then height should be 0.75 inches or taller when above and lower to around 0.25 inches to grab the object. If your manipulator does not lower that much, then adjust accordingly.

Problem 4. (30 pts) For the turtlebot groups, work out enumerated item 3 in the "Turtlebot: Sensing Part 1" module. This task should drive straight, using feedback to keep the orientation at 0. Also, answer the questions associated to the enumerated item. The demo for this will involve testing the ability to go straight down the van Leer hallway with minimal excursion from a stright line (not more than an inch or so along the entire length of the hallway, if I recall correctly).

Problem 4. (30 pts) Work out the next step in the biped project. It will involved going from static descriptions of the body to kinematic descriptions that live at the velocity level.

Problem 4. (30 pts)**.** If you are working on a group project, then your group contact will review the submissions associated to the prior tasks and provide a new set of tasks. You should work out whatever baby steps this group contact assigns the group as opposed to the lab problem. It is your responsibility to turn in the results to the group contact. There should be sufficient output for them to assess progress.