Legged Robotics

HW #3

Problem 1 – 50 pts.

Using the same code that we have developed during the Inverse and Forward Kinematics lectures, with the exact same robot parameters defined in the code, assume that the following leg lengths are given for the robot:

$\vec{l} = [l_1, l_2, l_3, l_4, l_5, l_6]^T = [250.1730,\ 247.7072,\ 253.3073,\ 277.6336,\ 278.4548,\ 254.3322]^T$

Calculate the pose (position and orientation) of the top platform, $\vec{P}$, if $\vec{\alpha} = [a, b, c]^T$ represents:

a) ***ZYZ*** Euler angles in degrees.
b) ***XYZ*** Euler angles in degrees.
c) Compare the result from a) with the result from b). Are they the same? Why? Please explain your answer clearly. What do you conclude?

Problem 2 – 100 pts.

In this problem, you will calculate and depict the workspace of a hexapod parallel manipulator in a specific height (a section of the workspace) and then calculate and depict the error propagation in the workspace as a result of errors in the kinematic parameters. Before trying to solve the problems, read through the questions carefully and make sure you understand what you are asked.

For the hexapod robot with the nominal and real parameters (Table 1 and Table 2) in Paper 3, do the following steps. If needed, consider the diameter of the top and base platform to be 250 mm and 650 mm, respectively. Consider l_{min} = 604.8652 mm and l_{max} = 1100 mm. Also, Consider $\alpha = 40^\circ$ and $\beta = 85^\circ$.

1) Calculate and depict the boundary of the constant orientation workspace of the robot when Z = 800 mm and the top platform is horizontal ($a = b = c = 0$).
   Hint: You do not have to calculate the entire workspace. Just find the intersection of the plane Z = 800 mm with the 12 spheres of workspace. In other words, you will find a $2D$ boundary of the workspace in Z = 800 mm plane.
   Important: Be careful when choosing centers of the workspace spheres!

2) Divide/mesh the workspace calculated in step 1 into 5 mm steps in both X and Y directions. After doing this, you will have a set of configurations in the form of [X Y 800 0 0 0]. This should result in having "thousands of" points/configs!

3) Consider the difference between the corresponding parameters in Table 2 and Table 1 as 42 errors of the kinematic parameters ($\delta\rho$) which are needed in Equation 9. Consider δ (Δl) = 0. Write a Matlab code to calculate the forward kinematic error model based on Equation 9 in the paper. Using your code, illustrate the position error ($RSS - mm$) within the workspace when

$Z = 800\ mm$. In other words, calculate the position error ($\delta\vec{P}$ (1: 3)) for configurations found in step 2 and then calculate RSS for each position error. Section 4.1 of the paper can help you since Fig. 4 is illustrated in the same way.

Good Luck!