Homework 7-8

(Due time: 24:00, 16 Apr., 2020)

1. *Subproblem* $2'$*: Rotation about two non-intersecting axes*

   Solve Subproblem 2 when the two axes ξ_1 and ξ_2 do not intersect and write the Matlab program function.

   Use this subproblem to solve the inverse kinematics for the elbow manipulator in Example 3.5 in the textbook when the first two joints do not intersect at a point.

2. *Subproblem* 4*: Rotation about two axes to given distances*

   Let ξ_1, ξ_2 be two zero-pitch, unit magnitude twists with intersecting axes, and p, q_1, and q_2 be points in $\mathbb{R}^3$ (see Figure 1). Find θ_1 and θ_2 such that

$$\left\| e^{\hat{\xi}_1 \theta_1} e^{\hat{\xi}_2 \theta_2} p - q_1 \right\| = \delta_1$$

   and

$$\left\| e^{\hat{\xi}_1 \theta_1} e^{\hat{\xi}_2 \theta_2} p - q_2 \right\| = \delta_2$$

   Write the Matlab program function.

   (Hint: Find a point q such that $q = e^{\hat{\xi}_1 \theta_1} e^{\hat{\xi}_2 \theta_2} p$, and q is on the intersection of the three spheres centered at, respectively, $q_1, q_2,$ and r, of radii $\delta_1, \delta_2,$ and $\|p - r\|$.)

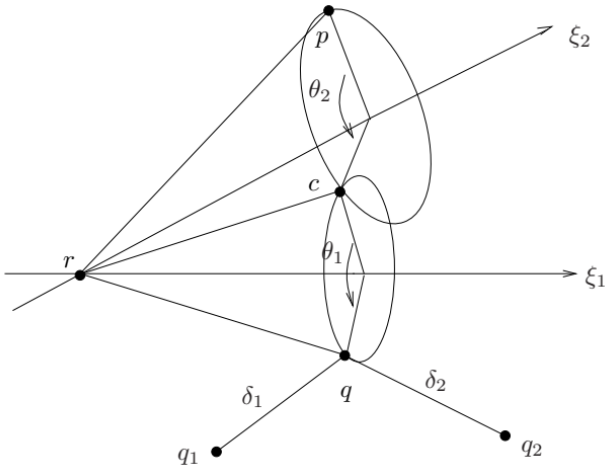


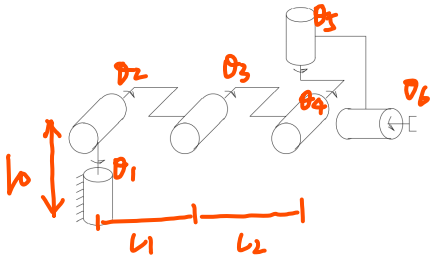
Figure 1: Subproblem 4: Rotate p about the axis of ξ_1 followed by a rotation about the axis of ξ_2 such that the final location of p is δ_1 from q_1 and δ_2 from q_2

3. For each of the manipulators shown schematically in Figure 2,

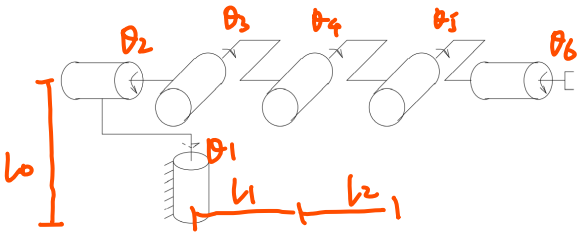
a) solve the inverse kinematics problem using the Paden-Kahan subproblems.

b) Write Matlab functions for Paden-Kahan subproblem 1 to 3 in the text and use the functions to write Matlab programs solving the inverse kinematics.

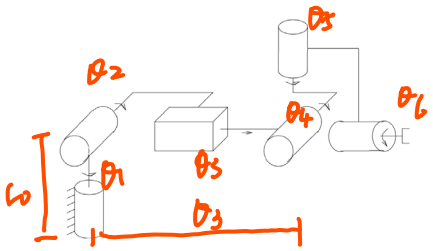
c) Verify your codes of the forward kinematics and the inverse kinematics by using two or more specific configuration examples.



(i) Elbow manipulator



(ii) Inverse elbow manipulator



(iii) Stanford manipulator

Fig 2. Sample manipulators. Revolute joints are represented by cylinders; prismatic joints are represented by rectangular boxes.