ENME489C/ENME808M Problem Set6

Prof. Axel Krieger
Fall 2017
Due Date: Wednesday, October 25th, at 5 PM

October 18, 2017

Exercise 1: 20 points

For any vectors a and p belonging to $\mathbb{R}^3$. Show that -

$$S(a)p = a \times p.$$

where $a \times p$ denotes the vector cross product and S is the skew-symmetric operator.

Exercise 2: 20 points

Given $R = R_{x,\theta}R_{y,\phi}$, compute $\frac{\partial R}{\partial \phi}$. Evaluate $\frac{\partial R}{\partial \phi}$ at $\theta = \frac{\pi}{2}$, $\phi = \frac{\phi}{2}$.

Exercise 3: 20 points

Two frames $o_0x_0y_0z_0$ and $o_1x_1y_1z_1$ are related by the homogeneous transformation

$$H = \begin{bmatrix} 0 & -1 & 0 & 1 \\ 1 & 0 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

A particle has velocity $v_1(t) = [3, 1, 0]^T$ relative to frame $o_1x_1y_1z_1$. What is the velocity of the particle in frame $o_0x_0y_0z_0$?

Exercise 4: 20 points

From figure 1 as the midterm problem,

a. Calculate the 2×2 Jacobian J_{v2}

b. Find the singularities

c. Calculate the 6×2 Jacobian J.

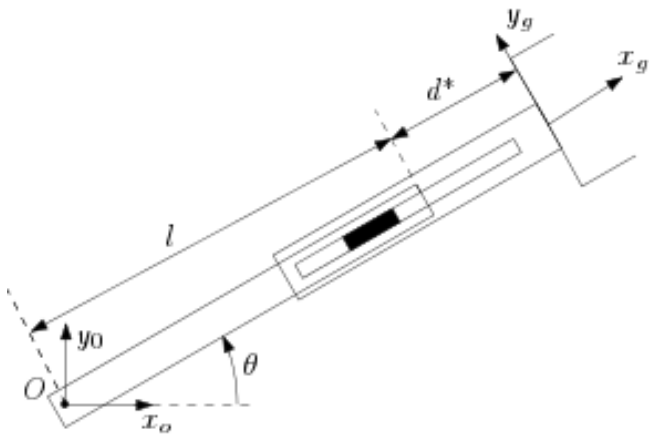

Figure 1: Exercise 4

Exercise 5: 20 points

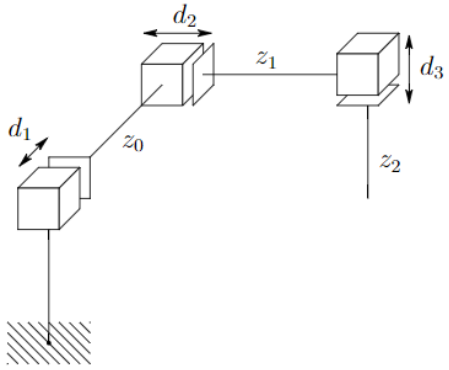

Figure 2: Exercise 5

Find the 6×3 Jacobian for Cartesian Manipulator in figure 2. Also, find the singular configuration for this Manipulator.

Exercise 6: 20 points

[**MUST for GRAD students and optional for undergrad students**].

Repeat question 5 for the cylindrical manipulator as shown in figure 3.

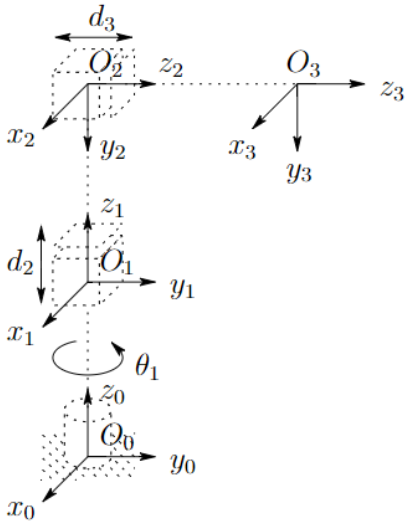

Figure 3: Exercise 6