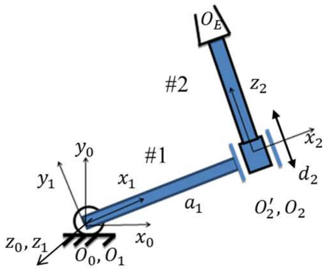
Robotics [IIT-Jodhpur]
Practical 5: Jacobian

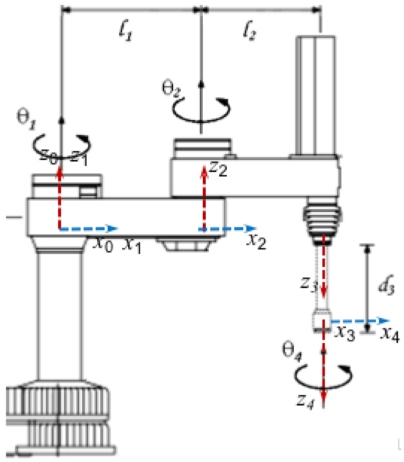
1 Write a MATLAB code for finding symbolic expressions of the Jacobian for an n-link serial robot. Take DH parameters as inputs to the code.
Note: You can build on code developed for Forward Kinematics

2 Validate code with the analytical results obtained for 2 link RP robot and SCARA robot shown in figure below.

3 Determine Singular configurations for the above robots.



link	α_i	a_i	d_i	θ_i
1	0	0	0	θ_1
2	-90	a_1	d_2	0



link	α_{i-1}	a_{i-1}	d_i	θ_i
1	0	0	0	θ_1
2	0	l_1	0	θ_2
3	180	l_2	d_3	0
4	0	0	0	θ_4

Figure 1

Hint:

$$\boldsymbol{t}_E^0 = \begin{bmatrix} \dot{\boldsymbol{o}}_E^0 \\ \boldsymbol{\omega}_n^0 \end{bmatrix} = [\boldsymbol{J}_1 \quad \boldsymbol{J}_2 \quad \cdots \quad \boldsymbol{J}_i \quad \cdots \quad \boldsymbol{J}_n] \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \vdots \\ \dot{q}_n \end{bmatrix}$$

$$\boldsymbol{J}_i = \begin{Bmatrix} \varepsilon_i \boldsymbol{z}_i^0 \times (\boldsymbol{o}_E^0 - \boldsymbol{o}_i^0) + (1 - \varepsilon_i)\boldsymbol{z}_i^0 \\ \varepsilon_i \boldsymbol{z}_i^0 \end{Bmatrix}$$

$$\varepsilon_i = \begin{cases} 1, & Revolute\ Joint \\ 0, & Prismatic\ Joint \end{cases}$$

$$\dot{q}_i = \begin{cases} \dot{\theta}_i, & Revolute\ Joint \\ \dot{d}_i, & Prismatic\ Joint \end{cases}$$

Find $$\boldsymbol{T}_i^o = \begin{bmatrix} \boldsymbol{R}_i^0 & \boldsymbol{o}_i^0 \\ \boldsymbol{0}^T & 1 \end{bmatrix} = \boldsymbol{T}_1^0(q_1)\boldsymbol{T}_2^1(q_1) \ldots \boldsymbol{T}_i^{i-1}(q_i)$$

$\boldsymbol{z}_i^0$: in Third column of $\boldsymbol{R}_i^0$

$\boldsymbol{o}_i^0$: in fourth column of $\boldsymbol{T}_i^o$

and $$\begin{bmatrix} \boldsymbol{o}_E^0 \\ 1 \end{bmatrix} = \boldsymbol{T}_n^0 \begin{bmatrix} \boldsymbol{a}_{nE}^n \\ 1 \end{bmatrix}$$