Tutorial 3: 3D Kinematics

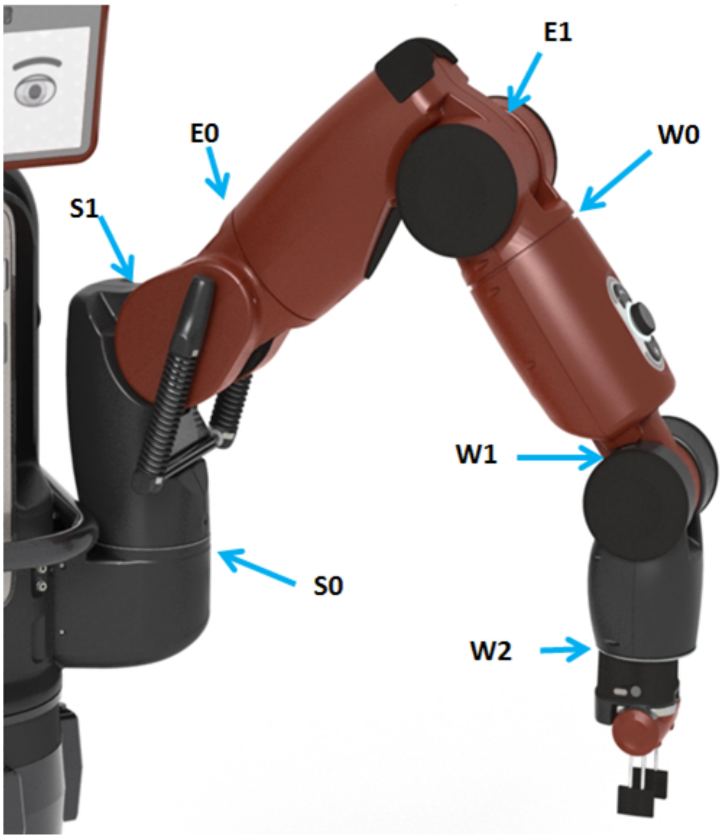

Figure 1: Baxter robot arm with 7 degrees of freedom

Q1. The angle ranges of a Baxter robot arm are given by

Joint	Min [rad]	Max [rad]
S0	-1.7016	1.7016
S1	-2.147	1.047
E0	-3.0541	3.0541
E1	-0.05	2.618
W0	-3.059	3.059
W1	-1.5707	2.094
W2	-3.059	3.059

the D-H table of a Baxter robot arm is given by

i	$a_i[m]$	$\alpha_i[rad]$	$d_i[m]$	$\theta_i[rad]$
1	0	0	0.2703	θ_1
2	0.069	-1.571	0	θ_2
3	0	1.571	0.3644	θ_3
4	0.069	-1.571	0	θ_4
5	0	1.571	0.3743	θ_5
6	0.01	-1.571	0	θ_6
7	0	1.571	0.2295	θ_7

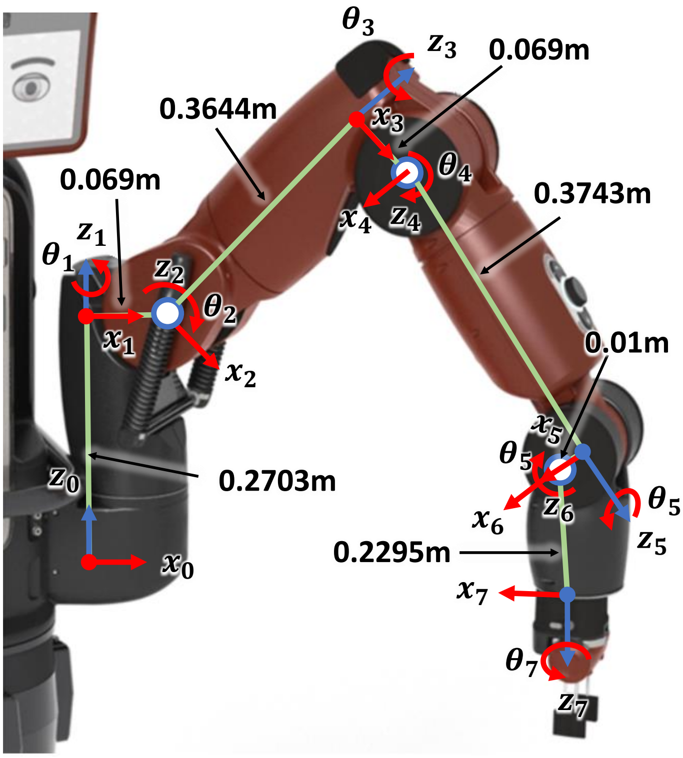

Figure 2: Reference frames of the Baxter robot arm

(a) Obtain the homogeneous transformation matrix for the above Baxter arm. [10%]

(b) Hence derive the Jacobian matrix. [10%]

(c) Use the Jacobian matrix to obtain the joint angle profiles to trace a circle given by $x(t) = 0.05\cos(0.5\pi t), y(t) = 0.05\sin(0.5\pi t), z(t) = 0$ at the end-effector of the arm. Assume the arm starts at the initial configuration given by for all i $q_i = LowerBound_i + 0.5Range_i[rad]$, and the sampling step size $\Delta t = 0.002[sec]$. [20%]

(d) Plot the joint angle profiles and end-effector speed profile against time up to 4 seconds. [10%]

(e) Repeat step Q1d for a different initial joint configuration of your choice and discuss your observations as to how different joints are sensitive to changes in the initial configuration in this circle tracing task. [20%]

Q2. Check if the shape of the circle $x(t) = 0.05\cos(0.5\pi t), y(t) = 0.05\sin(0.5\pi t), z(t) = 0$ traced by the end-effector looks like the following: [10%]

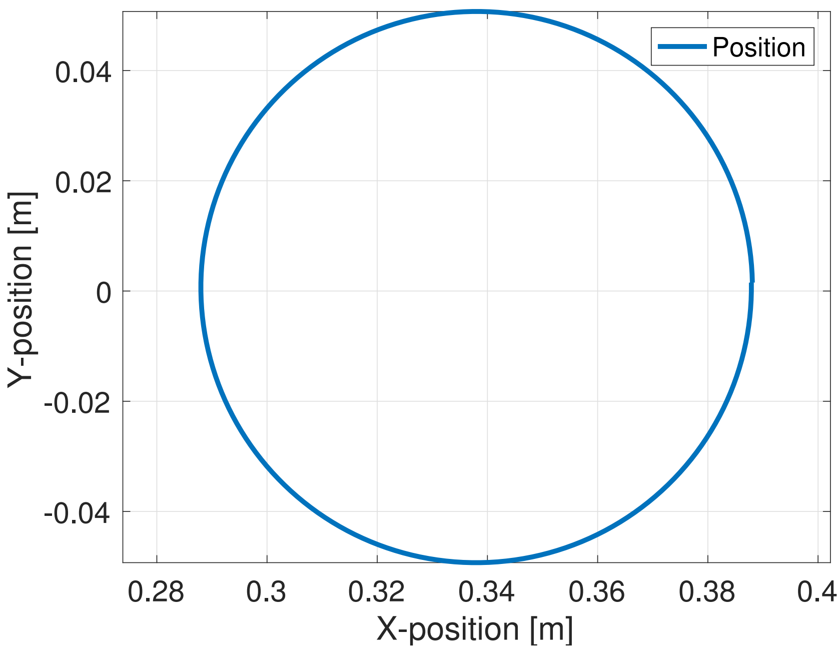

Figure 3: Desired end effector profile

Q3. Check if the answers to step Q1d look like the following:

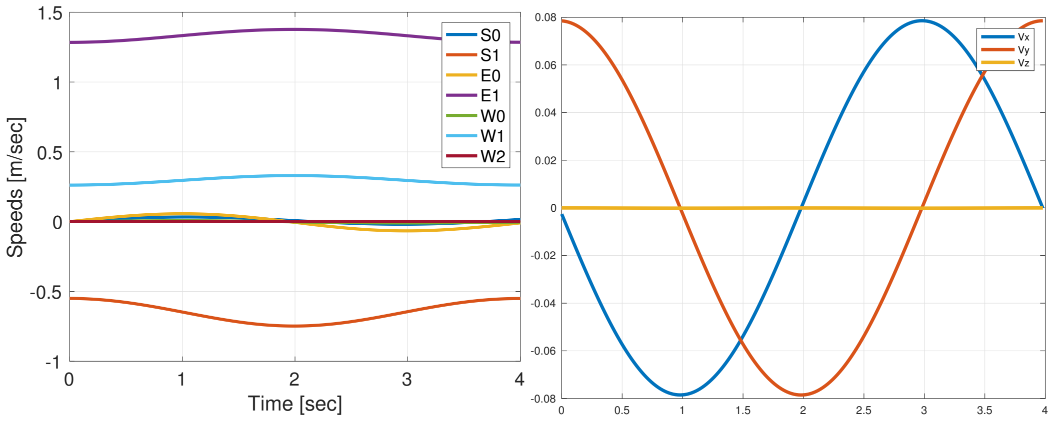

Figure 4: Joint angles and end-effector speed

Please feel free to plot any more information you think will be informative or allows you to do a good discussion. You get marks for being creative. [20%]