Baxter's Forward Kinematics Schematic and Derivation

Baxter's arm consists of seven revolute joints as shown in figure 1. Based on this figure a schematic of the joint for the left and the right arm can be made as shown in figure 2. Table 1 to 4 is the joint schematic and parameters for both left and right arm which will be essential for derivation of the final pose of the end effectors.

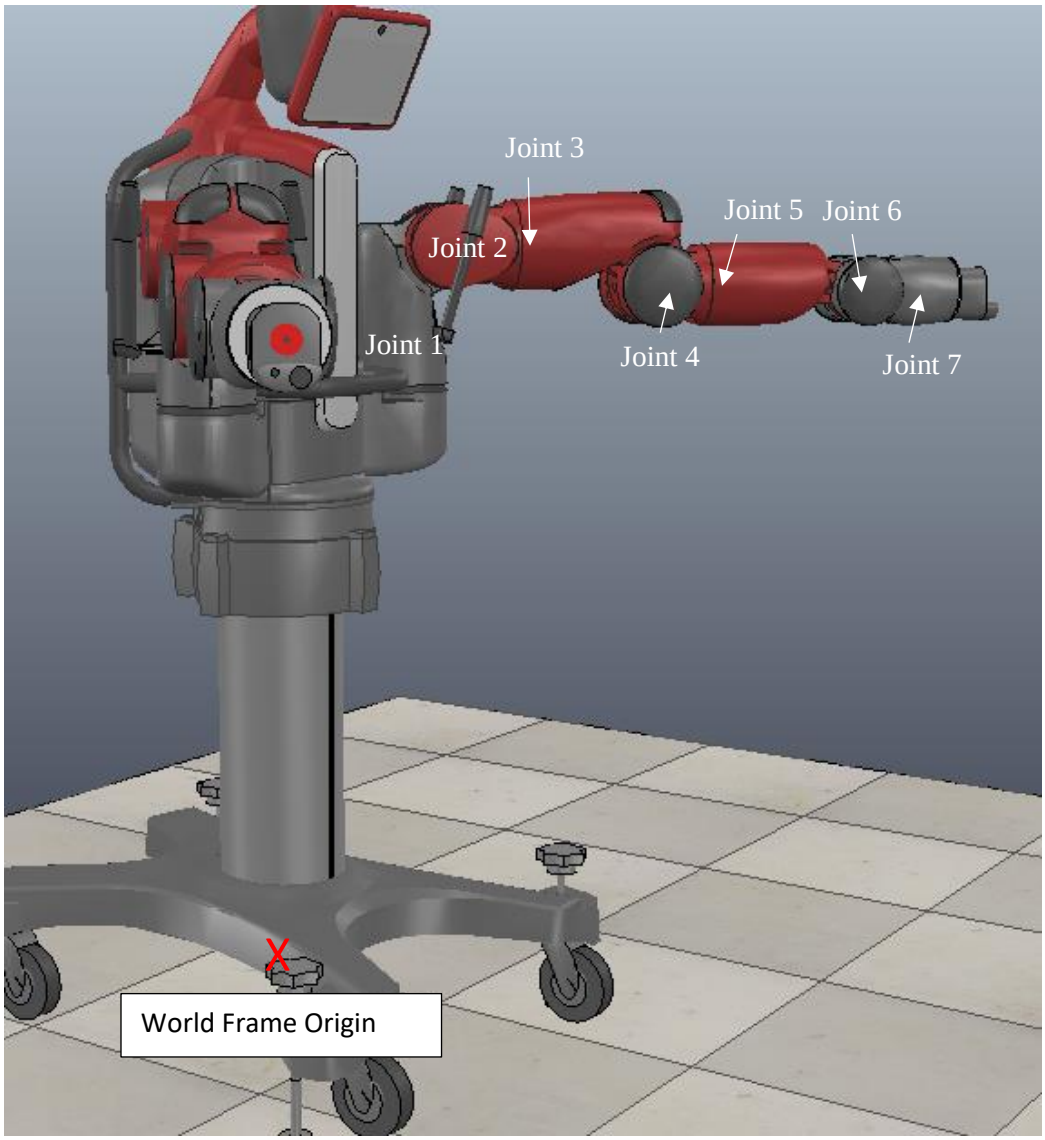

Figure 1. Baxter's arm joint and base frame location

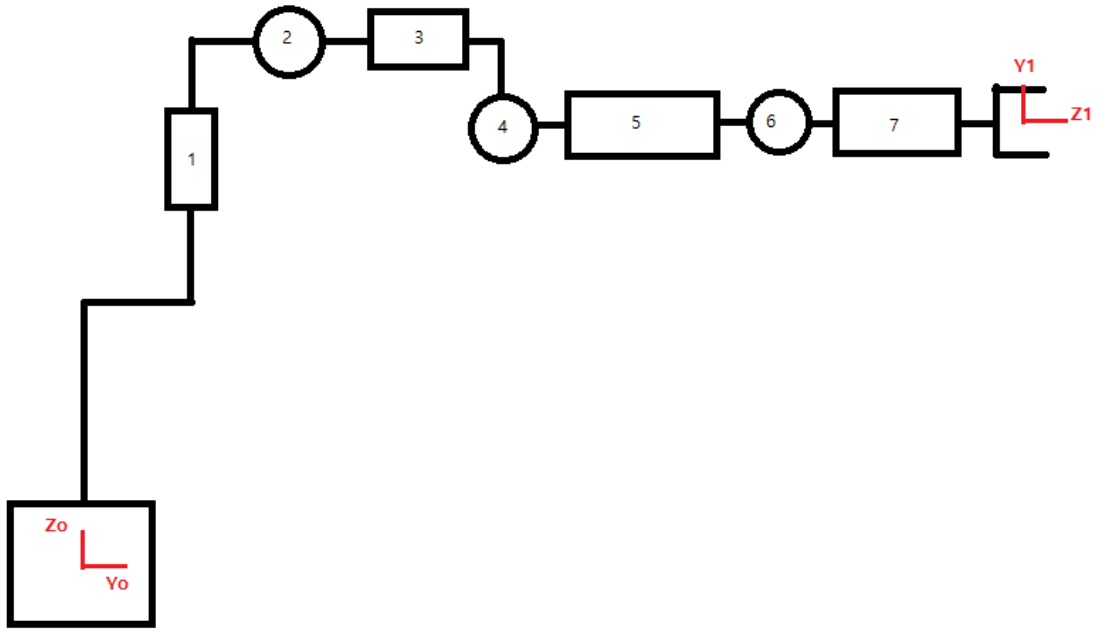

Figure 2. Left robot arm schematic

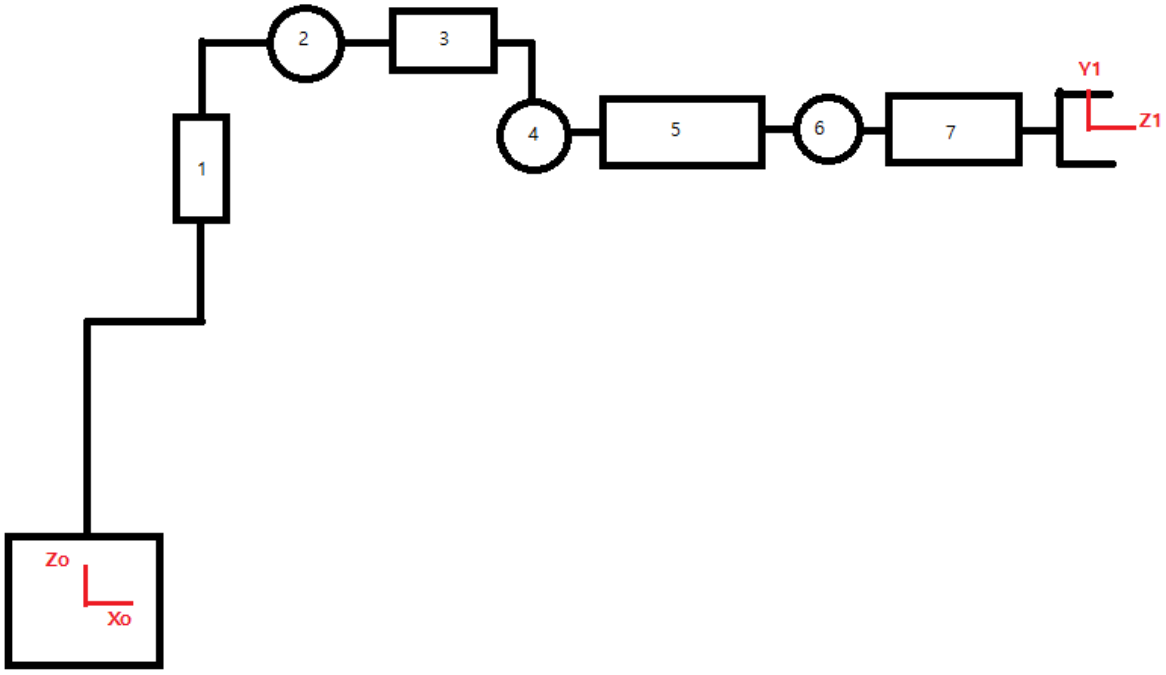

Figure 3. Right robot arm schematic

Table 1. Left arm's joint and end effector's position with respect to the world frame (x_0,y_0,z_0):

	X_0 (m)	**Y_0 (m)**	**Z_0 (m)**	**Direction of axis a_n**
1st Joint	-0.1278	0.2630	1.054	Z_0
2nd Joint	-0.1278	0.310	1.3244	$-X_0$
3rd Joint	-0.1278	0.4140	1.3244	Y_0
4th Joint	-0.1278	0.6765	1.2554	$-X_0$
5th Joint	-0.1278	0.7801	1.2554	Y_0
6th Joint	-0.1278	1.0508	1.2454	$-X_0$
7th Joint	-0.1278	1.1667	1.2454	Y_0
End Effector	-0.1278	1.3363	1.2445	

Table 2: Pose left end effector with respect to the world frame (x_0,y_0,z_0):

M =

-1	0	0	-0.1278
0	0	1	1.3363
0	1	0	1.2445
0	0	0	1

Table 3. Right arm's joint and end effector's position with respect to the world frame (x_0,y_0,z_0):

	X_0 (m)	**Y_0 (m)**	**Z_0 (m)**	**Direction of axis a_n**
1st Joint	0.2387	-0.1230	1.054	Z_0
2nd Joint	0.3077	-0.1230	1.3244	Y_0
3rd Joint	0.4097	-0.1230	1.3244	X_0
4th Joint	0.6722	-0.1230	1.2554	Y_0
5th Joint	0.7758	-0.1230	1.2554	X_0
6th Joint	1.0465	-0.1230	1.2454	Y_0
7th Joint	1.1624	-0.1230	1.2454	X_0
End Effector	1.3320	-0.1230	1.2445	

Table 4. Pose of right end effector with respect to the world frame (x_0,y_0,z_0):

M =

0	0	1	-0.1278
1	0	0	1.3363
0	1	0	1.2445
0	0	0	1

Given all the parameters of the left and the right arm deriving the pose of the right end effector after an input of seven θs can be found using forward kinematics. To derive the final pose of the end effector the screw of every joint needs to be calculated. The screw of a given revolute joint is derived using equation 1:

$$S_n = \begin{bmatrix} a_n \\ -[a_n] * q_n \end{bmatrix} \quad (1)$$

where a_n is the vector representing the direction of rotation and q_n is the position of the joint along the axis of the rotation which is given in table 1 and 3.

Once all the screws are calculated, the final pose can be calculated using matrix exponentials as shown in equation 2:

$$T_n^0 = e^{[S_1]\theta_1} * e^{[S_2]\theta_2} \dots e^{[S_{n-1}]\theta_{n-1}} * e^{[S_n]\theta_n} * M \quad (2)$$

where n is the number of joints from the world frame to the end effector and M is the initial pose of the end effector. For Baxter there are a total of 7 joints in the arm so $n = 7$ and M is given in table 2 and 4.