Reach Bravo Kinematics and Dynamics

Blueprint Lab

August 2020

1 Kinematics

Link	**d (mm)**	$\boldsymbol{\theta}$	**a (mm)**	$\boldsymbol{\alpha}$
0	107.4	$\theta_0 + \pi$	46.0	$\pi/2$
1	0.0	$\theta_1 - \pi/2 + \theta_a$	293.6	0.0
2	0.0	$\theta_2 - \pi/2 - \theta_a$	40.8	$-\pi/2$
3	-160.0	θ_3	40.8	$-\pi/2$
4	0.0	θ_4	40.8	$-\pi/2$
5	-223.5	θ_5	0.0	$\pi/2$
6	0.0	$-\pi/2$	120.0	0.0

Table 1: Standard DH Parameters for Bravo 7 where $\theta_a = \tan^{-1}\left(\frac{5.2}{293.55}\right)$

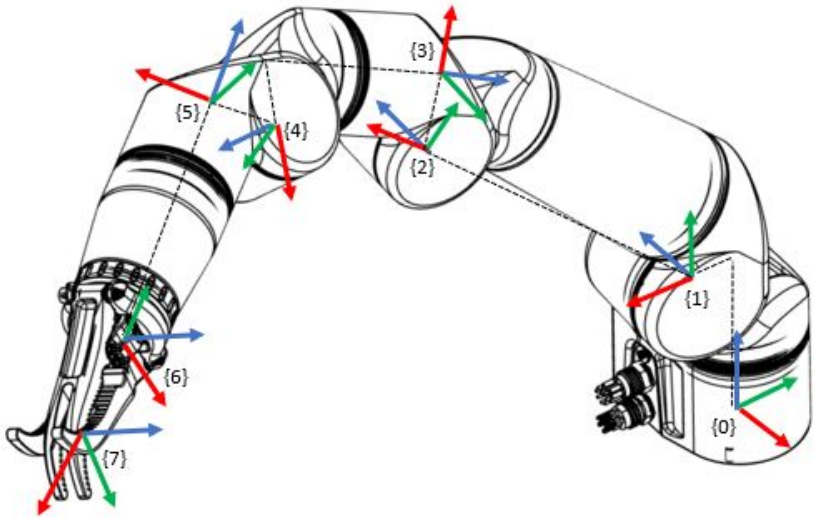

Figure 1: Bravo 7 joint frames (x,y,z)

2 Inertial Properties

Link	**Mass** (kg)	**COM** (mm)	**I** ($kg.mm^2$)
0	1.25	$\begin{pmatrix} -18 & -4 & -1 \end{pmatrix}$	$\begin{pmatrix} 2108 & 182 & -15 \\ 182 & 2573 & -21 \\ -15 & -21 & 3483 \end{pmatrix}$
1	1.55	$\begin{pmatrix} 17 & -7 & 57 \end{pmatrix}$	$\begin{pmatrix} 11442 & -484 & 3405 \\ -484 & 12980 & -1265 \\ 3405 & -1265 & 3202 \end{pmatrix}$
2	1.98	$\begin{pmatrix} 117 & 15 & 6 \end{pmatrix}$	$\begin{pmatrix} 3960 & 4200 & 3204 \\ 4200 & 69099 & -24 \\ 3204 & -24 & 70450 \end{pmatrix}$
3	1.14	$\begin{pmatrix} 22 & -29 & 1 \end{pmatrix}$	$\begin{pmatrix} 3213 & -1548 & -31 \\ -1548 & 2327 & 6 \\ -31 & 6 & 4340 \end{pmatrix}$
4	1.14	$\begin{pmatrix} 18 & 6 & -117 \end{pmatrix}$	$\begin{pmatrix} 21232 & 330 & -3738 \\ 330 & 22252 & -1278 \\ -3738 & -1278 & 2054 \end{pmatrix}$
5	1.03	$\begin{pmatrix} 20 & -24 & 1 \end{pmatrix}$	$\begin{pmatrix} 2430 & -1144 & -40 \\ -1144 & 2026 & 11 \\ -40 & 11 & 3330 \end{pmatrix}$
6	1.04	$\begin{pmatrix} 0 & 0 & -128 \end{pmatrix}$	$\begin{pmatrix} 22359 & 1 & -19 \\ 1 & 22363 & 15 \\ -19 & 15 & 936 \end{pmatrix}$
7	0.47	$\begin{pmatrix} 28 & -1 & 0 \end{pmatrix}$	$\begin{pmatrix} 244 & -12 & 0 \\ -12 & 1130 & 1 \\ 0 & 1 & 1178 \end{pmatrix}$

Table 2: Inertial properties for Bravo 7 (Link 7 is for interlocking jaws in the closed position)

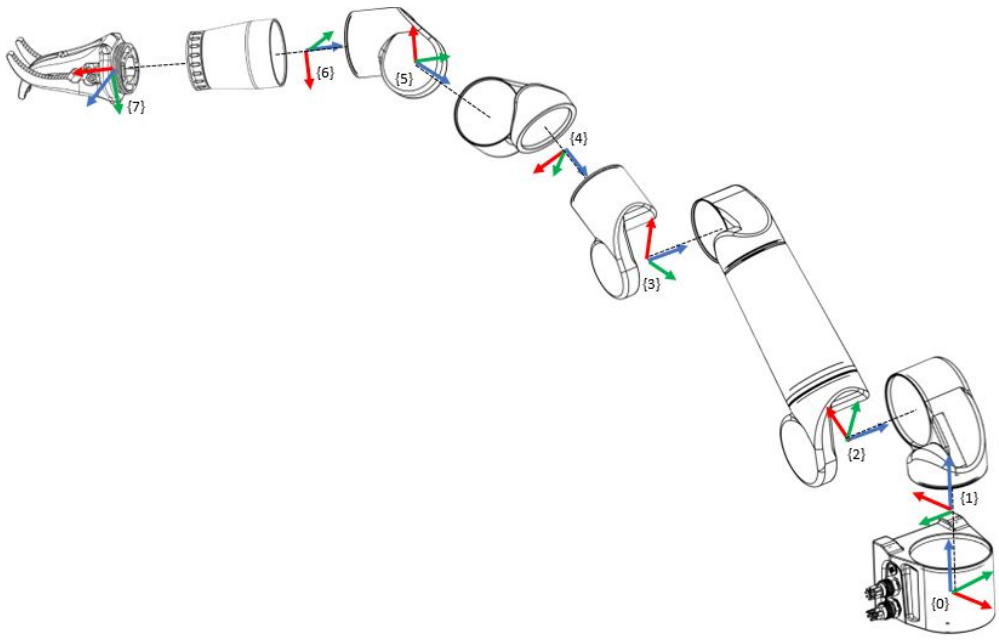

Figure 2: Inertial frames for Bravo 7

3 Hydrodynamic Properties

3.1 Buoyancy

Link	**Volume** (L)	**COB** (mm)
0	0.72	$\begin{pmatrix} -18 & -3 & -3 \end{pmatrix}$
1	0.60	$\begin{pmatrix} 27 & -11 & 92 \end{pmatrix}$
2	1.94	$\begin{pmatrix} 145 & 35 & -1 \end{pmatrix}$
3	0.47	$\begin{pmatrix} 33 & -43 & -7 \end{pmatrix}$
4	0.51	$\begin{pmatrix} 20 & 12 & -140 \end{pmatrix}$
5	0.43	$\begin{pmatrix} 33 & -38 & -8 \end{pmatrix}$
6	0.48	$\begin{pmatrix} 0 & 0 & -152 \end{pmatrix}$
7	0.16	$\begin{pmatrix} 28 & 1 & 0 \end{pmatrix}$

Table 3: Buoyancy terms with Centre of Buoyancy (COB)