UNIVERSAL ROBOTS Support

DH PARAMETERS FOR CALCULATIONS OF KINEMATICS AND DYNAMICS

Denavit Hartenberg Parameters - DH Parameters

Last modified on Jan 19, 2022

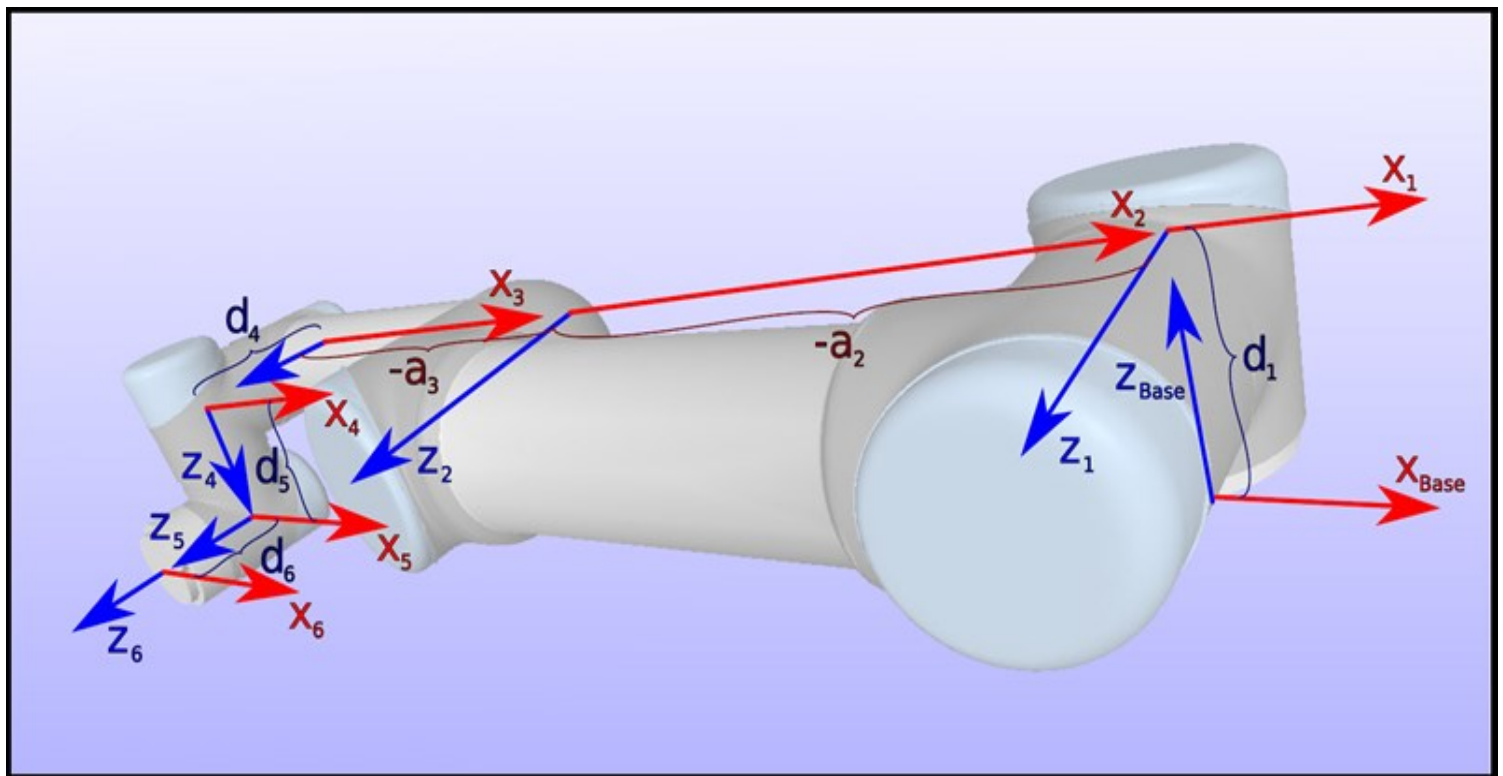*Denavit−Hartenberg parameters are used to calculate kinematics and dynamics of UR robots.*
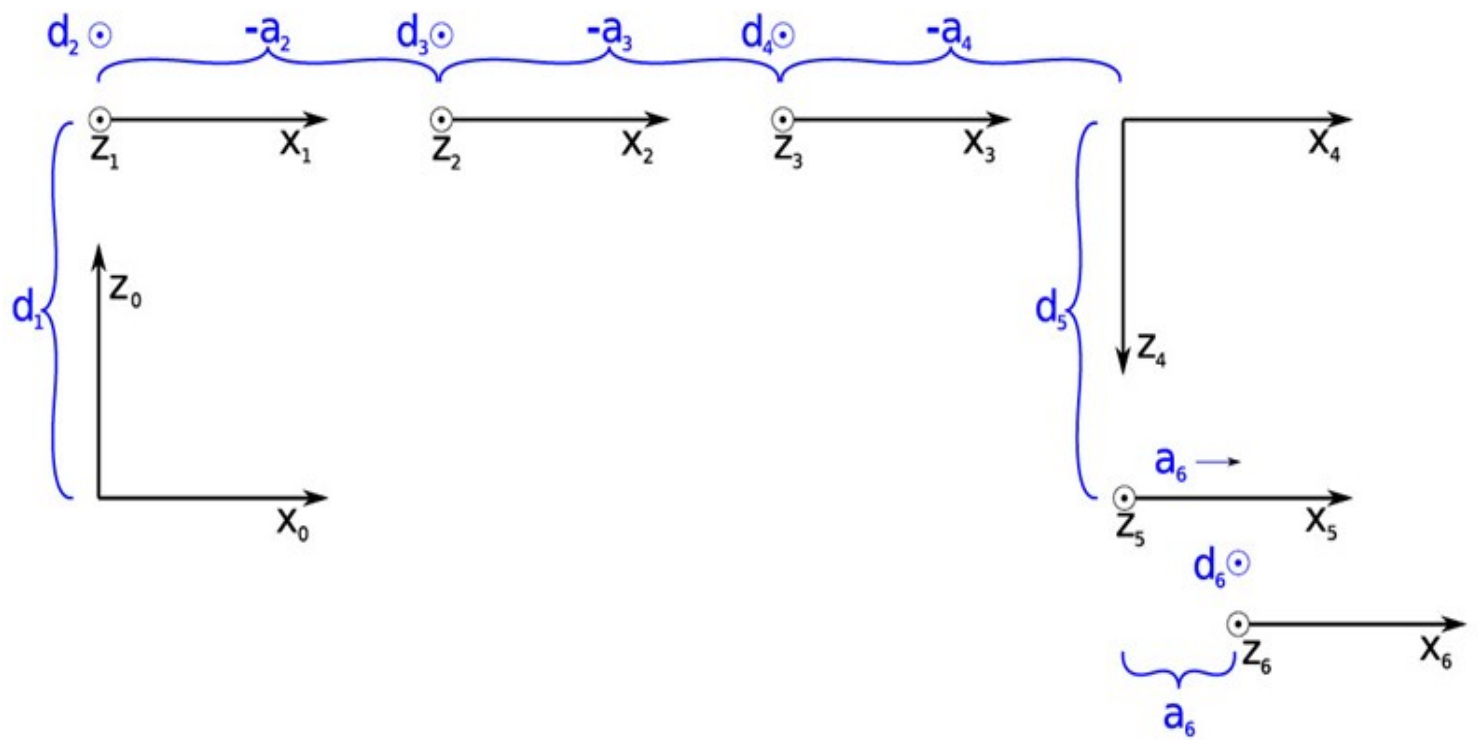
The definition of the Denavit−Hartenberg parameters can be found here: http://en.wikipedia.org/wiki/Denavit%E2%80%93Hartenberg_parameters

Animation to explain the Denavit−Hartenberg parameters: https://www.youtube.com/watch?v=rA9tm0gTln8

Note: UR "a" parameter = Wikipedia "r" parameter.

The Denavit−Hartenberg parameters in UR robots are described as the below diagrams.

The Denavit–Hartenberg parameters of UR robots are shown as below.

UR3e

Kinematics	theta [rad]	a [m]	d [m]	alpha [rad]	Dynamics	Mass [kg]	Center of Mass [m]
Joint 1	0	0	0.15185	π/2	Link 1	1.98	[0, -0.02, 0]
Joint 2	0	-0.24355	0	0	Link 2	3.4445	[0.13, 0, 0.1157]
Joint 3	0	-0.2132	0	0	Link 3	1.437	[0.05, 0, 0.0238]
Joint 4	0	0	0.13105	π/2	Link 4	0.871	[0, 0, 0.01]
Joint 5	0	0	0.08535	-π/2	Link 5	0.805	[0, 0, 0.01]
Joint 6	0	0	0.0921	0	Link 6	0.261	[0, 0, -0.02]

UR5e

Kinematics	theta [rad]	a [m]	d [m]	alpha [rad]	Dynamics	Mass [kg]	Center of Mass [m]
Joint 1	0	0	0.1625	π/2	Link 1	3.761	[0, -0.02561, 0.00193]
Joint 2	0	-0.425	0	0	Link 2	8.058	[0.2125, 0, 0.11336]
Joint 3	0	-0.3922	0	0	Link 3	2.846	[0.15, 0.0, 0.0265]
Joint 4	0	0	0.1333	π/2	Link 4	1.37	[0, -0.0018, 0.01634]
Joint 5	0	0	0.0997	-π/2	Link 5	1.3	[0, 0.0018,0.01634]
Joint 6	0	0	0.0996	0	Link 6	0.365	[0, 0, -0.001159]

UR10e

Kinematics	theta [rad]	a [m]	d [m]	alpha [rad]	Dynamics	Mass [kg]	Center of Mass [m]
Joint 1	0	0	0.1807	π/2	Link 1	7.369	[0.021, 0.000, 0.027]
Joint 2	0	-0.6127	0	0	Link 2	13.051	[0.38, 0.000, 0.158]
Joint 3	0	-0.57155	0	0	Link 3	3.989	[0.24, 0.000, 0.068]
Joint 4	0	0	0.17415	π/2	Link 4	2.1	[0.000, 0.007, 0.018]
Joint 5	0	0	0.11985	-π/2	Link 5	1.98	[0.000, 0.007, 0.018]
Joint 6	0	0	0.11655	0	Link 6	0.615	[0, 0, -0.026]

UR16e

Kinematics	theta [rad]	a [m]	d [m]	alpha [rad]	Dynamics	Mass [kg]	Center of Mass [m]
Joint 1	0	0	0.1807	π/2	Link 1	7.369	[0.000, -0.016, 0.030]
Joint 2	0	-0.4784	0	0	Link 2	10.450	[0.302, 0.000, 0.160]
							[0.194,

Joint 3	0	-0.36	0	0	Link 3	4.321	0.000, 0.065]
Joint 4	0	0	0.17415	π/2	Link 4	2.180	[0.000, -0.009, 0.011]
Joint 5	0	0	0.11985	-π/2	Link 5	2.033	[0.000, 0.018, 0.012]
Joint 6	0	0	0.11655	0	Link 6	0.907	[0, 0, -0.044]

UR3

Kinematics	theta [rad]	a [m]	d [m]	alpha [rad]	Dynamics	Mass [kg]	Center of Mass [m]
Joint 1	0	0	0.1519	π/2	Link 1	2	[0, -0.02, 0]
Joint 2	0	-0.24365	0	0	Link 2	3.42	[0.13, 0, 0.1157]
Joint 3	0	-0.21325	0	0	Link 3	1.26	[0.05, 0, 0.0238]
Joint 4	0	0	0.11235	π/2	Link 4	0.8	[0, 0, 0.01]
Joint 5	0	0	0.08535	-π/2	Link 5	0.8	[0, 0, 0.01]
Joint 6	0	0	0.0819	0	Link 6	0.35	[0, 0, -0.02]

UR5

Kinematics	theta [rad]	a [m]	d [m]	alpha [rad]	Dynamics	Mass [kg]	Center of Mass [m]
Joint 1	0	0	0.089159	π/2	Link 1	3.7	[0, -0.02561, 0.00193]
Joint 2	0	-0.425	0	0	Link 2	8.393	[0.2125, 0, 0.11336]
Joint 3	0	-0.39225	0	0	Link 3	2.33	[0.15, 0.0, 0.0265]
Joint 4	0	0	0.10915	π/2	Link 4	1.219	[0, -0.0018, 0.01634]
Joint 5	0	0	0.09465	-π/2	Link 5	1.219	[0, 0.0018,0.01634]
Joint 6	0	0	0.0823	0	Link 6	0.1879	[0, 0, -0.001159]

UR10

Kinematics	theta [rad]	a [m]	d [m]	alpha [rad]	Dynamics	Mass [kg]	Center of Mass [m]
Joint 1	0	0	0.1273	π/2	Link 1	7.1	[0.021, 0.000, 0.027]
Joint 2	0	-0.612	0	0	Link 2	12.7	[0.38, 0.000, 0.158]
Joint 3	0	-0.5723	0	0	Link 3	4.27	[0.24, 0.000, 0.068]
Joint 4	0	0	0.163941	π/2	Link 4	2	[0.000, 0.007, 0.018]

| Joint 5 | 0 | 0 | 0.1157 | -π/2 | Link 5 | 2 | [0.000, 0.007, 0.018] |
| Joint 6 | 0 | 0 | 0.0922 | 0 | Link 6 | 0.365 | [0, 0, -0.026] |

Denavit-Hartenberg-Parameter

| URSe | | Joint angle in rad | DH-Parameter from UR Supportwebsite | | |
Kinematics	Θ [Grad]	Θ [rad]	a [m]	d [m]	α [rad]
Joint 1 (Base)	302,00	5,270894341	0,0000	0,1625	1,570796327
Joint 2 (Shoulder)	190,00	3,316125579	-0,4250	0,0000	0
Joint 3 (Elbow)	59,00	1,029744259	-0,3922	0,0000	0
Joint 4 (Wirst 1)	199,00	3,473205211	0,0000	0,1333	1,570796327
Joint 5 (Wirst 2)	120,00	2,094395102	0,0000	0,0997	-1,57079633
Joint 6 (Wirst 3)	90,00	1,570796327	0,0000	0,0996	0

0T1

0,529919264	5,19492E-17	-0,8480481	0
-0,848048096	3,24615E-17	-0,52991926	0
0	1	6,12574E-17	0,1625
0	0	0	1

* 1T2

1T2

-0,984807753	0,173648178	0	0,418543295
-0,173648178	-0,984807753	0	0,073800476
0	0	1	0
0	0	0	1

Interim result

-0,52187	0,09202	-0,84805	0,22179
0,83516	-0,14726	-0,52992	-0,35494
-0,17365	-0,98481	0,00000	0,23630
0,00000	0,00000	0,00000	1,00000

* 2T3

2T3

0,515038075	-0,857167301	0	-0,20199793
0,857167301	0,515038075	0	-0,33618102
0	0	1	0
0	0	0	1

Interim result

-0,18991	0,49472	-0,84805	0,29628
0,30391	-0,79172	-0,52992	-0,47414
-0,93358	-0,35837	0,00000	0,60245
0,00000	0,00000	0,00000	1,00000

* 3T4

3T4

-0,945518576	1,99435E-17	-0,32556815	0
-0,325568154	-5,792E-17	0,945518576	0
0	1	6,12574E-17	0,1333
0	0	0	1

Interim result

0,01849	-0,84805	0,52960	0,18323
-0,02960	-0,52992	-0,84753	-0,54478
0,99939	0,00000	-0,03490	0,60245
0,00000	0,00000	0,00000	1,00000

* 4T5

4T5

-0,5	-5,30505E-17	-0,8660254	0
0,866025404	-3,06287E-17	-0,5	0
0	-1	6,12574E-17	0,0997
0	0	0	1

Interim result

-0,74368	-0,52960	0,40801	0,23603
-0,44413	0,84753	0,29059	-0,62928
-0,49970	0,03490	-0,86550	0,59897
0,00000	0,00000	0,00000	1,00000

* 5T6

5T6

6,12574E-17	-1	0	0
1	6,12574E-17	0	0
0	0	1	0,0996
0	0	0	1

Result 0T1*1T2*2T3*3T4*4T5*5T6

-0,52960	0,74368	0,40801	0,27667
0,84753	0,44413	0,29059	-0,60033
0,03490	0,49970	-0,86550	0,51277
0,00000	0,00000	0,00000	1,00000

Left vertical labels: ← Mulitplicated Denavit-Hartenberg transformation matrix 5T6 · ← Mulitplicated Denavit-Hartenberg transformation matrix 4T5 · ← Mulitplicated Denavit-Hartenberg transformation matrix 3T4 · ← Mulitplicated Denavit-Hartenberg transformation... · ← Mulitplicated Denavit...

X	Y	Z
0	0	0,1625
0,22179	-0,35494	0,23630
0,29628	-0,47414	0,60245
0,18323	-0,54478	0,60245
0,23603	-0,62928	0,59897
0,27667	-0,60033	0,51277
beta	alpha	gamma
1,60570	2,58309	2,09440
92,00000	148,00000	120,00000
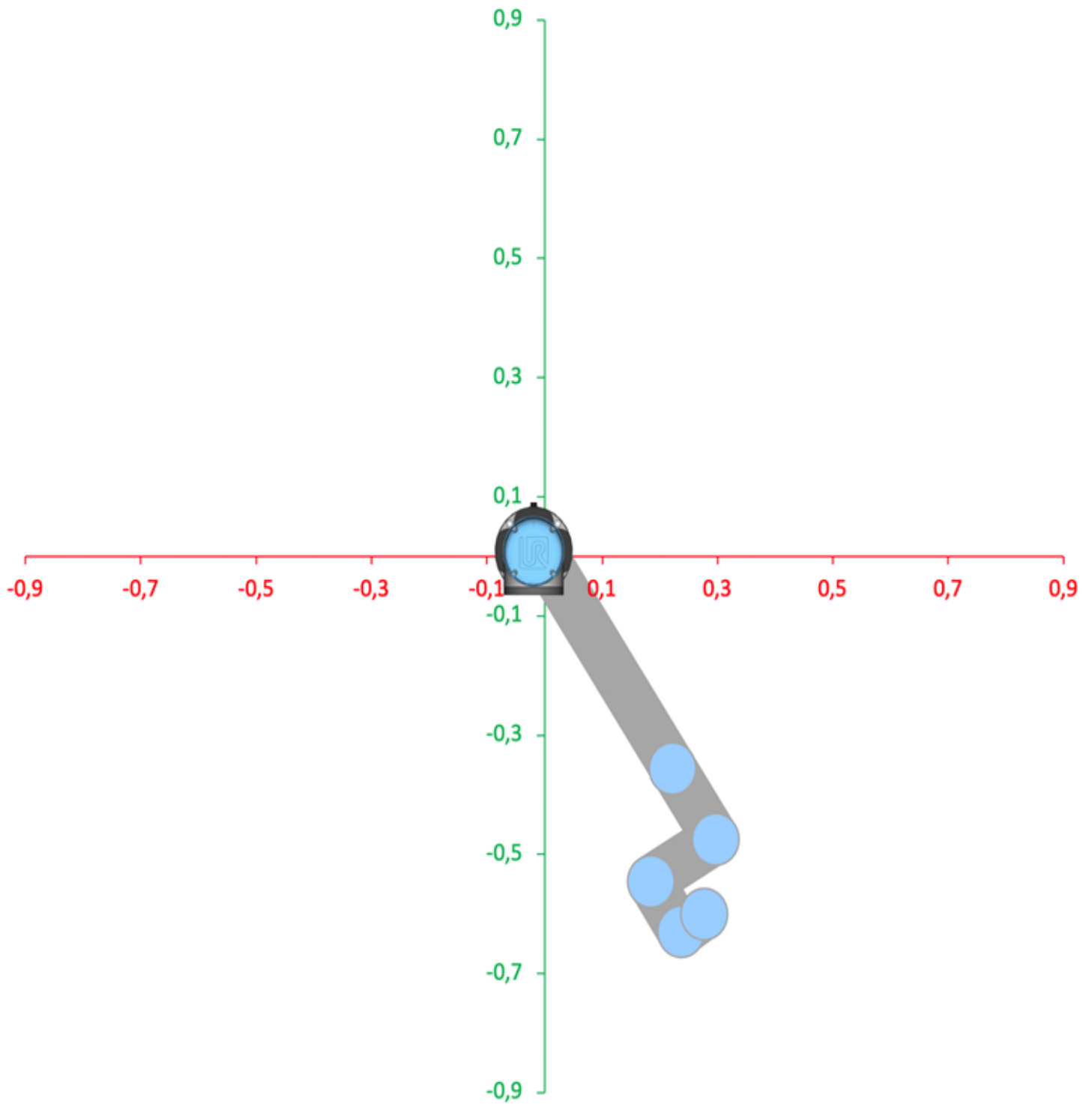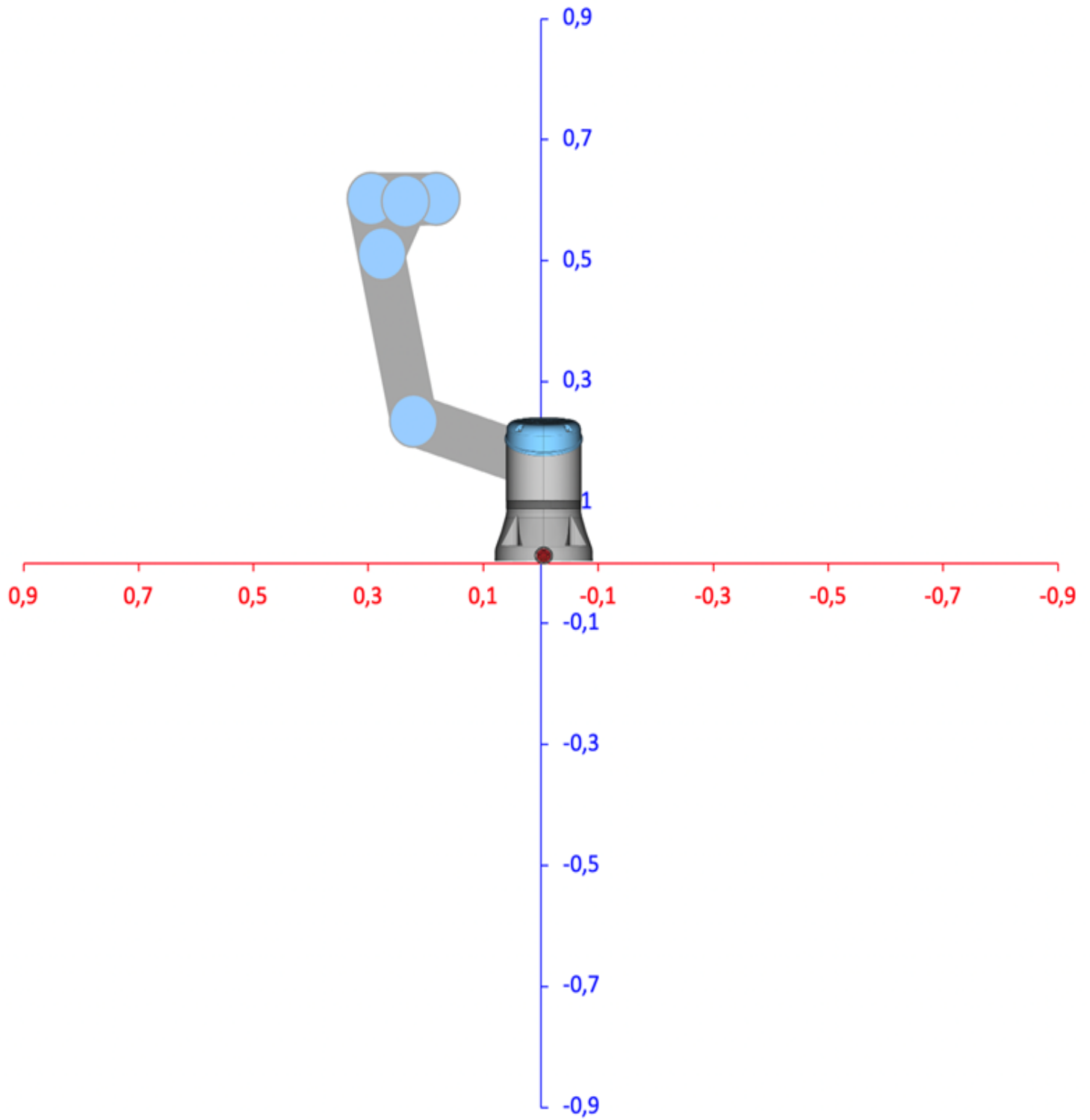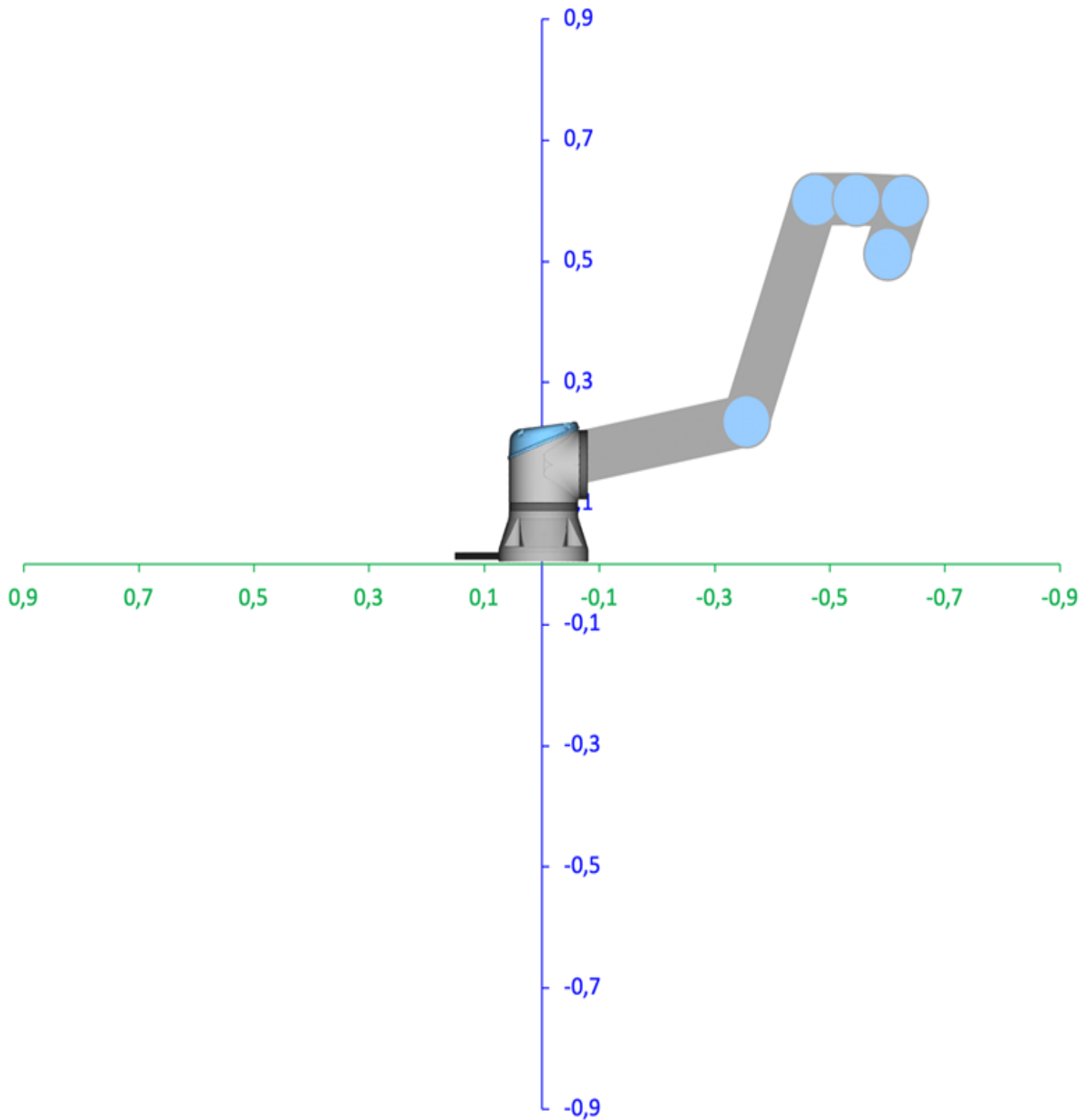
Download the excel file below for an overview and understanding how the transformation is done in regards to the position of the robot's joints.