530.646 Lab3 Open-ended answers

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2. The UR5 assignment of frames for DH parameters is shown in Figure 1.

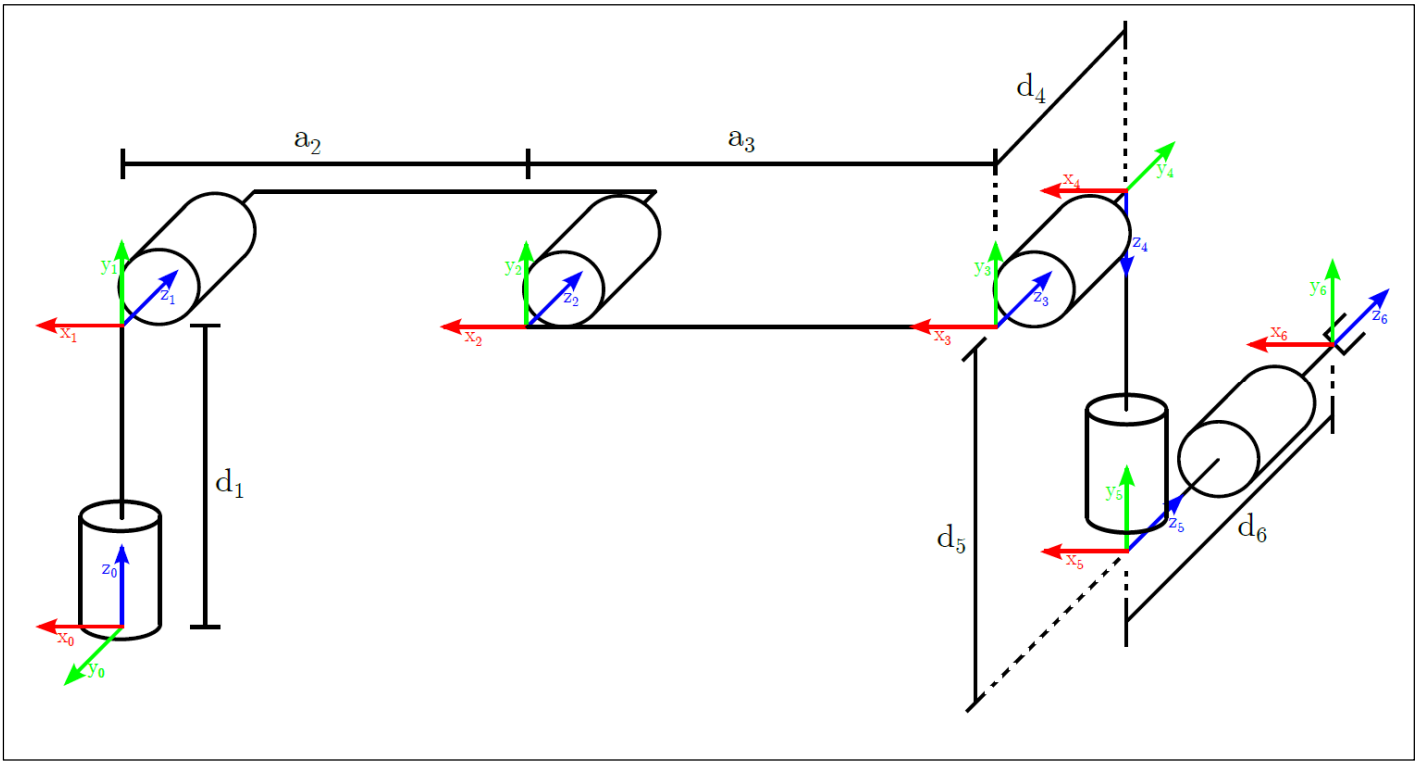

Figure 1. DH frame assignment (diagram modified from PS3 solution)

The DH parameter table for the frame assignment is shown in Table 1.

Link	***a***	***α***	***d***	***θ***
0→1	0	π/2	0.0892	θ_1
1→2	−0.425	0	0	θ_2
2→3	−0.392	0	0	θ_3
3→4	0	π/2	0.1093	θ_4
4→5	0	−π/2	0.09475	θ_5
5→6	0	0	0.0825	θ_6

Table 1. Table of DH parameters, unit of meters for "a" and "d", radians for "α" and "θ".

4. The UR5 in its zero position (i.e. all joint angles are 0) is shown in Figure 2. This pose corresponds to the robot sketch as shown in Figure 1, so the sketch for this question is the same as in Q2.

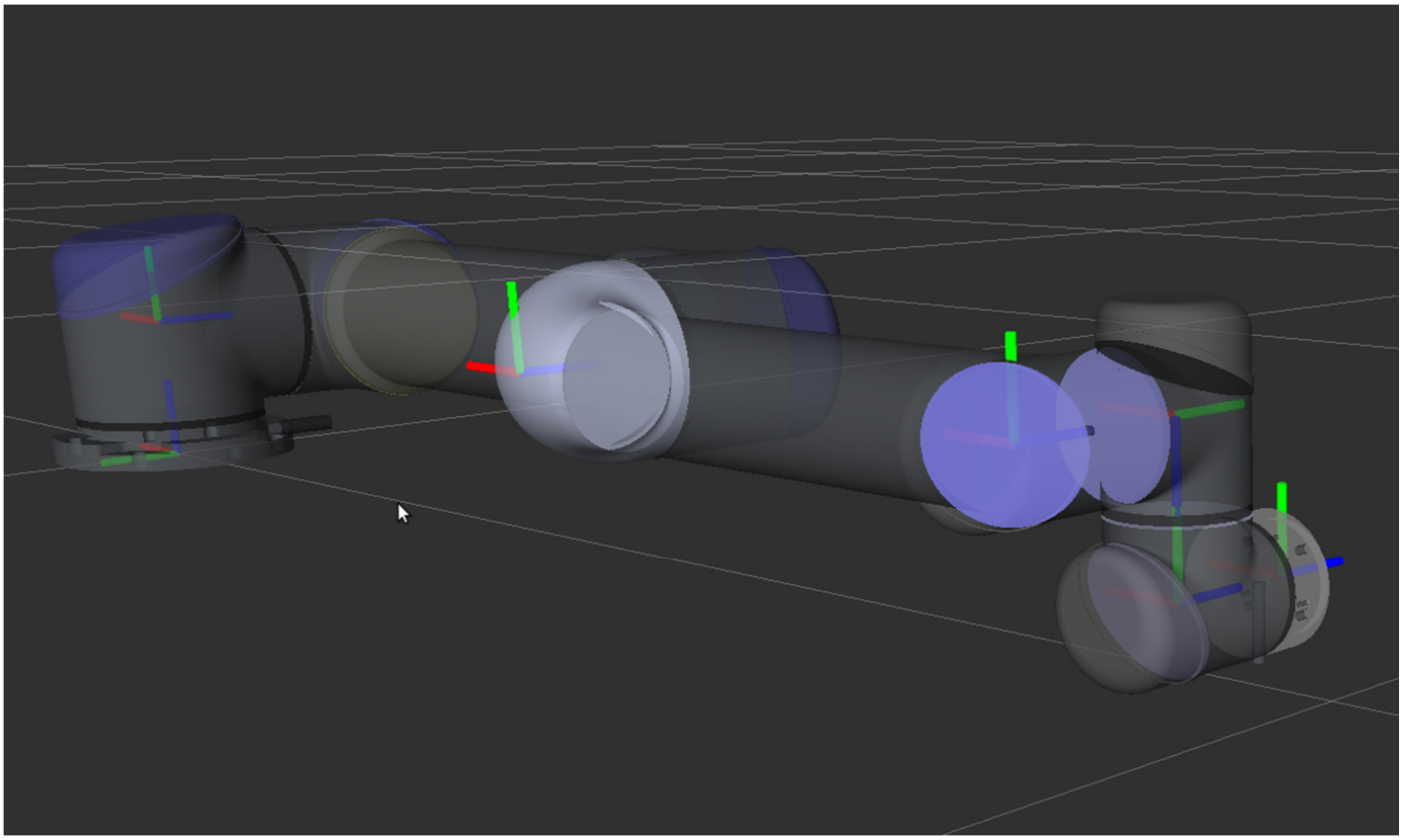

Figure 2. UR5 robot when all joints are 0 deg.

7. Figure 3 shows the UR5 in the pose with joint angles $\{90^0, -10^0, -40^0, 50^0, 20^0, 100^0\}$ and the transformation from the base to the end-effector is (angles in radians and distance in meters):

$$\begin{pmatrix} -0.059 & -0.34 & 0.94 & 0.19 \\ -0.16 & -0.93 & -0.34 & -0.7 \\ 0.98 & -0.17 & 0 & 0.37 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

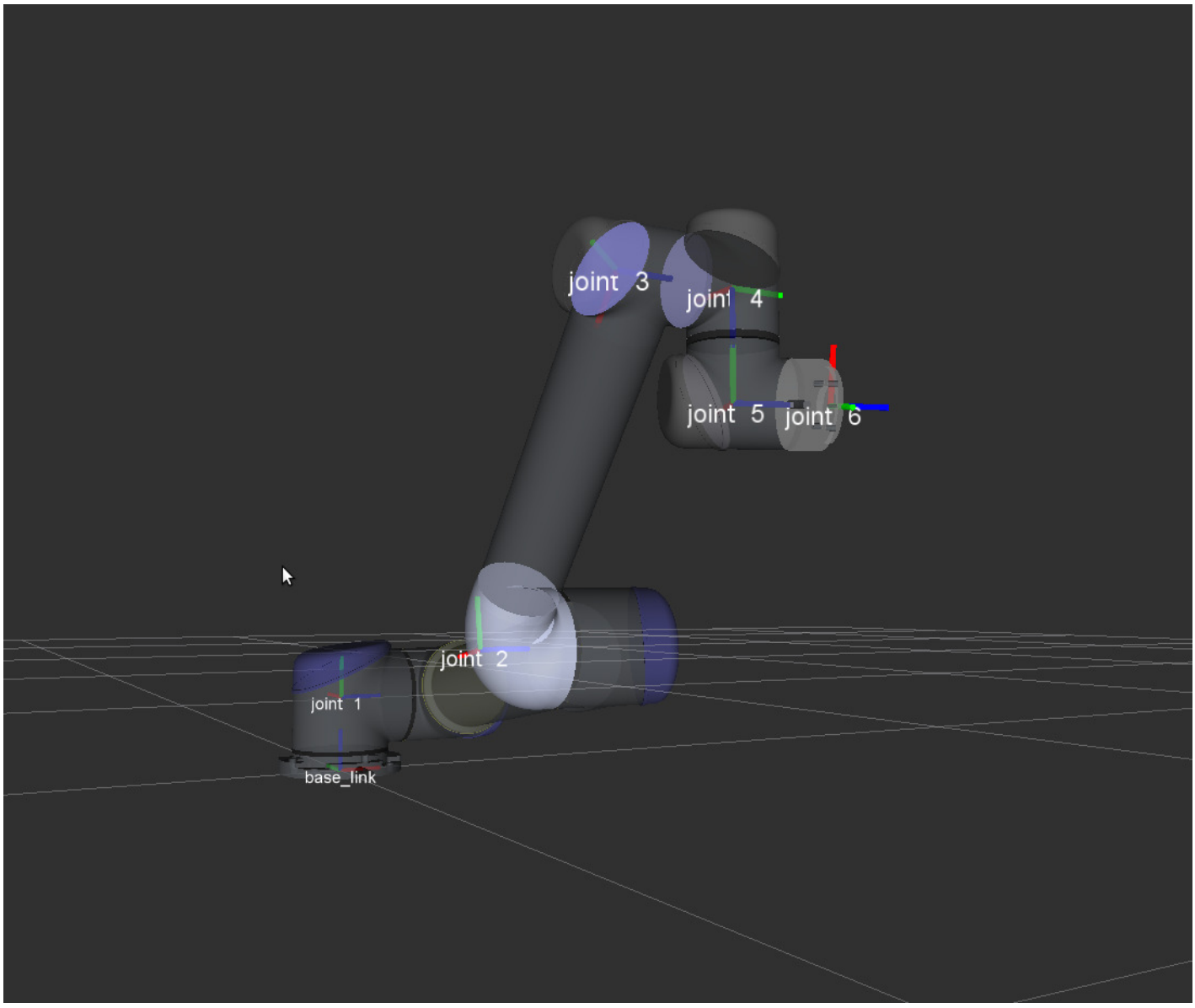

Figure 3. UR5 with joint angles $90^0, -10^0, -40^0, 50^0, 20^0, 100^0$

Figure 4 shows the UR5 in the pose with joint angles {0^0, 100^0, 20^0, -30^0, -90^0, 70^0} and the transformation from the base to the end-effector is (angles in radians and distance in meters):

$$\begin{pmatrix} -0.94 & -0.34 & 0 & 0.36 \\ 0.34 & -0.94 & 0 & -0.11 \\ 0 & 0 & 1 & -0.59 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

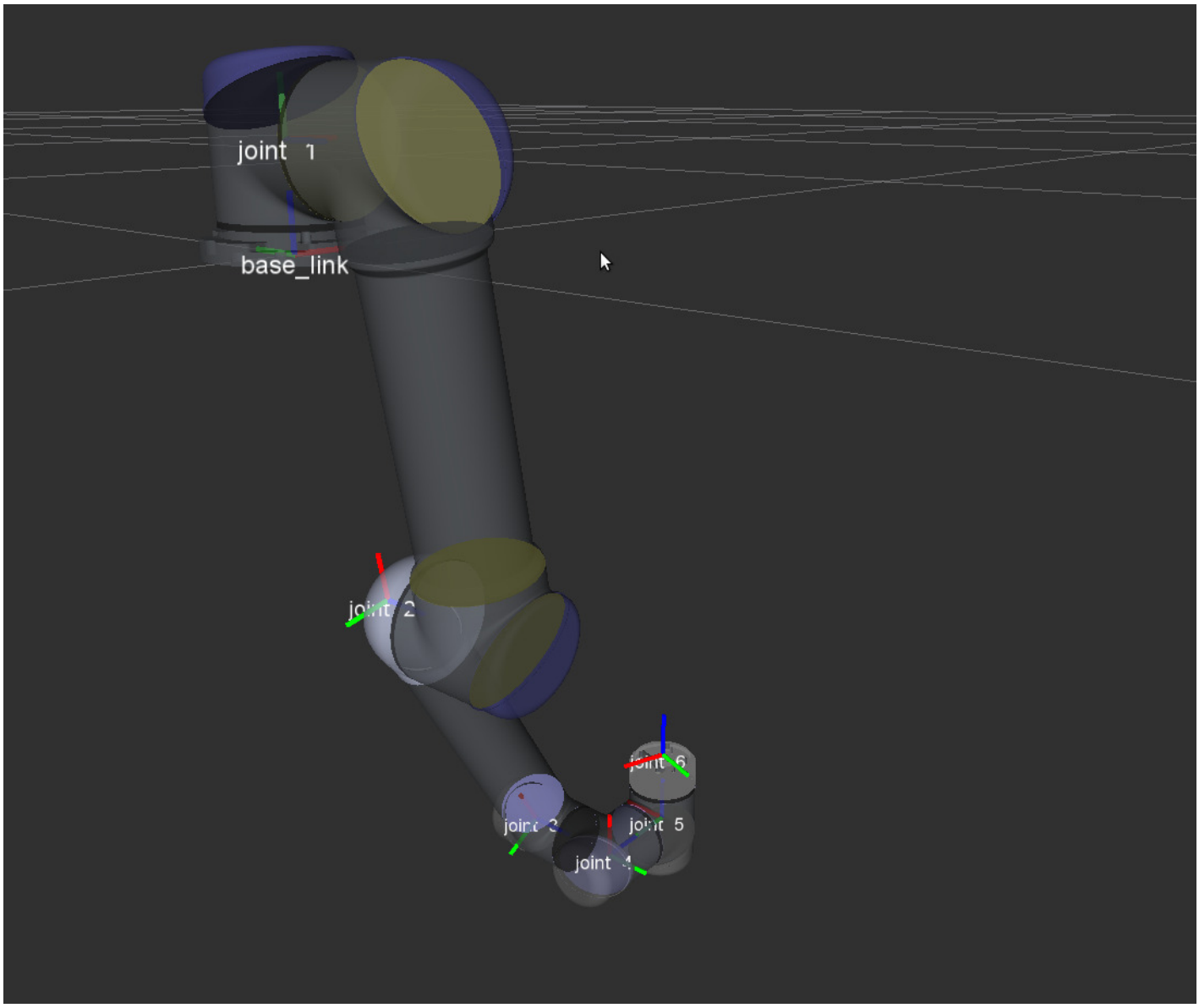

Figure 4. UR5 with joint angles 0^0, 100^0, 20^0, -30^0, -90^0, 70^0

Figure 5 shows the UR5 in the pose with joint angles {-120^0, 150^0, 10^0, -20^0, 60^0, 0^0} and the transformation from the base to the end-effector is (angles in radians and distance in meters):

$$\begin{pmatrix} -0.56 & 0.32 & -0.76 & -0.56 \\ 0.76 & 0.56 & -0.32 & -0.66 \\ 0.32 & -0.77 & -0.56 & -0.23 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

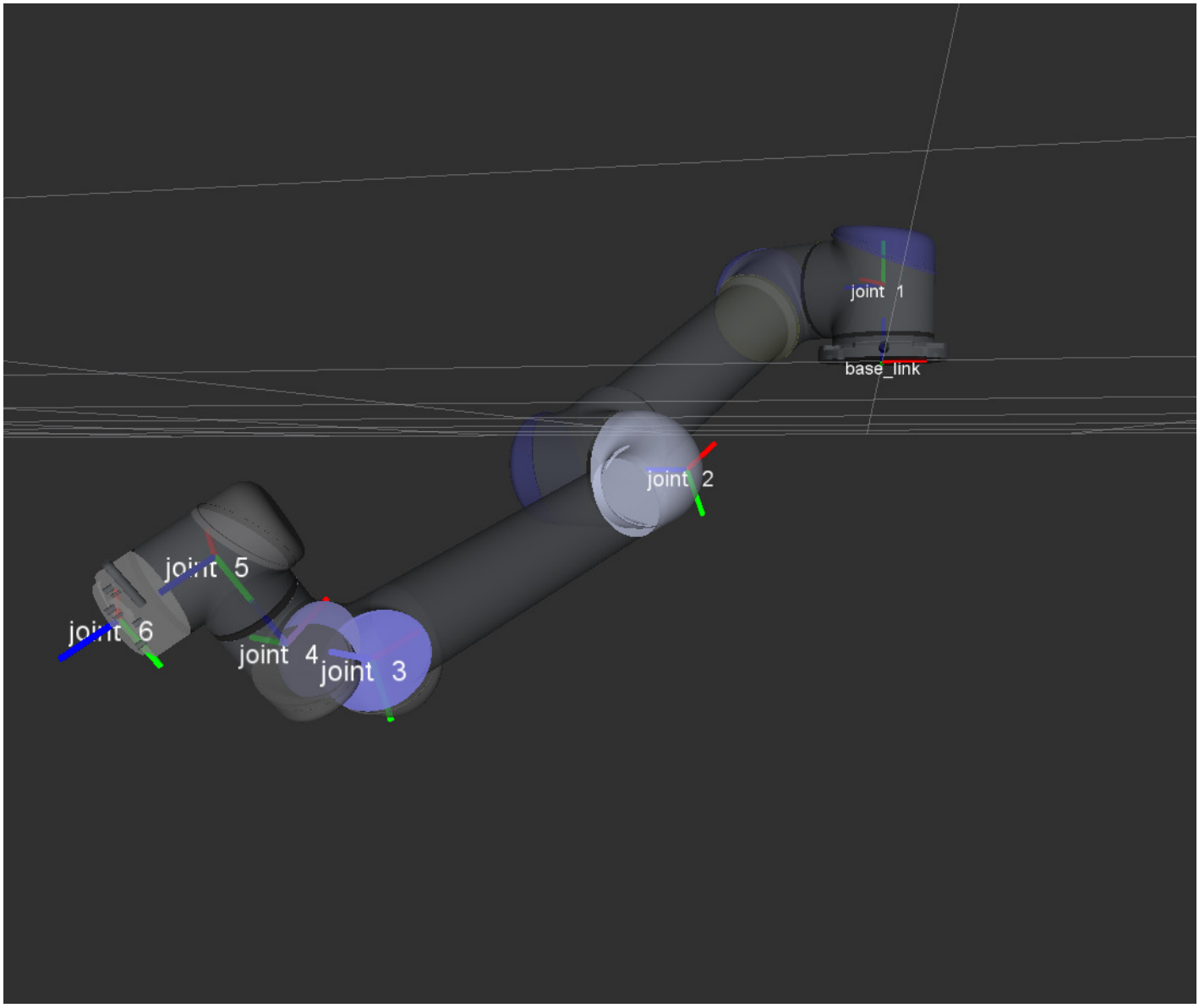

Figure 5. UR5 with joint angles -120^0, 150^0, 10^0, -20^0, 60^0, 0^0

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