Robotics Assignment #03

Paul Bienkowski, Konstantin Kobs

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Task 3.1. 1)

2)

Task 3.2. 1) The coordinate frames of the manipulator are chosen with respect to the modified Denavit-Hartenberg-convention.

Link i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0

2)

Task 3.3. 1) To calculate ${}^{base}T_{object}$, we need to invert the transformation ${}^{camera}T_{base}$. Then we can determine the desired transformation by computing

$$\begin{aligned} {}^{base}T_{object} &= {}^{camera}T_{base}{}^{-1} \cdot {}^{camera}T_{object} \\ &= {}^{base}T_{camera} \cdot {}^{camera}T_{object} \end{aligned}$$

The inverse of ${}^{camera}T_{base}$ is

$$\begin{pmatrix} 0 & -1 & 0 & 25 \\ -1 & 0 & 0 & 15 \\ 0 & 0 & -1 & 20 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

so we can compute the resulting matrix now

$$\begin{aligned} {}^{base}T_{object} &= {}^{camera}T_{base}{}^{-1} \cdot {}^{camera}T_{object} \\ &= \begin{pmatrix} 0 & -1 & 0 & 25 \\ -1 & 0 & 0 & 15 \\ 0 & 0 & -1 & 20 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 0 & -1 & 0 & 0 \\ -1 & 0 & 0 & -5 \\ 0 & 0 & -1 & 19 \\ 0 & 0 & 0 & 1 \end{pmatrix} \\ &= \begin{pmatrix} 1 & 0 & 0 & 30 \\ 0 & 1 & 0 & 15 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix} \end{aligned}$$

We can see, that the resulting homogeneous transformation is only a translation. This makes sense, because both the coordinate frame axes of the base and the part are parallel to each other.

2) We assume, that the front surface of the object is the surface in the figure, that we can see in front. Further we assume, that the robot will grasp the object by rotating its tool tip by $-90°$ around the z^t-axis. Then, when grasping the object, x^t and x^p are aligned. To align the other axes, we need to have a transformation by $180°$ around the x^p-axis. We already now the transformation ${}^{base}T_{object}$, and we can determine ${}^{object}T_{tool}$ with the given rotation. Then we can compute the resulting transformation

$$
\begin{aligned}
{}^{base}T_{tool} &= {}^{base}T_{object} \cdot {}^{object}T_{tool} \\
&= \begin{pmatrix} 1 & 0 & 0 & 30 \\ 0 & 1 & 0 & 15 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(180°) & -\sin(180°) & 0 \\ 0 & \sin(180°) & \cos(180°) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \\
&= \begin{pmatrix} 1 & 0 & 0 & 30 \\ 0 & \cos(180°) & -\sin(180°) & 15 \\ 0 & \sin(180°) & \cos(180°) & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix} \\
&= \begin{pmatrix} 1 & 0 & 0 & 30 \\ 0 & -1 & 0 & 15 \\ 0 & 0 & -1 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix}
\end{aligned}
$$

3)

4)