Robotics I

October 27, 2017

Consider the 6-dof robot Stäubli RX 160 in Fig. 1, described in the attached technical data sheet.

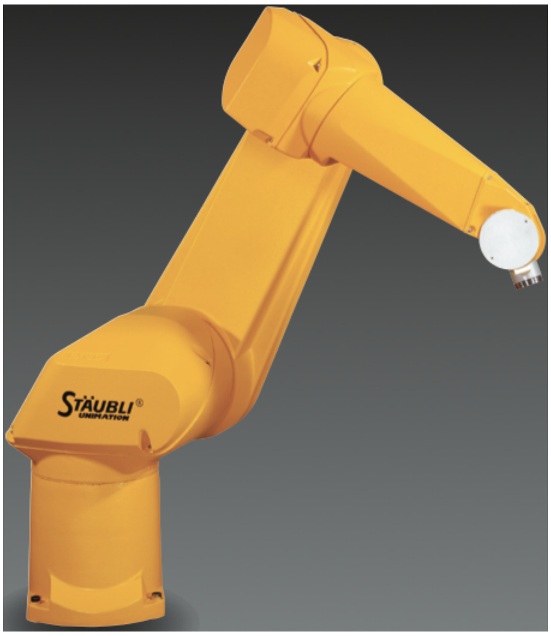

Figure 1: The Stäubli RX 160 robot.

1. Determine a frame assignment and the table of parameters according to the Denavit-Hartenberg (DH) convention.
2. Using the data sheet, specify the numerical values of the constant DH parameters.
3. Provide the numerical values of the variable DH parameters when the robot is in a stretched configuration pointing upwards.
4. Are the joint limits indicated in the data sheet consistent with the chosen DH convention? If not, explain why and which is the relation between the six DH variables $\boldsymbol{\theta}$ and the six joint angles $\boldsymbol{\theta}_S$ used by the Stäubli manufacturer.
5. How many distinct inverse kinematics solutions do you expect for this robot out of singularities? Would all these nonsingular inverse kinematics solutions be feasible with respect to the physical joint limits of the robot?
6. Derive the symbolic expression of the position $\boldsymbol{p}_{\mathbf{O}_4} = \boldsymbol{f}(\boldsymbol{\theta})$ of the origin $\mathbf{O}_4$ of the DH frame 4.
7. Has the robot a spherical wrist? If so, does $\mathbf{O}_4$ coincide with the center of the spherical wrist?
8. Compute the symbolic expression of the partial 3×3 Jacobian matrix $\boldsymbol{J}_{A,3}(\boldsymbol{\theta}_{\text{main}})$ that relates the velocity $\dot{\boldsymbol{\theta}}_{\text{main}} = \begin{pmatrix} \dot{\theta}_1 & \dot{\theta}_2 & \dot{\theta}_3 \end{pmatrix}^T \in \mathbb{R}^3$ of the first three (main) joint axes of the robot to the angular velocity $\boldsymbol{\omega}_3 \in \mathbb{R}^3$ of the DH frame 3.

[180 minutes, open books but no computer or smartphone]