Introduction to Robotics

Assignment #4

Due: 10.06.2015, 13.00

Task 4.1 (5 points) Jacobian: Determine the Jacobian matrix for the 3-joint planar manipulator shown in figure 1.

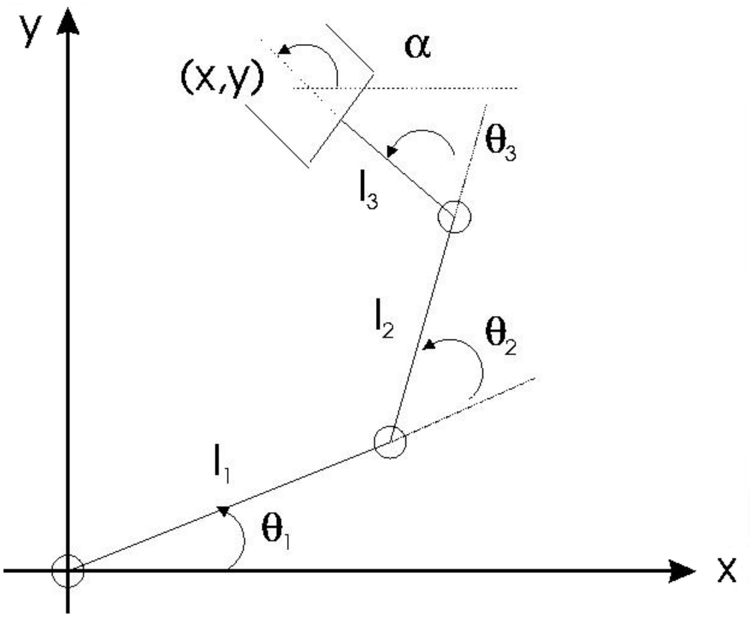

Figure 1: 3-joint planar manipulator.

Task 4.2 (6 points) Jacobian and singularities: Figure 2 shows a 2-joint planar manipulator with the following constraints: $0° \leq \theta_1 < 360°$, $0° \leq \theta_2 < 360°$ and $l_1 > l_2$.

4.2.1 (1 point): Illustrate the workspace of the manipulator.

4.2.2 (2 points): Determine the Jacobian matrix for the manipulator.

4.2.3 (1 point): Determine the singular configurations of the manipulator.

4.2.4 (2 points): Outline and explain the determined singular configurations.

Task 4.3 (4 points) Singularities of a PUMA560: Consider a PUMA560 manipulator as shown in figure 3. Explain at least two of the possible singular configurations!

Hint: *Workspace boundary singularities* occur whenever the manipulator is fully extended or is folding back onto itself.

Workspace-internal singularities occur if two or more joint axes enter a collinear configuration.

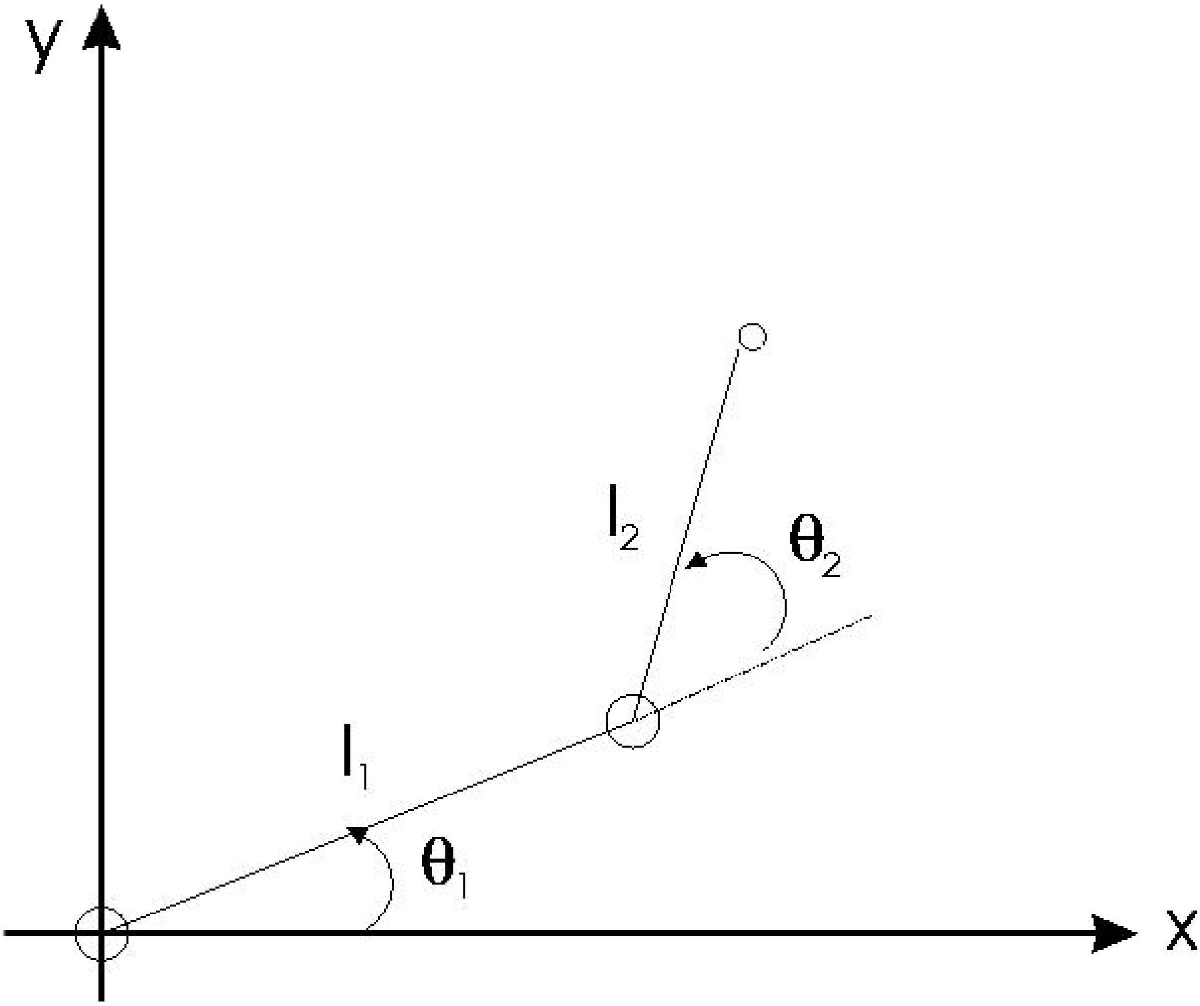

Figure 2: 2-joint planar manipulator.

Task 4.4 (5 points) Homogenous transformation: Derive the homogenous transformation $Rot_{\mathbf{k},\theta}$ (slide 129), which describes a rotation of θ around an arbitrary vector $\mathbf{k}$ ($\mathbf{k} = k_x \overrightarrow{i} + k_y \overrightarrow{j} + k_z \overrightarrow{k}$).

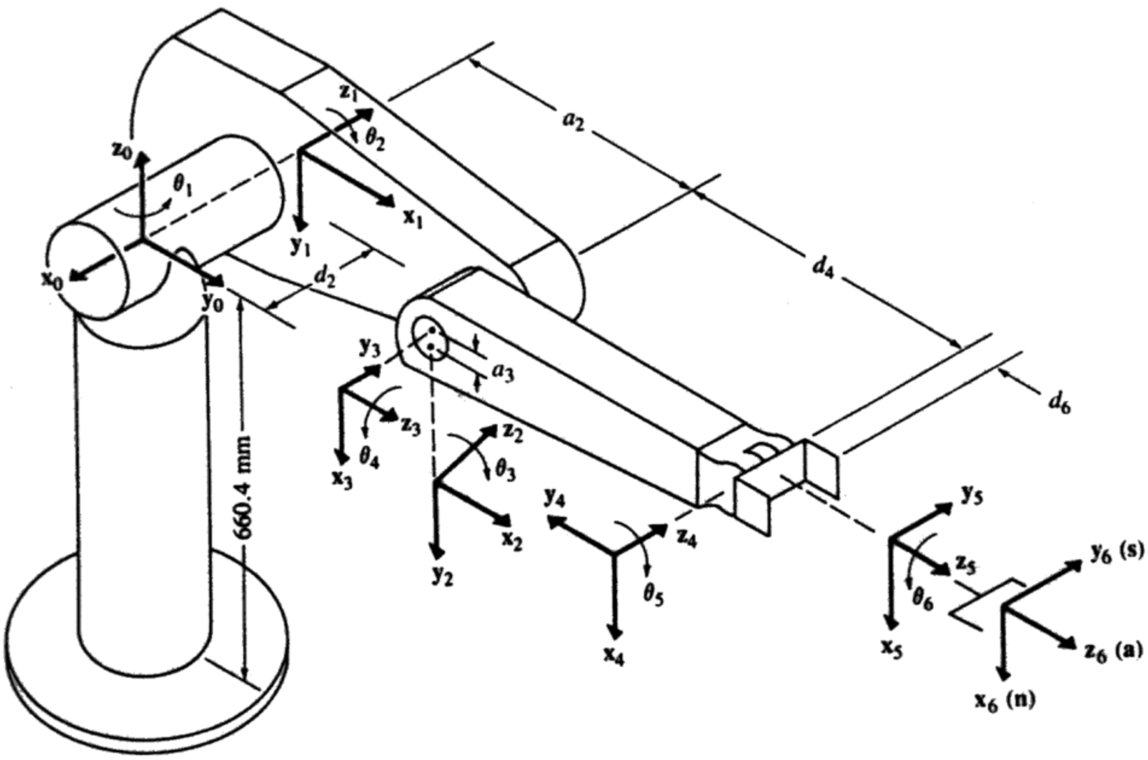

Figure 3: PUMA560 manipulator.