Introduction to Robotics

Assignment #4

Due: 13.06.2017, 23:59

Task 4.1 (9 points) Jacobian and singularities: Figure 1 shows a 2-joint planar manipulator with the following constraints: $10° \leq \theta_1 \leq 350°$, $0° < \theta_2 < 360°$ and $l_1 > l_2$.

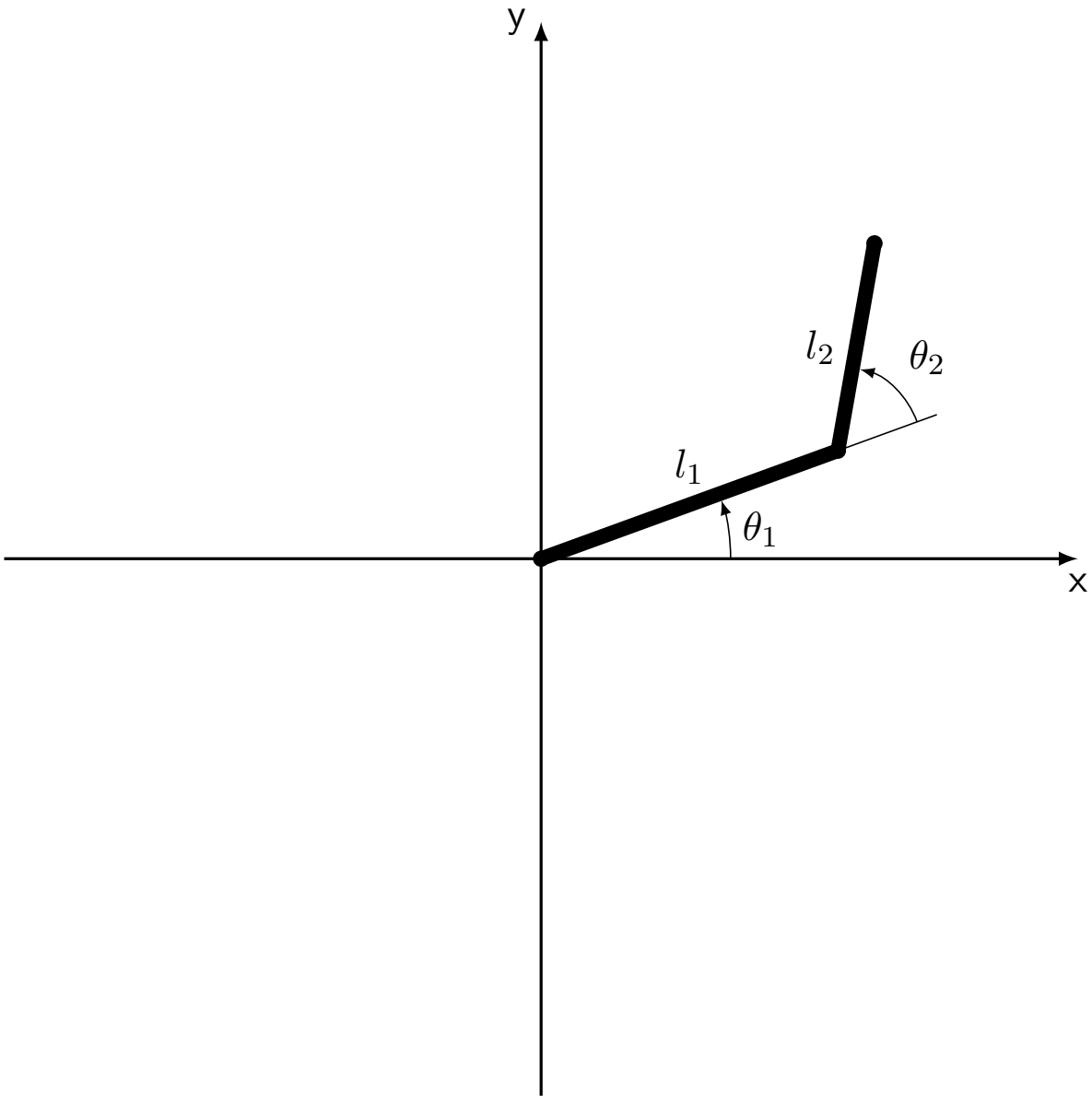

Figure 1: 2-joint planar manipulator.

4.1.1 (2 points): Illustrate the workspace of the manipulator.

4.1.2 (3 points): Determine the Jacobian matrix for the manipulator.

4.1.3 (2 points): Determine the singular configurations of the manipulator (mathematically or geometrical).

4.1.4 (2 points): Outline and explain the determined singular configurations (mathematically or geometrical).

Task 4.2 (2 points) Jacobian: Extend the Jacobian matrix for the 3-joint planar manipulator shown in figure 2.

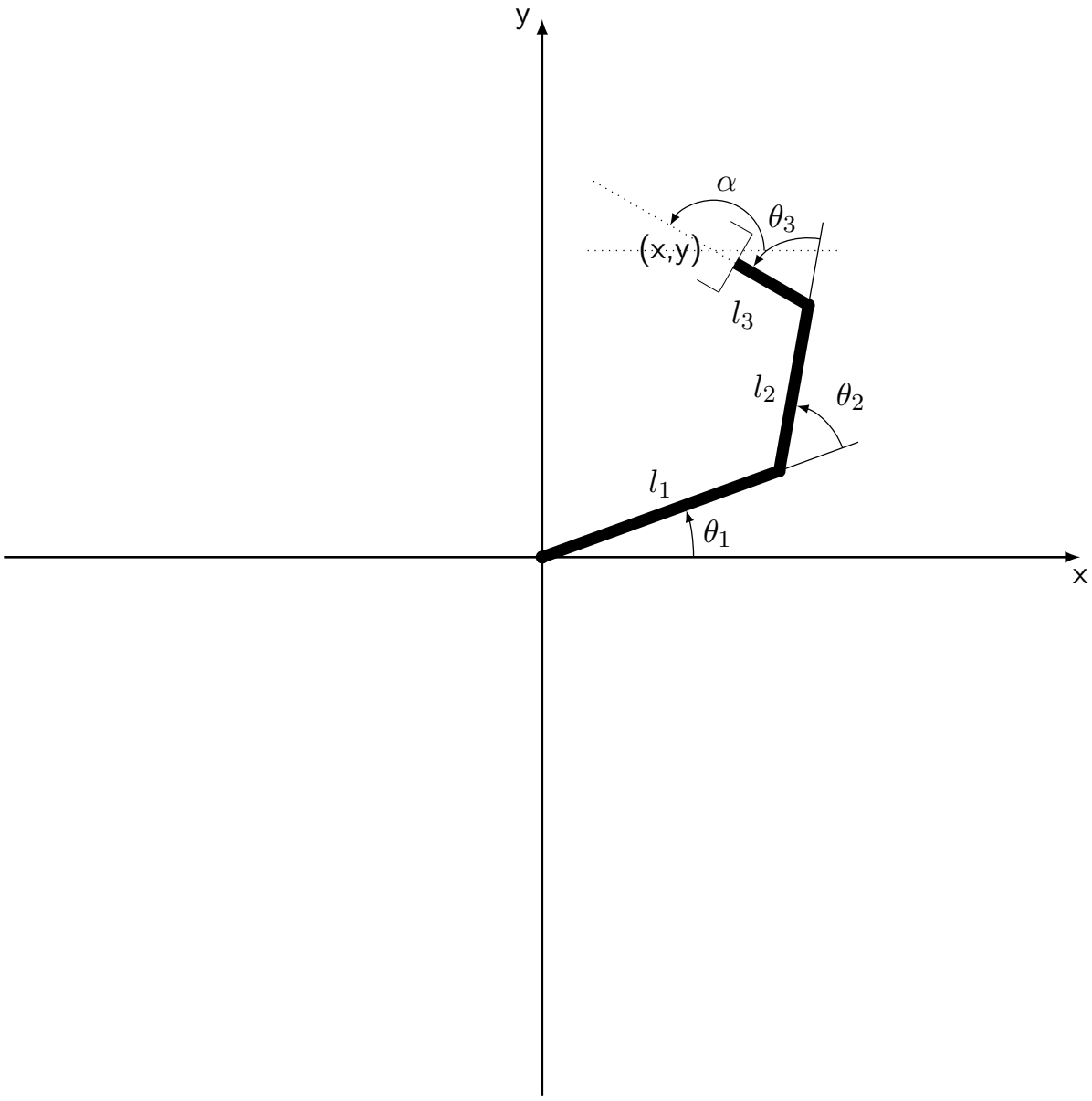

Figure 2: 3-joint planar manipulator.

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

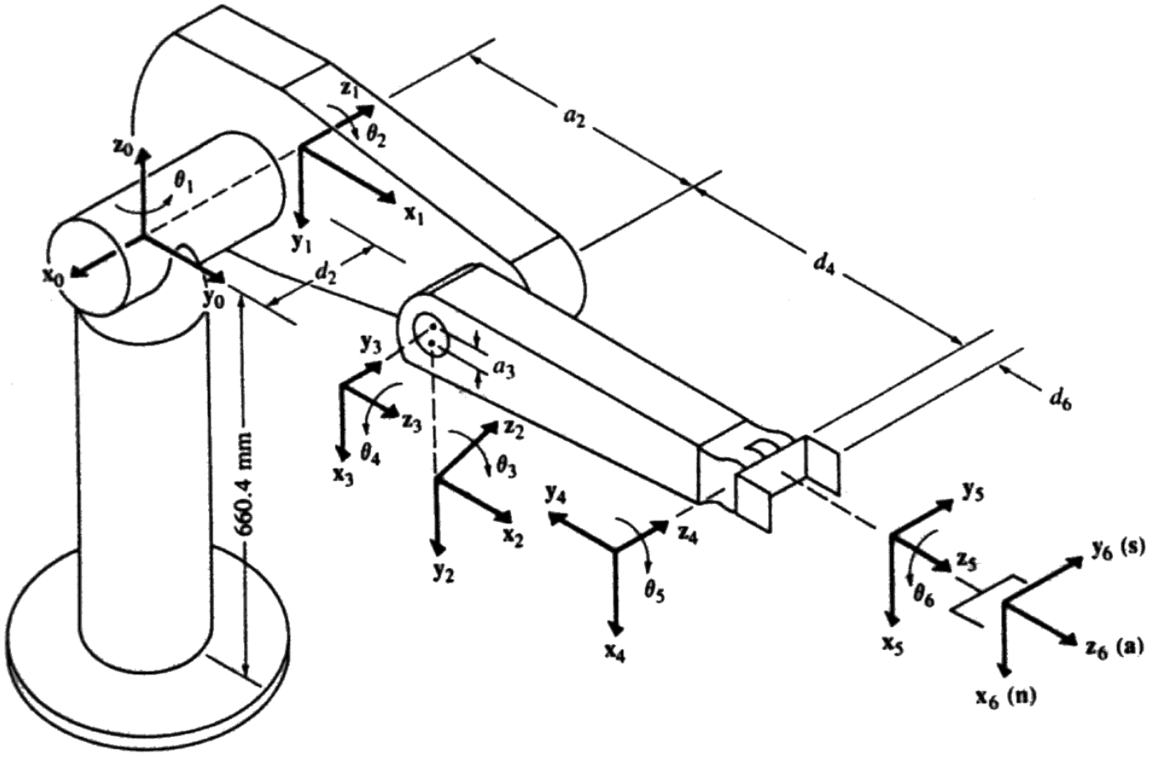

Figure 3: PUMA560 manipulator.

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.

Task 4.4 (5 points) Homogenous transformation: Derive the homogenous transformation $Rot_{\mathbf{k},\theta}$ (slide 165), which describes a rotation of θ around an arbitrary vector $\mathbf{k}$ ($\mathbf{k} = k_x \overrightarrow{i} + k_y \overrightarrow{j} + k_z \overrightarrow{k}$).