

Übungen zum Praktikum Control of Robot Manipulators

Inverse kinematics

Homework

1. In the lecture we computed the analytical inverse kinematic solution for some simple manipulators. Compute the inverse kinematic solution for a cylindrical manipulator. Remember that the joint state of a cylindrical manipulator is $Cyl(t_a, r_a, t_n) = \langle l_1, \alpha_2, l_3 \rangle$, and the forward kinematic

solution is
$$\begin{bmatrix} C\alpha_2 & -S\alpha_2 & 0 & l_3 C\alpha_2 \\ S\alpha_2 & C\alpha_2 & 0 & l_3 S\alpha_2 \\ 0 & 0 & 1 & l_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

2. Write a program that uses Roboop to compute the inverse kinematic solutions to the following queries. Note that the 6 values are given in the usual Roboop-order $\langle X, Y, Z, Roll, Pitch, Yaw \rangle$ and so the workspace poses are the same as in task 3 on exercise slide 6.

Hint: if queries do not converge but you think that your program is correct, have a look at task 3. Workspace poses:

- (a) $\langle -0.19, -0.47, 0.09, -2.31, -0.62, -2.03 \rangle$
- (b) $\langle 0.60, -0.00, 0.05, -2.67, -0.71, -0.31 \rangle$
- (c) $\langle 0.31, 0.41, -0.19, 3.14, -0.27, 0.9 \rangle$
- (d) $\langle 0.22, 0.21, 0.59, 0.79, -0.15, 2.71 \rangle$
- (e) $\langle 0.33, -0.24, -0.25, 2.88, 0.15, 1.59 \rangle$

3. Perhaps you noticed in task 2, that Roboop does not always converge even if there is a solution to an IK query. We presented some ideas that can be used to improve this problem.

- (a) Extend your program so that it loops over an IK query and sets a random initial pose before each call to *inv.kin*. Roboop should find IK solutions to all of the 5 IK queries from task 2, even if the first pose does not converge.
- (b) Moreover your program should reject solutions where a joint angle is not within its minimum and maximum angle. The minimum and maximum angles of all joints can be taken from the following table.

Joint maxima for left and right arm		
	θ_{min}	θ_{max}
0T_1	-270°	270°
1T_2	-270°	270°
2T_3	-135°	135°
3T_4	-270°	270°
4T_5	-120°	120°
5T_6	-270°	270°