INF3480/INF4380 - Assignment 2

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Due: Thursday, Mars 22nd 2018 - 12:00 (24h)

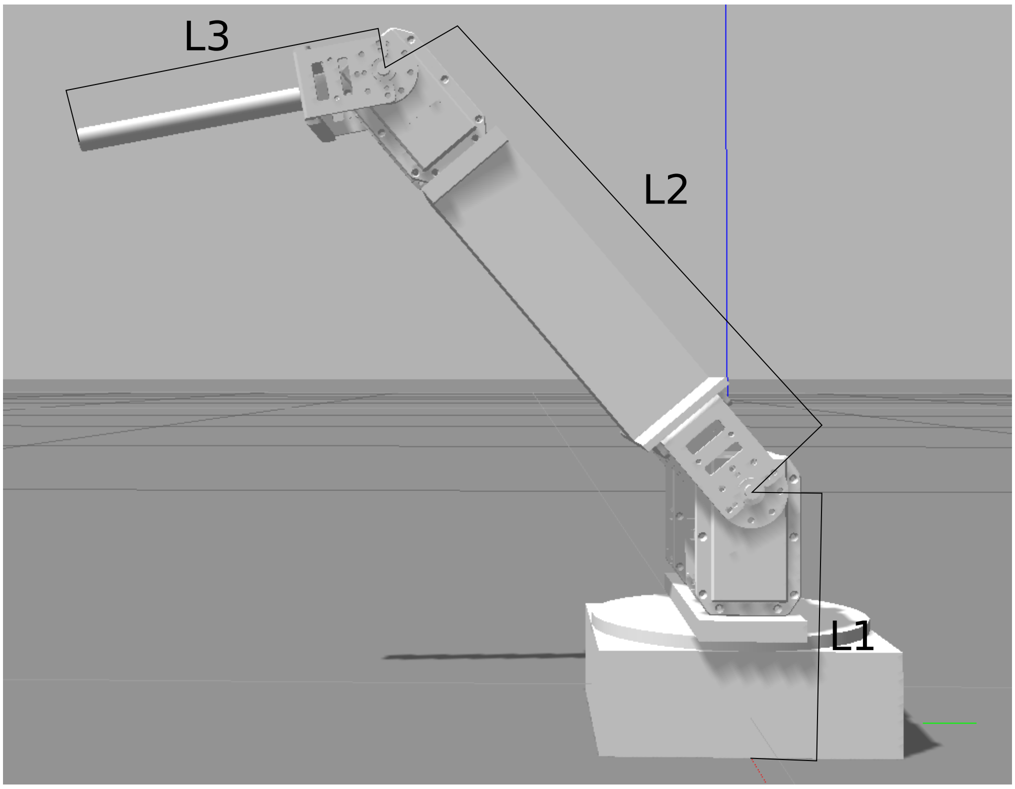

Figure 1: Simplified robot model in gazebo

Introduction

In this exercise we will keep working with the simplified CrustCrawler robot. The robot is displayed in figure 1. In this assignment you are free to choose your preferred programming language. Python will be a mandatory language in the next assignment. Dimensions; L1 = 100.9, L2 = 222,1, L3 = 136.2 in mm.

Task 1 - Forward and inverse kinematics

Implement the forward and inverse kinematics as functions.

a) The forward kinematics function takes 3 joint angles as input, and gives the corresponding cartesian coordinates for the tip of the arm as output:

function cart_cord = forward(joint_angles)

where both *cart_cord* and *joint_angles* are vectors of size 3.

b) The inverse kinematics function takes the cartesian position of the tip of the pen as input, and gives the corresponding joint configuration(s) as output:

function joint_angles = inverse(cart_cord)

where both *cart_cord* and *joint_angles* are vectors of size 3.

c) Use the functions to show how you can verify that the inverse and forward kinematics are correctly derived. Hint: Use a function like round() in MATLAB and at least 4 decimals accuracy.

d) The TCP (Tool Center Point) is located at [x,y,z]=[0;-323.9033;176.6988] in the Base coordinate frame. Calculate the four sets of solutions of the joint variables according to your DH setup.

Task 2 - Jacobian I

Use the same coordinate assignments as you did when you followed the DH convention.

a) Derive the Jacobian matrix for the simplified CrustCrawler robot.

b) What do we call configurations for which rank J(q) is less than the maximum value?

c) Use the Jacobian matrix to find the singular configurations for the robot.

d) Give an evaluation of these results, and draw at least one of these singular configurations. The drawing(s) shall have a simple 3D layout like the ones in the lecture slides, see referred standard below.

e) A natural extension of the simplified robot would be a spherical wrist on the end. How can a spherical wrist alone (only picturing the wrist) be in singularity? Draw and explain. The drawing shall be a simple 3D illustration.
Use the standard for symbolic representation of 3D robot joints, found in Chapter 1.1.1 in the course book. You can se an example of a correct 3D representation of robot joints on page 85 (and 75) in the course book, figure 3.7.

f) What is the practical consequenses of not handeling singularities?

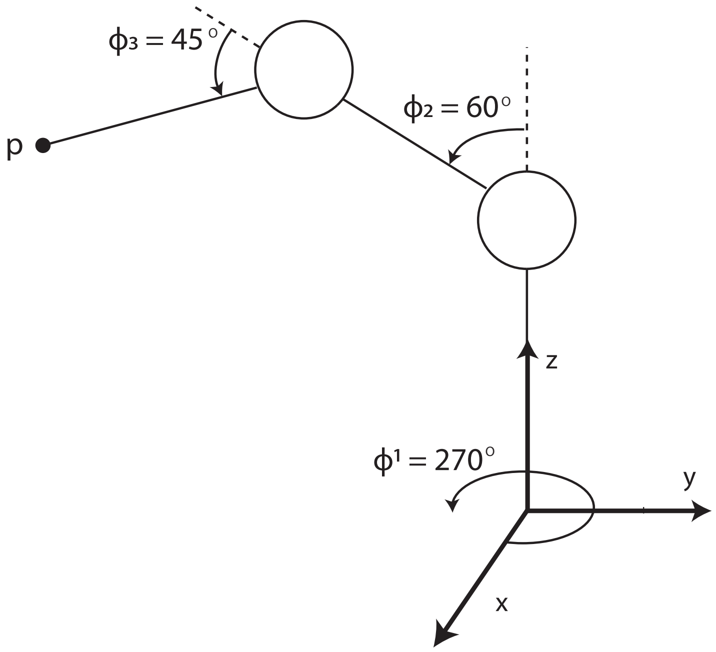

Figure 2: Robot configuration

Task 3 - Jacobian II

Use the same coordinate assignments as you did when you followed the DH convention.

a) Implement the Jacobian matrix as a function. It takes the instant joint angles and joint velocities as input, and gives a 3-dimensional vector of cartesian velocities of the tip of the pen as output.
The function shall look like this:

function cart_velocities = jacobian(joint_angles, joint_velocities)

where both *joint_angles*, *joint_velocities* and *cart_velocities* are vectors of size 3.

b) Point p is located at the end-effector of the robot (the tip of the last arm). We adjust the robot as displayed in figure 2, where $\phi_1 = 270°$, $\phi_2 = 60°$ and $\phi_3 = 45°$ (these angles are not to be used directly, you have to figure out the correct θ-angles corresponding to your placement of the joint coordinate frames, referred to when you derived your DH-parameters).

Given the configuration in figure 2 and the joint speed vector $\dot{q} = [\dot{\theta}_1, \dot{\theta}_2, \dot{\theta}_3]$, where $\dot{\theta}_1 = 0.1 rad/s$, $\dot{\theta}_2 = \dot{\theta}_3 = 0.05\ rad/s$, use your function to calculate the cartesian velocity of point "p" relative to the base coordinate frame.

Requirements:
Each student must hand in their own assignment, and you are required to have read the following declaration to student submissions at the department of informatics: http://www.ifi.uio.no/studinf/skjemaer/declaration.pdf

IMPORTANT: Name the pdf file: "inf3480-oblig1-*your_username.pdf*". All deadline and devilry3 questions are to be directed to Nikolai (email below).

Submit your assignment at https://devilry3.ifi.uio.no.
Your submission must include:

- A pdf-document with answers to the questions.
- The two illustrations asked for in question 2a and 2b
- **A README.txt containing a short reflection on the assignment**; what was dificult, what was easy, was there anything you could have done better?

If you have used MATLAB or other tools for computing an answer, your solution and approach must be illustrated and explained thoroughly in the pdf file.
The files containing the code must also be named and delivered.

Deadline: Thursday, Mars 22nd 2018 - 12:00 (24h)

You can use the slack channel *assignment 1* for general questions about the assignment, and the channels *forward kinematics* and *inverse kinematics* for discussion. Do not hesitate to contact us if you have any further questions.

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