INF3480/INF4380 - Assignment 3(a)

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Due: 12. April 2018, 12:00 (24h)

Introduction

In this last assignment we will look more closely at control of a robot. We will continue to work with the CrustCrawler and by the end of this assignment you will get to test your controller on the real robot. The first part of the assignment will start with modelling the robot arm to describe the dynamic equations. In the second part of the assignment (handed out in one week) we will move on to test control theory (PID) in practice and move on generate the robot trajectory. In the end, you will test your work on the real CrustCrawler!

Important: please note that this is just the first part of the assignment! The second part, requiring significantly more work, will be handed out one week later.

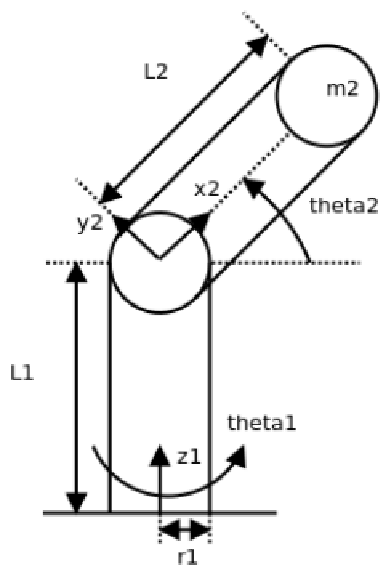

Figure 1: Joint 1 and 2 of the CrustCrawler.

Task 1

In this exercise we will further develop the model for the CrustCrawler. We will use the ***Euler Lagrange Equations*** to derive the dynamic equations. This method derives the ***Lagrangian*** $\mathcal{L}$ with respect to each joint variable.

$\mathcal{L} = \mathcal{K} - \mathcal{P}$, and the general formula for potential and kinetic energy can be written as

$$P = mgh \tag{1}$$

where m is the mass, g is the gravitational constant and h is the height above the defined zero plane. In our robot, the base is the zero plane.

$$K = \frac{1}{2}m\boldsymbol{v}^T\boldsymbol{v} + \frac{1}{2}\boldsymbol{\omega}^T\mathbf{I}\boldsymbol{\omega} \tag{2}$$

where the velocity vector $\boldsymbol{v}$ is a three dimensional vector and can be expressed in any reference frame. The inner product of the velocities produce a scalar value. In this task the velocities must be relative to the base frame. The kinetic energy for rotations is given in the last term, where $\mathbf{I}$ is the inertia tensor and $\boldsymbol{\omega}$ is the angular speed.

We will model joint 1 as a cylinder with radius r_1, height L_1 and an evenly distributed mass of m_1, see figure 1. Rotating the cylinder around z_1 gives a moment of inertia of

$$I_{1,zz} = \frac{m_1 r_1^2}{2} \tag{3}$$

The rest of the inertia tensor $\mathbf{I}_1$ is zero. For simplification, we set the inertia tensor $\mathbf{I}_2$ to zero

a) Derive the ***Lagrangian*** for the two link CrustCrawler. You can find the Jacobian in equation 4 for calculating velocities.

b) Derive the dynamic model for the two link CrustCrawler. Your answer should be two equations.

We will now expand the model to include three joints, see figure 2. We simplify by setting the inertia tensor $\mathbf{I}_3$ to zero.

$$\mathbf{J} = \begin{bmatrix} -s_1(L_2c_2 + L_3c_{23}) & -c_1(L_2s_2 + L_3s_{23}) & -c_1(L_3s_{23}) \\ c_1(L_2c_2 + L_3c_{23}) & -s_1(L_2s_2 + L_3s_{23}) & -s_1(L_3s_{23}) \\ 0 & (L_2c_2 + L_3c_{23}) & L_3c_{23} \\ 0 & s_1 & s_1 \\ 0 & -c_1 & -c_1 \\ 1 & 0 & 0 \end{bmatrix} \tag{4}$$

c) Derive the ***Lagrangian*** for the three link CrustCrawler.

d) Derive the dynamic model for the three link CrustCrawler. Did your dynamic equations for joint 1 and 2 match those from task b)?

e) Write the dynamic equations from d) in the following form

$$D(q)\ddot{q} + C(q, \dot{q})\dot{q} + G(q) = \tau$$

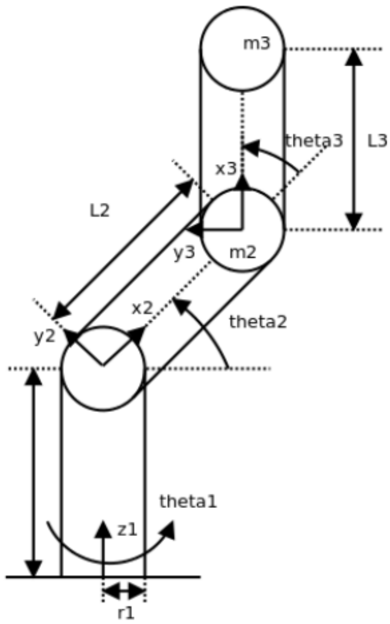

Figure 2: The simplified CrustCrawler robot showing joint 1, 2 and 3.

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-oblig3-*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.
- A README.txt containing a short reflection on the assignment; what was difficult, what was easy, was there anything you could have done better?

If you have used MATLAB, Sympy 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: 12. April 2018, 12:00 (24h)

You can use the slack channel *assignment 3* for general questions about the assignment, and the channel *dynamics* for discussion. Do not hesitate to contact us if you have any further questions.

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