Robot Dynamics & Control – A.A. 2021/2022

Assignment 3: Dynamic Robot Control

This assignment is focused on the Dynamic Control of a manipulator. You are provided with a simple simulation model of a **UR5 robot** which you can control providing torque commands to the joints. You can read joint position, velocity and acceleration. The model in the provided configuration is a zero-torque demo and you should se the robot fall down due to gravity. (If this doesn't happen let me know).

Apart from Matlab and Simulink you will need the following packages (from the Matlab Add-On browser):

- Robotic Systems Toolbox
- Simscape Multibody
- Robot Library Data Support Package

Hint: in the exercise you will have to use multiple blocks to retrieve proper information, they are all from the toolbox so read the documentation carefully.

Hint 2: the mesh visualization is useful to understand what's going on, but is not an evaluation metric, please provide plots in the report (control errors, q, dq, ddq and torques)

Evaluation rules

You have to send me via email a '.zip' file named as **'SurnameName_Assignment_3.zip'** which contains:

- A **'.pdf'** report (**'SurnameName_Assignment_3_report.pdf'**) with the motivated answers for each exercise and eventually drawings/diagrams to better motivate the solution. (**Note:** Any answer provided without a full motivation will not be considered for evaluation. All the steps towards the solution must be justified.).
- The Matlab/Simulink files with the numerical implementations of the exercises. If you define helper functions or blocks in other files which also have to be included.

The assignment is individual, so each student must deliver his/her .zip archive.

Exercise 1 – Gravity Compensation

Provide torque commands to the robot such that is doesn't fall due to gravity but holds the initial configuration.

Exercise 2 – Linear Joint Control

Given a desired joint configuration q* = q0 + Δq where q0 is the initial joint configuration and Δq = [pi/4, -pi/6, pi/4, pi/3, -pi/2, pi], provide torque commands in order to reach q*.

What happens if you don't compensate gravity? Make a comparative analysis.

Exercise 3 – Linear Cartesian Control

[0 0 0 0 0 0] ???

Given a desired cartesian configuration x* = x0 + Δx where x0 is the initial cartesian pose of the end effector ('ee_link') and Δx = [0.2, -0.08, -0.15, pi/4, -pi/4, pi/2], provide torque commands in order to reach x*.

Exercise 4 – Computed Torque Control

In industrial robot control systems even a simple regulation from a setpoint to another (like in Ex.2 and Ex.3) is done via joint trajectory tracking. Consider again q* from Ex.2 and generate joint-space trajectories in order to reach it from q0. (There are blocks which do it for you, check
Joint Space Motion Model
the docs)

A) Use feedback linearization to implement a computed torque control in order to track the desired joint trajectories. Velocity Product Torque
Joint Space Mass Matrix
B) Open the robot model and check the joint objects: at the label 'Internal Mechanics' you will notice that a damping coefficient is provide to simulate joint friction. Try to remove it from each joint and compare the performance of the computed torque controller.