Robotic Manipulation Course

Exercise 6

March 25, 2020

1 Assignment

The goal of the assignment is to implement a hybrid (position/force) controller of the following form:

$$\tau_{\text{ext}} = J^{\top}\left(k_p P \boldsymbol{x}_e(t) + (I - P)\boldsymbol{f}_d\right), \tag{1}$$

where τ_{ext} are external torques which are added to torques compensating gravity, J is a Jacobian matrix, P is a choice matrix, I is an identity matrix. Additionally, $\boldsymbol{x}_e(t)$ represents position error at time t and

$$\boldsymbol{f}_d = \begin{pmatrix} 10 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}^{\top} \tag{2}$$

represents desired forces/moments. The value of k_p is fixed to 50.0. Your goal is to implement equation (1) in the *update* function of the controller stored in *exercise6/src/Exercise6Controller.cpp*. You need to select the appropriate values of choice matrix P and position error $\boldsymbol{x}_e(t)$ s.t. the gripper will apply constant force in x-axis of robot base frame. Simultaneously, the robot will follow the trajectory shown in Fig. 1.

To test the controller, compile the workspace and use the following command to launch the simulation with two robots

```
roslaunch exercise6 sim.launch
```

Then run the following script to run the controller:

```
rosrun exercise6 run
```

The code collects the position and force profile of the end effector and puts the data into the files in your home folder */exercise6_robot1.csv* and */exercise6_robot2.csv* in format:

```
time, position_x, position_y, position_z, force_x, force_y, force_z, moment_x, moment_y, moment_z
```

Plot the collected data to see if your controller works correctly.

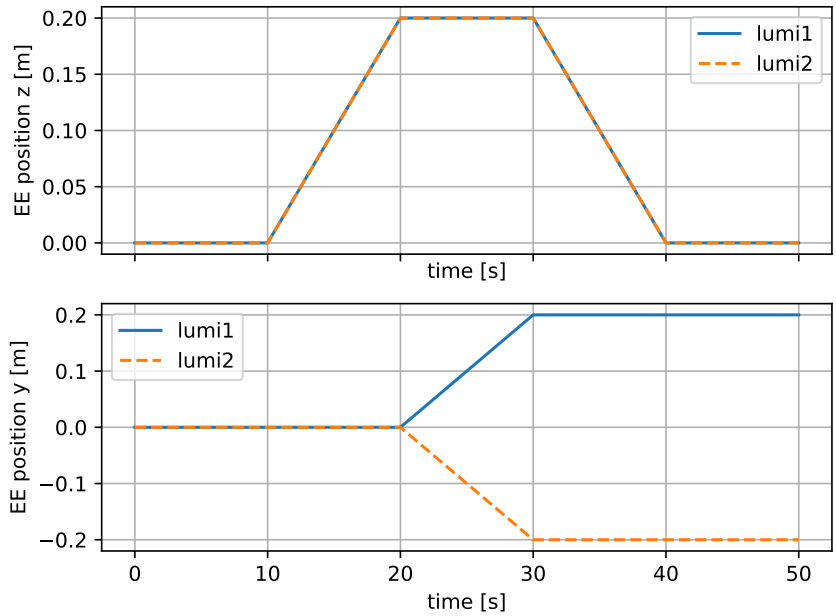

Figure 1: The trajectory of end effector for both robots measured relatively to the starting position.

2 Report

In addition to code, you are supposed to write a technical report (pdf) in which you will document the steps performed to fulfill the assignment. Your report should contains:

- your name, student number, date, exercise number and course name
- your choice of matrix P
- mathematical equations used to compute position error
- plots of the desired and applied force
- plots of the desired and followed paths
- discussion of the results and answers to the following questions:
  - Is the contact force equal to the desired force?
  - Does the followed trajectory correspond to the desired one?
  - Are all cartesian degrees of freedom followed equally accurately? If not, explain why.
- Estimate of time spent on this exercise.

3 Submission

To submit your code and report, fork a repository named *robotic_manipulation_2020/exercise6* to your gitlab. Modify the code in forked repository. Be sure to push your code before the assignment deadline. The commits

pushed after the deadline will be ignored.

4 Deadline

Deadline for this assignment is 5th of April at 23:59.