Aalto University
School of Electrical
Engineering

ELEC-E8126

ROBOTIC MANIPULATION

Report: Exercise -6

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April 2, 2020

1 your choice of matrix P:

$$P = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

The reason is that we are controlling the power in x-direction. So the $P(1,1) = 0$ and remaining all diagonal elements are 1.

2 mathematical equations used to compute position error:

Computation of desired position in z-direction:
Robot1 and Robot 2:

$$z(t) = \begin{cases} 0.0 & 0 < t < 10 \\ (t - 10.0) * 0.02) & 10 < t < 20 \\ 0.2 & 20 < t < 30 \\ ((40.0 - t) * 0.02) & 30 < t < 40 \\ 0.0 & t > 40 \end{cases}$$

Computation of desired position in y-direction:
Robot1 :

$$y(t) = \begin{cases} 0.0 & 0 < t < 20 \\ ((t - 20.0) * 0.02) & 20 < t < 30 \\ 0.2 & t > 30 \end{cases}$$

Robot2 :

$$y(t) = \begin{cases} 0.0 & 0 < t < 20 \\ ((t - 20.0) * (-0.02)) & 20 < t < 30 \\ -0.2 & t > 30 \end{cases}$$

The above is relative position from the start position, so to get absolute desired position, we use $desired\_position(t) = translation(0, y(t), z(t)) * starting\_position$ and finally

$$error(t) = desired\_pose.linear() * (desired\_pose.inverse() * current\_pose).translation();$$

3 plots of the desired and applied force:

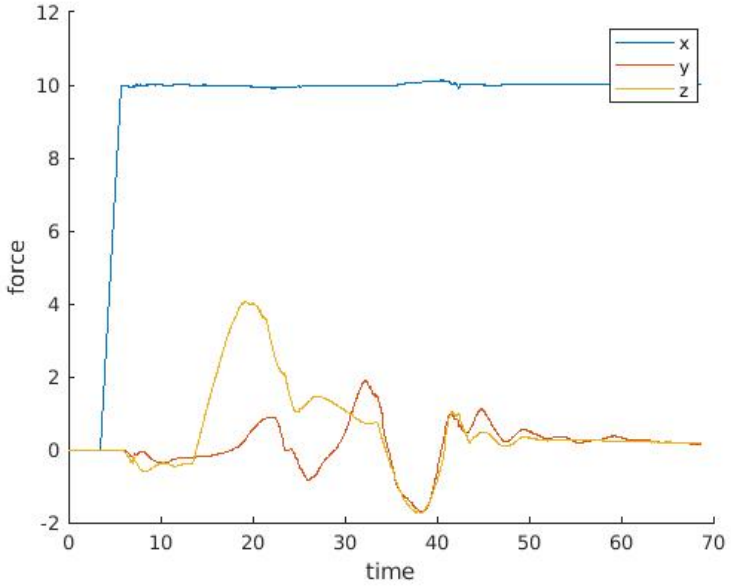

Figure 1: Applied force for Robot1

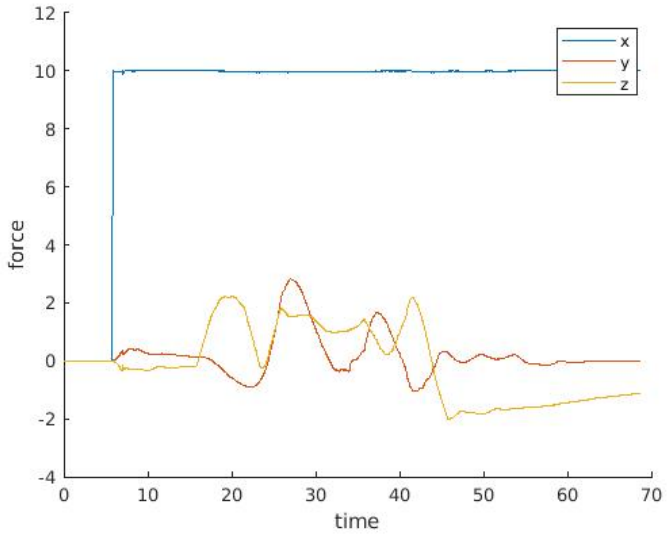

Figure 2: Applied force for Robot2

4 plots of the desired and followed paths:

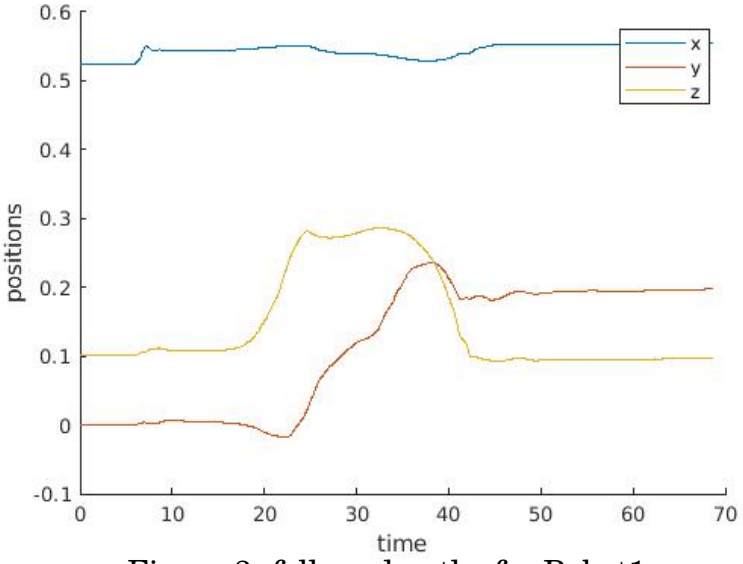

Figure 3: followed paths for Robot1

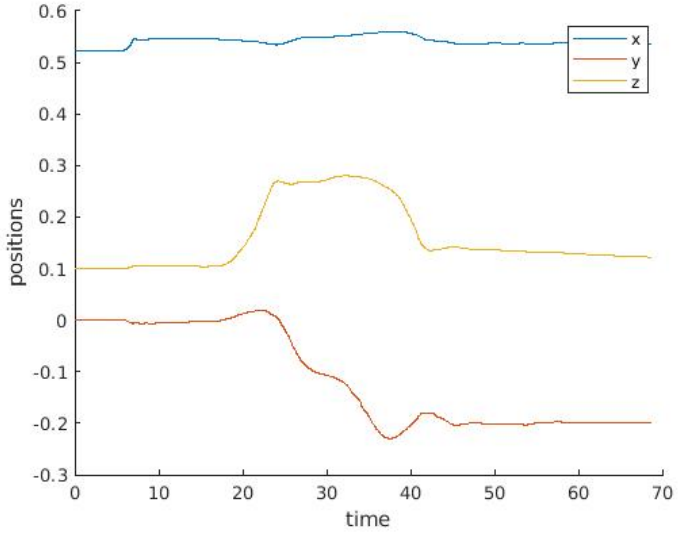

Figure 4: followed paths for Robot2

5 discussion of the results and answers to the following questions:

5.1 Is the contact force equal to the desired force?

I feel yes. the contact force in x-direction was same as in desired force. Although, due to change in position in y and z direction, we can see some force along those directions.

5.2 Does the followed trajectory correspond to the desired one?

The followed trajectory is very close to desired trajectory. But since we are using only P controller, the error shoots up and then it settles. I feel if we have a PI controller it will even more smoother. We can see some sharp peaks before the value settles in a particular state.

5.3 Are all Cartesian degrees of freedom followed equally accurately? If not, explain why.

They aren't followed equally, because we are controlling force in x-direction and controlling position in y and z direction.

No, they are not followed accurately, as we can see, we didn't apply force in y and z direction, yet we see some force in that direction. The reason being we give a certain change in position in those directions and to execute those positional errors, there is a minimal force required to be applied.

Also , as I mentioned earlier, the controller doesn't follow the exact desired path as we had mentioned in the program. Since we use a P-controller, its difficult to expect the exact result.

6 Estimate of time spent on this exercise:

Spent around 6 hours in this exercise. Should have spent less, Got stuck in a very simple bug and took some time and help to solve it.