Tutorial 3

Exercise 1

The task was to validate the derived differential kinematics for the given robot. Figure 1 shows the linear endeffector velocities, computed by numeric derivation of the forwards kinematics, and by the differential kinematics equations:

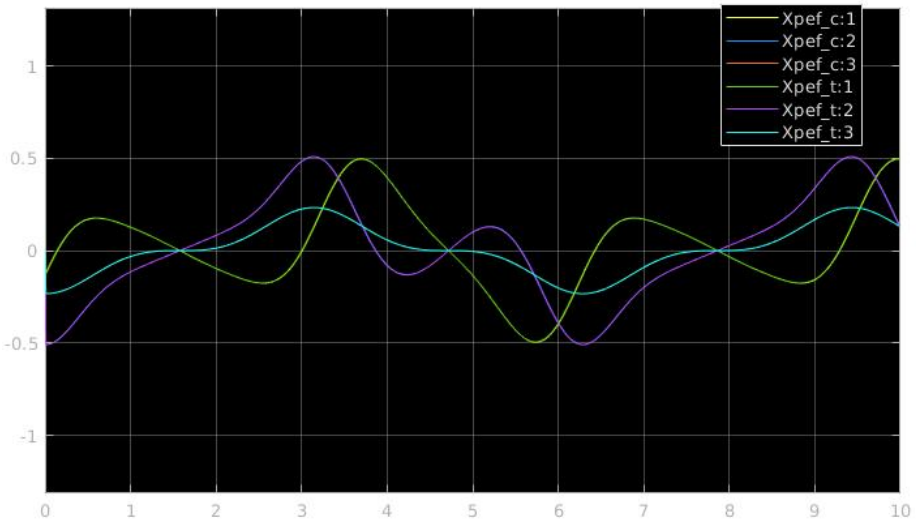


Figure 1: “Figure 1”

Figure 2 show the same validation for the Center of Mass 2:

Validating the angular velocities is not trivial since the euler angles are computed by the function `atan2(x)`. This function is not continuous. Aditionally the euler angles have edge cases where the computation changes. Thus to validate the angular velocities

Exercise 2

Tutorial 4

Build the catkin workspace and launch die launchfile in the msdof_bringup folder. Run the simulink model to see the simulation results.

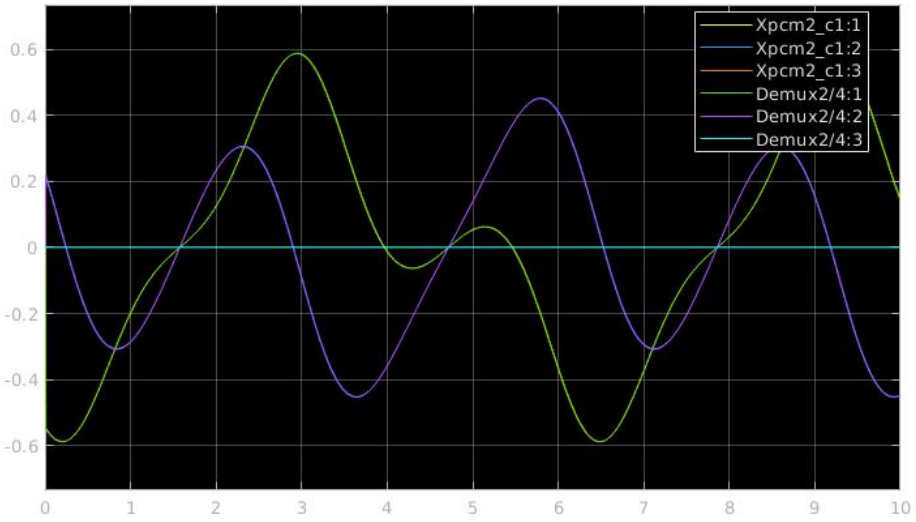


Figure 2: “Figure 2”

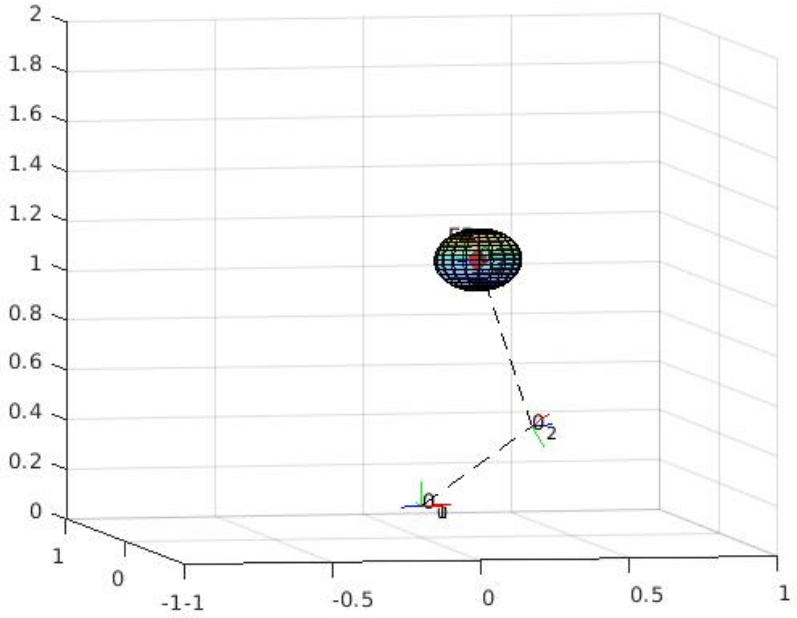


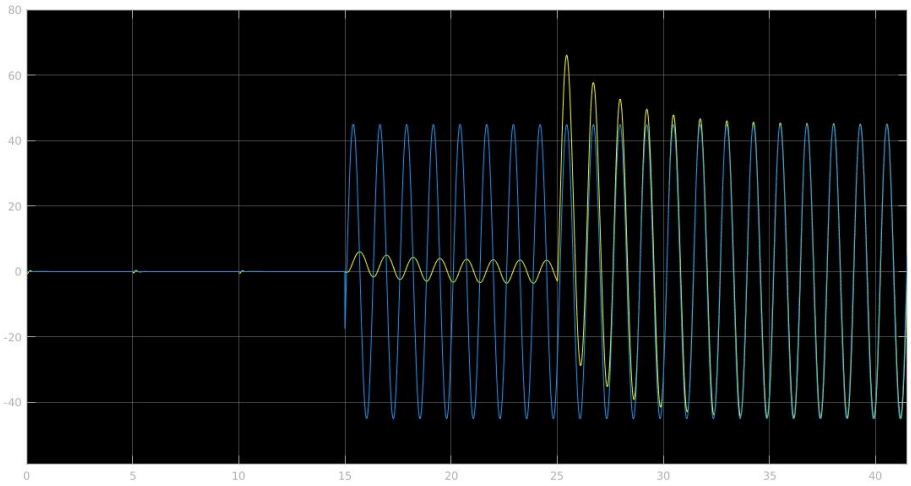
Figure 3: “Figure 3”

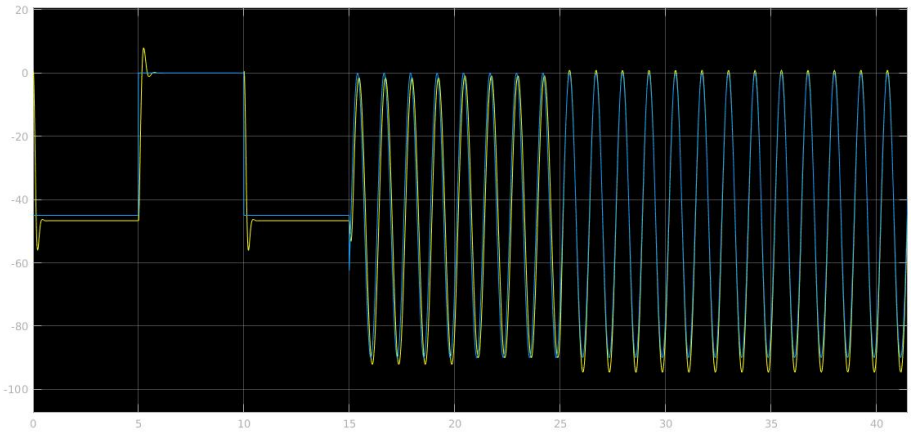
Tutorial 5

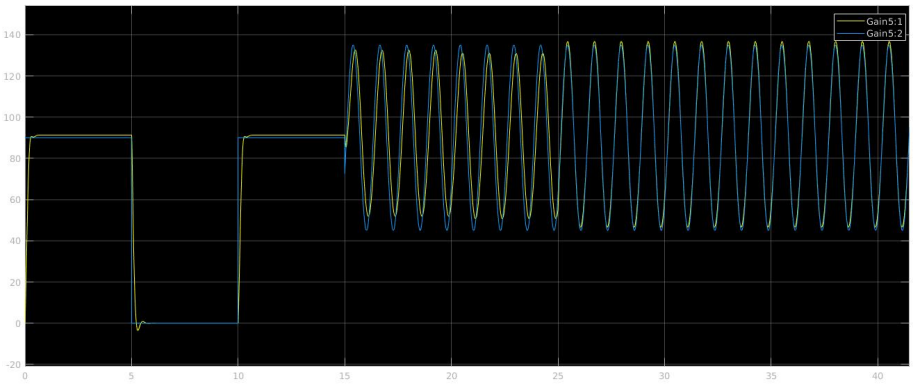
Run Simulation as in 4

Tutorial 6

Following are the figures of a sequence of control tasks. The first three intervals show regalution with a PD, PD+G and PID Contorller.







This type of controllers are quite hard to tune for such a complex robot as the UR10. And even after exstensive tuning the performance is not very good. The PID Controller does a good Job but it can be tricky to take care of the Intagral part, when the Position Error gets very big (Windup problem).

Tutorial 7

This Controller is very powerfull and much easier to tune then the previous ones. To take care of the windup problem extra measures had to been taken. The Results are quite nice though.

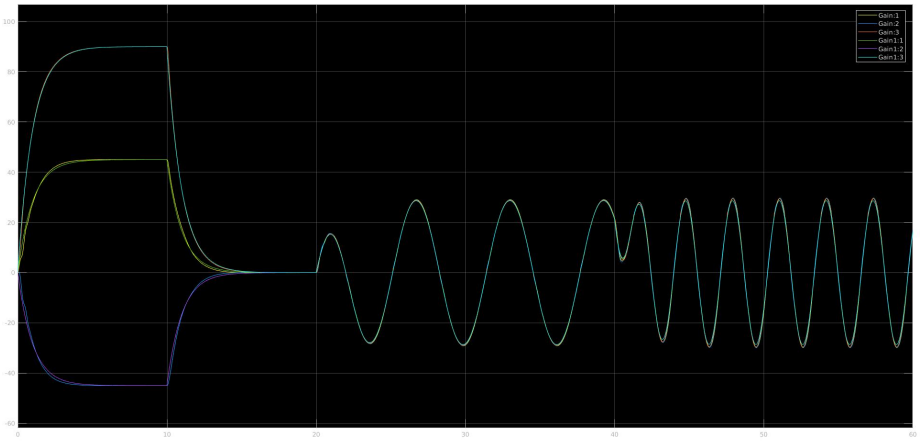


Figure 4: “Figure 3”

For the operational space controller see the matlab code.