Master's degree in Computer Engineering for Robotics and Smart Industry

Physical Human-Robot Interaction

Report on the assignments given during the 2022/2023 a.y.

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1 Assignment 1

1.1 Implement the single-input single-output four-channel bilateral teleoperation architecture

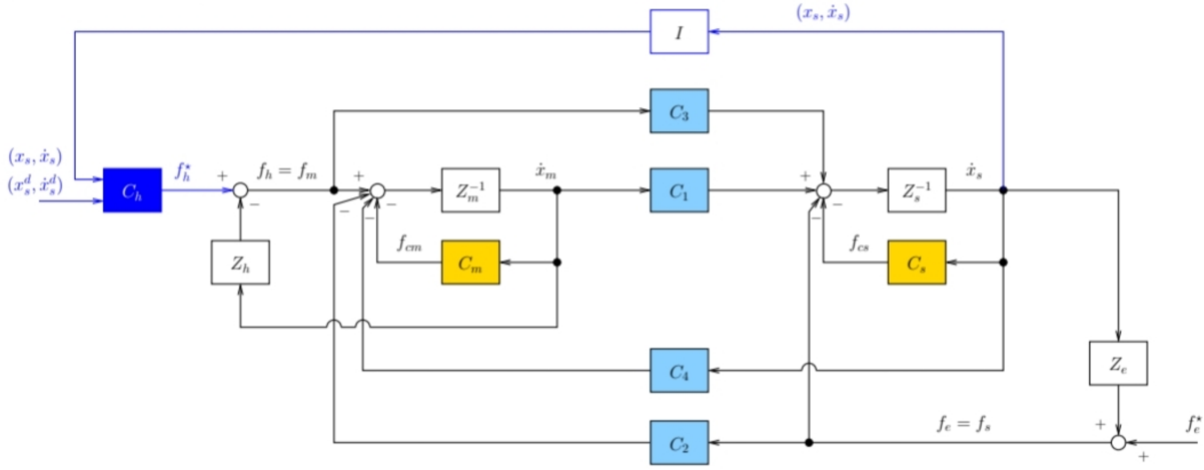

Figure 1: SISO 4ch bilateral teleoperation architecture

The inner controllers for the robots are defined as follows:

$$C_m = B_m + \frac{K_m}{s} \qquad C_s = B_s + \frac{K_s}{s}$$

To achieve perfect transparency, the coordination controllers must satisfy the following conditions:

$$\begin{cases} C_1 &= Z_s + C_s \\ C_2 &= I \\ C_3 &= I \\ C_4 &= -(Z_m + C_m) \end{cases} \qquad \text{with } Z_m = M_m s + D_m,\ Z_s = M_s s + D_s$$

with $M_m = 0.5, M_s = 2, D_m = D_s = 0$.

The human is modelled with inertia $J_h = 1$, damping $B_h = 1$ and stiffness $K_h = 0$. The human intention is modelled with a PD controller with $P_h = 10$ and $D_h = 16$.

The environment is modelled as a spring with inertia $B_e = 100$ and stiffness $K_e = 200$.

2 Assignment 2

2.1 Implement the three two-channel bilateral teleoperation architectures and the three-channel bilateral teleoperation architecture

2.2 What happens if transportation delays are added in series to the coordinating controllers?

3 Assignment 3

3.1 Implement the Kalman filter/predictor and estimate the velocity and acceleration from noisy position measurements

3.2 Implement the steady-state Kalman filter/predictor and estimate the velocity and acceleration from noisy position measurements

4 Assignment 4

4.1 Implement the Kalman smoother and estimate the velocity and acceleration from noisy position measurements

5 Assignment 5

5.1 Identify the parameters J and D using the LS and the RLS on the DC motors data

6 Assignment 6

6.1 Implement the Scattering-based bilateral teleoperation architecture for the F-P and P-P cases

6.2 Compare positions, velocities, forces, commands in free motion and in contact

6.3 Create another simulink model and (a) add the measurement noise to the position/force signals, and (b) estimate velocities from positions

7 Assignment 7

7.1 Implement the Tank-based bilateral teleoperation architecture for the F-P and P-P cases

7.2 Compare positions, velocities, forces, commands in free motion and in contact

7.3 Create another simulink model and (a) add the measurement noise to the position/force signals, and (b) estimate velocities from positions