Lecture 9.2 Exercises

1. The file exercise1.m contains code to run a simple feedback controller. The output of the system, y, is initialized to 1.0 and adjusted according to gain, K, for simlen=10 time steps by the difference between its current value and the target value, target=0. The output,y, is then plotted over all time steps.
    a. Implement varying delay levels and plot the output of the system for delay values 0, 1, 2, and 3. How does the feedback controller perform in the presence of delay?

    b. Vary the gain of the feedback controller. Does this help deal with feedback delay? What happens to the speed of convergence?

2. The file exercise2.m simulates control of a two-joint arm using a feedback controller model. The arm reaches to 4 targets. On each time step, the desired wrist position is computed using a min-jerk planner (minjerk.m), and is converted into a set of target joint angles (invkinematics.m). PD controllers are used to compute the desired torque for these joint angles (pdcontroller.m) and these are passed on to the plant (plant.m) to control the arm and the forward kinematics model (fkinematics.m) to compute the resulting wrist position. The trajectory of the wrist is shown during the simulation and afterwards, the angle, velocity, acceleration, and jerk of the shoulder and elbow joints is plotted.
    a. Add noise to the output of the PD controller, varying the coefficient of variation of the noise. What happens to the reaches?

    b. Add delay to the inputs that the PD controller receives. How does this affect reach performance?

    c. Adjust the gain and damping parameters of the PD controllers (kp, and kd). Can the system cope with delays with suitable parameter values?

3. The file exercise3.m simulates control of a single joint arm using a combination of feedback and feedforward control. On each time step, a forward model of the arm is used to estimate the angle, velocity, and acceleration of joint. This is used to compute a forward model torque which is combined with a feedback-based torque which is computed using a delayed copy of the actual joint angle. During the movement, a perturbation is applied to the joint. The actual, delayed, and target trajectory of the joint angle, as well as the perturbation and the total torque applied is plotted over the time steps of the simulation.
    a. Turn off the forward model by setting *Kp_forward* and *Kd_forward* to 0.0, turn off the perturbation by setting *pert_amp* to 0.0, and vary the delay by changing the value of *delay* in increments from 0.0 to 0.125. What happens when only feedback control is used as the sensory delay increases?

b. With the forward model turned off and the delay set to 0.0, turn the perturbation back on by setting *pert_amp* to 1. How does the feedback model perform when faced with perturbation?

c. Turn the forward model back on and turn off the feedback model by setting *Kp_feedback* and *Kd_feedback* to 0.0. Turn the perturbation off and set *delay* to 0.125. Is the forward model affected by delay?

d. With the feedback model turned off, set the delay to 0.0 and turn the perturbation back on by setting *pert_amp* to 1. How does the forward model alone deal with perturbation?