Control of Autonomous Systems – Autumn 2025

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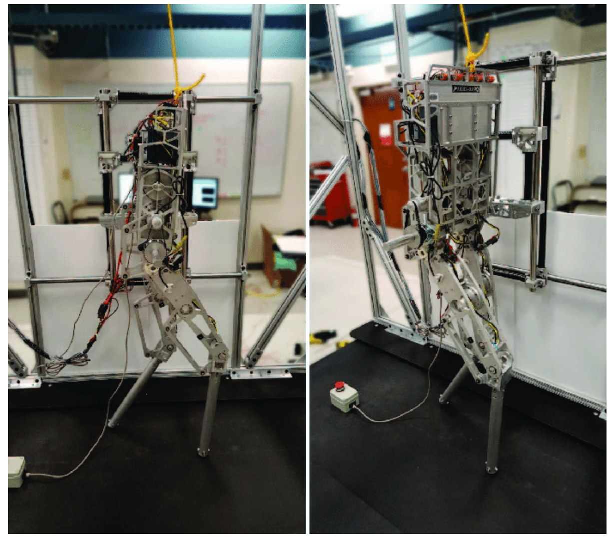
Exercise Session 8



1. **Model-based output-feedback azimuth control of a satellite antenna**. Consider the simplified model of the azimuth positioning system of a satellite antenna represented by the set of differential equations

$$\begin{cases} \dot{\theta} = \omega \\ \dot{\omega} = -a_m \omega + K_l K_g V \end{cases} \tag{1}$$

where $\theta(t)$ represents the azimuth angle of the antenna, $\omega(t)$ is the corresponding angular velocity, while the control input $V(t)$ is the voltage applied to the motor moving the antenna. The constant parameter values are $a_m = 1.71$, $K_l = 100$ and $K_g = 0.1$. We are measuring the azimuth angle with an encoder.

1.1. In a new Simulink file, create a subsystem where you implement system (1) (once again, set the sampling time for the solver of your simulation to $T_s = 0.01s$).

1.2. After checking whether your system is stable, design and implement a state-feedback controller, assuming for now that you measure the whole state.

1.3. Tune your controller such that the output of the system has a nice transient. Include a feedforward gain so that the output reaches a constant reference value.

1.4. Assume now that only the output y is measured. Design and implement an observer that will replace the direct measurement of the state by its estimate.

2. **Linear ADRC of the satellite antenna**. We would like to avoid having the know the model of system (1) and replace our observer-controller of the previous exercise by a linear ADRC.

   2.1. Deduce/compute the term b necessary for the implementation of your ADRC controller.

   2.2. Design and implement an Extended-State Observer corresponding to a second-order system.

   2.3. Close the loop of your control system with the stabilizing term and disturbance rejection term. The closed-loop poles should be -1.

   2.4. We now assume that you do not know the real value of b so well. Check the impact of small changes of this value, ie this uncertainty.

3. **Linear ADRC of the controlled pendulum**. Consider again the actuated pendulum

$$ml^2\ddot{\theta} + d\dot{\theta} + mgl\sin\theta = u \tag{2}$$

   where $m = 50$, $l = 1$, $g = 9.8$ and $d = 0.1$, which can be seen as the lower limb on a robotic leg.

   3.1. Re-use the Simulink model of system (2), which you made in exercise session 2.

   3.2. Deduce/compute the term b necessary for the implementation of your ADRC controller.

   3.3. Design and implement a linear ADRC controller such that the system output will go from 0 to -45 degrees.