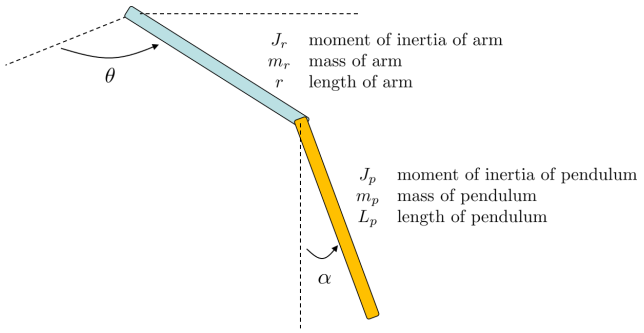
MECH468 Modern Control Engineering
MECH509 Controls

Homework 4. Due: March 22 (Monday), 11:59 pm, 2021.

State-Feedback Balancing Control of Inverted Pendulum (IP)

Consider a rotary pendulum shown below. This system has been taken from https://www.quanser.com/products/qube-servo-2/. The control objective is to balance the inverted-pendulum (IP) at the upright position. To do this homework, you need Quanser software "QLabs Virtual Experiments." Please see the file MECH468509_QLabs.pdf on Canvas.



Matlab files

You will get the following Matlab files on Canvas.

- HW4_main.m: Main file for this homework
- HW4_para.m: System parameters
- HW4_ABCD.m: Linearized model around pendulum upright position
- Simulink files
  - HW4_SF.slx: State-feedback control (Lectures 19-21)
  - HW4_Servo.slx: Servo control (Lecture 22)
  - HW4_OBS_SF.slx: Observer-based state-feedback control (Lectures 23-24)
  - HW4_OBS_Servo.slx: Observer-based servo control (Lecture 24)
  - HW4_blank.slx: Blank file (for those who want to make the Simulink files by themselves)

Control tasks

There are four tasks, in which you need to find eigenvalues of $A - BK$ for state-feedback systems and $A - LC$ for observers which lead to successful inverted-pendulum balancing control.

1. State-feedback controller design (balancing IP at $\theta = 0$)
2. Observer-based state-feedback controller design
3. Servo controller design (balancing IP and moving arm between -30 and 30 degree)
4. Observer-based servo controller design

Procedure

The basic procedure of running the QLab pendulum system is as follows.

1. Open 'Quanser Interactive Labs', 'QUBE - Pendulum', 'Pendulum Workspace'.
2. In 'HW4.m', specify pole locations (with the name having 'polevec'). Run 'HW4.m'.
3. Open and run a Simulink file (for example 'HW4_SF.slx' for state-feedback control).
4. In 'Pendulum Workspace', if the upper-edge of the pendulum base becomes green, the system is ready. Click 'Lift pendulum' from the top-right menu.
5. Once you see the control result in the animation, stop the simulink.

Report requirements

For each of the tasks above, only the followings are required in your report.

- Poles (eigenvalues) that you selected. We (TA) will check if your pole selections give your plots.
- Time responses of
  - pendulum angle α (Note that 0 degree corresponds to the upright position, as opposed to the figure above.)
  - arm angle θ
  - motor input voltage

——— (Have fun!) ———