Intelligent systems for control
TI0090

Homework III: Advanced control of a dynamic system

You have chosen one of the following dynamic systems:

S1: Three-tank system.

S2: Inverted pendulum.

S3: Hot and cold water mixing tank.

S4: Continuous bioreactor.

The objective of this homework is to control by mean of model based control techniques the dynamical system you modelled/simulated in the first homework, test the controllers developed in HW2 and make a comparison with the whole set of results obtained. You must comply the following tasks:

1. Design a linear optimal controller.
   - Identify the feasibility of applying a linear quadratic regulator (LQR) or a linear quadratic gaussian (LQG) controller, specifically discussing the pros and cons of the applicability of LQR/LQG of your specific system. If possible, develop a LQR/LQG in the language of your choice. Implement the optimal controller on your model and simulate/test your system under various input conditions and disturbances.
   - Test the optimal controller and discuss the results obtained. Compare them with the different controllers developed in HW2.
2. Development and implementation of a model predictive controller.
   - Design the model predictive controller (MPC) and examine/discuss the effect of the controller parameters. You might approach the problem defining a model predictive control on the language of your choice. Implement the MPC controller on your model and simulate/test your system under various input conditions and disturbances.
   - Test the predictive controller and discuss the results obtained. Compare it with the different controllers developed in HW2 and discuss the differences or benefits compare with the optimal controller in item (1) of this homework.
3. Final presentation.
   - Prepare a 15-minute presentation with a set of slides summarising the work done during the semester:

  - Objective of the work.
  - Description of the system of your choice.
  - Briefly describe the methodologies you adopted for controlling the system, discuss the theoretical background for the control algorithms you tested, the advantages and disadvantage of the methods.
  - Compare the results for the various control approaches. Highlight the challenges you faced developing the controllers and propose possible improvements.

4. Act as an opponent/reviewer of your peers.

   ◦ You will receive the final assignments of your colleagues, read it carefully.
   - Prepare at least one question for each report, you will act as an opponent during the seminar.
   - Provide your feedback as a written report (max 1 page), after the seminars. The report might include two sections (*i*) Comments to be read only by the professor; (*ii*) Anonymous comments to be read by the authors. Please comment on the following aspects of the manuscript:
     * Insight: Your evaluation of the interpretation of the level of insight given by the authors. If you feel there are flaws, please describe them in detail.
     * Clarity and context: Your view on the clarity and accessibility of the text, and whether the discussion has been provided with sufficient context.

Guidelines

Regardless of your choice of dynamical system, you must generate the following:

◦ Final Presentation: You must provide a clear and exhaustive summary of the work done during the semester. The presentations will be given to the students of the fifth semester participating to the course "TI0118 - Introduction to process control".

◦ Final Report: You must provide a clear and exhaustive summary of the development of HW1, HW2 and HW3. Follow the structure provided for the previous homework and increment it with the sections/paragraphs related to optimal and predictive controllers.

◦ Code listing: You must provide the executable/functioning code produced to model, simulate and perform the analysis on the system. The code can be packaged together with the report and sent trough SIGAA as a zip file.

The work will be evaluated based on: Adherence to the instructions, clear and critical argumentation, formatting and orthography. The work can be done individually or in pair. You can write your report/present either in English or Portuguese. You can base your work on the resources you might find on the web but you must adequately reference to them. The deadline for submission and presentation is set on sigaa.