Lab Assignment C

Non-linear control design

Examination: Submitted report in CANVAS.

Preparation:

- Read the manual and plan for your work
- Revise the models from Lab A
- Read the lecture(s) related to feedback linearization, static transformation and the sliding mode controller techniques carefully before starting!

1 Introduction

In this lab assignment a non-linear control design will be demonstrated. The main objectives are to develop

- feedback input/output linearizion (Nonlinear transformation) of the double tank.
- sliding mode controller of the double tank.

The work will be based on the theory of the feedback linearization, static transformation and the sliding mode controller techniques. **Read the related lecture(s) carefully before starting!**

In case you run into trouble and the trouble-shooting is not helpful, please contact us right away!

2 Problem description

Your task is to design and implement a nonlinear controller that is able to control the level of the lower tank. The work will be done in 2 different cases:

- **Case 1:** you are allowed to make use of the measurement in h_1 and h_2.
- **Case 2:** you are not allowed to make use of the measurement in h_1, but the measurement from h_2 should be used.

The implementation shall be done in Simulink. Any blocks are allowed.

2.1 Assumption

- Measurements: level measurement of the lower tank h_1 and h_2 for case one and only h_2 for case 2
- Control signal: pump voltage u

- The pump can be represented by a static map $f(u)$ (what is the influence of the pump dynamics?)
- The sensor calibration map $g(h)$ is only needed to map the voltage from the sensor to a level value in centimeters.

2.2 Developments Steps

- Simulation: Test the two cases on the simulation process that developed in Simulink in Lab A. For the second case when only h_2 is measured, use one of the designed estimators from Lab A.
- Real test: Test the Case 1 on the real process (Case 2 is optional).
- Robust:
  - The feedback linearization will not work perfectly with uncertain systems. This is due to the fact that the system will have extra terms after linearization that will deviate the equilibrium. Thus, it is required to add an extra component to overcome the deviation of performance. Many approaches are available to achieve this, a simple approach is to adopt an integrator to remove the modeling error and add it to the input of the controller.
  - The selection of μ of the sliding mode controller should be conducted carefully in order to overcome the model uncertainty.

2.3 Performance Specification-Feedback Linearization

Design a controller that will

- Reduce the settling time of the open loop system by a factor between 4 and 5 and with
  - **First Tunning:** No overshoot response .
  - **Second Tunning:** Critical damping response.
- The upper tank should not overflow.
- The robust controller will remove the steady state error without oscillation.
- The controller will be able to reject disturbances.

2.4 Performance Specification-Sliding Mode Controller

Design a Sliding Mode controller for the system, choose the sliding surface carefully and test the designed system in simulation. Choose the parameters carefully to overcome the uncertainty in the model and to ensure robust behavior of the controller. In the implementation, select ϵ to overcome relay chattering.

NOTE: In this task, you have to demonstrate the controller for the lab assistant in simulation before trying it on the real tanks.

Similar to the Feedback linearization case, it is required that:

- Reduce the settling time of the open loop system by a factor between 3 and 5.
- The upper tank should not overflow.
- The controller will be able to reject disturbances.

2.5 Optional-Gain Scheduling (challenge!)

Design a PID controller that adopt a gain scheduling with a settling time reduction by a factor between 2 and 3 and compare it with a switching PID. This task is based on the work done in R0002. The difference here is that the gain of the parameters of the PID controller will be a function of the levels of the tanks. The switching PID can be done by designing a different PID controllers for different operational points and then divide the system into zones and switching between these PID controllers.