Stochastic Adaptive Control

Excercise part 20

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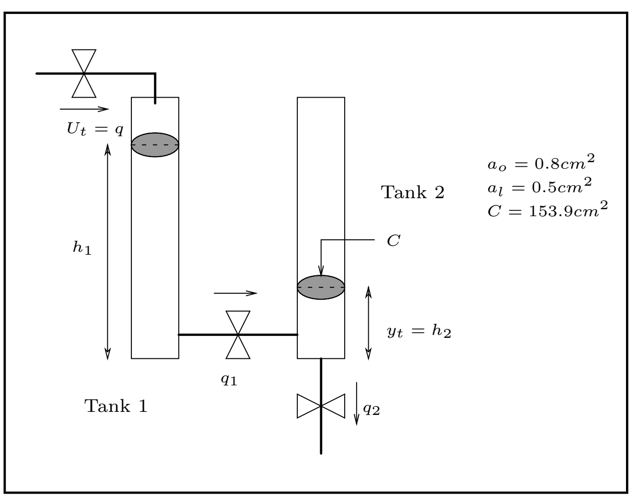
The focus in this exercise is on system identification. Stochastic controllers (and filters and predictors) are based on a model of the system and the stochastic disturbances. Systems identification deals with the problem of building models of dynamic systems on their disturbances from observed data.

Excercise 1

Let us again work with the coupled tank system as depicted in Figure 1, where the level in the last tank (ie, the system output and the quantity to be controlled) is measured. The input is the pump capacity. With a nonlinear simulation model several experiments have been carried out. The sampling period has been increased to $T_s = 25$ *sec* and the results are store in dat files (can be imported into matlab by using the *load* command).



Figur 1. The coupled tanks system

The distribution contains several files. In two of the files (*dat1.mat* and *dat2.mat*), the result of two identical experiments are stored. In these two experiments the input sequence is a square wave function. In the variable, data, the input (column 5) and resulting output (column 4) are stored. (That means that the *plt* command can be used for plotting the data). (*hint:* Since the data are obtained in connection to a non linear system, the off set is not zero, but can be removed with command *dtrend* . It can be recommended to investigate the possibilities in the identification toolbox, simply by typing *help ident*).

The general objective is to find a suitable model for the system and disturbances that have generated the data. The search is limited to external models.

Question 1.1 Start with a simple model and increase the complexity of the model. Monitor the evolution of the loss function as the model complexity increases. Use a F-test for determining a suitable model structure. □

Question 1.2 Perform the same investigation by using the BIC (Rissanen's minimum description length criterion) □

Question 1.3 The search can also be carried out by comparing the variation of the loss function for the estimation data set and a validation or test set (*dat2.mat*). The loss function will for the estimation data be a monotonic decreasing function whereas it will have a minimum for the validation data. □

Question 1.4 The structure of the system can also be found by checking the significance of the estimated parameters. (hint: use eg. *estpres*). The search can be carried out as a forward selection (starting with a simple model and then successively increase the complexity) or as a backward selection (starting with a complex model and graduately reducing the model until all parameters are significant). Find the model structure by applying such a method. □

Question 1.5 Check the candidate model for overlapping pole zeroes and check the corelation structure in the residuals. (hint: use *zpplot* and *resid*). □

The previous data has been generated as a simulation experiment on the two tank system, which is a non-linear system. The results above can be compared with a linearized and discretized (ie. sampled) model

$$\begin{aligned} x_{t+1} &= Ax_t + Bu_t + v_t \qquad && v_t \in N(0, R_1) \\ y_t &= Cx_t + e_t && e_t \in N(0, R_2) \end{aligned}$$

This model (including R_1 and R_2) can be obtained from sysinit. This model can also be given in the innovation form

$$\begin{aligned} x_{t+1} &= Ax_t + Bu_t + K\varepsilon_t \\ y_t &= Cx_t + \varepsilon_t \end{aligned}$$

where K is the gain in the predictive kalman filter. (Check *dlqe*).

Question 1.6 Based on the linear approximation of the system determine a model for the system. (hint: use *ss2tf* to determine the transfer function from ε_t to output). □

In the data files, *dat3.mat* and *dat4.mat* , the results of two other identical experiments are stored.

Question 1.7 With the structure found in previous question estimate the parameters and compare with the values indicated in the previous question. □