Stochastic Adaptive Control

Exercise part 17

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2015-04-07 06.58

The focus of this excercise is modelling and identification of dynamic stochastic systems.

Excercise 1

(A first order system)

Consider a dynamic system (ARX structure) given by

$$A(q^{-1})y_t = B(q^{-1})u_{t-1} + e_t$$

where $e_\in \mathbf{N}_{iid}\left(0, \sigma^2\right)$ and

$$A(q^{-1}) = 1 - 0.98\ q^{-1}$$
$$B(q^{-1}) = 2$$

Enter this system in the work bench (more precisely in *sysinit.m*). Run (with *wb.m*) a deterministic ($\sigma^2 = 0$) simulation (eg. with length equal 100) with a PRBS signal as input signal. The data are available in *data* .

Question 1.1 Estimate the parameters in the system. Hint: check *idpoly* , *th2par* and *polydata* Compare estimate with system parameters. □

Now run a stochastic simulation with $\sigma^2 = 0.1$.

Question 1.2 Estimate the parameters and compare with system parameters. Also check the confidence intervals (*estpres*). □

Question 1.3 Determine the residuals and plot the sequence. Note the sum of squares. Check the correlation function for the residuals (use eg. *resid*). Make an additional simulation for producing a test data set. Repeat the the first part of the question. Compare the loss function (sum of squares) for the estimation data set and the test set. □

Question 1.4 Produce a Bode plot (along with is uncertainty) for the estimated model and compare with the Bode plot for the system. Check *bode* . □

Question 1.5 Also estimate the emperical transfer function (using *etfe*) and compare with the previous question. □

Question 1.6 Do the previous question, but with spectral analysis (using *spa*). □

Excercise 2

(The effect of order and noise.)

Consider a dynamic system (ARX structure) given by

$$A(q^{-1})y_t = B(q^{-1})u_{t-1} + e_t$$

where $e \in \mathbf{N}_{iid}\left(0, \sigma^2\right)$ and

$$A(q^{-1}) = 1 - 1.5\ q^{-1} + 0.7\ q^{-2}$$
$$B(q^{-1}) = 1 + 0.1\ q^{-1}$$

Let the input signal be a PRBS signal. In this exercise we will study the effect of the model order and the noise level. In simulations we have the luxury of knowing the system and its order. This is not the case in real life.

Question 2.1 Produce a sequence of deterministic simulations and estimate (with *estarx* og *arx*) the parameters in an the model with order $n = 1,\ 2$ and 3 (if possible). Monitor the loss function and the condition number of the covariance matrix (it is proportional to the inverse of the Hessian matrix). Also check if the correct parameters are in 99% confidence interval. □

Question 2.2 Repeat the previous question for $\sigma^2 = 0.1$ and 1.0. □