INDIAN INSTITUTE OF TECHNOLOGY MADRAS

Department of Chemical Engineering

CH5230 System Identification

Assignment 4

Due: Friday, April 01, 2022

Exercises

1. A time-series is provided in the data file `a4_timeseries.mat`.

   (a) Using the ACF and PACF of the series, comment on the type of model (AR, MA or ARMA) that is suitable for the given series

   (b) Fit a suitable model for the given series (use `ar` or `arma` routines in MATLAB). The final model should be best in terms of predictability as well as parsimony of parameters. Present your choice of model with suitable justifications.

2. A process evolves according to the OE(1,1,2) structure $y[k] = \dfrac{b_2^0 q^{-2}}{1 + f_1^0 q^{-1}} u[k] + e[k]$, where $e[k] \sim \text{WN}(0, \sigma_e^2)$ and $u[k]$ has the properties of a WN sequence.

   (a) Develop expressions for σ_y^2, $\sigma_{yy}[1]$, $\sigma_{yu}[1]$, and $\sigma_{yu}[2]$ in terms of the variances of the input and the white-noise sequences, *i.e.*, σ_u^2 and σ_e^2 respectively.

   (b) Derive a correlation-based method for estimating the impulse response coefficients and hence the delay. Would your method work even when $u[k]$ is a coloured signal?

3. The p.s.d. of a stationary process is known to be $\gamma_{vv}(f) = \dfrac{1.68}{2.5625 - 3.24\cos(\pi f) + 0.7\cos(2\pi f)}$.

   (a) Determine the time-series model $H(q^{-1})$ that generates $v[k]$ assuming $\sigma_e^2 = 1$.

   (b) Find the ACVF of the stationary process.

4. (a) Determine the 3-step ahead prediction for a stationary process $v[k] = \dfrac{1}{1 + d_1 q^{-1}} e[k]$. Also compute the variance of the associated prediction error.

   (b) For a linear process, it is known that $\hat{y}[k|k-2] = L_1(q^{-1})u[k] + L_2(q^{-1})y[k]$. Determine the corresponding plant- and noise-models in terms of $L_1(q^{-1})$ and $L_2(q^{-1})$.