CHE 573- Signal Processing for Process Engineers

Assignment 3
Cross-covariance and Cross-correlation Functions

Due date: 15 February 2011 on or before 4:00 PM

Objectives: To understand the concept of cross-covariance and cross-correlation via a 'hands-on' experience in working with simulated and practical data. Specifically, to use the 'xcorr' and 'cra' functions in Matlab to estimate a model from experimental data collected on the stirred tank heater in room CME 274.

Q.1: For Questions 2 and 3 of assignment 2, obtain ACF and PACF plots and confirm the order and type of process that is the source of signal, y_k, with white noise input, a_k.

Q.2: Download discrete values of three measurements from the eClass web-page for CHE 573 (as stored in the Data folder in file, 'data4q2' in Matlab format). The data contains 3 columns of measured values with a sample time of T_s=1secs or F_s=1 sample per sec. Plot these signals and comment on their properties. (Hint: look at the ACF and PACF of these signals to comment on the characteristics of signals and the processes that generate such signals.)

Q.3: Consider the following discrete time transfer function of a first-order plus dead-time process. Generate a white noise input for this process and record the output of this process. Using the 'cra' function estimate 10 cross-correlation coefficients for lags 0 to 10.

$$y(t) = \left[\frac{5.0 z^{-3}}{1 - 0.8 z^{-1}} \right] u(t)$$

Separately: i) calculate the impulse response difference equation for this same process; ii) multiply both sides of the equation by u(t-k), assuming that the input is 'white', apply the expectation operator and compute the first 6 impulse response coefficients by hand and compare them with those estimated from the Matlab function 'cra'.

Q.4: The files "sthid" in the Data folder for CHE 573 eClass page contains a 275x2 matrix of experimental data in Matlab format. The first column contains the water temperature (T_2) as the output in ^{O}C, and the second column is the steam valve position (CV-1) in %. The sample rate for this data is 4 seconds. A schematic and short description of the continuous stirred tank heater process is attached to this page. Do the following using the data in file sthid.
Plot the input-output data and comment on the structure of the possible model. Estimate the time-delay, if any, for this model. Use the 'cra' function to obtain information on the time delay for this process and also on the time constant and gain of this process. Ignore the confidence bounds on the impulse response coefficients as the data length is relatively short.