Uppsala University
Department of Information Technology
Division of Systems and Control

Homework Assignment no. 2

Rational Parametric Methods

This second homework is based on **Exercise C3.18** (old book) / **C3.20** (new book) (and **Exercise C2.21/C2.23** in parts).
For your convenience, code for the different spectral estimators can be downloaded at `http://www.prenhall.com/stoica`. Make sure that you use these functions correctly, (use "`help`". If still in doubt how to use the functions, try by inspecting the code directly.) Here follow some explanations and clarifications for the corresponding parts of **Exercise C3.18/C3.20**:

By "Apply your favorite AR and ARMA estimator(s)" we mean that you should carefully consider how to choose the required user parameters, especially the model orders m and n. Motivate your choices.

For the "sunspot" data, plot the spectra for AR and ARMA separately using `subplot(2,2,·)` to keep the number of pages down and to make the comparison easier. For the "lynx" data, plot the resulting spectra using both methods separately, and in addition, plot the corresponding spectra obtained by first performing the logarithmic transform of **Exercise C2.21/C2.23** on the data. How do these two approaches differ? Use dB scale in all figures in order to simplify the interpretation of the results. Mark on each plot where the most significant signal peaks are located.

Discuss the questions and remarks raised in the textbook. Single sentence answers are not sufficient. For the discussion on nonparametric vs. parametric methods, you need to solve **Exercise C2.21/C2.23** partly as well. This should be straightforward. Discuss the differences between nonparametric and parametric methods. How could a combination of these two approaches be used to estimate the spectral and periodic structure of the data?

Exercise C3.20: AR and ARMA Estimators applied to Measured Data

Consider the data sets in the files `sunspotdata.mat` and `lynxdata.mat`. These files can be obtained from the text web site `www.prenhall.com/stoica`.

Apply your favorite AR and ARMA estimator(s) (for the `lynx` data, use both the original data and the logarithmically transformed data as in Exercise C2.23) to estimate the spectral content of these data. You will also need to determine appropriate model orders m and n (see, *e.g.*, Exercise C3.19). As in Exercise C2.23, try to answer the following questions: Are there sinusoidal components (or periodic structure) in the data? If so, how many components and at what frequencies? Discuss the relative strengths and weaknesses of parametric and nonparametric estimators for understanding the spectral content of these data. In particular, discuss how a combination of the two techniques can be used to estimate the spectral and periodic structure of the data.

Exercise C2.23: Periodogram–Based Estimators applied to Measured Data

Consider the data sets in the files `sunspotdata.mat` and `lynxdata.mat`. These files can be obtained from the text web site `www.prenhall.com/stoica`. Apply periodogram–based estimation techniques (possibly after some preprocessing; see the following) to estimate the spectral content of these data. Try to answer the following questions:

(a) Are there sinusoidal components (or periodic structure) in the data? If so, how many components and at what frequencies?

(b) Nonlinear transformations and linear or polynomial trend removal are often applied before spectral analysis of a time series. For the `lynx` data, compare your spectral analysis results from the original data, and the data transformed first by taking the logarithm of each sample and then by subtracting the sample mean of this logarithmic data. Does the logarithmic transformation make the data more sinusoidal in nature?