Automatic Spectral Estimation with Time Series Models

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This tutorial introduces the newly developed automatic identification of a single time series model for measured random data. One model is selected automatically from hundreds of candidates, with statistical rules. That model provides an accurate parametric representation of the power spectral density and of the autocorrelation function of the stochastic data. The accuracy of this autocorrelation function is always better than the usual autocorrelation estimate obtained with lagged products of the random observations. Likewise, the accuracy of the spectral density is always better than the accuracy of tapered and windowed periodograms.

Let the data themselves decide about their best representation, they can !!

Three types of time series models can be distinguished: autoregressive or AR, moving average or MA and combined ARMA. The recent possibility to identify automatically a well fitting time series model for measured stochastic data has three causes: the increased computational speed, the finite sample order selection criteria and developments in the reliability of time series algorithms. Time series models are excellent for random data, if the model type and the model order are known in advance. With the new ARMAsel toolbox, that a priori information is no longer required. For unknown data characteristics, a large number of candidate models is computed. The ARMAsel Matlab computer program automatically selects the best model order for each of the three model types and also the best model type. That single selected model includes precisely the significant details that are present in the autocorrelation function and in the spectrum of the data. It is now possible to compute more than 500 or 1000 different time series models and to let the computer select only one, which certainly is one of the better models if not the very best. That model optimally characterizes the spectral density and the autocorrelation function of the data.

The tutorial treats time series theory, estimation methods, finite sample order selection and many practical examples in physics, prosthesis control, radar, satellite data, improved forecasting of river levels and the application to missing data problems and irregular data.