Postgraduate Course
Time Series Analysis
(MSc)

Instructor Information

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Course Information

Course Description

This course is an introduction to the theory and practice of time series analysis, providing statistical tools to analyze random data that are ordered in time. It begins with a review of the theory of stochastic processes, which are the underlying mathematical description of time-varying random phenomena. Then, some classical parametric models for time series are presented, along with techniques to estimate their parameters. Time series are often analyzed in the frequency domain, so the course also covers topics on spectral estimation. Finally, the theory of optimal filtering and prediction is also presented, developed under the general framework of Bayesian estimation.

Prerequisites

Probability and Stochastic Processes for Engineers

Deterministic Signals and Systems Theory

Course Goal

To develop an understanding of the concepts and mathematical techniques that underlie the analysis of time series.

Summary of intended course outcomes

The students will understand advanced concepts related to discrete-time random signals. In particular, they will learn how to model time series (both in the time and in the frequency domain) so that useful information about the underlying phenomenon giving rise to the data can be extracted from the model parameters. The students will also understand the concept of optimal filter and how to design optimal filters for prediction, filtering and smoothing of a time series. By the end of the course, students should be able to:

- Be familiar with the description, analysis and modeling of discrete-time random processes.

- Be familiar with the fundamental concept of optimal filter and the different approaches that can be used to design optimal processing structures.
- Choose the appropriate modeling and filtering tools in order to extract useful information from a time series.

Syllabus

Random processes and sequences
Basic definitions. Classification.
Probabilistic descriptions.
Special classes of processes.
Stationarity. Power spectra.
Linear systems.
Ergodicity.

Time series modeling
Linear stationary models: AR, MA y ARMA.
Linear nonstationary models: ARIMA.
Nonlinear models: ARCH.
Parameter estimation.

Spectral estimation
Autocorrelation estimation.
Classic spectral estimation.
Parametric methods.

Optimal filtering
Bayesian estimation.
Wiener filter.
Linear prediction.
Recursive estimation: Kalman filter.

Bibliography

- Discrete Random Signals and Statistical Signal Processing. C. W. Therrien. Prentice-Hall, 1992.
- Probability, Random Processes, and Statistical Analysis. H. Kobayashi et al. Cambridge University Press, 2011.
- Statistical Digital Signal Processing and Modeling. M. H. Hayes. Wiley, 1996.
- Random Signals: Detection, Estimation and Data Analysis. K. Sam Shanmugan, A. M. Breipohl. Wiley, 1988.
- Time Series Analysis and Its Applications: With R Examples. R. H. Shumway, D. S. Stoffer. Springer, 2010. (http://www.stat.pitt.edu/stoffer/tsa3/)
- A First Course on Time Series Analysis: Examples with SAS. M. Falk et al. University of Würzburg, 2012. (http://www.statistik-mathematik.uni-wuerzburg.de/wissenschaftforschung/time_series/the_book/)

- Introduction to Time Series and Forecasting. P. J. Brockwell, R. A. Davis. Springer, 2010.
- Time Series Analysis with Application in R. D.C. Cryer, K. Chan. Springer, 2008.
- Time Series Analysis: Forecasting and Control. G. E. P. Box, G. M. Jenkins, G. C. Reinsel, G. M. Ljung. Wiley, 2015.

Student Assessment Criteria

Homework exercises	25%
Computer assignments	25%
Final examination	50%

Exercises will be proposed throughout the course to be solved by the students. Some of them will need the use of computer programs written in MATLAB or R.

Exercises and computer assignments are mandatory. It is also required to obtain a minimum grade of 3.5/10 in the final examination and an overall average grade of at least 5/10.