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Elements of nonlinear time series analysis and forecasting. (English) Zbl 1376.62001

Springer Series in Statistics. Cham: Springer (ISBN 978-3-319-43251-9/hbk; 978-3-319-43252-6). xxi, 618 p. (2017).

This book is designed to be used as a course in the subject or in Nonlinear Model Identification to graduate students in systems engineering, mathematics, statistics, and econometrics.

The book is organized into 12 chapters.

Chapter 1 gives an introduction to the basic problems and concepts studied in the book. Real data sets taken from different subject areas are discussed as examples of applications of some techniques studied in the book. These techniques are complemented with tests for exploratory data analysis.

Chapter 2 introduces a number of "classic" parametric univariate nonlinear models that have proven to be useful in modeling many nonlinear phenomena, among them, some nonlinear non-Gaussian models and artificial neural networks.

Chapter 3 reviews some of the important probabilistic properties of stochastic processes, mainly Markov chains on a general state space, and necessary and sufficient conditions for stationarity and invertibility of nonlinear time series.

Chapter 4 deals with frequency-domain linearity and Gaussianity test statistics. The alternative hypothesis only states that the DGP is nonlinear, not specifying the type of nonlinearity. Only nonparametrics tests are considered.

Chapter 5 considers statistics testing the null hypothesis that a time series is generated by a linear process against a pre-chosen particular nonlinear alternative.

Chapter 6 focuses on quasi maximum likelihood estimation, nonlinear least squares (NLS) estimation, and conditional linear square estimation methods within the framework of identifiable parametric stochastic models

$$Y_t = g\left(Y_{t-1}, \ldots, Y_{t-p}, \varepsilon_{t-1}, \ldots, \varepsilon_{t-q}; \theta_g\right) + \eta_t$$

where

$$\eta_t = \left(h\left(Y_{t-1}, \ldots, Y_{t-u}, \varepsilon_{t-1}, \ldots, \varepsilon_{t-v}; \theta_h\right)\right)^{1/2} \varepsilon_t.$$

Here $\{Y_t, t \in \mathbb{Z}\}$ is a strictly stationary and ergodic univariate stochastic process; $g(\theta_g)$ and $h(\theta_h)$ are two real-valued measurable (known) functions on $\mathbb{R}^{p+q}$ and $\mathbb{R}^{u+v}$ $(u \leq p)$, respectively; and $\theta = \left(\theta_g', \theta_h'\right)'$ is a vector of unknown parameters to be estimated from observations $\{Y_t, t = 1, \ldots, T\}$.

Chapter 7 considers both historic and more recent work in the area of nonparametric serial independence tests for conditional mean models.

Chapter 8 is titled "Time-reversibility" (TR). A stochastic process is said to be time-reversible if its probabilistic structure is unaffected by reversing ("mirroring") the direction of time. This chapter gives a brief overview of some of the major developments in this area.

Chapter 9 is focused on some methods available for semi- and nonparametric time series forecasting.

Chapter 10 covers several important issues related to forecasting from parametric nonlinear models. About the chapter the author says "the chapter may well serve as a starting point for anyone who intends to do empirical work."

Chapter 11 extends the univariate nonlinear parametric time series framework to multiple, related time series exhibiting nonlinear behavior.

In Chapter 12, various aspects related to data-driven estimation and forecasting methods are discussed, as well as to the detection of dependence structures and interrelationships in multivariate time series. In addition, three semiparametric multivariate regression methods are considered. Issues such as stationarity, ergodicity, and variable selection of the fitted semiparametric models are still largely open for research.

The book is a good text for researchers and advanced undergraduate and graduate students of several disciplines, among others, mathematical statistics, engineering, and economy.

For the scientific quality of its content I do not exaggerate if I consider this book as a treasure.

Reviewer: Oscar Bustos (Córdoba)

MSC:

62-01 Textbooks (statistics)
62M10 Time series, auto-correlation, regression, etc. (statistics)
62M20 Prediction; filtering (statistics)
60G25 Prediction theory
60J10 Markov chains (discrete-time Markov processes on discrete state spaces)
62G08 Nonparametric regression
62G10 Nonparametric hypothesis testing

Keywords:

non-linear time series; estimation; prediction; forecasting; parametric univariate nonlinear models; Markov chains; nonparametric test

Software:

CAViaR; Matlab

Full Text: DOI