

Article

State Space Modeling of Event Count Time Series

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Abstract: This paper proposes a class of algorithms for analyzing event count time series, based on state space modeling and Kalman filtering. While the dynamics of the state space model is kept Gaussian and linear, a nonlinear observation function is chosen. In order to estimate the states, an iterated extended Kalman filter is employed. Positive definiteness of covariance matrices is preserved by a square-root filtering approach, based on singular value decomposition. Non-negativity of the count data is ensured, either by an exponential observation function, or by a newly introduced “affinely distorted hyperbolic” observation function. The resulting algorithm is applied to time series of the daily number of seizures of drug-resistant epilepsy patients. This number may depend on dosages of simultaneously administered anti-epileptic drugs, their superposition effects, delay effects, and unknown factors, making the objective analysis of seizure counts time series arduous. For the purpose of validation, a simulation study is performed. The results of the time series analysis by state space modeling, using the dosages of the anti-epileptic drugs as external control inputs, provide a decision on the effect of the drugs in a particular patient, with respect to reducing or increasing the number of seizures.

Keywords: nonlinear state space model; iterated extended Kalman filter; Bayesian filtering; count time series; singular value decomposition



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1. Introduction

Temporal data sequences resulting from counting discrete events over a given time interval represent a particular variant of time series called discrete-valued or event count time series. These count data arise in various fields, such as physics, epidemiology, finance, econometrics, or medicine. Much of the existing framework on time series analysis relies on the assumptions of Gaussianity and linearity. The non-negativity and integrity constraints inherent in count time series have led to the development of alternative modeling approaches that instead employ probability distributions of Poisson type. As prominent examples we mention generalized linear models (GLMs) [1], dynamic generalized linear models [2,3], integer-valued autoregressive (INAR) models [4], and integer-valued generalized autoregressive conditional heteroscedasticity (INGARCH) models [5–7].

However, in this paper we aim at modeling count time series within the linear Gaussian regime as long as possible, while introducing non-negativity and integrity only at the last stage of modeling, namely, at the stage of modeling the observation process. The suitable framework for this agenda is given by classical state space modeling [8]. In state space modeling, the dynamical process underlying the data is explicitly separated from the observation process, such that the former can be kept Gaussian and linear, which considerably simplifies state estimation and model identification. Further advantages of the state space approach are given by the possibility to discriminate between dynamical noise and observation noise, and by the option of straightforward generalization to the multivariate case.

State Space Modeling Of Time Series

Bela G. Liptak



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State Space Modeling of Time Series Masanao Aoki, 2013-03-09 model's predictive capability These are some of the questions that need to be answered in proposing any time series model construction method This book addresses these questions in Part II Briefly the covariance matrices between past data and future realizations of time series are used to build a matrix called the Hankel matrix Information needed for constructing models is extracted from the Hankel matrix For example its numerically determined rank will be the dimension of the state model Thus the model dimension is determined by the data after balancing several sources of error for such model construction The covariance matrix of the model forecasting error vector is determined by solving a certain matrix Riccati equation This matrix is also the covariance matrix of the innovation process which drives the model in generating model forecasts In these model construction steps a particular model representation here referred to as balanced is used extensively This mode of model representation facilitates error analysis such as assessing the error of using a lower dimensional model than that indicated by the rank of the Hankel matrix The well known Akaike's canonical correlation method for model construction is similar to the one used in this book There are some important differences however Akaike uses the normalized Hankel matrix to extract canonical vectors while the method used in this book does not normalize the Hankel matrix

Time Series Analysis by State Space Methods James Durbin, Siem Jan Koopman, 2001-06-21 State space time series analysis emerged in the 1960s in engineering but its applications have spread to other fields Durbin statistics London School of Economics and Political Science and Koopman econometrics Free U Amsterdam extol the virtues of such models over the main analytical system currently used for time series data Box Jenkins ARIMA What distinguishes state space time models is that they separately model components such as trend seasonal regression elements and disturbance terms Part I focuses on traditional and new techniques based on the linear Gaussian model Part II presents new material extending the state space model to non Gaussian observations c Book News Inc

Time Series Modeling of Neuroscience Data Tohru Ozaki, 2012-01-26 Recent advances in brain science measurement technology have given researchers access to very large scale time series data such as EEG MEG data 20 to 100 dimensional and fMRI 140 000 dimensional data To analyze such massive data efficient computational and statistical methods are required Time Series Modeling of Neuroscience Data shows how to

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Bayesian Statistical Modeling with Stan, R, and Python Kentaro Matsuura,2023-01-24 This book provides a highly practical introduction to Bayesian statistical modeling with Stan which has become the most popular probabilistic programming language The book is divided into four parts The first part reviews the theoretical background of modeling and Bayesian inference and presents a modeling workflow that makes modeling more engineering than art The second part discusses the use of Stan CmdStanR and CmdStanPy from the very beginning to basic regression analyses The third part then introduces a number of probability distributions nonlinear models and hierarchical multilevel models which are essential to mastering statistical modeling It also describes a wide range of frequently used modeling techniques such as censoring outliers missing data speed up and parameter constraints and discusses how to lead convergence of MCMC Lastly the fourth part examines advanced topics for real world data longitudinal data analysis state space models spatial data analysis Gaussian processes Bayesian optimization dimensionality reduction model selection and information criteria demonstrating that Stan can solve any one of these problems in as little as 30 lines Using numerous easy to understand examples the book explains key concepts which continue to be useful when using future versions of Stan and when using other statistical modeling tools The examples do not require domain knowledge and can be generalized to many fields The book presents full explanations of code and math formulas enabling readers to extend models for their own problems All the code and data are on GitHub

An Introduction to State Space Time Series Analysis Jacques J.F. Commandeur,Siem Jan Koopman,2007-07-19 This text provides an introduction to time series analysis using state space methodology to readers who are neither familiar with time series analysis nor with state space methods This is the first in a series of books designed to provide practitioners researchers and students with practical introductions to various topics in econometrics

System-Theoretic Methods in Economic Modelling I S. Mitnik,2014-06-28 The value of applying system theoretic concepts to economic modelling problems arises from the fact that it offers a unifying framework for modelling dynamic systems In addition to offering this powerful conceptual framework it provides a wide range of tools useful in applied work System theoretic techniques enter predominantly two stages of economic modelling efforts the stage of model construction and the stage of model application in accordance with the modelling The objective of this and subsequent volumes on System Theoretic Methods in Economic Modelling I is to initiate and or intensify dialogues between researchers and practitioners within and across the disciplines involved This first volume brings together papers exhibiting a wide range of system theoretic techniques and applications to economic problems The papers have been divided into two groups following roughly

but not necessarily the above classification into the construction and application stages of economic modelling The papers in the first group focus on the identification of dynamic and static systems while the papers in the second group address dynamic optimization problems

Advanced Intelligent Computing Technology and Applications De-Shuang Huang, Yijie Pan, Wei Chen, Bo Li, 2025-07-23 The 20 volume set LNCS 15842 15861 together with the 4 volume set LNAI 15862 15865 and the 4 volume set LNBI 15866 15869 constitutes the refereed proceedings of the 21st International Conference on Intelligent Computing ICIC 2025 held in Ningbo China during July 26 29 2025 The 1206 papers presented in these proceedings books were carefully reviewed and selected from 4032 submissions They deal with emerging and challenging topics in artificial intelligence machine learning pattern recognition bioinformatics and computational biology

Nonlinear Filters Suetrong Sugimoto, Masaya Murata, Katsumi Ohnishi, Genshiro Kitagawa, Hisashi Tanizaki, Katsuji Uosaki, Kazufumi Ito, Kiyotugu Takaba, Masaaki Murata, Masaki Yamakita, Sarah A. King, Shinji Ishihara, Tohru Katayama, Yukihiro Kubo, 2020-12-10 This book covers a broad range of filter theories algorithms and numerical examples The representative linear and nonlinear filters such as the Kalman filter the steady state Kalman filter the H infinity filter the extended Kalman filter the Gaussian sum filter the statistically linearized Kalman filter the unscented Kalman filter the Gaussian filter the cubature Kalman filter are first visited Then the non Gaussian filters such as the ensemble Kalman filter and the particle filters based on the sequential Bayesian filter and the sequential importance resampling are described together with their recent advances Moreover the information matrix in the nonlinear filtering the nonlinear smoother based on the Markov Chain Monte Carlo the continuous discrete filters factorized filters and nonlinear filters based on stochastic approximation method are detailed 1 Review of the Kalman Filter and Related Filters 2 Information Matrix in Nonlinear Filtering 3 Extended Kalman Filter and Gaussian Sum Filter 4 Statistically Linearized Kalman Filter 5 The Unscented Kalman Filter 6 General Gaussian Filters and Applications 7 The Ensemble Kalman Filter 8 Particle Filter 9 Nonlinear Smoother with Markov Chain Monte Carlo 10 Continuous Discrete Filters 11 Factorized Filters 12 Nonlinear Filters Based on Stochastic Approximation Method

Handbook of Intraindividual Variability Across the Life Span Manfred Diehl, Karen Hooker, Martin J. Sliwinski, 2014-12-08 Intraindividual variability IIV of human development and behavior across the entire life span is explored in this new book Leading researchers summarize recent findings on the extent role and function of IIV in human development with a focus on how when and why individuals change over time The latest theoretical methodological and technological advances are reviewed The book explores the historical and theoretical background and challenges of IIV research along with its role and function in childhood adolescence and adulthood Edited to maximize consistency and accessibility each chapter includes an introduction and a review of the research and most explore future directions new theoretical developments and conclusions and implications Readers are shown that by focusing on the individual as a unit of analysis across different time scales conditions and situations researchers can effectively demonstrate behavioral and

developmental regularities at different points of the life span As such this book is a must have for anybody interested in IIV research The book explores New designs and methods for the analysis of intensive repeated measures data The importance of real time data for more time sensitive and ecologically valid measurements The role and function of intraindividual variability in behavior and development across the life span from infancy to later life Numerous examples of how intraindividual variability research is conducted Topics and findings that are commonly treated in disparate bodies of literature from various disciplines Part 1 provides a historical conceptual and methodological overview of the study of intraindividual variability IIV IIV during childhood and adolescence and its application in the investigation of development of language acquisition infant parent interactions development of motor skills cognitive development mood regulation and identity development are examined in Part 2 Part 3 focuses on IIV during adult development including its use in neuropsychological functioning and attention and in personality development and mood regulation IIV in the context of adults health behavior is also reviewed Part 4 examines the key issues and challenges of IIV research in human development such as whether IIV in adult development is an indicator of vulnerability or resilience the association between short term IIV and long term developmental change and multiple time scale design and analysis The volume concludes with a look at the future of intraindividual variation analysis Intended for advanced students and researchers in developmental psychology across the life span social personality and health psychology as well as sociology family studies gerontology education and medicine interested in intraindividual variability of behavior and its role in human development this book also serves as a text for graduate courses on longitudinal analysis multilevel modeling and or advanced data analysis offered in these departments Knowledge in human development or life course sociology and graduate level statistics is recommended

State Space Modeling Of Time Series Book Review: Unveiling the Magic of Language

In a digital era where connections and knowledge reign supreme, the enchanting power of language has become much more apparent than ever. Its capability to stir emotions, provoke thought, and instigate transformation is truly remarkable. This extraordinary book, aptly titled "**State Space Modeling Of Time Series**," compiled by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound impact on our existence. Throughout this critique, we will delve into the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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