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

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

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State Space Modeling Of Time Series:

   State Space Modeling of Time Series Masanao Aoki,2013-03-09 In this book the author adopts a state space approach to time series modeling to provide a new computer oriented method for building models for vector valued time series This second edition has been completely reorganized and rewritten Background material leading up to the two types of estimators of the state space models is collected and presented coherently in four consecutive chapters New fuller descriptions are given of state space models for autoregressive models commonly used in the econometric and statistical literature Backward innovation models are newly introduced in this edition in addition to the forward innovation models and both are used to construct instrumental variable estimators for the model matrices Further new items in this edition include statistical properties of the two types of estimators more details on multiplier analysis and identification of structural models using estimated models incorporation of exogenous signals and choice of model size A whole new chapter is devoted to modeling of integrated nearly integrated and co integrated time series   **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   **Instrument Engineers' Handbook, Volume Two** Bela G. Liptak,2018-10-08 The latest update to Bela Liptak s acclaimed bible of instrument engineering is now available Retaining the format that made the previous editions bestsellers in their own right the fourth edition of Process Control and Optimization continues the tradition of providing quick and easy access to highly practical information The authors are practicing engineers not theoretical people from academia and their from the trenches advice has been repeatedly tested in real life applications Expanded coverage includes descriptions of overseas manufacturer s products and concepts model based optimization in control theory new major inventions and innovations in control valves and a full chapter devoted to safety With more than 2000 graphs figures and tables this all inclusive encyclopedic volume replaces an entire library with one authoritative reference The fourth edition brings the content of the previous editions completely up to date incorporates the developments of the last decade and broadens the horizons of the work from an American to a global perspective B la G Lipt k speaks on Post Oil Energy Technology on the AT T Tech Channel   *Time Series Analysis for the State-Space Model with R/Stan* Junichiro Hagiwara,2021 This book provides a comprehensive and concrete illustration of time series analysis focusing on the state space model which has recently attracted increasing attention in a broad range of fields The major feature of the book lies in its consistent Bayesian

treatment regarding whole combinations of batch and sequential solutions for linear Gaussian and general state space models MCMC and Kalman particle filter The reader is given insight on flexible modeling in modern time series analysis The main topics of the book deal with the state space model covering extensively from introductory and exploratory methods to the latest advanced topics such as real time structural change detection Additionally a practical exercise using R Stan based on real data promotes understanding and enhances the reader s analytical capability **Techniques in Mathematical Modelling** Gautami Devar,2025-02-20 Techniques in Mathematical Modelling is a comprehensive textbook designed to provide students researchers and practitioners with a solid foundation in the principles techniques and applications of mathematical modelling We cover a wide range of topics from fundamental concepts and analytical techniques to validation methods and emerging trends Each chapter includes practical examples case studies and exercises to reinforce learning and demonstrate real world applications Our book emphasizes the interdisciplinary nature of mathematical modelling with applications in physics biology economics engineering social sciences and more We encourage hands on learning through practical exercises simulations and projects allowing readers to apply theoretical concepts to real world scenarios Additionally we explore emerging trends and challenges in the field including advancements in computational techniques data analytics and interdisciplinary collaborations Written in clear and accessible language Techniques in Mathematical Modelling caters to readers with varying levels of mathematical background making it suitable for undergraduate and graduate students as well as professionals **System-Theoretic Methods in Economic Modelling I** S. Mittnik,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 **Probabilistic Machine Learning for Civil Engineers** James-A. Goulet,2020-04-14 An introduction to key concepts and techniques in probabilistic machine learning for civil engineering students and professionals with many step by step examples illustrations and exercises This book introduces probabilistic machine learning concepts to civil engineering students and professionals presenting key approaches and techniques in a way that is accessible to readers without a specialized background in statistics or computer

science It presents different methods clearly and directly through step by step examples illustrations and exercises Having mastered the material readers will be able to understand the more advanced machine learning literature from which this book draws The book presents key approaches in the three subfields of probabilistic machine learning supervised learning unsupervised learning and reinforcement learning It first covers the background knowledge required to understand machine learning including linear algebra and probability theory It goes on to present Bayesian estimation which is behind the formulation of both supervised and unsupervised learning methods and Markov chain Monte Carlo methods which enable Bayesian estimation in certain complex cases The book then covers approaches associated with supervised learning including regression methods and classification methods and notions associated with unsupervised learning including clustering dimensionality reduction Bayesian networks state space models and model calibration Finally the book introduces fundamental concepts of rational decisions in uncertain contexts and rational decision making in uncertain and sequential contexts Building on this the book describes the basics of reinforcement learning whereby a virtual agent learns how to make optimal decisions through trial and error while interacting with its environment **Intelligent Information and Database Systems** Ngoc Thanh Nguyen,Chong-Gun Kim,Adam Janiak,2011-04-16 The two volume set LNAI 6591 and LNCS 6592 constitutes the refereed proceedings of the Third International Conference on Intelligent Information and Database Systems ACIIDS 2011 held in Daegu Korea in April 2011 The 110 revised papers presented together with 2 keynote speeches were carefully reviewed and selected from 310 submissions The papers are thematically divided into two volumes they cover the following topics intelligent database systems data warehouses and data mining natural language processing and computational linguistics semantic Web social networks and recommendation systems technologies for intelligent information systems collaborative systems and applications e business and e commerce systems e learning systems information modeling and requirements engineering information retrieval systems intelligent agents and multi agent systems intelligent information systems intelligent internet systems intelligent optimization techniques object relational DBMS ontologies and knowledge sharing semi structured and XML database systems unified modeling language and unified processes Web services and semantic Web computer networks and communication systems Instrument Engineers' Handbook,(Volume 2) Third Edition Bela G. Liptak,1995-05-15 This third edition of the Instrument Engineers Handbook most complete and respected work on process instrumentation and control helps you Adaptive Systems in Control and Signal Processing 1986 K.J. Aström,B. Wittenmark,2016-07-21 This second IFAC workshop discusses the variety and applications of adaptive systems in control and signal processing The various approaches to adaptive control systems are covered and their stability and adaptability analyzed The volume also includes papers taken from two poster sessions to give a concise and comprehensive overview treatment of this increasingly important field **5th International Meeting on Statistical Climatology** ,1992 Process Control Béla G. Lipták,2013-10-02 Instrument Engineers Handbook Third Edition Process

Control provides information pertinent to control hardware including transmitters controllers control valves displays and computer systems This book presents the control theory and shows how the unit processes of distillation and chemical reaction should be controlled Organized into eight chapters this edition begins with an overview of the method needed for the state of the art practice of process control This text then examines the relative merits of digital and analog displays and computers Other chapters consider the basic industrial annunciators and other alarm systems which consist of multiple individual alarm points that are connected to a trouble contact a logic module and a visual indicator This book discusses as well the data loggers available for process control applications The final chapter deals with the various pump control systems the features and designs of variable speed drives and the metering pumps This book is a valuable resource for engineers

Proceedings of the Statistical Computing Section American Statistical Association. Statistical Computing Section,1996 **Proceedings of the International Symposium on Manufacturing Science and Technology for the 21st Century** Zhou Zhaoying,1994 **A State Space Model Approach to Functional Time Series and Time Series Driven by Differential Equations** Jiabin Wang,2012 This dissertation studies the modeling of time series driven by unobservable processes using state space model New models and methodologies are proposed and applied on a variety of real life examples arising from finance and biology More specifically we mainly consider two types of time series partially observed dynamic systems driven by differential equations and functional time series driven by its feature process The first type of time series data is generated by a hidden dynamic process controlled by some underlying differential equation with a set of unknown parameters We propose a state space approach to fit these models with observation data which is only available at sparsely separated time points as well as with measurement error and estimate the corresponding parameters More specifically we approximate the target nonlinear deterministic stochastic differential equations by difference equations and convert the dynamic into a state space model SSM which is further calibrated by the likelihood calculated from the filtering scheme The first application converts the HIV dynamic into a linear SSM and estimates all HIV viral dynamic parameters successfully without many constraints The second application focus on the well studied ecological SIR model An efficient filtering scheme is proposed to overcome the difficulty caused by the sparsity of the observed data The methodology is illustrated and evaluated in the simulation studies and the analysis of bartonella infection data set %When the coefficients in the converted difference equation only involve the observed time series the system could be formed to a linear state space model and the optimal filtering scheme Kalman Filter could be easily applied to get the likelihood for inferring unknown parameters This is demonstrated in the first application of modeling the HIV dynamic from limited clinical data Simulation studies are conducted to compare the performance of the proposed model with some previous approaches and show superior performance On the clinical data of two individual HIV infected patients treated with antiretroviral therapies the proposed model is successful in estimating all HIV viral dynamic parameters without many constraints on the parameters When the

converted state space model takes a nonlinear form and the stochastic perturbation in the state process is large an efficient filtering scheme taken from the idea in cite doucetPFSDE are proposed It alleviated the large perturbation accumulated over the large time interval between two observations by using a more informed propagation distribution It utilizes the information from next observable data Due to the effectiveness of the filtering scheme a small filter size yields reasonable approximation of the loglikelihood and a multi level grid search is applied to locate the MLE The proposed methodology is applied in the calibration of the well studied ecological SIR model Simulation studies for both deterministic and stochastic SIR models are conducted and shown superior estimation accuracy than existing methods in the SIR model via state space model It is also illustrated in the bartonella infection data set The second part of the thesis applied state space model approach on functional time series driven by its feature process with illustration on two financial data sets We first find the underlying feature process and build its transitional relationship which provides the basis to build a SSM form Then we infer the unknown parameters from likelihood calculated from the filtering scheme The first application analyzes the U S treasury yield curve from January 1985 through June 2000 and proposed a two regime AR model on its feature process level slope and curvature of the yield curve The second application applies the framework on the daily return distributions of the 1000 largest capitalization stocks from 1991 to 2002 A novel skew t distribution is used to fit the target distribution and to extract the parameters of the distribution as the feature process which is further fitted by a vector moving average model Compared to competing models our model shows superior prediction performance in both applications   *System-theoretic Methods in Economic Modelling* E. Y. Rodin,1989   *Proceedings of the 26th IEEE Conference on Decision and Control* ,1987   *INTERNATIONAL JOUNRAL OF FORECASTING* ,2000   **Canadian Journal of Fisheries and Aquatic Sciences** ,2012-10   **Computational Statistics** Yadolah Dodge,Joe Whittaker,1992-08-05 The Role of the Computer in Statistics David Cox Nuffield College Oxford OXIINF U K A classification of statistical problems via their computational demands hinges on four components I the amount and complexity of the data il the specificity of the objectives of the analysis iii the broad aspects of the approach to analysis ill the conceptual mathematical and numerical analytic complexity of the methods Computational requi rements may be limiting in I and ill either through the need for special programming effort or because of the difficulties of initial data management or because of the load of detailed analysis The implications of modern computational developments for statistical work can be illustrated in the context of the study of specific probabilistic models the development of general statistical theory the design of investigations and the analysis of empirical data While simulation is usually likely to be the most sensible way of investigating specific complex stochastic models computerized algebra has an obvious role in the more analyti cal work It seems likely that statistics and applied probability have made insufficient use of developments in numerical analysis associated more with classical applied mathematics in particular in the solution of large systems of ordinary and partial differential equations integral equations and integra differential equations and for the raction

of useful in formation from integral transforms Increasing emphasis on models incorporating specific subject matter considerations is one route to bridging the gap between statistical ana

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