

# SINGULAR SPECTRUM ANALYSIS

A New Tool in Time  
Series Analysis

James B. Elsner  
and  
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# Singular Spectrum Analysis A New Tool In Time Series Analysis

**Nina Golyandina, Anatoly Zhigljavsky**



## **Singular Spectrum Analysis A New Tool In Time Series Analysis:**

**Singular Spectrum Analysis** J.B. Elsner,A.A. Tsonis,2013-03-09 The term singular spectrum comes from the spectral eigenvalue decomposition of a matrix  $A$  into its set spectrum of eigenvalues These eigenvalues  $A$  are the numbers that make the matrix  $A$  AI singular The term singular spectrum analysis is unfortunate since the traditional eigenvalue decomposition involving multivariate data is also an analysis of the singular spectrum More properly singular spectrum analysis SSA should be called the analysis of time series using the singular spectrum Spectral decomposition of matrices is fundamental to much the ory of linear algebra and it has many applications to problems in the natural and related sciences Its widespread use as a tool for time series analysis is fairly recent however emerging to a large extent from applications of dynamical systems theory sometimes called chaos theory SSA was introduced into chaos theory by Fraedrich 1986 and Broomhead and King 1986a Prior to this SSA was used in biological oceanography by Colebrook 1978 In the digi tal signal processing community the approach is also known as the Karhunen Loeve K L expansion Pike et al 1984 Like other techniques based on spectral decomposition SSA is attractive in that it holds a promise for a reduction in the dimen Singular spectrum analysis is sometimes called singular systems analysis or singular spectrum approach vii viii Preface sionality This reduction in dimensionality is often accompanied by a simpler explanation of the underlying physics Singular Spectrum Analysis J.B. Elsner,A.A. Tsonis,1996-10-31 This original new text provides an easily accessible introduction to this important new topic in time series analysis The authors emphasize examples over theoretical explanations and the need for proper and careful statistical tests in the context of data exploration The book s focus is on the application of the method in signal detection filtering and prediction Instructors and students will appreciate the step by step presentation of underlying ideas

**Singular Spectrum Analysis for Time Series** Nina Golyandina,Anatoly Zhigljavsky,2020-11-23 This book gives an overview of singular spectrum analysis SSA SSA is a technique of time series analysis and forecasting combining elements of classical time series analysis multivariate statistics multivariate geometry dynamical systems and signal processing SSA is multi purpose and naturally combines both model free and parametric techniques which makes it a very special and attractive methodology for solving a wide range of problems arising in diverse areas Rapidly increasing number of novel applications of SSA is a consequence of the new fundamental research on SSA and the recent progress in computing and software engineering which made it possible to use SSA for very complicated tasks that were unthinkable twenty years ago In this book the methodology of SSA is concisely but at the same time comprehensively explained by two prominent statisticians with huge experience in SSA The book offers a valuable resource for a very wide readership including professional statisticians specialists in signal and image processing as well as specialists in numerous applied disciplines interested in using statistical methods for time series analysis forecasting signal and image processing The second edition of the book contains many updates and some new material including a thorough discussion on the place of SSA among other

methods and new sections on multivariate and multidimensional extensions of SSA

**Singular Spectrum Analysis for Time Series** Nina Golyandina, Anatoly Zhigljavsky, 2013-01-19 Singular spectrum analysis SSA is a technique of time series analysis and forecasting combining elements of classical time series analysis multivariate statistics multivariate geometry dynamical systems and signal processing SSA seeks to decompose the original series into a sum of a small number of interpretable components such as trend oscillatory components and noise It is based on the singular value decomposition of a specific matrix constructed upon the time series Neither a parametric model nor stationarity are assumed for the time series This makes SSA a model free method and hence enables SSA to have a very wide range of applicability The present book is devoted to the methodology of SSA and shows how to use SSA both safely and with maximum effect Potential readers of the book include professional statisticians and econometricians specialists in any discipline in which problems of time series analysis and forecasting occur specialists in signal processing and those needed to extract signals from noisy data and students taking courses on applied time series analysis

*Singular Spectrum Analysis* Hossein Hassani, Rahim Mahmoudvand, 2018-06-25 This book provides a broad introduction to computational aspects of Singular Spectrum Analysis SSA which is a non parametric technique and requires no prior assumptions such as stationarity normality or linearity of the series This book is unique as it not only details the theoretical aspects underlying SSA but also provides a comprehensive guide enabling the user to apply the theory in practice using the R software Further it provides the user with step by step coding and guidance for the practical application of the SSA technique to analyze their time series databases using R The first two chapters present basic notions of univariate and multivariate SSA and their implementations in R environment The next chapters discuss the applications of SSA to change point detection missing data imputation smoothing and filtering This book is appropriate for researchers upper level students masters level and beyond and practitioners wishing to revive their knowledge of times series analysis or to quickly learn about the main mechanisms of SSA

*Singular Spectrum Analysis with R* Nina Golyandina, Anton Korobeynikov, Anatoly Zhigljavsky, 2018-06-14 This comprehensive and richly illustrated volume provides up to date material on Singular Spectrum Analysis SSA SSA is a well known methodology for the analysis and forecasting of time series Since quite recently SSA is also being used to analyze digital images and other objects that are not necessarily of planar or rectangular form and may contain gaps SSA is multi purpose and naturally combines both model free and parametric techniques which makes it a very special and attractive methodology for solving a wide range of problems arising in diverse areas most notably those associated with time series and digital images An effective comfortable and accessible implementation of SSA is provided by the R package Rssa which is available from CRAN and reviewed in this book Written by prominent statisticians who have extensive experience with SSA the book a presents the up to date SSA methodology including multidimensional extensions in language accessible to a large circle of users b combines different versions of SSA into a single tool c shows the diverse tasks that SSA can be used for d formally describes the main SSA

methods and algorithms and e provides tutorials on the Rssa package and the use of SSA The book offers a valuable resource for a very wide readership including professional statisticians specialists in signal and image processing as well as specialists in numerous applied disciplines interested in using statistical methods for time series analysis forecasting signal and image processing The book is written on a level accessible to a broad audience and includes a wealth of examples hence it can also be used as a textbook for undergraduate and postgraduate courses on time series analysis and signal processing

**Analysis of Time Series Structure** Nina Golyandina,Vladimir Nekrutkin,Anatoly A Zhigljavsky,2001-01-23 Over the last 15 years singular spectrum analysis SSA has proven very successful It has already become a standard tool in climatic and meteorological time series analysis and well known in nonlinear physics and signal processing However despite the promise it holds for time series applications in other disciplines SSA is not widely known among statisticians and econometrists and although the basic SSA algorithm looks simple understanding what it does and where its pitfalls lay is by no means simple

**Analysis of Time Series Structure SSA and Related Techniques** provides a careful lucid description of its general theory and methodology Part I introduces the basic concepts and sets forth the main findings and results then presents a detailed treatment of the methodology After introducing the basic SSA algorithm the authors explore forecasting and apply SSA ideas to change point detection algorithms Part II is devoted to the theory of SSA Here the authors formulate and prove the statements of Part I They address the singular value decomposition SVD of real matrices time series of finite rank and SVD of trajectory matrices Based on the authors original work and filled with applications illustrated with real data sets this book offers an outstanding opportunity to obtain a working knowledge of why when and how SSA works It builds a strong foundation for successfully using the technique in applications ranging from mathematics and nonlinear physics to economics biology oceanology social science engineering financial econometrics and market research

**Nonlinear Time Series Analysis in the Geosciences** Reik V. Donner,2008-08-18 The understanding of dynamical processes in the complex system Earth requires the appropriate analysis of a large amount of data from observations and or model simulations In this volume modern nonlinear approaches are introduced and used to study specific questions relevant to present day geoscience The approaches include spatio temporal methods time frequency analysis dimension analysis in particular for multivariate data nonlinear statistical decomposition methods designed for treating data with uneven sampling or missing values nonlinear correlation and synchronization analysis surrogate data techniques network approaches and nonlinear methods of noise reduction This book aims to present a collection of state of the art scientific contributions used in current studies by some of the world s leading scientists in this field

**Complexity of Seismic Time Series** Tamaz Chelidze,Filippos Vallianatos,Luciano Telesca,2018-05-21 Complexity of Seismic Time Series Measurement and Application applies the tools of nonlinear dynamics to seismic analysis allowing for the revelation of new details in micro seismicity new perspectives in seismic noise and new tools for prediction of seismic events The book summarizes both advances and applications in the field

thus meeting the needs of both fundamental and practical seismology Merging the needs of the classical field and the very modern terms of complexity science this book covers theory and its application to advanced nonlinear time series tools to investigate Earth's vibrations making it a valuable tool for seismologists hazard managers and engineers Covers the topic of Earth's vibrations involving many different aspects of theoretical and observational seismology Identifies applications of advanced nonlinear time series tools for the characterization of these Earth's signals Merges the needs of geophysics with the applications of complexity theory Describes different methodologies to analyze problems not only in the context of geosciences but also those associated with different complex systems across disciplines

*Data Driven Model Learning for Engineers* Guillaume Mercère, 2023-08-09 The main goal of this comprehensive textbook is to cover the core techniques required to understand some of the basic and most popular model learning algorithms available for engineers then illustrate their applicability directly with stationary time series A multi step approach is introduced for modeling time series which differs from the mainstream in the literature Singular spectrum analysis of univariate time series trend and seasonality modeling with least squares and residual analysis and modeling with ARMA models are discussed in more detail As applications of data driven model learning become widespread in society engineers need to understand its underlying principles then the skills to develop and use the resulting data driven model learning solutions After reading this book the users will have acquired the background the knowledge and confidence to i read other model learning textbooks more easily ii use linear algebra and statistics for data analysis and modeling iii explore other fields of applications where model learning from data plays a central role Thanks to numerous illustrations and simulations this textbook will appeal to undergraduate and graduate students who need a first course in data driven model learning It will also be useful for practitioners thanks to the introduction of easy to implement recipes dedicated to stationary time series model learning Only a basic familiarity with advanced calculus linear algebra and statistics is assumed making the material accessible to students at the advanced undergraduate level

*Multiscale Forecasting Models* Lida Mercedes Barba Maggi, 2018-08-23 This book presents two new decomposition methods to decompose a time series in intrinsic components of low and high frequencies The methods are based on Singular Value Decomposition SVD of a Hankel matrix HSVD The proposed decomposition is used to improve the accuracy of linear and nonlinear autoregressive models Linear Autoregressive models AR ARMA and ARIMA and Autoregressive Neural Networks ANNs have been found insufficient because of the highly complicated nature of some time series Hybrid models are a recent solution to deal with non stationary processes which combine pre processing techniques with conventional forecasters some pre processing techniques broadly implemented are Singular Spectrum Analysis SSA and Stationary Wavelet Transform SWT Although the flexibility of SSA and SWT allows their usage in a wide range of forecast problems there is a lack of standard methods to select their parameters The proposed decomposition HSVD and Multilevel SVD are described in detail through time series coming from the transport and fishery sectors Further for comparison

purposes it is evaluated the forecast accuracy reached by SSA and SWT both jointly with AR based models and ANNs

**Statistical Methods in the Atmospheric Sciences** Daniel S. Wilks, 2011-07-04 Statistical Methods in the Atmospheric Sciences Third Edition explains the latest statistical methods used to describe analyze test and forecast atmospheric data This revised and expanded text is intended to help students understand and communicate what their data sets have to say or to make sense of the scientific literature in meteorology climatology and related disciplines In this new edition what was a single chapter on multivariate statistics has been expanded to a full six chapters on this important topic Other chapters have also been revised and cover exploratory data analysis probability distributions hypothesis testing statistical weather forecasting forecast verification and time series analysis There is now an expanded treatment of resampling tests and key analysis techniques an updated discussion on ensemble forecasting and a detailed chapter on forecast verification In addition the book includes new sections on maximum likelihood and on statistical simulation and contains current references to original research Students will benefit from pedagogical features including worked examples end of chapter exercises with separate solutions and numerous illustrations and equations This book will be of interest to researchers and students in the atmospheric sciences including meteorology climatology and other geophysical disciplines Accessible presentation and explanation of techniques for atmospheric data summarization analysis testing and forecasting Many worked examples End of chapter exercises with answers provided

**Time Series Analysis - Recent Advances, New Perspectives and Applications** Jorge Rocha, Sandra Oliveira, Cláudia Viana, 2024-05-22 Time series analysis describes explains and predicts changes in a phenomenon through time People have utilized techniques that add a distinctive spatial dimension to this type of analysis Major applications of spatiotemporal analysis include forecasting epidemics analyzing the development of traffic conditions in urban networks and forecasting backcasting economic risks such as those associated with changing house prices and the occurrence of hazardous events This book includes contributions from researchers scholars and professionals about the most recent theory models and applications for interdisciplinary and multidisciplinary research encircling disciplines of computer science mathematics statistics geography and more in time series analysis and forecasting backcasting

**Nonlinear Dynamics in Geosciences** Anastasios A. Tsonis, James B. Elsner, 2007-10-23 Nonlinear Dynamics in Geosciences is comprised of the proceedings of 20 Years of Nonlinear Dynamics in Geosciences held June 11 16 2006 in Rhodes Greece as part of the Aegean Conferences The volume brings together the most up to date research from the atmospheric sciences hydrology geology and other areas of geosciences and discusses the advances made and the future directions of nonlinear dynamics Topics covered include predictability ensemble prediction nonlinear prediction nonlinear time series analysis low dimensional chaos nonlinear modeling fractals and multifractals bifurcation and other aspects of nonlinear science

**Iterative Methods and Preconditioning for Large and Sparse Linear Systems with Applications** Daniele Bertaccini, Fabio Durastante, 2018-02-19 This book describes in a basic way the most useful and

effective iterative solvers and appropriate preconditioning techniques for some of the most important classes of large and sparse linear systems The solution of large and sparse linear systems is the most time consuming part for most of the scientific computing simulations Indeed mathematical models become more and more accurate by including a greater volume of data but this requires the solution of larger and harder algebraic systems In recent years research has focused on the efficient solution of large sparse and or structured systems generated by the discretization of numerical models by using iterative solvers

**Statistics** Türkmen Göksel, 2018-11-07 Since data grows faster than ever the role of statistics becomes more and more crucial nowadays and there is no doubt that statistics will be even more critical in the future The application of statistics is extensive and in our daily lives there is almost no human activity where the use of statistics is not needed In this limited volume we try to cover as many as different and multidisciplinary fields in statistics as possible and aim to present recent developments and applications of statistical analysis Therefore this book is organized into three sections The Role of Statistics on Quantification Applications of Statistics on Economics and Development and Applications of Statistics on Various Topics

**Hurricanes of the North Atlantic** James B. Elsner, A. Birol Kara, 1999 As people continue to develop coastal areas society's liability to hurricanes will dramatically increase regardless of changes in the environment This book addresses these key issues providing a detailed examination of

**Digital Terrain Analysis in Soil Science and Geology** Igor Florinsky, 2012 This book is the first attempt to synthesize knowledge on theory methods and applications of digital terrain analysis in the context of multiscale problems of soil science and geology The content of the book is based on long standing interdisciplinary research of the author The book is addressed to geomorphometrists soil scientists geologists geoscientists geomorphologists geographers and GIS scientists at scholar lecturer and postgraduate student levels with mathematical skills This book is also intended for the GIS professionals in industry and research laboratories focusing on geoscientific and soil research The book is divided into three parts Part I represents main concepts principles and methods of digital terrain modeling Part II discusses various aspects of the use of digital terrain analysis in soil science Part III looks at applications of digital terrain modeling in geology

*Modeling Atmospheric and Oceanic Flows* Thomas von Larcher, Paul D. Williams, 2014-10-30 *Modeling Atmospheric and Oceanic Flows Insights from Laboratory Experiments and Numerical Simulations* provides a broad overview of recent progress in using laboratory experiments and numerical simulations to model atmospheric and oceanic fluid motions This volume not only surveys novel research topics in laboratory experimentation but also highlights recent developments in the corresponding computational simulations As computing power grows exponentially and better numerical codes are developed the interplay between numerical simulations and laboratory experiments is gaining paramount importance within the scientific community The lessons learnt from the laboratory model comparisons in this volume will act as a source of inspiration for the next generation of experiments and simulations Volume highlights include Topics pertaining to atmospheric science climate physics physical oceanography

marine geology and geophysics Overview of the most advanced experimental and computational research in geophysics Recent developments in numerical simulations of atmospheric and oceanic fluid motion Unique comparative analysis of the experimental and numerical approaches to modeling fluid flow Modeling Atmospheric and Oceanic Flows will be a valuable resource for graduate students researchers and professionals in the fields of geophysics atmospheric sciences oceanography climate science hydrology and experimental geosciences      *Encyclopedia of Mathematical Geosciences* B. S. Daya Sagar,Qiuming Cheng,Jennifer McKinley,Frits Agterberg,2023-07-13 The Encyclopedia of Mathematical Geosciences is a complete and authoritative reference work It provides concise explanation on each term that is related to Mathematical Geosciences Over 300 international scientists each expert in their specialties have written around 350 separate articles on different topics of mathematical geosciences including contributions on Artificial Intelligence Big Data Compositional Data Analysis Geomathematics Geostatistics Geographical Information Science Mathematical Morphology Mathematical Petrology Multifractals Multiple Point Statistics Spatial Data Science Spatial Statistics and Stochastic Process Modeling Each topic incorporates cross referencing to related articles and also has its own reference list to lead the reader to essential articles within the published literature The entries are arranged alphabetically for easy access and the subject and author indices are comprehensive and extensive

This book delves into Singular Spectrum Analysis A New Tool In Time Series Analysis. Singular Spectrum Analysis A New Tool In Time Series Analysis is a vital topic that must be grasped by everyone, from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Singular Spectrum Analysis A New Tool In Time Series Analysis, encompassing both the fundamentals and more intricate discussions.

1. This book is structured into several chapters, namely:
    - Chapter 1: Introduction to Singular Spectrum Analysis A New Tool In Time Series Analysis
    - Chapter 2: Essential Elements of Singular Spectrum Analysis A New Tool In Time Series Analysis
    - Chapter 3: Singular Spectrum Analysis A New Tool In Time Series Analysis in Everyday Life
    - Chapter 4: Singular Spectrum Analysis A New Tool In Time Series Analysis in Specific Contexts
    - Chapter 5: Conclusion
  2. In chapter 1, the author will provide an overview of Singular Spectrum Analysis A New Tool In Time Series Analysis. The first chapter will explore what Singular Spectrum Analysis A New Tool In Time Series Analysis is, why Singular Spectrum Analysis A New Tool In Time Series Analysis is vital, and how to effectively learn about Singular Spectrum Analysis A New Tool In Time Series Analysis.
  3. In chapter 2, the author will delve into the foundational concepts of Singular Spectrum Analysis A New Tool In Time Series Analysis. The second chapter will elucidate the essential principles that need to be understood to grasp Singular Spectrum Analysis A New Tool In Time Series Analysis in its entirety.
  4. In chapter 3, this book will examine the practical applications of Singular Spectrum Analysis A New Tool In Time Series Analysis in daily life. The third chapter will showcase real-world examples of how Singular Spectrum Analysis A New Tool In Time Series Analysis can be effectively utilized in everyday scenarios.
  5. In chapter 4, this book will scrutinize the relevance of Singular Spectrum Analysis A New Tool In Time Series Analysis in specific contexts. The fourth chapter will explore how Singular Spectrum Analysis A New Tool In Time Series Analysis is applied in specialized fields, such as education, business, and technology.
  6. In chapter 5, the author will draw a conclusion about Singular Spectrum Analysis A New Tool In Time Series Analysis. This chapter will summarize the key points that have been discussed throughout the book.
- The book is crafted in an easy-to-understand language and is complemented by engaging illustrations. This book is highly recommended for anyone seeking to gain a comprehensive understanding of Singular Spectrum Analysis A New Tool In Time Series Analysis.

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### **Singular Spectrum Analysis A New Tool In Time Series Analysis Introduction**

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