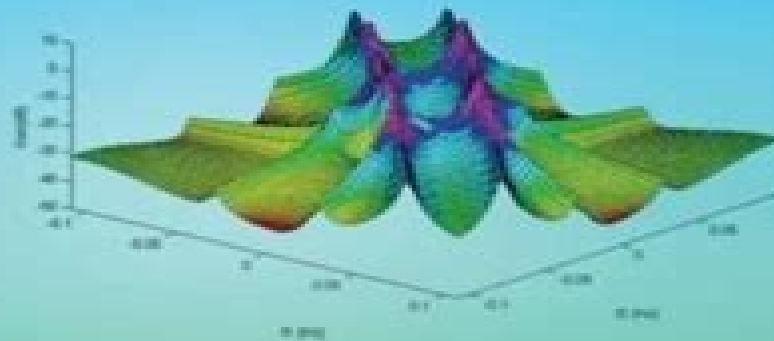


Nonlinear System Identification

NARMAX Methods
in the Time, Frequency,
and Spatio-Temporal Domains



Stephen A Billings

WILEY

Nonlinear System Identification Narmax Methods In The Time Frequency And Spatio Temporal Domains

**George Panoutsos, Mahdi
Mahfouf, Lyudmila S Mihaylova**



Nonlinear System Identification Narmax Methods In The Time Frequency And Spatio Temporal Domains:

Nonlinear System Identification Stephen A. Billings, 2013-07-29 Nonlinear System Identification NARMAX Methods in the Time Frequency and Spatio Temporal Domains describes a comprehensive framework for the identification and analysis of nonlinear dynamic systems in the time frequency and spatio temporal domains This book is written with an emphasis on making the algorithms accessible so that they can be applied and used in practice Includes coverage of The NARMAX nonlinear autoregressive moving average with exogenous inputs model The orthogonal least squares algorithm that allows models to be built term by term where the error reduction ratio reveals the percentage contribution of each model term Statistical and qualitative model validation methods that can be applied to any model class Generalised frequency response functions which provide significant insight into nonlinear behaviours A completely new class of filters that can move split spread and focus energy The response spectrum map and the study of sub harmonic and severely nonlinear systems Algorithms that can track rapid time variation in both linear and nonlinear systems The important class of spatio temporal systems that evolve over both space and time Many case study examples from modelling space weather through identification of a model of the visual processing system of fruit flies to tracking causality in EEG data are all included to demonstrate how easily the methods can be applied in practice and to show the insight that the algorithms reveal even for complex systems NARMAX algorithms provide a fundamentally different approach to nonlinear system identification and signal processing for nonlinear systems NARMAX methods provide models that are transparent which can easily be analysed and which can be used to solve real problems This book is intended for graduates postgraduates and researchers in the sciences and engineering and also for users from other fields who have collected data and who wish to identify models to help to understand the dynamics of their systems

Nonlinear System Identification Stephen A. Billings, 2013-09-23 Nonlinear System Identification NARMAX Methods in the Time Frequency and Spatio Temporal Domains describes a comprehensive framework for the identification and analysis of nonlinear dynamic systems in the time frequency and spatio temporal domains This book is written with an emphasis on making the algorithms accessible so that they can be applied and used in practice Includes coverage of The NARMAX nonlinear autoregressive moving average with exogenous inputs model The orthogonal least squares algorithm that allows models to be built term by term where the error reduction ratio reveals the percentage contribution of each model term Statistical and qualitative model validation methods that can be applied to any model class Generalised frequency response functions which provide significant insight into nonlinear behaviours A completely new class of filters that can move split spread and focus energy The response spectrum map and the study of sub harmonic and severely nonlinear systems Algorithms that can track rapid time variation in both linear and nonlinear systems The important class of spatio temporal systems that evolve over both space and time Many case study examples from modelling space weather through identification of a model of the visual processing system of fruit flies to tracking causality

in EEG data are all included to demonstrate how easily the methods can be applied in practice and to show the insight that the algorithms reveal even for complex systems NARMAX algorithms provide a fundamentally different approach to nonlinear system identification and signal processing for nonlinear systems NARMAX methods provide models that are transparent which can easily be analysed and which can be used to solve real problems This book is intended for graduates postgraduates and researchers in the sciences and engineering and also for users from other fields who have collected data and who wish to identify models to help to understand the dynamics of their systems *Advances in Computational Intelligence Systems*

George Panoutsos, Mahdi Mahfouf, Lyudmila S Mihaylova, 2024-05-18 The scope of this book is to present the papers included at the 21st UK Workshop on Computational Intelligence UKCI 2022 hosted by The University of Sheffield between 7 and 9 September 2022 Sheffield UK This marks the first fully in person UKCI conference following the pandemic a testament to the success and resilience of the UKCI community as well as to the importance of computational intelligence CI research The papers in this book are divided into five sections fuzzy logic systems machine learning hybrid methods and network systems deep learning and neural networks and optimization and search **Recent Advances in Structural Engineering, Volume 1**

A. Rama Mohan Rao, K. Ramanjaneyulu, 2018-08-01 This book is a collection of select papers presented at the Tenth Structural Engineering Convention 2016 SEC 2016 It comprises plenary invited and contributory papers covering numerous applications from a wide spectrum of areas related to structural engineering It presents contributions by academics researchers and practicing structural engineers addressing analysis and design of concrete and steel structures computational structural mechanics new building materials for sustainable construction mitigation of structures against natural hazards structural health monitoring wind and earthquake engineering vibration control and smart structures condition assessment and performance evaluation repair rehabilitation and retrofit of structures Also covering advances in construction techniques practices behavior of structures under blast impact loading fatigue and fracture composite materials and structures and structures for non conventional energy wind and solar it will serve as a valuable resource for researchers students and practicing engineers alike **Adaptive Learning Methods for Nonlinear System Modeling**

Danilo Comminiello, Jose C. Principe, 2018-06-11 Adaptive Learning Methods for Nonlinear System Modeling presents some of the recent advances on adaptive algorithms and machine learning methods designed for nonlinear system modeling and identification Real life problems always entail a certain degree of nonlinearity which makes linear models a non optimal choice This book mainly focuses on those methodologies for nonlinear modeling that involve any adaptive learning approaches to process data coming from an unknown nonlinear system By learning from available data such methods aim at estimating the nonlinearity introduced by the unknown system In particular the methods presented in this book are based on online learning approaches which process the data example by example and allow to model even complex nonlinearities e g showing time varying and dynamic behaviors Possible fields of applications of such algorithms includes distributed sensor

networks wireless communications channel identification predictive maintenance wind prediction network security vehicular networks active noise control information forensics and security tracking control in mobile robots power systems and nonlinear modeling in big data among many others This book serves as a crucial resource for researchers PhD and post graduate students working in the areas of machine learning signal processing adaptive filtering nonlinear control system identification cooperative systems computational intelligence This book may be also of interest to the industry market and practitioners working with a wide variety of nonlinear systems Presents the key trends and future perspectives in the field of nonlinear signal processing and adaptive learning Introduces novel solutions and improvements over the state of the art methods in the very exciting area of online and adaptive nonlinear identification Helps readers understand important methods that are effective in nonlinear system modelling suggesting the right methodology to address particular issues

Nonlinear Dynamics, Volume 1 Gaetan Kerschen, 2025-08-07 Nonlinear Dynamics Volume 1 Proceedings of the 35th IMAC A Conference and Exposition on Structural Dynamics 2017 the first volume of ten from the Conference brings together contributions to this important area of research and engineering The collection presents early findings and case studies on fundamental and applied aspects of Nonlinear Dynamics including papers on Nonlinear System Identification Nonlinear Modeling Simulation Nonlinear Reduced order Modeling Nonlinearity in Practice Nonlinearity in Aerospace Systems Nonlinearity in Multi Physics Systems Nonlinear Modes and Modal Interactions Experimental Nonlinear Dynamics

Neural Network Modeling and Identification of Dynamical Systems Yury Tiumentsev, Mikhail Egorchev, 2019-05-17 Neural Network Modeling and Identification of Dynamical Systems presents a new approach on how to obtain the adaptive neural network models for complex systems that are typically found in real world applications The book introduces the theoretical knowledge available for the modeled system into the purely empirical black box model thereby converting the model to the gray box category This approach significantly reduces the dimension of the resulting model and the required size of the training set This book offers solutions for identifying controlled dynamical systems as well as identifying characteristics of such systems in particular the aerodynamic characteristics of aircraft Covers both types of dynamic neural networks black box and gray box including their structure synthesis and training Offers application examples of dynamic neural network technologies primarily related to aircraft Provides an overview of recent achievements and future needs in this area

System Identification of Stochastic Nonlinear Dynamic Systems using Takagi-Sugeno Fuzzy Models Salman Zaidi, 2019-02-22 Some novel approaches to estimate Nonlinear Output Error NOE models using TS fuzzy models for a class of nonlinear dynamic systems having variability in their outputs is presented in this dissertation Instead of using unrealistic assumptions about uncertainty the most common of which is normality the proposed methodology tends to capture effects caused by the real uncertainty observed in the data The methodology requires that the identification method must be repeated offline a number of times under similar conditions This leads to multiple inputoutput time series from the

underlying system These time series are preprocessed using the techniques of statistics and probability theory to generate the envelopes of response at each time instant By incorporating interval data in fuzzy modelling and using the theory of symbolic interval valued data a TS fuzzy model with interval antecedent and consequent parameters is obtained The proposed identification algorithm provides for a model for predicting the center valued response as well as envelopes as the measure of uncertainty in system output

Intelligent Robotics and Applications Xuguang Lan,Xuesong Mei,Caigui Jiang,Fei Zhao,Zhiqiang Tian,2025-01-21 The 10 volume set LNAI 15201 15210 constitutes the proceedings of the 17th International Conference on Intelligent Robotics and Applications ICIRA 2024 which took place in Xi an China during July 31 August 2 2024 The 321 full papers included in these proceedings were carefully reviewed and selected from 489 submissions They were organized in topical sections as follows Part I Innovative Design and Performance Evaluation of Robot Mechanisms Part II Robot Perception and Machine Learning Cognitive Intelligence and Security Control for Multi domain Unmanned Vehicle Systems Part III Emerging Techniques for Intelligent Robots in Unstructured Environment Soft Actuators and Sensors and Advanced Intelligent and Flexible Sensor Technologies for Robotics Part IV Optimization and Intelligent Control of Underactuated Robotic Systems and Technology and application of modular robots Part V Advanced actuation and intelligent control in medical robotics Advancements in Machine Vision for Enhancing Human Robot Interaction and Hybrid Decision making and Control for Intelligent Robots Part VI Advances in Marine Robotics Visual Linguistic Affective Agents Hybrid augmented Agents for Robotics and Wearable Robots for Assistance Augmentation and Rehabilitation of human movements Part VII Integrating World Models for Enhanced Robotic Autonomy Advanced Sensing and Control Technologies for Intelligent Human Robot Interaction and Mini Invasive Robotics for In Situ Manipulation Part VIII Robot Skill Learning and Transfer Human Robot Dynamic System Learning Modelling and Control AI Driven Smart Industrial Systems and Natural Interaction and Coordinated Collaboration of Robots in Dynamic Unstructured Environments Part IX Robotics in Cooperative Manipulation MultiSensor Fusion and Multi Robot Systems Human machine Co adaptive Interface Brain inspired intelligence for robotics Planning control and application of bionic novel concept robots and Robust Perception for Safe Driving Part X AI Robot Technology for Healthcare as a Service Computational Neuroscience and Cognitive Models for Adaptive Human Robot Interactions Dynamics and Perception of Human Robot Hybrid Systems and Robotics for Rehabilitation Innovations Challenges and Future Directions

Technoscientific Research Roman Z. Morawski,2024-06-04 Unlike the bulk majority of publications on philosophy of science and research ethics which are authored by professional philosophers and intended for philosophers this book has been written by a research practitioner and intended for research practitioners It is distinctive by its integrative approach to methodological and ethical issues related to research practice with special emphasis of mathematical modelling and measurement as well as by attempted application of engineering design methodology to moral decision making It is also distinctive by more than 200 real world examples drawn from various domains of science and

technology It is neither a philosophical treaty nor a quick reference guide It is intended to encourage young researchers especially Ph D students to deeper philosophical reflection over research practice They are not expected to have any philosophical background but encouraged to consult indicated sources of primary information and academic textbooks containing syntheses of information from primary sources This book can be a teaching aid for students attending classes aimed at identification of methodological and ethical issues related to technoscientific research followed by introduction to the methodology of analysing dilemmas arising in this context

Solving Computationally Expensive Engineering Problems
 Slawomir Koziel, Leifur Leifsson, Xin-She Yang, 2014-10-01 Computational complexity is a serious bottleneck for the design process in virtually any engineering area While migration from prototyping and experimental based design validation to verification using computer simulation models is inevitable and has a number of advantages high computational costs of accurate high fidelity simulations can be a major issue that slows down the development of computer aided design methodologies particularly those exploiting automated design improvement procedures e g numerical optimization The continuous increase of available computational resources does not always translate into shortening of the design cycle because of the growing demand for higher accuracy and necessity to simulate larger and more complex systems Accurate simulation of a single design of a given system may be as long as several hours days or even weeks which often makes design automation using conventional methods impractical or even prohibitive Additional problems include numerical noise often present in the simulation data possible presence of multiple locally optimum designs as well as multiple conflicting objectives In this edited book various techniques that can alleviate solving computationally expensive engineering design problems are presented One of the most promising approaches is the use of fast replacement models so called surrogates that reliably represent the expensive simulation based model of the system device of interest but they are much cheaper and analytically tractable Here a group of international experts summarize recent developments in the area and demonstrate applications in various disciplines of engineering and science The main purpose of the work is to provide the basic concepts and formulations of the surrogate based modeling and optimization paradigm as well as discuss relevant modeling techniques optimization algorithms and design procedures Therefore this book should be useful to researchers and engineers from any discipline where computationally heavy simulations are used on daily basis in the design process

New Technologies, Development and Application VI
 Isak Karabegovic, Ahmed Kovačević, Sadko Mandzuka, 2023-05-19 This book features papers focusing on the implementation of new and future technologies which were presented at the International Conference on New Technologies Development and Application held at the Academy of Science and Arts of Bosnia and Herzegovina in Sarajevo on 22-24 June 2023 It covers a wide range of future technologies and technical disciplines including complex systems such as Industry 4.0 patents in industry 4.0 robotics mechatronics systems automation manufacturing cyber physical and autonomous systems sensors networks control energy and renewable energy sources automotive and biological systems

vehicular networking and connected vehicles effectiveness and logistics systems smart grids nonlinear systems power social and economic systems education and IoT This book is oriented towards Fourth Industrial Revolution Industry 4.0 which implementation will improve many aspects of human life in all segments and lead to changes in business paradigms and production models Further new business methods are emerging transforming production systems transport delivery and consumption which need to be monitored and implemented by every company involved in the global market

Machine Learning Techniques for Space Weather Enrico Camporeale, Simon Wing, Jay Johnson, 2018-05-31 Machine Learning Techniques for Space Weather provides a thorough and accessible presentation of machine learning techniques that can be employed by space weather professionals Additionally it presents an overview of real world applications in space science to the machine learning community offering a bridge between the fields As this volume demonstrates real advances in space weather can be gained using nontraditional approaches that take into account nonlinear and complex dynamics including information theory nonlinear auto regression models neural networks and clustering algorithms Offering practical techniques for translating the huge amount of information hidden in data into useful knowledge that allows for better prediction this book is a unique and important resource for space physicists space weather professionals and computer scientists in related fields Collects many representative non traditional approaches to space weather into a single volume Covers in an accessible way the mathematical background that is not often explained in detail for space scientists Includes free software in the form of simple MATLAB scripts that allow for replication of results in the book also familiarizing readers with algorithms

Nonlinear Modeling of Solar Radiation and Wind Speed Time Series Luigi Fortuna, Giuseppe Nunnari, Silvia Nunnari, 2016-06-21 This brief is a clear concise description of the main techniques of time series analysis stationary autocorrelation mutual information fractal and multifractal analysis chaos analysis etc as they are applied to the influence of wind speed and solar radiation on the production of electrical energy from these renewable sources The problem of implementing prediction models is addressed by using the embedding phase space approach a powerful technique for the modeling of complex systems Readers are also guided in applying the main machine learning techniques for classification of the patterns hidden in their time series and so will be able to perform statistical analyses that are not possible by using conventional techniques The conceptual exposition avoids unnecessary mathematical details and focuses on concrete examples in order to ensure a better understanding of the proposed techniques Results are well illustrated by figures and tables

Proceedings of the TEPEN International Workshop on Fault Diagnostic and Prognostic Zuolu Wang, Kai Zhang, Ke Feng, Yuandong Xu, Wenxian Yang, 2024-10-19 This book gathers the latest advances innovations and applications in the field of efficiency and performance engineering as presented by leading international researchers and engineers at the TEPEN International Workshop on Fault Diagnostics and Prognostics TEPEN IWFD held in Qingdao China on May 8-11 2024 Topics include machine and structural health monitoring non destructive testing and fault detection diagnostic and

prognostic for both operational and manufacturing processes maintenance optimization and asset management smart metamaterials and metastructures artificial intelligent and machine learning The contributions which are selected through a rigorous international peer review process share exciting ideas that spur novel research directions and foster new multidisciplinary collaborations

Handbook of Research on Advanced Intelligent Control Engineering and Automation Azar, Ahmad Taher, 2014-11-30 In industrial engineering and manufacturing control of individual processes and systems is crucial to developing a quality final product Rapid developments in technology are pioneering new techniques of research in control and automation with multi disciplinary applications in electrical electronic chemical mechanical aerospace and instrumentation engineering The Handbook of Research on Advanced Intelligent Control Engineering and Automation presents the latest research into intelligent control technologies with the goal of advancing knowledge and applications in various domains This text will serve as a reference book for scientists engineers and researchers as it features many applications of new computational and mathematical tools for solving complicated problems of mathematical modeling simulation and control

Intelligent and Fuzzy Techniques for Emerging Conditions and Digital Transformation Cengiz Kahraman, Selcuk Cebi, Sezi Cevik Onar, Basar Oztaysi, A. Cagri Tolga, Irem Ucal Sari, 2021-08-23 This book presents recent research in intelligent and fuzzy techniques Emerging conditions such as pandemic wars natural disasters and various high technologies force people for significant changes in business and social life The adoption of digital technologies to transform services or businesses through replacing non digital or manual processes with digital processes or replacing older digital technology with newer digital technologies through intelligent systems is the main scope of this book It focuses on revealing the reflection of digital transformation in our business and social life under emerging conditions through intelligent and fuzzy systems The latest intelligent and fuzzy methods and techniques on digital transformation are introduced by theory and applications The intended readers are intelligent and fuzzy systems researchers lecturers M Sc and Ph D students studying digital transformation Usage of ordinary fuzzy sets and their extensions heuristics and metaheuristics from optimization to machine learning from quality management to risk management makes the book an excellent source for researchers

Handbook of Experimental Structural Dynamics Randall Allemang, Peter Avitabile, 2022-06-30 The SEM Handbook of Experimental Structural Dynamics stands as a comprehensive overview and reference for its subject applicable to workers in research product design and manufacture and practice The Handbook is devoted primarily to the areas of structural mechanics served by the Society for Experimental Mechanics IMAC community such as modal analysis rotating machinery structural health monitoring shock and vibration sensors and instrumentation aeroelasticity ground testing finite element techniques model updating sensitivity analysis verification and validation experimental dynamics sub structuring quantification of margin and uncertainty and testing of civil infrastructure Chapters offer comprehensive detailed coverage of decades of scientific and technologic advance and all demonstrate an experimental perspective Several sections specifically

discuss the various types of experimental testing and common practices utilized in the automotive aerospace and civil structures industries History of Experimental Structural Mechanics DIC Methods Dynamic Photogrammetry LDV Methods Applied Digital Signal Processing Introduction to Spectral Basic Measurements Structural Measurements FRF Random and Shock Testing Rotating System Analysis Methods Sensors Signal Conditioning Instrumentation Design of Modal Tests Experimental Modal Methods Experimental Modal Parameter Evaluation Operating Modal Analysis Methods Analytical Numerical Substructuring Finite Element Model Correlation Model Updating Damping of Materials and Structures Model Calibration and Validation in Structures Uncertainty Quantification UQ QMU and Statistics Nonlinear System Analysis Methods Experimental Structural Health Monitoring and Damage Detection Experimental Substructure Modeling Modal Modeling Response Impedance Modeling Nonlinear Normal Mode Analysis Techniques Analytical Modal Modeling with Nonlinear Connection Elements Analytical Acoustics of Structural Systems VibroAcoustics Automotive Structural Testing Civil Structural Testing Aerospace Perspective for Modeling and Validation Sports Equipment Testing Applied Math for Experimental Structural Mechanics Contributions present important theory behind relevant experimental methods as well as application and technology Topical authors emphasize and dissect proven methods and offer detail beyond a simple review of the literature Additionally chapters cover practical needs of scientists and engineers who are new to the field In most cases neither the pertinent theory nor in particular the practical issues have been presented formally in current academic textbooks Each chapter in the Handbook represents a must read for someone new to the subject or for someone returning to the field after an absence Reference lists in each chapter consist of the seminal papers in the literature This Handbook stands in parallel to the SEM Handbook of Experimental Solid Mechanics where this Handbook focuses on experimental dynamics of structures at a macro scale often involving multiple components and materials where the SEM Handbook of Experimental Solid Mechanics focuses on experimental mechanics of materials at a nano scale and or micro scale

Statistical Modeling for Degradation Data Ding-Geng (Din) Chen,Yuhlong Lio,Hon Keung Tony Ng,Tzong-Ru Tsai,2017-08-31 This book focuses on the statistical aspects of the analysis of degradation data In recent years degradation data analysis has come to play an increasingly important role in different disciplines such as reliability public health sciences and finance For example information on products reliability can be obtained by analyzing degradation data In addition statistical modeling and inference techniques have been developed on the basis of different degradation measures The book brings together experts engaged in statistical modeling and inference presenting and discussing important recent advances in degradation data analysis and related applications The topics covered are timely and have considerable potential to impact both statistics and reliability engineering

Recent Advances in AI-enabled Automated Medical Diagnosis Richard Jiang,Li Zhang,Hua-Liang Wei,Danny Crookes,Paul Chazot,2022-10-20 Developments in deep learning in the past decade have led to phenomenal growth in AI based automated medical diagnosis opening a door to a new era of both medical

research and medical industry It is a golden age for researchers involved in the development and application of advanced machine learning techniques for medical and clinical problems This book captures the most recent important advances in this cross disciplinary topic and brings the latest advances to a wide audience including experts researchers students industry developers and medical services

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