



# System Identification Methods And Applications

**Ylva Jung**



## **System Identification Methods And Applications:**

*Identification of Dynamic Systems* Rolf Isermann, Marco Münchhof, 2010-11-22 Precise dynamic models of processes are required for many applications ranging from control engineering to the natural sciences and economics Frequently such precise models cannot be derived using theoretical considerations alone Therefore they must be determined experimentally This book treats the determination of dynamic models based on measurements taken at the process which is known as system identification or process identification Both offline and online methods are presented i e methods that post process the measured data as well as methods that provide models during the measurement The book is theory oriented and application oriented and most methods covered have been used successfully in practical applications for many different processes Illustrative examples in this book with real measured data range from hydraulic and electric actuators up to combustion engines Real experimental data is also provided on the Springer webpage allowing readers to gather their first experience with the methods presented in this book Among others the book covers the following subjects determination of the non parametric frequency response fast Fourier transform correlation analysis parameter estimation with a focus on the method of Least Squares and modifications identification of time variant processes identification in closed loop identification of continuous time processes and subspace methods Some methods for nonlinear system identification are also considered such as the Extended Kalman filter and neural networks The different methods are compared by using a real three mass oscillator process a model of a drive train For many identification methods hints for the practical implementation and application are provided The book is intended to meet the needs of students and practicing engineers working in research and development design and manufacturing *System Identification: Methods and Applications* Harriet H. Natsuyama, 1974

System Identification Lennart Ljung, 1998-12-29 The field's leading text now completely updated Modeling dynamical systems theory methodology and applications Lennart Ljung's *System Identification Theory for the User* is a complete coherent description of the theory methodology and practice of System Identification This completely revised Second Edition introduces subspace methods methods that utilize frequency domain data and general non linear black box methods including neural networks and neuro fuzzy modeling The book contains many new computer based examples designed for Ljung's market leading software *System Identification Toolbox for MATLAB* Ljung combines careful mathematics a practical understanding of real world applications and extensive exercises He introduces both black box and tailor made models of linear as well as non linear systems and he describes principles properties and algorithms for a variety of identification techniques Nonparametric time domain and frequency domain methods Parameter estimation methods in a general prediction error setting Frequency domain data and frequency domain interpretations Asymptotic analysis of parameter estimates Linear regressions iterative search methods and other ways to compute estimates Recursive adaptive estimation techniques Ljung also presents detailed coverage of the key issues that can make or break system identification projects such

as defining objectives designing experiments controlling the bias distribution of transfer function estimates and carefully validating the resulting models The first edition of System Identification has been the field's most widely cited reference for over a decade This new edition will be the new text of choice for anyone concerned with system identification theory and practice

**System Identification** Karel J. Keesman, 2011-05-16 System Identification shows the student reader how to approach the system identification problem in a systematic fashion The process is divided into three basic steps experimental design and data collection model structure selection and parameter estimation and model validation each of which is the subject of one or more parts of the text Following an introduction on system theory particularly in relation to model representation and model properties the book contains four parts covering data based identification non parametric methods for use when prior system knowledge is very limited time invariant identification for systems with constant parameters time varying systems identification primarily with recursive estimation techniques and model validation methods A fifth part composed of appendices covers the various aspects of the underlying mathematics needed to begin using the text The book uses essentially semi physical or gray box modeling methods although data based transfer function system descriptions are also introduced The approach is problem based rather than rigorously mathematical The use of finite input output data is demonstrated for frequency and time domain identification in static dynamic linear nonlinear time invariant and time varying systems Simple examples are used to show readers how to perform and emulate the identification steps involved in various control design methods with more complex illustrations derived from real physical chemical and biological applications being used to demonstrate the practical applicability of the methods described End of chapter exercises for which a downloadable instructors Solutions Manual is available from [fill in URL here](#) will both help students to assimilate what they have learned and make the book suitable for self tuition by practitioners looking to brush up on modern techniques Graduate and final year undergraduate students will find this text to be a practical and realistic course in system identification that can be used for assessing the processes of a variety of engineering disciplines System Identification will help academic instructors teaching control related to give their students a good understanding of identification methods that can be used in the real world without the encumbrance of undue mathematical detail

**Subspace Methods for System Identification** Tohru Katayama, 2005-10-11 An in depth introduction to subspace methods for system identification in discrete time linear systems thoroughly augmented with advanced and novel results this text is structured into three parts Part I deals with the mathematical preliminaries numerical linear algebra system theory stochastic processes and Kalman filtering Part II explains realization theory as applied to subspace identification Stochastic realization results based on spectral factorization and Riccati equations and on canonical correlation analysis for stationary processes are included Part III demonstrates the closed loop application of subspace identification methods Subspace Methods for System Identification is an excellent reference for researchers and a useful text for tutors and graduate students involved in control and signal processing courses It can be

used for self study and will be of interest to applied scientists or engineers wishing to use advanced methods in modeling and identification of complex systems **Inverse system identification with applications in predistortion** Ylva

Jung,2018-12-19 Models are commonly used to simulate events and processes and can be constructed from measured data using system identification The common way is to model the system from input to output but in this thesis we want to obtain the inverse of the system Power amplifiers PAs used in communication devices can be nonlinear and this causes interference in adjacent transmitting channels A prefilter called predistorter can be used to invert the effects of the PA such that the combination of predistorter and PA reconstructs an amplified version of the input signal In this thesis the predistortion problem has been investigated for outphasing power amplifiers where the input signal is decomposed into two branches that are amplified separately by highly efficient nonlinear amplifiers and then recombined We have formulated a model structure describing the imperfections in an outphasing abbrPA and the matching ideal predistorter The predistorter can be estimated from measured data in different ways Here the initially nonconvex optimization problem has been developed into a convex problem The predistorters have been evaluated in measurements The goal with the inverse models in this thesis is to use them in cascade with the systems to reconstruct the original input It is shown that the problems of identifying a model of a preinverse and a postinverse are fundamentally different It turns out that the true inverse is not necessarily the best one when noise is present and that other models and structures can lead to better inversion results To construct a predistorter for a PA for example a model of the inverse is used and different methods can be used for the estimation One common method is to estimate a postinverse and then using it as a preinverse making it straightforward to try out different model structures Another is to construct a model of the system and then use it to estimate a preinverse in a second step This method identifies the inverse in the setup it will be used but leads to a complicated optimization problem A third option is to model the forward system and then invert it This method can be understood using standard identification theory in contrast to the ones above but the model is tuned for the forward system not the inverse Models obtained using the various methods capture different properties of the system and a more detailed analysis of the methods is presented for linear time invariant systems and linear approximations of block oriented systems The theory is also illustrated in examples When a preinverse is used the input to the system will be changed and typically the input data will be different than the original input This is why the estimation of preinverses is more complicated than for postinverses and one set of experimental data is not enough Here we have shown that identifying a preinverse in series with the system in repeated experiments can improve the inversion performance *Bounding Approaches to System Identification* M. Milanese,J. Norton,H. Piet-Lahanier,É. Walter,2013-06-29

In response to the growing interest in bounding error approaches the editors of this volume offer the first collection of papers to describe advances in techniques and applications of bounding of the parameters or state variables of uncertain dynamical systems Contributors explore the application of the bounding approach as an alternative to the probabilistic analysis of such

systems relating its importance to robust control system design      **Applications of Quasilinearization Theory to System Identification** George A. Zupp, Bart Childs, 1969      **Flight Test System Identification** Roger Larsson, 2019-05-15

With the demand for more advanced fighter aircraft relying on unstable flight mechanical characteristics to gain flight performance more focus has been put on model based system engineering to help with the design work The flight control system design is one important part that relies on this modeling Therefore it has become more important to develop flight mechanical models that are highly accurate in the whole flight envelope For today s modern fighter aircraft the basic flight mechanical characteristics change between linear and nonlinear as well as stable and unstable as an effect of the desired capability of advanced maneuvering at subsonic transonic and supersonic speeds This thesis combines the subject of system identification which is the art of building mathematical models of dynamical systems based on measurements with aeronautical engineering in order to find methods for identifying flight mechanical characteristics Here some challenging aeronautical identification problems estimating model parameters from flight testing are treated Two aspects are considered The first is online identification during flight testing with the intent to aid the engineers in the analysis process when looking at the flight mechanical characteristics This will also ensure that enough information is available in the resulting test data for post flight analysis Here a frequency domain method is used An existing method has been developed further by including an Instrumental Variable approach to take care of noisy data including atmospheric turbulence and by a sensor fusion step to handle varying excitation during an experiment The method treats linear systems that can be both stable and unstable working under feedback control An experiment has been performed on a radio controlled demonstrator aircraft For this multisine input signals have been designed and the results show that it is possible to perform more time efficient flight testing compared with standard input signals The other aspect is post flight identification of nonlinear characteristics Here the properties of a parameterized observer approach using a prediction error method are investigated This approach is compared with four other methods for some test cases It is shown that this parameterized observer approach is the most robust one with respect to noise disturbances and initial offsets Another attractive property is that no user parameters have to be tuned by the engineers in order to get the best performance All methods in this thesis have been validated on simulated data where the system is known and have also been tested on real flight test data Both of the investigated approaches show promising results

**Proceedings of the 2nd European Simulation Congress, Sept. 9-12, 1986, The Park Hotel, Antwerp, Belgium** Philippe Geril, 1986      *System Identification* Lennart Ljung, 1999      *Identification and System Parameter Estimation 1982* G. A. Bekey, G. N. Saridis, 2016-06-06

*Identification and System Parameter Estimation 1982* covers the proceedings of the Sixth International Federation of Automatic Control IFAC Symposium The book also serves as a tribute to Dr Naum S Rajbman The text covers issues concerning identification and estimation such as increasing interrelationships between identification estimation and other aspects of system theory including control theory signal

processing experimental design numerical mathematics pattern recognition and information theory The book also provides coverage regarding the application and problems faced by several engineering and scientific fields that use identification and estimation such as biological systems traffic control geophysics aeronautics robotics economics and power systems Researchers from all scientific fields will find this book a great reference material since it presents topics that concern various disciplines

**Nonlinear system identification. 1. Nonlinear system parameter identification** Robert Haber, László Keviczky, 1999 The first of two volumes this handbook presents a comprehensive overview of nonlinear dynamic system parameter identification The volumes cover many aspects of nonlinear processes including modelling parameter estimation structure search nonlinearity and model validity tests

**System Identification (SYSID '03)** Paul Van Den Hof, Bo Wahlberg, Siep Weiland, 2004-06-29 The scope of the symposium covers all major aspects of system identification experimental modelling signal processing and adaptive control ranging from theoretical methodological and scientific developments to a large variety of engineering application areas It is the intention of the organizers to promote SYSID 2003 as a meeting place where scientists and engineers from several research communities can meet to discuss issues related to these areas Relevant topics for the symposium program include Identification of linear and multivariable systems identification of nonlinear systems including neural networks identification of hybrid and distributed systems Identification for control experimental modelling in process control vibration and modal analysis model validation monitoring and fault detection signal processing and communication parameter estimation and inverse modelling statistical analysis and uncertainty bounding adaptive control and data based controller tuning learning data mining and Bayesian approaches sequential Monte Carlo methods including particle filtering applications in process control systems motion control systems robotics aerospace systems bioengineering and medical systems physical measurement systems automotive systems econometrics transportation and communication systems Provides the latest research on System Identification Contains contributions written by experts in the field Part of the IFAC Proceedings Series which provides a comprehensive overview of the major topics in control engineering

**Identification Des Systèmes Pour Le Développement Intégré Des Aéronefs Et Les Essais en Vol**, 1999

**System Identification** R. Isermann, 2014-05-23 System Identification is a special section of the International Federation of Automatic Control IFAC Journal Automatica that contains tutorial papers regarding the basic methods and procedures utilized for system identification Topics include modeling and identification step response and frequency response methods correlation methods least squares parameter estimation and maximum likelihood and prediction error methods After analyzing the basic ideas concerning the parameter estimation methods the book elaborates on the asymptotic properties of these methods and then investigates the application of the methods to particular model structures The text then discusses the practical aspects of process identification which includes the usual general procedures for process identification selection of input signals and sampling time offline and on line identification comparison of parameter

estimation methods data filtering model order testing and model verification Computer program packages are also discussed This compilation of tutorial papers aims to introduce the newcomers and non specialists in this field to some of the basic methods and procedures used for system identification

**Application of System Identification in Engineering** H.G. Natke,2014-05-04 System identification is a powerful tool in engineering Its various methods in the frequency and in the time domain have been extensively discussed in earlier CISM courses The aim of this course is to describe the state of the art in specific application areas such as estimation of eigenquantities in the aerospace industry in civil engineering in naval engineering etc noise source detection fault detection by investigation of dynamic properties such as machine sound characteristics and the identification of the dynamic behaviour of flow induced systems e g aerolastic problems Geotechnical applications are also among the fields of interest The lecture notes contain demonstrations of several methods and include a valuation by combining various kinds of experience Such complex information includes not only theoretical aspects of identification but also advice on practical handling for example concerning testing effort and data handling

Control Applications in Marine Systems 2004 Reza Katebi,Sauro Longhi,2006-01-06 *Methods and Applications of Systems Identification* A. G. Behring,1972 A Schmidt filter is proposed to compute an optimal orthonormal basis for a set of noisy filter input functions Procedures for determining the transfer function and inverse transfer function of the filter are given The Schmidt filter is applied to the problem of determining mathematical models of discrete stationary linear dynamic systems for the case where measurements may be corrupted by noise of unknown statistics The identification problem is reconsidered for the case where noise and signal moments are specified Procedures are given which insure unbiased adaptive estimates of system order and parameters for this case These theoretical propositions are applied to the modeling of speculative prices The stock market is formulated as a discrete linear dynamic system and the results of several simulation studies are presented Evidence indicates that certain segments of the market can be approximated by high order linear systems computed from small samples and tends to refute the random walk hypothesis Computer programs written in PL 1 are presented which allow for efficient digital realization of the theoretical procedures discussed in the body of this work

Abstract leaf iii **An Intelligent Nonlinear System Identification Method with an Application to Condition Monitoring** Clara Echavarria,2015 Neural networks are black box model structures that map inputs to outputs and do not require underlying mathematical models between the two They are frequently used in the field of system identification the area that deals with the development of system models based on input output data In this work a hybrid system identification method is implemented with neural networks NN and the Minimum Model Error estimator MME on different benchmark experimental setups as well as simulations The MME algorithm uses a cost function with a covariance constraint to determine smooth state estimates of a system given noisy measurement data and an assumed model As a byproduct it generates a vector of unmodeled nonlinear or linear system dynamics which can then be modeled by a neural network

Combining this neural network with the assumed model from MME a system plant model is obtained The purpose of neural networks in this research is two fold to demonstrate the advantages of combined MME NN models over some common system identification methods and to investigate the feasibility of using the data stored in the network structure of those models to develop a classification scheme for condition monitoring The approach to classification that is used in this research does not lead to successful implementation of such a scheme Abstract

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