



Nonlinear Model Based Process Control

Edited by

Ridvan Berber and Costas Kravaris

NATO ASI Series

Nonlinear Model Based Process Control

Peter L. Lee



Nonlinear Model Based Process Control:

Nonlinear Model-based Process Control Rashid M. Ansari, Moses O. Tade, 2011-12-12 The series Advances in Industrial Control aims to report and encourage technology transfer in control engineering The rapid development of control technology has an impact on all areas of the control discipline New theory new controllers actuators sensors new industrial processes computer methods new applications new philosophies new challenges Much of this development work resides in industrial reports feasibility study papers and the reports of advanced collaborative projects The series offers an opportunity for researchers to present an extended exposition of such new work in all aspects of industrial control for wider and rapid dissemination The last decade has seen considerable interest in reviving the fortunes of non linear control In contrast to the approaches of the 60S 70S and 80S a very pragmatic agenda for non linear control is being pursued using the model based predictive control paradigm This text by R Ansari and M Tade gives an excellent synthesis of this new direction Two strengths emphasized by the text are i four applications found in refinery processes are used to give the text a firm practical continuity ii a non linear model based control architecture is used to give the method a coherent theoretical framework

Nonlinear Model Based Process Control R. Berber, Costas Kravaris, 2012-12-06 The ASI on Nonlinear Model Based Process Control August 10 20 1997 Antalya Turkey convened as a continuation of a previous ASI which was held in August 1994 in Antalya on Methods of Model Based Process Control in a more general context In 1994 the contributions and discussions convincingly showed that industrial process control would increasingly rely on nonlinear model based control systems Therefore the idea for organizing this ASI was motivated by the success of the first one the enthusiasm expressed by the scientific community for continuing contact and the growing incentive for on line control algorithms for nonlinear processes This is due to tighter constraints and constantly changing performance objectives that now force the processes to be operated over a wider range of conditions compared to the past and the fact that many of industrial operations are nonlinear in nature The ASI intended to review in depth and in a global way the state of the art in nonlinear model based control The list of lecturers consisted of 12 eminent scientists leading the principal developments in the area as well as industrial specialists experienced in the application of these techniques Selected out of a large number of applications there was a high quality active audience composed of 59 students from 20 countries Including family members accompanying the participants the group formed a large body of 92 persons Out of the 71 participants 11 were from industry Nonlinear Model-Based Control R. Russell Rhinehart, 2024-04-22 Nonlinear Model Based Control Using First Principles Models in Process Control First principles models engineering models are used in industry for process design troubleshooting training online analysis and supervisory optimization The author s vision is to use them for control Why They effectively handle nonlinearity nonstationary behavior and interacting variables with just one tuning coefficient per controlled variable CV Using optimization the controller can handle constraints and shape the manipulated variables to achieve desired controlled

variable trajectories Using first principles models for control can also enhance the operational staff's understanding of the process support auxiliary process management and keep the mathematics at the engineers' comfort level In addition unifying all models across diverse process management operations ensures continuity and compatibility The book explains four control techniques using first principles models that have been credibly demonstrated for industrial practice generic model control process model based control predictive functional control and horizon predictive control It illustrates their applications and discusses the pros and cons of each To provide a better understanding of first principles models the book includes examples of setting up functions for controllers and discusses inherent properties such as ease of tuning the handling of nonlinearity and interaction feedforward constraints and the range of operation

Nonlinear Model Based Process Control Ridvan Berber, Costas Kravaris, 1998 The increasingly competitive environment within which modern industry has to work means that processes have to be operated over a wider range of conditions in order to meet constantly changing performance targets Add to this the fact that many industrial operations are nonlinear and the need for on line control algorithms for nonlinear processes becomes clear Major progress has been booked in constrained model based control and important issues of nonlinear process control have been solved This text surveys the state of the art in nonlinear model based control technology by writers who have actually created the scientific profile A broad range of issues are covered in depth from traditional nonlinear approaches to nonlinear model predictive control from nonlinear process identification and state estimation to control integrated design Advances in the control of inverse response and unstable processes are presented Comparisons with linear control are given and case studies are used for illustration

Methods of Model Based Process Control R. Berber, 1995-05-31 Model based control has emerged as an important way to improve plant efficiency in the process industries while meeting processing and operating policy constraints The reader of Methods of Model Based Process Control will find state of the art reports on model based control technology presented by the world's leading scientists and experts from industry All the important issues that a model based control system has to address are covered in depth ranging from dynamic simulation and control relevant identification to information integration Specific emerging topics are also covered such as robust control and nonlinear model predictive control In addition to critical reviews of recent advances the reader will find new ideas industrial applications and views of future needs and challenges Audience A reference for graduate level courses and a comprehensive guide for researchers and industrial control engineers in their exploration of the latest trends in the area

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Model Based Control Paul Serban Agachi,Zoltán K. Nagy,Mircea Vasile Cristea,Árpád Imre-Lucaci,2007-09-24 Filling a gap in the literature for a practical approach to the topic this book is unique in including a whole section of case studies presenting a wide range of applications from polymerization reactors and bioreactors to distillation column and complex fluid catalytic cracking units A section of general tuning guidelines of MPC is also present These thus aid readers in facilitating the implementation of MPC in process engineering and automation At the same time many theoretical computational and implementation aspects of model based control are explained with a look at both linear and nonlinear model predictive control Each chapter presents details related to the modeling of the process as well as the implementation of different model based control approaches and there is also a discussion of both the dynamic behaviour and the economics of industrial processes and plants The book is unique in the broad coverage of different model based control strategies and in the variety of applications presented A special merit of the book is in the included library of dynamic models of several industrially relevant processes which can be used by both the industrial and academic community to study and implement advanced control strategies

Process Structure-Aware Machine Learning Modeling for State Estimation and Model Predictive Control of Nonlinear Processes Mohammed S. Alhajeri,2022 Big data is a cornerstone component of the fourth industrial revolution which calls onengineers and researchers to fully utilize data in order to make smart decisions and enhance the efficiency of industrial processes as well as control systems In practice industrial process control systems typically rely on a data driven model often linear with parameters that are determined by industrial simulation data However in some scenarios such as in profit critical or quality critical control loops first principles concepts that are based on the underlying physico chemical phenomena may also need to be employed in the modeling phase to improve data based process models Hence process systems engineers still face significant challenges when it comes to modeling large scale complicated nonlinear processes Modeling will continue to be crucial since process models are essential components of cutting edge model based control systems such as model predictive control MPC Machine learning models have a lot of potential based on their success in numerousapplications Specifically recurrent neural network RNN models designed to account for every input output interconnection have gained popularity in providing approximation of various highly nonlinear chemical processes to a desired accuracy Although the training error of neural networks that are dense and

fully connected may often be made sufficiently small their accuracy can be further improved by incorporating prior knowledge in the structure development of such machine learning models Physics based recurrent neural networks modeling has yielded more reliable machine learning models than traditional fully black box machine learning modeling methods Furthermore the development of systematic and rigorous approaches to integrate such machine learning techniques into nonlinear model based process control systems is only getting started In particular physics based machine learning modeling techniques can be employed to derive more accurate and well conditioned dynamic process models to be utilized in advanced control systems such as model predictive control Along with Lyapunov based stability constraints this scheme has the potential to significantly improve process operational performance and dynamics Hence investigating the effectiveness of this control scheme under the various long standing challenges in the field of process systems engineering such as incomplete state measurements and noise and uncertainty is essential Also a theoretical framework for constructing and assessing the generalizability of this type of machine learning models to be utilized in model predictive control systems is lacking In light of the aforementioned considerations this dissertation addresses the incorporation of prior process knowledge into machine learning models for model predictive control of nonlinear chemical processes The motivation background and outline of this dissertation are first presented Then the use of machine learning modeling techniques to construct two different data driven state observers to compensate for incomplete process measurements is presented The closed loop stability under Lyapunov based model predictive controllers is then addressed Next the development of process structure based machine learning models to approximate large nonlinear chemical processes is presented with the improvements yielded by this approach demonstrated via open loop and closed loop simulations Subsequently the reliability of process structure based machine learning models is investigated in the presence of different types of industrial noise Two novel approaches are proposed to enhance the accuracy of machine learning models in the presence of noise Lastly a theoretical framework that connects the accuracy of an RNN model to its structure is presented where an upper bound on a physics based RNN model s generalization error is established Nonlinear chemical process examples are numerically simulated or modeled in Aspen Plus Dynamics to illustrate the effectiveness and performance of the proposed control methods throughout the dissertation

Nonlinear Process Control: Peter L. Lee, 2012-12-06 It is a valuable contribution to the task of filling the theory and practice gap that exists in Process Control The volume editor has drawn together a number of industrial case studies where Generic Model Control has been successfully applied Each case study is documented and described in detail Nonlinear Process Control will be of particular interest to industrial practitioners It provides a tutorial introduction to Generic Model Control and assists them in applying modern control methods to their processes Model Based Process Control International Federation of Automatic Control, 1989-03-30 Presented at this workshop were mathematical models upon which process control is based and the practical applications of this method of control within industry case studies include

examples from the paper and pulp industry materials industry and the chemical industry among others From these presentations emerged a need for further research and development into process control Containing 19 papers these Proceedings will be a valuable reference work for all those involved in the designing of continuous production processes for industry and for the end user involved in the practical application of process control within their manufacturing process

Techniques of Model-based Control Coleman Brosilow, Babu Joseph, 2002 Annotation In this book two of the field's leading experts bring together powerful advances in model based control for chemical process engineering From start to finish Coleman Brosilow and Babu Joseph introduce practical approaches designed to solve real world problems not just theory The book contains extensive examples and exercises and an accompanying CD ROM contains hands on MATLAB files that supplement the examples and help readers solve the exercises a feature found in no other book on the topic

Nonlinear Model Based Control with Application to Polymerization Reactors Michael P. Niemiec, 2000 **AICHE Symposium Series** American Institute of Chemical Engineers, 1997 **Nonlinear Model-based Multivariable Control of Refinery Processes** Rashid Muhammad Ansari, 1998 One of the key objectives of the applied research work in this thesis was to develop and implement in real time the nonlinear model based multivariable control and constraint optimization algorithms on various refinery processes with strong nonlinearities and process interaction The implementation of these strategies and techniques in real time has demonstrated an improved control performance over linear control emphasizing the need of a high performance model based nonlinear multivariable control system **Digital Computer Applications to Process Control**, 1986 *The Proceedings of the Third IEEE Conference on Control Applications* IEEE Control Systems Society, 1994 **Proceedings of the 1991 American Control Conference**, 1991 *Proceedings of the National Science Council, Republic of China*, 1995 CJChE, 2007-08 **Chemical Process Control-V** Jeffrey C. Kantor, Carlos E. García, Brice Carnahan, 1997

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