Matthew Ellis
Jinfeng Liu
Panagiotis D. Christofides

Economic Model Predictive Control

Theory, Formulations and Chemical Process Applications

AIC

Springer

Fundamentals Of Economic Model Predictive Control

Simon Pirkelmann

Fundamentals Of Economic Model Predictive Control:

Distributed and economic model predictive control: beyond setpoint stabilization Matthias A. Müller,2014 In this thesis we study model predictive control MPC schemes for control tasks which go beyond the classical objective of setpoint stabilization In particular we consider two classes of such control problems namely distributed MPC for cooperative control in networks of multiple interconnected systems and economic MPC where the main focus is on the optimization of some general performance criterion which is possibly related to the economics of a system The contributions of this thesis are to analyze various systems theoretic properties occurring in these type of control problems and to develop distributed and economic MPC schemes with certain desired closed loop guarantees To be more precise in the field of distributed MPC we propose different algorithms which are suitable for general cooperative control tasks in networks of interacting systems We show that the developed distributed MPC frameworks are such that the desired cooperative goal is achieved while coupling constraints between the systems are satisfied Furthermore we discuss implementation and scalability issues for the derived algorithms as well as the necessary communication requirements between the systems In the field of economic MPC the contributions of this thesis are threefold Firstly we analyze a crucial dissipativity condition in particular its necessity for optimal steady state operation of a system and its robustness with respect to parameter changes Secondly we develop economic MPC schemes which also take average constraints into account Thirdly we propose an economic MPC framework with self tuning terminal cost and a generalized terminal constraint and we show how self tuning update rules for the terminal weight can be derived such that desirable closed loop performance bounds can be established **Economic Model Predictive Control** Matthew Ellis,Jinfeng Liu,Panagiotis D. Christofides,2016-07-27 This book presents general methods for the design of economic model predictive control EMPC systems for broad classes of nonlinear systems that address key theoretical and practical considerations including recursive feasibility closed loop stability closed loop performance and computational efficiency Specifically the book proposes Lyapunov based EMPC methods for nonlinear systems two tier EMPC architectures that are highly computationally efficient and EMPC schemes handling explicitly uncertainty time varying cost functions time delays and multiple time scale dynamics The proposed methods employ a variety of tools ranging from nonlinear systems analysis through Lyapunov based control techniques to nonlinear dynamic optimization The applicability and performance of the proposed methods are demonstrated through a number of chemical process examples The book presents state of the art methods for the design of economic model predictive control systems for chemical processes In addition to being mathematically rigorous these methods accommodate key practical issues for example direct optimization of process economics time varying economic cost functions and computational efficiency Numerous comments and remarks providing fundamental understanding of the merging of process economics and feedback control into a single framework are included A control engineer can easily tailor the many detailed examples of industrial

relevance given within the text to a specific application The authors present a rich collection of new research topics and references to significant recent work making Economic Model Predictive Control an important source of information and inspiration for academics and graduate students researching the area and for process engineers interested in applying its ideas   **Performance and Constraint Satisfaction in Robust Economic Model Predictive Control** Florian A. Bayer ,2017 In this thesis we develop a novel framework for model predictive control MPC which combines the concepts of robust MPC and economic MPC The goal of this thesis is to develop and analyze MPC schemes for nonlinear discrete time systems which explicitly consider the influence of disturbances on arbitrary performance criteria Instead of regarding the two aspects separately we propose robust economic MPC approaches that integrate information which is available about the disturbance directly into the economic framework In more detail we develop three concepts which differ in which information about the disturbance is used and how this information is taken into account Furthermore we provide a thorough theoretical analysis for each of the three approaches To this end we present results on the asymptotic average performance as well as on optimal operating regimes Optimal operating regimes are closely related to the notion of dissipativity which is therefore analyzed for the presented concepts Under suitable assumptions results on necessity and sufficiency of dissipativity for optimal steady state operation are established for all three robust economic MPC concepts A detailed discussion is provided which compares the different performance statements derived for the approaches as well as the respective notions of dissipativity

Handbook of Model Predictive Control Saša V. Raković,William S. Levine,2018-09-01 Recent developments in model predictive control promise remarkable opportunities for designing multi input multi output control systems and improving the control of single input single output systems This volume provides a definitive survey of the latest model predictive control methods available to engineers and scientists today The initial set of chapters present various methods for managing uncertainty in systems including stochastic model predictive control With the advent of affordable and fast computation control engineers now need to think about using computationally intensive controls so the second part of this book addresses the solution of optimization problems in real time for model predictive control The theory and applications of control theory often influence each other so the last section of Handbook of Model Predictive Control rounds out the book with representative applications to automobiles healthcare robotics and finance The chapters in this volume will be useful to working engineers scientists and mathematicians as well as students and faculty interested in the progression of control theory Future developments in MPC will no doubt build from concepts demonstrated in this book and anyone with an interest in MPC will find fruitful information and suggestions for additional reading   *Coulson and Richardson's Chemical Engineering* Sohrab Rohani,2017-08-23 Coulson and Richardson s Chemical Engineering Volume 3B Process Control Fourth Edition covers reactor design flow modeling and gas liquid and gas solid reactions and reactors Converted from textbooks into fully revised reference material Content ranges from foundational through to technical Added emerging applications

numerical methods and computational tools *Solving Urban Infrastructure Problems Using Smart City Technologies* John R. Vacca,2020-09-22 Solving Urban Infrastructure Problems Using Smart City Technologies is the most complete guide for integrating next generation smart city technologies into the very foundation of urban areas worldwide showing how to make urban areas more efficient more sustainable and safer Smart cities are complex systems of systems that encompass all aspects of modern urban life A key component of their success is creating an ecosystem of smart infrastructures that can work together to enable dynamic real time interactions between urban subsystems such as transportation energy healthcare housing food entertainment work social interactions and governance Solving Urban Infrastructure Problems Using Smart City Technologies is a complete reference for building a holistic system level perspective on smart and sustainable cities leveraging big data analytics and strategies for planning zoning and public policy It offers in depth coverage and practical solutions for how smart cities can utilize resident s intellectual and social capital press environmental sustainability increase personalization mobility and higher quality of life Brings together experts from academia government and industry to offer state of the art solutions for urban system problems showing how smart technologies can be used to improve the lives of the billions of people living in cities across the globe Demonstrates practical implementation solutions through real life case studies Enhances reader comprehension with learning aid such as hands on exercises questions and answers checklists chapter summaries chapter review questions exercise problems and more **Real-time Monitoring and Operational Control of Drinking-Water Systems** Vicenç Puig,Carlos Ocampo-Martínez,Ramon Pérez,Gabriela Cembrano,Joseba Quevedo,Teresa Escobet,2017-05-18 This book presents a set of approaches for the real time monitoring and control of drinking water networks based on advanced information and communication technologies It shows the reader how to achieve significant improvements in efficiency in terms of water use energy consumption water loss minimization and water quality guarantees The methods and approaches presented are illustrated and have been applied using real life pilot demonstrations based on the drinking water network in Barcelona Spain The proposed approaches and tools cover decision making support for real time optimal control of water transport networks explaining how stochastic model predictive control algorithms that take explicit account of uncertainties associated with energy prices and real demand allow the main flow and pressure actuators pumping stations and pressure regulation valves and intermediate storage tanks to be operated to meet demand using the most sustainable types of source and with minimum electricity costs decision making support for monitoring water balance and distribution network quality in real time implementing fault detection and diagnosis techniques and using information from hundreds of flow pressure and water quality sensors together with hydraulic and quality parameter evolution models to detect and locate leaks in the network possible breaches in water quality and failures in sensors and or actuators consumer demand prediction based on smart metering techniques producing detailed analyses and forecasts of consumption patterns providing a customer communications service and suggesting economic measures intended to promote

more efficient use of water at the household level Researchers and engineers working with drinking water networks will find this a vital support in overcoming the problems associated with increased population environmental sensitivities and regulation aging infrastructures energy requirements and limited water sources *Dynamic Modeling, Predictive Control and Performance Monitoring* Biao Huang,Ramesh Kadali,2008-03-02 A typical design procedure for model predictive control or control performance monitoring consists of 1 identification of a parametric or nonparametric model 2 derivation of the output predictor from the model 3 design of the control law or calculation of performance indices according to the predictor Both design problems need an explicit model form and both require this three step design procedure Can this design procedure be simplified Can an explicit model be avoided With these questions in mind the authors eliminate the first and second step of the above design procedure a data driven approach in the sense that no traditional parametric models are used hence the intermediate subspace matrices which are obtained from the process data and otherwise identified as a first step in the subspace identification methods are used directly for the designs Without using an explicit model the design procedure is simplified and the modelling error caused by parameterization is eliminated **Perry's Chemical Engineers' Handbook, 9th Edition** Don W. Green,Marylee Z. Southard,2018-07-13 Up to Date Coverage of All Chemical Engineering Topics from the Fundamentals to the State of the Art Now in its 85th Anniversary Edition this industry standard resource has equipped generations of engineers and chemists with vital information data and insights Thoroughly revised to reflect the latest technological advances and processes Perry s Chemical Engineers Handbook Ninth Edition provides unsurpassed coverage of every aspect of chemical engineering You will get comprehensive details on chemical processes reactor modeling biological processes biochemical and membrane separation process and chemical plant safety and much more This fully updated edition covers Unit Conversion Factors and Symbols Physical and Chemical Data including Prediction and Correlation of Physical Properties Mathematics including Differential and Integral Calculus Statistics Optimization Thermodynamics Heat and Mass Transfer Fluid and Particle Dynamics Reaction Kinetics Process Control and Instrumentation Process Economics Transport and Storage of Fluids Heat Transfer Operations and Equipment Psychrometry Evaporative Cooling and Solids Drying Distillation Gas Absorption and Gas Liquid System Design Liquid Liquid Extraction Operations and Equipment Adsorption and Ion Exchange Gas Solid Operations and Equipment Liquid Solid Operations and Equipment Solid Solid Operations and Equipment Chemical Reactors Bio based Reactions and Processing Waste Management including Air Wastewater and Solid Waste Management Process Safety including Inherently Safer Design Energy Resources Conversion and Utilization Materials of Construction *Economic Model Predictive Control of Nonlinear Process Systems Using Empirical Models* Anas Wael Alanqar,2015 Economic model predictive control EMPC is a feedback control technique that attempts to tightly integrate economic optimization and feedback control since it is a predictive control scheme that is formulated with an objective function representing the process economics As its name implies EMPC

requires the availability of a dynamic model to compute its control actions and such a model may be obtained either through application of first principles or though system identification techniques However in industrial practice it may be difficult in general to obtain an accurate first principles model of the process Motivated by this in the present work Lyapunov based economic model predictive control LEMPC is designed with an empirical model that allows for closed loop stability guarantees in the context of nonlinear chemical processes Specifically when the linear model provides a sufficient degree of accuracy in the region where time varying economically optimal operation is considered conditions for closed loop stability under the LEMPC scheme based on the empirical model are derived The LEMPC scheme is applied to a chemical process example to demonstrate its closed loop stability and performance properties as well as significant computational advantages

Chemical Engineering Progress ,2009   *Applied Science & Technology Index* ,1997   **An Empirical Study of the Explanatory Power of Macroeconomic Variables on Malaysian Stock Market** Kai Loon Chung,2009   **Journal of Economic Dynamics & Control** ,2002   **Economic Model Predictive Control and Time-Varying Systems** Simon Pirkelmann,2020   **Cumulated Index to the Books** ,1999   **Consumer Confidence and Economic Fluctuations** John G. Matsusaka,1993   The Chemical Engineer ,2008   **Robust Economic Model Predictive Control** Zihang Dong,2019   **Index to Theses with Abstracts Accepted for Higher Degrees by the Universities of Great Britain and Ireland and the Council for National Academic Awards** ,2005

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