

Advances in Industrial Control

Matthew Ellis
Jinfeng Liu
Panagiotis D. Christofides

Economic Model Predictive Control

AIC

 Springer

Fundamentals Of Economic Model Predictive Control

Dominique Bonvin



Fundamentals Of Economic Model Predictive Control:

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

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

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

New Directions on Model Predictive Control Jinfeng Liu,Helen E Durand,2019-01-16 This book is a printed edition of the Special Issue *New Directions on Model Predictive Control* that was published in *Mathematics*

[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

Real-Time Optimization Dominique Bonvin,2018-07-05 This book is a printed edition of the Special Issue *Real Time Optimization* that was published in *Processes*

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 residents 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

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 through 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

Economic Model Predictive Control and Time-Varying Systems Simon Pirkelmann, 2020 *Perry's Chemical Engineers' Handbook* Robert H. Perry, Don W. Green, James O. Maloney, 1997 Reference work for chemical and process engineers Newest developments advances achievements and methods in various fields [Economic Model Predictive Control for Time-Varying System: Performance and Stability Results](#) Lars Grüne, Simon Pirkelmann, 2018 **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 *Linear and Nonlinear Distributed Economic Model Predictive Control* Jaehwa Lee, 2013 **Model Predictive Control** Aris Daniilidis, Lars Grüne, Josef Haunschmied, Gernot Tragler, 2025-06-07 The book explores the field of model predictive control MPC It reports on the latest developments in MPC current applications and presents various subfields of MPC The book features topics such as uncertain and stochastic MPC variants learning and neural network approaches easy to use numerical implementations as well as multi agent systems and scheduling and coordination tasks While MPC is rooted in engineering science this book illustrates the potential of using MPC theory and methods in non engineering sciences and applications such as economics finance and environmental sciences *Robust Economic Model Predictive Control* Zihang Dong, 2019 [Economic Model Predictive Control Without Terminal Constraints: Optimal Periodic Operation](#) Matthias A. Müller, Lars Grüne, 2015 **Distributed Economic Model Predictive Control: Cost-efficient Operation of Interconnected Systems** Philipp N. Köhler, 2020 **Closed-loop Performance Analysis for Economic Model Predictive Control of Time-varying Systems** Lars Grüne, Simon Pirkelmann, 2017 [Chemical Engineering Progress](#), 2009 **Economic Model Predictive Control Using Data-Based Empirical Models** ANAS W. I. ALANQAR, 2017 The increasingly competitive and continuously changing world economy has made it necessary to exploit the economic potential of chemical processes which has led engineers to economically optimize process operation to provide long term economic growth Approaches for increasing the profitability of industrial processes include directly incorporating process economic considerations into the system's operation and control policy A fairly recent control strategy termed

economic model predictive control EMPC is capable of coordinating dynamic economic plant optimization with a feedback control policy to allow real time energy management The key underlying assumption to design and apply an EMPC is that a process system dynamic model is available to predict the future process state evolution Constructing models of dynamical systems is done either through first principles and or from process input output data First principle models attempt to account for the essential mechanisms behind the observed physico chemical phenomena However arriving at a first principles model may be a challenging task for complex and or poorly understood processes in which system identification serves as a suitable alternative Motivated by this the first part of my doctoral research has focused on introducing novel economic model predictive control schemes that are designed utilizing models obtained from advanced system identification methods Various system identification schemes were investigated in the EMPC designs including linear modeling multiple models and on line model identification On line model identification is used to obtain more accurate models when the linear empirical models are not capable of capturing the nonlinear dynamics as a result of significant plant disturbances and variations actuator faults or when it is desired to change the region of operation An error triggered on line model identification approach is introduced where a moving horizon error detector is used to quantify prediction error and trigger model re identification when necessary The proposed EMPC schemes presented great economic benefit precise predictions and significant computational time reduction These benefits indicate the effectiveness of the proposed EMPC schemes in practical industrial applications The second part of the dissertation focuses on EMPC that utilizes well conditioned polynomial nonlinear state space PNLSS models for processes with nonlinear dynamics A nonlinear system identification technique is introduced for a broad class of nonlinear processes which leads to the construction of polynomial nonlinear state space dynamic models which are well conditioned with respect to explicit numerical integration methods This development allows using time steps that are significantly larger than the ones required by nonlinear state space models identified via existing techniques Finally the dissertation concludes by investigating the use of EMPC in tracking a production schedule Specifically given that only a small subset of the total process state vector is typically required to track certain production schedules a novel EMPC is introduced scheme that forces specific process states to meet the production schedule and varies the rest of the process states in a way that optimizes process economic performance

The Enigmatic Realm of **Fundamentals Of Economic Model Predictive Control**: Unleashing the Language is Inner Magic

In a fast-paced digital era where connections and knowledge intertwine, the enigmatic realm of language reveals its inherent magic. Its capacity to stir emotions, ignite contemplation, and catalyze profound transformations is nothing short of extraordinary. Within the captivating pages of **Fundamentals Of Economic Model Predictive Control** a literary masterpiece penned by a renowned author, readers set about a transformative journey, unlocking the secrets and untapped potential embedded within each word. In this evaluation, we shall explore the book's core themes, assess its distinct writing style, and delve into its lasting impact on the hearts and minds of those who partake in its reading experience.

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