Fundamentals of Economic Model Predictive Control

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CDC Meeting
Maui, HI
December 10-14, 2012

Fundamentals Of Economic Model Predictive Control

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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 **Introduction to Process Control** Jose A. Romagnoli,Ahmet Palazoglu,2020-07-14 Introduction to Process Control Third Edition continues to provide a bridge between traditional and modern views of process control by

blending conventional topics with a broader perspective of integrated process operation control and information systems Updated and expanded throughout this third edition addresses issues highly relevant to today s teaching of process control Discusses smart manufacturing new data preprocessing techniques and machine learning and artificial intelligence concepts that are part of current smart manufacturing decisions Includes extensive references to guide the reader to the resources needed to solve modeling classification and monitoring problems Introduces the link between process optimization and process control optimizing control including the effect of disturbances on the optimal plant operation the concepts of steady state and dynamic back off as ways to quantify the economic benefits of control and how to determine an optimal transition policy during a planned production change Incorporates an introduction to the modern architectures of industrial computer control systems with real case studies and applications to pilot scale operations Analyzes the expanded role of process control in modern manufacturing including model centric technologies and integrated control systems Integrates data processing reconciliation and intelligent monitoring in the overall control system architecture Drawing on the authors combined 60 years of teaching experiences this classroom tested text is designed for chemical engineering students but is also suitable for industrial practitioners who need to understand key concepts of process control and how to implement them The text offers a comprehensive pedagogical approach to reinforce learning and presents a concept first followed by an example allowing students to grasp theoretical concepts in a practical manner and uses the same problem in each chapter culminating in a complete control design strategy A vast number of exercises throughout ensure readers are supported in their learning and comprehension Downloadable MATLAB toolboxes for process control education as well as the main simulation examples from the book offer a user friendly software environment for interactively studying the examples in the text These can be downloaded from the publisher s website Solutions manual is available for qualifying professors from the publisher *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 **Relaxed Barrier Function Based Model Predictive Control** Christian Feller,2017 In this thesis we introduce the novel concept of relaxed barrier function based model predictive control and present a comprehensive theoretical and algorithmic framework for the design analysis and implementation of relaxed barrier function based MPC approaches Instead of treating the underlying optimization as an idealized static map a key motive of the MPC results and algorithms presented in this thesis is to study the interconnected dynamics of controlled plant and iterative optimization algorithm in an integrated barrier function based framework and to analyze the resulting overall closed loop system both from a systems theoretic and algorithmic perspective One of the presented main results is a novel class of barrier function based anytime MPC algorithms that guarantee important properties of the closed loop system independently of the number of optimization algorithm iterations that are performed at each sampling step The obtained theoretical results are illustrated by various numerical examples and benchmark tests as well as by an experimental case

study in which the proposed class of barrier function based MPC algorithms is applied to the predictive control of a self driving car **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 **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 **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 *13th International Symposium on Process Systems Engineering – PSE 2018, July 1-5 2018* Mario R. Eden,Gavin Towler,Maria Ierapetritou,2018-07-19 Process Systems Engineering brings together the international community of researchers and engineers interested in computing based methods in process engineering This conference highlights the contributions of the PSE community towards the sustainability of modern society and is based on the 13th International Symposium on Process Systems Engineering PSE 2018 event held San Diego CA July 1 5 2018 The book contains contributions from academia and industry establishing the core products of PSE defining the new and changing scope of our results and future challenges Plenary and keynote lectures discuss real world challenges globalization energy environment and health and contribute to discussions on the widening scope of PSE versus the consolidation of the core topics of PSE Highlights how the Process Systems Engineering community contributes to the sustainability of modern society Establishes the core products of Process Systems Engineering Defines the future challenges of Process Systems Engineering

27th European Symposium on Computer Aided Process Engineering ,2017-09-21 27th European Symposium on Computer Aided Process Engineering Volume 40 contains the papers presented at the 27th European Society of Computer Aided Process Engineering ESCAPE event held in Barcelona October 1 5 2017 It is a valuable resource for chemical engineers chemical process engineers researchers in industry and academia students and consultants for chemical industries Presents findings and discussions from the 27th European Society of Computer Aided Process Engineering ESCAPE event

Predictive Control Yugeng Xi,Dewei Li,2019-06-28 This book is a comprehensive introduction to model predictive control MPC including its basic principles and algorithms system analysis and design methods strategy developments and practical applications The main contents of the book include an overview of the development trajectory and basic principles of MPC typical MPC algorithms quantitative analysis of classical MPC systems design and tuning methods for MPC parameters constrained multivariable MPC algorithms and online optimization decomposition methods Readers will then progress to more advanced topics such as nonlinear MPC and its related algorithms the diversification development of MPC with respect to control structures and optimization strategies and robust MPC Finally applications of MPC and its generalization to optimization based dynamic problems other than control will be discussed Systematically introduces

fundamental concepts basic algorithms and applications of MPC Includes a comprehensive overview of MPC development emphasizing recent advances and modern approaches Features numerous MPC models and structures based on rigorous research Based on the best selling Chinese edition which is a key text in China Predictive Control Fundamentals and Developments is written for advanced undergraduate and graduate students and researchers specializing in control technologies It is also a useful reference for industry professionals engineers and technicians specializing in advanced optimization control technology Advanced Solutions in Diagnostics and Fault Tolerant Control Jan M. Kościelny,Michał Syfert,Anna Sztyber,2017-07-28 This book highlights the latest achievements concerning the theory methods and practice of fault diagnostics fault tolerant systems and cyber safety When considering the diagnostics of industrial processes and systems increasingly important safety issues cannot be ignored In this context diagnostics plays a crucial role as a primary measure of the improvement of the overall system safety integrity level Obtaining the desired diagnostic coverage or providing an appropriate level of inviolability of the integrity of a system is now practically inconceivable without the use of fault detection and isolation methods Given the breadth and depth of its coverage the book will be of interest to researchers faced with the challenge of designing technical and medical diagnosis systems as well as junior researchers and students in the fields of automatic control robotics computer science and artificial intelligence **Alternative Energy Sources and Technologies** Mariano Martín,2016-03-22 Presenting a comprehensive analysis of the use of alternative sources of energy and technologies to produce fuels and power this book describes the energy value chain from harvesting the raw material i e solar wind biomass or shale gas followed by analysis of the processing steps into power fuels and or chemicals and finally the distribution of the products Featuring an examination of the techno economic processes and integration opportunities which can add value to by products or promote the use of different sources of energy within the same facility this book looks at the tools that can make this integration possible as well as utilising a real world case study The case study of the operation of El hierro island is used as an example of the current effort towards more efficient use of the resources available Tackling head on the open challenges of the supply the variability of the source and its prediction the description of novel processes that are being developed and evaluated for their transformation as well as how we can distribute them to the consumer and how we can integrate the new chemicals fuels and power within the current system and infrastructure the book takes a process based perspective with such an approach able to help us in the use and integration of these sources of energy and novel technologies Currency Wars Jeffrey Yi-Lin Forrest,Yirong Ying,Zaiwu Gong,2017-11-25 This book uses systemic thinking and applies it to the study of financial crises It systematically presents how the systemic yoyo model its thinking logic and its methodology can be employed as a common playground and intuition to the study of money international finance and economic reforms This book establishes theoretical backings for why some of the most employed interferences of the market and empirical experiences actually work It has become urgent for economists and policy makers to understand how

international speculative capital affects the economic security of various nations By looking at the issues of monetary movement around the world this book shows that there are clearly visible patterns behind the flows of capital and that there are a uniform language and logic of reasoning that can be powerfully employed in the studies of international finance As shown in this book many of the conclusions drawn on the basis of these visible patterns language and logic of thinking can be practically applied to produce tangible economic benefits Currency Wars Offense and Defense through Systemic Thinking is divided into six parts The first part addresses issues related to systemic modeling of economic entities and processes and explains how a few policy changes can adjust the performance of the extremely complex economy Part II of the book investigates the problem of how instabilities lead to opportunities for currency attacks the positive and negative effects of foreign capital and how international capital flows can cause disturbances of various degrees on a nation s economic security Part III examines how a currency war is initiated why currency conflicts and wars are inevitable and a specific way of how currency attacks can take place In Part IV the book shows how one nation can potential defend itself by manipulating exchange rate of its currency how the nation under siege can protect itself against financial attacks by using strategies based on the technique of feedback and develops a more general approach of self defense Part V focuses on issues related to the cleanup of the disastrous aftermath of currency attacks through using policies and reforms Finally the book concludes in Part VI as it analyzes specific real life cases and addresses the ultimate problem of whether or not currency wars can be avoided all together *Fundamentals of Process Safety Engineering* Samarendra Kumar Biswas,Umesh Mathur,Swapan Kumar Hazra,2021-08-16 This textbook covers the essential aspects of process safety engineering in a practical and comprehensive manner It provides readers with an understanding of process safety hazards in the refining and petrochemical industries and how to manage them in a reliable and professional manner It covers the most important concepts static electricity intensity of thermal radiation thermodynamics of fluid phase equilibria boiling liquid expanding vapor explosion BLEVE emission source models hazard identification methods risk control and methods for achieving manufacturing excellence while also focusing on safety Extensive case studies are included Aimed at senior undergraduate and graduate chemical engineering students and practicing engineers this book covers process safety principles and engineering practice authoritatively with comprehensive examples Fundamentals methods and procedures for the industrial practice of process safety engineering The thermodynamic fundamentals and computational methods for release rates from ruptures in pipelines vessels and relief valves Fundamentals of static electricity hazards and their mitigation Quantitative assessment of fires and explosions Principles of dispersion calculations for toxic or flammable gases and vapors Methods of qualitative and quantitative risk assessment and control *Nonlinear Model Predictive Control of Combustion Engines* Thivaharan Albin Rajasingham,2021-04-27 This book provides an overview of the nonlinear model predictive control NMPC concept for application to innovative combustion engines Readers can use this book to become more expert in advanced combustion

engine control and to develop and implement their own NMPC algorithms to solve challenging control tasks in the field The significance of the advantages and relevancy for practice is demonstrated by real world engine and vehicle application examples The author provides an overview of fundamental engine control systems and addresses emerging control problems showing how they can be solved with NMPC The implementation of NMPC involves various development steps including reduced order modeling of the process analysis of system dynamics formulation of the optimization problem and real time feasible numerical solution of the optimization problem Readers will see the entire process of these steps from the fundamentals to several innovative applications The application examples highlight the actual difficulties and advantages when implementing NMPC for engine control applications Nonlinear Model Predictive Control of Combustion Engines targets engineers and researchers in academia and industry working in the field of engine control The book is laid out in a structured and easy to read manner supported by code examples in MATLAB Simulink thus expanding its readership to students and academics who would like to understand the fundamental concepts of NMPC Advances in Industrial Control reports and encourages the transfer of technology in control engineering The rapid development of control technology has an impact on all areas of the control discipline The series offers an opportunity for researchers to present an extended exposition of new work in all aspects of industrial control Dynamic Modeling, Predictive Control and Performance Monitoring Biao Huang,Ramesh Kadali,2008-04-11 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

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