

Matthias A. Müller

**Distributed and economic
model predictive control:
beyond setpoint stabilization**



Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization

Zihang Dong



Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization:

Distributed and Economic Model Predictive Control Matthias A. Müller, 2014 [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

Recent Advances in Model Predictive Control

Timm Faulwasser, Matthias A. Müller, Karl Worthmann, 2021-04-17 This book focuses on distributed and economic Model Predictive Control MPC with applications in different fields MPC is one of the most successful advanced control methodologies due to the simplicity of the basic idea measure the current state predict and optimize the future behavior of the plant to determine an input signal and repeat this procedure ad infinitum and its capability to deal with constrained nonlinear multi input multi output systems While the basic idea is simple the rigorous analysis of the MPC closed loop can be quite involved Here distributed means that either the computation is distributed to meet real time requirements for very large scale systems or that distributed agents act autonomously while being coupled via the constraints and or the control objective In the latter case communication is necessary to maintain feasibility or to recover system wide optimal performance The term economic refers to general control tasks and thus goes beyond the typically predominant control objective of set point stabilization Here recently developed concepts like strict dissipativity of optimal control problems or turnpike properties play a crucial role The book collects research and survey articles on recent ideas and it provides perspectives on current trends in nonlinear model predictive control Indeed the book is the outcome of a series of six workshops funded by the German

Research Foundation DFG involving early stage career scientists from different countries and from leading European industry stakeholders

Economic Nonlinear Model Predictive Control Timm Faulwasser, Lars Grüne, Matthias A. Müller, 2018-01-12 In recent years Economic Model Predictive Control EMPC has received considerable attention of many research groups The present tutorial survey summarizes state of the art approaches in EMPC In this context EMPC is to be understood as receding horizon optimal control with a stage cost that does not simply penalize the distance to a desired equilibrium but encodes more sophisticated economic objectives This survey provides a comprehensive overview of EMPC stability results with and without terminal constraints with and without dissipativity assumptions with averaged constraints formulations with multiple objectives and generalized terminal constraints as well as Lyapunov based approaches

Linear and Nonlinear Distributed Economic Model Predictive Control Jaehwa Lee, 2013

Distributed Economic Model

Predictive Control: Cost-efficient Operation of Interconnected Systems Philipp N. Köhler, 2020

Distributed Economic Model Predictive Control Under Inexact Minimization with Application to Power Systems Johannes Köhler, 2017

Distributed Model Predictive Control Made Easy José M. Maestre, Rudy R. Negenborn, 2013-11-10 The rapid evolution of computer science communication and information technology has enabled the application of control techniques to systems beyond the possibilities of control theory just a decade ago Critical infrastructures such as electricity water traffic and intermodal transport networks are now in the scope of control engineers The sheer size of such large scale systems requires the adoption of advanced distributed control approaches Distributed model predictive control MPC is one of the promising control methodologies for control of such systems This book provides a state of the art overview of distributed MPC approaches while at the same time making clear directions of research that deserve more attention The core and rationale of 35 approaches are carefully explained Moreover detailed step by step algorithmic descriptions of each approach are provided These features make the book a comprehensive guide both for those seeking an introduction to distributed MPC as well as for those who want to gain a deeper insight in the wide range of distributed MPC techniques available

[Economic Model Predictive Control for Time-Varying System: Performance and Stability Results](#) Lars Grüne, Simon Pirkelmann, 2018

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

Stability and Computations in Cooperative Distributed Model Predictive Control Christian Conte,2014 Robust Economic Model Predictive Control Zihang Dong,2019 **Networked and Distributed Predictive Control** Panagiotis D. Christofides,Jinfeng Liu,David Muñoz de la Peña,2013-05-29 Networked and Distributed Predictive Control presents rigorous yet practical methods for the design of networked and distributed predictive control systems the first book to do so The design of model predictive control systems using Lyapunov based techniques accounting for the influence of asynchronous and delayed measurements is followed by a treatment of networked control architecture development This shows how networked control can augment dedicated control systems in a natural way and takes advantage of additional potentially asynchronous and delayed measurements to maintain closed loop stability and significantly to improve closed loop performance The text then shifts focus to the design of distributed predictive control systems that cooperate efficiently in computing optimal manipulated input trajectories that achieve desired stability performance and robustness specifications but spend a fraction of the time required by centralized control systems Key features of this book include new techniques for networked and distributed control system design insight into issues associated with networked and distributed predictive control and their solution detailed appraisal of industrial relevance using computer simulation of nonlinear chemical process networks and wind and solar energy generation systems and integrated exposition of novel research topics and rich resource of references to significant recent work A full understanding of Networked and Distributed Predictive Control requires a basic knowledge of differential equations linear and nonlinear control theory and optimization methods and the book is intended for academic researchers and graduate students studying control and for process control engineers The constant attention to practical matters associated with implementation of the theory discussed will help each of these groups understand the application of the book s methods in greater depth **Stability and Performance in Transient Average**

Constrained Economic Model Predictive Control Without Terminal Constraints Mario Rosenfelder,2019

Distributed Model Predictive Control with Event-Based Communication Groß, Dominic,2015-02-25 In this thesis several algorithms for distributed model predictive control over digital communication networks with parallel computation are developed and analyzed Distributed control aims at efficiently controlling large scale dynamical systems which consist of interconnected dynamical systems by means of communicating local controllers Such distributed control problems arise in applications such as chemical processes formation control and control of power grids In distributed model predictive control the underlying idea is to solve a large scale model predictive control problem in a distributed fashion in order to achieve

faster computation and better robustness against local failures Distributed model predictive control often heavily relies on frequent communication between the local model predictive controllers However a digital communication network may induce uncertainties such as a communication delays especially if the load on the communication network is high One topic of this thesis is to develop a distributed model predictive control algorithm for subsystems interconnected by constraints and common control goals which is robust with respect to time varying communication delays

Distributed Cooperative Model Predictive Control of Networked Systems Yuanyuan Zou, Shaoyuan Li, 2022-10-03 This book is inspired by the development of distributed model predictive control of networked systems to save computation and communication sources The significant new contribution is to show how to design efficient DMPCs that can be coordinated asynchronously with the increasing effectiveness of the event triggering mechanism and how to improve the event triggered DMPC for different requirements improvement of control performance extension to interconnected networked systems etc The book is likely to be of interest to the persons who are engaged in researching control theory in academic institutes the persons who go in for developing control systems in R D institutes or companies the control engineers who are engaged in the implementation of control algorithms and people who are interested in the distributed MPC

Economic Model Predictive Control Without Terminal Constraints: Optimal Periodic Operation Matthias A. Müller, Lars Grüne, 2015

Economic Model Predictive Control Matthew Ellis, Jinfeng Liu, Panagiotis D. Christofides, 2016-08-09 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

A Quadratic Constraint Approach to

Model Predictive Control of Interconnected Systems Anthony Tri Tran C., Quang Ha, 2018-03-06 This book focuses on the stabilization and model predictive control of interconnected systems with mixed connection configurations It introduces the concept of dissipation based quadratic constraint for developing attractivity assurance methods for interconnected systems In order to develop these methods distributed and decentralized architectures are employed whereby the communication between subsystems is fully connected partially connected or completely disconnected Given that the control inputs are entirely or partially decoupled between subsystems and no additional constraints are imposed on the interactive variables beyond the coupling constraint itself the proposed approaches can be used with various types of systems and applications Further the book describes how the effects of coupling delays and data losses in device networks are resolved From a practical perspective the innovations presented are of benefit in applications in a broad range of fields including the process and manufacturing industries networked robotics and network centric systems such as chemical process systems power systems telecommunication networks transportation networks and no less importantly supply chain automation Economic

Model Predictive Control and Time-Varying Systems Simon Pirkelmann, 2020

Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization Book Review: Unveiling the Magic of Language

In a digital era where connections and knowledge reign supreme, the enchanting power of language has been apparent than ever. Its ability to stir emotions, provoke thought, and instigate transformation is really remarkable. This extraordinary book, aptly titled "**Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization**," written by a highly acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound effect on our existence. Throughout this critique, we will delve into the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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Table of Contents Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization

1. Understanding the eBook Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - The Rise of Digital Reading Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - Advantages of eBooks Over Traditional Books
2. Identifying Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - User-Friendly Interface
4. Exploring eBook Recommendations from Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization

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- Personalized Recommendations
 - Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization User Reviews and Ratings
 - Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization and Bestseller Lists
5. Accessing Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization Free and Paid eBooks
 - Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization Public Domain eBooks
 - Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization eBook Subscription Services
 - Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization Budget-Friendly Options
 6. Navigating Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization eBook Formats
 - ePub, PDF, MOBI, and More
 - Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization Compatibility with Devices
 - Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization Enhanced eBook Features
 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - Highlighting and Note-Taking Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - Interactive Elements Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 8. Staying Engaged with Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 9. Balancing eBooks and Physical Books Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time

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11. Cultivating a Reading Routine Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - Setting Reading Goals Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - Fact-Checking eBook Content of Distributed And Economic Model Predictive Control Beyond Setpoint Stabilization
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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