New Predictive Control Scheme For Networked Control Systems

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Nonlinear Model Predictive Control
Springer Science & Business Media
Thepastthree decadeshaveseenrapiddevelopmentin the areaofmodelpred- tive control with respect to both theoretical and application aspects. Over these 30 years, model predictive control for linear systems has been widely applied, especially in the area of process control. However, today's applications often require driving the process over a wide region and close to the boundaries of - erability, while satisfying constraints and achieving near-optimal performance. Consequently, the application of linear control methods does not always lead to satisfactory performance, and here nonlinear methods must be employed. This is one of the reasons why nonlinear model predictive control (NMPC) has - joyed signi?cant attention over the past years,with a number of recent advances on both the theoretical and application frontier. Additionally, the widespread availability and steadily increasing power of today's computers, as well as the development of specially tailored numerical solution methods for NMPC, bring thepracticalapplicabilityof NMPCwithinreachevenforveryfastsystems.This has led to a series of new, exciting developments, along with new challenges in the area of NMPC.
Applied Predictive Control
Springer Science & Business Media
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.

Explicit Nonlinear Model Predictive Control BoD – Books on Demand

Over the past few years significant progress has been achieved in the field of nonlinear model predictive control (NMPC), also referred to as receding horizon control or moving horizon control. More than 250 papers have been published in 2006 in ISI Journals. With this book we want to bring together the contributions of a diverse group of internationally well recognized researchers and industrial practitioners, to critically assess the current status of the NMPC field and to discuss future directions and needs. The book consists of selected papers presented at the International Workshop on Assessment an Future Directions of Nonlinear Model Predictive Control that took place from September 5 to 9, 2008, in Pavia, Italy.

Adaptive Control of Chemical Processes 1985 Springer Science & Business Media

The second edition of "Model Predictive Control" provides a thorough introduction to theoretical and practical aspects of the most commonly used MPC strategies. It bridges the gap between the powerful but often abstract techniques of control researchers and the more empirical approach of practitioners. The book demonstrates that a powerful technique does not always require complex control algorithms. Many new exercises and examples have also been added throughout. Solutions available for download from the authors' website save the tutor time and enable the student to follow results more closely even when the tutor isn't present.

Model Predictive Control for Nonlinear Continuous-Time Systems with and Without Time-Delays Springer Science & Business Media

In this original book on model predictive control (MPC) for power electronics, the focus is put on high-power applications with multilevel converters operating at switching frequencies well below 1 kHz, such as medium-voltage drives and modular multi-level converters. Consisting of two main parts, the first offers a detailed review of three-phase power electronics, electrical machines, carrier-based pulse width modulation, optimized pulse patterns, state-of-the art converter control methods and the principle of MPC. The second part is an in-depth treatment of MPC methods that fully exploit the performance potential of high-power converters. These control methods combine the fast control responses of deadbeat control with the optimal steady-state performance of optimized pulse patterns by resolving the antagonism between the two. MPC is expected to evolve into the control method of choice for power electronic systems operating at low pulse numbers with multiple coupled variables and tight operating constraints it. Model Predictive Control of High Power Converters and Industrial Drives will enable to reader to learn how to increase the power

capability of the converter, lower the current distortions, reduce the filter size, achieve very fast transient responses and ensure the reliable operation within safe operating area constraints. Targeted at power electronic practitioners working on control-related aspects as well as control engineers, the material is intuitively accessible, and the mathematical formulations are augmented by illustrations, simple examples and a book companion website featuring animations. Readers benefit from a concise and comprehensive treatment of MPC for industrial power electronics, enabling them to understand, implement and advance the field of high-performance MPC schemes.

Machine Learning and Systems Engineering CRC Press

The book shows how the operation of renewable-energy microgrids can be facilitated by the use of model predictive control (MPC). It gives readers a wide overview of control methods for microgrid operation at all levels, ranging from quality of service, to integration in the electricity market. MPC-based solutions are provided for the main control issues related to energy management and optimal operation of microgrids. The authors present MPC techniques for case studies that include different renewable sources – mainly photovoltaic and wind – as well as hybrid storage using batteries, hydrogen and supercapacitors. Experimental results for a pilot-scale microgrid are also presented, as well as simulations of scheduling in the electricity market and integration of electric and hybrid vehicles into the microgrid. in order to replicate the examples provided in the book and to develop and validate control algorithms on existing or projected microgrids. Model Predictive Control of Microgrids will interest researchers and practitioners, enabling them to keep abreast of a rapidly developing field. The text will also help to guide graduate students through processes from the conception and initial design of a microgrid through its implementation to the optimization of microgrid management. 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.

Model Predictive Control of Wastewater Systems Springer

The second edition of "Model Predictive Control" provides a thorough introduction to theoretical and practical aspects of the most commonly used MPC strategies. It bridges the gap between the powerful but often abstract techniques of control researchers and the more empirical approach of practitioners. The book demonstrates that a powerful technique does not always require complex control algorithms. Many new exercises and examples have also been added throughout. Solutions available for download from the authors' website save the tutor time and enable the student to follow results more closely even when the tutor isn't present.

Distributed Model Predictive Control Made

Easy Springer
The objective of this thesis is the development of novel model predictive control (MPC) schemes for nonlinear continuous-time systems with and without time-delays in the states which guarantee asymptotic stability of the closed-loop. The most well-studied MPC approaches with guaranteed stability use a control Lyapunov function as terminal cost. Since the actual calculation of such a function can be difficult, it is desirable to replace this assumption by a less restrictive controllability assumption. For discrete-time systems, the latter assumption has been used in the literature for the stability analysis of so-called unconstrained MPC, i.e., MPC without terminal cost and terminal constraints. The contributions of this thesis are twofold. In the first part, we propose novel MPC schemes with guaranteed stability based on a controllability assumption, whereas we extend different MPC schemes with guaranteed stability to nonlinear time-delay systems in the second part. In the first part of this thesis, we derive explicit stability conditions on the prediction horizon as well as performance guarantees for unconstrained MPC. Starting from this result, we propose novel alternative MPC formulations based on combinations of the controllability assumption with terminal cost and terminal constraints. One of the main contributions is the development of a unifying MPC framework which allows to consider both MPC schemes with terminal cost and terminal constraints as well as unconstrained MPC as limit cases of our framework. In the second part of this thesis, we show that several MPC schemes with and without terminal constraints can be extended to nonlinear time-delay systems. Due to the infinite-dimensional nature of these systems, the problem is more involved and additional assumptions are required in the controller design. We investigate different MPC schemes with and without terminal constraints and/or terminal cost terms and derive novel stability conditions. Furthermore, we pay particular attention to the calculation of the involved control design parameters.
Handbook of Model Predictive Control Springer
Gas Turbines Modeling, Simulation, and Control: Using Artificial Neural Networks provides new approaches and novel solutions to the modeling, simulation, and control of gas turbines (GTs) using artificial neural networks (ANNs). After delivering a brief introduction to GT performance and classification, the book: Outlines important criteria to consider at the beginning of the GT modeling process, such as GT types and configurations, control system types and configurations, and modeling methods and objectives Highlights research in the fields of white-box and black-box modeling, simulation, and control of GTs, exploring models of low-power GTs, industrial power plant gas turbines (IPGTs), and aero GTs Discusses the structure of ANNs and the ANN-based model-building process, including system analysis, data acquisition and preparation, network architecture, and network training and validation Presents a noteworthy ANN-based methodology for offline system identification of GTs, complete with validated models using both

simulated and real operational data Covers the modeling of GT transient behavior and start-up operation, and the design of proportional-integral-derivative (PID) and neural network-based controllers Gas Turbines Modeling, Simulation, and Control: Using Artificial Neural Networks not only offers a comprehensive review of the state of the art of gas turbine modeling and intelligent techniques, but also demonstrates how artificial intelligence can be used to solve complicated industrial problems, specifically in the area of GTs.

Computationally Efficient Approaches for Polynomial and Neural Structures John Wiley & Sons

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 water and wastewater industry has undergone many changes in recent years. Of particular importance has been a renewed emphasis on improving resource management with tighter regulatory controls setting new targets on pricing, industry efficiency and loss reduction for both water and wastewater with more stringent environmental discharge conditions for wastewater. Meantime, the demand for water and wastewater services grows as the population increases and wishes for improved living conditions involving, among other items, domestic appliances that use water. Consequently, the installed infrastructure of the industry has to be continuously upgraded and extended, and employed more effectively to accommodate the new demands, both in throughput and in meeting the new regulatory conditions. Investment in fixed infrastructure is capital-intensive and slow to come on-stream. One outcome of these changes and demands is that the industry is examining the potential benefits of, and in many cases using, more advanced control systems.

Generalized Predictive Control And Bioengineering Elsevier

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.

A Quadratic Constraint Approach to Model Predictive Control of Interconnected Systems Springer Nature

A timely introduction to current research on PID and predictive control by one of the leading authors on the subject PID and Predictive Control of Electric Drives and Power Supplies using MATLAB/Simulink examines the classical control system strategies, such as PID control, feed-forward control and cascade control, which are widely used in current practice. The authors share their experiences in actual design and implementation of the control systems on laboratory test-beds, taking the reader from the fundamentals through to more sophisticated design and analysis. The book contains sections on closed-loop performance analysis in both frequency domain and time domain, presented to help the designer in selection of controller parameters and validation of the control system. Continuous-time model predictive control systems are designed for the drives and power supplies, and operational constraints are imposed in the design. Discrete-time model predictive control systems are designed based on the discretization of the physical models, which will appeal to readers who are more familiar with sampled-data control system. Soft sensors and observers will be discussed for low cost implementation. Resonant control of the electric drives and power supply will be discussed to deal with the problems of bias in sensors and unbalanced three phase AC currents. Brings together both classical control systems and predictive control systems in a logical style from introductory through to advanced levels Demonstrates how simulation and experimental results are used to support theoretical analysis and the proposed design algorithms MATLAB and Simulink tutorials are given in each chapter to show the readers how to take the theory to applications. Includes MATLAB and Simulink software using xPC Target for teaching purposes A companion website is available Researchers and industrial engineers; and graduate students on electrical engineering courses will find this a valuable resource.

Frontiers of Model Predictive Control MDPI

Describes the general principles and current research into Model Predictive Control (MPC); the most up-to-date control method for power converters and drives The book starts with an introduction to the subject before the first chapter on classical control methods for power converters and drives. This covers classical converter control methods and classical electrical drives control methods. The next chapter on Model predictive control first

looks at predictive control methods for power converters and drives and presents the basic principles of MPC. It then looks at MPC for power electronics and drives. The third chapter is on predictive control applied to power converters. It discusses: control of a three-phase inverter; control of a neutral point clamped inverter; control of an active front end rectifier, and; control of a matrix converter. In the middle of the book there is Chapter four - Predictive control applied to motor drives. This section analyses predictive torque control of industrial machines and predictive control of permanent magnet synchronous motors. Design and implementation issues of model predictive control is the subject of the final chapter. The following topics are described in detail: cost function selection; weighting factors design; delay compensation; effect of model errors, and prediction of future references. While there are hundreds of books teaching control of electrical energy using pulse width modulation, this will be the very first book published in this new topic. Unique in presenting a completely new theoretic solution to control electric power in a simple way Discusses the application of predictive control in motor drives, with several examples and case studies Matlab is included on a complementary website so the reader can run their own simulations *Volume 1* Springer

Model Predictive Control System Design and Implementation Using MATLAB® proposes methods for design and implementation of MPC systems using basis functions that confer the following advantages: - continuous- and discrete-time MPC problems solved in similar design frameworks; - a parsimonious parametric representation of the control trajectory gives rise to computationally efficient algorithms and better on-line performance; and - a more general discrete-time representation of MPC design that becomes identical to the traditional approach for an appropriate choice of parameters. After the theoretical presentation, coverage is given to three industrial applications. The subject of quadratic programming, often associated with the core optimization algorithms of MPC is also introduced and explained. The technical contents of this book is mainly based on advances in MPC using state-space models and basis functions. This volume includes numerous analytical examples and problems and MATLAB® programs and exercises.

Proceedings of the IFAC Workshop, Frankfurt/Main, 21-22 October 1985 John Wiley & Sons

An invaluable academic reference for the area of high-power converters, covering all the latest developments in the field High-power multilevel converters are well known in industry and academia as one of the preferred choices for efficient power conversion. Over the past decade, several power converters have been developed and commercialized in the form of standard and customized products that power a wide range of industrial applications. Currently, the modular multilevel converter is a fast-growing technology and has received wide acceptance from both industry and academia. Providing adequate technical background for

graduate- and undergraduate-level teaching, this book includes a comprehensive analysis of the conventional and advanced modular multilevel converters employed in motor drives, HVDC systems, and power quality improvement. Modular Multilevel Converters: Analysis, Control, and Applications provides an overview of high-power converters, reference frame theory, classical control methods, pulse width modulation schemes, advanced model predictive control methods, modeling of ac drives, advanced drive control schemes, modeling and control of HVDC systems, active and reactive power control, power quality problems, reactive power, harmonics and unbalance compensation, modeling and control of static synchronous compensators (STATCOM) and unified power quality compensators. Furthermore, this book: Explores technical challenges, modeling, and control of various modular multilevel converters in a wide range of applications such as transformer and transformerless motor drives, high voltage direct current transmission systems, and power quality improvement Reflects the latest developments in high-power converters in medium-voltage motor drive systems Offers design guidance with tables, charts graphs, and MATLAB simulations Modular Multilevel Converters: Analysis, Control, and Applications is a valuable reference book for academic researchers, practicing engineers, and other professionals in the field of high power converters. It also serves well as a textbook for graduate-level students.

John Wiley & Sons

Analysis and Synthesis of Networked Control Systems focuses on essential aspects of this field, including quantization over networks, data fusion over networks, predictive control over networks and fault detection over networks. The networked control systems have led to a complete new range of real-world applications. In recent years, the techniques of Internet of Things are developed rapidly, the research of networked control systems plays a key role in Internet of Things. The book is self-contained, providing sufficient mathematical foundations for understanding the contents of each chapter. It will be of significant interest to scientists and engineers engaged in the field of Networked Control Systems. Dr. Yuanqing Xia, a professor at Beijing Institute of Technology, has been working on control theory and its applications for over ten years.

Theory and Applications John Wiley & Sons

Stochastic model predictive control (MPC) is a fascinating field for research and of increasing practical importance since optimal control techniques have been intensively investigated in modern control system design. With the development of computer technologies and communication networks, networked control systems (NCSs) or cyber-physical systems (CPSs) have become an interest of research due to the comprehensive integration of physical systems, such as sensors, actuators and plants, with intricate cyber components, possessing information communication and computation. In CPSs, advantages of low installation cost, high

reliability, flexible modularity, improved efficiency, and greater autonomy can be obtained by the tight coordination of physical and cyber components. Several sectors, including robotics, transportation, health care, smart buildings, and smart grid, have witnessed the successful application of CPSs design. The integration of extensive cyber capability and physical plants with ubiquitous uncertainties also introduces concerns over communication efficiency, robustness and stability of the CPSs. Thus, to achieve satisfactory performance metrics of efficiency, robustness and stability, a detailed investigation into control synthesis of CPSs under the stochastic model predictive control framework is of importance. The stochastic model predictive control synthesis plays a vital role in CPSs design since the multivariable stochastic system subject to probabilistic constraints can be controlled in an optimized way. On the other hand, aperiodically sampled, or event-based, model predictive control has also been applied to CPSs extensively to improve communication efficiency. In this thesis, the control synthesis and analysis of aperiodically sampled stochastic model predictive control for CPSs is considered. Chapter 1 provides an introductory literature review of the current development of stochastic MPC, distributed stochastic MPC and event-based MPC. Chapter 2 presents a stochastic self-triggered model predictive control scheme for linear systems with additive uncertainty and with the states and inputs being subject to chance constraints. In the proposed control scheme, the succeeding sampling time instant and current control inputs are computed online by solving a formulated optimization problem. Chapter 3 discusses a stochastic self-triggered model predictive control algorithm with an adaptive prediction horizon. The communication cost is explicitly considered by adding a damping factor in the cost function. Sufficient conditions are provided to guarantee closed-loop chance constraints satisfactions. Furthermore, the recursive feasibility of the algorithm is analyzed, and the closed-loop system is shown to be stable. Chapter 4 proposes a distributed self-triggered stochastic MPC control scheme for CPSs under coupled chance constraints and additive disturbances. Based on the assumptions on stochastic disturbances, both local and coupled probabilistic constraints are transformed into the deterministic form using the tube-based method, and improved terminal constraints are constructed to guarantee the recursive feasibility of the control scheme. Theoretical analysis has shown that the overall closed-loop CPSs are quadratically stable. Numerical examples illustrate the efficacy of the proposed control method in terms of data transmission reductions. Chapter 5 concludes the thesis and suggests some promising directions for future research.

Nonlinear Model Predictive Control John Wiley & Sons

Predictive control is a powerful tool in dealing with those processes with large time delays. Generalized Predictive Control GPC is the most popular approach to the subject, and this text discusses the application of GPC starting with the

concept of long-range predictive control and its need in medicine particularly automated drug deliveries.; The concept of adaptation is also emphasized with respect to patient-to-patient parameter variations. Subsequent chapters discuss interactions, comparisons and various aspects of GPC. The book concludes by putting into perspective the generic nature of the architecture built around GPC and which provides model-based fault diagnosis with control.

Predictive Control

Springer Science & Business Media

Model Predictive Control (MPC) usually refers to a class of control algorithms in which a dynamic process model is used to predict and optimize process performance, but it is can also be seen as a term denoting a natural control strategy that matches the human thought form most closely. Half a century after its birth, it has been widely accepted in many engineering fields and has brought much benefit to us. The purpose of the book is to show the recent advancements of MPC to the readers, both in theory and in engineering. The idea was to offer guidance to researchers and engineers who are interested in the frontiers of MPC. The examples provided in the first part of this exciting collection will help you comprehend some typical boundaries in theoretical research of MPC. In the second part of the book, some excellent applications of MPC in modern engineering field are presented. With the rapid development of modeling and computational technology, we believe that MPC will remain as energetic in the future.

Distributed Model Predictive Control for Plant-Wide Systems

CRC Press

This volume is concerned with the control and dynamics of time delay systems; a research field with at least six-decade long history that has been very active especially in the past two decades. In parallel to the new challenges emerging from engineering, physics, mathematics, and economics, the volume covers several new directions including topology induced stability, large-scale interconnected systems, roles of networks in stability, and new trends in predictor-based control and consensus dynamics. The associated applications/problems are described by highly complex models, and require solving inverse problems as well as the development of new theories, mathematical tools, numerically-tractable algorithms for real-time control. The volume, which is targeted to present these developments in this rapidly evolving field, captures a careful selection of the most recent papers contributed by experts and collected under five parts: (i) Methodology: From Retarded to Neutral Continuous Delay Models, (ii) Systems, Signals and Applications, (iii): Numerical Methods, (iv) Predictor-based Control and Compensation, and (v) Networked Control Systems and Multi-agent Systems.