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DCM7MR - CABRERA MACIAS

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.

Optimization is an important tool used in decision science and for the analysis of physical systems used in engineering. One can trace its roots to the Calculus of Variations and the work of Euler and Lagrange. This natural and reasonable approach to mathematical programming covers numerical methods for finite-dimensional optimization problems. It begins with very simple ideas progressing through more complicated concepts, concentrating on methods for both unconstrained and constrained optimization.

This thesis addresses constrained control of systems under stochastic disturbances and model uncertainty. In particular, stochastic and adaptive model predictive control (MPC) algorithms that solve such problems are presented and studied.Given a stochastic disturbance model, the focus is put on chance constraints, tractable approximations, and their implication on feasibility of the online optimization in a receding horizon framework. For systems with model uncertainty, online parameter identification to reduce conservatism and improve closed-loop performance is addressed.More specifically, building upon the analysis of conceptual aspects, we develop computational approaches for linear systems with additive and multiplicative disturbances. The analysis of a non-conservative, computationally tractable relaxation of chance constraints leads to an important separation of sufficient conditions for feasibility and stability. The latter is of particular interest for rigorously applying approximations, such as finite sample approximations, to solve the online stochastic optimal control problem. We discuss the differences between online and offline sampling approximations and, for systems that are linear in the state and input variables, provide explicit bounds on the sample complexity to guarantee satisfaction of chance constraints with a user chosen confidence. The proposed algorithms provide rigorous guarantees for relevant properties like feasibility of the online optimization, constraint satisfaction, and convergence of the closed-loop system.

This text introduces the fundamental techniques for controlling dead-time processes from simple monovariable to complex multivariable cases. Dead-time-process-control problems are studied using classical proportional-integral-differential (PID) control for the simpler examples and dead-time-compensator (DTC) and model predictive control (MPC) methods for progressively more complex ones. Downloadable MATLAB® code makes the examples and ideas more convenient and simpler.

For the first time, a textbook that brings together classical predictive control with treatment of up-to-date robust and stochastic techniques. Model Predictive Control describes the development of tractable algorithms for uncertain, stochastic, constrained systems. The starting point is classical predictive control and the appropriate formulation of performance objectives and constraints to provide guarantees of closed-loop stability and performance. Moving on to robust predictive control, the text explains how similar guarantees may be obtained for cases in which the model describing the system dynamics is subject to additive disturbances and parametric uncertainties. Open- and closed-loop optimization are considered and the state of the art in computationally tractable methods based on uncertainty tubes presented for systems with additive model uncertainty. Finally, the tube framework is also applied to model predictive control problems involving hard or probabilistic constraints for the cases of multiplicative and stochastic model uncertainty. The book provides: extensive use of illustrative examples; sample problems; and discussion of novel control applications such as resource allocation for sustainable development and turbine-blade control for maximized power capture with simultaneously reduced risk of turbulence-induced damage. Graduate students pursuing courses in model predictive control or more generally in advanced or process control and senior undergraduates in need of a specialized treatment will find Model Predictive Control an invaluable guide to the state of the art in this important subject. For the instructor it provides an authoritative resource for the construction of courses.

Despite its sub-optimality, Model Predictive Control (MPC) has received much attention over the recent decades due to its ability to handle constraints. In particular, stochastic MPC, which includes uncertainty in the system dynamics, is one of the most active recent research topics in MPC. In this dissertation, we focus on (1) increasing computation speed of constrained stochastic MPC of linear systems with additive noise and, (2) improving the accuracy of an approximate solution involving systems with additive and multiplicative noise. Constrained MPC for linear systems with additive noise has been successfully formulated as a semidefinite programming problem (SDP) using the Youla parameterization or innovation feedback and linear matrix inequalities. Unfortunately, this method can be prohibitively slow even for problems with moderate size state. Thus, in this thesis we develop an interior point algorithm which can more efficiently solve the problem. This algorithm converts the stochastic problem into a deterministic one using the mean and the covariance matrix as the system state and using affine feedback. A line search interior point method is then directly applied to the nonlinear deterministic optimization problem. In the process, we take advantage of a recursive structure that appears when a control problem is solved via the line search interior point method in order to decrease the algorithmic complexity of the solution. We compare the computation time and complexity of our algorithm against an SDP solver. The second part of the dissertation deals with systems with additive and multiplicative noise under probabilistic constraints. This class of systems differs from the additive noise case in that the probability distribution of a state is neither Gaussian nor known in closed form. This causes a problem when the probability constraints are dealt with. In previous studies, this problem has been tackled by approximating the state as a Gaussian random variable or by approximating the probability bound as an ellipsoid. In this dissertation, we use the Cornish-Fisher expansion to approximate the probability bounds of the constraints. Since the Cornish--Fisher expansion utilizes quantile values with the first several moments, the probabilistic constraints have the same form as those in the additive noise case when the constraints are converted to deterministic ones. This makes the procedure smooth when we apply the developed algorithm to a linear system with multiplicative noise. Moreover, we can easily extend the application of the algorithm to a linear system with additive plus multiplicative noise.

The focus of the book is the construction of optimal investment strategies in a security market model where the prices follow diffusion processes. It begins by presenting the complete Black-Scholes type model and then moves on to incomplete models and models including constraints and transaction costs. The models and methods presented will include the stochastic control method of Merton, the martingale method of Cox-Huang and Karatzas et al., the log optimal method of Cover and Jamshidian, the value-preserving model of Hellwig etc. Stress is laid on rigorous mathematical presentation and clear economic interpretations while technicalities are kept to the minimum. The underlying mathematical concepts will be provided. No a priori knowledge of stochastic calculus, stochastic control or partial differential equations is necessary (however some knowledge in stochastics and calculus is needed). Contents:Introduction and Discrete-Time ModelsThe Continuous-Time Market ModelThe Continuous-Time Portfolio

ProblemConstrained Continuous-Time ProblemsPortfolio Optimisation in the Presence of Transaction CostsNon-Utility Based Portfolio Selection ModelsAppendix Readership: Professionals in the financial industry, economists, mathematicians, physicians and students in stochastic processes. keywords: “This book provides not only a survey of the continuous-time porfolio selection theory, but also can be recommended to those who want to obtain a quick overview about methods of portfolio theory. Because of its friendly and inviting style, parts of this book are also suitable as a first introduction to this theory for those not familiar with stochastic analysis.” Metrika

Exploration of stochastic control theory in terms of analysis, parametric optimization, and optimal stochastic control. Limited to linear systems with quadratic criteria; covers discrete time and continuous time systems. 1970 edition.

The presence of uncertainty in a system description has always been a critical issue in control. The main objective of Randomized Algorithms for Analysis and Control of Uncertain Systems, with Applications (Second Edition) is to introduce the reader to the fundamentals of probabilistic methods in the analysis and design of systems subject to deterministic and stochastic uncertainty. The approach propounded by this text guarantees a reduction in the computational complexity of classical control algorithms and in the conservativeness of standard robust control techniques. The second edition has been thoroughly updated to reflect recent research and new applications with chapters on statistical learning theory, sequential methods for control and the scenario approach being completely rewritten. Features: · self-contained treatment explaining Monte Carlo and Las Vegas randomized algorithms from their genesis in the principles of probability theory to their use for system analysis; · development of a novel paradigm for (convex and nonconvex) controller synthesis in the presence of uncertainty and in the context of randomized algorithms; · comprehensive treatment of multivariate sample generation techniques, including consideration of the difficulties involved in obtaining identically and independently distributed samples; · applications of randomized algorithms in various endeavours, such as PageRank computation for the Google Web search engine, unmanned aerial vehicle design (both new in the second edition), congestion control of high-speed communications networks and stability of quantized sampled-data systems. Randomized Algorithms for Analysis and Control of Uncertain Systems (second edition) is certain to interest academic researchers and graduate control students working in probabilistic, robust or optimal control methods and control engineers dealing with system uncertainties. The present book is a very timely contribution to the literature. I have no hesitation in asserting that it will remain a widely cited reference work for many years. M. Vidyasagar

This book offers readers a thorough and rigorous introduction to nonlinear model predictive control (NMPC) for discrete-time and sampled-data systems. NMPC schemes with and without stabilizing terminal constraints are detailed, and intuitive examples illustrate the performance of different NMPC variants. NMPC is interpreted as an approximation of infinite-horizon optimal control so that important properties like closed-loop stability, inverse optimality and suboptimality can be derived in a uniform manner. These results are complemented by discussions of feasibility and robustness. An introduction to nonlinear optimal control algorithms yields essential insights into how the nonlinear optimization routine—the core of any nonlinear model predictive controller—works. Accompanying software in MATLAB® and C++ (downloadable from extras.springer.com/), together with an explanatory appendix in the book itself, enables readers to perform computer experiments exploring the possibilities and limitations of NMPC. The second edition has been substantially rewritten, edited and updated to reflect the significant advances that have been made since the publication of its predecessor, including: • a new chapter on economic NMPC relaxing the assumption that the running cost penalizes the distance to a pre-defined equilibrium; • a new chapter on distributed NMPC discussing methods which facilitate the control of large-scale systems by splitting up the optimization into smaller subproblems; • an extended discussion of stability and performance using approximate updates rather than full optimization; • replacement of the pivotal sufficient condition for stability without stabilizing terminal conditions with a weaker alternative and inclusion of an alternative and much simpler proof in the analysis; and • further variations and extensions in response to suggestions from readers of the first edition. Though primarily aimed at academic researchers and practitioners working in control and optimization, the text is self-contained, featuring background material on infinite-horizon optimal control and Lyapunov stability theory that also makes it accessible for graduate students in control engineering and applied mathematics.

Nonlinear Model Predictive Control (NMPC) has become the accepted methodology to solve complex control problems related to process industries. The main motivation behind explicit NMPC is that an explicit state feedback law avoids the need for executing a numerical optimization algorithm in real time. The benefits of an explicit solution, in addition to the efficient on-line computations, include also verifiability of the implementation and the possibility to design embedded control systems with low software and hardware complexity. This book considers the multi-parametric Nonlinear Programming (mp-NLP) approaches to explicit approximate NMPC of constrained nonlinear systems, developed by the authors, as well as their applications to various NMPC problem formulations and several case studies. The following types of nonlinear systems are considered, resulting in different NMPC problem formulations: Nonlinear systems described by first-principles models and nonlinear systems described by black--box models; - Nonlinear systems with continuous control inputs and nonlinear systems with quantized control inputs; - Nonlinear systems without uncertainty and nonlinear systems with uncertainties (polyhedral description of uncertainty and stochastic description of uncertainty); - Nonlinear systems, consisting of interconnected nonlinear sub-systems. The proposed mp-NLP approaches are illustrated with applications to several case studies, which are taken from diverse areas such as automotive mechatronics, compressor control, combustion plant control, reactor control, pH maintaining system control, cart and spring system control, and diving computers.

Because they incorporate both time- and event-driven dynamics, stochastic hybrid systems (SHS) have become ubiquitous in a variety of fields, from mathematical finance to biological processes to communication networks to engineering. Comprehensively integrating numerous cutting-edge studies, Stochastic Hybrid Systems presents a captivating treatment of some of the most ambitious types of dynamic systems. Cohesively edited by leading experts in the field, the book introduces the theoretical basics, computational methods, and applications of SHS. It first discusses the underlying principles behind SHS and the main design limitations of SHS. Building on these fundamentals, the authoritative contributors present methods for computer calculations that apply SHS analysis and synthesis techniques in practice. The book concludes with examples of systems encountered in a wide range of application areas, including molecular biology, communication networks, and air traffic management. It also explains how to resolve practical problems associated with these systems. Stochastic Hybrid Systems achieves an ideal balance between a theoretical treatment of SHS and practical considerations. The book skillfully explores the interaction of physical processes with computerized equipment in an uncertain environment, enabling a better understanding of sophisticated as well as everyday devices and processes.

REINFORCEMENT LEARNING AND STOCHASTIC OPTIMIZATION Clearing the jungle of stochastic optimization Sequential decision problems, which consist of “decision, information, decision, information,” are ubiquitous, spanning virtually every human activity ranging from business applications, health (personal and public health, and medical decision making), energy, the sciences, all fields of engineering, finance, and e-commerce. The diversity of applications attracted the attention of at least 15 distinct fields of research, using eight distinct notational systems which produced a vast array of analytical tools. A byproduct is that powerful tools developed in one community may be unknown to other communities. Reinforcement Learning and Stochastic Optimization offers a single canonical framework that can model any sequential decision problem using five core components: state variables, decision variables, exogenous information variables, transition function, and objective function. This book highlights twelve types of uncertainty that might enter any model and pulls together the diverse set of methods for making decisions, known as policies, into four fundamental classes that span every method suggested in the academic literature or used in practice. Reinforcement Learning and Stochastic Optimization is the first book to provide a balanced treatment of the different methods for modeling and solving sequential decision problems, following the style used by most books on machine learning, optimization, and simulation. The presentation is designed for readers with a course in probability and statistics, and an interest in modeling and applications. Linear programming is occasionally used for specific problem classes. The book is designed for readers who are new to the field, as well as those with some background in optimization under uncertainty. Throughout this book, readers will find references to over 100 different applications, spanning pure learning problems, dynamic resource allocation problems, general state-dependent problems, and hybrid learning/resource allocation problems such as those that arose in the COVID pandemic. There are 370 exercises, organized into seven groups, ranging from review questions, modeling, computation, problem solving, theory, programming exercises and a “diary problem” that a reader chooses at the beginning of the book, and which is used as a basis for questions throughout the rest of the book.

Since its origins in the 1940s, the subject of decision making under uncertainty has grown into a diversified area with application in several branches of engineering and in those areas of the social sciences concerned with policy analysis and prescription. These approaches required a computing capacity too expensive for the time, until the ability to collect and process huge quantities of data engendered an explosion of work in the area. This book provides succinct and rigorous treatment of the foundations of stochastic control; a unified approach to filtering, estimation, prediction, and stochastic and adaptive control; and the conceptual framework necessary to understand current trends in stochastic control, data mining, machine learning, and robotics.

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.

Controlling a system with control and state constraints is one of the most important problems in control theory, but also one of the most challenging. Another important but just as demanding topic is robustness against uncertainties in a controlled system. One of the most successful approaches, both in theory and practice, to control constrained systems is model predictive control (MPC). The basic idea in MPC is to repeatedly solve optimization problems on-line to find an optimal input to the controlled system. In recent years, much effort has been spent to incorporate the robustness problem into this framework. The main part of the thesis revolves around minimax formulations of MPC for uncertain constrained linear discrete-time systems. A minimax strategy in MPC means that worst-case performance with respect to uncertainties is optimized. Unfortunately, many minimax MPC formulations yield intractable optimization problems with exponential complexity. Minimax algorithms for a number of uncertainty models are derived in the thesis. These include systems with bounded external additive disturbances, systems with uncertain gain, and systems described with linear fractional transformations. The central theme in the different algorithms is semidefinite relaxations. This means that the minimax problems are written as uncertain semidefinite programs, and then conservatively approximated using robust optimization theory. The result is an optimization problem with polynomial complexity. The use of semidefinite relaxations enables a framework that allows extensions of the basic algorithms, such as joint minimax control and estimation, and approx- imation of closed-loop minimax MPC using a convex programming framework. Additional topics include development of an efficient optimization algorithm to solve the resulting semidefinite programs and connections between deterministic minimax MPC and stochastic risk-sensitive control. The remaining part of the thesis is devoted to stability issues in MPC for continuous-time nonlinear unconstrained systems. While stability of MPC for un-constrained linear systems essentially is solved with the linear quadratic controller, no such simple solution exists in the nonlinear case. It is shown how tools from modern nonlinear control theory can be used to synthesize finite horizon MPC controllers with guaranteed stability, and more importantly, how some of the tech- nical assumptions in the literature can be dispensed with by using a slightly more complex controller.

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.

This book is a compilation of peer-reviewed papers from the 2018 Asia-Pacific International Symposium on Aerospace Technology (APISAT 2018). The symposium is a common endeavour between the four national aerospace societies in China, Australia, Korea and Japan, namely, the Chinese Society of Aeronautics and Astronautics (CSAA), Royal Aeronautical Society Australian Division (RAeS Australian Division), the Korean Society for Aeronautical and Space Sciences (KSAS) and the Japan Society for Aeronautical and Space Sciences (JSASS). APISAT is an annual event initiated in 2009 to provide an opportunity for researchers and engineers from Asia-Pacific countries to discuss current and future advanced topics in aeronautical and space engineering.

Energy storage systems have been recognized as viable solutions for implementing the smart grid paradigm, but have created challenges in terms of load levelling, integrating renewable and intermittent sources, voltage and frequency regulation, grid resiliency, improving power quality and reliability, reducing energy import during peak demand periods, and so on. In particular, distributed energy storage addresses a wide range of the above potential issues, and it is gaining attention from customers, utilities, and regulators. Distributed energy storage has considerable potential for reducing costs and improving the quality of electric services. However, installation costs and lifespan are the main drawbacks to the wide diffusion of this technology. In this context, a serious challenge is the adoption of new techniques and strategies for the optimal planning, control, and management of grids that include distributed energy storage devices. Regulatory guidance and proactive policies are urgently needed to ensure a smooth rollout of this technology. This book collects recent contributions of methodologies applied to the integration of distributed energy storage devices in smart power systems. Several areas of research (optimal siting and sizing of energy storage systems, adaption of energy storage systems to load leveling and harmonic compensation, integration for electric vehicles, and optimal control systems) are investigated in the contributions collected in this book.

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.

Large scale manufacturing systems are often run with constant process parameters although continuous and abrupt disturbances influence the process. To reduce quality variations and scrap, a closed-loop control of the process variables becomes indispensable. In this thesis, a modeling and control framework for multistage manufacturing systems is developed, in which the systems are subject to abrupt faults, such as component defects, and continuous disturbances. In this context, three main topics are considered: the development of a modeling framework, the design of robust distributed controllers, and the application of both to the models of a real hot stamping line. The focus of all topics is on the control of the product properties considering the available knowledge of faults and disturbances.

This book presents the latest research advancements in the operation of smart homes. It comprises new operation techniques including cooperative distributed energy scheduling, framework to react to malicious cyberattacks, framework for demand-side management, and framework for the design of smart homes to support residents' wellness as well as new optimization techniques such as stochastic model predictive control and multi-time scale optimization. In addition, the book analyzes 11,000 studies that have been indexed in scientific databases and categorizes them based on various data points, including the field and the subject of the research, the name of the institutions, and the nationality of the authors. Presents new operation techniques of smart homes; Introduces new optimization techniques for operation of smart homes; Analyses 11,000 studies and categorizes them based on different data points.

Robust optimization is still a relatively new approach to optimization problems affected by uncertainty, but it has already proved so useful in real applications that it is difficult to tackle such problems today without considering this powerful methodology. Written by the principal developers of robust optimization, and describing the main achievements of a decade of research, this is the first book to provide a comprehensive and up-to-date account of the subject. Robust optimization is designed to meet some major challenges associated with uncertainty-affected optimization problems: to operate under lack of full information on the nature of uncertainty; to model the problem in a form that can be solved efficiently; and to provide guarantees about the performance of the solution. The book starts with a relatively simple treatment of uncertain linear programming, proceeding with a deep analysis of the interconnections between the construction of appropriate uncertainty sets and the classical chance constraints (probabilistic) approach. It then develops the robust optimization theory for uncertain conic quadratic and semidefinite optimization problems and dynamic (multistage) problems. The theory is supported by numerous examples and computational illustrations. An essential book for anyone working on optimization and decision making under uncertainty, Robust Optimization also makes an ideal graduate textbook on the subject.

This book nds its origin in the WIDE PhD School on Networked Control Systems, which we organized in July 2009 in Siena, Italy. Having gathered experts on all the aspects of networked control systems, it was a small step to go from the summer school to the book, certainly given the enthusiasm of the lecturers at the school. We felt that a book collecting overviewson the important developmentsand open pr- lems in the eld of networked control systems could stimulate and support future research in this appealing area. Given the tremendouscurrentinterests in distributed control exploiting wired and wireless communication networks, the time seemed to be right for the book that lies now in front of you. The goal of the book is to set out the core techniques and tools that are ava- able for the modeling, analysis and design of networked control systems. Roughly speaking, the book consists of three parts. The rst part presents architectures for distributed control systems and models of wired and wireless communication n- works. In particular, in the rst chapter important technological and architectural aspects on distributed control systems are discussed. The second chapter provides insight in the behavior of communication channels in terms of delays, packet loss and information constraints leading to suitable modeling paradigms for commu- cation networks.

This book exemplifies how smart buildings have a crucial role to play for the future of energy. The book investigates what already exists in regards to technologies, approaches and solutions both with a scientific and technological point of view. The authors cover solutions for mirroring and tracing human activities, optimal strategies to configure home settings, and generating explanations and persuasive dashboards to get occupants better committed in their home energy managements. Solutions are adapted from the fields of Internet of Things, physical modeling, optimization, machine learning and applied artificial intelligence. Practical applications are given throughout.

Economic Model Predictive Control (EMPC) is a control strategy that moves process operation away from the steady-state paradigm toward a potentially time-varying operating strategy to improve process profitability. The EMPC literature is replete with evidence that this new paradigm may enhance process profits when a model of the chemical process provides a sufficiently accurate representation of the process dynamics. Systems using EMPC often neglect the dynamics associated with equipment and are often neglected when modeling a chemical process. Recent studies have shown they can significantly impact the effectiveness of an EMPC system. Concentrating on valve behavior in a chemical process, this monograph develops insights into the manner in which equipment behavior should impact the design process for EMPC and to provide a perspective on a number of open research topics in this direction. Written in tutorial style, this monograph provides the reader with a full literature review of the topic and demonstrates how these techniques can be adopted in a practical system.

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 thepracticalapplicabilityofNMPCwithinreachevenforveryfastsystems.This has led to a series of new, exciting developments, along with new challenges in the area of NMPC.

This is the 3rd edition of a research monograph providing a synthesis of old research on the foundations of dynamic programming (DP), with the modern theory of approximate DP and new research on semicontractive models. It aims at a unified and economical development of the core theory and algorithms of total cost sequential decision problems, based on the strong connections of the subject with fixed point theory. The analysis focuses on the abstract mapping that underlies DP and defines the mathematical character of the associated problem. The discussion centers on two fundamental properties that this mapping may have: monotonicity and (weighted sup-norm) contraction. It turns out that the nature of the analytical and algorithmic DP theory is determined primarily by the presence or absence of these two properties, and the rest of the problem's structure is largely inconsequential. New research is focused on two areas: 1) The ramifications of these properties in the context of algorithms for approximate DP, and 2) The new class of semicontractive models, exemplified by stochastic shortest path problems, where some but not all policies are contractive. The 3rd edition is very similar to the

2nd edition, except for the addition of a new chapter (Chapter 5), which deals with abstract DP models for sequential minimax problems and zero-sum games, The book is an excellent supplement to several of our books: Neuro-Dynamic Programming (Athena Scientific, 1996), Dynamic Programming and Optimal Control (Athena Scientific, 2017), Reinforcement Learning and Optimal Control (Athena Scientific, 2019), and Rollout, Policy Iteration, and Distributed Reinforcement Learning (Athena Scientific, 2020).

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.

Model Predictive Control is an important technique used in the process control industries. It has developed considerably in the last few years, because it is the most general way of posing the process control problem in the time domain. The Model Predictive Control formulation integrates optimal control, stochastic control, control of processes with dead time, multivariable control and future references. The finite control horizon makes it possible to handle constraints and non linear processes in general which are frequently found in industry. Focusing on implementation issues for Model Predictive Controllers in industry, it fills the gap between the empirical way practitioners use control algorithms and the sometimes abstractly formulated techniques developed by researchers. The text is firmly based on material from lectures given to senior undergraduate and graduate students and articles written by the authors.

A complete and accessible introduction to the real-world applications of approximate dynamic programming With the growing levels of sophistication in modern-day operations, it is vital for practitioners to understand how to approach, model, and solve complex industrial problems. Approximate Dynamic Programming is a result of the author's decades of experience working in large industrial settings to develop practical and high-quality solutions to problems that involve making decisions in the presence of uncertainty. This groundbreaking book uniquely integrates four distinct disciplines—Markov design processes, mathematical programming, simulation, and statistics—to demonstrate how to successfully model and solve a wide range of real-life problems using the techniques of approximate dynamic programming (ADP). The reader is introduced to the three curses of dimensionality that impact complex problems and is also shown how the post-decision state variable allows for the use of classical algorithmic strategies from operations research to treat complex stochastic optimization problems. Designed as an introduction and assuming no prior training in dynamic programming of any form, Approximate Dynamic Programming contains dozens of algorithms that are intended to serve as a starting point in the design of practical solutions for real problems. The book provides detailed coverage of implementation challenges including: modeling complex sequential decision processes under uncertainty, identifying robust policies, designing and estimating value function approximations, choosing effective stepsize rules, and resolving convergence issues. With a focus on modeling and algorithms in conjunction with the language of mainstream operations research, artificial intelligence, and control theory, Approximate Dynamic Programming: Models complex, high-dimensional problems in a natural and practical way, which draws on years of industrial projects Introduces and emphasizes the power of estimating a value function around the post-decision state, allowing solution algorithms to be broken down into three fundamental steps: classical simulation, classical optimization, and classical statistics Presents a thorough discussion of recursive estimation, including fundamental theory and a number of issues that arise in the development of practical algorithms Offers a variety of methods for approximating dynamic programs that have appeared in previous literature, but that have never been presented in the coherent format of a book Motivated by examples from modern-day operations research, Approximate Dynamic Programming is an accessible introduction to dynamic modeling and is also a valuable guide for the development of high-quality solutions to problems that exist in operations research and engineering. The clear and precise presentation of the material makes this an appropriate text for advanced undergraduate and beginning graduate courses, while also serving as a reference for researchers and practitioners. A companion Web site is available for readers, which includes additional exercises, solutions to exercises, and data sets to reinforce the book's main concepts.

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.

With a simple approach that includes real-time applications and algorithms, this book covers the theory of model predictive control (MPC).

Model Predictive Control (MPC) refers to a class of control algorithms in which a dynamic process model is used to predict and optimize process performance. From lower request of modeling accuracy and robustness to complicated process plants, MPC has been widely accepted in many practical fields. As the guide for researchers and engineers all over the world concerned with the latest developments of MPC, the purpose of "Advanced Model Predictive Control" is to show the readers the recent achievements in this area. The first part of this exciting book will help you comprehend the frontiers in theoretical research of MPC, such as Fast MPC, Nonlinear MPC, Distributed MPC, Multi-Dimensional MPC and Fuzzy-Neural MPC. In the second part, several excellent applications of MPC in modern industry are proposed and efficient commercial software for MPC is introduced. Because of its special industrial origin, we believe that MPC will remain energetic in the future.