Optimal Control Of Nonlinear Systems Using The Homotopy

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Neighboring Optimal Control of Nonlinear Systems Using Bounded Control

This book discusses theoretical approaches to the study of optimal control problems governed by non-linear evolutions - including semi-linear equations, variational inequalities and systems with phase transitions. It also provides algorithms for solving non-linear parabolic systems and multiphase Stefan-like systems.

Neural Network Control of Nonlinear Discrete-Time Systems

This outstanding reference presents current, state-of-the-art research on importantproblems of finite-dimensional nonlinear optimal control and controllability theory. Itpresents an overview of a broad variety of new techniques useful in solving classicalcontrol theory problems.Written and edited by renowned mathematicians at the forefront of research in thisevolving field, Nonlinear Controllability and Optimal Control providesdetailed coverage of the construction of solutions of differential inclusions by means ofdirectionally continuous sections Lie algebraic conditions for local controllability the use of the Campbell-Hausdorff series to derive properties of optimal trajectories the Fuller phenomenon the theory of orbits and more.Containing more than 1,300 display equations, this exemplary, instructive reference is aninvaluable source for mathematical researchers and applied mathematicians, electrical andelectronics, aerospace, mechanical, control, systems, and computer engineers, and graduatestudents in these disciplines .

Optimal Control of Constrained Piecewise Affine Systems

Nonlinear Dynamical Systems and Control presents and develops an extensive treatment of stability analysis and control design of nonlinear dynamical systems, with an emphasis on Lyapunov-based methods. Dynamical system theory lies at the heart of mathematical sciences and engineering. The application of dynamical systems has crossed interdisciplinary boundaries from chemistry to biochemistry to chemical kinetics, from medicine to biology to population genetics, from economics to sociology to psychology, and from physics to mechanics to engineering. The increasingly complex nature of engineering systems requiring feedback control to obtain a desired system behavior also gives rise to dynamical systems. Wassim Haddad and VijaySekhar Chellaboina provide an exhaustive treatment of nonlinear systems theory and control using the highest standards of exposition and rigor. This graduate-level textbook goes well beyond standard treatments by developing Lyapunov stability theory, partial stability, boundedness, input-to-state stability, input-output stability, finite-time stability, semistability, stability of sets and periodic orbits, and stability theorems via vector Lyapunov functions. A complete and thorough treatment of dissipativity theory, absolute stability theory, stability of feedback systems, optimal control, disturbance rejection control, and robust control for nonlinear dynamical systems is also given. This book is an indispensable resource for applied mathematicians, dynamical systems theorists, control theorists, and engineers.

Optimal Control

This book presents a class of novel, self-learning, optimal control schemes based on adaptive dynamic programming techniques, which quantitatively obtain the optimal control schemes of the systems. It analyzes the properties identified by the programming methods, including the convergence of the iterative value functions and the stability of the system under iterative control laws, helping to guarantee the effectiveness of the methods developed. When the system model is known, self-learning optimal control is designed on the basis of the system model; when the system model is not known, adaptive dynamic programming is implemented according to the system data, effectively making the performance of the system converge to the optimum. With various real-world examples to complement and substantiate the mathematical analysis, the book is a valuable guide for engineers, researchers, and students in control science and engineering.

Nonlinear Systems

This edited book contains selected papers presented at the Louisiana Conference on Mathematical Control Theory (MCT'03), which brought together over 35 prominent world experts in mathematical control theory and its applications. The book forms a well-integrated exploration of those areas of mathematical control theory in which nonsmooth analysis is having a major impact. These include necessary and sufficient conditions in optimal control, Lyapunov characterizations of stability, input-to-state stability, the construction of feedback mechanisms, viscosity solutions of Hamilton-Jacobi equations, invariance, approximation theory, impulsive systems, computational issues for nonlinear systems, and other topics of interest to mathematicians and control engineers. The book has a strong interdisciplinary component and was designed to facilitate the interaction between leading mathematical experts in nonsmooth analysis and engineers who are increasingly using nonsmooth analytic tools.

Optimal Control of Nonlinear Processes

This book is devoted to new methods of control for complex dynamical systems and deals with nonlinear control systems having several degrees of freedom, subjected to unknown disturbances, and containing uncertain parameters. Various constraints are imposed on control inputs and state variables or their combinations. The book contains an introduction to the theory of optimal control and the theory of stability of motion, and also a description of some known methods based on these theories. Major attention is given to new methods of control developed by the authors over the last 15 years. Mechanical and electromechanical systems described by nonlinear Lagrange’s equations are considered. General methods are proposed for an effective construction of the required control, often in an explicit form. The book contains various techniques including the decomposition of nonlinear control systems with many degrees of freedom, piecewise linear feedback control based on Lyapunov’s functions, methods which elaborate and extend the approaches of the conventional control theory, optimal control, differential games, and the theory of stability. The distinctive feature of the methods developed in the book is that the c- trols obtained satisfy the imposed constraints and steer the dynamical system to a prescribed terminal state in ?nite time. Explicit upper estimates for the time of the process are given. In all cases, the control algorithms and the estimates obtained are strictly proven.

Optimal Control Theory

This book presents a carefully selected group of methods for unconstrained and bound constrained optimization problems and analyzes them in depth both theoretically and algorithmically. It focuses on clarity in algorithmic description and analysis rather than generality, and while it provides pointers to the literature for the most general theoretical results and robust software, the author thinks it is more important that readers have a complete understanding of special cases that convey essential ideas. A companion to Kelley's book, Iterative Methods for Linear and Nonlinear Equations (SIAM, 1995), this book contains many exercises and examples and can be used as a text, a tutorial for self-study, or a reference. Iterative Methods for Optimization does more than cover traditional gradient-based optimization: it is the first book to treat sampling methods, including the Hooke-Jeeves, implicit filtering, MDS, and Nelder-Mead schemes in a unified way, and also the first book to make connections between sampling methods and the traditional gradient-methods. Each of the main algorithms in the text is described in pseudocode, and a collection of MATLAB codes is available. Thus, readers can experiment with the algorithms in an easy way as well as implement them in other languages.

Optimal Control of Partial Differential Equations

This timely work presents the definitive treatment of stability analysis and robust control design for nonlinear uncertain systems. While other books on the subject deal with robust control in linear systems, this is the first book to tackle robust control design for such nonlinear entities as power systems, robotics, and more. It combines examples, proofs, and applications-clearly showing how to build high performance and better control into systems that are too complex to be modeled accurately. A unique feature of this book is its Lyapunov-based approach to control design, which is the only universal approach for nonlinear systems. The Lyapunov direct method is used here to develop all design procedures, to correlate leading techniques in the field to the structural properties of uncertain systems, and to compare robust and nonrobust types of controls such as adaptive control, learning control, and optimal control. The subject is introduced with a self-contained treatment of the nonlinear stability theory originally proposed by Lyapunov and LaSalle. Emphasizing the basics, the introductory chapters incorporate three types of solutions, stability concepts, and various theorems. The main body of the text offers a comprehensive treatment for current design methods, including state space robust control designs, properties of various robust controllers, input-output control, and discrete robust control designs. In Robust Control of Nonlinear Uncertain Systems, author Zhihua Qu presents the complete set of control design procedures for nonlinear uncertain systems, including backward recurisve design, forward recursive design, recursive-interlacing design, feedback linearization, nonlinear optimal control, and sub-optimal control. Also featured here is the breakthrough recursive interlacing design that facilitates robust control for uncertain systems with all cascaded, feedback, and feedforward dynamics. Throughout, Professor Qu presents the pros and cons of specific methods, rationales for choosing particular design parameters,and tips on questions of stability, performance, and systems structure. For engineers and graduate students in mechanical, electrical, and aerospace engineering, Robust Control of Nonlinear Uncertain Systems imparts the technical know-how for effective design, explores key theoretical issues in control, and provides insight into future trends in the field.

Iterative Methods for Optimization

A collection of 28 refereed papers grouped according to four broad topics: duality and optimality conditions, optimization algorithms, optimal control, and variational inequality and equilibrium problems. Suitable for researchers, practitioners and postgrads.

Nonlinear Controllability and Optimal Control

The book consists mainly of two parts: Chapter 1 - Chapter 7 and Chapter 8 -

Chapter 14. Chapter 1 and Chapter 2 treat design techniques based on linearization of nonlinear systems. An analysis of nonlinear system over quantum mechanics is discussed in Chapter 3. Chapter 4 to Chapter 7 are estimation methods using Kalman filtering while solving nonlinear control systems using iterative approach. Optimal approaches are discussed in Chapter 8 with retarded control of nonlinear system in singular situation, and Chapter 9 extends optimal theory to H-infinity control for a nonlinear control system.Chapters 10 and 11 present the control of nonlinear dynamic systems, twin-rotor helicopter and 3D crane system, which are both underactuated, cascaded dynamic systems. Chapter 12 applies controls to antisynchronization/synchronization in the chaotic models based on Lyapunov exponent theorem, and Chapter 13 discusses developed stability analytic approaches in terms of Lyapunov stability. The analysis of economic activities, especially the relationship between stock return and economic growth, is presented in Chapter 14.

Nonlinear and Optimal Control Systems

A focused presentation of how sparse optimization methods can be used to solve optimal control and estimation problems.

Robust Control of Nonlinear Uncertain Systems

There has been much excitement over the emergence of new mathematical techniques for the analysis and control of nonlinear systems. In addition, great technological advances have bolstered the impact of analytic advances and produced many new problems and applications which are nonlinear in an essential way. This book lays out in a concise mathematical framework the tools and methods of analysis which underlie this diversity of applications.

Switching in Systems and Control

Nonlinear Control Systems and Power System Dynamics presents a comprehensive description of nonlinear control of electric power systems using nonlinear control theory, which is developed by the differential geometric approach and nonlinear robust control method. This book explains in detail the concepts, theorems and algorithms in nonlinear control theory, illustrated by step-by-step examples. In addition, all the mathematical formulation involved in deriving the nonlinear control laws of power systems are sufficiently presented. Considerations and cautions involved in applying nonlinear control theory to practical engineering control designs are discussed and special attention is given to the implementation of nonlinear control laws using microprocessors. Nonlinear Control Systems and Power System Dynamics serves as a text for advanced level courses and is an excellent reference for engineers and researchers who are interested in the application of modern nonlinear control theory to practical engineering control designs.

Nonlinear Dynamical Systems and Control

Backstepping Control of Nonlinear Dynamical Systems addresses both the fundamentals of backstepping control and advances in the field. The latest techniques explored include ‘active backstepping control’, ‘adaptive backstepping control’, ‘fuzzy backstepping control’ and ‘adaptive fuzzy backstepping control’. The reference book provides numerous simulations using MATLAB and circuit design. These illustrate the main results of theory and applications of backstepping control of nonlinear control systems. Backstepping control encompasses varied aspects of mechanical engineering and has many different applications within the field. For example, the book covers aspects related to robot manipulators, aircraft flight control systems, power systems, mechanical systems, biological systems and chaotic systems. This multifaceted view of subject areas means that this useful reference resource will be ideal for a large cross section of the mechanical engineering community. Details the real-world applications of backstepping control Gives an up-to-date insight into the theory, uses and application of backstepping control Bridges the gaps for different fields of engineering, including mechanical engineering, aeronautical engineering, electrical engineering, communications engineering, robotics and biomedical instrumentation

Deep Reinforcement Learning with Guaranteed Performance

Upper-level undergraduate text introduces aspects of optimal control theory: dynamic programming, Pontryagin's minimum principle, and numerical techniques for trajectory optimization. Numerous figures, tables. Solution guide available upon request. 1970 edition.

Practical Methods for Optimal Control Using Nonlinear Programming, Third Edition

Originally published: London; New York: Academic Press, 1980, in series: Mathematics in science and engineering; v. 156.

Optimization and Control with Applications

Nonlinear Optimal Control Theory

How do you fly an airplane from one point to another as fast as possible? What is the best way to administer a vaccine to fight the harmful effects of disease? What is the most efficient way to produce a chemical substance? This book presents practical methods for solving real optimal control problems such as these. Practical Methods for Optimal Control Using Nonlinear Programming, Third Edition focuses on the direct transcription method for optimal control. It features a summary of relevant material in constrained optimization, including nonlinear programming; discretization techniques appropriate for ordinary differential equations and differential-algebraic equations; and several examples and descriptions of computational algorithm formulations that implement this discretize-then-optimize strategy. The third edition has been thoroughly updated and includes new material on implicit Runge–Kutta discretization techniques, new chapters on partial differential equations and delay equations, and more than 70 test problems and open source FORTRAN code for all of the problems. This book will be valuable for academic and industrial research and development in optimal control theory and applications. It is appropriate as a primary or supplementary text for advanced undergraduate and graduate students.

Nonlinear and Optimal Control Theory

This book presents a class of novel, self-learning, optimal control schemes based on adaptive dynamic programming techniques, which quantitatively obtain the optimal control schemes of the systems. It analyzes the properties identified by the programming methods, including the convergence of the iterative value functions and the stability of the system under iterative control laws, helping to guarantee the effectiveness of the methods developed. When the system model is known, self-learning optimal control is designed on the basis of the system model; when the system model is not known, adaptive dynamic programming is implemented according to the system data, effectively making the performance of the system converge to the optimum. With various real-world examples to complement and substantiate the mathematical analysis, the book is a valuable guide for engineers, researchers, and students in control science and engineering.

Practical Methods for Optimal Control and Estimation Using Nonlinear Programming

Intelligent systems are a hallmark of modern feedback control systems. But as these systems mature, we have come to expect higher levels of performance in speed and accuracy in the face of severe nonlinearities, disturbances, unforeseen dynamics, and unstructured uncertainties. Artificial neural networks offer a combination of adaptability, parallel processing, and learning capabilities that outperform other intelligent control methods in more complex systems. Borrowing from Biology Examining neurocontroller design in discrete-time for the first time, Neural Network Control of Nonlinear Discrete-Time Systems presents powerful modern control techniques based on the parallelism and adaptive capabilities of biological nervous systems. At every step, the author derives rigorous stability proofs and presents simulation examples to demonstrate the concepts. Progressive Development After an introduction to neural networks, dynamical systems, control of nonlinear systems, and feedback linearization, the book builds systematically from actuator nonlinearities and strict feedback in nonlinear systems to nonstrict feedback, system identification, model reference adaptive control, and novel optimal control using the Hamilton-Jacobi-Bellman formulation. The author concludes by developing a framework for implementing intelligent control in actual industrial systems using embedded hardware. Neural Network Control of Nonlinear Discrete-Time Systems fosters an understanding of neural network controllers and explains how to build them using detailed derivations, stability analysis, and computer simulations.

Discrete-Time Inverse Optimal Control for Nonlinear Systems

Optimal Networked Control Systems with MATLAB® discusses optimal controller design in discrete time for networked control systems (NCS). The authors apply several powerful modern control techniques in discrete time to the design of intelligent controllers for such NCS. Detailed derivations, rigorous stability proofs, computer simulation examples, and downloadable MATLAB® codes are included for each case. The book begins by providing background on NCS, networked imperfections, dynamical systems, stability theory, and stochastic optimal adaptive controllers in discrete time for linear and nonlinear systems. It lays the foundation for reinforcement learning-based optimal adaptive controller use for finite and infinite horizons. The text then: Introduces quantization effects for linear and nonlinear NCS, describing the design of stochastic adaptive controllers for a class of linear and nonlinear systems Presents two-player zero-sum game-theoretic formulation for linear systems in input–output form enclosed by a communication network Addresses the stochastic optimal control of nonlinear NCS by using neuro dynamic programming Explores stochastic optimal design for nonlinear two-player zero-sum games under communication constraints Treats an event-sampled distributed NCS to minimize transmission of state and control signals within the feedback loop via the communication network Covers distributed joint optimal network scheduling and control design for wireless NCS, as well as the effect of network protocols on the wireless NCS controller design An ideal reference for graduate students, university researchers, and practicing engineers, Optimal Networked Control Systems with MATLAB® instills a solid understanding of neural network controllers and how to build them.

Optimal Networked Control Systems with MATLAB

This book offers a three-step approach to generating a robust nonlinear controller: modeling, synthesis, and robustness analysis. The publication is targeted to practicing engineers and graduate-level students working in guidance, information command and control systems, and CAD/CAM. The methods covered in this book allow the user to design and analyze nonlinear controllers for nonlinear systems with several important and unique characteristics: the ability to specify the closed loop systems frequency response via requirements on the sensitivity (S) and complementary sensitivity (T), the ability to directly minimize an undesirable resonance or peak in the frequency response while simultaneously closing all loops from the input to the output vector in essentially one single design step, and the ability to analyze the stability characteristics for multiple independent and dependent problem variables. The approach uniquely allows the user to achieve stable and robust performance for systems which are both unstable and contain discontinuous nonlinearities using adaptive nonlinear controllers.

Applications of Robust Control to Nonlinear Systems

This book discusses methods and algorithms for the near-optimal adaptive control of nonlinear systems, including the corresponding theoretical analysis and simulative examples, and presents two innovative methods for the redundancy resolution of redundant manipulators with consideration of parameter uncertainty and periodic disturbances. It also reports on a series of systematic investigations on a near-optimal adaptive control method based on the Taylor expansion, neural networks, estimator design approaches, and the idea of sliding mode control, focusing on the tracking control problem of nonlinear systems under different scenarios. The book culminates with a presentation of two new redundancy resolution methods; one addresses adaptive kinematic control of redundant manipulators, and the other centers on the effect of periodic input disturbance on redundancy resolution. Each self-contained chapter is clearly written, making the book accessible to graduate students as well as academic and industrial researchers in the fields of adaptive and optimal control, robotics, and dynamic neural networks.

Optimal Control, Stabilization and Nonsmooth Analysis

The first comprehensive, self–contained text on nonlinear analysis and robust control Increasingly, robust control plays a greater role in achieving high performance for systems that are too complex to be modeled accurately. Using Lyapunov′s direct method to develop design procedures, compare different controls, and give the reader a definite feel for stability analysis and robust control for nonlinear systems with significant uncertainty, this unique text: ∗ Presents the complete set of robust control design procedures for nonlinear uncertain systems ∗ Introduces the recursive interlacing design method that will generate robust control for uncertain systems with cascaded, feedback, and feedforward dynamics ∗ Covers a broad range of robust control designs, including state feedback and input–output, continuous–time and digital, and static and dynamic controls ∗ Gives advice on selecting design parameters according to their impact on stability and performance ∗ Features illustrations as well as end–of–chapter exercises and references

Self-Learning Optimal Control of Nonlinear Systems

H-infinity control originated from an effort to codify classical control methods, where one shapes frequency response functions for linear systems to meet certain objectives. H-infinity control underwent tremendous development in the 1980s and made considerable strides toward systematizing classical control. This book addresses the next major issue of how this extends to nonlinear systems. At the core of nonlinear control theory lie two partial differential equations (PDEs). One is a first-order evolution equation called the information state equation, which constitutes the dynamics of the controller. One can view this equation as a nonlinear dynamical system. Much of this volume is concerned with basic properties of this system, such as the nature of trajectories, stability, and, most important, how it leads to a general solution of the nonlinear H-infinity control problem.

Functional Analysis and Linear Control Theory

Analysis and Control of Nonlinear Infinite Dimensional Systems

Robust Control of Nonlinear Uncertain Systems

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.

Optimal Trajectory Tracking of Nonlinear Dynamical Systems

One of the most important and challenging problems in control is the derivation of systematic tools for the computation of controllers for constrained nonlinear systems that can guarantee closed-loop stability, feasibility, and optimality with respect to some performance index. This book focuses on the efficient and systematic computation of closed-form optimal controllers for the powerful class of fast-sampled constrained piecewise affine systems. These systems may exhibit rather complex behavior and are equivalent to many other hybrid system formalisms (combining continuous-valued dynamics with logic rules) reported in the literature. Furthermore, piecewise affine systems are a useful modeling tool that can capture general nonlinearities (e.g. by local approximation), constraints, saturations, switches, and other hybrid modeling phenomena. The first part of the book presents an introduction to the mathematical and control theoretical background material needed for the full understanding of the book. The second part provides an in depth look at the computational and control theoretic properties of the controllers and part three presents different analysis and post-processing techniques.

Nonlinear H-Infinity Control, Hamiltonian Systems and Hamilton-Jacobi Equations

By establishing an alternative foundation of control theory, this thesis represents a significant advance in the theory of control systems, of interest to a broad range of scientists and engineers. While common control strategies for dynamical systems center on the system state as the object to be controlled, the approach developed here focuses on the state trajectory. The concept of precisely realizable trajectories identifies those trajectories that can be accurately achieved by applying appropriate control signals. The resulting simple expressions for the control signal lend themselves to immediate application in science and technology. The approach permits the generalization of many well-known results from the control theory of linear systems, e.g. the Kalman rank condition to nonlinear systems. The relationship between controllability, optimal control and trajectory tracking are clarified. Furthermore, the existence of linear structures underlying nonlinear optimal control is revealed, enabling the derivation of exact analytical solutions to an entire class of nonlinear optimal trajectory tracking problems. The clear and self-contained presentation focuses on a general and mathematically rigorous analysis of controlled dynamical systems. The concepts developed are visualized with the help of particular dynamical systems motivated by physics and chemistry.

Nonlinear Model Predictive Control

This book is based on lectures from a one-year course at the Far Eastern Federal University (Vladivostok, Russia) as well as on workshops on optimal control offered to students at various mathematical departments at the university level. The main themes of the theory of linear and nonlinear systems are considered, including the basic problem of establishing the necessary and sufficient conditions of optimal processes. In the first part of the course, the theory of linear control systems is constructed on the basis of the separation theorem and the concept of a reachability set. The authors prove the closure of a reachability set in the class of piecewise continuous controls, and the problems of controllability, observability, identification, performance and terminal control are also considered. The second part of the course is devoted to nonlinear control systems. Using the method of variations and the Lagrange multipliers rule of nonlinear problems, the authors prove the Pontryagin maximum principle for problems with mobile ends of trajectories. Further exercises and a large number of additional tasks are provided for use as practical training in order for the reader to consolidate the theoretical material.

Nonlinear Systems

A comprehensive overview of nonlinear H∞ control theory for both continuous-time and discrete-time systems, Nonlinear H∞-Control, Hamiltonian Systems and Hamilton-Jacobi Equations covers topics as diverse as singular nonlinear H∞-control, nonlinear H∞ -filtering, mixed H2/ H∞-nonlinear control and filtering, nonlinear H∞-almost-disturbance-decoupling, and algorithms for solving the ubiquitous Hamilton-Jacobi-Isaacs equations. The link between the subject and analytical mechanics as well as the theory of partial differential equations is also elegantly summarized in a single chapter. Recent progress in developing computational schemes for solving the Hamilton-Jacobi equation (HJE) has facilitated the application of Hamilton-Jacobi theory in both mechanics and control. As there is currently no efficient systematic analytical or numerical approach for solving them, the biggest bottle-neck to the practical application of the nonlinear equivalent of the H∞-control theory has been the difficulty in solving the Hamilton-Jacobi-Isaacs partial differential-equations (or inequalities). In light of this challenge, the author hopes to inspire continuing research and discussion on this topic via examples and simulations, as well as helpful notes and a rich bibliography. Nonlinear H∞-Control, Hamiltonian Systems and Hamilton-Jacobi Equations was written for practicing professionals, educators, researchers and graduate students in electrical, computer, mechanical, aeronautical, chemical, instrumentation, industrial and systems engineering, as well as applied mathematics, economics and management.

Optimal Control of Nonlinear Parabolic Systems

Recently, the subject of nonlinear control systems analysis has grown rapidly and this book provides a simple and self-contained presentation of their stability and feedback stabilization which enables the reader to learn and understand major techniques used in mathematical control theory. In particular: the important techniques of proving global stability properties are presented closely linked with corresponding methods of nonlinear feedback stabilization; a general framework of methods for proving stability is given, thus allowing the study of a wide class of nonlinear systems, including finite-dimensional systems described by ordinary differential equations, discrete-time systems, systems with delays and sampled-data systems; approaches to the proof of classical global stability properties are extended to non-classical global stability properties such as non-uniform-in-time stability and input-to-output stability; and new tools for stability analysis and control design of a wide class of nonlinear systems are introduced. The presentational emphasis of Stability and Stabilization of Nonlinear Systems is theoretical but the theory's importance for concrete control problems is highlighted with a chapter specifically dedicated to applications and with numerous illustrative examples. Researchers working on nonlinear control theory will find this monograph of interest while graduate students of systems and control can also gain much insight and assistance from the methods and proofs detailed in this book.

Control of Nonlinear Dynamical Systems

Designed for one-semester introductory senior-or graduate-level course, the authors provide the student with an introduction of analysis techniques used in the design of nonlinear and optimal feedback control systems. There is special emphasis on the fundamental topics of stability, controllability, and optimality, and on the corresponding geometry associated with these topics. Each chapter contains several examples and a variety of exercises.

Nonlinear Control Systems and Power System Dynamics

The theory of switched systems is related to the study of hybrid systems, which has gained attention from control theorists, computer scientists, and practicing engineers. This book examines switched systems from a control-theoretic perspective, focusing on stability analysis and control synthesis of systems that combine continuous dynamics with switching events. It includes a vast bibliography and a section of technical and historical notes.

Backstepping Control of Nonlinear Dynamical Systems

Nonlinear Optimal Control Theory presents a deep, wide-ranging introduction to the mathematical theory of the optimal control of processes governed by ordinary differential equations and certain types of differential equations with memory. Many examples illustrate the mathematical issues that need to be addressed when using optimal control techniques in diverse areas. Drawing on classroom-tested material from Purdue University and North Carolina State University, the book gives a unified account of bounded state problems governed by ordinary, integrodifferential, and delay systems. It also discusses Hamilton-Jacobi theory. By providing a sufficient and rigorous treatment of finite dimensional control problems, the book equips readers with the foundation to deal with other types of control problems, such as those governed by stochastic differential equations, partial differential equations, and differential games.

Stability and Stabilization of Nonlinear Systems

Nonlinear Model Predictive Control is a thorough and rigorous introduction to nonlinear model predictive control (NMPC) for discrete-time and sampled-data systems. 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. NMPC schemes with and without stabilizing terminal constraints are detailed and intuitive examples illustrate the performance of different NMPC variants. An introduction to nonlinear optimal control algorithms gives insight into how the nonlinear optimisation routine – the core of any NMPC controller – works. An appendix covering NMPC software and accompanying software in MATLAB® and C++(downloadable from www.springer.com/ISBN) enables readers to perform computer experiments exploring the possibilities and limitations of NMPC.

Self-Learning Optimal Control of Nonlinear Systems

Dynamic optimization is rocket science – and more. This volume teaches researchers and students alike to harness the modern theory of dynamic optimization to solve practical problems. These problems not only cover those in space flight, but also in emerging social applications such as the control of drugs, corruption, and terror. This volume is designed to be a lively introduction to the mathematics and a bridge to these hot topics in the economics of crime for current scholars. The authors celebrate Pontryagin’s Maximum Principle – that crowning intellectual achievement of human understanding. The rich theory explored here is complemented by numerical methods available through a companion web site.

Analysis and Control of Nonlinear Infinite Dimensional Systems

Discrete-Time Inverse Optimal Control for Nonlinear Systems proposes a novel inverse optimal control scheme for stabilization and trajectory tracking of discrete-time nonlinear systems. This avoids the need to solve the associated Hamilton-Jacobi-Bellman equation and minimizes a cost functional, resulting in a more efficient controller. Design More Efficient Controllers for Stabilization and Trajectory Tracking of Discrete-Time Nonlinear Systems The book presents two approaches for controller synthesis: the first based on passivity theory and the second on a control Lyapunov function (CLF). The synthesized discrete-time optimal controller can be directly implemented in real-time systems. The book also proposes the use of recurrent neural networks to model discrete-time nonlinear systems. Combined with the inverse optimal control approach, such models constitute a powerful tool to deal with uncertainties such as unmodeled dynamics and disturbances. Learn from Simulations and an In-Depth Case Study The authors include a variety of simulations to illustrate the effectiveness of the synthesized controllers for stabilization and trajectory tracking of discrete-time nonlinear systems. An in-depth case study applies the control schemes to glycemic control in patients with type 1 diabetes mellitus, to calculate the adequate insulin delivery rate required to prevent hyperglycemia and hypoglycemia levels. The discrete-time optimal and robust control techniques proposed can be used in a range of industrial applications, from aerospace and energy to biomedical and electromechanical systems. Highlighting optimal and efficient control algorithms, this is a valuable resource for researchers, engineers, and students working in nonlinear system control.

Nonlinear Model Predictive Control

The lectures gathered in this volume present some of the different aspects of Mathematical Control Theory. Adopting the point of view of Geometric Control Theory and of Nonlinear Control Theory, the lectures focus on some aspects of the Optimization and Control of nonlinear, not necessarily smooth, dynamical systems. Specifically, three of the five lectures discuss respectively: logic-based switching control, sliding mode control and the input to the state stability paradigm for the control and stability of nonlinear systems. The remaining two lectures are devoted to Optimal Control: one investigates the connections between Optimal Control Theory, Dynamical Systems and Differential Geometry, while the second presents a very general version, in a non-smooth context, of the Pontryagin Maximum Principle. The arguments of the whole volume are self-contained and are directed to everyone working in Control Theory. They offer a sound presentation of the methods employed in the control and optimization of nonlinear dynamical systems.

Extending H-infinity Control to Nonlinear Systems

"Optimal control theory is concerned with finding control functions that minimize cost functions for systems described by differential equations. The methods have found widespread applications in aeronautics, mechanical engineering, the life sciences, and many other disciplines. This book focuses on optimal control problems where the state equation is an elliptic or parabolic partial differential equation. Included are topics such as the existence of optimal solutions, necessary optimality conditions and adjoint equations, second-order sufficient conditions, and main principles of selected numerical techniques. It also contains a survey on the Karush-Kuhn-Tucker theory of nonlinear programming in Banach spaces. The exposition begins with control problems with linear equations, quadratic cost functions and control constraints. To make the book self-contained, basic facts on weak solutions of elliptic and parabolic equations are introduced. Principles of functional analysis are introduced and explained as they are needed. Many simple examples illustrate the theory and its hidden difficulties. This start to the book makes it fairly self-contained and suitable for advanced undergraduates or beginning graduate students. Advanced control problems for nonlinear partial differential equations are also discussed. As prerequisites, results on boundedness and continuity of solutions to semilinear elliptic and parabolic equations are addressed. These topics are not yet readily available in books on PDEs, making the exposition also interesting for researchers. Alongside the main theme of the analysis of problems of optimal control, Tr'oltzsch also discusses numerical techniques. The exposition is confined to brief introductions into the basic ideas in order to give the reader an impression of how the theory can be realized numerically. After reading this book, the reader will be familiar with the main principles of the numerical analysis of PDE-constrained optimization."--Publisher's description.