

William W. Hager and  
Panos M. Pardalos

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# **OPTIMAL CONTROL**

**Theory, Algorithms and  
Applications**

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# Optimal Control Theory Algorithms And Applications

**G. Di Pillo**



## **Optimal Control Theory Algorithms And Applications:**

**Optimal Control** William W. Hager, Panos M. Pardalos, 2013-04-17 February 27 March 1 1997 the conference Optimal Control Theory Algorithms and Applications took place at the University of Florida hosted by the Center for Applied Optimization The conference brought together researchers from universities industry and government laboratories in the United States Germany Italy France Canada and Sweden There were forty five invited talks including seven talks by students The conference was sponsored by the National Science Foundation and endorsed by the SIAM Activity Group on Control and Systems Theory the Mathematical Programming Society the International Federation for Information Processing IFIP and the International Association for Mathematics and Computers in Simulation IMACS Since its inception in the 1940s and 1950s Optimal Control has been closely connected to industrial applications starting with aerospace The program for the Gainesville conference which reflected the rich cross disciplinary flavor of the field included aerospace applications as well as both novel and emerging applications to superconductors diffractive optics nonlinear optics structural analysis bioreactors corrosion detection acoustic flow process design in chemical engineering hydroelectric power plants sterilization of canned foods robotics and thermoelastic plates and shells The three days of the conference were organized around the three conference themes theory algorithms and applications This book is a collection of the papers presented at the Gainesville conference We would like to take this opportunity to thank the sponsors and participants of the conference the authors the referees and the publisher for making this volume possible Mathematical Control Theory John B. Baillieu, J.C. Willems, 2012-12-06 This volume on mathematical control theory contains high quality articles covering the broad range of this field The internationally renowned authors provide an overview of many different aspects of control theory offering a historical perspective while bringing the reader up to the very forefront of current research **Mathematical Control Theory** Eduardo D. Sontag, 1998-07-17 Geared primarily to an audience consisting of mathematically advanced undergraduate or beginning graduate students this text may additionally be used by engineering students interested in a rigorous proof oriented systems course that goes beyond the classical frequency domain material and more applied courses The minimal mathematical background required is a working knowledge of linear algebra and differential equations The book covers what constitutes the common core of control theory and is unique in its emphasis on foundational aspects While covering a wide range of topics written in a standard theorem proof style it also develops the necessary techniques from scratch In this second edition new chapters and sections have been added dealing with time optimal control of linear systems variational and numerical approaches to nonlinear control nonlinear controllability via Lie algebraic methods and controllability of recurrent nets and of linear systems with bounded controls Control Theory for Partial Differential Equations: Volume 1, Abstract Parabolic Systems Irena Lasiecka, Roberto Triggiani, 2000-02-13 Originally published in 2000 this is the first volume of a comprehensive two volume treatment of quadratic optimal control theory for partial differential

equations over a finite or infinite time horizon and related differential integral and algebraic Riccati equations Both continuous theory and numerical approximation theory are included The authors use an abstract space operator theoretic approach which is based on semigroups methods and which is unifying across a few basic classes of evolution The various abstract frameworks are motivated by and ultimately directed to partial differential equations with boundary point control Volume 1 includes the abstract parabolic theory for the finite and infinite cases and corresponding PDE illustrations as well as various abstract hyperbolic settings in the finite case It presents numerous fascinating results These volumes will appeal to graduate students and researchers in pure and applied mathematics and theoretical engineering with an interest in optimal control problems

**Symmetric Constrained Optimal Control** Claus Danielson, 2014 This dissertation develops the theory of symmetry for constrained linear systems We use symmetry to design model predictive controllers for constrained linear systems with reduced complexity The dissertation is divided into three parts In the first part we review the relevant results from model predictive control and group theory In particular we present algorithms and data structures from computational group theory used to efficiently search groups In the second part we develop the theory of symmetry for constrained linear systems and model predictive control problems Symmetries of constrained linear systems are linear transformations that preserve the dynamics and constraints A symmetry of a model predictive control problem is a symmetry of the underlying constrained system that also preserves the cost We use a group theoretic formalism to derive properties of symmetric constrained linear systems and symmetric model predictive control problems We prove conditions under which the model predictive controller is symmetric and present a procedure for efficiently computing the symmetries of constrained linear systems and model predictive control problems Our method transforms the problem of finding generators for the symmetry group into a graph automorphism problem These symmetries are used to design model predictive control algorithms with reduced complexity We also present two novel explicit model predictive control designs Both reduce memory requirements by discarding symmetrically redundant pieces of the control law The control law in the eliminated pieces can be reconstructed online using symmetry We show that storing the symmetries of the problem requires less memory than storing the controller pieces In the third part of this dissertation we apply our symmetry theory to the battery balancing problem We use symmetry to reduce the memory requirements for explicit model predictive controllers for seven battery balancing hardware designs proposed in the literature This application demonstrates that our symmetric controller designs can significantly reduce the memory requirements of explicit model predictive control In particular for four out of seven of the designs in our numerical study the number of pieces in the symmetric controller did not increase as the battery pack size was increased

Optimization and Differentiation Simon Serovajsky, 2017-09-13 Optimization and Differentiation is an introduction to the application of optimization control theory to systems described by nonlinear partial differential equations As well as offering a useful reference work for researchers in these fields it is also suitable for graduate students of optimal

control theory      **Equilibrium Problems: Nonsmooth Optimization and Variational Inequality Models** F. Giannessi, A. Maugeri, Panos M. Pardalos, 2006-04-11 The aim of the book is to cover the three fundamental aspects of research in equilibrium problems the statement problem and its formulation using mainly variational methods its theoretical solution by means of classical and new variational tools the calculus of solutions and applications in concrete cases The book shows how many equilibrium problems follow a general law the so called user equilibrium condition Such law allows us to express the problem in terms of variational inequalities Variational inequalities provide a powerful methodology by which existence and calculation of the solution can be obtained      **Optimal Control of Dynamic Systems Driven by Vector Measures** N. U. Ahmed, Shian Wang, 2021-09-13 This book is devoted to the development of optimal control theory for finite dimensional systems governed by deterministic and stochastic differential equations driven by vector measures The book deals with a broad class of controls including regular controls vector valued measurable functions relaxed controls measure valued functions and controls determined by vector measures where both fully and partially observed control problems are considered In the past few decades there have been remarkable advances in the field of systems and control theory thanks to the unprecedented interaction between mathematics and the physical and engineering sciences Recently optimal control theory for dynamic systems driven by vector measures has attracted increasing interest This book presents this theory for dynamic systems governed by both ordinary and stochastic differential equations including extensive results on the existence of optimal controls and necessary conditions for optimality Computational algorithms are developed based on the optimality conditions with numerical results presented to demonstrate the applicability of the theoretical results developed in the book This book will be of interest to researchers in optimal control or applied functional analysis interested in applications of vector measures to control theory stochastic systems driven by vector measures and related topics In particular this self contained account can be a starting point for further advances in the theory and applications of dynamic systems driven and controlled by vector measures      *Approximation and Optimization of Discrete and Differential Inclusions* Elimhan N Mahmudov, 2011-08-25 Optimal control theory has numerous applications in both science and engineering This book presents basic concepts and principles of mathematical programming in terms of set valued analysis and develops a comprehensive optimality theory of problems described by ordinary and partial differential inclusions In addition to including well recognized results of variational analysis and optimization the book includes a number of new and important ones Includes practical examples      **Recent Advances in Model Predictive Control** Timm Faulwasser, Matthias A. Müller, Karl Worthmann, 2021-04-17 This book focuses on distributed and economic Model Predictive Control MPC with applications in different fields MPC is one of the most successful advanced control methodologies due to the simplicity of the basic idea measure the current state predict and optimize the future behavior of the plant to determine an input signal and repeat this procedure ad infinitum and its capability to deal with constrained nonlinear multi input multi output systems While the basic

idea is simple the rigorous analysis of the MPC closed loop can be quite involved Here distributed means that either the computation is distributed to meet real time requirements for very large scale systems or that distributed agents act autonomously while being coupled via the constraints and or the control objective In the latter case communication is necessary to maintain feasibility or to recover system wide optimal performance The term economic refers to general control tasks and thus goes beyond the typically predominant control objective of set point stabilization Here recently developed concepts like strict dissipativity of optimal control problems or turnpike properties play a crucial role The book collects research and survey articles on recent ideas and it provides perspectives on current trends in nonlinear model predictive control Indeed the book is the outcome of a series of six workshops funded by the German Research Foundation DFG involving early stage career scientists from different countries and from leading European industry stakeholders

Pareto-Nash-Stackelberg Game and Control Theory Valeriu Ungureanu,2018-03-09 This book presents a comprehensive new multi objective and integrative view on traditional game and control theories Consisting of 15 chapters it is divided into three parts covering noncooperative games mixtures of simultaneous and sequential multi objective games and multi agent control of Pareto Nash Stackelberg type games respectively Can multicriteria optimization game theory and optimal control be integrated into a unique theory Are there mathematical models and solution concepts that could constitute the basis of a new paradigm Is there a common approach and method to solve emerging problems The book addresses these and other related questions and problems to create the foundation for the Pareto Nash Stackelberg Game and Control Theory It considers a series of simultaneous Nash and sequential Stackelberg games single criterion and multicriteria Pareto games combining Nash and Stackelberg game concepts and Pareto optimization as well as a range of notions related to system control In addition it considers the problems of finding and representing the entire set of solutions Intended for researches professors specialists and students in the areas of game theory operational research applied mathematics economics computer science and engineering it also serves as a textbook for various courses in these fields

**Splitting Algorithms, Modern Operator Theory, and Applications** Heinz H. Bauschke,Regina S. Burachik,D. Russell Luke,2019-11-06 This book brings together research articles and state of the art surveys in broad areas of optimization and numerical analysis with particular emphasis on algorithms The discussion also focuses on advances in monotone operator theory and other topics from variational analysis and nonsmooth optimization especially as they pertain to algorithms and concrete implementable methods The theory of monotone operators is a central framework for understanding and analyzing splitting algorithms Topics discussed in the volume were presented at the interdisciplinary workshop titled Splitting Algorithms Modern Operator Theory and Applications held in Oaxaca Mexico in September 2017 Dedicated to Jonathan M Borwein one of the most versatile mathematicians in contemporary history this compilation brings theory together with applications in novel and insightful ways

**Optimization** Simon Serovajsky,2024-07-30 Optimization 100 Examples is a book devoted to the analysis

of scenarios for which the use of well known optimization methods encounter certain difficulties Analysing such examples allows a deeper understanding of the features of these optimization methods including the limits of their applicability In this way the book seeks to stimulate further development and understanding of the theory of optimal control The study of the presented examples makes it possible to more effectively diagnose problems that arise in the practical solution of optimal control problems and to find ways to overcome the difficulties that have arisen Features Vast collection of examples Simple accessible presentation Suitable as a research reference for anyone with an interest in optimization and optimal control theory including mathematicians and engineers Examples differ in properties i e each effect for each class of problems is illustrated by a unique example Simon Serovajsky is a professor of mathematics at Al Farabi Kazakh National University in Kazakhstan He is the author of many books published in the area of optimization and optimal control theory mathematical physics mathematical modelling philosophy and history of mathematics as well as a long list of high quality publications in learned journals

*Control Theory in Engineering* Constantin Volosencu,Xian Du,Ali Saghafinia,Sohom Chakrabarty,2020-05-27 The subject matter of this book ranges from new control design methods to control theory applications in electrical and mechanical engineering and computers The book covers certain aspects of control theory including new methodologies techniques and applications It promotes control theory in practical applications of these engineering domains and shows the way to disseminate researchers contributions in the field This project presents applications that improve the properties and performance of control systems in analysis and design using a higher technical level of scientific attainment The authors have included worked examples and case studies resulting from their research in the field Readers will benefit from new solutions and answers to questions related to the emerging realm of control theory in engineering applications and its implementation

### **Control Applications of Nonlinear Programming and Optimization**

G. Di Pillo,2014-05-17 Control Applications of Nonlinear Programming and Optimization presents the proceedings of the Fifth IFAC Workshop held in Capri Italy on June 11 14 1985 The book covers various aspects of the optimization of control systems and of the numerical solution of optimization problems The text also discusses specific applications concerned with the optimization of aircraft trajectories of mineral and metallurgical processes of wind tunnels and of nuclear reactors The book also considers computer aided design of control systems The book is useful to mathematicians engineers and computer engineers

**Optimization and Optimal Control** Altannar Chinchuluun,Panos M. Pardalos,Rentsen Enkhbat,Ider Tseveendorj,2010-08-05 Optimization and optimal control are the main tools in decision making Because of their numerous applications in various disciplines research in these areas is accelerating at a rapid pace Optimization and Optimal Control Theory and Applications brings together the latest developments in these areas of research as well as presents applications of these results to a wide range of real world problems This volume can serve as a useful resource for researchers practitioners and advanced graduate students of mathematics and engineering working in research areas where results in

optimization and optimal control can be applied      **Applied Mechanics Reviews** ,1970      **Optimal Control** Michael Athans, Peter L. Falb, 2013-04-26 Geared toward advanced undergraduate and graduate engineering students this text introduces the theory and applications of optimal control. It serves as a bridge to the technical literature enabling students to evaluate the implications of theoretical control work and to judge the merits of papers on the subject. Rather than presenting an exhaustive treatise, *Optimal Control* offers a detailed introduction that fosters careful thinking and disciplined intuition. It develops the basic mathematical background with a coherent formulation of the control problem and discussions of the necessary conditions for optimality based on the maximum principle of Pontryagin. In-depth examinations cover applications of the theory to minimum time, minimum fuel, and to quadratic criteria problems. The structure properties and engineering realizations of several optimal feedback control systems also receive attention. Special features include numerous specific problems carried through to engineering realization in block diagram form. The text treats almost all current examples of control problems that permit analytic solutions and its unified approach makes frequent use of geometric ideas to encourage students' intuition.

**Reinforcement Learning and Optimal Control** Dimitri Bertsekas, 2019-07-01 This book considers large and challenging multistage decision problems which can be solved in principle by dynamic programming (DP) but their exact solution is computationally intractable. We discuss solution methods that rely on approximations to produce suboptimal policies with adequate performance. These methods are collectively known by several essentially equivalent names: reinforcement learning, approximate dynamic programming, neuro dynamic programming. They have been at the forefront of research for the last 25 years and they underlie among others the recent impressive successes of self learning in the context of games such as chess and Go. Our subject has benefited greatly from the interplay of ideas from optimal control and from artificial intelligence as it relates to reinforcement learning and simulation based neural network methods. One of the aims of the book is to explore the common boundary between these two fields and to form a bridge that is accessible by workers with background in either field. Another aim is to organize coherently the broad mosaic of methods that have proved successful in practice while having a solid theoretical and/or logical foundation. This may help researchers and practitioners to find their way through the maze of competing ideas that constitute the current state of the art. This book relates to several of our other books: *Neuro Dynamic Programming* Athena Scientific 1996, *Dynamic Programming and Optimal Control* 4th edition Athena Scientific 2017, *Abstract Dynamic Programming* 2nd edition Athena Scientific 2018 and *Nonlinear Programming* Athena Scientific 2016. However the mathematical style of this book is somewhat different. While we provide a rigorous albeit short mathematical account of the theory of finite and infinite horizon dynamic programming and some fundamental approximation methods, we rely more on intuitive explanations and less on proof-based insights. Moreover our mathematical requirements are quite modest: calculus, a minimal use of matrix/vector algebra and elementary probability. Mathematically complicated arguments involving laws of large numbers and stochastic convergence are bypassed in favor of intuitive explanations. The



book illustrates the methodology with many examples and illustrations and uses a gradual expository approach which proceeds along four directions a From exact DP to approximate DP We first discuss exact DP algorithms explain why they may be difficult to implement and then use them as the basis for approximations b From finite horizon to infinite horizon problems We first discuss finite horizon exact and approximate DP methodologies which are intuitive and mathematically simple and then progress to infinite horizon problems c From deterministic to stochastic models We often discuss separately deterministic and stochastic problems since deterministic problems are simpler and offer special advantages for some of our methods d From model based to model free implementations We first discuss model based implementations and then we identify schemes that can be appropriately modified to work with a simulator The book is related and supplemented by the companion research monograph Rollout Policy Iteration and Distributed Reinforcement Learning Athena Scientific 2020 which focuses more closely on several topics related to rollout approximate policy iteration multiagent problems discrete and Bayesian optimization and distributed computation which are either discussed in less detail or not covered at all in the present book The author s website contains class notes and a series of videolectures and slides from a 2021 course at ASU which address a selection of topics from both books

**Mathematical Control Theory I** M. Kanat Camlibel, A. Agung Julius, Ramkrishna Pasumathy, Jacquélien M.A. Scherpen, 2015-07-15 This treatment of modern topics related to mathematical systems theory forms the proceedings of a workshop Mathematical Systems Theory From Behaviors to Nonlinear Control held at the University of Groningen in July 2015 The workshop celebrated the work of Professors Arjan van der Schaft and Harry Trentelman honouring their 60th Birthdays The first volume of this two volume work covers a variety of topics related to nonlinear and hybrid control systems After giving a detailed account of the state of the art in the related topic each chapter presents new results and discusses new directions As such this volume provides a broad picture of the theory of nonlinear and hybrid control systems for scientists and engineers with an interest in the interdisciplinary field of systems and control theory The reader will benefit from the expert participants ideas on exciting new approaches to control and system theory and their predictions of future directions for the subject that were discussed at the workshop

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