

Dynamic Programming and Optimal Control

Dimitri P. Bertsekas



Dynamic Programming And Its Applications To Optimal Control

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Dynamic Programming And Its Applications To Optimal Control:

Catholic Church in the Diocese of Maitland, 1986 *Dynamic Programming and Optimal Control* Dimitri Bertsekas, 2012-10-23 This is the leading and most up to date textbook on the far ranging algorithmic methodology of Dynamic Programming which can be used for optimal control Markovian decision problems planning and sequential decision making under uncertainty and discrete combinatorial optimization The treatment focuses on basic unifying themes and conceptual foundations It illustrates the versatility power and generality of the method with many examples and applications from engineering operations research and other fields It also addresses extensively the practical application of the methodology possibly through the use of approximations and provides an extensive treatment of the far reaching methodology of Neuro Dynamic Programming Reinforcement Learning Among its special features the book 1 provides a unifying framework for sequential decision making 2 treats simultaneously deterministic and stochastic control problems popular in modern control theory and Markovian decision popular in operations research 3 develops the theory of deterministic optimal control problems including the Pontryagin Minimum Principle 4 introduces recent suboptimal control and simulation based approximation techniques neuro dynamic programming which allow the practical application of dynamic programming to complex problems that involve the dual curse of large dimension and lack of an accurate mathematical model 5 provides a comprehensive treatment of infinite horizon problems in the second volume and an introductory treatment in the first volume *Dynamic Programming and Its Application to Optimal Control* Hui Li, Yongsui Wen, 2018-04 *Dynamic programming and its application to optimal control* R. Boudarel, J. Delmas, P. Guichet, 1971

Adaptive Dynamic Programming with Applications in Optimal Control Derong Liu, Qinglai Wei, Ding Wang, Xiong Yang, Hongliang Li, 2017-01-04 This book covers the most recent developments in adaptive dynamic programming ADP The text begins with a thorough background review of ADP making sure that readers are sufficiently familiar with the fundamentals In the core of the book the authors address first discrete and then continuous time systems Coverage of discrete time systems starts with a more general form of value iteration to demonstrate its convergence optimality and stability with complete and thorough theoretical analysis A more realistic form of value iteration is studied where value function approximations are assumed to have finite errors Adaptive Dynamic Programming also details another avenue of the ADP approach policy iteration Both basic and generalized forms of policy iteration based ADP are studied with complete and thorough theoretical analysis in terms of convergence optimality stability and error bounds Among continuous time systems the control of affine and nonaffine nonlinear systems is studied using the ADP approach which is then extended to other branches of control theory including decentralized control robust and guaranteed cost control and game theory In the last part of the book the real world significance of ADP theory is presented focusing on three application examples developed from the authors work renewable energy scheduling for smart power grids coal gasification processes and water gas shift

reactions Researchers studying intelligent control methods and practitioners looking to apply them in the chemical process and power supply industries will find much to interest them in this thorough treatment of an advanced approach to control

Dynamic Programming and Its Application to Optimal Control, 1971-10-11 In this book we study theoretical and practical aspects of computing methods for mathematical modelling of nonlinear systems A number of computing techniques are considered such as methods of operator approximation with any given accuracy operator interpolation techniques including a non Lagrange interpolation methods of system representation subject to constraints associated with concepts of causality memory and stationarity methods of system representation with an accuracy that is the best within a given class of models methods of covariance matrix estimation methods for low rank matrix approximations hybrid methods based on a combination of iterative procedures and best operator approximation and methods for information compression and filtering under condition that a filter model should satisfy restrictions associated with causality and different types of memory As a result the book represents a blend of new methods in general computational analysis and specific but also generic techniques for study of systems theory and its particular branches such as optimal filtering and information compression Best operator approximation Non Lagrange interpolation Generic Karhunen Loeve transform Generalised low rank matrix approximation Optimal data compression Optimal nonlinear filtering [Dynamic Programming and Its Applications](#) Martin L.

Puterman, 2014-05-10 Dynamic Programming and Its Applications provides information pertinent to the theory and application of dynamic programming This book presents the development and future directions for dynamic programming Organized into four parts encompassing 23 chapters this book begins with an overview of recurrence conditions for countable state Markov decision problems which ensure that the optimal average reward exists and satisfies the functional equation of dynamic programming This text then provides an extensive analysis of the theory of successive approximation for Markov decision problems Other chapters consider the computational methods for deterministic finite horizon problems and present a unified and insightful presentation of several foundational questions This book discusses as well the relationship between policy iteration and Newton's method The final chapter deals with the main factors severely limiting the application of dynamic programming in practice This book is a valuable resource for growth theorists economists biologists mathematicians and applied management scientists

An Introduction to Optimal Control Theory Onésimo Hernández-Lerma, Leonardo R. Laura-Guarachi, Saul Mendoza-Palacios, David González-Sánchez, 2023-02-21 This book introduces optimal control problems for large families of deterministic and stochastic systems with discrete or continuous time parameter These families include most of the systems studied in many disciplines including Economics Engineering Operations Research and Management Science among many others The main objective is to give a concise systematic and reasonably self contained presentation of some key topics in optimal control theory To this end most of the analyses are based on the dynamic programming DP technique This technique is applicable to almost all control problems that appear in

theory and applications They include for instance finite and infinite horizon control problems in which the underlying dynamic system follows either a deterministic or stochastic difference or differential equation In the infinite horizon case it also uses DP to study undiscounted problems such as the ergodic or long run average cost After a general introduction to control problems the book covers the topic dividing into four parts with different dynamical systems control of discrete time deterministic systems discrete time stochastic systems ordinary differential equations and finally a general continuous time MCP with applications for stochastic differential equations The first and second part should be accessible to undergraduate students with some knowledge of elementary calculus linear algebra and some concepts from probability theory random variables expectations and so forth Whereas the third and fourth part would be appropriate for advanced undergraduates or graduate students who have a working knowledge of mathematical analysis derivatives integrals and stochastic processes

Optimal Control Theory Suresh P. Sethi, 2018-11-28 This fully revised 3rd edition offers an introduction to optimal control theory and its diverse applications in management science and economics It brings to students the concept of the maximum principle in continuous as well as discrete time by using dynamic programming and Kuhn Tucker theory While some mathematical background is needed the emphasis of the book is not on mathematical rigor but on modeling realistic situations faced in business and economics The book exploits optimal control theory to the functional areas of management including finance production and marketing and to economics of growth and of natural resources In addition this new edition features materials on stochastic Nash and Stackelberg differential games and an adverse selection model in the principal agent framework The book provides exercises for each chapter and answers to selected exercises to help deepen the understanding of the material presented Also included are appendices comprised of supplementary material on the solution of differential equations the calculus of variations and its relationships to the maximum principle and special topics including the Kalman filter certainty equivalence singular control a global saddle point theorem Sethi Skiba points and distributed parameter systems Optimal control methods are used to determine optimal ways to control a dynamic system The theoretical work in this field serves as a foundation for the book which the author has applied to business management problems developed from his research and classroom instruction The new edition has been completely refined and brought up to date Ultimately this should continue to be a valuable resource for graduate courses on applied optimal control theory but also for financial and industrial engineers economists and operational researchers concerned with the application of dynamic optimization in their fields

Design Methods of Control Systems D. Franke, F. Kraus, 2014-05-23 These Proceedings contain a selection of papers presented at the first IFAC Symposium on Design Methods of Control Systems The volume contains three plenary papers and 97 technical papers the latter classified under 15 section headings as listed in the contents

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

Adaptive Dynamic Programming for Control Huaguang

Zhang, Derong Liu, Yanhong Luo, Ding Wang, 2012-12-14 There are many methods of stable controller design for nonlinear systems In seeking to go beyond the minimum requirement of stability Adaptive Dynamic Programming in Discrete Time approaches the challenging topic of optimal control for nonlinear systems using the tools of adaptive dynamic programming ADP The range of systems treated is extensive affine switched singularly perturbed and time delay nonlinear systems are discussed as are the uses of neural networks and techniques of value and policy iteration The text features three main aspects of ADP in which the methods proposed for stabilization and for tracking and games benefit from the incorporation of optimal control methods infinite horizon control for which the difficulty of solving partial differential Hamilton Jacobi Bellman equations directly is overcome and proof provided that the iterative value function updating sequence converges to the infimum of all the value functions obtained by admissible control law sequences finite horizon control implemented in discrete time nonlinear systems showing the reader how to obtain suboptimal control solutions within a fixed number of control steps and with results more easily applied in real systems than those usually gained from infinite horizon control nonlinear games for which a pair of mixed optimal policies are derived for solving games both when the saddle point does not exist and when it does avoiding the existence conditions of the saddle point Non zero sum games are studied in the context of a single network scheme in which policies are obtained guaranteeing system stability and minimizing the individual performance function yielding a Nash equilibrium In order to make the coverage suitable for the student as well as for the expert reader Adaptive Dynamic Programming in Discrete Time establishes the fundamental theory involved clearly with each chapter devoted to a clearly identifiable control paradigm demonstrates convergence proofs of the ADP algorithms to deepen understanding of the derivation of stability and convergence with the iterative computational methods used and shows how ADP methods can be put to use both in simulation and in real applications This text will be of considerable interest to researchers interested in optimal control and its applications in operations research applied mathematics computational intelligence and engineering Graduate students working in control and operations research will also find the ideas presented here to be a source of powerful methods for furthering their study *Encyclopedia of Optimization* Christodoulos A. Floudas, Panos M. Pardalos, 2008-09-04 The goal of the Encyclopedia of Optimization is to introduce the reader to a complete set of topics that show the spectrum of research the richness of ideas and the breadth of applications that has come from this field The second edition builds on the success of the former edition with more than 150 completely new entries designed to ensure that the reference addresses recent areas where optimization theories and techniques have advanced Particularly heavy attention resulted in health science and transportation with entries such as Algorithms for Genomics Optimization and Radiotherapy Treatment Design and Crew Scheduling Automatic Control in Aerospace 1989 T. Nishimura, 2014-05-23 The papers presented at the Symposium covered the areas in aerospace technology where automatic control plays a vital role These included navigation and guidance space robotics flight management systems and

satellite orbital control systems The information provided reflects the recent developments and technical advances in the application of automatic control in space technology

Theory and Applications of Non-integer Order Systems Artur Babiarz, Adam Czornik, Jerzy Klamka, Michał Niezabitowski, 2016-09-15 This book collects papers from the 8th Conference on Non Integer Order Calculus and Its Applications that have been held on September 20 21 2016 in Zakopane Poland The preceding two conferences were held in Szczecin Poland in 2015 and in Opole Poland in 2014 This conference provides a platform for academic exchange on the theory and application of fractional calculus between domestic and international universities research institutes corporate experts and scholars The Proceedings of the 8th Conference on Non Integer Order Calculus and Its Applications 2016 brings together rigorously reviewed contributions from leading international experts The included papers cover novel various important aspects of mathematical foundations of fractional calculus modeling and control of fractional systems as well as controllability detectability observability and stability problems for this systems

SIAM Journal on Control and Optimization Society for Industrial and Applied Mathematics, 1998 *The Application of Dynamic Programming to Optimal Control of a Second Order Process* Dennis LeRoy Dutcher, 1967

Lectures on Mathematics for Economic and Financial Analysis Giorgio Giorgi, Bienvenido Jiménez, Vicente Novo, 2025-03-21 This book offers a comprehensive yet approachable introduction to essential mathematical concepts tailored specifically for undergraduate and first year graduate students in Economics and Social Sciences Based on lectures delivered at the University of Pavia s Department of Economics and Management and also in UNED Department of Applied Mathematics in Madrid it aims to equip students with the mathematical tools necessary to better understand their courses in economics and finance where math is applied directly Unlike texts focused on formalized topics like Mathematical Economics or Operations Research this book presents basic mathematical principles and methods that are immediately relevant to students With a clear accessible approach it includes numerous examples some with economic applications to illustrate key concepts and make them easier to grasp The authors have carefully chosen proofs that are straightforward and beneficial for students to encounter offering an introduction to important proof techniques without overwhelming complexity The book also provides a select bibliography allowing readers to explore topics in greater depth if desired Drawing on years of teaching experience the authors have created a valuable resource that serves as both a foundation and a practical guide for students navigating the mathematical aspects of economics and social science courses

Stochastic Optimal Control in Infinite Dimension Giorgio Fabbri, Fausto Gozzi, Andrzej Święch, 2017-06-22 Providing an introduction to stochastic optimal control in infinite dimension this book gives a complete account of the theory of second order HJB equations in infinite dimensional Hilbert spaces focusing on its applicability to associated stochastic optimal control problems It features a general introduction to optimal stochastic control including basic results e g the dynamic programming principle with proofs and provides examples of applications A complete and up to date exposition of the existing theory of viscosity solutions and regular solutions of second

order HJB equations in Hilbert spaces is given together with an extensive survey of other methods with a full bibliography In particular Chapter 6 written by M Fuhrman and G Tessitore surveys the theory of regular solutions of HJB equations arising in infinite dimensional stochastic control via BSDEs The book is of interest to both pure and applied researchers working in the control theory of stochastic PDEs and in PDEs in infinite dimension Readers from other fields who want to learn the basic theory will also find it useful The prerequisites are standard functional analysis the theory of semigroups of operators and its use in the study of PDEs some knowledge of the dynamic programming approach to stochastic optimal control problems in finite dimension and the basics of stochastic analysis and stochastic equations in infinite dimensional spaces *Journal of Economic Dynamics & Control* ,1981

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