

THIRD EDITION

VOLUME 2

Dynamic Programming and Optimal Control

DIMITRI P. BERTSEKAS



Athena Scientific

Dynamic Programming And Optimal Control Vol Ii

Jan H. van Schuppen



Dynamic Programming And Optimal Control Vol II:

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

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

Einführung in Operations Research Wolfgang Domschke, Andreas Drexl, Robert Klein, Armin Scholl, 2015-10-01 Didaktisch effektives und effizientes Standardwerk in der 9 Auflage Dieses Buch entstand aus Vorlesungen zur Einführung in Operations Research OR für Studierende der Betriebs und Volkswirtschaftslehre des Wirtschaftsingenieurwesens der Wirtschaftsinformatik und der Wirtschaftsmathematik Es zeichnet sich in der Vermittlung der Grundlagen des OR durch eine gelungene didaktische Aufbereitung des Stoffes aus und ist auch zum Selbststudium geeignet Die Autoren beschreiben Verfahren algorithmisch und verdeutlichen sie anhand von aussagekräftigen Beispielen Der Text behandelt lineare ganzzahlige und kombinatorische dynamische sowie nichtlineare Optimierung Graphen und Warteschlangentheorie Netzplantechnik und Simulation Das Schlusskapitel vermittelt die Lösung von OR Problemen mittels Tabellenkalkulationssoftware Zur Vertiefung und Anwendung der vorgestellten Methoden wird das Buch mit Übungen und Fallbeispiele zum Operations Research derselben Autoren empfohlen Es enthält eine große Anzahl an Übungsaufgaben und eine Einführung in die Optimierung mit Standardsoftware

Optimierung und ökonomische Analyse Peter Stahlecker, Nils Hauenschild, Markus Klintworth, 2013-03-07 Gegenstand des Buches sind die Darstellung Herleitung und Erläuterung sowohl statischer als auch dynamischer Optimierungsmethoden die zur Behandlung ökonomischer Modelle benutzt werden Dabei wird ein großes Gewicht auf das Zusammenspiel zwischen ökonomischer Interpretation auf der einen und mathematischer

Argumentation auf der anderen Seite gelegt Alle Optimierungsprobleme werden zunächst anhand ökonomischer Beispiele begründet Nach der mathematischen Herleitung verschiedener prinzipieller Lösungsmethoden werden diese dann konkret auf die eingangs betrachteten ökonomischen Modelle angewandt Die verwendete Satz Beweis Struktur macht das Buch auch zu einem guten Nachschlagewerk

A Course in Reinforcement Learning: 2nd Edition Dimitri Bertsekas, 2024-12-20 This is the 2nd edition of the textbook used at the author's ASU research oriented course on Reinforcement Learning RL offered in each of the last six years Its purpose is to give an overview of the RL methodology particularly as it relates to problems of optimal and suboptimal decision and control as well as discrete optimization While in this book mathematical proofs are deemphasized there is considerable related analysis which supports the conclusions and can be found in the author's recent RL and DP books These books also contain additional material on off line training of neural networks on the use of policy gradient methods for approximation in policy space and on aggregation

Dynamic programming and optimal control, vol. 2 Dimitri P. Bertsekas, 2000

Dynamic Optimization Karl Hinderer, Ulrich Rieder, Michael Stieglitz, 2017-01-12 This book explores discrete time dynamic optimization and provides a detailed introduction to both deterministic and stochastic models Covering problems with finite and infinite horizon as well as Markov renewal programs Bayesian control models and partially observable processes the book focuses on the precise modelling of applications in a variety of areas including operations research computer science mathematics statistics engineering economics and finance Dynamic Optimization is a carefully presented textbook which starts with discrete time deterministic dynamic optimization problems providing readers with the tools for sequential decision making before proceeding to the more complicated stochastic models The authors present complete and simple proofs and illustrate the main results with numerous examples and exercises without solutions With relevant material covered in four appendices this book is completely self contained

Operations Research Proceedings 2006 Karl-Heinz Waldmann, Ulrike M. Stocker, 2007-05-07 This volume contains a selection of papers referring to lectures presented at the symposium Operations Research 2006 held at the University of Karlsruhe The symposium presented the state of the art in Operations Research and related areas in Economics Mathematics and Computer Science and demonstrated the broad applicability of its core themes placing particular emphasis on Basel II one of the most topical challenges of Operations Research

Insights in Reinforcement Learning, 2011 A key aspect of artificial intelligence is the ability to learn from experience If examples of correct solutions exist supervised learning techniques can be used to predict what the correct solution will be for future observations However often such examples are not readily available The field of reinforcement learning investigates methods that can learn from experience when no examples of correct behavior are given but a reinforcement signal is supplied to the learning entity Many problems fit this problem description In games the reinforcement signal might be whether or not the game was won In economic settings the reinforcement can represent the profit or loss that is eventually made Furthermore in robotics it is often easier to specify how well the robot is doing than it is

to find examples of good behavior beforehand. An advantage of reinforcement learning is that the designer of the system need not know what good solutions to a problem may be. Rather the system will find good solutions by trial and error. Of particular interest to us are model free temporal difference algorithms. These algorithms do not use experiences to build an explicit model of the environment but construct an approximation of the expected value for each possible action. The values can then be used to construct solutions. These methods are computationally efficient, easy to implement and often find solutions quickly. Additionally in many settings it is easier to find a good policy to select actions than to model the whole environment and then to use this model to try to determine what to do. In this dissertation we analyze several existing model free temporal difference algorithms. We discuss some problems with these approaches such as a potentially huge overestimation of the action values by the popular Q learning algorithm. We discuss ways to prevent these issues and propose a number of new algorithms. We analyze the new algorithms and compare their performance on a number of tasks. We conclude that it depends highly on the characteristics of the problem which algorithm performs best. We give some indications on which algorithms are to be preferred in different problem settings. To solve problems with unknown characteristics we propose using ensemble methods that combine action selection policies of a number of different entities. We discuss several approaches to combine these policies and demonstrate empirically that good solutions can reliably be found. Additionally we extend the idea of model free temporal difference algorithms to problems with continuous action spaces. In such problems conventional approaches are not applicable because they can not handle the infinite number of possible actions. We propose a new algorithm that is explicitly designed for continuous spaces and show that it compares favorably to the current state of the art.

Handbook of Artificial Intelligence and Data Sciences for Routing Problems Carlos A.S. Oliveira, Miltiades P. Pardalos, 2025-03-13

This handbook delves into the rapidly evolving field of artificial intelligence and optimization focusing on the intersection of machine learning, combinatorial optimization and real world applications in transportation and network design. Covering an array of topics from classical optimization problems such as the Traveling Salesman Problem and the Knapsack Problem to modern techniques including advanced heuristic methods, Generative Adversarial Networks and Variational Autoencoders, this book provides a roadmap for solving complex problems. The included case studies showcase practical implementations of algorithms in predicting route sequences, traffic management and eco friendly transportation. This comprehensive guide is essential for researchers, practitioners and students interested in AI and optimization. Whether you are a researcher seeking standard approaches or a professional looking for practical solutions to industry challenges, this book offers valuable insights into modern AI algorithms.

A Concise Introduction to Decentralized POMDPs Frans A. Oliehoek, Christopher Amato, 2016-06-03. This book introduces multiagent planning under uncertainty as formalized by decentralized partially observable Markov decision processes (Dec POMDPs). The intended audience is researchers and graduate students working in the fields of artificial intelligence related to sequential decision making, reinforcement learning, decision theoretic planning.

for single agents classical multiagent planning decentralized control and operations research **Stochastic Modeling And Analytics In Healthcare Delivery Systems** Jingshan Li,Nan Kong,Xiaolei Xie,2017-09-22 In recent years there has been an increased interest in the field of healthcare delivery systems Scientists and practitioners are constantly searching for ways to improve the safety quality and efficiency of these systems in order to achieve better patient outcome This book focuses on the research and best practices in healthcare engineering and technology assessment With contributions from researchers in the fields of healthcare system stochastic modeling simulation optimization and management this is a valuable read Stability Theory of Switched Dynamical Systems Zhendong Sun,Shuzhi Sam Ge,2011-01-06 There are plenty of challenging and interesting problems open for investigation in the field of switched systems Stability issues help to generate many complex nonlinear dynamic behaviors within switched systems The authors present a thorough investigation of stability effects on three broad classes of switching mechanism arbitrary switching where stability represents robustness to unpredictable and undesirable perturbation constrained switching including random within a known stochastic distribution dwell time with a known minimum duration for each subsystem and autonomously generated with a pre assigned mechanism switching and designed switching in which a measurable and freely assigned switching mechanism contributes to stability by acting as a control input For each of these classes this book propounds detailed stability analysis and or design related robustness and performance issues connections to other control problems and many motivating and illustrative examples

MATHEMATICAL MODELS OF LIFE SUPPORT SYSTEMS - Volume II Valeri I. Agoshko , Jean-Pierre Puel,2009-10-10 Mathematical Models of Life Support Systems is a component of Encyclopedia of Mathematical Sciences in which is part of the global Encyclopedia of Life Support Systems EOLSS an integrated compendium of twenty one Encyclopedias The Theme is organized into several topics which represent the main scientific areas of the theme The first topic Introduction to Mathematical Modeling discusses the foundations of mathematical modeling and computational experiments which are formed to support new methodologies of scientific research The succeeding topics are Mathematical Models in Water Sciences Climate Environmental Pollution and Degradation Energy Sciences Food and Agricultural Sciences Population Immunology Medical Sciences and Control of Catastrophic Processes These two volumes are aimed at the following five major target audiences University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers and NGOs **Applied Mechanics Reviews** ,1992 **Control and System Theory of Discrete-Time Stochastic Systems** Jan H. van Schuppen,2021-08-02 This book helps students researchers and practicing engineers to understand the theoretical framework of control and system theory for discrete time stochastic systems so that they can then apply its principles to their own stochastic control systems and to the solution of control filtering and realization problems for such systems Applications of the theory in the book include the control of ships shock absorbers traffic and communications networks and power systems with fluctuating power flows The focus of the book

is a stochastic control system defined for a spectrum of probability distributions including Bernoulli finite Poisson beta gamma and Gaussian distributions The concepts of observability and controllability of a stochastic control system are defined and characterized Each output process considered is with respect to conditions represented by a stochastic system called a stochastic realization The existence of a control law is related to stochastic controllability while the existence of a filter system is related to stochastic observability Stochastic control with partial observations is based on the existence of a stochastic realization of the filtration of the observed process

Markov Decision Processes with Applications to Finance Nicole Bäuerle, Ulrich Rieder, 2011-06-06 The theory of Markov decision processes focuses on controlled Markov chains in discrete time The authors establish the theory for general state and action spaces and at the same time show its application by means of numerous examples mostly taken from the fields of finance and operations research By using a structural approach many technicalities concerning measure theory are avoided They cover problems with finite and infinite horizons as well as partially observable Markov decision processes piecewise deterministic Markov decision processes and stopping problems The book presents Markov decision processes in action and includes various state of the art applications with a particular view towards finance It is useful for upper level undergraduates Master's students and researchers in both applied probability and finance and provides exercises without solutions

Continuous-Time Markov Decision Processes Xianping Guo, Onésimo Hernández-Lerma, 2009-09-18 Continuous time Markov decision processes MDPs also known as controlled Markov chains are used for modeling decision making problems that arise in operations research for instance inventory manufacturing and queueing systems computer science communications engineering control of populations such as fisheries and epidemics and management science among many other fields This volume provides a unified systematic self contained presentation of recent developments on the theory and applications of continuous time MDPs The MDPs in this volume include most of the cases that arise in applications because they allow unbounded transition and reward cost rates Much of the material appears for the first time in book form

Proceedings of the 2011 Joint Workshop of Fraunhofer IOSB and Institute for Anthropomatics, Vision and Fusion Laboratory Jürgen Beyerer, Alexey Pak, 2014-07-29 This book is a collection of 15 reviewed technical reports summarizing the presentations at the 2011 Joint Workshop of Fraunhofer IOSB and Institute for Anthropomatics Vision and Fusion Laboratory The covered topics include image processing optical signal processing visual inspection pattern recognition and classification human machine interaction world and situation modeling autonomous system localization and mapping information fusion and trust propagation in sensor networks

Modeling, Estimation and Control Alessandro Chiuso, Augusto Ferrante, Stefano Pinzoni, 2007-10-24 This Festschrift is intended as a homage to our esteemed colleague friend and maestro Giorgio Picci on the occasion of his sixty fth birthday We have known Giorgiosince our undergraduate studies at the University of Padova where we first experienced his fascinating teaching in the class of System Identification While progressing through the PhD

program then continuing to collaborate with him and eventually becoming colleagues we have had many opportunities to appreciate the value of Giorgio as a professor and a scientist and chiefly as a person. We learned a lot from him and we feel indebted for his scientific guidance, his constant support, encouragement and enthusiasm. For these reasons we are proud to dedicate this book to Giorgio. The articles in the volume will be presented by prominent researchers at the International Conference on Modeling, Estimation and Control, A Symposium in Honor of Giorgio Picci on the Occasion of his Sixty-Fifth Birthday to be held in Venice on October 4-5, 2007. The material covers a broad range of topics in mathematical systems theory, estimation, identification and control reflecting the wide network of scientific relationships established during the last thirty years between the authors and Giorgio. Critical discussion of fundamental concepts, close collaboration on specific topics, joint research programs in this group of talented people have nourished the development of the field where Giorgio has contributed to establishing several cornerstones.

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