

Optimization Over Time Dynamic Programming And Stochastic Control Wiley Series In Probability And Statistics Applied Probability And Statistics Section Volume 1

Based on the results of over 10 years of research and development by the authors, this book presents a broad cross section of dynamic programming (DP) techniques applied to the optimization of dynamical systems. The main goal of the research effort was to develop a robust path planning/trajectory optimization tool that did not require an initial guess. The goal was partially met with a combination of DP and homotopy algorithms. DP algorithms are presented here with a theoretical development, and their successful application to variety of practical engineering problems is emphasized.

A path-breaking account of Markov decision processes-theory and computation This book's clear presentation of theory, numerous chapter-end problems, and development of a unified method for the computation of optimal policies in both discrete and continuous time make it an excellent course text for graduate students and advanced undergraduates. Its comprehensive coverage of important recent advances in stochastic dynamic programming makes it a valuable working resource for operations research professionals, management scientists, engineers, and others. Stochastic Dynamic Programming and the Control of Queueing Systems presents the theory of optimization under the finite horizon, infinite horizon discounted, and average cost criteria. It then shows how optimal rules of operation (policies) for each criterion may be numerically determined. A great wealth of examples from the application area of the control of queueing systems is presented. Nine numerical programs for the computation of optimal policies are fully explicated. The Pascal source code for the programs is available for viewing and downloading on the Wiley Web site at www.wiley.com/products/subject/mathematics. The site contains a link to the author's own Web site and is also a place where readers may discuss developments on the programs or other aspects of the material. The source files are also available via ftp at ftp://ftp.wiley.com/public/sci_tech_med/stochastic Stochastic Dynamic Programming and the Control of Queueing Systems features: * Path-breaking advances in Markov decision process techniques, brought together for the first time in book form * A theorem/proof format (proofs may be omitted without loss of continuity) * Development of a unified method for the computation of optimal rules of system operation * Numerous examples drawn mainly from the control of queueing systems * Detailed discussions of nine numerical programs * Helpful chapter-end problems * Appendices with complete treatment of background material

The main purpose of the book is to show how a viscosity approach can be used to tackle control problems in insurance. The problems covered are the maximization of survival probability as well as the maximization of dividends in the classical collective risk model. The authors consider the possibility of controlling the risk process by reinsurance as well as by investments. They show that optimal value functions are characterized as either the unique or the smallest viscosity solution of the associated Hamilton-Jacobi-Bellman equation; they also study the structure of the optimal strategies and show how to find them. The viscosity approach was widely used in control problems related to mathematical finance but until quite recently it was not used to solve control problems related to actuarial mathematical science. This book is designed to familiarize the reader on how to use this approach. The intended audience is graduate students as well as researchers in this area.

The focus of the present volume is stochastic optimization of dynamical systems in discrete time where - by concentrating on the role of information regarding optimization problems - it discusses the related discretization issues. There is a growing need to tackle uncertainty in applications of optimization. For example the massive introduction of renewable energies in power systems challenges traditional ways to manage them. This book lays out basic and advanced tools to handle and numerically solve such problems and thereby is building a bridge between Stochastic Programming and Stochastic Control. It is intended for graduates readers and scholars in optimization or stochastic control, as well as engineers with a background in applied mathematics.

Great advances have been made in recent years in the field of computational probability. In particular, the state of the art - as it relates to queuing systems, stochastic Petri-nets and systems dealing with reliability - has benefited significantly from these advances. The objective of this book is to make these topics accessible to researchers, graduate students, and practitioners. Great care was taken to make the exposition as clear as possible. Every line in the book has been evaluated, and changes have been made whenever it was felt that the initial exposition was not clear enough for the intended readership. The work of major research scholars in this field comprises the individual chapters of Computational Probability. The first chapter describes, in nonmathematical terms, the challenges in computational probability. Chapter 2 describes the methodologies available for obtaining the transition matrices for Markov chains, with particular emphasis on stochastic Petri-nets. Chapter 3 discusses how to find transient probabilities and transient rewards for these Markov chains. The next two chapters indicate how to find steady-state probabilities for Markov chains with a finite number of states. Both direct and iterative methods are described in Chapter 4. Details of these methods are given in Chapter 5. Chapters 6 and 7 deal with infinite-state Markov chains, which occur frequently in queueing, because there are times one does not want to set a bound for all queues. Chapter 8 deals with transforms, in particular Laplace transforms. The work of Ward Whitt and his collaborators, who have recently developed a number of numerical methods for Laplace transform inversions, is emphasized in this chapter. Finally, if one wants to optimize a system, one way to do the optimization is through Markov decision making, described in Chapter 9. Markov modeling has found applications in many areas, three of which are described in detail: Chapter 10 analyzes discrete-time queues, Chapter 11 describes networks of queues, and Chapter 12 deals with reliability theory.

Introduction to Stochastic Dynamic Programming presents the basic theory and examines the scope of applications of stochastic dynamic programming. The book begins with a chapter on various finite-stage models, illustrating the wide range of applications of stochastic dynamic programming. Subsequent chapters study infinite-stage models: discounting future returns, minimizing nonnegative costs, maximizing nonnegative returns, and maximizing the long-run average return. Each of these chapters first considers whether an optimal policy need exist—providing counterexamples where appropriate—and then presents methods for obtaining such policies when they do. In addition, general areas of application are presented. The final two chapters are concerned with more specialized models. These include stochastic scheduling models and a type of process known as a multiproject bandit. The mathematical prerequisites for

this text are relatively few. No prior knowledge of dynamic programming is assumed and only a moderate familiarity with probability—including the use of conditional expectation—is necessary. A research monograph providing a synthesis of old research on the foundations of dynamic programming, with the modern theory of approximate dynamic programming and new research on semicontractive models. It aims at a unified and economical development of the core theory and algorithms of total cost sequential decision problems, based on the strong connections of the subject with fixed point theory. The analysis focuses on the abstract mapping that underlies dynamic programming and defines the mathematical character of the associated problem. The discussion centers on two fundamental properties that this mapping may have: monotonicity and (weighted sup-norm) contraction. It turns out that the nature of the analytical and algorithmic DP theory is determined primarily by the presence or absence of these two properties, and the rest of the problem's structure is largely inconsequential. New research is focused on two areas: 1) The ramifications of these properties in the context of algorithms for approximate dynamic programming, and 2) The new class of semicontractive models, exemplified by stochastic shortest path problems, where some but not all policies are contractive. The 2nd edition aims primarily to amplify the presentation of the semicontractive models of Chapter 3 and Chapter 4 of the first (2013) edition, and to supplement it with a broad spectrum of research results that I obtained and published in journals and reports since the first edition was written (see below). As a result, the size of this material more than doubled, and the size of the book increased by nearly 40%. The book is an excellent supplement to several of our books: *Dynamic Programming and Optimal Control* (Athena Scientific, 2017), and *Neuro-Dynamic Programming* (Athena Scientific, 1996).

A complete resource to Approximate Dynamic Programming (ADP), including on-line simulation code Provides a tutorial that readers can use to start implementing the learning algorithms provided in the book Includes ideas, directions, and recent results on current research issues and addresses applications where ADP has been successfully implemented The contributors are leading researchers in the field

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.

Presents a unified theory of dynamic programming and Markov decision processes and its application to a major field of operations research and operations management: inventory control. For continuous time, this book concentrates only on models of interest to inventory control. For discrete time, the focus is mainly on infinite horizon models.

Combinatorial data analysis (CDA) refers to a wide class of methods for the study of relevant data sets in which the arrangement of a collection of objects is absolutely central. The focus of this monograph is on the identification of arrangements, which are then further restricted to where the combinatorial search is carried out by a recursive optimization process based on the general principles of dynamic programming (DP).

First published in 2004, this is a rigorous but user-friendly book on the application of stochastic control theory to economics. A distinctive feature of the book is that mathematical concepts are introduced in a language and terminology familiar to graduate students of economics. The standard topics of many mathematics, economics and finance books are illustrated with real examples documented in the economic literature. Moreover, the book emphasises the dos and don'ts of stochastic calculus, cautioning the reader that certain results and intuitions cherished by many economists do not extend to stochastic models. A special chapter (Chapter 5) is devoted to exploring various methods of finding a closed-form representation of the value function of a stochastic control problem, which is essential for ascertaining the optimal policy functions. The book also includes many practice exercises for the reader. Notes and suggested readings are provided at the end of each chapter for more references and possible extensions.

The volume contains a selection of manuscripts of lectures presented at the International Symposium on Operations Research (SOR 96). The Symposium took place at the Technical University of Braunschweig, September 3-6, 1996. SOR 96 was organized under the auspices of the two German societies of Operations Research, Deutsche Gesellschaft für Operations Research (DGOR) and Gesellschaft für Mathematik, Ökonomie und Operations Research (GMOOR) in cooperation with the Working Group Discrete Optimization of the IFIP (WG7.4). Since 1995, DGOR and GMOOR jointly prepare the Symposium as a common annual conference. In particular, the annual general meetings of the DGOR, the GMOOR and the WG7.4 took place during the conference. The Symposium had 527 participants from 32 countries around the world, including 92 participants from Eastern Europe. The Symposium obviously attracts an international audience of workers fully covering the broad spectrum of Operations Research and related areas in economics, mathematics and computer science. The importance of a highly interdisciplinary field as Operations Research is increasing owing to the growth in applications in related disciplines. Technological advances in computer science and algorithmic mathematics are crucial for attacking the great challenges waiting in the areas of applications of Operations Research effectively. As a participant of SOR 96 one could well observe the current pace of achievements. Many of these results are in these proceedings. The program consisted of two plenary, 17 semiplenary, and 335 contributed lectures in 18 sections.

Stochastic optimization problems arise in decision-making problems under uncertainty, and find various applications in economics and finance. On the other hand, problems in finance have recently led to new developments in the theory of stochastic control. This volume provides a systematic treatment of stochastic optimization problems applied to finance by presenting the different existing methods: dynamic programming, viscosity solutions, backward stochastic differential equations, and martingale duality methods. The theory is discussed in the context of recent developments in this field, with complete and detailed proofs, and is illustrated by means of concrete examples from the world of finance: portfolio allocation, option hedging, real options, optimal investment, etc. This book is directed towards graduate students and researchers in mathematical finance, and will also benefit applied mathematicians interested in financial applications and practitioners wishing to know more about the use of stochastic optimization methods in finance.

This book introduces a fairly universal approach to the design and analysis of exact optimization algorithms for multi-objective combinatorial optimization problems. It proposes the circuits without repetitions representing the sets of feasible solutions along with the increasing and strictly increasing cost functions as a model for such problems. The book designs the algorithms for multi-stage and bi-criteria optimization and for counting the solutions in the framework of this model. As applications, this book studies eleven known combinatorial optimization problems: matrix chain multiplication, global sequence alignment, optimal paths in directed graphs, binary search trees, convex polygon triangulation, line breaking (text justification), one-dimensional clustering, optimal bitonic tour, segmented least squares, optimization of matchings in trees, and 0/1 knapsack problem. The results presented are useful for researchers in combinatorial optimization. This book is also useful as the basis for graduate courses.

Dynamic programming is an efficient technique for solving optimization problems. It is based on breaking the initial problem down into simpler ones and solving these sub-problems, beginning with the simplest ones. A conventional dynamic programming algorithm returns an optimal object from a given set of objects. This book develops extensions of dynamic programming, enabling us to (i) describe the set of objects under consideration; (ii) perform a multi-stage optimization of objects relative to different criteria; (iii) count the number of optimal objects; (iv) find the set of Pareto optimal points for bi-criteria optimization problems; and (v) to study relationships between two criteria. It considers various applications, including optimization of decision trees and decision rule systems as algorithms for problem solving, as ways for knowledge representation, and as classifiers; optimization of element partition trees for rectangular meshes, which are used in finite element methods for solving PDEs; and multi-stage optimization for such classic combinatorial optimization problems as matrix chain multiplication, binary search trees, global sequence alignment, and shortest paths. The results presented are useful for researchers in combinatorial optimization, data mining, knowledge discovery, machine learning, and finite element methods, especially those working in rough set theory, test theory, logical analysis of data, and PDE solvers. This book can be used as the basis for graduate courses.

Sequential Stochastic Optimization provides mathematicians and applied researchers with a well-developed framework in which stochastic optimization problems can be formulated and solved. Offering much material that is either new or has never before appeared in book form, it lucidly presents a unified theory of optimal stopping and optimal sequential control of stochastic processes. This book has been carefully organized so that little prior knowledge of the subject is assumed; its only prerequisites are a standard graduate course in probability theory and some familiarity with discrete-parameter martingales. Major topics covered in Sequential Stochastic Optimization include: * Fundamental notions, such as essential supremum, stopping points, accessibility, martingales and supermartingales indexed by \mathbb{N} * Conditions which ensure the integrability of certain suprema of partial sums of arrays of independent random variables * The general theory of optimal stopping for processes indexed by \mathbb{N} * Structural properties of information flows * Sequential sampling and the theory of optimal sequential control * Multi-armed bandits, Markov chains and optimal switching between random walks

This book presents the first part of a planned two-volume series devoted to a systematic exposition of some recent developments in the theory of discrete-time Markov control processes (MCPs). Interest is mainly confined to MCPs with Borel state and control (or action) spaces, and possibly unbounded costs and noncompact control constraint sets. MCPs are a class of stochastic control problems, also known as Markov decision processes, controlled Markov processes, or stochastic dynamic programs; sometimes, particularly when the state space is a countable set, they are also called Markov decision (or controlled Markov) chains. Regardless of the name used, MCPs appear in many fields, for example, engineering, economics, operations research, statistics, renewable and nonrenewable resource management, (control of) epidemics, etc. However, most of the literature (say, at least 90%) is concentrated on MCPs for which (a) the state space is a countable set, and/or (b) the costs-per-stage are bounded, and/or (c) the control constraint sets are compact. But curiously enough, the most widely used control model in engineering and economics--namely the LQ (Linear system/Quadratic cost) model--satisfies none of these conditions. Moreover, when dealing with "partially observable" systems a standard approach is to transform them into equivalent "completely observable" systems in a larger state space (in fact, a space of probability measures), which is uncountable even if the original state process is finite-valued.

Optimization models play an increasingly important role in financial decisions. This is the first textbook devoted to explaining how recent advances in optimization models, methods and software can be applied to solve problems in computational finance more efficiently and accurately. Chapters discussing the theory and efficient solution methods for all major classes of optimization problems alternate with chapters illustrating their use in modeling problems of mathematical finance. The reader is guided through topics such as volatility estimation, portfolio optimization problems and constructing an index fund, using techniques such as nonlinear optimization models, quadratic programming formulations and integer programming models respectively. The book is based on Master's courses in financial engineering and comes with worked examples, exercises and case studies. It will be welcomed by applied mathematicians, operational researchers and others who work in mathematical and computational finance and who are seeking a text for self-learning or for use with courses.

"Dynamic Optimization" takes an applied approach to its subject, offering many examples and solved problems that draw from aerospace, robotics, and mechanics. The abundance of thoroughly tested general algorithms and Matlab codes provide the reader with the practice necessary to master this inherently difficult subject, while the realistic engineering problems and examples keep the material interesting and relevant. FEATURES/BENEFITS Covers dynamic programming, relating it to the calculus of variations and optimal control, and neighboring optimum control (differential dynamic programming), a practical method for nonlinear feedback control. Includes a disk that contains 40 gradient and shooting codes, as well as codes that solve the time-varying Riccati equation (the DYNOPT Toolbox). These codes have been thoroughly tested on hundreds of problems. Contains many realistic examples and problems.

Solutions to the examples and problems, as well as the codes that produce the figures, are included on the accompanying disk. Covers dynamic optimization with inequality constraints and singular arcs using inverse dynamic optimization (differential inclusion).

Portrays dynamic programming as a methodology, identifying its constituent components, and explaining how it approaches problems and tackles them. Does not consider it as a practical tool, nor how it might address any actual situations in the real world. Assumes calculus, set theory, and some optimi

Praise for Robust Portfolio Optimization and Management "In the half century since Harry Markowitz introduced his elegant theory for selecting portfolios, investors and scholars

have extended and refined its application to a wide range of real-world problems, culminating in the contents of this masterful book. Fabozzi, Kolm, Pachamanova, and Focardi deserve high praise for producing a technically rigorous yet remarkably accessible guide to the latest advances in portfolio construction." --Mark Kritzman, President and CEO, Windham Capital Management, LLC "The topic of robust optimization (RO) has become 'hot' over the past several years, especially in real-world financial applications. This interest has been sparked, in part, by practitioners who implemented classical portfolio models for asset allocation without considering estimation and model robustness a part of their overall allocation methodology, and experienced poor performance. Anyone interested in these developments ought to own a copy of this book. The authors cover the recent developments of the RO area in an intuitive, easy-to-read manner, provide numerous examples, and discuss practical considerations. I highly recommend this book to finance professionals and students alike." --John M. Mulvey, Professor of Operations Research and Financial Engineering, Princeton University

Since its initial publication, this text has defined courses in dynamic optimization taught to economics and management science students. The two-part treatment covers the calculus of variations and optimal control. 1998 edition.

Forest Management and Planning provides a focused understanding of contemporary forest management issues through real life examples to engage students. The methodology for the development of quantitatively-derived forest management plans – from gathering information to the implementation of plans at the forest level – are clearly explained. Emphasis is placed on the development of traditional commodity production forest plans using linear programming, the development of alternative forest plans, and problem resolution in planning. The authors have developed this book based on their personal experience in teaching forest management courses and the review of ten forestry programs (Auburn University, University of Georgia, Iowa State University, Louisiana State University, Northern Arizona University, Ohio State University, Pennsylvania State University, University of Florida, Virginia Tech, and Oregon State University). The integration of extended case studies of a variety of scenarios as well as the inclusion of a section on report writing will engage students. Acknowledgement and integration of various software packages for forest management provide the most useful tools for those studying forest management and distinguish this book from the competition. This book is an ideal resource for students of Forest Management – primarily an upper-level course in forestry, and natural resource management, wildlife, and recreation programs. Real-life examples illustrated mathematically and graphically End-of-chapter questions Modern coverage of the planning and management of US Forest timber production Case study analysis Expansive applications drawn for examples in the western US, the Lake States, the northeastern US, the southern US and Canada Detailed descriptions of models and solution methods for integrating a variety of wildlife habitat constraints

This monograph applies the relative optimization approach to time nonhomogeneous continuous-time and continuous-state dynamic systems. The approach is intuitively clear and does not require deep knowledge of the mathematics of partial differential equations. The topics covered have the following distinguishing features: long-run average with no under-selectivity, non-smooth value functions with no viscosity solutions, diffusion processes with degenerate points, multi-class optimization with state classification, and optimization with no dynamic programming. The book begins with an introduction to relative optimization, including a comparison with the traditional approach of dynamic programming. The text then studies the Markov process, focusing on infinite-horizon optimization problems, and moves on to discuss optimal control of diffusion processes with semi-smooth value functions and degenerate points, and optimization of multi-dimensional diffusion processes. The book concludes with a brief overview of performance derivative-based optimization. Among the more important novel considerations presented are: the extension of the Hamilton–Jacobi–Bellman optimality condition from smooth to semi-smooth value functions by derivation of explicit optimality conditions at semi-smooth points and application of this result to degenerate and reflected processes; proof of semi-smoothness of the value function at degenerate points; attention to the under-selectivity issue for the long-run average and bias optimality; discussion of state classification for time nonhomogeneous continuous processes and multi-class optimization; and development of the multi-dimensional Tanaka formula for semi-smooth functions and application of this formula to stochastic control of multi-dimensional systems with degenerate points. The book will be of interest to researchers and students in the field of stochastic control and performance optimization alike.

Microeconomic Foundations I develops the choice, price, and general equilibrium theory topics typically found in first-year theory sequences, but in deeper and more complete mathematical form than most standard texts provide. The objective is to take the reader from acquaintance with these foundational topics to something closer to mastery of the models and results connected to them. Provides a rigorous treatment of some of the basic tools of economic modeling and reasoning, along with an assessment of the strengths and weaknesses of these tools Complements standard texts Covers choice, preference, and utility; structural properties of preferences and utility functions; basics of consumer demand; revealed preference and Afriat's Theorem; choice under uncertainty; dynamic choice; social choice and efficiency; competitive and profit-maximizing firms; expenditure minimization; demand theory (duality methods); producer and consumer surplus; aggregation; general equilibrium; efficiency and the core; GET, time, and uncertainty; and other topics Features a free web-based student's guide, which gives solutions to approximately half the problems, and a limited-access instructor's manual, which provides solutions to the rest of the problems Contains appendixes that review most of the specific mathematics employed in the book, including a from-first-principles treatment of dynamic programming

A new edition of a student text which provides a broad study of optimization methods. It builds on the base of simple economic theory, elementary linear algebra and calculus, and reinforces each new mathematical idea by relating it to its economic application.

Adaptive Stochastic Optimization Techniques with Applications provides a single, convenient source for state-of-the-art information on optimization techniques used to solve problems with adaptive, dynamic, and stochastic features. Presenting modern advances in static and dynamic optimization, decision analysis, intelligent systems, evolutionary pro

This book is concerned with numerical methods for stochastic control and optimal stochastic control problems. The random process models of the controlled or uncontrolled stochastic systems are either diffusions or jump diffusions. Stochastic control is a very active area of research and new problem formulations and sometimes surprising applications appear regularly. We have chosen forms of the models which cover the great bulk of the formulations of the continuous time stochastic control problems which have appeared to date. The standard formats are covered, but much emphasis is given to the newer and less well known formulations. The controlled process might be either stopped or absorbed on leaving a constraint set or upon first hitting a target set, or it might be reflected or "projected" from the boundary of a constraining set. In some of the more recent applications of the reflecting boundary problem, for example the so-called heavy traffic approximation problems, the directions of reflection are actually discontinuous. In general, the control might be representable as a bounded function or it might be of the so-called impulsive or singular control types. Both the "drift" and the "variance" might be controlled. The cost functions might be any of the standard types: Discounted, stopped on first exit from a set, finite time, optimal stopping, average cost per unit time over the infinite time interval, and so forth.

As the demand for energy continues to grow, optimization has risen to the forefront of power engineering research and development. Continuing in the bestselling tradition of the first edition, Electric Power System Applications of Optimization, Second Edition presents the theoretical background of optimization from a practical power system point of view, exploring advanced techniques, new directions, and continuous application problems. The book provides both the analytical formulation of optimization and various algorithmic issues that arise in the application of various methods in power system planning and operation. The second edition adds new functions involving market programs, pricing, reliability, and advances in intelligent systems with implemented algorithms and illustrative examples. It describes recent developments in the field of Adaptive Critics Design and practical applications of approximate dynamic programming. To round out the coverage, the final chapter combines fundamental theories and theorems from functional optimization, optimal control, and dynamic programming to explain new Adaptive Dynamic Programming concepts and variants. With its one-of-a-kind integration of cornerstone optimization principles with application examples, this second edition propels power engineers to new discoveries in providing optimal supplies of energy.

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.

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