

APPLICATIONS  
OF MATHEMATICS

STOCHASTIC  
MODELLING  
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PROBABILITY

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Harold J. Kushner  
G. George Yin

# Stochastic Approximation and Recursive Algorithms and Applications

Second Edition



Springer

# Stochastic Approximation And Recursive Algorithms And Applications

**Harold Kushner, G. George Yin**



## **Stochastic Approximation And Recursive Algorithms And Applications:**

**Stochastic Approximation and Recursive Algorithms and Applications** Harold Kushner, G. George Yin, 2013-11-11  
In recent years algorithms of the stochastic approximation type have found applications in new and diverse areas and new techniques have been developed for proofs of convergence and rate of convergence The actual and potential applications in signal processing have exploded New challenges have arisen in applications to adaptive control This book presents a thorough coverage of the ODE method used to analyze these algorithms

**Stochastic Approximation and Recursive Algorithms and Applications** Harold Kushner, G. George Yin, 2006-05-04 The basic stochastic approximation algorithms introduced by Robbins and Monro and by Kiefer and Wolfowitz in the early 1950s have been the subject of an enormous literature both theoretical and applied This is due to the large number of applications and the interesting theoretical issues in the analysis of dynamically defined stochastic processes The basic paradigm is a stochastic difference equation such as  $Y_{n+1} = Y_n + \alpha_n (g(Y_n) + \text{noise})$  where  $Y_n$  takes values in some Euclidean space  $Y$  is a random variable and the step size  $\alpha_n$  is small and might go to zero as  $n \rightarrow \infty$  In its simplest form  $Y_n$  is a parameter of a system and the random vector  $Y$  is a function of  $n$  noise corrupted observations taken on the system when the parameter is set to  $Y_n$  One recursively adjusts the parameter so that some goal is met asymptotically This book is concerned with the qualitative and asymptotic properties of such recursive algorithms in the diverse forms in which they arise in applications There are analogous continuous time algorithms but the conditions and proofs are generally very close to those for the discrete time case The original work was motivated by the problem of finding a root of a continuous function  $g$  where the function is not known but the experimenter is able to take noisy measurements at any desired value of  $Y$  Recursive methods for root finding are common in classical numerical analysis and it is reasonable to expect that appropriate stochastic analogs would also perform well

**Stochastic Approximation Algorithms and Applications**, 1997 There is a thorough treatment of rate of convergence iterate averaging high dimensional problems ergodic cost problems stability methods for correlated noise and decentralized and asynchronous algorithms

*Stochastic Approximation and Recursive Algorithms and Applications* Harold Kushner, G. George Yin, 2014-01-15

**Stochastic Recursive Algorithms for Optimization** S. Bhatnagar, H.L. Prasad, L.A. Prashanth, 2012-08-11 Stochastic Recursive Algorithms for Optimization presents algorithms for constrained and unconstrained optimization and for reinforcement learning Efficient perturbation approaches form a thread unifying all the algorithms considered Simultaneous perturbation stochastic approximation and smooth fractional estimators for gradient and Hessian based methods are presented These algorithms are easily implemented do not require an explicit system model and work with real or simulated data Chapters on their application in service systems vehicular traffic control and communications networks illustrate this point The book is self contained with necessary mathematical results placed in an appendix The text provides easy to use off the shelf algorithms that are given detailed mathematical treatment so the material presented will be of significant interest to

practitioners academic researchers and graduate students alike The breadth of applications makes the book appropriate for reader from similarly diverse backgrounds workers in relevant areas of computer science control engineering management science applied mathematics industrial engineering and operations research will find the content of value

**Handbook of Simulation Optimization** Michael C Fu, 2014-11-13 The Handbook of Simulation Optimization presents an overview of the state of the art of simulation optimization providing a survey of the most well established approaches for optimizing stochastic simulation models and a sampling of recent research advances in theory and methodology Leading contributors cover such topics as discrete optimization via simulation ranking and selection efficient simulation budget allocation random search methods response surface methodology stochastic gradient estimation stochastic approximation sample average approximation stochastic constraints variance reduction techniques model based stochastic search methods and Markov decision processes This single volume should serve as a reference for those already in the field and as a means for those new to the field for understanding and applying the main approaches The intended audience includes researchers practitioners and graduate students in the business engineering fields of operations research management science operations management and stochastic control as well as in economics finance and computer science

**Handbook of Computational Statistics** James E. Gentle, Wolfgang Karl Härdle, Yuichi Mori, 2012-07-06 The Handbook of Computational Statistics Concepts and Methods second edition is a revision of the first edition published in 2004 and contains additional comments and updated information on the existing chapters as well as three new chapters addressing recent work in the field of computational statistics This new edition is divided into 4 parts in the same way as the first edition It begins with How Computational Statistics became the backbone of modern data science Ch 1 an overview of the field of Computational Statistics how it emerged as a separate discipline and how its own development mirrored that of hardware and software including a discussion of current active research The second part Chs 2 15 presents several topics in the supporting field of statistical computing Emphasis is placed on the need for fast and accurate numerical algorithms and some of the basic methodologies for transformation database handling high dimensional data and graphics treatment are discussed The third part Chs 16 33 focuses on statistical methodology Special attention is given to smoothing iterative procedures simulation and visualization of multivariate data Lastly a set of selected applications Chs 34 38 like Bioinformatics Medical Imaging Finance Econometrics and Network Intrusion Detection highlight the usefulness of computational statistics in real world applications

Distributed Computing in Sensor Systems Rajmohan Rajaraman, Thomas Moscibroda, Adam Dunkels, Anna Scaglione, 2010-06-02 The book constitutes the refereed proceedings of the 6th International Conference on Distributed Computing in Sensor Systems DCOSS 2010 held in Santa Barbara CA USA in June 2010 The 28 revised full papers presented were carefully reviewed and selected from 76 submissions The research contributions in this proceedings span important aspects of sensor systems including energy management communication coverage and tracking time synchronization and

scheduling key establishment and authentication compression medium access control code update and mobility

**Risk-Averse Optimization and Control** Darinka Dentcheva, Andrzej Ruszczyński, 2024-06-29 This book offers a comprehensive presentation of the theory and methods of risk averse optimization and control Problems of this type arise in finance energy production and distribution supply chain management medicine and many other areas where not only the average performance of a stochastic system is essential but also high impact and low probability events must be taken into account The book is a self contained presentation of the utility theory the theory of measures of risk including systemic and dynamic measures of risk and their use in optimization and control models It also covers stochastic dominance relations and their application as constraints in optimization models Optimality conditions for problems with nondifferentiable and nonconvex functions and operators involving risk measures and stochastic dominance relations are discussed Much attention is paid to multi stage risk averse optimization problems and to risk averse Markov decision problems Specialized algorithms for solving risk averse optimization and control problems are presented and analyzed stochastic subgradient methods for risk optimization decomposition methods for dynamic problems event cut and dual methods for stochastic dominance constraints and policy iteration methods for control problems The target audience is researchers and graduate students in the areas of mathematics business analytics insurance and finance engineering and computer science The theoretical considerations are illustrated with examples which make the book useful material for advanced courses in the area      **Mathematical**

**Modelling and Numerical Methods in Finance** Alain Bensoussan, Qiang Zhang, 2009-06-16 Mathematical finance is a prolific scientific domain in which there exists a particular characteristic of developing both advanced theories and practical techniques simultaneously Mathematical Modelling and Numerical Methods in Finance addresses the three most important aspects in the field mathematical models computational methods and applications and provides a solid overview of major new ideas and results in the three domains Coverage of all aspects of quantitative finance including models computational methods and applications Provides an overview of new ideas and results Contributors are leaders of the field      *IoT for Defense and National Security* Robert Douglass, Keith Gremban, Ananthram Swami, Stephan Gerali, 2023-01-25 IoT for Defense and National Security Practical case based guide illustrating the challenges and solutions of adopting IoT in both secure and hostile environments IoT for Defense and National Security covers topics on IoT security architecture robotics sensing policy operations and more including the latest results from the premier IoT research initiative of the U S Defense Department the Internet of Battle Things The text also discusses challenges in converting defense industrial operations to IoT and summarizes policy recommendations for regulating government use of IoT in free societies As a modern reference this book covers multiple technologies in IoT including survivable tactical IoT using content based routing mobile ad hoc networks and electronically formed beams Examples of IoT architectures include using KepServerEX for edge connectivity and AWS IoT Core and Amazon S3 for IoT data To aid in reader comprehension the text uses case studies illustrating the

challenges and solutions for using robotic devices in defense applications plus case studies on using IoT for a defense industrial base Written by leading researchers and practitioners of IoT technology for defense and national security IoT for Defense and National Security also includes information on Changes in warfare driven by IoT weapons logistics and systems IoT resource allocation monitoring existing resources and reallocating them in response to adversarial actions Principles of AI enabled processing for Internet of Battlefield Things including machine learning and inference Vulnerabilities in tactical IoT communications networks servers and architectures and strategies for securing them Adapting rapidly expanding commercial IoT to power IoT for defense For application engineers from defense related companies as well as managers policy makers and academics IoT for Defense and National Security is a one of a kind resource providing expansive coverage of an important yet sensitive topic that is often shielded from the public due to classified or restricted distributions

**Identification of Dynamic Systems** Rolf Isermann, Marco Münchhof, 2010-11-22 Precise dynamic models of processes are required for many applications ranging from control engineering to the natural sciences and economics Frequently such precise models cannot be derived using theoretical considerations alone Therefore they must be determined experimentally This book treats the determination of dynamic models based on measurements taken at the process which is known as system identification or process identification Both offline and online methods are presented i e methods that post process the measured data as well as methods that provide models during the measurement The book is theory oriented and application oriented and most methods covered have been used successfully in practical applications for many different processes Illustrative examples in this book with real measured data range from hydraulic and electric actuators up to combustion engines Real experimental data is also provided on the Springer webpage allowing readers to gather their first experience with the methods presented in this book Among others the book covers the following subjects determination of the non parametric frequency response fast Fourier transform correlation analysis parameter estimation with a focus on the method of Least Squares and modifications identification of time variant processes identification in closed loop identification of continuous time processes and subspace methods Some methods for nonlinear system identification are also considered such as the Extended Kalman filter and neural networks The different methods are compared by using a real three mass oscillator process a model of a drive train For many identification methods hints for the practical implementation and application are provided The book is intended to meet the needs of students and practicing engineers working in research and development design and manufacturing

*Numerical Probability* Gilles Pagès, 2018-07-31 This textbook provides a self contained introduction to numerical methods in probability with a focus on applications to finance Topics covered include the Monte Carlo simulation including simulation of random variables variance reduction quasi Monte Carlo simulation and more recent developments such as the multilevel paradigm stochastic optimization and approximation discretization schemes of stochastic differential equations as well as optimal quantization methods The author further presents detailed applications to

numerical aspects of pricing and hedging of financial derivatives risk measures such as value at risk and conditional value at risk implicitation of parameters and calibration Aimed at graduate students and advanced undergraduate students this book contains useful examples and over 150 exercises making it suitable for self study      **Tractability** Lucas Bordeaux,Youssef Hamadi,Pushmeet Kohli,2014-02-06 An overview of the techniques developed to circumvent computational intractability a key challenge in many areas of computer science      **Inference and Learning from Data** Ali H. Sayed,2022-12-22 Discover core topics in inference and learning with the first volume of this extraordinary three volume set      Learning Theory from First Principles Francis Bach,2024-12-24 A comprehensive and cutting edge introduction to the foundations and modern applications of learning theory Research has exploded in the field of machine learning resulting in complex mathematical arguments that are hard to grasp for new comers In this accessible textbook Francis Bach presents the foundations and latest advances of learning theory for graduate students as well as researchers who want to acquire a basic mathematical understanding of the most widely used machine learning architectures Taking the position that learning theory does not exist outside of algorithms that can be run in practice this book focuses on the theoretical analysis of learning algorithms as it relates to their practical performance Bach provides the simplest formulations that can be derived from first principles constructing mathematically rigorous results and proofs without overwhelming students Provides a balanced and unified treatment of most prevalent machine learning methods Emphasizes practical application and features only commonly used algorithmic frameworks Covers modern topics not found in existing texts such as overparameterized models and structured prediction Integrates coverage of statistical theory optimization theory and approximation theory Focuses on adaptivity allowing distinctions between various learning techniques Hands on experiments illustrative examples and accompanying code link theoretical guarantees to practical behaviors      *Statistical Machine Learning* Richard Golden,2020-06-24 The recent rapid growth in the variety and complexity of new machine learning architectures requires the development of improved methods for designing analyzing evaluating and communicating machine learning technologies Statistical Machine Learning A Unified Framework provides students engineers and scientists with tools from mathematical statistics and nonlinear optimization theory to become experts in the field of machine learning In particular the material in this text directly supports the mathematical analysis and design of old new and not yet invented nonlinear high dimensional machine learning algorithms Features Unified empirical risk minimization framework supports rigorous mathematical analyses of widely used supervised unsupervised and reinforcement machine learning algorithms Matrix calculus methods for supporting machine learning analysis and design applications Explicit conditions for ensuring convergence of adaptive batch minibatch MCEM and MCMC learning algorithms that minimize both unimodal and multimodal objective functions Explicit conditions for characterizing asymptotic properties of M estimators and model selection criteria such as AIC and BIC in the presence of possible model misspecification This advanced text is suitable for graduate students or highly motivated undergraduate

students in statistics computer science electrical engineering and applied mathematics The text is self contained and only assumes knowledge of lower division linear algebra and upper division probability theory Students professional engineers and multidisciplinary scientists possessing these minimal prerequisites will find this text challenging yet accessible About the Author Richard M Golden Ph D M S E E B S E E is Professor of Cognitive Science and Participating Faculty Member in Electrical Engineering at the University of Texas at Dallas Dr Golden has published articles and given talks at scientific conferences on a wide range of topics in the fields of both statistics and machine learning over the past three decades His long term research interests include identifying conditions for the convergence of deterministic and stochastic machine learning algorithms and investigating estimation and inference in the presence of possibly misspecified probability models

**Formal Methods in Macro-Biology** François Fages, Carla Piazza, 2014-08-14 This book constitutes the refereed proceedings of the First International Conference on Formal Methods in Macro Biology FMMB 2014 held in Nouméa, New Caledonia in September 2014 The 7 revised full and 3 short papers presented together with 7 invited presentations were carefully reviewed and selected from 17 submissions The scientific program consists of papers on a wide variety of topics including ecological systems medical applications logical frameworks and discrete continuous and hybrid models for the analysis of biological systems at macroscopic levels

**Econophysics & Economics of Games, Social Choices and Quantitative Techniques** Banasri Basu, Bikas K. Chakrabarti, Satya R. Chakravarty, Kausik Gangopadhyay, 2010-06-01 The combined efforts of the Physicists and the Economists in recent years in analyzing and modelling various dynamic phenomena in monetary and social systems have led to encouraging developments generally classified under the title of Econophysics These developments share a common ambition with the already established field of Quantitative Economics This volume intends to offer the reader a glimpse of these two parallel initiatives by collecting review papers written by well known experts in the respective research frontiers in one cover This massive book presents a unique combination of research papers contributed almost equally by Physicists and Economists Additional contributions from Computer Scientists and Mathematicians are also included in this volume The book consists of two parts the first part concentrates on Econophysics problems and the second part stresses on various quantitative issues in Economics Both parts specialize on frontier problems in Games and Social Choices

Distributional Reinforcement Learning Marc G. Bellemare, Will Dabney, Mark Rowland, 2023-05-30 The first comprehensive guide to distributional reinforcement learning providing a new mathematical formalism for thinking about decisions from a probabilistic perspective Distributional reinforcement learning is a new mathematical formalism for thinking about decisions Going beyond the common approach to reinforcement learning and expected values it focuses on the total reward or return obtained as a consequence of an agent's choices specifically how this return behaves from a probabilistic perspective In this first comprehensive guide to distributional reinforcement learning Marc G Bellemare Will Dabney and Mark Rowland who spearheaded development of the field present its key concepts and



review some of its many applications They demonstrate its power to account for many complex interesting phenomena that arise from interactions with one's environment The authors present core ideas from classical reinforcement learning to contextualize distributional topics and include mathematical proofs pertaining to major results discussed in the text They guide the reader through a series of algorithmic and mathematical developments that in turn characterize compute estimate and make decisions on the basis of the random return Practitioners in disciplines as diverse as finance risk management computational neuroscience computational psychiatry psychology macroeconomics and robotics are already using distributional reinforcement learning paving the way for its expanding applications in mathematical finance engineering and the life sciences More than a mathematical approach distributional reinforcement learning represents a new perspective on how intelligent agents make predictions and decisions

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