Stochastic Approximation And Recursive Algorithms And Applications 2nd Edition

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Random Iterative Models Springer Science & Business Media
This research is concerned with recursive algorithms for constructing decision functions in pattern classification problems. The principal objective of this thesis is to provide a comprehensive interpretation that will be a common basis for (i) discussing the heretofore fragmented collection of existing algorithms and (ii) deriving new algorithms. All of the algorithms will be discussed as methods for minimizing pre-specified criterion functions. In deterministic pattern classification problems (those problems where there are a fixed, finite number of patterns each having a unique classification), the recursive algorithms are interpreted as special cases of a general gradient descent algorithm. In stochastic pattern classification problems (where the classification of a particular pattern is not unique but is expressed as a probability), the recursive algorithms are found to be special cases of a general stochastic approximation algorithm. This algorithm is the stochastic analog of the deterministic gradient descent algorithm. The stochastic approximation algorithm is also useful for approximating probability distribution and density functions. In this problem, there is no information about the unknown distribution of density functions being approximated. Only samples of the random variables are available. In the final chapter, the recursive algorithms are applied to problems in optimal control, estimation, and pattern classification. (Author).
Methologies and Traditional Applications Springer Science & Business Media
This book is devoted to sequential methods of solving a class of problems to which belongs, for example, the problem of finding a maximum point of a function if each measured value of this function contains a random error. Some basic procedures of stochastic approximation are investigated from a single point of view, namely the theory of Markov processes and martingales. Examples are considered of applications of the theorems to some problems of estimation theory, educational theory and control theory, and also to some problems of information transmission in the presence of inverse feedback.
Stochastic Learning and Optimization Springer
Control and communications engineers, physicists, and probability theorists, among others, will find this book unique. It contains a detailed development of approximation and limit theorems and methods for random processes and applies them to numerous problems of practical importance. In particular, it develops usable and broad conditions and techniques for showing that a sequence of processes converges to a Markov diffusion or jump process. This is useful when the natural physical model is quite complex, in which case a simpler approximation la diffusion process, for example) is usually made. The book simplifies and extends some important older methods and develops some powerful new ones applicable to a wide variety of limit and approximation problems. The theory of weak convergence of probability measures is introduced along with general and usable methods (for example, perturbed test function, martingale, and direct averaging) for proving tightness and weak convergence. Kushner's study begins with a systematic development of the method. It then treats dynamical system models that have state-dependent noise or nonsmooth dynamics. Perturbed Liapunov function methods are developed for stability studies of nonMarkovian problems and for the study of asymptotic distributions of non-Markovian systems. Three chapters are devoted to applications in control and communication theory (for example, phase-locked loops and adoptive filters). Smallnoise problems and an introduction to the theory of large deviations and applications conclude the book. Harold J. Kushner is Professor of Applied Mathematics and Engineering at Brown University and is one of the leading researchers in the area of stochastic processes concerned with analysis and synthesis in control and communications theory. This book is the sixth in The MIT Press Series in Signal Processing, Optimization, and Control, edited by Alan S. Willsky.

Learning Decision Sequences For Repetitive Processes—Selected Algorithms MIT Press
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.
Stochastic Approximation Methods for Constrained and Unconstrained Systems Springer Science & Business Media
Kalman filtering algorithm gives optimal (linear, unbiased and minimum error-variance) estimates of the unknown state vectors of a linear dynamic-observation system, under the regular conditions such as perfect data information; complete noise statistics; exact linear modeling; ideal well-conditioned matrices in computation and strictly centralized filtering.In practice, however, one or more of the aforementioned conditions may not be satisfied, so that the standard Kalman filtering algorithm cannot be directly used, and hence ?approximate Kalman filtering? becomes necessary. In the last decade, a great deal of attention has been focused on modifying and/or extending the standard Kalman filtering technique to handle such irregular cases. It has been realized that approximate Kalman filtering is even more important and useful in applications.This book is a collection of several tutorial and survey articles summarizing recent contributions to the field, along the line of approximate Kalman filtering with emphasis on both its theoretical and practical aspects.
Recursive Estimation and Control for Stochastic Systems Stochastic Approximation and Recursive Algorithms and Applications
Asymptotic properties of Robbins-Munro and Kiefer-Wolfowitz type stochastic approximation algorithms are obtained via the theory of large deviations. The conditions are weak and can even yield w.p.l. convergence results. The probability of escape of the iterates from a neighborhood of a stable point of the algorithm is estimated and shown to be considerably smaller than suggested by the classical asymptotic normality of local normalized errors method of getting the asymptotic properties. The escape probabilities are a natural quantity of interest. In many applications, they are more useful than the local normalized mean square errors. Other large deviations estimates are also obtained. Keywords: Recursive algorithms.
Algorithms for Reinforcement Learning CRC Press
Performance optimization is vital in the design and operation of modern engineering systems, including communications, manufacturing, robotics, and logistics. Most engineering systems are too complicated to model, or the system parameters cannot be easily identified, so learning techniques have to be applied. This book provides a unified framework based on a sensitivity point of view. It also introduces new approaches and proposes new research topics within this sensitivity-based framework. This new perspective on a popular topic is presented by a well respected expert in the field.
Stochastic Approximation and Recursive Algorithms and Applications Springer Science & Business Media
An up-to-date account of the interplay between optimization and machine learning, accessible to students and researchers in both communities. The interplay between optimization and machine

learning is one of the most important developments in modern computational science. Optimization formulations and methods are proving to be vital in designing algorithms to extract essential knowledge from huge volumes of data. Machine learning, however, is not simply a consumer of optimization technology but a rapidly evolving field that is itself generating new optimization ideas. This book captures the state of the art of the interaction between optimization and machine learning in a way that is accessible to researchers in both fields. Optimization approaches have enjoyed prominence in machine learning because of their wide applicability and attractive theoretical properties. The increasing complexity, size, and variety of today's machine learning models call for the reassessment of existing assumptions. This book starts the process of reassessment. It describes the resurgence in novel contexts of established frameworks such as first-order methods, stochastic approximations, convex relaxations, interior-point methods, and proximal methods. It also devotes attention to newer themes such as regularized optimization, robust optimization, gradient and subgradient methods, splitting techniques, and second-order methods. Many of these techniques draw inspiration from other fields, including operations research, theoretical computer science, and subfields of optimization. The book will enrich the ongoing cross-fertilization between the machine learning community and these other fields, and within the broader optimization community.

The Theory of Large Deviations and the Asymptotic Analysis of Recursive Algorithms and Stochastic Approximation CRC Press

This ENCYCLOPAEDIA OF MATHEMATICS aims to be a reference work for all parts of mathe matics. It is a translation with updates and editorial comments of the Soviet Mathematical Encyclopaedia published by 'Soviet Encyclopaedia Publishing House' in five volumes in 1977-1985. The annotated translation consists of ten volumes including a special index volume. There are three kinds of articles in this ENCYCLOPAEDIA. First of all there are survey-type articles dealing with the various main directions in mathematics (where a rather fme subdivi sion has been used). The main requirement for these articles has been that they should give a reasonably complete up-to-date account of the current state of affairs in these areas and that they should be maximally accessible. On the whole, these articles should be understandable to mathematics students in their first specialization years, to graduates from other mathematical areas and, depending on the specific subject, to specialists in other domains of science, en gineers and teachers of mathematics. These articles treat their material at a fairly general level and aim to give an idea of the kind of problems, techniques and concepts involved in the area in question. They also contain background and motivation rather than precise statements of precise theorems with detailed definitions and technical details on how to carry out proofs and constructions. The second kind of article, of medium length, contains more detailed concrete problems, results and techniques.

Introduction to Stochastic Search and Optimization Springer Science & Business Media

Recursive Identification and Parameter Estimation describes a recursive approach to solving system identification and parameter estimation problems arising from diverse areas. Supplying rigorous theoretical analysis, it presents the material and proposed algorithms in a manner that makes it easy to understand—providing readers with the modeling and identification skills required for successful theoretical research and effective application. The book begins by introducing the basic concepts of probability theory, including martingales, martingale difference sequences, Markov chains, mixing processes, and stationary processes. Next, it discusses the root-seeking problem for functions, starting with the classic RM algorithm, but with attention mainly paid to the stochastic approximation algorithms with expanding truncations (SAAWET) which serves as the basic tool for recursively solving the problems addressed in the book. The book not only identifies the results of system identification and parameter estimation, but also demonstrates how to apply the proposed approaches for addressing problems in a range of areas, including: Identification of ARMAX systems without imposing restrictive conditions Identification of typical nonlinear systems Optimal adaptive tracking Consensus of multi-agents systems Principal component analysis Distributed randomized PageRank computation This book recursively identifies autoregressive and moving average with exogenous input (ARMAX) and discusses the identification of non-linear systems. It concludes by addressing the problems arising from different areas that are solved by SAAWET. Demonstrating how to apply the proposed approaches to solve problems across a range of areas, the book is suitable for students, researchers, and engineers working in systems and control, signal processing, communication, and mathematical statistics.

Encyclopaedia of Mathematics Springer Science & Business Media

Spectral methods refer to the use of eigenvalues, eigenvectors, singular values and singular vectors. They are widely used in Engineering, Applied Mathematics and Statistics. More recently, spectral methods have found numerous applications in Computer Science to "discrete" as well "continuous" problems. Spectral Algorithms describes modern applications of spectral methods, and novel algorithms for estimating spectral parameters. The first part of the book presents applications of spectral methods to problems from a variety of topics including combinatorial optimization, learning and clustering. The second part of the book is motivated by efficiency considerations. A feature of many modern applications is the massive amount of input data. While sophisticated algorithms for matrix computations have been developed over a century, a more recent development is algorithms based on "sampling on the y" from massive matrices. Good estimates of singular values and low rank approximations of the whole matrix can be provably derived from a sample. The main emphasis in the second part of the book is to present these sampling methods with rigorous error bounds. It also presents recent extensions of spectral methods from matrices to tensors and their applications to some combinatorial optimization problems.

Partially Observed Markov Decision Processes Springer Science & Business Media

Stochastic differential equations are differential equations whose solutions are stochastic processes. They exhibit appealing mathematical properties that are useful in modeling uncertainties and noisy phenomena in many disciplines. This book is motivated by applications of stochastic differential equations in target tracking and medical technology and, in particular, their use in methodologies such as filtering, smoothing, parameter estimation, and machine learning. It builds an intuitive hands-on understanding of what stochastic differential equations are all about, but also covers the essentials of Ito calculus, the central theorems in the field, and such approximation schemes as stochastic Runge-Kutta. Greater emphasis is given to solution methods than to analysis of theoretical properties of the equations. The book's practical approach assumes only prior understanding of ordinary differential equations. The numerous worked examples and end-of-chapter exercises include application-driven derivations and computational assignments. MATLAB/Octave source code is available for download, promoting hands-on work with the methods.

Stochastic Approximation and Recursive Algorithms and Applications MIT Press

Stochastic Averaging and Extremum Seeking treats methods inspired by attempts to understand the seemingly non-mathematical question of bacterial chemotaxis and their application in other environments. The text presents significant generalizations on existing stochastic averaging theory developed from scratch and necessitated by the need to avoid violation of previous theoretical assumptions by algorithms which are otherwise effective in treating these systems. Coverage is given to four main topics. Stochastic averaging theorems are developed for the analysis of continuous-time nonlinear systems with random forcing, removing prior restrictions on nonlinearity growth and on the finiteness of the time interval. The new stochastic averaging theorems are usable not only as approximation tools but also for providing stability guarantees. Stochastic extremum-seeking algorithms are introduced for optimization of systems without available models. Both gradient- and Newton-based algorithms are presented, offering the user the choice between the simplicity of implementation (gradient) and the ability to achieve a known, arbitrary convergence rate (Newton). The design of algorithms for non-cooperative/adversarial games is described. The analysis of their convergence to Nash equilibria is provided. The algorithms are illustrated on models of economic competition and on problems of the deployment of teams of robotic vehicles. Bacterial locomotion, such as chemotaxis in E. coli, is explored with the aim of identifying two simple feedback laws for climbing nutrient gradients. Stochastic extremum seeking is shown to be a biologically-plausible interpretation for chemotaxis. For the same chemotaxis-inspired stochastic feedback laws, the book also provides a detailed analysis of convergence for models of nonholonomic robotic vehicles operating in GPS-denied environments. The book contains block diagrams and several simulation examples, including examples arising from bacterial locomotion, multi-agent robotic systems, and economic market models. Stochastic Averaging and Extremum Seeking will be informative for control engineers from backgrounds in electrical, mechanical, chemical and aerospace engineering and to applied mathematicians. Economics researchers, biologists, biophysicists and roboticists will find the applications examples instructive.

Stochastic Approximation and Recursive Estimation Springer Science & Business Media

This book presents a thorough development of the modern theory of stochastic approximation or recursive stochastic algorithms for both constrained and unconstrained problems. This second edition is a thorough revision, although the main features and structure remain unchanged. It contains many additional applications and results as well as more detailed discussion.

Approximate Kalman Filtering Birkhäuser

On-line learning is one of the most commonly used techniques for training neural networks. Though it has been used successfully in many real-world applications, most training methods are based on heuristic observations. The lack of theoretical support damages the credibility as well as the efficiency of neural networks training, making it hard to choose reliable or optimal methods. This book presents a coherent picture of the state of the art in the theoretical analysis of on-line learning. An introduction relates the subject to other developments in neural networks and explains the overall picture. Surveys by leading experts in the field combine new and established material and enable nonexperts to learn more about the techniques and methods used. This book, the first in the area, provides a comprehensive view of the subject and will be welcomed by mathematicians, scientists and engineers, both in industry and academia.

Recursive Algorithms for Pattern Classification Cambridge University Press

Covering formulation, algorithms, and structural results, and linking theory to real-world applications in controlled sensing (including social learning, adaptive radars and sequential detection), this book focuses on the conceptual foundations of partially observed Markov decision processes (POMDPs). It emphasizes structural results in stochastic dynamic programming, enabling graduate students and researchers in engineering, operations research, and economics to understand the underlying unifying themes without getting weighed down by mathematical technicalities. Bringing together research from across the literature, the book provides an introduction to nonlinear filtering followed by a systematic development of stochastic dynamic programming, lattice programming and reinforcement learning for POMDPs. Questions addressed in the book include: when does a POMDP have a threshold optimal policy? When are myopic policies optimal? How do local and global decision makers interact in adaptive decision making in multi-agent social learning where there is herding and data incest? And how can sophisticated radars and sensors adapt their sensing in real time?

Stochastic Averaging and Stochastic Extremum Seeking Now Publishers Inc

This self-contained reference for statisticians and engineers in system and control theory, analyzes the effect of convergent recursive estimation algorithms and stochastic approximation on the dependent noise case and the classic independent case. It discusses control and adaptive control problems related to recursive estimation, and introduces the combined probabilistic and differential equation method of data analysis.

Stochastic Approximations Via Large Deviations: Asymptotic Properties Springer

This book is devoted to sequential methods of solving a class of problems to which belongs, for example, the problem of finding a maximum point of a function if each measured value of this function contains a random error. Some basic procedures of stochastic approximation are investigated from a single point of view, namely the theory of Markov processes and martingales. Examples are considered of applications of the theorems to some problems of estimation theory, educational theory and control theory, and also to some problems of information transmission in the presence of inverse feedback.

Adaptive Algorithms and Stochastic Approximations Elsevier

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.

Machine Learning and Knowledge Discovery in Databases Springer Science & Business Media

Recursive Identification and Parameter Estimation describes a recursive approach to solving system identification and parameter estimation problems arising from diverse areas. Supplying rigorous theoretical analysis, it presents the material and proposed algorithms in a manner that makes it easy to understand—providing readers with the modeling and identification skills required for successful theoretical research and effective application. The book begins by introducing the basic concepts of probability theory, including martingales, martingale difference sequences, Markov chains, mixing processes, and stationary processes. Next, it discusses the root-seeking problem for functions, starting with the classic RM algorithm, but with attention mainly paid to the stochastic approximation algorithms with expanding truncations (SAAWET) which serves as the basic tool for recursively solving the problems addressed in the book. The book not only identifies the results of system identification and parameter estimation, but also demonstrates how to apply the proposed approaches for addressing problems in a range of areas, including: Identification of ARMAX systems without imposing restrictive conditions Identification of typical nonlinear systems Optimal adaptive tracking Consensus of multi-agents systems Principal component analysis Distributed randomized

PageRank computation This book recursively identifies autoregressive and moving average with exogenous input (ARMAX) and discusses the identification of non-linear systems. It concludes by addressing the problems arising from different areas that are solved by SAAWET. Demonstrating how to apply the proposed approaches to solve problems across a range of areas, the book is suitable for students, researchers, and engineers working in systems and control, signal processing, communication, and mathematical statistics.