PROBABILITY, MARKOV CHAINS, QUEUES, AND SIMULATION

The Mathematical Basis of Performance Modeling

WILLIAM J. STEWART

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Probability, Markov Chains, Queues, and Simulation William J. Stewart, 2009-07-06 Probability Markov Chains Queues and Simulation provides a modern and authoritative treatment of the mathematical processes that underlie performance modeling The detailed explanations of mathematical derivations and numerous illustrative examples make this textbook readily accessible to graduate and advanced undergraduate students taking courses in which stochastic processes play a fundamental role The textbook is relevant to a wide variety of fields including computer science engineering operations research statistics and mathematics. The textbook looks at the fundamentals of probability theory from the basic concepts of set based probability through probability distributions to bounds limit theorems and the laws of large numbers Discrete and continuous time Markov chains are analyzed from a theoretical and computational point of view Topics include the Chapman Kolmogorov equations irreducibility the potential fundamental and reachability matrices random walk problems reversibility renewal processes and the numerical computation of stationary and transient distributions The M M 1 queue and its extensions to more general birth death processes are analyzed in detail as are queues with phase type arrival and service processes The M G 1 and G M 1 queues are solved using embedded Markov chains the busy period residual service time and priority scheduling are treated Open and closed queueing networks are analyzed. The final part of the book addresses the mathematical basis of simulation Each chapter of the textbook concludes with an extensive set of exercises An instructor s solution manual in which all exercises are completely worked out is also available to professors only Numerous examples illuminate the mathematical theories Carefully detailed explanations of mathematical derivations guarantee a valuable pedagogical approach Each chapter concludes with an extensive set of exercises **Introduction to the Numerical** Solution of Markov Chains William J. Stewart, 2021-01-12 A cornerstone of applied probability Markov chains can be used to help model how plants grow chemicals react and atoms diffuse and applications are increasingly being found in such areas as engineering computer science economics and education To apply the techniques to real problems however it is necessary to understand how Markov chains can be solved numerically In this book the first to offer a systematic and detailed treatment of the numerical solution of Markov chains William Stewart provides scientists on many levels with the power to put this theory to use in the actual world where it has applications in areas as diverse as engineering economics and education His efforts make for essential reading in a rapidly growing field Here Stewart explores all aspects of numerically computing solutions of Markov chains especially when the state is huge He provides extensive background to both discrete time and continuous time Markov chains and examines many different numerical computing methods direct single and multi vector iterative and projection methods More specifically he considers recursive methods often used when the structure of the Markov chain is upper Hessenberg iterative aggregation disaggregation methods that are particularly appropriate when

it is NCD nearly completely decomposable and reduced schemes for cases in which the chain is periodic There are chapters on methods for computing transient solutions on stochastic automata networks and finally on currently available software Throughout Stewart draws on numerous examples and comparisons among the methods he so thoroughly explains

Computations with Markov Chains William J. Stewart, 2012-12-06 Computations with Markov Chains presents the edited and reviewed proceedings of the Second International Workshop on the Numerical Solution of Markov Chains held January 16 18 1995 in Raleigh North Carolina New developments of particular interest include recent work on stability and conditioning Krylov subspace based methods for transient solutions quadratic convergent procedures for matrix geometric problems further analysis of the GTH algorithm the arrival of stochastic automata networks at the forefront of modelling stratagems and more An authoritative overview of the field for applied probabilists numerical analysts and systems modelers including computer scientists and engineers Queueing Networks and Markov Chains Gunter Bolch, Stefan Greiner, Hermann de Meer, Kishor S. Trivedi, 2006-04-14 Critically acclaimed text for computer performance analysis now in its second edition The Second Edition of this now classic text provides a current and thorough treatment of queueing systems queueing networks continuous and discrete time Markov chains and simulation Thoroughly updated with new content as well as new problems and worked examples the text offers readers both the theory and practical guidance needed to conduct performance and reliability evaluations of computer communication and manufacturing systems Starting with basic probability theory the text sets the foundation for the more complicated topics of queueing networks and Markov chains using applications and examples to illustrate key points Designed to engage the reader and build practical performance analysis skills the text features a wealth of problems that mirror actual industry challenges New features of the Second Edition include Chapter examining simulation methods and applications Performance analysis applications for wireless Internet I2EE and Kanban systems Latest material on non Markovian and fluid stochastic Petri nets as well as solution techniques for Markov regenerative processes Updated discussions of new and popular performance analysis tools including ns 2 and OPNET New and current real world examples including DiffServ routers in the Internet and cellular mobile networks With the rapidly growing complexity of computer and communication systems the need for this text which expertly mixes theory and practice is tremendous Graduate and advanced undergraduate students in computer science will find the extensive use of examples and problems to be vital in mastering both the basics and the fine points of the field while industry professionals will find the text essential for developing systems that comply with industry standards and regulations

Probability, Markov Chains, Queues William J. Stewart, 2009-09-01 Markov Chains Pierre Brémaud, 2020-05-23 Primarily an introduction to the theory of stochastic processes at the undergraduate or beginning graduate level the primary objective of this book is to initiate students in the art of stochastic modelling However it is motivated by significant applications and progressively brings the student to the borders of contemporary research Examples are from a wide range

of domains including operations research and electrical engineering Researchers and students in these areas as well as in physics biology and the social sciences will find this book of interest Markov Chains Pierre Bremaud, 2013-03-09 In this book the author begins with the elementary theory of Markov chains and very progressively brings the reader to the more advanced topics He gives a useful review of probability that makes the book self contained and provides an appendix with detailed proofs of all the prerequisites from calculus algebra and number theory A number of carefully chosen problems of varying difficulty are proposed at the close of each chapter and the mathematics are slowly and carefully developed in order to make self study easier The author treats the classic topics of Markov chain theory both in discrete time and continuous time as well as the connected topics such as finite Gibbs fields nonhomogeneous Markov chains discrete time regenerative processes Monte Carlo simulation simulated annealing and queuing theory The result is an up to date textbook on stochastic processes Students and researchers in operations research and electrical engineering as well as in physics and biology will find it very accessible and relevant **Computations with Markov Chains** William J Stewart, 1995-02-28 Methods in Markov Chain Modeling Research Institute for Advanced Computer Science (U.S.), Bernard Philippe, Youcef Saad, William J. Stewart, 1989 Continuous-Time Markov Chains William J. Anderson, 2012-12-06 Continuous time parameter Markov chains have been useful for modeling various random phenomena occurring in queueing theory genetics demography epidemiology and competing populations This is the first book about those aspects of the theory of continuous time Markov chains which are useful in applications to such areas It studies continuous time Markov chains through the transition function and corresponding q matrix rather than sample paths An extensive discussion of birth and death processes including the Stielties moment problem and the Karlin McGregor method of solution of the birth and death processes and multidimensional population processes is included and there is an extensive bibliography Virtually all of this material is appearing in book form for the first time Queueing Networks and Markov Chains, 2008 Eintrag fr die Universit tsbibliographie Finite Markov Chains and Algorithmic Applications Olle Häggström, 2002-05-30 Based on a lecture course given at Chalmers University of Technology this 2002 book is ideal for advanced undergraduate or beginning graduate students The author first develops the necessary background in probability theory and Markov chains before applying it to study a range of randomized algorithms with important applications in optimization and other problems in computing Amongst the algorithms covered are the Markov chain Monte Carlo method simulated annealing and the recent Propp Wilson algorithm This book will appeal not only to mathematicians but also to students of statistics and computer science The subject matter is introduced in a clear and concise fashion and the numerous exercises included will help students to deepen their understanding Numerical Methods in Markov Chains and Bulk Queues T. P. Bagchi, J. G. C. Templeton, 2012-12-06 Markov Chains and Mixing Times David Asher Levin, Yuval Peres, Elizabeth Lee Wilmer, This book is an introduction to the modern approach to the theory of Markov chains The main goal of this approach is to determine the

rate of convergence of a Markov chain to the stationary distribution as a function of the size and geometry of the state space The authors develop the key tools for estimating convergence times including coupling strong stationary times and spectral methods Whenever possible probabilistic methods are emphasized The book includes many examples and provides brief introductions to some central models of statistical mechanics Also provided are accounts of random walks on networks including hitting and cover times and analyses of several methods of shuffling cards As a prerequisite the authors assume a modest understanding of probability theory and linear algebra at an undergraduate level Markov Chains and Mixing Times is meant to bring the excitement of this active area of research to a wide audience **Markov Chains and Dependability Theory** Gerardo Rubino, Bruno Sericola, 2014-06-12 Dependability metrics are omnipresent in every engineering field from simple ones through to more complex measures combining performance and dependability aspects of systems This book presents the mathematical basis of the analysis of these metrics in the most used framework Markov models describing both basic results and specialised techniques The authors first present both discrete and continuous time Markov chains before focusing on dependability measures which necessitate the study of Markov chains on a subset of states representing different user satisfaction levels for the modelled system Topics covered include Markovian state lumping analysis of sojourns on subset of states of Markov chains analysis of most dependability metrics fundamentals of performability analysis and bounding and simulation techniques designed to evaluate dependability measures The book is of interest to graduate students and researchers in all areas of engineering where the concepts of lifetime repair duration availability reliability and risk are important Mathematical Aspects of Mixing Times in Markov Chains Ravi R. Montenegro, Prasad Tetali, 2006 Mathematical Aspects of Mixing Times in Markov Chains begins with a gentle introduction to the analytical aspects of the theory of finite Markov chain mixing times and guickly ramps up to explain the latest developments in the topic Several theorems are revisited and often derived in simpler transparent ways and illustrated with examples The highlights include spectral logarithmic Sobolev techniques the evolving set methodology and issues of nonreversibility Mathematical Aspects of Mixing Times in Markov Chains is a comprehensive well written review of the subject that will be of interest to researchers and students in computer and mathematical sciences Markov Chains J. R. Norris, 1998-07-28 Markov chains are central to the understanding of random processes This is not only because they pervade the applications of random processes but also because one can calculate explicitly many quantities of interest This textbook aimed at advanced undergraduate or MSc students with some background in basic probability theory focuses on Markov chains and quickly develops a coherent and rigorous theory whilst showing also how actually to apply it Both discrete time and continuous time chains are studied A distinguishing feature is an introduction to more advanced topics such as martingales and potentials in the established context of Markov chains There are applications to simulation economics optimal control genetics gueues and many other topics and exercises and examples drawn both from theory and practice It will therefore be an ideal text either for

elementary courses on random processes or those that are more oriented towards applications Markov Chains Paul A. Gagniuc, 2017-07-05 A fascinating and instructive guide to Markov chains for experienced users and newcomers alike This unique quide to Markov chains approaches the subject along the four convergent lines of mathematics implementation simulation and experimentation It introduces readers to the art of stochastic modeling shows how to design computer implementations and provides extensive worked examples with case studies Markov Chains From Theory to Implementation and Experimentation begins with a general introduction to the history of probability theory in which the author uses quantifiable examples to illustrate how probability theory arrived at the concept of discrete time and the Markov model from experiments involving independent variables An introduction to simple stochastic matrices and transition probabilities is followed by a simulation of a two state Markov chain The notion of steady state is explored in connection with the long run distribution behavior of the Markov chain Predictions based on Markov chains with more than two states are examined followed by a discussion of the notion of absorbing Markov chains Also covered in detail are topics relating to the average time spent in a state various chain configurations and n state Markov chain simulations used for verifying experiments involving various diagram configurations Fascinating historical notes shed light on the key ideas that led to the development of the Markov model and its variants Various configurations of Markov Chains and their limitations are explored at length Numerous examples from basic to complex are presented in a comparative manner using a variety of color graphics All algorithms presented can be analyzed in either Visual Basic Java Script or PHP Designed to be useful to professional statisticians as well as readers without extensive knowledge of probability theory Covering both the theory underlying the Markov model and an array of Markov chain implementations within a common conceptual framework Markov Chains From Theory to Implementation and Experimentation is a stimulating introduction to and a valuable reference for those wishing to deepen their understanding of this extremely valuable statistical tool Paul A Gagniuc PhD is Associate Professor at Polytechnic University of Bucharest Romania He obtained his MS and his PhD in genetics at the University of Bucharest Dr Gagniuc s work has been published in numerous high profile scientific journals ranging from the Public Library of Science to BioMed Central and Nature journals He is the recipient of several awards for exceptional scientific results and a highly active figure in the review process for different scientific areas **Markov Chains and Decision Processes for Engineers and Managers** Theodore J. Sheskin, 2016-04-19 Recognized as a powerful tool for dealing with uncertainty Markov modeling can enhance your ability to analyze complex production and service systems However most books on Markov chains or decision processes are often either highly theoretical with few examples or highly prescriptive with little justification for the steps of the algorithms u Markov Chains and Stochastic Stability Sean Meyn, Richard L. Tweedie, 2009-04-02 Meyn and Tweedie is back The bible on Markov chains in general state spaces has been brought up to date to reflect developments in the field since 1996 many of them sparked by publication of the first edition The pursuit of more efficient simulation algorithms for

complex Markovian models or algorithms for computation of optimal policies for controlled Markov models has opened new directions for research on Markov chains As a result new applications have emerged across a wide range of topics including optimisation statistics and economics New commentary and an epilogue by Sean Meyn summarise recent developments and references have been fully updated This second edition reflects the same discipline and style that marked out the original and helped it to become a classic proofs are rigorous and concise the range of applications is broad and knowledgeable and key ideas are accessible to practitioners with limited mathematical background

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