Finite Markov Processes And Their Applications Dover Books On Mathematics

A volume of this nature containing a collection of papers has been brought out to honour a gentleman - a friend and a colleague - whose work has, to a large extent, advanced and popularized the use of stochastic point processes. Professor Srinivasan celebrated his sixt~ first 1:!irth d~ on December 16,1990 and will be retiring as

Professor of Applied Mathematics from the Indian Institute of Technolo~, Madras on June 30,1991. In view of his outstanding contributions to the theor~ and applications of stochastic processes over a time span of thirt~ ~ears, it seemed appropriate not to let his birth d~ and retirement pass unnoticed. A s~posium in his honour and the publication of the proceedings appeared to us to be the most natural and sui table ~ to mark the occasion. The Indian Societ~ for ProbabU it~ and Statistics volunteered to organize the S~posium as part of their XII Annual conference in Bomba~. We requested a number of long-time friends, colleagues and former students of Professor Srinivasan to contribute a paper preferabl~ in the area of stochastic processes and their applications. The positive response and the enthusiastic cooperation of these distinguished scientists have resulted in the present collection. The contributions to this volume are divided into four parts: Stochastic Theor~ (2 articles), P~sics (6 articles), Biolo~ (4 articles) and Operations Research (12 articles). In addition the ke~note address delivered b~ Professor Srinivasan in the S~posium is also included.

This book provides a rigorous but elementary introduction to the theory of Markov Processes on a countable state space. It should be accessible to students with a solid undergraduate background in mathematics, including students from engineering, economics, physics, and biology. Topics covered are: Doeblin's theory, general ergodic properties, and continuous time processes. Applications are dispersed throughout the book. In addition, a whole chapter is devoted to reversible processes and the use of their associated Dirichlet forms to estimate the rate of convergence to equilibrium. These results are then applied to the analysis of the Metropolis (a.k.a simulated annealing) algorithm. The corrected and enlarged 2nd edition contains a new chapter in which the author develops computational methods for Markov chains on a finite state space. Most intriguing is the section with a new technique for computing stationary measures, which is applied to derivations of Wilson's algorithm and Kirchoff's formula for spanning trees in a connected graph. Besides the investigation of general chains the book contains chapters which are concerned with eigenvalue techniques, conductance, stopping times, the strong Markov property, couplings, strong uniform times, Markov chains on arbitrary finite groups (including a crash-course in harmonic analysis), random generation and counting, Markov random fields, Gibbs fields, the Metropolis sampler, and simulated annealing. With 170 exercises. Provides a more accessible introduction than other books on Markov processes by emphasizing the structure of the subject and avoiding sophisticated measure theory Leads the reader to a rigorous understanding of basic theory Markov Chains Continuous Semi-Markov Processes Sequential Decisions and Finite Markov Processes: a Survey Cycle Representations of

Markov Processes
Sojourn Times in Finite Markov Processes

This new edition of Markov Chains: Models, Algorithms and Applications has been completely reformatted as a text, complete with end-of-chapter exercises, a new focus on management science, new applications of the models, and new examples with applications in financial risk management and modeling of financial data. This book consists of eight chapters. Chapter 1 gives a brief introduction to the classical theory on both discrete and continuous time Markov chains. The relationship between Markov chains of finite states and matrix theory will also be highlighted. Some classical iterative methods for solving linear systems will be introduced for finding the stationary distribution of a Markov chain. The chapter then covers the basic theories and algorithms for hidden Markov models (HMMs) and Markov decision processes

(MDPs). Chapter 2 discusses the applications of continuous time Markov chains to model queueing systems and discrete time Markov chain for computing the PageRank, the ranking of websites on the Internet. Chapter 3 studies Markovian models for manufacturing and re-manufacturing systems and presents closed form solutions and fast numerical algorithms for solving the captured systems. In Chapter 4, the authors present a simple hidden Markov model (HMM) with fast numerical algorithms for estimating the model parameters. An application of the HMM for customer classification is also presented. Chapter 5 discusses Markov decision processes for customer lifetime values. Customer Lifetime Values (CLV) is an important concept and quantity in marketing management. The authors present an approach based on Markov decision processes for the calculation of CLV using real data. Chapter 6 considers higher-order Markov chain models, particularly a class of parsimonious higher-order Markov chain models. Efficient estimation methods for model parameters based on linear programming are presented. Contemporary research results on applications to demand predictions, inventory control and financial risk measurement are also presented. In Chapter 7, a class of parsimonious multivariate Markov models is introduced. Again, efficient estimation methods based on linear programming are presented. Applications to demand predictions, inventory control policy and modeling credit ratings data are discussed. Finally, Chapter 8 re-visits hidden Markov models, and the authors present a new class of hidden Markov models with efficient algorithms for estimating the model parameters. Applications to modeling interest rates, credit ratings and default data are discussed. This book is aimed at senior undergraduate students, postgraduate students, professionals, practitioners, and researchers in applied mathematics, computational science, operational research, management science and finance, who are interested in the formulation and computation of queueing networks, Markov chain models and related topics. Readers are expected to have some basic knowledge of probability theory, Markov processes and matrix theory.

This book provides an undergraduate introduction to discrete and continuous-time Markov chains and their applications. A large focus is placed on the first step analysis technique and its applications to average hitting times and ruin probabilities. Classical topics such as recurrence and transience, stationary and limiting distributions, as well as branching processes, are also covered. Two major examples (gambling processes and random walks) are treated in detail from the beginning, before the general theory itself is presented in the subsequent chapters. An introduction to discrete-time martingales and their relation to ruin probabilities and mean exit times is also provided, and the book includes a chapter on spatial Poisson processes with some recent results on moment identities and deviation inequalities for Poisson stochastic integrals. The concepts presented are illustrated by examples and by 72 exercises and their complete solutions.

This text on stochastic processes and their applications is based on a set of lectures given during the past several years at the University of

California, Santa Barbara (UCSB). It is an introductory graduate course designed for classroom purposes. Its objective is to provide graduate students of statistics with an overview of some basic methods and techniques in the theory of stochastic processes. The only prerequisites are some rudiments of measure and integration theory and an intermediate course in probability theory. There are more than 50 examples and applications and 243 problems and complements which appear at the end of each chapter. The book consists of 10 chapters. Basic concepts and definitions are pro vided in Chapter 1. This chapter also contains a number of motivating ex amples and applications illustrating the practical use of the concepts. The last five sections are devoted to topics such as separability, continuity, and measurability of random processes, which are discussed in some detail. The concept of a simple point process on R+ is introduced in

Chapter 2. Using the coupling inequality and Le Cam's lemma, it is shown that if its counting function is stochastically continuous and has independent increments, the point process is Poisson. When the counting function is Markovian, the sequence of arrival times is also a Markov process. Some related topics such as independent thinning and marked point processes are also discussed. In the final section, an application of these results to flood modeling is presented. This graduate-level text explores the relationship between Markov processes and potential theory, in addition to aspects of the theory of additive functionals.

Topics include Markov processes, excessive functions, multiplicative functionals and subprocesses, and additive functionals and their potentials. A concluding chapter examines dual processes and potential theory. 1968 edition.

The Dynkin Festschrift

Perturbed Semi-Markov Type Processes I

Ergodicity of Markov Processes via Nonstandard Analysis
Elements of the Theory of Markov Processes and Their Applications
Gibbs Fields, Monte Carlo Simulation and Queues
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. Self-contained treatment covers both theory and applications. Topics include the fundamental role of homogeneous infinite Markov chains in the mathematical modeling of psychology and genetics. 1980 edition.

The theory of Markov Processes has become a powerful tool in partial differential equations and potential theory with important applications to physics. Professor Dynkin has made many profound contributions to the subject and in this volume are collected several of his most important expository and survey articles. The content of these articles has not been covered in any monograph as yet. This account is accessible to graduate students in mathematics and operations research and will be welcomed by all those interested in stochastic processes and their applications. Semi-Markov Processes: Applications in System Reliability and Maintenance is a modern view of discrete state space and continuous time semi-Markov processes and their applications in reliability and maintenance. The book explains how to construct semi-Markov models and discusses the different reliability parameters and characteristics that can be obtained from those models. The book is a useful resource for mathematicians, engineering practitioners, and PhD and MSc students who want to understand the basic concepts and results of semi-Markov process theory. Clearly defines the properties and theorems from discrete state Semi-Markov Process (SMP) theory. Describes the method behind constructing Semi-Markov (SM) models and SM decision models in the field of reliability and maintenance. Provides numerous individual versions of SM models, including the most recent and their impact on system reliability and maintenance.

FUNCTIONS OF FINITE MARKOV CHAINS AND EXPONENTIAL TYPE PROCESSES.

A Study of Processes Associated with a

Finite Markov Chain
Introduction to Markov Chains
An Introduction
Elements of Applied Stochastic Processes
The modem theory of Markov processes has its origins in the studies of

A. A. MARKOV (1906-1907) on sequences of experiments "connected in a chain" and in the attempts to describe mathematically the physical phenomenon known as Brownian motion (L. BACHELlER 1900,

A. EIN STEIN
1905). The first
correct
mathematical
construction of
a Markov process
with continuous
trajectories was
given by N.
WIENER in 1923.
(This process is
often called the
Wiener process.)
The general

theory of Markov processes was developed in the 1930's and 1940's by A. N. KOL MOGOROV, W. FELLER, W. DOEBLlN, P. LEVY, J. L. DOOB, and others. During the past ten years the theory of Markov processes has entered a new period of intensive development. The methods of the theory of semigroups of linear operators made possible further progress in the classification of Markov processes by their infinitesimal characteristics. The broad classes of Markov processes with continuous trajectories be came the main object of study. The connections between Markov pro cesses and classical analysis were further developed. It has become possible not only to apply the results and methods of analysis to the problems of probability theory, but also to investigate analytic problems using probabilistic methods. Remarkable new connections between Markov processes and potential theory were revealed. The foundations of the theory were reviewed critically: the

new concept of strong Markov process acquired for the whole theory of Markov processes great importance.
This title considers the special of random processes known as semi-Markov processes. These

possess the Markov property with respect to any intrinsic Markov time such as the first exit time from an open set or a finite iteration of these times. The class of semi-Markov processes includes strong

Markov processes, Lévy and Smith stepped semi-Markov processes, and some other subclasses. Extensive coverage is devoted to non-Markovian semi-Markov processes with continuous trajectories and, in particular, to semi-Markov diffusion processes. Readers looking to enrich their knowledge on Markov processes will find this book a valuable resource.

Markov processes

are used to model systems with limited memory. They are used in many areas including communications systems, transportation networks, image segmentation and analysis, biological systems and DNA sequence analysis, random atomic motion and diffusion in physics, social mobility, population studies, epidemiology, animal and insect migration, queueing systems, resource management, dams, financial engineering, actuarial science, and decision systems. This book, which is written for upper level undergraduate and graduate students, and researchers, presents a unified presentation of Markov processes. In addition to traditional topics such as Markovian queueing system, the book discusses such topics as continuous-time random walk,correlated random walk, Brownian motion, diffusion processes, hidden Markov models, Markov random fields, Markov point processes and Markov chain Monte Carlo.

Continuous-time random walk is currently used in econophysics to model the financial market, which has traditionally been modelled as a Brownian motion. Correlated random walk is popularly used in ecological studies to model animal and insect movement. Hidden Markov models are used in speech analysis and DNA sequence analysis while Markov random fields and Markov point processes are used in image analysis. Thus, the book is designed to have a very broad appeal. - Provides the practical, current applications of Markov processes - Coverage of HMM, Point processes, and Monte Carlo - Includes enough theory to help students gain throrough understanding of the subject - Principles can be immediately applied in many specific research projects, saving researchers time - End of chapter exercises provide reinforcement, practice and increased understanding to the student Fundamental concepts of Markov chains; The classical approach to markov chains; The algebraic approach to Markov chains; Nonstationary Markov chains and the ergodic coeficient; Analysis of a markov chain on a computer; Continuous time Markov chains. Markov Chains on

Metric Spaces
Limit Theorems for Rare-Event Times and Processes
Markov Processes for Stochastic Modeling
With Special Emphasis on Rapid Mixing
Conditional Markov Processes and Their

Application to the Theory of Optimal Control

At first there was the Markov property. The theory of stochastic processes, which can be considered as an exten sion of probability theory, allows the modeling of the evolution of systems through the time. It cannot be properly understood just as pure mathemat ics, separated from the body of experience and examples that have brought it to life. The theory of stochastic processes entered a period of intensive develop ment, which is not finished yet, when the idea of the Markov property was brought in. Not even a serious study of the renewal processes is possible without using the strong tool of Markov processes. The modern theory of Markov processes has its origins in the studies by A. A: Markov (1856-1922) of sequences of experiments "connected in a chain" and in the attempts to describe mathematically the physical phenomenon known as Brownian mo tion. Later, many generalizations (in fact all kinds of weakenings of the Markov property) of Markov type stochastic processes were proposed. Some of them have led to new classes of stochastic processes and useful applications. Let us mention some of them:

systems with complete connections [90, 91, 45, 86]; K-dependent Markov processes [44]; semi-Markov processes, and so forth. The semi-Markov processes generalize the renewal processes as well as the Markov jump processes and have numerous applications, especially in relia bility.

This book provides new

insight into Markovian dependence via the cycle decompositions. It presents a systematic account of a class of stochastic processes known as cycle (or circuit) processes - so-called because they may be defined by directed cycles. An important application of this approach is the insight it provides to electrical networks and the duality principle of networks. This expanded second edition adds new advances, which reveal wide-ranging interpretations of cycle representations such as homologic decompositions, orthogonality equations, Fourier series, semigroup equations, and disintegration of

measures. The text includes chapter summaries as well as a number of detailed illustrations.
Onishchik, A. A. Kirillov, and E. B. Vinberg, who obtained their first results on Lie groups in Dynkin's seminar. At a later stage, the work of the seminar was greatly enriched by the active

participation of 1. 1. Pyatetskii Shapiro. As already noted, Dynkin started to work in probability as far back as his undergraduate studies. In fact, his first published paper deals with a problem arising in Markov chain theory. The most significant among his earliest probabilistic results concern sufficient statistics. In [15] and [17], Dynkin described all families of one-dimensional probability distributions admitting non-trivial sufficient statistics. These papers have considerably influenced the subsequent research in this field. But Dynkin's most famous results in probability concern the theory of Markov processes. Following Kolmogorov, Feller, Doob and Ito, Dynkin opened a new chapter in the theory of Markov processes. He created the fundamental concept of a Markov process as a family of measures corresponding to var ious initial times and states and he defined time homogeneous processes in terms of the shift operators ()t. In a joint paper with his student A.

View the abstract.

Finite Markov Chains and Algorithmic Applications

A Short Course

An Introduction to Finite Markov Processes

Stochastic Processes and their Applications

Markov Processes and their Applications

Markov processes are among the most important stochastic processes for both theory and applications. This book develops the general theory of these processes, and applies this theory to various special examples.
The report contains an exhaustive list of references in the theory of Markov renewal

processes, semi-Markov processes and their applications. Both published papers and technical reports have been listed. (Author). 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.
This book gives an introduction to discrete-time Markov chains which evolve on a separable metric space. The focus is on the ergodic properties of such chains, i.e., on their long-term

statistical behaviour. Among the main topics are existence and uniqueness of invariant probability measures, irreducibility, recurrence, regularizing properties for Markov kernels, and convergence to equilibrium. These concepts are investigated with tools such as Lyapunov functions, petite and small sets, Doeblin and accessible points, coupling, as well as key notions from classical ergodic theory. The theory is illustrated through several recurring classes of examples, e.g., random contractions, randomly switched vector fields, and stochastic differential equations, the latter providing a bridge to continuous-time Markov processes. The book can serve as the core for a semester- or year-long graduate course in probability theory with an emphasis on Markov chains or random dynamics. Some of the material is also well suited for an ergodic theory course. Readers should have taken an introductory course on probability theory, based on measure theory. While there is a chapter devoted to chains on a countable state space, a certain familiarity with Markov chains on a finite state space is also recommended.

Markov Processes

Understanding Markov Chains

Markov Processes and Potential Theory
A Working Bibliography of Markov Renewal Processes and Their Applications
Ergodic Theorems for Multi-Alternating Regenerative Processes
This book presents an algebraic development of the theory of countable

state space Markov chains with discrete- and continuous-time parameters. A Markov chain is a stochastic process characterized by the Markov prop erty that the distribution of future depends only on the current state, not on the whole history. Despite its simple form of dependency, the Markov property has enabled us to develop a rich system of concepts and theorems and to derive many results that are useful in applications. In fact, the areas that can be modeled, with varying degrees of success, by Markov chains are vast and are still expanding. The aim of this book is a discussion of the time-dependent behavior, called the transient behavior, of Markov chains. From the practical point of view, when modeling a stochastic system by a Markov chain, there are many instances in which time-limiting results such as stationary distributions have no meaning. Or, even when the stationary distribution is of some importance, it is often dangerous to use the stationary result alone without knowing the transient behavior of the Markov chain. Not many books have paid much attention to this topic, despite its obvious importance.

Clear, rigorous, and intuitive, Markov Processes provides a bridge from an undergraduate probability course to a course in stochastic processes and also as a reference for those that want to see detailed proofs of the theorems of Markov processes. It contains copious computational examples that motivate and illustrate the theorems. The text is desi

Random variables. Probability generating functions.

Exponential-type distributions and maximum likelihood estimation. Branching process, random walk and ruin problem. Markov chains. Algebraic treatment of finite Markov chains. Renewal processes. Some stochastic models of population growth. A general birth process, an equality and an epidemic model. Birth-death processes and queueing processes. A simple illness-death process - fix-neyman processes. Multiple transition probabilities in the simple illness death process. Multiple transition time in the simple illness death process - an alternating renewal process. The kolmogorov differential equations and finite markov processes.

Kolmogorov differential equations and finite markov processes - continuation. A general illness-death process. Migration processes and birth-illness-death processes.
This book is the second volume of a

two-volume monograph devoted to the study of limit and ergodic theorems for regularly and singularly perturbed Markov chains, semi-Markov processes, and multi-alternating regenerative processes with semi-

Markov modulation. The second volume presents a complete classification of ergodic theorems for alternating regenerative processes, including more than twenty-five such theorems. The text addresses new asymptotic recurrent algorithms of phase space reduction for multi-alternating regenerative processes modulating by regularly and singularly perturbed finite semi-Markov processes. It also features a new study of super-long, long, and short time ergodic theorems for these processes. The book also contains a comprehensive bibliography of major works in the field. It provides an effective reference for both graduate students as well as theoretical and applied researchers studying stochastic processes and their applications. Proceedings of the Symposium held in honour of Professor S.K. Srinivasan at the Indian Institute of Technology Bombay, India, December 27–30, 1990

Finite Markov Processes and Their Applications

Theory and Applications

An Introduction to Markov Processes

Statistical Inference for Markov Processes

The relatively young theory of structured dependence between stochastic processes has many real-life applications in areas including finance, insurance, seismology, neuroscience, and genetics. With this monograph, the first to be devoted to the modeling of structured dependence between random processes, the authors not only meet the demand for a solid theoretical account but also develop a stochastic processes counterpart of the classical copula theory that exists for finite-dimensional random variables. Presenting both the technical aspects and the applications of the theory, this is a valuable reference for researchers and practitioners in the field, as well as for graduate students in pure and applied mathematics programs. Numerous theoretical examples are included, alongside examples of both current and potential applications, aimed at helping those who need to model structured dependence between dynamic random phenomena. Here is a work that adds much to the sum of our knowledge in a key area of science today. It is concerned with the estimation of discrete-time semi-Markov and hidden semi-Markov processes. A unique feature of the book is the use of discrete time, especially useful in some specific applications where the time scale is intrinsically discrete. The models presented in the book are specifically adapted to reliability studies and DNA analysis. The book is mainly intended for applied probabilists and statisticians interested in semi-Markov chains theory, reliability and DNA analysis, and for theoretical oriented reliability and bioinformatics engineers.

This book is the first volume of a two-volume monograph devoted to the study of limit and ergodic theorems for regularly and singularly perturbed Markov chains, semi-Markov processes, and multi-alternating regenerative processes with semi-Markov modulation. The first volume presents necessary and sufficient conditions for weak convergence for first-rare-event times and convergence in the topology J for first-rare-event processes defined on regularly perturbed finite Markov chains and semi-Markov processes. The text introduces new asymptotic recurrent algorithms of phase space reduction. It also addresses both effective conditions of weak convergence for distributions of hitting times as well as convergence of expectations of hitting times for regularly and singularly perturbed finite Markov chains and semi-Markov processes. The book also contains a comprehensive bibliography of major works in the field. It provides an effective reference for both graduate students as well as theoretical and applied researchers studying stochastic processes and their applications.

This graduate-level text and reference in probability, with numerous applications to several fields of science, presents nonmeasure-theoretic introduction to theory of Markov processes. The work also covers mathematical models based on the theory, employed in various applied fields. Prerequisites are a knowledge of elementary probability theory, mathematical statistics, and analysis.

Appendixes. Bibliographies. 1960 edition.

Semi-Markov Processes and Reliability

Semi-Markov Chains and Hidden Semi-Markov Models toward Applications

Perturbed Semi-Markov Type Processes II

Models, Algorithms and Applications Examples and Applications Fundamentals of Queueing Theory, 2nd Edition Donald Gross and Carl M. Harris A graduate text and reference treating queueing theory from the development of standard models to applications. The emphasis is on real analysis of queueing systems, applications, and problem solving. It has been brought up-to-date by modernizing older treatments. 1985 (0 471-89067-7) 475 pp. Multivariate Descriptive Analysis Correspondence

Analysis and Related Techniques for Large Matrices Ludovic Lebart, Alain Morineau and Kenneth M. Warwick Presents a set of statistical methods for exploratory analysis of large date sets and categorical data. This unique approach uses graphical aspects of multidimensional scaling techniques within the context of exploratory data analysis. 1984 (0 471-86743-8) 231 pp. Introduction to Linear Regression Analysis Douglas C. Montgomery and Elizabeth A. Peck A definitive introduction to linear regression analysis covering basic topics as well as recent approaches in the field. It blends theory and application in a way that enables readers to apply regression methodology in a variety of practical settings. Many detailed examples drawn directly from various fields of engineering, physical science, and the management sciences provide clear guidance to the use of the techniques. The interface with widely available computer programs for regression analysis is illustrated throughout with numerous actual

computer printouts.
1982 (0 471-05850-5)
504 pp.
Markov Processes and
Related Problems of
Analysis
Volume 1
Structured
Dependence between
Stochastic Processes
Their Use in
Reliability and DNA
Analysis

An Introduction to Stochastic Processes and Their Applications