Free read Lecture notes markov chains (2023)

this book provides an undergraduate level introduction to discrete and continuous time markov chains and their applications with a particular focus on the first step analysis technique and its applications to average hitting times and ruin probabilities it also discusses classical topics such as recurrence and transience stationary and limiting distributions as well as branching processes it first examines in detail two important examples gambling processes and random walks before presenting the general theory itself in the subsequent chapters it also provides an introduction to discrete time martingales and their relation to ruin probabilities and mean exit times together with a chapter on spatial poisson processes the concepts presented are illustrated by examples 138 exercises and 9 problems with their solutions a fascinating and instructive guide to markov chains for experienced users and newcomers alike this unique guide 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 with the first edition out of print we decided to arrange for republi cation of denumerrible markov ohains with additional bibliographic material the new edition contains a section additional notes that indicates some of the developments in markov chain theory over the last ten years as in the first edition and for the same reasons we have resisted the temptation to follow the theory in directions that deal with uncountable state spaces or continuous time a section entitled additional references complements the additional notes j w pitman pointed out an error in theorem 9 53 of the first edition which we have corrected more detail about the correction appears in the additional notes aside from this change we have left intact the text of the first eleven chapters the second edition contains a twelfth chapter written by david griffeath on markov random fields we are grateful to ted cox for his help in preparing this material notes for the chapter appear in the section additional notes j g k j l s a w k this book covers the classical theory of markov chains on general state spaces as well as many recent developments the theoretical results are illustrated by simple examples many of which are taken from markov chain monte carlo methods the book is self contained while all the results are carefully and concisely proven bibliographical notes are added at the end of each chapter to provide an overview of the literature part i lays the foundations of the theory of markov chain on general states space part ii covers the basic theory of irreducible markov chains on general states space relying heavily on regeneration techniques these two parts can serve as a text on general state space applied markov chain theory although the choice of topics is quite different from what is usually covered where most of the emphasis is put on countable state space a graduate student should be able to read almost all these developments without any mathematical background deeper than that needed to study countable state space very little measure theory is required part iii covers advanced topics on the theory of irreducible markov chains the emphasis is on geometric and subgeometric convergence rates and also on computable bounds some results appeared for a first time in a book and others are original part iv are selected topics on markov chains covering mostly hot recent developments this book is an introduction to the modern theory of markov chains whose goal is to determine the rate of convergence to the stationary distribution as a function of state space size and geometry this topic has important connections to combinatorics statistical physics and theoretical computer science many of the techniques presented originate in these disciplines the central tools for estimating convergence times including coupling strong stationary times and spectral methods are developed the authors discuss many examples including card shuffling and the ising model from statistical mechanics and present the connection of random walks to electrical networks and apply it to estimate hitting and cover times the first edition has been used in courses in mathematics and computer science departments of numerous universities the second edition features three new chapters on monotone chains the exclusion process and stationary times and also includes smaller additions and corrections throughout updated notes at the end of each chapter inform the reader of recent research developments focusing on discrete time scale markov chains the contents of this book are an outgrowth of some of the authors recent research the motivation stems from existing and emerging applications in optimization and control of complex hybrid markovian systems in manufacturing wireless communication and financial engineering much effort in this book is devoted to designing system models arising from these applications analyzing them via analytic and probabilistic techniques and developing feasible computational algorithms so as to reduce the inherent complexity this book presents results including asymptotic expansions of probability vectors structural properties of occupation measures exponential bounds aggregation and decomposition and associated limit processes and interface of discrete time and continuous time systems one of the salient features is that it contains a diverse range of applications on filtering estimation control optimization and markov decision processes and financial engineering this book will be an important reference for researchers in the areas of applied probability control theory

operations research as well as for practitioners who use optimization techniques part of the book can also be used in a graduate course of applied probability stochastic processes and applications markov chains are a fundamental class of stochastic processes they are widely used to solve problems in a large number of domains such as operational research computer science communication networks and manufacturing systems the success of markov chains is mainly due to their simplicity of use the large number of available theoretical results and the quality of algorithms developed for the numerical evaluation of many metrics of interest the author presents the theory of both discrete time and continuous time homogeneous markov chains he carefully examines the explosion phenomenon the kolmogorov equations the convergence to equilibrium and the passage time distributions to a state and to a subset of states these results are applied to birth and death processes he then proposes a detailed study of the uniformization technique by means of banach algebra this technique is used for the transient analysis of several queuing systems contents 1 discrete time markov chains 2 continuous time markov chains 3 birth and death processes 4 uniformization 5 queues about the authors bruno sericola is a senior research scientist at inria rennes bretagne atlantique in france his main research activity is in performance evaluation of computer and communication systems dependability analysis of fault tolerant systems and stochastic models markov chain monte carlo mcmc originated in statistical physics but has spilled over into various application areas leading to a corresponding variety of techniques and methods that variety stimulates new ideas and developments from many different places and there is much to be gained from cross fertilization this book presents five expository essays by leaders in the field drawing from perspectives in physics statistics and genetics and showing how different aspects of mcmc come to the fore in different contexts the essays derive from tutorial lectures at an interdisciplinary program at the institute for mathematical sciences singapore which exploited the exciting ways in which mcmc spreads across different disciplines presents the theory of general irreducible markov chains and its connection to the perron frobenius theory of nonnegative operators the purpose of these notes is to explore some simple relations between markovian path and loop measures the poissonian ensembles of loops they determine their occupation fields uniform spanning trees determinants and gaussian markov fields such as the free field these relations are first studied in complete generality for the finite discrete setting then partly generalized to specific examples in infinite and continuous spaces 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 stieltjes 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 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 no detailed description available for strong stable markov chains this volume contains recent information on topics of fundamental importance in comparative endocrinology and reproduction it comprises 35 chapters on the following topics hypothalamus and pituitary gonads and reproduction pineal gland hormones and general metabolism the book will be a valuable source of recent information and reference for students teachers and scientists engaged in teaching and research in comparative endocrinology and reproduction controlled markov chains graphs hamiltonicity summarizes a line of research that maps certain classical problems of discrete mathematics such as the hamiltonian cycle and the traveling salesman problems into convex domains where continuum analysis can be carried out mathematics provides a novel treatment of many problems in controlled markov chains based on occupation measures and convex analysis includes a rederivation of many classical results a general treatment of the ergodic control problems and an extensive study of the asymptotic behavior of the self tuning adaptive controller and its variant the kumar becker lin scheme also includes a novel treatment of some multiobjective control problems inaccessible to traditional methods annotation copyrighted by book news inc portland or this book gives a systematic treatment of singularly perturbed systems that naturally arise in control and optimization queueing networks manufacturing systems and financial engineering it presents results on asymptotic expansions of solutions of komogorov forward and backward equations properties of functional occupation measures exponential upper bounds and functional limit results for markov chains with weak and strong interactions to bridge the gap between theory and applications a large portion of the book is devoted to applications in controlled dynamic systems production planning and numerical methods for controlled markovian systems with large scale and complex structures in the real world problems this second edition has been updated throughout and includes two new chapters on asymptotic expansions of solutions for backward equations and hybrid lqg problems the chapters on analytic and probabilistic properties of two time scale markov chains have been almost completely rewritten and the notation has been streamlined and simplified this book is written for applied mathematicians engineers operations researchers and applied scientists selected material from the book can also be used for a one semester advanced graduate level course in applied probability and stochastic processes the present lecture notes aim for an introduction to the ergodic behaviour of markov processes and addresses graduate students post graduate students and interested readers different tools and methods for the study of upper bounds on uniform and weak ergodic rates of markov processes are introduced these techniques are then applied to study limit theorems for functionals of markov processes this lecture course originates in two mini courses held at university of potsdam technical university of berlin and humboldt university in spring 2013 and ritsumameikan university in summer 2013 alexei kulik doctor of sciences is a leading researcher at the institute of mathematics of ukrainian national academy of sciences 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 about discrete time time homogeneous markov chains mes and their ergodic behavior to this end most of the material is in fact about stable mes by which we mean mes that admit an invariant probability measure to state this more precisely and give an overview of the questions we shall be dealing with we will first introduce some notation and terminology let x b be a measurable space and consider a x valued markov chain k k 0 1 with transition probability function t pj p x b i e p x b prob k 1 e b i k x for each x e x b e b and k 0 1 the me is said to be

stable if there exists a probability measure p m l on b such that vb eb l b ix l dx p x b if holds then l is called an invariant p m for the me or the t p f p this book studies the large deviations for empirical measures and vector valued additive functionals of markov chains with general state space under suitable recurrence conditions the ergodic theorem for additive functionals of a markov chain asserts the almost sure convergence of the averages of a real or vector valued function of the chain to the mean of the function with respect to the invariant distribution in the case of empirical measures the ergodic theorem states the almost sure convergence in a suitable sense to the invariant distribution the large deviation theorems provide precise asymptotic estimates at logarithmic level of the probabilities of deviating from the preponderant behavior asserted by the ergodic theorems this book shows how techniques from the perturbation theory of operators applied to a quasi compact positive kernel may be used to obtain limit theorems for markov chains or to describe stochastic properties of dynamical systems a general framework for this method is given and then applied to treat several specific cases an essential element of this work is the description of the peripheral spectra of a quasi compact markov kernel and of its fourier laplace perturbations this is first done in the ergodic but non mixing case this work is extended by the second author to the non ergodic case the only prerequisites for this book are a knowledge of the basic techniques of probability theory and of notions of elementary functional analysis this monograph is a slightly revised version of my phd thesis 86 com pleted in the department of computer science at the university of edin burgh in june 1988 with an additional chapter summarising more recent developments some of the material has appeared in the form of papers 50 88 the underlying theme of the monograph is the study of two classical problems counting the elements of a finite set of combinatorial structures and generating them uniformly at random in their exact form these prob lems appear to be intractable for many important structures so interest has focused on finding efficient randomised algorithms that solve them ap proxim ly with a small probability of error for most natural structures the two problems are intimately connected at this level of approximation so it is natural to study them together at the heart of the monograph is a single algorithmic paradigm sim ulate a markov chain whose states are combinatorial structures and which converges to a known probability distribution over them this technique has applications not only in combinatorial counting and generation but also in several other areas such as statistical physics and combinatorial optimi sation the efficiency of the technique in any application depends crucially on the rate of convergence of the markov chain markov chains are widely used as stochastic models to study a broad spectrum of system performance and dependability characteristics this monograph is devoted to compositional specification and analysis of markov chains based on principles known from process algebra the author systematically develops an algebra of interactive markov chains by presenting a number of distinguishing results of both theoretical and practical nature the author substantiates the claim that interactive markov chains are more than just another formalism among other an algebraic theory of interactive markov chains is developed devise algorithms to mechanize compositional aggregation are presented and state spaces of several million states resulting from the study of an ordinary telefone system are analyzed the markov model showed only slight predictive advantage over the no change model for short term forecasting of supermarket choices for a sample of 45 families while this does not imply a blanket rejection of the markov technique for forecasting it is important to recall that this case held to a minimum many of the problems facing markovian analysis aggregation of dissimilar units relatively low purchase rates and requirement of such long sample periods to build up an adequate sample of events that the critical markovian assumption of stable probabilities is almost certainly violated under these circumstances the simpler model which says that nothing changes performs almost as well as the more refined markov formulation it is possible of course that the slight advantage of the markov model will outweigh the increased cost of using such a model but the no change model has advantages both with regard to simplicity and to applying control chart types of procedures to track series for stability over time the usual qualifications about representativeness of geographic areas panels samples of panel members and time periods of course apply to this analysis this book focuses on two time scale markov chains in discrete time our motivation stems from existing and emerging applications in optimization and control of complex systems in manufacturing wireless communication and nancial engineering much of our e ort in this book is devoted to designing system models arising from various applications analyzing them via analytic and probabilistic techniques and developing feasible compu tionalschemes ourmainconcernistoreducetheinherentsystemcompl ity although each of the applications has its own distinct characteristics all of them are closely related through the modeling of uncertainty due to jump or switching random processes oneofthesalientfeaturesofthisbookistheuseofmulti timescalesin markovprocessesandtheirapplications intuitively notallpartsorcom nents of a large scale system evolve at the same rate some of them change rapidly and others vary slowly the di erent rates of variations allow us to reduce complexity via decomposition and aggregation it would be ideal if we could divide a large system into its smallest irreducible subsystems completely separable from one another and treat each subsystem indep dently however this is often infeasible in reality due to various physical constraints and other considerations thus we have to deal with situations in which the systems are only nearly decomposable in the sense that there are weak links among the irreducible subsystems which dictate the oc sional regime changes of the system an e ective way to treat such near decomposability is time scale separation that is we set up the systems as if there were two time scales fast vs slow xii preface followingthetime scaleseparation weusesingularperturbationmeth ology to treat the underlying systems 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 using a singular perturbation approach this is a systematic treatment of those systems that naturally arise in queuing theory control and optimisation and manufacturing gathering a number of ideas which were previously scattered throughout the literature the book presents results on asymptotic expansions of the corresponding probability distributions functional occupation measures exponential upper bounds and asymptotic normality to bridge the gap between theory and applications a large portion of the book is devoted to various applications thus reducing the dimensionality for problems under markovian disturbances and providing tools for dealing with large scale and complex real world situations much of this stems from the authors recent research presenting results which have not appeared elsewhere an important

reference for researchers in applied mathematics probability and stochastic processes operations research control theory and optimisation practical and easy to use reference progresses from simple to advanced topics covering among other topics renewal theory markov chains poisson approximation ergodicity and strassen s theorem 1992 edition 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 this book is representative of the work of chinese probabilists on probability theory and its applications in physics it presents a unique treatment of general markov jump processes uniqueness various types of ergodicity markovian couplings reversibility spectral gap etc it also deals with a typical class of non equilibrium particle systems including the typical schlögl model taken from statistical physics the constructions ergodicity and phase transitions for this class of markov interacting particle systems namely reaction diffusion processes are presented in this new edition a large part of the text has been updated and two and a half chapters have been rewritten the book is self contained and can be used in a course on stochastic processes for graduate students intersecting two large research areas numerical analysis and applied probability queuing theory this book is a self contained introduction to the numerical solution of structured markov chains which have a wide applicability in queuing theory and stochastic modeling and include m g 1 and gi m 1 type markov chain quasi birth death processes non skip free queues and tree like stochastic processes written for applied probabilists and numerical analysts but accessible to engineers and scientists working on telecommunications and evaluation of computer systems performances it provides a systematic treatment of the theory and algorithms for important families of structured markov chains and a thorough overview of the current literature the book consisting of nine chapters is presented in three parts part 1 covers a basic description of the fundamental concepts related to markov chains a systematic treatment of the structure matrix tools including finite toeplitz matrices displacement operators fft and the infinite block toeplitz matrices their relationship with matrix power series and the fundamental problems of solving matrix equations and computing canonical factorizations part 2 deals with the description and analysis of structure markov chains and includes m g 1 quasi birth death processes non skip free queues and tree like processes part 3 covers solution algorithms where new convergence and applicability results are proved each chapter ends with bibliographic notes for further reading and the book ends with an appendix collecting the main general concepts and results used in the book a list of the main annotations and algorithms used in the book and an extensive index non homogeneous markov chains and systems theory and applications fulfills two principal goals it is devoted to the study of non homogeneous markov chains in the first part and to the evolution of the theory and applications of non homogeneous markov systems populations in the second the book is self contained requiring a moderate background in basic probability theory and linear algebra common to most undergraduate programs in mathematics statistics and applied probability there are some advanced parts which need measure theory and other advanced mathematics but the readers are alerted to these so they may focus on the basic results features a broad and accessible overview of non homogeneous markov chains and systems fills a significant gap in the current literature a good balance of theory and applications with advanced mathematical details separated from the main results many illustrative examples of potential applications from a variety of fields suitable for use as a course text for postgraduate students of applied probability or for self study potential applications included could lead to other quantitative areas the book is primarily aimed at postgraduate students researchers and practitioners in applied probability and statistics and the presentation has been planned and structured in a way to provide flexibility in topic selection so that the text can be adapted to meet the demands of different course outlines the text could be used to teach a course to students studying applied probability at a postgraduate level or for self study it includes many illustrative examples of potential applications in order to be useful to researchers from a variety of fields this well written book provides a clear and accessible treatment of the theory of discrete and continuous time markov chains with an emphasis towards applications the mathematical treatment is precise and rigorous without superfluous details and the results are immediately illustrated in illuminating examples this book will be extremely useful to anybody teaching a course on markov processes jean françois le gall professor at université de paris orsay france markov processes is the class of stochastic processes whose past and future are conditionally independent given their present state they constitute important models in many applied fields after an introduction to the monte carlo method this book describes discrete time markov chains the poisson process and continuous time markov chains it also presents numerous applications including markov chain monte carlo simulated annealing hidden markov models annotation and alignment of genomic sequences control and filtering phylogenetic tree reconstruction and queuing networks the last chapter is an introduction to stochastic calculus and mathematical finance features include the monte carlo method discrete time markov chains the poisson process and continuous time jump markov processes an introduction to diffusion processes mathematical finance and stochastic calculus applications of markov processes to various fields ranging from mathematical biology to financial engineering and computer science numerous exercises and problems with solutions to most of them

Understanding Markov Chains *2018-08-03*

this book provides an undergraduate level introduction to discrete and continuous time markov chains and their applications with a particular focus on the first step analysis technique and its applications to average hitting times and ruin probabilities it also discusses classical topics such as recurrence and transience stationary and limiting distributions as well as branching processes it first examines in detail two important examples gambling processes and random walks before presenting the general theory itself in the subsequent chapters it also provides an introduction to discrete time martingales and their relation to ruin probabilities and mean exit times together with a chapter on spatial poisson processes the concepts presented are illustrated by examples 138 exercises and 9 problems with their solutions

Markov Chains *2017-07-31*

a fascinating and instructive guide to markov chains for experienced users and newcomers alike this unique guide 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

Denumerable Markov Chains *2012-12-06*

with the first edition out of print we decided to arrange for republi cation of denumerrible markov ohains with additional bibliographic material the new edition contains a section additional notes that indicates some of the developments in markov chain theory over the last ten years as in the first edition and for the same reasons we have resisted the temptation to follow the theory in directions that deal with uncountable state spaces or continuous time a section entitled additional references complements the additional notes j w pitman pointed out an error in theorem 9 53 of the first edition which we have corrected more detail about the correction appears in the additional notes aside from this change we have left intact the text of the first eleven chapters the second edition contains a twelfth chapter written by david griffeath on markov random fields we are grateful to ted cox for his help in preparing this material notes for the chapter appear in the section additional notes j g k j l s a w k

Markov Chains *2018-12-11*

this book covers the classical theory of markov chains on general state spaces as well as many recent developments the theoretical results are illustrated by simple examples many of which are taken from markov chain monte carlo methods the book is self contained while all the results are carefully and concisely proven bibliographical notes are added at the end of each chapter to provide an overview of the literature part i lays the foundations of the theory of markov chain on general states space part ii covers the basic theory of irreducible markov chains on general states space relying heavily on regeneration techniques these two parts can serve as a text on general state space applied markov chain theory although the choice of topics is quite different from what is usually covered where most of the emphasis is put on countable state space a graduate student should be able to read almost all these developments without any mathematical background deeper than that needed to study countable state space very little measure theory is required part iii covers advanced topics on the theory of irreducible markov chains the emphasis is on geometric and subgeometric convergence rates and also on computable bounds some results appeared for a first time in a book and others are original part iv are selected topics on markov chains covering mostly hot recent developments

Markov Chains and Mixing Times: Second Edition *2017-10-31*

this book is an introduction to the modern theory of markov chains whose goal is to determine the rate of convergence to the stationary distribution as a function of state space size and geometry this topic has important connections to combinatorics statistical physics and theoretical computer science many of the techniques presented originate in these disciplines the central tools for estimating convergence times including coupling strong stationary times and spectral methods are developed the authors discuss many examples including card shuffling and the ising model from statistical mechanics and present the connection of random walks to electrical

networks and apply it to estimate hitting and cover times the first edition has been used in courses in mathematics and computer science departments of numerous universities the second edition features three new chapters on monotone chains the exclusion process and stationary times and also includes smaller additions and corrections throughout updated notes at the end of each chapter inform the reader of recent research developments

Lecture Notes on Limit Theorems for Markov Chain Transition Probabilities *1971*

focusing on discrete time scale markov chains the contents of this book are an outgrowth of some of the authors recent research the motivation stems from existing and emerging applications in optimization and control of complex hybrid markovian systems in manufacturing wireless communication and financial engineering much effort in this book is devoted to designing system models arising from these applications analyzing them via analytic and probabilistic techniques and developing feasible computational algorithms so as to reduce the inherent complexity this book presents results including asymptotic expansions of probability vectors structural properties of occupation measures exponential bounds aggregation and decomposition and associated limit processes and interface of discrete time and continuous time systems one of the salient features is that it contains a diverse range of applications on filtering estimation control optimization and markov decision processes and financial engineering this book will be an important reference for researchers in the areas of applied probability control theory operations research as well as for practitioners who use optimization techniques part of the book can also be used in a graduate course of applied probability stochastic processes and applications

Discrete-Time Markov Chains 2005

markov chains are a fundamental class of stochastic processes they are widely used to solve problems in a large number of domains such as operational research computer science communication networks and manufacturing systems the success of markov chains is mainly due to their simplicity of use the large number of available theoretical results and the quality of algorithms developed for the numerical evaluation of many metrics of interest the author presents the theory of both discrete time and continuous time homogeneous markov chains he carefully examines the explosion phenomenon the kolmogorov equations the convergence to equilibrium and the passage time distributions to a state and to a subset of states these results are applied to birth and death processes he then proposes a detailed study of the uniformization technique by means of banach algebra this technique is used for the transient analysis of several queuing systems contents 1 discrete time markov chains 2 continuous time markov chains 3 birth and death processes 4 uniformization 5 queues about the authors bruno sericola is a senior research scientist at inria rennes bretagne atlantique in france his main research activity is in performance evaluation of computer and communication systems dependability analysis of fault tolerant systems and stochastic models

Markov Chains 2013-08-05

markov chain monte carlo mcmc originated in statistical physics but has spilled over into various application areas leading to a corresponding variety of techniques and methods that variety stimulates new ideas and developments from many different places and there is much to be gained from cross fertilization this book presents five expository essays by leaders in the field drawing from perspectives in physics statistics and genetics and showing how different aspects of mcmc come to the fore in different contexts the essays derive from tutorial lectures at an interdisciplinary program at the institute for mathematical sciences singapore which exploited the exciting ways in which mcmc spreads across different disciplines

A Note on the Use of Markov Chains in Forecasting Store Choice *1968*

presents the theory of general irreducible markov chains and its connection to the perron frobenius theory of nonnegative operators

Markov Chain Monte Carlo 2005

the purpose of these notes is to explore some simple relations between markovian path and loop measures the poissonian ensembles of loops they determine their occupation fields uniform spanning trees determinants and gaussian markov fields such as the free field these relations are first studied in complete generality for the finite discrete setting then partly generalized to specific examples in infinite and continuous spaces

General Irreducible Markov Chains and Non-Negative Operators *2004-06-03*

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 stieltjes 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

Markov Paths, Loops and Fields *2011-07-06*

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

Continuous-Time Markov Chains *2012-12-06*

no detailed description available for strong stable markov chains

Markov Chains *1976-03-05*

this volume contains recent information on topics of fundamental importance in comparative endocrinology and reproduction it comprises 35 chapters on the following topics hypothalamus and pituitary gonads and reproduction pineal gland hormones and general metabolism the book will be a valuable source of recent information and reference for students teachers and scientists engaged in teaching and research in comparative endocrinology and reproduction

Strong Stable Markov Chains *2019-01-14*

controlled markov chains graphs hamiltonicity summarizes a line of research that maps certain classical problems of discrete mathematics such as the hamiltonian cycle and the traveling salesman problems into convex domains where continuum analysis can be carried out mathematics

Markov Set-Chains *1998-08-20*

provides a novel treatment of many problems in controlled markov chains based on occupation measures and convex analysis includes a rederivation of many classical results a general treatment of the ergodic control problems and an extensive study of the asymptotic behavior of the self tuning adaptive controller and its variant the kumar becker lin scheme also includes a novel treatment of some multiobjective control problems inaccessible to traditional methods annotation copyrighted by book news inc portland or

Controlled Markov Chains, Graphs and Hamiltonicity *2007*

this book gives a systematic treatment of singularly perturbed systems that naturally arise in control and optimization queueing networks manufacturing systems and financial engineering it presents results on asymptotic expansions of solutions of komogorov forward and backward equations properties of functional occupation measures exponential upper bounds and functional limit results for markov chains with weak and strong interactions to bridge the gap between theory and applications a large portion of the book is devoted to applications in controlled dynamic systems production planning and numerical methods for controlled markovian systems with large scale and complex structures in the real world problems this second edition has been updated throughout and includes two new chapters on asymptotic expansions of solutions for backward equations and hybrid lqg problems the chapters on analytic and probabilistic properties of two time scale markov chains have been almost completely rewritten and the notation has been streamlined and simplified this book is written for applied mathematicians engineers operations researchers and applied scientists selected material from the book can also be used for a one semester advanced graduate level course in applied probability and stochastic processes

Numerical Methods in Markov Chains and Bulk Queues *2012-12-06*

the present lecture notes aim for an introduction to the ergodic behaviour of markov processes and addresses graduate students post graduate students and interested readers different tools and methods for the study of upper bounds on uniform and weak ergodic rates of markov processes are introduced these techniques are then applied to study limit theorems for functionals of markov processes this lecture course originates in two mini courses held at university of potsdam technical university of berlin and humboldt university in spring 2013 and ritsumameikan university in summer 2013 alexei kulik doctor of sciences is a leading researcher at the institute of mathematics of ukrainian national academy of sciences

Topics in Controlled Markov Chains *1991*

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

Cont Markov Chains *1991-04-30*

this book is about discrete time time homogeneous markov chains mes and their ergodic behavior to this end most of the material is in fact about stable mes by which we mean mes that admit an invariant probability measure to state this more precisely and give an overview of the questions we shall be dealing with we will first introduce some notation and terminology let x b be a measurable space and consider a x valued markov chain k k 0 1 with transition probability function t pj p x b i e p x b prob k 1 e b i k x for each x e x b e b and k 0 1 the me is said to be

stable if there exists a probability measure p m l on b such that vb eb l b ix l dx p x b if holds then l is called an invariant p m for the me or the t p f p

Continuous-Time Markov Chains and Applications *2012-11-14*

this book studies the large deviations for empirical measures and vector valued additive functionals of markov chains with general state space under suitable recurrence conditions the ergodic theorem for additive functionals of a markov chain asserts the almost sure convergence of the averages of a real or vector valued function of the chain to the mean of the function with respect to the invariant distribution in the case of empirical measures the ergodic theorem states the almost sure convergence in a suitable sense to the invariant distribution the large deviation theorems provide precise asymptotic estimates at logarithmic level of the probabilities of deviating from the preponderant behavior asserted by the ergodic theorems

Sums Arizing in the Theory of Markov Chains *1960*

this book shows how techniques from the perturbation theory of operators applied to a quasi compact positive kernel may be used to obtain limit theorems for markov chains or to describe stochastic properties of dynamical systems a general framework for this method is given and then applied to treat several specific cases an essential element of this work is the description of the peripheral spectra of a quasi compact markov kernel and of its fourier laplace perturbations this is first done in the ergodic but non mixing case this work is extended by the second author to the non ergodic case the only prerequisites for this book are a knowledge of the basic techniques of probability theory and of notions of elementary functional analysis

Introduction to Ergodic rates for Markov chains and processes *2015-10-20*

this monograph is a slightly revised version of my phd thesis 86 com pleted in the department of computer science at the university of edin burgh in june 1988 with an additional chapter summarising more recent developments some of the material has appeared in the form of papers 50 88 the underlying theme of the monograph is the study of two classical problems counting the elements of a finite set of combinatorial structures and generating them uniformly at random in their exact form these prob lems appear to be intractable for many important structures so interest has focused on finding efficient randomised algorithms that solve them ap proxim ly with a small probability of error for most natural structures the two problems are intimately connected at this level of approximation so it is natural to study them together at the heart of the monograph is a single algorithmic paradigm sim ulate a markov chain whose states are combinatorial structures and which converges to a known probability distribution over them this technique has applications not only in combinatorial counting and generation but also in several other areas such as statistical physics and combinatorial optimi sation the efficiency of the technique in any application depends crucially on the rate of convergence of the markov chain

Semi-Markov Chains and Hidden Semi-Markov Models toward Applications *2009-01-07*

markov chains are widely used as stochastic models to study a broad spectrum of system performance and dependability characteristics this monograph is devoted to compositional specification and analysis of markov chains based on principles known from process algebra the author systematically develops an algebra of interactive markov chains by presenting a number of distinguishing results of both theoretical and practical nature the author substantiates the claim that interactive markov chains are more than just another formalism among other an algebraic theory of interactive markov chains is developed devise algorithms to mechanize compositional aggregation are presented and state spaces of several million states resulting from the study of an ordinary telefone system are analyzed

Markov Chains and Invariant Probabilities *2012-12-06*

the markov model showed only slight predictive advantage over the no change model for short term forecasting of supermarket choices for a sample of 45 families while this does not imply a blanket rejection of the markov technique for forecasting it is important to recall that this case held to a minimum many of the problems facing markovian analysis aggregation of dissimilar units relatively low purchase rates and requirement of such long sample periods to build up an adequate sample of events that the critical markovian assumption of stable probabilities is almost certainly violated under these circumstances the simpler model which says that nothing changes performs almost as well as the more refined markov formulation it is possible of course that the slight advantage of the markov model will outweigh the increased cost of using such a model but the no change model has advantages both with regard to simplicity and to applying control chart types of procedures to track series for stability over time the usual qualifications about representativeness of geographic areas panels samples of panel members and time periods of course apply to this analysis

Large Deviations for Markov Chains *2022-10-12*

this book focuses on two time scale markov chains in discrete time our motivation stems from existing and emerging applications in optimization and control of complex systems in manufacturing wireless communication and nancial engineering much of our e ort in this book is devoted to designing system models arising from various applications analyzing them via analytic and probabilistic techniques and developing feasible compu tionalschemes ourmainconcernistoreducetheinherentsystemcompl ity although each of the applications has its own distinct characteristics all of them are closely related through the modeling of uncertainty due to jump or switching random processes oneofthesalientfeaturesofthisbookistheuseofmulti timescalesin

markovprocessesandtheirapplications intuitively notallpartsorcom nents of a large scale system evolve at the same rate some of them change rapidly and others vary slowly the di erent rates of variations allow us to reduce complexity via decomposition and aggregation it would be ideal if we could divide a large system into its smallest irreducible subsystems completely separable from one another and treat each subsystem indep dently however this is often infeasible in reality due to various physical constraints and other considerations thus we have to deal with situations in which the systems are only nearly decomposable in the sense that there are weak links among the irreducible subsystems which dictate the oc sional regime changes of the system an e ective way to treat such near decomposability is time scale separation that is we set up the systems as if there were two time scales fast vs slow xii preface followingthetime scaleseparation weusesingularperturbationmeth ology to treat the underlying systems

Limit Theorems for Markov Chains and Stochastic Properties of Dynamical Systems by Quasi-Compactness *2001-08*

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

Algorithms for Random Generation and Counting: A Markov Chain Approach 2012-12-06

using a singular perturbation approach this is a systematic treatment of those systems that naturally arise in queuing theory control and optimisation and manufacturing gathering a number of ideas which were previously scattered throughout the literature the book presents results on asymptotic expansions of the corresponding probability distributions functional occupation measures exponential upper bounds and asymptotic normality to bridge the gap between theory and applications a large portion of the book is devoted to various applications thus reducing the dimensionality for problems under markovian disturbances and providing tools for dealing with large scale and complex real world situations much of this stems from the authors recent research presenting results which have not appeared elsewhere an important reference for researchers in applied mathematics probability and stochastic processes operations research control theory and optimisation

Interactive Markov Chains *2002-09-11*

practical and easy to use reference progresses from simple to advanced topics covering among other topics renewal theory markov chains poisson approximation ergodicity and strassen s theorem 1992 edition

Topics in Controlled Markov Chains *1991*

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

A Note on the Use of Markov Chains in Forecasting Store Choice 2011

this book is representative of the work of chinese probabilists on probability theory and its applications in physics it presents a unique treatment of general markov jump processes uniqueness various types of ergodicity markovian couplings reversibility spectral gap etc it also deals with a typical class of non equilibrium particle systems including the typical schlögl model taken from statistical physics the constructions ergodicity and phase transitions for this class of markov interacting particle systems namely reaction diffusion processes are presented in this new edition a large part of the text has been updated and two and a half chapters have been rewritten the book is self contained and can be used in a course on stochastic processes for graduate students

Discrete-Time Markov Chains 2006-03-30

intersecting two large research areas numerical analysis and applied probability queuing theory this book is a self contained introduction to the numerical solution of structured markov chains which have a wide applicability in queuing theory and stochastic modeling and include m g 1 and gi m 1 type markov chain quasi birth death processes non skip free queues and tree like stochastic processes written for applied probabilists and numerical analysts but accessible to engineers and scientists working on telecommunications and evaluation of computer systems performances it provides a systematic treatment of the theory and algorithms for important families of structured markov chains and a thorough overview of the current literature the book consisting of nine chapters is presented in three parts part 1 covers a basic description of the fundamental concepts related to markov chains a systematic treatment of the structure matrix tools including finite toeplitz matrices displacement operators fft and the infinite block toeplitz matrices their relationship with matrix power series and the fundamental problems of solving matrix equations and computing canonical factorizations part 2 deals with the description and analysis of structure markov chains and includes m g 1 quasi birth death processes non skip free queues and tree like processes part 3 covers solution algorithms where new convergence and applicability results are proved each chapter ends with bibliographic notes for further reading and the book ends with an appendix collecting the main

general concepts and results used in the book a list of the main annotations and algorithms used in the book and an extensive index

Markov Chains and Mixing Times *2012-12-06*

non homogeneous markov chains and systems theory and applications fulfills two principal goals it is devoted to the study of non homogeneous markov chains in the first part and to the evolution of the theory and applications of non homogeneous markov systems populations in the second the book is self contained requiring a moderate background in basic probability theory and linear algebra common to most undergraduate programs in mathematics statistics and applied probability there are some advanced parts which need measure theory and other advanced mathematics but the readers are alerted to these so they may focus on the basic results features a broad and accessible overview of non homogeneous markov chains and systems fills a significant gap in the current literature a good balance of theory and applications with advanced mathematical details separated from the main results many illustrative examples of potential applications from a variety of fields suitable for use as a course text for postgraduate students of applied probability or for self study potential applications included could lead to other quantitative areas the book is primarily aimed at postgraduate students researchers and practitioners in applied probability and statistics and the presentation has been planned and structured in a way to provide flexibility in topic selection so that the text can be adapted to meet the demands of different course outlines the text could be used to teach a course to students studying applied probability at a postgraduate level or for self study it includes many illustrative examples of potential applications in order to be useful to researchers from a variety of fields

Continuous-Time Markov Chains and Applications *2012-08-15*

this well written book provides a clear and accessible treatment of the theory of discrete and continuous time markov chains with an emphasis towards applications the mathematical treatment is precise and rigorous without superfluous details and the results are immediately illustrated in illuminating examples this book will be extremely useful to anybody teaching a course on markov processes jean françois le gall professor at université de paris orsay france markov processes is the class of stochastic processes whose past and future are conditionally independent given their present state they constitute important models in many applied fields after an introduction to the monte carlo method this book describes discrete time markov chains the poisson process and continuous time markov chains it also presents numerous applications including markov chain monte carlo simulated annealing hidden markov models annotation and alignment of genomic sequences control and filtering phylogenetic tree reconstruction and queuing networks the last chapter is an introduction to stochastic calculus and mathematical finance features include the monte carlo method discrete time markov chains the poisson process and continuous time jump markov processes an introduction to diffusion processes mathematical finance and stochastic calculus applications of markov processes to various fields ranging from mathematical biology to financial engineering and computer science numerous exercises and problems with solutions to most of them

Lectures on the Coupling Method *2010*

Continuous Time Markov Processes *2004*

From Markov Chains to Non-equilibrium Particle Systems *2005-02-03*

Numerical Methods for Structured Markov Chains *2022-12-21*

Non-Homogeneous Markov Chains and Systems 2008-11-20

Markov Processes and Applications

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