Application Of Markov Chains To Analyze And Predict The

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.

The emergence of huge amounts of data which require analysis and in some cases real-time processing has forced exploration into fast algorithms for handling very large data sizes. Analysis of x-ray images in medical applications, cyber security data, crime data, telecommunications and stock market data, health records and business analytics data are but a few areas of interest.

Applications and platforms including R, RapidMiner and Weka provide the basis for analysis, often used by practitioners who pay little to no attention to the underlying mathematics and processes impacting the data. This often leads to an inability to explain results or correct mistakes, or to spot errors. Applied Data Analytics - Principles and Applications seeks to bridge this missing gap by providing some of the most sought after techniques in big data analytics. Establishing strong foundations in these topics provides practical ease when big data analyses are undertaken using the widely available open source and commercially orientated computation platforms, languages and visualization systems. The book, when combined with such platforms, provides a complete set of tools required to handle big data and can lead to fast implementations and applications. The book contains a mixture of machine learning foundations, deep learning, artificial intelligence, statistics and evolutionary learning mathematics written from the usage point of view with rich explanations on what the concepts mean. The author has thus avoided the complexities often associated with these concepts when found in research papers. The tutorial nature of the book and the applications provided are some of the reasons why the book is suitable for undergraduate, postgraduate and big data analytics enthusiasts. This text should ease the fear of mathematics often associated with practical data analytics and support rapid applications in artificial intelligence, environmental sensor data modelling and analysis, health informatics, business data analytics, data from Internet of Things and deep learning applications.

Provides an introduction to basic structures of probabilitywith a view towards applications in information technology A First Course in Probability and Markov Chains presentsan introduction to the basic elements in probability and focuses ontwo main areas. The first part explores notions and structures inprobability, including combinatorics, probability measures,probability distributions, conditional probability,inclusion-exclusion formulas, random variables, dispersion indexes,independent random variables as well as weak and strong laws oflarge numbers and central limit theorem. In the second part of thebook, focus is given to Discrete Time Discrete Markov Chains whichis addressed together with an introduction to Poisson processes andContinuous Time Discrete Markov Chains. This book also looks atmaking use of measure theory notations that unify all thepresentation, in particular avoiding the separate treatment ofcontinuous and discrete distributions. A First Course in Probability and Markov Chains: Presents the basic elements of probability. Explores elementary probability with combinatorics, uniformprobability, the inclusion-exclusion principle, independence andconvergence of random variables. Features applications of Law of Large Numbers. Introduces Bernoulli and Poisson processes as well as discreteand continuous time Markov Chains with discrete states. Includes illustrations and examples throughout, along withsolutions to problems featured in this book. The authors present a unified and comprehensive overview ofprobability and Markov Chains aimed at educating engineers workingwith probability and statistics as well as advanced undergraduatestudents in sciences and engineering with a basic background inmathematical analysis and linear algebra.

In this 2002 book, the author develops the necessary background in probability theory and Markov chains then discusses important computing applications.

Markov ChainsCambridge University Press

The subject is critical in many modern applications such as mathematical finance, quantitative management, insurance and actuarial studies.

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.

Markov chains make it possible to predict the future state of a system from its present state ignoring its past history. Surprisingly, despite the widespread use of Markov chains in many areas of science and technology, their applications in chemical engineering have been relatively meager. A possible reason for this phenomenon might be that books containing material on this subject have been written in such a way that the simplicity of Markov chains has been shadowed by the tedious mathematical derivations. Thus, the major objective of writing this book has been to try to change this situation. There are many advantages, detailed in Chapter 1, of using the discrete Markov-chain model in chemical engineering. Probably, the most important advantage is that physical models can be presented in a unified description via state vector and a one-step transition probability matrix. Consequently, a process is demonstrated solely by the probability of a system to occupy or not occupy a state. The book has been written in an easy and understandable form, where complex mathematical derivations are abandoned. The fundamentals of Markov chains are presented in Chapter 2 with examples from the bible, art and real life problems. An extremely wide collection is given of examples viz., reactions, reactors, reactions and reactors as well as combined processes, including their solution and a graphical presentation of it, all of which demonstrates the usefulness of applying Markov chains in chemical engineering.

Markov chains are central to the understanding of random processes. This is not only because they pervade the applications of random processes, but also because one can calculate explicitly many quantities of interest. This textbook, aimed at advanced undergraduate or MSc students with some background in basic probability theory, focuses on Markov chains and quickly develops a coherent and rigorous theory whilst showing also how actually to apply it. Both discrete-time and continuous-time chains are studied. A distinguishing feature is an introduction to more advanced topics such as martingales and potentials in the established context of Markov chains. There are applications to simulation, economics, optimal control, genetics, queues and many other topics, and exercises and examples drawn both from theory and practice. It will therefore be an ideal text either for elementary courses on random processes or those that are more oriented towards applications.

A website's ranking on Google can spell the difference between success and failure for a new business. NCAA football ratings determine which schools get to play for the big money in postseason bowl games. Product ratings influence everything from the clothes we wear to the movies we select on Netflix. Ratings and rankings are everywhere, but how exactly do they work? Who's #1? offers an engaging and accessible account of how scientific rating and ranking methods are created and applied to a variety of uses. Amy Langville and Carl Meyer provide the first comprehensive overview of the mathematical algorithms and methods used to rate and rank sports teams, political candidates, products, Web pages, and more. In a series of interesting asides, Langville and Meyer provide fascinating insights into the ingenious contributions of many of the field's pioneers. They survey and compare the different methods employed today, showing why their strengths and weaknesses depend on the underlying goal, and explaining why and when a given method should be considered. Langville and Meyer also describe what can and can't be expected from the most widely used systems. The science of rating and ranking touches virtually every facet of our lives, and now you don't need to be an expert to understand how it really works. Who's #1? is the definitive introduction to the subject. It features easy-to-understand examples and interesting trivia and historical facts, and much of the required mathematics is included.

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 are a particularly powerful and widely used tool for analyzing a variety of stochastic (probabilistic) systems over time. This monograph will present a series of Markov models, starting from the basic models and then building up to higher-order models. Included in the higher-order discussions are multivariate models, higher-order multivariate models, and higher-order hidden models. In each case, the focus is on the important kinds of applications that can be made with the class of models being considered in the current chapter. Special attention is given to numerical algorithms that can efficiently solve the models. Therefore, Markov Chains: Models, Algorithms and Applications outlines recent developments of Markov chain models for modeling queueing sequences, Internet, re-manufacturing systems, reverse logistics, inventory systems, bio-informatics, DNA sequences, genetic networks, data mining, and many other

practical systems.
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.
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. Oneofthesalientfeature softhisbookistheuseofmulti-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 Follo wingthetime-
scaleseparation,weusesingularperturbationmeth- ology to treat the underlying systems.

New up-to-date edition of this influential classic on Markov chains in general state spaces. Proofs are rigorous and concise, the range of applications is broad and knowledgeable, and key ideas are accessible to practitioners with limited mathematical background. New commentary by Sean Meyn, including updated references, reflects developments since 1996.

This technical note develops an application of the theory of the Z-transform to the problem of finding the nth power of a transition matrix, motivated by the need of such a solution in the theory of Markov Chains. To illustrate the theory, an example involving vehicle maintenance is presented in detail. (Author).

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.

This book is an introduction to Markov chain modeling with applications to communication networks. It begins with a general introduction to performance modeling in Chapter 1 where we introduce different performance models. We then introduce basic ideas of Markov chain modeling: Markov property, discrete time Markov chain (DTMC) and continuous time Markov chain (CTMC). We also discuss how to find the steady state distributions from these Markov chains and how they can be used to compute the system performance metric. The solution methodologies include a balance equation technique, limiting probability technique, and the uniformization. We try to minimize the theoretical aspects of the Markov chain so that the book is easily accessible to readers without deep mathematical backgrounds. We then

introduce how to develop a Markov chain model with simple applications: a forwarding system, a cellular system blocking, slotted ALOHA, Wi-Fi model, and multichannel based LAN model. The examples cover CTMC, DTMC, birth-death process and non birth-death process. We then introduce more difficult examples in Chapter 4, which are related to wireless LAN networks: the Bianchi model and Multi-Channel MAC model with fixed duration. These models are more advanced than those introduced in Chapter 3 because they require more advanced concepts such as renewal-reward theorem and the queueing network model. We introduce these concepts in the appendix as needed so that readers can follow them without difficulty. We hope that this textbook will be helpful to students, researchers, and network practitioners who want to understand and use mathematical modeling techniques. Table of Contents: Performance Modeling / Markov Chain Modeling / Developing Markov Chain Performance Models / Advanced Markov Chain Models
Markov Chains and Stochastic Stability is part of the Communications and Control Engineering Series (CCES) edited by Professors B.W. Dickinson, E.D. Sontag, M. Thoma, A. Fettweis, J.L. Massey and J.W. Modestino. The area of Markov chain theory and application has matured over the past 20 years into something more accessible and complete. It is of increasing interest and importance. This publication deals with the action of Markov chains on general state spaces. It discusses the theories and the use to be gained, concentrating on the areas of engineering, operations research and control theory. Throughout, the theme of stochastic stability and the search for practical methods of verifying such stability, provide a new and powerful technique. This does not only affect applications but also the development of the theory itself. The impact of the theory on specific models is discussed in detail, in order to provide

examples as well as to demonstrate the importance of these models. Markov Chains and Stochastic Stability can be used as a textbook on applied Markov chain theory, provided that one concentrates on the main aspects only. It is also of benefit to graduate students with a standard background in countable space stochastic models. Finally, the book can serve as a research resource and active tool for practitioners.
This book trains the next generation of scientists representing different disciplines to leverage the data generated during routine patient care. It formulates a more complete lexicon of evidence-based recommendations and support shared, ethical decision making by doctors with their patients. Diagnostic and therapeutic technologies continue to evolve rapidly, and both individual practitioners and clinical teams face increasingly complex ethical decisions. Unfortunately, the current state of medical knowledge does not provide the guidance to make the majority of clinical decisions on the basis of evidence. The present research infrastructure is inefficient and frequently produces unreliable results that cannot be replicated. Even randomized controlled trials (RCTs), the traditional gold standards of the research reliability hierarchy, are not without limitations. They can be costly, labor intensive, and slow, and can return results that are seldom generalizable to every patient population. Furthermore, many pertinent but unresolved clinical and medical systems issues do not seem to have attracted the interest of the research enterprise, which has come to focus instead on cellular and molecular investigations and single-agent (e.g., a drug or device) effects. For clinicians, the end result is a bit of a “data desert” when it comes to making decisions. The new research infrastructure proposed in this book will help the medical profession to make ethically sound and well informed decisions for their patients.
This book constitutes the refereed proceedings of the Third

European Conference on Principles and Practice of Knowledge Discovery in Databases, PKDD'99, held in Prague, Czech Republic in September 1999. The 28 revised full papers and 48 poster presentations were carefully reviewed and selected from 106 full papers submitted. The papers are organized in topical sections on time series, applications, taxonomies and partitions, logic methods, distributed and multirelational databases, text mining and feature selection, rules and induction, and interesting and unusual issues.

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 processes are processes that have limited memory. In particular, their dependence on the past is only through the previous state. They are used to model the behavior of many systems 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. Covering a wide range of areas of application of Markov processes, this second edition is revised to highlight the most important aspects as well as the most recent trends and applications of Markov processes. The author spent over 16 years in the industry before returning to academia, and he has applied many of the principles covered in this book in multiple research projects. Therefore, this is an applications-oriented book that also includes enough theory to provide a solid ground in the subject for the reader. Presents both the theory and applications of the different aspects of Markov processes Includes numerous solved examples as well as detailed diagrams that make it easier to understand the principle being presented Discusses different applications of hidden Markov models, such as DNA sequence analysis and speech analysis.

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 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

The objective of this thesis was to model the migration of items between categories in a large inventory system as a Markov chain. The Markovian states were defined as the various inventory categories. Transition matrices were constructed from five years of quarterly data. A maximum likelihood estimate of the actual transition matrix was developed and the system was tested for stationarity and prediction capability. The transition probabilities were found to be time dependent and this led to a division of the population into two subgroups. These subgroups were then modeled as separate Markov chains. While none of the Markov models accurately described the actual system, the information gathered on the time dependent nature of the system was used to develop an alternative inventory policy. The proposed policy takes advantage of this improved understanding of the migration process and will help control inventory costs and reduce backorders in a system where forecasting demand accurately is difficult. Originator-Supplied keywords include: Stochastic Process, Markov Process, Inventory Control.

From observation to simulation -- Building the stochastic matrix -- Predictions by using 2-state Markov chains -- Predictions by using N-state

Markov chains -- Absorbing Markov chains -- The average time spent in each state -- Discussions on different configurations of chains -- The simulation of an N-state Markov chain

Markov chains are a fundamental class of stochastic processes.They are widely used to solve problems in a large number of domainssuch as operational research, computer science, communicationnetworks and manufacturing systems. The success of Markov chains ismainly due to their simplicity of use, the large number ofavailable theoretical results and the quality of algorithmsdeveloped for the numerical evaluation of many metrics ofinterest. The author presents the theory of both discrete-time andcontinuous-time homogeneous Markov chains. He carefully examinesthe explosion phenomenon, the Kolmogorov equations, the convergenceto equilibrium and the passage time distributions to a state and toa subset of states. These results are applied to birth-and-deathprocesses. He then proposes a detailed study of the uniformizationtechnique by means of Banach algebra. This technique is used forthe 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 activityis in performance evaluation of computer and communication systems,dependability analysis of fault-tolerant systems and stochasticmodels.

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 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.

Recognized as a powerful tool for dealing with uncertainty, Markov modeling can enhance your ability to analyze complex production and service systems. However, most books on Markov chains or decision processes are often either highly theoretical, with few examples, or highly prescriptive, with little justification for the steps of the algorithms used to solve Markov models. Providing a unified treatment of Markov chains and Markov decision processes in a single volume, Markov Chains and Decision Processes for Engineers and Managers supplies a highly detailed description of the construction and solution of Markov models that

facilitates their application to diverse processes. Organized around Markov chain structure, the book begins with descriptions of Markov chain states, transitions, structure, and models, and then discusses steady state distributions and passage to a target state in a regular Markov chain. The author treats canonical forms and passage to target states or to classes of target states for reducible Markov chains. He adds an economic dimension by associating rewards with states, thereby linking a Markov chain to a Markov decision process, and then adds decisions to create a Markov decision process, enabling an analyst to choose among alternative Markov chains with rewards so as to maximize expected rewards. An introduction to state reduction and hidden Markov chains rounds out the coverage. In a presentation that balances algorithms and applications, the author provides explanations of the logical relationships that underpin the formulas or algorithms through informal derivations, and devotes considerable attention to the construction of Markov models. He constructs simplified Markov models for a wide assortment of processes such as the weather, gambling, diffusion of gases, a waiting line, inventory, component replacement, machine maintenance, selling a stock, a charge account, a career path, patient flow in a hospital, marketing, and a production line. This treatment helps you harness the power of Markov modeling and apply it to your organization's processes.
Kronecker products are used to define the underlying Markov chain (MC) in various modeling formalisms, including compositional Markovian models, hierarchical

Markovian models, and stochastic process algebras. The motivation behind using a Kronecker structured representation rather than a flat one is to alleviate the storage requirements associated with the MC. With this approach, systems that are an order of magnitude larger can be analyzed on the same platform. The developments in the solution of such MCs are reviewed from an algebraic point of view and possible areas for further research are indicated with an emphasis on preprocessing using reordering, grouping, and lumping and numerical analysis using block iterative, preconditioned projection, multilevel, decompositional, and matrix analytic methods. Case studies from closed queueing networks and stochastic chemical kinetics are provided to motivate decompositional and matrix analytic methods, respectively.