Application Of Markov Chains To Analyze And Predict The

In this 2002 book, the author develops the necessary background in probability theory and Markov chains then discusses important computing applications.
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.
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.
An Application of Markov Chains to Solve a Problem in International Economics
Applications of Markov Chains to Reliability of Long-haul Communication Systems
An Application of Markov Chains to the Problem of Migration in Inventory Systems
Theory and Applications
Understanding Markov Chains
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.
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 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.

A Comparison with a Standard Approach

Continuous-Time Markov Chains and Applications

Queueing Networks and Markov Chains

The Application of Markov Chains to Discrete Extremum-seeking Adaptive Systems

Markov Processes and Applications

"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

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 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.

Continuous-Time Markov Chains

Finite Markov Processes and Their Applications

An Application of Markov Chains for Affirmative Action Planning

Analyzing Markov Chains using Kronecker Products

On the Application of Markov Chains to Social Processes

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.

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

some recent results on moment identities and deviation inequalities for Poisson stochastic integrals. The concepts presented are illustrated by examples and by 72 exercises and their complete solutions.

This 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).

Markov Chains: Models, Algorithms and Applications

Gibbs Fields, Monte Carlo Simulation, and Queues

Finite Markov Chains and Algorithmic Applications

An Application of Markov Chains to Tenure and Size of Farm

Application of Absorbing Markov Chains to a Maintenance Decision Model

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.

Primarily an introduction to the theory of stochastic processes at the undergraduate or beginning graduate level, the primary objective of this book is to initiate students in the art of stochastic modelling. However it is motivated by significant applications and progressively brings the student to the borders of contemporary research. Examples are from a wide range of domains, including operations research and electrical engineering. Researchers and students in these areas as well as in physics, biology and the social sciences will find this book of interest.

"This thesis applies Markov chain methods to evaluate the reliability of multipath switching networks and optical amplified systems in long-haul communication systems. When conventional methods proved impractical to evaluate the reliability of multipath switching networks and optical amplified systems, some practical methods based on Markov chains were developed by Whitmore and others (1987, 1988, 1991) and used successfully to evaluate the reliability of such systems. This work aims at describing the details of Markov chain methods for reliability calculation, and demonstrating their application to reliability evaluation of multipath switching networks and optical amplified systems." --

An Applications-Oriented Approach

Application of Z-transform Methods to Markov Chain Problems, with a Maintenance Example

Markov Chains

Examples and Applications

Applications of Markov Chains in Chemical Engineering

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.

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 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.

Algorithms, Networks, Genome and Finance

Markov Chains and Mixing Times

Their Use in Reliability and DNA Analysis

Markov Chains and Decision Processes for Engineers and Managers

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.

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 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 computationalschemes. 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 indepdently. 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.

Modeling and Performance Evaluation with Computer Science Applications

An Application of Markov Chains to a Management Decision

An Application of Markov Chains to a Marketing Problem

Applied Data Analytics - Principles and Applications

Discrete-Time Markov Chains

Markov Chains: Models, Algorithms and ApplicationsSpringer

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.

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.

Application of Markov Chains to Predict Spillback at Isolated Intersections

A Two-Time-Scale Approach

An Application of Markov Chains

Two-Time-Scale Methods and Applications

Markov Chains and Stochastic Stability

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.

Critically acclaimed text for computer performance analysis--now in its second edition The Second Edition of this now-classic text provides a current and thorough treatment of queueing systems, queueing networks, continuous and discrete-time Markov chains, and simulation. Thoroughly updated with new content, as well as new problems and worked examples, the text offers readers both the theory and practical guidance needed to conduct performance and reliability evaluations of computer, communication, and manufacturing systems. Starting with basic probability theory, the

*text sets the foundation for the more complicated topics of queueing networks and Markov chains, using applications and examples to illustrate key points. Designed to engage the reader and build practical performance analysis skills, the text features a wealth of problems that mirror actual industry challenges. New features of the Second Edition include: * Chapter examining simulation methods and applications * Performance analysis applications for wireless, Internet, J2EE, and Kanban systems * Latest material on non-Markovian and fluid stochastic Petri nets, as well as solution techniques for Markov regenerative processes * Updated discussions of new and popular performance analysis tools, including ns-2 and OPNET * New and current real-world examples, including DiffServ routers in the Internet and cellular mobile networks With the rapidly growing complexity of computer and communication systems, the need for this text, which expertly mixes theory and practice, is tremendous. Graduate and advanced undergraduate students in computer science will find the extensive use of examples and problems to be vital in mastering both the basics and the fine points of the field, while industry professionals will find the text essential for developing systems that comply with industry standards and regulations.*

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.

An Application of Markov Chains to the Analysis of the Growth and Decline of Settlements in the Ljubljana Metropolitan Area

From Theory to Implementation and Experimentation

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

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.