INVARIANT MEASURES FOR MARKOV CHAINS AND FELLER EXTENSIONS OF CHAINS

M. G. SHUR

Introduction

1. Independent of the form of the phase space, the question of existence of nontrivial invariant measures for a Markov chain is most often connected with reflexivity conditions (see [3], [5]–[8]). However, even in the absence of reflexivity this question is of significant interest and in fact it is to this situation that the works [10]–[12] (see also [9], § 13) as well as the present article are devoted. In contrast to earlier articles, probabilities with exclusions are not used in our conditions of existence of invariant measures, the role of jumps of large size is distinctly apparent. These conditions appear most simply in the Feller case (see Theorem 3.1; the Feller property is defined in subsection 2), and the general case is reduced in Section 4 to the Feller case by means of an extension of the initial chain to a Feller one. The latter is achieved by means of Theorem 1.1, which is a variant of the well-known theme of Knight [4] in the theory of Markov resolvents. Some special properties of Feller extensions of irreducible chains may be found in Theorem 2.1. which is essentially used in Section 4.

2. As a rule, our terminology is that generally used (see [5] and especially [7]). Usually we start out from a *separable phase space* $(E, \mathcal{B})$, in other words, from a measurable space $(E, \mathcal{B})$ with a separable σ-algebra $\mathcal{B}$ containing all singleton sets in E. By $b\mathcal{B}$ we mean the collection of $\mathcal{B}$-measurable bounded functions; $b\mathcal{B}^+ = \{f \in b\mathcal{B} : f \geq 0\}$. The symbol 1_A denotes the indicator of the set $A \subset E$ and A^c its complement.

With a Markov (more precisely, a homogeneous Markov) chain $X = \{X_n ; n \geq 0\}$ defined in $(E, \mathcal{B})$ are associated the standard attributes: $\mathbf{P}_x$ is the probability measure in the space of elementary events arising under the initial distribution concentrated at $x \in E$; $P_n(x, A)$ is the transition probability from x into $A \in \mathcal{B}$ after n steps ($P_0(x, \cdot)$ is the measure concentrated at x with unit total mass); $G^\alpha(x, \cdot) = \sum e^{-\alpha n} P_n(x, \cdot)$ are the Green measures, where $\alpha \geq 0$, $x \in E$ (instead of $P_1(x, \cdot)$ and $G^0(x, \cdot)$ one writes $P(x, \cdot)$ and $G(x, \cdot)$). If the function $G(\cdot, A)$ is bounded, the set A is called *completely transient*. As usual we introduce on $b\mathcal{B}$ the operators P_n and G^α, $n \geq 0$, $\alpha > 0$; for example,

$$G^\alpha f(x) = \int f(y) G^\alpha(x, dy) \quad \text{for } f \in b\mathcal{B}.$$

Markov Chains On Metric Spaces Invariant Measures And Asymptotic Behaviour

Jacek Banasiak,Jacek Miekisz

Markov Chains On Metric Spaces Invariant Measures And Asymptotic Behaviour:

   Markov Chains on Metric Spaces Niclas Carlsson,2005 Sammanfattning   *Markov Processes, Structure and Asymptotic Behavior* Murray Rosenblatt,2012-12-06 This book is concerned with a set of related problems in probability theory that are considered in the context of Markov processes Some of these are natural to consider especially for Markov processes Other problems have a broader range of validity but are convenient to pose for Markov processes The book can be used as the basis for an interesting course on Markov processes or stationary processes For the most part these questions are considered for discrete parameter processes although they are also of obvious interest for continuous time parameter processes This allows one to avoid the delicate measure theoretic questions that might arise in the continuous parameter case There is an attempt to motivate the material in terms of applications Many of the topics concern general questions of structure and representation of processes that have not previously been presented in book form A set of notes comment on the many problems that are still left open and related material in the literature It is also hoped that the book will be useful as a reference to the reader who would like an introduction to these topics as well as to the reader interested in extending and completing results of this type   **Markov Chains on Metric Spaces** Michel Benaïm,Tobias Hurth,2022-11-21 This book gives an introduction to discrete time Markov chains which evolve on a separable metric space The focus is on the ergodic properties of such chains i e on their long term statistical behaviour Among the main topics are existence and uniqueness of invariant probability measures irreducibility recurrence regularizing properties for Markov kernels and convergence to equilibrium These concepts are investigated with tools such as Lyapunov functions petite and small sets Doeblin and accessible points coupling as well as key notions from classical ergodic theory The theory is illustrated through several recurring classes of examples e g random contractions randomly switched vector fields and stochastic differential equations the latter providing a bridge to continuous time Markov processes The book can serve as the core for a semester or year long graduate course in probability theory with an emphasis on Markov chains or random dynamics Some of the material is also well suited for an ergodic theory course Readers should have taken an introductory course on probability theory based on measure theory While there is a chapter devoted to chains on a countable state space a certain familiarity with Markov chains on a finite state space is also recommended   *Stochastic Networked Control Systems* Serdar Yüksel,Tamer Başar,2013-05-21 Networked control systems are increasingly ubiquitous today with applications ranging from vehicle communication and adaptive power grids to space exploration and economics The optimal design of such systems presents major challenges requiring tools from various disciplines within applied mathematics such as decentralized control stochastic control information theory and quantization A thorough self contained book Stochastic Networked Control Systems Stabilization and Optimization under Information Constraints aims to connect these diverse disciplines with precision and rigor while conveying design guidelines to controller architects Unique in the literature it lays a comprehensive theoretical

foundation for the study of networked control systems and introduces an array of concrete tools for work in the field Salient features included Characterization comparison and optimal design of information structures in static and dynamic teams Operational structural and topological properties of information structures in optimal decision making with a systematic program for generating optimal encoding and control policies The notion of signaling and its utilization in stabilization and optimization of decentralized control systems Presentation of mathematical methods for stochastic stability of networked control systems using random time state dependent drift conditions and martingale methods Characterization and study of information channels leading to various forms of stochastic stability such as stationarity ergodicity and quadratic stability and connections with information and quantization theories Analysis of various classes of centralized and decentralized control systems Jointly optimal design of encoding and control policies over various information channels and under general optimization criteria including a detailed coverage of linear quadratic Gaussian models Decentralized agreement and dynamic optimization under information constraints This monograph is geared toward a broad audience of academic and industrial researchers interested in control theory information theory optimization economics and applied mathematics It could likewise serve as a supplemental graduate text The reader is expected to have some familiarity with linear systems stochastic processes and Markov chains but the necessary background can also be acquired in part through the four appendices included at the end Characterization comparison and optimal design of information structures in static and dynamic teams Operational structural and topological properties of information structures in optimal decision making with a systematic program for generating optimal encoding and control policies The notion of signaling and its utilization in stabilization and optimization of decentralized control systems Presentation of mathematical methods for stochastic stability of networked control systems using random time state dependent drift conditions and martingale methods Characterization and study of information channels leading to various forms of stochastic stability such as stationarity ergodicity and quadratic stability and connections with information and quantization theories Analysis of various classes of centralized and decentralized control systems Jointly optimal design of encoding and control policies over various information channels and under general optimization criteria including a detailed coverage of linear quadratic Gaussian models Decentralized agreement and dynamic optimization under information constraints This monograph is geared toward a broad audience of academic and industrial researchers interested in control theory information theory optimization economics and applied mathematics It could likewise serve as a supplemental graduate text The reader is expected to have some familiarity with linear systems stochastic processes and Markov chains but the necessary background can also be acquired in part through the four appendices included at the end   **Stochastic Teams, Games, and Control under Information Constraints** Serdar Yüksel,Tamer Başar,2024-06-19 This monograph presents a mathematically rigorous and accessible treatment of the interaction between information decision control and probability in single agent and multi agent systems The book provides a

comprehensive and unified theory of information structures for stochastic control stochastic teams stochastic games and networked control systems Part I of the text is concerned with a general mathematical theory of information structures for stochastic teams leading to systematic characterizations and classifications geometric and topological properties implications on existence approximations and relaxations their comparison and regularity of optimal solutions in information Information structures in stochastic games are then considered in Part II and the dependence of equilibrium solutions and behavior on information is demonstrated Part III studies information design through information theory in networked control systems both linear and nonlinear and discusses optimality and stability criteria Finally Part IV introduces information and signaling games under several solution concepts with applications to prior mismatch cost mismatch and privacy reputation games and jamming This text will be a valuable resource for researchers and graduate students interested in control theory information theory statistics game theory and applied mathematics Readers should be familiar with the basics of linear systems theory stochastic processes and Markov chains   Probability Measures on Semigroups Göran Högnäs,Arunava Mukherjea,2010-11-02 This second edition presents up to date material on the theory of weak convergance of convolution products of probability measures in semigroups the theory of random walks on semigroups and their applications to products of random matrices In addition this unique work examines the essentials of abstract semigroup theory and its application to concrete semigroups of matrices This substantially revised text includes exercises at various levels at the end of each section and includes the best available proofs on the most important theorems used in a book making it suitable for a one semester course on semigroups In addition it could also be used as a main text or supplementary material for courses focusing on probability on algebraic structures or weak convergence This book is ideally suited to graduate students in mathematics and students in other fields such as engineering and the sciences with an interest in probability Students in statistics using advanced probability will also find this book useful   Fokker-Planck-Kolmogorov Equations Vladimir I. Bogachev,Nicolai V. Krylov,Michael Röckner,Stanislav V. Shaposhnikov,2015-12-17 This book gives an exposition of the principal concepts and results related to second order elliptic and parabolic equations for measures the main examples of which are Fokker Planck Kolmogorov equations for stationary and transition probabilities of diffusion processes Existence and uniqueness of solutions are studied along with existence and Sobolev regularity of their densities and upper and lower bounds for the latter The target readership includes mathematicians and physicists whose research is related to diffusion processes as well as elliptic and parabolic equations   Random Perturbations of Dynamical Systems Yuri Kifer,2012-12-06 Mathematicians often face the question to which extent mathematical models describe processes of the real world These models are derived from experimental data hence they describe real phenomena only approximately Thus a mathematical approach must begin with choosing properties which are not very sensitive to small changes in the model and so may be viewed as properties of the real process In particular this concerns real processes which can be described by means of ordinary differential equations By

this reason different notions of stability played an important role in the qualitative theory of ordinary differential equations commonly known nowdays as the theory of dynamical systems Since physical processes are usually affected by an enormous number of small external fluctuations whose resulting action would be natural to consider as random the stability of dynamical systems with respect to random perturbations comes into the picture There are differences between the study of stability properties of single trajectories i e the Lyapunov stability and the global stability of dynamical systems The stochastic Lyapunov stability was dealt with in Hasminskii Has In this book we are concerned mainly with questions of global stability in the presence of noise which can be described as recovering parameters of dynamical systems from the study of their random perturbations The parameters which is possible to obtain in this way can be considered as stable under random perturbations and so having physical sense 1 Our set up is the following *Acta Academiae Aboensis* Åbo akademi (1918-),2007 **Limit Theorems for Markov Chains and Stochastic Properties of Dynamical Systems by Quasi-Compactness** Hubert Hennion,Loic Herve,2003-07-01 The usefulness of from the of techniques perturbation theory operators to kernel for limit theorems for a applied quasi compact positive Q obtaining Markov chains for stochastic of or dynamical by describing properties systems of Perron Frobenius has been demonstrated in several All use a operator papers these works share the features the features that must be same specific general used in each stem from the nature of the functional particular case precise space where the of is and from the number of quasi compactness Q proved eigenvalues of of modulus 1 We here a functional framework for Q give general analytical this method and we the aforementioned behaviour within it It asymptotic prove is worth that this framework is to allow the unified noticing sufficiently general treatment of all the cases considered in the literature the previously specific characters of model translate into the verification of of simple hypotheses every a functional nature When to Markov kernels or to Perr applied Lipschitz Frobenius associated with these statements rise operators expanding give maps to new results and the of known The main clarify proofs already properties of the deals with a Markov kernel for which 1 is a part quasi compact Q paper of modulus 1 An essential but is not the simple eigenvalue unique eigenvalue element of the work is the of the of peripheral Q precise description spectrums and of its To conclude the the results obtained perturbations Lyapunov Exponents Ludwig Arnold,Hans Crauel,Jean-Pierre Eckmann,2006-11-14 Since the predecessor to this volume LNM 1186 Eds L Arnold V Wihstutz appeared in 1986 significant progress has been made in the theory and applications of Lyapunov exponents one of the key concepts of dynamical systems and in particular pronounced shifts towards nonlinear and infinite dimensional systems and engineering applications are observable This volume opens with an introductory survey article Arnold Crauel followed by 26 original fully refereed research papers some of which have in part survey character From the Contents L Arnold H Crauel Random Dynamical Systems I Ya Goldscheid Lyapunov exponents and asymptotic behaviour of the product of random matrices Y Peres Analytic dependence of Lyapunov exponents on transition probabilities O Knill The upper Lyapunov exponent of Sl 2 R cocycles

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Metrical and Ergodic Theory of Continued Fraction Algorithms Gabriela Ileana Sebe,Dan Lascu,2025-04-22 This monograph presents the work of the authors in metrical theory of continued fractions in the last two decades The monograph cuts a particular path through this extensive theory and describes the theory in its current form for three families of continued fractions namely continued fractions N continued fractions and generalized R nyi continued fractions The book systematically lays out the required preliminaries making the book easy to read This monograph provides a solid introduction into the theory of continued fractions The book is intended for researchers in metrical theory as well as advanced graduate students and mathematicians interested in this field *Functions of Least Gradient* Wojciech Górny,José M. Mazón,2024-05-22 This book is devoted to the least gradient problem and its variants The least gradient problem concerns minimization of the total variation of a function with prescribed values on the boundary of a Lipschitz domain It is the model problem for studying minimization problems involving functionals with linear growth Functions which solve the least gradient problem for their own boundary data which arise naturally in the study of minimal surfaces are called functions of least gradient The main part of the book is dedicated to presenting the recent advances in this theory Among others are presented an Euler Lagrange characterization of least gradient functions an anisotropic counterpart of the least gradient problem motivated by an inverse problem in medical imaging and state of the art results concerning existence regularity and structure of solutions Moreover the authors present a surprising connection between the least gradient problem and the Monge Kantorovich optimal transport problem and some of its consequences and discuss formulations of the least gradient problem in the nonlocal and metric settings Each chapter is followed by a discussion section concerning other research directions generalizations of presented results and presentation of some open problems The book is intended as an introduction to the theory of least gradient functions and a reference tool for a general audience in analysis and PDEs The readers are assumed to have a basic understanding of functional analysis and partial differential equations Apart from this the text is self contained and the book ends with five appendices on functions of bounded variation geometric measure theory convex analysis optimal transport and analysis in metric spaces **SIAM Journal on Control and Optimization** Society for Industrial and Applied Mathematics,1976 Contains research articles on the mathematics and applications of control theory and on those parts of optimization theory concerned with the dynamics of deterministic or stochastic systems in continuous or discrete time or otherwise dealing with differential equations dynamics infinite dimensional spaces or fundamental issues in variational analysis and geometry Thinking in Patterns Benoit B. Mandelbrot,Miroslav Michal

Novak,2004 Fractal geometry together with the broader fields of nonlinear dynamics and complexity represented a large segment of modern science at the end of the 20th century Penetration of the resulting new paradigms into practically all academic disciplines has confirmed the fundamental assertion of universal formalism common to a wide range of human endeavors This book contains an extended article by B B Mandelbrot reviewing his contribution to fractal geometry and outlining some unsolved problems with illustrations especially of finance and physics It covers a range of multidisciplinary topics OCo from the biology of aging through the self similar shape of plants image decompression and solar magnetic fields to sound reflection in the street The book is a treasure trove for innovative researchers working in fields related to fractal geometry The proceedings have been selected for coverage in OCo Index to Scientific Technical Proceedings ISTP ISI Proceedings OCo Index to Scientific Technical Proceedings ISTP CDROM version ISI Proceedings OCo CC Proceedings OCo Engineering Physical Sciences **Probability Theory Subject Indexes from Mathematical Reviews** American Mathematical Society,1987 **Mathematical Reviews** ,2004 **Multiscale Problems in the Life Sciences** Jacek Banasiak,Jacek Miekisz,2008-05-30 The aim of this volume that presents lectures given at a joint CIME and Banach Center Summer School is to offer a broad presentation of a class of updated methods providing a mathematical framework for the development of a hierarchy of models of complex systems in the natural sciences with a special attention to biology and medicine Mastering complexity implies sharing different tools requiring much higher level of communication between different mathematical and scientific schools for solving classes of problems of the same nature Today more than ever one of the most important challenges derives from the need to bridge parts of a system evolving at different time and space scales especially with respect to computational affordability As a result the content has a rather general character the main role is played by stochastic processes positive semigroups asymptotic analysis kinetic theory continuum theory and game theory **Markov Chains and Stochastic Stability** Sean Meyn,Richard L. Tweedie,2009-04-02 Meyn and Tweedie is back The bible on Markov chains in general state spaces has been brought up to date to reflect developments in the field since 1996 many of them sparked by publication of the first edition The pursuit of more efficient simulation algorithms for complex Markovian models or algorithms for computation of optimal policies for controlled Markov models has opened new directions for research on Markov chains As a result new applications have emerged across a wide range of topics including optimisation statistics and economics New commentary and an epilogue by Sean Meyn summarise recent developments and references have been fully updated This second edition reflects the same discipline and style that marked out the original and helped it to become a classic proofs are rigorous and concise the range of applications is broad and knowledgeable and key ideas are accessible to practitioners with limited mathematical background **Current Index to Statistics, Applications, Methods and Theory** ,1999 The Current Index to Statistics CIS is a bibliographic index of publications in statistics probability and related fields

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