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A REVIEW OF CONDITIONAL RARE EVENT SIMULATION FOR TAIL PROBABILITIES OF HEAVY TAILED RANDOM VARIABLES

LEONARDO ROJAS-NANDAYAPA

ABSTRACT. Approximating the tail probability of a sum of heavy-tailed random variables is a difficult problem. In this review we exhibit the challenges of approximating such probabilities and concentrate on a rare event simulation methodology capable of delivering the most reliable results: Conditional Monte Carlo. To provide a better flavor of this topic we further specialize on two algorithms which were specifically designed for tackling this problem: the Asmussen-Binswanger estimator and the Asmussen-Kroese estimator. We extend the applicability of these estimators to the non-independent case and prove their efficiencies.

1. Introduction

The term *rare event* is used to designate all those events whose probabilities are small, yet non-negligible and characterized by the difficulty of its calculation. Often, these rare events are extremely important in applications; for instance, consider the consequences of a natural disaster for an insurance company, or an economic crisis for a financial institution or the sudden arrival of huge number of jobs to a server as it often occurs in a web server. Many of the probability models employed for dealing with these problems contain multiple random variables (not necessarily independent) and the quantities of interest are given in terms of transformations such as sums, products or extremes. In consequence, the explicit calculation of a distribution of interest is often non-trivial and one must rely on approximation methods. Among these, the Monte Carlo method is considered to be one the most reliable, specially in cases where analytical approximations are not available.

In this review we mainly focus on the Monte Carlo method for approximating rare event probabilities, but we also discuss asymptotic approximations; the reason for this is that the implementation of efficient Monte Carlo estimators often requires to draw elements from asymptotic theory. In particular, we specialize on tail probabilities of a sum of random variables

$$\mathbb{P}(S_n > x), \qquad x \to \infty.$$

When the involved random variables are light tailed, the approximation of such probabilities is dealt via Large Deviations theory. Notwithstanding, certain phenomena are better modeled with heavy-tailed distributions. However, the approximation of rare event probabilities in the presence of heavy tails is often more involved and it has been considered a challenging problem among the applied

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Rare Event Simulation In Models With Heavytailed Random Variables

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Rare Event Simulation In Models With Heavytailed Random Variables:

Social Benefits and the Flow Approach to the Labor Market Nam Kyoo Boots,Udo Kock,2002 *Rare Event Simulation using Monte Carlo Methods* Gerardo Rubino,Bruno Tuffin,2009-03-18 In a probabilistic model a rare event is an event with a very small probability of occurrence The forecasting of rare events is a formidable task but is important in many areas For instance a catastrophic failure in a transport system or in a nuclear power plant the failure of an information processing system in a bank or in the communication network of a group of banks leading to financial losses Being able to evaluate the probability of rare events is therefore a critical issue Monte Carlo Methods the simulation of corresponding models are used to analyze rare events This book sets out to present the mathematical tools available for the efficient simulation of rare events Importance sampling and splitting are presented along with an exposition of how to apply these tools to a variety of fields ranging from performance and dependability evaluation of complex systems typically in computer science or in telecommunications to chemical reaction analysis in biology or particle transport in physics Graduate students researchers and practitioners who wish to learn and apply rare event simulation techniques will find this book beneficial **Computing Rare-event Probabilities for Affine Models and General State Space Markov Processes** Xiaowei Zhang,2011 Rare event simulation concerns computing small probabilities i e rare event probabilities This dissertation investigates efficient simulation algorithms based on importance sampling for computing rare event probabilities for different models and establishes their efficiency via asymptotic analysis The first part discusses asymptotic behavior of affine models Stochastic stability of affine jump diffusions are carefully studied In particular positive recurrence ergodicity and exponential ergodicity are established for such processes under various conditions via a Foster Lyapunov type approach The stationary distribution is characterized in terms of its characteristic function Furthermore the large deviations behavior of affine point processes are explicitly computed based on which a logarithmically efficient importance sampling algorithm is proposed for computing rare event probabilities for affine point processes The second part is devoted to a much more general setting i e general state space Markov processes The current state of the art algorithm for computing rare event probabilities in this context heavily relies on the solution of a certain eigenvalue problem which is often unavailable in closed form unless certain special structure is present e g affine structure for affine models To circumvent this difficulty assuming the existence of a regenerative structure we propose a bootstrap based algorithm that conducts the importance sampling on the regenerative cycle path space instead of the original one step transition kernel The efficiency of this algorithm is also discussed

Advances in Heavy Tailed Risk Modeling Gareth W. Peters,Pavel V. Shevchenko,2015-05-21 ADVANCES IN HEAVY TAILED RISK MODELING A cutting edge guide for the theories applications and statistical methodologies essential to heavy tailed risk modeling Focusing on the quantitative aspects of heavy tailed loss processes in operational risk and relevant insurance analytics Advances in Heavy Tailed Risk Modeling A Handbook of Operational Risk presents comprehensive

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Handbook of Monte Carlo Methods is an excellent reference for applied statisticians and practitioners working in the fields of engineering and finance who use or would like to learn how to use Monte Carlo in their research It is also a suitable supplement for courses on Monte Carlo methods and computational statistics at the upper undergraduate and graduate levels **Monte Carlo Methods and Models in Finance and Insurance** Ralf Korn,Elke Korn,Gerald Kroisandt,2010-02-26 Offering a unique balance between applications and calculations Monte Carlo Methods and Models in Finance and Insurance incorporates the application background of finance and insurance with the theory and applications of Monte Carlo methods It presents recent methods and algorithms including the multilevel Monte Carlo method the statistical Rom *Handbooks in Operations Research and Management Science: Simulation* Shane G. Henderson,Barry L. Nelson,2006-09-02 This Handbook is a collection of chapters on key issues in the design and analysis of computer simulation experiments on models of stochastic systems The chapters are tightly focused and written by experts in each area For the purpose of this volume simulation refers to the analysis of stochastic processes through the generation of sample paths realization of the processes Attention focuses on design and analysis issues and the goal of this volume is to survey the concepts principles tools and techniques that underlie the theory and practice of stochastic simulation design and analysis Emphasis is placed on the ideas and methods that are likely to remain an intrinsic part of the foundation of the field for the foreseeable future The chapters provide up to date references for both the simulation researcher and the advanced simulation user but they do not constitute an introductory level how to guide Computer scientists financial analysts industrial engineers management scientists operations researchers and many other professionals use stochastic simulation to design understand and improve communications financial manufacturing logistics and service systems A theme that runs throughout these diverse applications is the need to evaluate system performance in the face of uncertainty including uncertainty in user load interest rates demand for product availability of goods cost of transportation and equipment failures Tightly focused chapters written by experts Surveys concepts principles tools and techniques that underlie the theory and practice of stochastic simulation design and analysis Provides an up to date reference for both simulation researchers and advanced simulation users *Projects for shareholder value. A capital budgetting perspective* Mehari Mekonnen Akalu,2003

Stochastic Biomathematical Models Mostafa Bachar,Jerry J. Batzel,Susanne Ditlevsen,2012-10-19 Stochastic biomathematical models are becoming increasingly important as new light is shed on the role of noise in living systems In certain biological systems stochastic effects may even enhance a signal thus providing a biological motivation for the noise observed in living systems Recent advances in stochastic analysis and increasing computing power facilitate the analysis of more biophysically realistic models and this book provides researchers in computational neuroscience and stochastic systems with an overview of recent developments Key concepts are developed in chapters written by experts in their respective fields Topics include one dimensional homogeneous diffusions and their boundary behavior large deviation theory and its

application in stochastic neurobiological models a review of mathematical methods for stochastic neuronal integrate and fire models stochastic partial differential equation models in neurobiology and stochastic modeling of spreading cortical depression *Stochastic Models with Power-Law Tails* Dariusz Buraczewski,Ewa Damek,Thomas Mikosch,2016-07-04 In this monograph the authors give a systematic approach to the probabilistic properties of the fixed point equation X AX B A probabilistic study of the stochastic recurrence equation X_t A_tX_ t 1 B_t for real and matrix valued random variables A_t where A_t B_t constitute an iid sequence is provided The classical theory for these equations including the existence and uniqueness of a stationary solution the tail behavior with special emphasis on power law behavior moments and support is presented The authors collect recent asymptotic results on extremes point processes partial sums central limit theory with special emphasis on infinite variance stable limit theory large deviations in the univariate and multivariate cases and they further touch on the related topics of smoothing transforms regularly varying sequences and random iterative systems The text gives an introduction to the Kesten Goldie theory for stochastic recurrence equations of the type X_t A_tX_ t 1 B_t It provides the classical results of Kesten Goldie Guivarc h and others and gives an overview of recent results on the topic It presents the state of the art results in the field of affine stochastic recurrence equations and shows relations with non affine recursions and multivariate regular variation **Ruin Probabilities** S?ren Asmussen,Hansj□rg Albrecher,2010 The book gives a comprehensive treatment of the classical and modern ruin probability theory Some of the topics are Lundberg s inequality the Cram r Lundberg approximation exact solutions other approximations e g for heavy tailed claim size distributions finite horizon ruin probabilities extensions of the classical compound Poisson model to allow for reserve dependent premiums Markov modulation periodicity change of measure techniques phase type distributions as a computational vehicle and the connection to other applied probability areas like queueing theory In this substantially updated and extended second version new topics include stochastic control fluctuation theory for Levy processes Gerber Shiu functions and dependence **Real estate securitization and corporate strategy. From bricks to bucks** Dirk Brounen,2003 **Extreme Value Theory for Time Series** Thomas Mikosch,Olivier Wintenberger,2024-08-02 This book deals with extreme value theory for univariate and multivariate time series models characterized by power law tails These include the classical ARMA models with heavy tailed noise and financial econometrics models such as the GARCH and stochastic volatility models Rigorous descriptions of power law tails are provided through the concept of regular variation Several chapters are devoted to the exploration of regularly varying structures The remaining chapters focus on the impact of heavy tails on time series including the study of extremal cluster phenomena through point process techniques A major part of the book investigates how extremal dependence alters the limit structure of sample means maxima order statistics sample autocorrelations This text illuminates the theory through hundreds of examples and as many graphs showcasing its applications to real life financial and simulated data The book can serve as a text for PhD and Master courses on applied

probability extreme value theory and time series analysis It is a unique reference source for the heavy tail modeler Its reference quality is enhanced by an exhaustive bibliography annotated by notes and comments making the book broadly and easily accessible *Risk, Resettlement and Relations* Marleen Dekker,2004 **Monte Carlo and Quasi-Monte Carlo Methods 2000** Kai-Tai Fang,Fred J. Hickernell,Harald Niederreiter,2011-06-28 This book represents the refereed proceedings of the Fourth International Conference on Monte Carlo and Quasi Monte Carlo Methods in Scientific Computing which was held at Hong Kong Baptist University in 2000 An important feature are invited surveys of the state of the art in key areas such as multidimensional numerical integration low discrepancy point sets random number generation and applications of Monte Carlo and quasi Monte Carlo methods These proceedings include also carefully selected contributed papers on all aspects of Monte Carlo and quasi Monte Carlo methods The reader will be informed about current research in this very active field **Credit Securitisations and Derivatives** Daniel Rösch,Harald Scheule,2013-04-03 A comprehensive resource providing extensive coverage of the state of the art in credit secruritisations derivatives and risk management Credit Securitisations and Derivatives is a one stop resource presenting the very latest thinking and developments in the field of credit risk Written by leading thinkers from academia the industry and the regulatory environment the book tackles areas such as business cycles correlation modelling and interactions between financial markets institutions and instruments in relation to securitisations and credit derivatives credit portfolio risk credit portfolio risk tranching credit ratings for securitisations counterparty credit risk and clearing of derivatives contracts and liquidity risk As well as a thorough analysis of the existing models used in the industry the book will also draw on real life cases to illustrate model performance under different parameters and the impact that using the wrong risk measures can have *Human resource management within small and medium-sized enterprises* Jan de Kok,2003 Issues in Applied Computing: 2012 Edition ,2013-01-10 Issues in Applied Computing 2012 Edition is a ScholarlyEditions eBook that delivers timely authoritative and comprehensive information about Materials Engineering The editors have built Issues in Applied Computing 2012 Edition on the vast information databases of ScholarlyNews You can expect the information about Materials Engineering in this eBook to be deeper than what you can access anywhere else as well as consistently reliable authoritative informed and relevant The content of Issues in Applied Computing 2012 Edition has been produced by the world s leading scientists engineers analysts research institutions and companies All of the content is from peer reviewed sources and all of it is written assembled and edited by the editors at ScholarlyEditions and available exclusively from us You now have a source you can cite with authority confidence and credibility More information is available at http www ScholarlyEditions com

Queue Structures and Algorithms Richard Johnson,2025-05-31 Queue Structures and Algorithms Queue Structures and Algorithms offers a comprehensive exploration of queues a foundational concept in computer science and systems engineering The book guides readers from fundamental abstract definitions and operational guarantees of queues through

the mathematical underpinnings of queue behaviors to nuanced analyses of algorithmic complexity and real world use cases Clear and rigorous treatment of both classical and modern queue variants including circular bounded persistent and generalized FIFO structures equips practitioners and researchers alike with a deep understanding of these essential data structures The text moves seamlessly from theory into practical implementation addressing challenges such as memory modeling concurrency controls high performance tuning and fault tolerant design Rich discussions around advanced topics such as priority queues and heaps lock free and wait free queues distributed messaging patterns and queueing networks ensure that the book caters to the needs of software engineers distributed system architects and algorithm designers working at the forefront of technology Case studies featuring Kafka RabbitMQ and SQS provide insight into state of the art production systems while coverage of auditing compliance and security concerns ensures that reliability and robustness remain central themes throughout Finally the book embraces the future of queue technologies by surveying emerging areas like adaptive queue management integration with persistent and non volatile memory trustless environments powered by blockchain and even nascent quantum and bio inspired approaches With detailed modeling techniques grounded in queueing theory insights into stochastic methods and an eye toward open research challenges Queue Structures and Algorithms is a definitive forward looking resource for anyone seeking mastery over the design and application of modern queue systems

Modelling Extremal Events Paul Embrechts,Claudia Klüppelberg,Thomas Mikosch,2013-03-14 A reader s first impression on leafing through this book is of the large number of graphs and diagrams used to illustrate shapes of distributions and to show real data examples in various ways A closer reading reveals a nice mix of theory and applications with the copious graphical illustrations alluded to Such a mixture is of course dear to the heart of the applied probabilist statistician and should impress even the most ardent theorists MATHEMATICAL REVIEWS

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