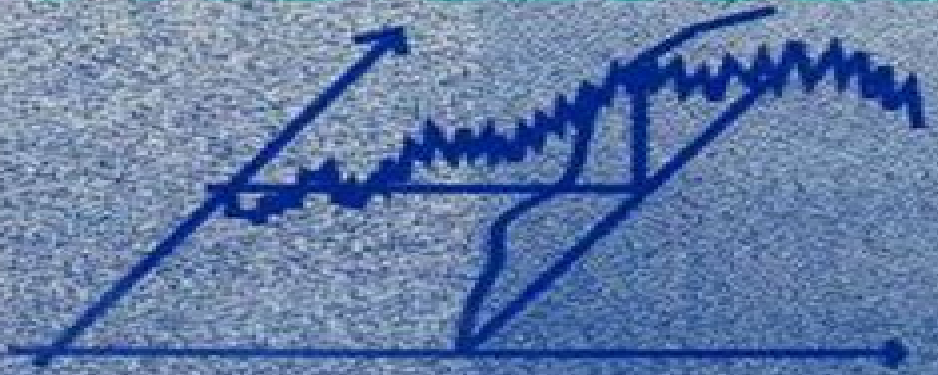
NUMERICAL METHODS FOR STOCHASTIC PROCESSES



Nicolas Bouleau
Dominique Lépingle

Wiley Series in Probability and Mathematical Statistics:
Applied Probability and Statistics Section

Numerical Methods For Stochastic Processes

G.N. Milstein

Numerical Methods For Stochastic Processes:

Numerical Methods for Stochastic Processes Nicolas Bouleau,Dominique Lépingle,1994-01-14 Gives greater rigor to numerical treatments of stochastic models Contains Monte Carlo and quasi Monte Carlo techniques simulation of major stochastic procedures deterministic methods adapted to Markovian problems and special problems related to stochastic integral and differential equations Simulation methods are given throughout the text as well as numerous exercises

Numerical Methods for Stochastic Control Problems in Continuous Time Harold Kushner,Paul G. Dupuis,2012-12-06 This book is concerned with numerical methods for stochastic control and optimal stochastic control problems The random process models of the controlled or uncontrolled stochastic systems are either diffusions or jump diffusions Stochastic control is a very active area of research and new prob lem formulations and sometimes surprising applications appear regularly We have chosen forms of the models which cover the great bulk of the for mulations of the continuous time stochastic control problems which have appeared to date The standard formats are covered but much emphasis is given to the newer and less well known formulations The controlled process might be either stopped or absorbed on leaving a constraint set or upon first hitting a target set or it might be reflected or projected from the boundary of a constraining set In some of the more recent applications of the reflecting boundary problem for example the so called heavy traffic approximation problems the directions of reflection are actually discontin uous In general the control might be representable as a bounded function or it might be of the so called impulsive or singular control types Both the drift and the variance might be controlled The cost functions might be any of the standard types Discounted stopped on first exit from a set finite time optimal stopping average cost per unit time over the infinite time interval and so forth **Numerical Methods in Stochastic Processes** Patrick James Corbett,1969 **Numerical Solution of Stochastic Differential Equations** Peter E. Kloeden,Eckhard Platen,2013-04-17 The aim of this book is to provide an accessible introduction to stochastic differ ential equations and their applications together with a systematic presentation of methods available for their numerical solution During the past decade there has been an accelerating interest in the de velopment of numerical methods for stochastic differential equations SDEs This activity has been as strong in the engineering and physical sciences as it has in mathematics resulting inevitably in some duplication of effort due to an unfamiliarity with the developments in other disciplines Much of the reported work has been motivated by the need to solve particular types of problems for which even more so than in the deterministic context specific methods are required The treatment has often been heuristic and ad hoc in character Nevertheless there are underlying principles present in many of the papers an understanding of which will enable one to develop or apply appropriate numerical schemes for particular problems or classes of problems *Numerical Methods for Stochastic Partial Differential Equations with White Noise* Zhongqiang Zhang,George Em Karniadakis,2017-09-01 This book covers numerical methods for stochastic partial differential equations with white noise using the framework of Wong Zakai approximation The book begins

with some motivational and background material in the introductory chapters and is divided into three parts Part I covers numerical stochastic ordinary differential equations Here the authors start with numerical methods for SDEs with delay using the Wong Zakai approximation and finite difference in time Part II covers temporal white noise Here the authors consider SPDEs as PDEs driven by white noise where discretization of white noise Brownian motion leads to PDEs with smooth noise which can then be treated by numerical methods for PDEs In this part recursive algorithms based on Wiener chaos expansion and stochastic collocation methods are presented for linear stochastic advection diffusion reaction equations In addition stochastic Euler equations are exploited as an application of stochastic collocation methods where a numerical comparison with other integration methods in random space is made Part III covers spatial white noise Here the authors discuss numerical methods for nonlinear elliptic equations as well as other equations with additive noise Numerical methods for SPDEs with multiplicative noise are also discussed using the Wiener chaos expansion method In addition some SPDEs driven by non Gaussian white noise are discussed and some model reduction methods based on Wick Malliavin calculus are presented for generalized polynomial chaos expansion methods Powerful techniques are provided for solving stochastic partial differential equations This book can be considered as self contained Necessary background knowledge is presented in the appendices Basic knowledge of probability theory and stochastic calculus is presented in Appendix A In Appendix B some semi analytical methods for SPDEs are presented In Appendix C an introduction to Gauss quadrature is provided In Appendix D all the conclusions which are needed for proofs are presented and in Appendix E a method to compute the convergence rate empirically is included In addition the authors provide a thorough review of the topics both theoretical and computational exercises in the book with practical discussion of the effectiveness of the methods Supporting Matlab files are made available to help illustrate some of the concepts further Bibliographic notes are included at the end of each chapter This book serves as a reference for graduate students and researchers in the mathematical sciences who would like to understand state of the art numerical methods for stochastic partial differential equations with white noise Stochastic Simulation and Monte Carlo Methods Carl Graham,Denis Talay,2013-07-16 In various scientific and industrial fields stochastic simulations are taking on a new importance This is due to the increasing power of computers and practitioners aim to simulate more and more complex systems and thus use random parameters as well as random noises to model the parametric uncertainties and the lack of knowledge on the physics of these systems The error analysis of these computations is a highly complex mathematical undertaking Approaching these issues the authors present stochastic numerical methods and prove accurate convergence rate estimates in terms of their numerical parameters number of simulations time discretization steps As a result the book is a self contained and rigorous study of the numerical methods within a theoretical framework After briefly reviewing the basics the authors first introduce fundamental notions in stochastic calculus and continuous time martingale theory then develop the analysis of pure jump Markov processes Poisson processes and

stochastic differential equations In particular they review the essential properties of It integrals and prove fundamental results on the probabilistic analysis of parabolic partial differential equations These results in turn provide the basis for developing stochastic numerical methods both from an algorithmic and theoretical point of view The book combines advanced mathematical tools theoretical analysis of stochastic numerical methods and practical issues at a high level so as to provide optimal results on the accuracy of Monte Carlo simulations of stochastic processes It is intended for master and Ph D students in the field of stochastic processes and their numerical applications as well as for physicists biologists economists and other professionals working with stochastic simulations who will benefit from the ability to reliably estimate and control the accuracy of their simulations **Numerical Methods for Stochastic Control Problems in Continuous Time** Harold J. Kushner,Paul Dupuis,2001 The required background is surveyed and there is an extensive development of methods of approximation and computational algorithms The book is written on two levels algorithms and applications and mathematical proofs Thus the ideas should be very accessible to a broad audience BOOK JACKET **Stochastic Dynamical Systems** Josef Honerkamp,1996-12-17 Dieser einzigartige Band f hrt den Leser in die mathematische Begriffsbildung f r komplexe Systeme ein Er ist ideal f r Studenten der Mathematik Physik Chemie und Medizin die sich in ihrem Studium erstmals mit stochastischen dynamischen Systemen besch ftigen Das Buch stellt praktische Methoden zur Verf gung um mit solchen Systemen umgehen zu k nnen und stellt die zugundeliegenden Definitionen und theoretischen Annahmen wo erforderlich klar heraus Im Gegensatz zu anderen B chern ber dieses Gebiet die oft einen bestimmten Zugang bevorzugen deckt Stochastical Dynamical Systems eine Vielzahl von stochastischen und statistischen Methoden ab die f r die Untersuchung von komplexen Systemen wie Polymerschmelzen dem menschlichen K rper und der Atmosph re absolut notwendig sind Das Buch behandelt die Datenanalyse ebenso wie Simulationsmethoden f r gegebene Modelle Die ganze Vielfalt der klassischen und neuartigen Begriffe der mathematischen Stochastik wird in einem leicht verst ndlichen Stil erkl rt so da die Leser diese Konzepte leicht f r die Untersuchung ihrer Daten anwenden k nnen **Stochastic Numerical Methods** Raúl Toral,Pere Colet,2014-06-26 Stochastic Numerical Methods introduces at Master level the numerical methods that use probability or stochastic concepts to analyze random processes The book aims at being rather general and is addressed at students of natural sciences Physics Chemistry Mathematics Biology etc and Engineering but also social sciences Economy Sociology etc where some of the techniques have been used recently to numerically simulate different agent based models Examples included in the book range from phase transitions and critical phenomena including details of data analysis extraction of critical exponents finite size effects etc to population dynamics interfacial growth chemical reactions etc Program listings are integrated in the discussion of numerical algorithms to facilitate their understanding From the contents Review of Probability Concepts Monte Carlo Integration Generation of Uniform and Non uniform Random Numbers Non correlated Values Dynamical Methods Applications to Statistical Mechanics Introduction to Stochastic Processes Numerical Simulation of

Ordinary and Partial Stochastic Differential Equations Introduction to Master Equations Numerical Simulations of Master Equations Hybrid Monte Carlo Generation of n Dimensional Correlated Gaussian Variables Collective Algorithms for Spin Systems Histogram Extrapolation Multicanonical Simulations **Numerical Solution of Stochastic Differential Equations with Jumps in Finance** Eckhard Platen,Nicola Bruti-Liberati,2010-07-23 In financial and actuarial modeling and other areas of application stochastic differential equations with jumps have been employed to describe the dynamics of various state variables The numerical solution of such equations is more complex than that of those only driven by Wiener processes described in Kloeden Platen Numerical Solution of Stochastic Differential Equations 1992 The present monograph builds on the above mentioned work and provides an introduction to stochastic differential equations with jumps in both theory and application emphasizing the numerical methods needed to solve such equations It presents many new results on higher order methods for scenario and Monte Carlo simulation including implicit predictor corrector extrapolation Markov chain and variance reduction methods stressing the importance of their numerical stability Furthermore it includes chapters on exact simulation estimation and filtering Besides serving as a basic text on quantitative methods it offers ready access to a large number of potential research problems in an area that is widely applicable and rapidly expanding Finance is chosen as the area of application because much of the recent research on stochastic numerical methods has been driven by challenges in quantitative finance Moreover the volume introduces readers to the modern benchmark approach that provides a general framework for modeling in finance and insurance beyond the standard risk neutral approach It requires undergraduate background in mathematical or quantitative methods is accessible to a broad readership including those who are only seeking numerical recipes and includes exercises that help the reader develop a deeper understanding of the underlying mathematics Stochastic Processes: Modeling and Simulation D N Shanbhag,Calyampudi Radhakrishna Rao,2003-02-24 This sequel to volume 19 of Handbook on Statistics on Stochastic Processes Modelling and Simulation is concerned mainly with the theme of reviewing and in some cases unifying with new ideas the different lines of research and developments in stochastic processes of applied flavour This volume consists of 23 chapters addressing various topics in stochastic processes These include among others those on manufacturing systems random graphs reliability epidemic modelling self similar processes empirical processes time series models extreme value therapy applications of Markov chains modelling with Monte Carlo techniques and stochastic processes in subjects such as engineering telecommunications biology astronomy and chemistry particular with modelling simulation techniques and numerical methods concerned with stochastic processes The scope of the project involving this volume as well as volume 19 is already clarified in the preface of volume 19 The present volume completes the aim of the project and should serve as an aid to students teachers researchers and practitioners interested in applied stochastic processes **Simulation and Numerical Methods for Stochastic Processes** Timothy Charles Stutz,2020 Stochastic processes and randomness are vital features of mathematical modeling in biology

Unfortunately analytical results are rarely available for even moderately complex stochastic processes leaving simulation and numerical techniques the main avenues of attack We begin this work by exploring coupling bounds for birth death processes a fundamental type of stochastic process that describes how populations of individuals change over time By forming a coupling between a truncated version of the process and the original unbounded version we are able to compute both moments and transition probabilities for the true process within an acceptable error bound Second we present an algorithm design framework for Interacting Particle Systems IPSs These are complex stochastic processes with wide application to spatial phenomenon across many scientific disciplines Here we describe a method for efficiently sorting particles into classes based off of their type and spatial configuration in such a fashion that reduces the spatial simulation to that of a non spatial well mixed process albeit with a more complicated update step This also allows us to apply a large suite of well developed stochastic simulation algorithms to IPSs with little additional coding cost Third we return to numerical methods this time for multi type branching processes applied to gene therapy We derive a series of ordinary differential equations that govern the evolution of the probability generating function and provide a straightforward numerical inversion approach to obtain marginalized probability distributions for probabilistic quantities of interest We provide examples of our techniques applied to lentiviral gene therapy and the associated risk of oncogenesis in transplanted hematopoietic stem cell lines Finally we conclude with a chapter on future directions both related to the previous three chapters as well as projects not previously addressed in this work *Numerical Analysis of Systems of Ordinary and Stochastic Differential Equations* S. S. Artemiev,T. A. Averina,2011-02-11 No detailed description available for Numerical Analysis of Systems of Ordinary and Stochastic Differential Equations **Probability and Stochastic Processes** Ionut Florescu,2014-11-07 A comprehensive and accessible presentation of probability and stochastic processes with emphasis on key theoretical concepts and real world applications With a sophisticated approach Probability and Stochastic Processes successfully balances theory and applications in a pedagogical and accessible format The book s primary focus is on key theoretical notions in probability to provide a foundation for understanding concepts and examples related to stochastic processes Organized into two main sections the book begins by developing probability theory with topical coverage on probability measure random variables integration theory product spaces conditional distribution and conditional expectations and limit theorems The second part explores stochastic processes and related concepts including the Poisson process renewal processes Markov chains semi Markov processes martingales and Brownian motion Featuring a logical combination of traditional and complex theories as well as practices Probability and Stochastic Processes also includes Multiple examples from disciplines such as business mathematical finance and engineering Chapter by chapter exercises and examples to allow readers to test their comprehension of the presented material A rigorous treatment of all probability and stochastic processes concepts An appropriate textbook for probability and stochastic processes courses at the upper undergraduate and graduate level in

mathematics business and electrical engineering Probability and Stochastic Processes is also an ideal reference for researchers and practitioners in the fields of mathematics engineering and finance *Numerical Analysis of Stochastic Processes* Wolf-Jürgen Beyn,Raphael Kruse,2016-10-15 This textbook introduces into the art of analysing approximating and solving stochastic differential equations Random number generation and monte carlo methods as well as convergence theorems and discretisation effects are discussed Apart from mathematical problems these equations occur in physical engineering and economic models e g due to a lack of knowledge of the underlying complex systems **Stochastic Processes, Multiscale Modeling, and Numerical Methods for Computational Cellular Biology** David Holcman,2017-10-04 This book focuses on the modeling and mathematical analysis of stochastic dynamical systems along with their simulations The collected chapters will review fundamental and current topics and approaches to dynamical systems in cellular biology This text aims to develop improved mathematical and computational methods with which to study biological processes At the scale of a single cell stochasticity becomes important due to low copy numbers of biological molecules such as mRNA and proteins that take part in biochemical reactions driving cellular processes When trying to describe such biological processes the traditional deterministic models are often inadequate precisely because of these low copy numbers This book presents stochastic models which are necessary to account for small particle numbers and extrinsic noise sources The complexity of these models depend upon whether the biochemical reactions are diffusion limited or reaction limited In the former case one needs to adopt the framework of stochastic reaction diffusion models while in the latter one can describe the processes by adopting the framework of Markov jump processes and stochastic differential equations Stochastic Processes Multiscale Modeling and Numerical Methods for Computational Cellular Biology will appeal to graduate students and researchers in the fields of applied mathematics biophysics and cellular biology **Monte-Carlo Methods and Stochastic Processes** Emmanuel Gobet,2016-09-15 Developed from the author s course at the Ecole Polytechnique Monte Carlo Methods and Stochastic Processes From Linear to Non Linear focuses on the simulation of stochastic processes in continuous time and their link with partial differential equations PDEs It covers linear and nonlinear problems in biology finance geophysics mechanics chemistry and other application areas The text also thoroughly develops the problem of numerical integration and computation of expectation by the Monte Carlo method The book begins with a history of Monte Carlo methods and an overview of three typical Monte Carlo problems numerical integration and computation of expectation simulation of complex distributions and stochastic optimization The remainder of the text is organized in three parts of progressive difficulty The first part presents basic tools for stochastic simulation and analysis of algorithm convergence The second part describes Monte Carlo methods for the simulation of stochastic differential equations The final part discusses the simulation of non linear dynamics **Numerical Methods for Stochastic Computations** Dongbin Xiu,2010-07-01 The first graduate level textbook to focus on fundamental aspects of numerical methods for

stochastic computations this book describes the class of numerical methods based on generalized polynomial chaos gPC These fast efficient and accurate methods are an extension of the classical spectral methods of high dimensional random spaces Designed to simulate complex systems subject to random inputs these methods are widely used in many areas of computer science and engineering The book introduces polynomial approximation theory and probability theory describes the basic theory of gPC methods through numerical examples and rigorous development details the procedure for converting stochastic equations into deterministic ones using both the Galerkin and collocation approaches and discusses the distinct differences and challenges arising from high dimensional problems The last section is devoted to the application of gPC methods to critical areas such as inverse problems and data assimilation Ideal for use by graduate students and researchers both in the classroom and for self study Numerical Methods for Stochastic Computations provides the required tools for in depth research related to stochastic computations The first graduate level textbook to focus on the fundamentals of numerical methods for stochastic computations Ideal introduction for graduate courses or self study Fast efficient and accurate numerical methods Polynomial approximation theory and probability theory included Basic gPC methods illustrated through examples **Numerical Methods for Stochastic Processes with Applications in Chemical Kinetics and Biology** Basil Bayati,2011 **Numerical Integration of Stochastic Differential Equations** G.N. Milstein,2013-03-09 This book is devoted to mean square and weak approximations of solutions of stochastic differential equations SDE These approximations represent two fundamental aspects in the contemporary theory of SDE Firstly the construction of numerical methods for such systems is important as the solutions provided serve as characteristics for a number of mathematical physics problems Secondly the employment of probability representations together with a Monte Carlo method allows us to reduce the solution of complex multidimensional problems of mathematical physics to the integration of stochastic equations Along with a general theory of numerical integrations of such systems both in the mean square and the weak sense a number of concrete and sufficiently constructive numerical schemes are considered Various applications and particularly the approximate calculation of Wiener integrals are also dealt with This book is of interest to graduate students in the mathematical physical and engineering sciences and to specialists whose work involves differential equations mathematical physics numerical mathematics the theory of random processes estimation and control theory

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