



G. George Yin  
Chao Zhu

STOCHASTIC MODELLING  
AND APPLIED PROBABILITY

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# Hybrid Switching Diffusions

Properties and Applications



Springer

# Hybrid Switching Diffusions Properties And Applications Stochastic Modelling And Applied Probability

**Serguei Primak, Valeri  
Kontorovich, Vladimir Lyandres**



## **Hybrid Switching Diffusions Properties And Applications Stochastic Modelling And Applied Probability:**

**Hybrid Switching Diffusions** G. George Yin, Chao Zhu, 2012-02-25 This book encompasses the study of hybrid switching diffusion processes and their applications. The word hybrid signifies the coexistence of continuous dynamics and discrete events which is one of the distinct features of the processes under consideration. Much of the book is concerned with the interactions of the continuous dynamics and the discrete events. Our motivations for studying such processes originate from emerging and existing applications in wireless communications, signal processing, queueing networks, production planning, biological systems, ecosystems, financial engineering, and modeling, analysis, and control and optimization of large scale systems under the influence of random environments. Displaying mixture distributions, switching diffusions may be described by the associated operators or by systems of stochastic differential equations together with the probability transition laws of the switching actions. We either have Markov modulated switching diffusions or processes with continuous state dependent switching. The latter turns out to be much more challenging to deal with. Viewing the hybrid diffusions as a number of diffusions joined together by the switching process, they may be seemingly not much different from their diffusion counterpart. Nevertheless, the underlying problems become more difficult to handle especially when the switching processes depend on continuous states. The difficulty is due to the interaction of the discrete and continuous processes and the tangled and hybrid information pattern.

**Hybrid Switching Diffusions** G. George Yin, Chao Zhu, 2009-10-03 This book encompasses the study of hybrid switching diffusion processes and their applications. The word hybrid signifies the coexistence of continuous dynamics and discrete events which is one of the distinct features of the processes under consideration. Much of the book is concerned with the interactions of the continuous dynamics and the discrete events. Our motivations for studying such processes originate from emerging and existing applications in wireless communications, signal processing, queueing networks, production planning, biological systems, ecosystems, financial engineering, and modeling, analysis, and control and optimization of large scale systems under the influence of random environments. Displaying mixture distributions, switching diffusions may be described by the associated operators or by systems of stochastic differential equations together with the probability transition laws of the switching actions. We either have Markov modulated switching diffusions or processes with continuous state dependent switching. The latter turns out to be much more challenging to deal with. Viewing the hybrid diffusions as a number of diffusions joined together by the switching process, they may be seemingly not much different from their diffusion counterpart. Nevertheless, the underlying problems become more difficult to handle especially when the switching processes depend on continuous states. The difficulty is due to the interaction of the discrete and continuous processes and the tangled and hybrid information pattern.

Modeling, Stochastic Control, Optimization, and Applications George Yin, Qing Zhang, 2019-07-16 This volume collects papers based on invited talks given at the IMA workshop in Modeling Stochastic Control Optimization and Related Applications held at the Institute for Mathematics and Its Applications, University of Minnesota during May and

June 2018 There were four week long workshops during the conference They are 1 stochastic control computation methods and applications 2 queueing theory and networked systems 3 ecological and biological applications and 4 finance and economics applications For broader impacts researchers from different fields covering both theoretically oriented and application intensive areas were invited to participate in the conference It brought together researchers from multi disciplinary communities in applied mathematics applied probability engineering biology ecology and networked science to review and substantially update most recent progress As an archive this volume presents some of the highlights of the workshops and collect papers covering a broad range of topics

**Stochastic Analysis, Stochastic Systems, and Applications to Finance** Allanus Hak-Man Tsoi, David Nualart, George Yin, 2011 Pt I Stochastic analysis and systems 1 Multidimensional Wick Ito formula for Gaussian processes D Nualart and S Ortiz Latorre 2 Fractional white noise multiplication A H Tsoi 3 Invariance principle of regime switching diffusions C Zhu and G Yin pt II Finance and stochastics 4 Real options and competition A Bensoussan J D Diltz and S R Hoe 5 Finding expectations of monotone functions of binary random variables by simulation with applications to reliability finance and round robin tournaments M Brown E A Pekoz and S M Ross 6 Filtering with counting process observations and other factors applications to bond price tick data X Hu D R Kuipers and Y Zeng 7 Jump bond markets some steps towards general models in applications to hedging and utility problems M Kohlmann and D Xiong 8 Recombining tree for regime switching model algorithm and weak convergence R H Liu 9 Optimal reinsurance under a jump diffusion model S Luo 10 Applications of counting processes and martingales in survival analysis J Sun 11 Stochastic algorithms and numerics for mean reverting asset trading Q Zhang C Zhuang and G Yin

**Algebra Without Borders** Melanija Mitrović, Mahouton Norbert Hounkonnou, 2025-09-26 This book addresses the well known capability and flexibility of classical and constructive semigroups inherited from algebraic structures to model solve problems in extremely diverse situations and develop interesting new algebraic ideas with many applications and connections to other areas of mathematics logic biomathematics analysis geometry etc natural sciences engineering and life sciences interconnections between semigroups cognitive sciences social sciences arts and humanities The book promotes the idea that algebra came at the core of interdisciplinarity belongs to all life disciplines and serves in a variety of mathematics applications It focuses on recent developments in classical and constructive semigroups and other basic algebraic structures as well as on some of their potential applications in other fields Further it helps shed light on ways in which classical and constructive semigroups have been developing and applying in various domains and extended with other sciences The content is based on contributions of an international team of renowned scientists with expertise in different disciplines of mathematics classical and constructive semigroups other algebraic structures and their applications in logic cognitive sciences linguistics biology machine learning and collective phenomena

**Piecewise Deterministic Processes in Biological Models** Ryszard Rudnicki, Marta Tyran-Kamińska, 2017-07-20 This book presents a concise introduction to piecewise deterministic Markov processes PDMPs

with particular emphasis on their applications to biological models Further it presents examples of biological phenomena such as gene activity and population growth where different types of PDMPs appear continuous time Markov chains deterministic processes with jumps processes with switching dynamics and point processes Subsequent chapters present the necessary tools from the theory of stochastic processes and semigroups of linear operators as well as theoretical results concerning the long time behaviour of stochastic semigroups induced by PDMPs and their applications to biological models As such the book offers a valuable resource for mathematicians and biologists alike The first group will find new biological models that lead to interesting and often new mathematical questions while the second can observe how to include seemingly disparate biological processes into a unified mathematical theory and to arrive at revealing biological conclusions The target audience primarily comprises of researchers in these two fields but the book will also benefit graduate students

**Mathematical Methods in Robust Control of Linear Stochastic Systems** Vasile Dragan, Toader

Morozan, Adrian-Mihail Stoica, 2013-10-04 This second edition of Mathematical Methods in the Robust Control of Linear Stochastic Systems includes a large number of recent results in the control of linear stochastic systems More specifically the new results presented are A unified and abstract framework for Riccati type equations arising in the stochastic control Stability and control problems for systems perturbed by homogeneous Markov processes with infinite number of states Mixed H<sub>2</sub>/H<sub>∞</sub> control problem and numerical procedures Linear differential equations with positive evolution on ordered Banach spaces with applications for stochastic systems including both multiplicative white noise and Markovian jumps represented by a Markov chain with countable infinite set of states Kalman filtering for stochastic systems subject both to state dependent noise and Markovian jumps H<sub>∞</sub> reduced order filters for stochastic systems The book will appeal to graduate students researchers in advanced control engineering finance mathematical systems theory applied probability and stochastic processes and numerical analysis From Reviews of the First Edition This book is concerned with robust control of stochastic systems One of the main features is its coverage of jump Markovian systems Overall this book presents results taking into consideration both white noise and Markov chain perturbations It is clearly written and should be useful for people working in applied mathematics and in control and systems theory The references cited provide further reading sources George Yin Mathematical Reviews Issue 2007 m This book considers linear time varying stochastic systems subjected to white noise disturbances and system parameter Markovian jumping in the context of optimal control robust stabilization and disturbance attenuation The material presented in the book is organized in seven chapters The book is very well written and organized is a valuable reference for all researchers and graduate students in applied mathematics and control engineering interested in linear stochastic time varying control systems with Markovian parameter jumping and white noise disturbances Zoran Gajic SIAM Review Vol 49 3 2007 Option Pricing and Estimation of Financial Models with

R Stefano M. Iacus, 2011-02-23 Presents inference and simulation of stochastic process in the field of model calibration for

financial times series modelled by continuous time processes and numerical option pricing Introduces the bases of probability theory and goes on to explain how to model financial times series with continuous models how to calibrate them from discrete data and further covers option pricing with one or more underlying assets based on these models Analysis and implementation of models goes beyond the standard Black and Scholes framework and includes Markov switching models Levy models and other models with jumps e g the telegraph process Topics other than option pricing include volatility and covariation estimation change point analysis asymptotic expansion and classification of financial time series from a statistical viewpoint The book features problems with solutions and examples All the examples and R code are available as an additional R package therefore all the examples can be reproduced

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*Mathematical Reviews*, 2003

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**Switching Diffusion Systems with Past-dependent Switching Having a Countable State Space** Hai Dang Nguyen, 2018 Emerging and existing applications in wireless communications queueing networks biological models financial engineering and social networks demand the mathematical modeling and analysis of hybrid models in which continuous dynamics and discrete events coexist Assuming that the systems are in continuous times stemming from stochastic differential equation based models and random discrete events switching diffusions come into being In such systems continuous states and discrete events discrete states coexist and interact A switching diffusion is a two component process  $X_t$   $\alpha_t$  a continuous component and a discrete component taking values in a discrete set a set consisting of isolated points When the discrete component takes a value  $i$  i e  $\alpha_t = i$  the continuous component  $X_t$  evolves according to the diffusion process whose drift and diffusion coefficients depend on  $i$  Until very recently in most of the literature  $\alpha_t$  was assumed to be a process taking values in a finite set and that the switching rates of  $\alpha_t$  are either independent or depend only on the current state of  $X_t$  To be able to treat more realistic models and to broaden the applicability this dissertation undertakes the task of investigating the dynamics of  $X_t$   $\alpha_t$  in a much more general setting in which  $\alpha_t$  has a countable state space and its switching intensities depend on the history of the continuous component  $X_t$  We systematically established important properties of this system well posedness the Markov Feller property and the recurrence and ergodicity of the associated function valued process We have also studied several types of stability for the system

*Stochastic Control of Hereditary Systems and Applications* Mou-Hsiung Chang, 2008-01-03 This research monograph develops the Hamilton Jacobi Bellman HJB theory via the dynamic programming principle for a class of optimal control problems for stochastic hereditary differential equations SHDEs driven by a standard Brownian motion and with a bounded or an unbounded but fading memory These equations represent a class of infinite dimensional stochastic systems that become increasingly important and have wide range of

applications in physics chemistry biology engineering and economics nance The wide applicability of these systems is due to the fact that the reaction of re world systems to exogenous e ects signals is never instantaneous and it needs some time time that can be translated into a mathematical language by some delay terms Therefore to describe these delayed e ects the drift and di usion coe cients of these stochastic equations depend not only on the current state but also explicitly on the past history of the state variable The theory developed herein extends the nite dimensional HJB theory of controlled di usion processes to its in nite dimensional counterpart for c trolledSHDEsinwhichacertainin nite dimensionalBanachspaceorHilbert space is critically involved in order to account for the bounded or unbounded memory Another type of in nite dimensional HJB theory that is not treated in this monograph but arises from real world application problems can often be modeled by controlled stochastic partial di erential equations Although they are both in nite dimensional in nature and are both in the infancy of their developments the SHDE exhibits many characteristics that are not in common with stochastic partial di erential equations Consequently the HJB theory for controlled SHDEs is parallel to and cannot betreated as a subset of the theory developed for controlled stochastic partial di erential equations      Hybrid Stochastic Systems Tuan A. Hoang,2017

This dissertation is concerned with the so called stochastic hybrid systems which are featured by the coexistence of continuous dynamics and discrete events and their interactions Such systems have drawn much needed attentions in recent years One of the main reasons is that such systems can be used to better reflect the reality for a wide range of applications in networked systems communication systems economic systems cyber physical systems and biological and ecological systems among others Our main interest is centered around one class of such hybrid systems known as switching diffusions In such a system in addition to the driving force of a Brownian motion as in a stochastic system represented by a stochastic differential equation SDE there is an additional continuous time switching process that models the environmental changes due to random events In the first part we develops numerical schemes for stochastic differential equations with Markovian switching Markovian switching SDEs By utilizing a special form of It o s formula for switching SDEs and special structural of the jumps of the switching component we derived a new scheme to simulate switching SDEs in the spirit of Milstein s scheme for purely SDEs We also develop a new approach to establish the convergence of the proposed algorithm that incorporates martingale methods quadratic variations and Markovian stopping times Detailed and delicate analysis is carried out Under suitable conditions which are natural extensions of the classical ones the convergence of the algorithms is established The rate of convergence is also ascertained The second part is concerned with a limit theorem for general stochastic differential equations with Markovian regime switching Given a sequence of stochastic regime switching systems where the discrete switching processes are independent of the state of the systems In the first part we develops numerical schemes for stochastic differential equations with Markovian switching Markovian switching SDEs By utilizing a special form of Ito s formula for switching SDEs and special structural of the jumps of the switching component we derived a new scheme to

simulate switching SDEs in the spirit of Milstein's scheme for purely SDEs. We also develop a new approach to establish the convergence of the proposed algorithm that incorporates martingale methods, quadratic variations and Markovian stopping times. Detailed and delicate analysis is carried out. Under suitable conditions which are natural extensions of the classical ones, the convergence of the algorithms is established. The rate of convergence is also ascertained. The second part is concerned with a limit theorem for general stochastic differential equations with Markovian regime switching. Given a sequence of stochastic regime switching systems where the discrete switching processes are independent of the state of the systems, the continuous state component of these systems are governed by stochastic differential equations with driving processes that are continuous increasing processes and square integrable martingales. We establish the convergence of the sequence of systems to the one described by a state independent regime switching diffusion process when the two driving processes converge to the usual time process and the Brownian motion in suitable sense. The third part is concerned with controlled hybrid systems that are good approximations to controlled switching diffusion processes. In lieu of a Brownian motion noise, we use a wide band noise formulation which facilitates the treatment of non Markovian models. The wide band noise is one whose spectrum has band width wide enough. We work with a basic stationary mixing type process. On top of this wide band noise process, we allow the system to be subject to random discrete event influence. The discrete event process is a continuous time Markov chain with a finite state space. Although the state space is finite, we assume that the state space is rather large and the Markov chain is irreducible. Using a two time scale formulation and assuming the Markov chain also subjects to fast variations, using weak convergence and singular perturbation test function method, we first proved that when controlled by nearly optimal and equilibrium controls, the state and the corresponding costs of the original systems would converge to those of controlled diffusions systems. Using the limit controlled dynamic system as a guidance, we construct controls for the original problem and show that the controls so constructed are near optimal and nearly equilibrium.

Controlled Diffusion Processes N.V. Krylov, 2011-10-12. Stochastic control theory is a relatively young branch of mathematics. The beginning of its intensive development falls in the late 1950s and early 1960s. During that period, an extensive literature appeared on optimal stochastic control using the quadratic performance criterion (see references in Wonham 76J). At the same time, Girsanov 25J and Howard 26J made the first steps in constructing a general theory based on Bellman's technique of dynamic programming developed by him somewhat earlier 4J. Two types of engineering problems engendered two different parts of stochastic control theory. Problems of the first type are associated with multistep decision making in discrete time and are treated in the theory of discrete stochastic dynamic programming. For more on this theory, we note in addition to the work of Howard and Bellman mentioned above, the books by Derman 8J, Mine and Osaki 55J, and Dynkin and Yushkevich 12. Another class of engineering problems which encouraged the development of the theory of stochastic control involves time continuous control of a dynamic system in the presence of random noise. The case where the



system is described by a differential equation and the noise is modeled as a time continuous random process is the core of the optimal control theory of diffusion processes This book deals with this latter theory Probabilistic Reachability for Stochastic Hybrid Systems Alessandro Abate,2007 Qualitative Properties of Stochastic Hybrid Systems and Applications Mohamad Alwan,2011 Hybrid systems with or without stochastic noise and with or without time delay are addressed and the qualitative properties of these systems are investigated The main contribution of this thesis is distributed in three parts In Part I nonlinear stochastic impulsive systems with time delay SISD with variable impulses are formulated and some of the fundamental properties of the systems such as existence of local and global solution uniqueness and forward continuation of the solution are established After that stability and input to state stability ISS properties of SISD with fixed impulses are developed where Razumikhin methodology is used These results are then carried over to discussed the same qualitative properties of large scale SISD Applications to automated control systems and control systems with faulty actuators are used to justify the proposed approaches Part II is devoted to address ISS of stochastic ordinary and delay switched systems To achieve a variety stability like results multiple Lyapunov technique as a tool is applied Moreover to organize the switching among the system modes a newly developed initial state dependent dwell time switching law and Markovian switching are separately employed Part III deals with systems of differential equations with piecewise constant arguments with and without random noise These systems are viewed as a special type of hybrid systems Existence and uniqueness results are first obtained Then comparison principles are established which are later applied to develop some stability results of the systems

**Stochastic Methods and their Applications to Communications** Serguei Primak,Valeri Kontorovich,Vladimir Lyandres,2005-01-28 Stochastic Methods their Applications to Communications presents a valuable approach to the modelling synthesis and numerical simulation of random processes with applications in communications and related fields The authors provide a detailed account of random processes from an engineering point of view and illustrate the concepts with examples taken from the communications area The discussions mainly focus on the analysis and synthesis of Markov models of random processes as applied to modelling such phenomena as interference and fading in communications Encompassing both theory and practice this original text provides a unified approach to the analysis and generation of continuous impulsive and mixed random processes based on the Fokker Planck equation for Markov processes Presents the cumulated analysis of Markov processes Offers a SDE Stochastic Differential Equations approach to the generation of random processes with specified characteristics Includes the modelling of communication channels and interferences using SDE Features new results and techniques for the of solution of the generalized Fokker Planck equation Essential reading for researchers engineers and graduate and upper year undergraduate students in the field of communications signal processing control physics and other areas of science this reference will have wide ranging appeal **Applied Stochastic Control of Jump Diffusions** Bernt Øksendal,Agnès Sulem,2005-11-25 Here is a rigorous introduction to the most important and useful

solution methods of various types of stochastic control problems for jump diffusions and its applications Discussion includes the dynamic programming method and the maximum principle method and their relationship The text emphasises real world applications primarily in finance Results are illustrated by examples with end of chapter exercises including complete solutions The 2nd edition adds a chapter on optimal control of stochastic partial differential equations driven by Lévy processes and a new section on optimal stopping with delayed information Basic knowledge of stochastic analysis measure theory and partial differential equations is assumed

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