

**CONTROL  
ENGINEERING**

Andrey V. Savkin

Robin J. Evans

# Hybrid Dynamical Systems

Controller and Sensor  
Switching Problems

**Birkhäuser**

# Hybrid Dynamical Systems Controller And Sensor Switching Problems

**Andrey V. Savkin, Robin J. Evans**



## **Hybrid Dynamical Systems Controller And Sensor Switching Problems:**

*Hybrid Dynamical Systems* Andrey V. Savkin, Robin J. Evans, 2012-12-06 This book is primarily a research monograph that presents in a unified manner some recent research on a class of hybrid dynamical systems HDS The book is intended both for researchers and advanced postgraduate students working in the areas of control engineering theoretical computer science or applied mathematics and with an interest in the emerging field of hybrid dynamical systems The book assumes competence in the basic mathematical techniques of modern control theory The material presented in this book derives from a period of fruitful research collaboration between the authors that began in 1994 and is still ongoing Some of the material contained herein has appeared as isolated results in journal papers and conference proceedings This work presents this material in an integrated and coherent manner and also presents many new results Much of the material arose from joint work with students and colleagues and the authors wish to acknowledge the major contributions made by Ian Petersen Efstratios Skafidas Valery Ugrinovskii David Cook Iven Mareels and Bill Moran There is currently no precise definition of a hybrid dynamical system however in broad terms it is a dynamical system that involves a mixture of discrete valued and continuous valued variables Since the early 1990s a bewildering array of results have appeared under the umbrella of HDS ranging from the analysis of elementary on off control systems to sophisticated mathematical logic based descriptions of large real time software systems Switching in Systems and Control Daniel Liberzon, 2012-12-06 Many systems

encountered in practice involve a coupling between continuous dynamics and discrete events Systems in which these two kinds of dynamics coexist and interact are usually called hybrid For example the following phenomena give rise to hybrid behavior a valve or a power switch opening and closing a thermostat turning the heat on and off biological cells growing and dividing a server switching between buffers in a queueing network aircraft entering crossing and leaving an air traffic control region dynamics of a car changing abruptly due to wheels locking and unlocking on ice Hybrid systems constitute a relatively new and very active area of current research They present interesting theoretical challenges and are important in many real world problems Due to its inherently interdisciplinary nature the field has attracted the attention of people with diverse backgrounds primarily computer scientists applied mathematicians and engineers Researchers with a background and interest in continuous time systems and control theory are concerned primarily with properties of the continuous dynamics such as Lyapunov stability A detailed investigation of the discrete behavior on the other hand is usually not a goal in itself In fact rather than dealing with specifics of the discrete dynamics it is often useful to describe and analyze a more general category of systems which is known to contain a particular model of interest **On the Numerical Solution of**

**Nonlinear and Hybrid Optimal Control Problems** Matthias Rungger, 2012 Hybrid Feedback Control Ricardo G. Sanfelice, 2021-01-12 A comprehensive introduction to hybrid control systems and design Hybrid control systems exhibit both discrete changes or jumps and continuous changes or flow An example of a hybrid control system is the automatic control of

the temperature in a room the temperature changes continuously but the control algorithm toggles the heater on or off intermittently triggering a discrete jump within the algorithm Hybrid control systems feature widely across disciplines including biology computer science and engineering and examples range from the control of cellular responses to self driving cars Although classical control theory provides powerful tools for analyzing systems that exhibit either flow or jumps it is ill equipped to handle hybrid control systems In Hybrid Feedback Control Ricardo Sanfelice presents a self contained introduction to hybrid control systems and develops new tools for their analysis and design Hybrid behavior can occur in one or more subsystems of a feedback system and Sanfelice offers a unified control theory framework filling an important gap in the control theory literature In addition to the theoretical framework he includes a plethora of examples and exercises a Matlab toolbox as well as two open source versions and an insightful overview at the beginning of each chapter Relevant to dynamical systems theory applied mathematics and computer science Hybrid Feedback Control will be useful to students and researchers working on hybrid systems cyber physical systems control and automation

**Hybrid Systems: Computation and Control** Maria D. Di Benedetto, Alberto Sangiovanni-Vincentelli, 2001-03-14 This volume contains the proceedings of the Fourth Workshop on Hybrid Systems Computation and Control HSCC 2001 held in Rome Italy on March 28 30 2001 The Workshop on Hybrid Systems attracts researchers from industry and academia interested in modeling analysis synthesis and implementation of dynamic and reactive systems involving both discrete integer logical symbolic and continuous behaviors It is a forum for the discussion of the test developments in all aspects of hybrid systems including formal models and computational representations algorithms and heuristics computational tools and new challenging applications The Fourth HSCC International Workshop continues the series of workshops held in Grenoble France HART 97 Berkeley California USA HSCC 98 Nijmegen The Netherlands HSCC 99 and Pittsburgh Pennsylvania USA HSCC 2000 Proceedings of these workshops have been published in the Lecture Notes in Computer Science LNCS series by Springer Verlag In line with the beautiful work that led to the design of the palace in which the workshop was held Palazzo Lancellotti in Rome resulting from the collaboration of many artists and architects of different backgrounds the challenge faced by the hybrid system community is to harmonize and extract the best from two main research areas computer science and control theory

*Nonlinear Control of Dynamic Networks* Tengfei Liu, Zhong-Ping Jiang, David J. Hill, 2018-09-03 Significant progress has been made on nonlinear control systems in the past two decades However many of the existing nonlinear control methods cannot be readily used to cope with communication and networking issues without nontrivial modifications For example small quantization errors may cause the performance of a well designed nonlinear control system to deteriorate Motivated by the need for new tools to solve complex problems resulting from smart power grids biological processes distributed computing networks transportation networks robotic systems and other cutting edge control applications Nonlinear Control of Dynamic Networks tackles newly arising theoretical and real world challenges for stability analysis and control design including nonlinearity

dimensionality uncertainty and information constraints as well as behaviors stemming from quantization data sampling and impulses Delivering a systematic review of the nonlinear small gain theorems the text Supplies novel cyclic small gain theorems for large scale nonlinear dynamic networks Offers a cyclic small gain framework for nonlinear control with static or dynamic quantization Contains a combination of cyclic small gain and set valued map designs for robust control of nonlinear uncertain systems subject to sensor noise Presents a cyclic small gain result in directed graphs and distributed control of nonlinear multi agent systems with fixed or dynamically changing topology Based on the authors recent research Nonlinear Control of Dynamic Networks provides a unified framework for robust quantized and distributed control under information constraints Suggesting avenues for further exploration the book encourages readers to take into consideration more communication and networking issues in control designs to better handle the arising challenges **Set-theoretic**

**Fault-tolerant Control in Multisensor Systems** Florin Stoican, Sorin Olaru, 2013-06-12 Fault tolerant control theory is a well studied topic but the use of the sets in detection isolation and or reconfiguration is rather tangential The authors of this book propose a systematic analysis of the set theoretic elements and devise approaches which exploit advanced elements within the field The main idea is to translate fault detection and isolation conditions into those conditions involving sets Furthermore these are to be computed efficiently using positive invariance and reachability notions Constraints imposed by exact fault control are used to define feasible references which impose persistent excitation and thus non convex feasible sets Particular attention is given to the reciprocal influences between fault detection and isolation on the one hand and control reconfiguration on the other Contents 1 State of the Art in Fault tolerant Control 2 Fault Detection and Isolation in Multisensor Systems 3 Residual Generation and Reference Governor Design 4 Reconfiguration of the Control Mechanism for Fault tolerant Control 5 Related Problems and Applications About the Authors Florin Stoican received a B E degree from the Politehnica University of Bucharest Romania in 2008 and his PhD from SUPELEC France in 2011 He held an ERCIM Postdoctoral Fellowship with NTNU Trondheim Norway in 2012 and is currently Assistant Professor at Politehnica University of Bucharest His main interest is the fault tolerant control of dynamical systems through the prism of set theoretic elements His current work involves further results in set theory and constrained optimization problems Sorin Olaru received an M S degree from the Politehnica University of Bucharest Romania and both his PhD and Habilitation from University Paris XI France being awarded the European Commission Archimedes Prize in 2002 Since 2001 he has held different positions at INRIA and SUPELEC in France and visiting appointments at the University of Newcastle Australia and NTNU Trondheim Norway He is currently Professor at SUPELEC a member of the INRIA Disco team and senior member of IEEE His research interests include optimization based control design and the set theoretic characterization of constrained dynamical systems

**Nonlinear Hybrid Continuous/Discrete-Time Models** Marat Akhmet, 2011-05-03 The book is mainly about hybrid systems with continuous discrete time dynamics The major part of the book consists of the theory of equations with piece

wise constant argument of generalized type The systems as well as technique of investigation were introduced by the author very recently They both generalized known theory about differential equations with piece wise constant argument introduced by K Cook and J Wiener in the 1980s Moreover differential equations with fixed and variable moments of impulses are used to model real world problems We consider models of neural networks blood pressure distribution and a generalized model of the cardiac pacemaker All the results of the manuscript have not been published in any book yet They are very recent and united with the presence of the continuous discrete dynamics of time It is of big interest for specialists in biology medicine engineering sciences electronics Theoretical aspects of the book meet very strong expectations of mathematicians who investigate differential equations with discontinuities of any type

**Switched Linear Systems** Zhendong Sun, 2006-03-30

Switched linear systems have enjoyed a particular growth in interest since the 1990s The large amount of data and ideas thus generated have until now lacked a co ordinating framework to focus them effectively on some of the fundamental issues such as the problems of robust stabilizing switching design feedback stabilization and optimal switching This deficiency is resolved by this book which features nucleus of constructive design approaches based on canonical decomposition and forming a sound basis for the systematic treatment of secondary results theoretical exploration and logical association of several independent but pivotal concerns in control design as they pertain to switched linear systems controllability and observability feedback stabilization optimization and periodic switching a reliable foundation for further theoretical research as well as design guidance for real life engineering applications through the integration of novel ideas fresh insights and rigorous results

*Communications for Control in Cyber Physical Systems* Husheng Li, 2016-07-08

Communications and Controls in Cyber Physical Systems Theory Design and Applications in Smart Grids provides readers with all they need to know about cyber physical systems CPSs such as smart grids which have attracted intensive studies in recent years Communications and controls are of key importance for maintaining and stabilizing the operation of the physical dynamics in these complicated systems This book presents a systematic treatment on the communication and control aspects of CPSs along with applications to the smart grid in four parts including the basics of CPS communications and controls an explanation of the integration with CPS coverage of controls with information constraints in CPS and an applications oriented focus on smart grids as a CPS Drawing upon years of practical experience and using numerous examples and illustrations the authors discuss key communication and controls design methods that can be integrated into a CPS how communication and control schemes can be applied in practical systems such as smart grids new directions and approaches for traditional engineers and researchers in communications and controls and power systems as they relates to CPSs Presents a systematic treatment on the communication and control aspects of cyber physical systems CPSs Discusses key communication and controls design methods that can be integrated into a CPS Demonstrates how communication and control schemes can be applied in practical systems such as smart grids Includes new directions and approaches for traditional engineers and

researchers in communications controls and power systems as they relate to CPSs      Fractional Dynamical Systems: Methods, Algorithms and Applications Piotr Kulczycki, Józef Korbicz, Janusz Kacprzyk, 2022-01-04 This book presents a wide and comprehensive spectrum of issues and problems related to fractional order dynamical systems It is meant to be a full fledge comprehensive presentation of many aspects related to the broadly perceived fractional order dynamical systems which constitute an extension of the traditional integer order type descriptions This implies far reaching consequences both analytic and algorithmic because in general properties of the traditional integer order systems cannot be directly extended by a straightforward generalization to fractional order systems modeled by fractional order differential equations involving derivatives of a non integer order This can be useful for describing and analyzing for instance anomalies in the behavior of various systems chaotic behavior etc The book contains both analytic contributions with state of the art and theoretical foundations algorithmic implementation of tools and techniques and finally some examples of relevant and successful practical applications      *Safe Robot Navigation Among Moving and Steady Obstacles* Andrey V. Savkin, Alexey S. Matveev, Michael Hoy, Chao Wang, 2015-09-25 Safe Robot Navigation Among Moving and Steady Obstacles is the first book to focus on reactive navigation algorithms in unknown dynamic environments with moving and steady obstacles The first three chapters provide introduction and background on sliding mode control theory sensor models and vehicle kinematics Chapter 4 deals with the problem of optimal navigation in the presence of obstacles Chapter 5 discusses the problem of reactively navigating In Chapter 6 border patrolling algorithms are applied to a more general problem of reactively navigating A method for guidance of a Dubins like mobile robot is presented in Chapter 7 Chapter 8 introduces and studies a simple biologically inspired strategy for navigation a Dubins car Chapter 9 deals with a hard scenario where the environment of operation is cluttered with obstacles that may undergo arbitrary motions including rotations and deformations Chapter 10 presents a novel reactive algorithm for collision free navigation of a nonholonomic robot in unknown complex dynamic environments with moving obstacles Chapter 11 introduces and examines a novel purely reactive algorithm to navigate a planar mobile robot in densely cluttered environments with unpredictably moving and deforming obstacles Chapter 12 considers a multiple robot scenario For the Control and Automation Engineer this book offers accessible and precise development of important mathematical models and results All the presented results have mathematically rigorous proofs On the other hand the Engineer in Industry can benefit by the experiments with real robots such as Pioneer robots autonomous wheelchairs and autonomous mobile hospital First book on collision free reactive robot navigation in unknown dynamic environments Bridges the gap between mathematical model and practical algorithms Presents implementable and computationally efficient algorithms of robot navigation Includes mathematically rigorous proofs of their convergence A detailed review of existing reactive navigation algorithm for obstacle avoidance Describes fundamentals of sliding mode control      **Closed-Loop Control of Blood Glucose** Frederick Chee, Tyrone Fernando, 2007-10-01 This book presents closed

loop blood glucose control in a simple manner which includes the hardware and software components that make up the control system. It provides examples on how mathematical models are formulated as well as the control algorithms that stem from mathematical exercises. The book also describes the basic physiology of blood glucose regulation during fasting and meal from a functional level. Nonlinear Systems and Controls Jürgen Adamy, 2024-03-30. This textbook provides a clear introduction to the theory and application of nonlinear systems and controls. The author explains the methods of nonlinear control which are known from control theory research and are becoming increasingly important in industrial applications. The fundamentals of nonlinear dynamics, stability theory, controllability, nonlinear control of linear and nonlinear systems, and nonlinear state transformations are covered. Furthermore, the concepts of observability and the theory and application of nonlinear observers are described. The main features of the book are the comprehensive presentation of the theory, excellent comprehensibility, many example applications, and more than a hundred exercises with solutions which are illustrated by numerous color diagrams. This book is aimed at advanced engineering students and engineers in industry. **Scientia Magna, Vol. 6, No. 2, 2010** Zhang Wenpeng, Papers on Smarandache's Orthic Theorem, Smarandache's Concurrent Lines Theorem, character graph in Brauer graph's model, robust stability of switched linear systems with time-varying delay, majority neighborhood number of a graph, divisibility tests for Smarandache semigroups, Hopf bifurcation in a predator-prey model with distributed delays, and similar topics. Contributors: R. S. Maragatham, S. Asawasamarit, U. Leerawat, S. Balasubramanian, D. Senthilkumar, M. Khoshnevisan, D. Senthilkumar, Sherinjoy, S. M. and others. Evolution Equations: Applications to Physics, Industry, Life Sciences and Economics Mimmo Iannelli, Gunter Lumer, 2012-12-06. The seventh International Conference on Evolution Equations and their main areas of Applications, where the emphasis evolves as time and problems change, was held October 30 to November 4 at the CIRM Centro Internazionale per la Ricerca Matematica in Trento, Italy. In keeping with the basic principles and the recent tendencies governing these International Conferences, it brought together many of the world's leading experts in the fields mentioned, with particular effort on facilitating the interaction of established scientists and emerging young promising researchers, as well as the interaction of pure and applied specialists. In the latter directions, emphasis was extended here to include, in addition to Physical and Life Sciences, also Industry and Economics. Topics among the recent advances treated here concern new developments in moving boundary problems, asymptotics in non-linear Volterra equations, and other asymptotics-related developments, Poincaré inequality on stratified sets, time operator and Markov processes in physics, related advances, behavior of granular matter, stochastic aspects of Hamilton-Jacobi-Bellman equation, very general Paley-Wiener results applied to both classical and generalized functions, Ornstein-Uhlenbeck operators and processes, quasilinear PDEs with memory operators, semi-group approach in economics, pricing theory, and other semi-group-related developments, convolution evolution equation in aeroelasticity, new developments in the study of age-structured models, new developments in maximal regularity. **Intelligent**



**Manufacturing Systems 2003** Gérard Morel, Botond Kádár, László Monostori, 2003 Presents the findings of experts and practitioners from the major soft computing themes Provides an overview of the theory and applications of IMS systems The Area of Intelligence in manufacturing has generated a considerable amount of interest occasionally verging on controversy both in the research community and in the industrial sector This proceedings looks at the broad manufacturing domain dealing with both technical and organizational issues intelligent control is only part albeit important of optimal integration and control of intelligent techniques The importance of creating a synergy of efforts aiming at efficient employment of intelligence in global technological development for manufacturing was recognized by the international IMS intelligent manufacturing Systems Initiative and is discussed in this proceedings volume Secure Localization and Time Synchronization for Wireless Sensor and Ad Hoc Networks Radha Poovendran, Cliff Wang, Sumit Roy, 2007-12-03 Localization is a critical process in mobile ad hoc networks and wireless sensor networks Wireless sensor node or MANET devices need to know the network's location or its relative location with respect to the rest of the network neighbors However due to the open spectrum nature of wireless communication it is subject to attacks and intrusions Hence the wireless network synchronization needs to be both robust and secure Furthermore issues such as energy constraints and mobility make the localization process even more challenging Secure Localization and Time Synchronization for Wireless Sensor and Ad Hoc Networks presents the latest research results in the area of secure localization for both wireless mobile ad hoc networks and wireless sensor networks Handbook of Applications of Chaos Theory Christos H. Skiadas, Charilaos Skiadas, 2017-12-19 In addition to explaining and modeling unexplored phenomena in nature and society chaos uses vital parts of nonlinear dynamical systems theory and established chaotic theory to open new frontiers and fields of study Handbook of Applications of Chaos Theory covers the main parts of chaos theory along with various applications to diverse areas Expert contributors from around the world show how chaos theory is used to model unexplored cases and stimulate new applications Accessible to scientists engineers and practitioners in a variety of fields the book discusses the intermittency route to chaos evolutionary dynamics and deterministic chaos and the transition to phase synchronization chaos It presents important contributions on strange attractors self-exciting and hidden attractors stability theory Lyapunov exponents and chaotic analysis It explores the state of the art of chaos in plasma physics plasma harmonics and overtone coupling It also describes flows and turbulence chaotic interference versus decoherence and an application of microwave networks to the simulation of quantum graphs The book proceeds to give a detailed presentation of the chaotic rogue and noisy optical dissipative solitons parhelic like circle and chaotic light scattering and interesting forms of the hyperbolic prism the Poincaré disc and foams It also covers numerous application areas from the analysis of blood pressure data and clinical digital pathology to chaotic pattern recognition to economics to musical arts and research *Emergent Problems in Nonlinear Systems and Control* Bijoy Ghosh, Clyde F. Martin, Yishao Zhou, 2009-10-13 Papers in this collection partly represent the set of talks that were presented at Texas Tech

University on the occasion of Daya s memorial workshop in the year 2007 Daya had a varied interest in the field of Dynamics and Control Theory and the papers bring out the essence of his involvement in these activities He also had a large number of collaborators and this collection represent a good fraction of them The papers included here cover his interest in control theory Also included are papers from application areas that we believe are of strong interest to him

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