



# Sliding Mode Control

**B. Bandyopadhyay, S. Janardhanan**



## **Sliding Mode Control:**

Sliding Mode Control and Observation Yuri Shtessel, Christopher Edwards, Leonid Fridman, Arie Levant, 2013-06-01 The sliding mode control methodology has proven effective in dealing with complex dynamical systems affected by disturbances uncertainties and unmodeled dynamics Robust control technology based on this methodology has been applied to many real world problems especially in the areas of aerospace control electric power systems electromechanical systems and robotics Sliding Mode Control and Observation represents the first textbook that starts with classical sliding mode control techniques and progresses toward newly developed higher order sliding mode control and observation algorithms and their applications The present volume addresses a range of sliding mode control issues including Conventional sliding mode controller and observer design Second order sliding mode controllers and differentiators Frequency domain analysis of conventional and second order sliding mode controllers Higher order sliding mode controllers and differentiators Higher order sliding mode observers Sliding mode disturbance observer based control Numerous applications including reusable launch vehicle and satellite formation control blood glucose regulation and car steering control are used as case studies Sliding Mode Control and Observation is aimed at graduate students with a basic knowledge of classical control theory and some knowledge of state space methods and nonlinear systems while being of interest to a wider audience of graduate students in electrical mechanical aerospace engineering and applied mathematics as well as researchers in electrical computer chemical civil mechanical aeronautical and industrial engineering applied mathematicians control engineers and physicists Sliding Mode Control and Observation provides the necessary tools for graduate students researchers and engineers to robustly control complex and uncertain nonlinear dynamical systems Exercises provided at the end of each chapter make this an ideal text for an advanced course taught in control theory

Road Map for Sliding Mode Control Design Vadim Utkin, Alex Poznyak, Yury V. Orlov, Andrey Polyakov, 2020-04-13 This book is devoted to control of finite and infinite dimensional processes with continuous time and discrete time control focusing on suppression problems and new methods of adaptation applicable for systems with sliding motions only Special mathematical methods are needed for all the listed control tasks These methods are addressed in the initial chapters with coverage of the definition of the multidimensional sliding modes the derivation of the differential equations of those motions and the existence conditions Subsequent chapters discuss various areas of further research The book reflects the consensus view of the authors regarding the current status of SMC theory It is addressed to a broad spectrum of engineers and theoreticians working in diverse areas of control theory and applications It is well suited for use in graduate and postgraduate courses in such university programs as Electrical Engineering Control of Nonlinear Systems and Mechanical Engineering

Sliding Mode Control In Engineering Wilfrid Perruquetti, Jean-Pierre Barbot, 2002-01-29 Provides comprehensive coverage of the most recent developments in the theory of non Archimedean pseudo differential equations and its application to stochastics and mathematical physics offering current methods of

construction for stochastic processes in the field of  $p$  adic numbers and related structures Develops a new theory for parabolic equations

*Modern Sliding Mode Control Theory* Giorgio Bartolini, Leonid Fridman, Alessandro Pisano, Elio Usai, 2008-04-05 This concise book covers modern sliding mode control theory The authors identify key contributions defining the theoretical and applicative state of the art of the sliding mode control theory and the most promising trends of the ongoing research activities

**Sliding Mode Control in Electro-Mechanical Systems** Vadim Utkin, Juergen Guldner, Jingxin Shi, 2017-12-19 Apply Sliding Mode Theory to Solve Control Problems Interest in SMC has grown rapidly since the first edition of this book was published This second edition includes new results that have been achieved in SMC throughout the past decade relating to both control design methodology and applications In that time Sliding Mode Control SMC has continued to gain increasing importance as a universal design tool for the robust control of linear and nonlinear electro mechanical systems Its strengths result from its simple flexible and highly cost effective approach to design and implementation Most importantly SMC promotes inherent order reduction and allows for the direct incorporation of robustness against system uncertainties and disturbances These qualities lead to dramatic improvements in stability and help enable the design of high performance control systems at low cost Written by three of the most respected experts in the field including one of its originators this updated edition of Sliding Mode Control in Electro Mechanical Systems reflects developments in the field over the past decade It builds on the solid fundamentals presented in the first edition to promote a deeper understanding of the conventional SMC methodology and it examines new design principles in order to broaden the application potential of SMC SMC is particularly useful for the design of electromechanical systems because of its discontinuous structure In fact where the hardware of many electromechanical systems such as electric motors prescribes discontinuous inputs SMC becomes the natural choice for direct implementation This book provides a unique combination of theory implementation issues and examples of real life applications reflective of the authors own industry leading work in the development of robotics automobiles and other technological breakthroughs

**Emerging Trends in Sliding Mode Control** Axaykumar Mehta, Bijan Bandyopadhyay, 2020-12-21 This book compiles recent developments on sliding mode control theory and its applications Each chapter presented in the book proposes new dimension in the sliding mode control theory such as higher order sliding mode control event triggered sliding mode control networked control higher order discrete time sliding mode control and sliding mode control for multi agent systems Special emphasis has been given to practical solutions to design involving new types of sliding mode control This book is a reference guide for graduate students and researchers working in the domain for designing sliding mode controllers The book is also useful to professional engineers working in the field to design robust controllers for various applications

**Sliding Mode Control Using MATLAB** Jinkun Liu, 2017-05-25 Sliding Mode Control Using MATLAB provides many sliding mode controller design examples along with simulation examples and MATLAB programs Following the review of sliding mode control the book

includes sliding mode control for continuous systems robust adaptive sliding mode control sliding mode control for underactuated systems backstepping and dynamic surface sliding mode control sliding mode control based on filter and observer sliding mode control for discrete systems fuzzy sliding mode control neural network sliding mode control and sliding mode control for robot manipulators The contents of each chapter are independent providing readers with information they can use for their own needs It is suitable for the readers who work on mechanical and electronic engineering electrical automation engineering etc and can also be used as a teaching reference for universities Provides many sliding mode controller design examples to help readers solve their research and design problems Includes various implementable robust sliding mode control design solutions from engineering applications Provides the simulation examples and MATLAB programs for each sliding mode control algorithm

Discrete-time Sliding Mode Control B. Bandyopadhyay, S. Janardhanan, 2005-10-17 Sliding mode control is a simple and yet robust control technique where the system states are made to confine to a selected subset With the increasing use of computers and discrete time samplers in controller implementation in the recent past discrete time systems and computer based control have become important topics This monograph presents an output feedback sliding mode control philosophy which can be applied to almost all controllable and observable systems while at the same time being simple enough as not to tax the computer too much It is shown that the solution can be found in the synergy of the multirate output sampling concept and the concept of discrete time sliding mode control

*Advances in Sliding Mode Control* B Bandyopadhyay, S Janardhanan, Sarah K. Spurgeon, 2013-03-15 The sliding mode control paradigm has become a mature technique for the design of robust controllers for a wide class of systems including nonlinear uncertain and time delayed systems This book is a collection of plenary and invited talks delivered at the 12th IEEE International Workshop on Variable Structure System held at the Indian Institute of Technology Mumbai India in January 2012 After the workshop these researchers were invited to develop book chapters for this edited collection in order to reflect the latest results and open research questions in the area The contributed chapters have been organized by the editors to reflect the various themes of sliding mode control which are the current areas of theoretical research and applications focus namely articulation of the fundamental underpinning theory of the sliding mode design paradigm sliding modes for decentralized system representations control of time delay systems the higher order sliding mode concept results applicable to nonlinear and underactuated systems sliding mode observers discrete sliding mode control together with cutting edge research contributions in the application of the sliding mode concept to real world problems This book provides the reader with a clear and complete picture of the current trends in Variable Structure Systems and Sliding Mode Control Theory

**Fractional-Order Sliding Mode Control: Methodologies and Applications** Guanghui Sun, Chengwei Wu, Xiaolei Li, Zhiqiang Ma, Shidong Xu, Xiangyu Shao, 2024-06-21 This book delves deep into fractional order control and fractional order sliding mode techniques addressing key challenges in the control design of linear motor systems and control for the

deployment of space tethered systems Innovative strategies such as adaptive fractional order sliding mode control and fractional order fuzzy sliding mode control schemes are devised to enhance system performance Divided into three parts it covers a brief view of fractional order control strength in modeling and control fractional order sliding mode control of linear motor systems and fractional order sliding mode control for the deployment of space tethered systems Each chapter offers valuable insights and solutions Simulations and experiments validate the efficacy of these approaches making this book essential for researchers engineers and practitioners in control systems and aerospace engineering Sliding Mode Control Andrzej Bartoszewicz, 2011-04-11 The main objective of this monograph is to present a broad range of well worked out recent application studies as well as theoretical contributions in the field of sliding mode control system analysis and design The contributions presented here include new theoretical developments as well as successful applications of variable structure controllers primarily in the field of power electronics electric drives and motion steering systems They enrich the current state of the art and motivate and encourage new ideas and solutions in the sliding mode control area **Event-Triggered Sliding Mode Control** Bijan Bandyopadhyay, Abhisek K. Behera, 2018-02-20 This edited monograph provides a comprehensive and in depth analysis of sliding mode control focusing on event triggered implementation The technique allows to prefix the steady state bounds of the system and this is independent of any boundary disturbances The idea of event triggered SMC is developed for both single input single output and multi input multi output linear systems Moreover the reader learns how to apply this method to nonlinear systems The book primarily addresses research experts in the field of sliding mode control but the book may also be beneficial for graduate students Sliding Mode Control Using Novel Sliding Surfaces B. Bandyopadhyay, Fulwani Deepak, Kyung-Soo Kim, 2009-10-14 After a survey paper by Utkin in the late 1970s sliding mode control methodologies emerged as an effective tool to tackle uncertainty and disturbances which are inevitable in most of the practical systems Sliding mode control is a particular class of variable structure control which was introduced by Emel'yanov and his colleagues The design paradigms of sliding mode control has now become a mature design technique for the design of robust controller of uncertain system In sliding mode technique the state trajectory of the system is constrained on a chosen manifold or within some neighborhood thereof by an appropriate control action This manifold is also called a switching surface or a sliding surface During sliding mode system dynamics is governed by the chosen manifold which results in a well celebrated invariance property towards certain classes of disturbance and model mismatches The purpose of this monograph is to give a different dimension to sliding surface design to achieve high performance of the system Design of the switching surface is vital because the closed loop dynamics is governed by the parameters of the sliding surface Therefore sliding surface should be designed to meet the closed loop specifications Many systems demand high performance with robustness To address this issue of achieving high performance with robustness we propose nonlinear surfaces for different classes of systems The nonlinear surface is designed such that it changes the system's closed loop damping ratio from its

initial low value to a final high value      *Sliding Modes after the first Decade of the 21st Century* Leonid Fridman, Jaime Moreno, Rafael Iriarte, 2011-09-10 The book presents the newest results of the major world research groups working in the area of Variable Structure Systems and Sliding Mode Control VSS SMC The research activity of these groups is coordinated by the IEEE Technical Committee on Variable Structure Systems VSS and Sliding Modes SM The presented results include the reports of the research groups collaborating in a framework of the Uni n European Union M xico project of Fondo de Cooperaci n Internacional en Ciencia y Tecnolog a FONCICyT 93302 titled Automatization and Monitoring of Energy Production Processes via Sliding Mode Control The book starts with the overview of the sliding mode control concepts and algorithms that were developed and discussed in the last two decades The research papers are combined in three sections Part I VSS and SM Algorithms and their Analysis Part II SMC Design Part III Applications of VSS and SMC The book will be of interests of engineers researchers and graduate students working in the area of the control systems design Novel mathematical theories and engineering concepts of control systems are rigorously discussed and supported by numerous applications to practical tasks      Advances in Discrete-Time Sliding Mode Control Ahmadreza Argha, Steven Su, Li Li, Hung Tan Nguyen, Branko George Celler, 2018-06-14 The focus of this book is on the design of a specific control strategy using digital computers This control strategy referred to as Sliding Mode Control SMC has its roots in continuous time relay control This book aims to explain recent investigations output in the field of discrete time sliding mode control DSMC The book starts by explaining a new robust LMI based state feedback and observer based output feedback DSMC including a new scheme for sparsely distributed control It includes a novel event driven control mechanism called actuator based event driven scheme using a synchronized rate biofeedback system for heart rate regulation during cycle ergometer Key Features Focuses on LMI based SMC sliding mode control for uncertain discrete time system using novel nonlinear components in the control law Makes reader understand the techniques of designing a discrete controller based on the flexible sliding functions Proposes new algorithms for sparsifying control and observer network through multi objective optimization frameworks Discusses a framework for the design of SMC for two dimensional systems along with analyzing the controllability of two dimensional systems Discusses novel schemes for sparsifying the control network      *Advances and Applications in Sliding Mode Control systems* Ahmad Taher Azar, Quanmin Zhu, 2014-11-01 This book describes the advances and applications in Sliding mode control SMC which is widely used as a powerful method to tackle uncertain nonlinear systems The book is organized into 21 chapters which have been organised by the editors to reflect the various themes of sliding mode control The book provides the reader with a broad range of material from first principles up to the current state of the art in the area of SMC and observation presented in a clear matter of fact style As such it is appropriate for graduate students with a basic knowledge of classical control theory and some knowledge of state space methods and nonlinear systems The resulting design procedures are emphasized using Matlab Simulink software      **Sliding Mode Control** Hebertt

Sira-Ramírez,2015-05-25 This monograph presents a novel method of sliding mode control for switch regulated nonlinear systems The Delta Sigma modulation approach allows one to implement a continuous control scheme using one or multiple independent switches thus effectively merging the available linear and nonlinear controller design techniques with sliding mode control Sliding Mode Control The Delta Sigma Modulation Approach combines rigorous mathematical derivation of the unique features of Sliding Mode Control and Delta Sigma modulation with numerous illustrative examples from diverse areas of engineering In addition engineering case studies demonstrate the applicability of the technique and the ease with which one can implement the exposed results This book will appeal to researchers in control engineering and can be used as graduate level textbook for a first course on sliding mode control      **Applications of Sliding Mode Control** Nabil

Derbel,Jawhar Ghommam,Quanmin Zhu,2016-10-14 This book presents essential studies and applications in the context of sliding mode control highlighting the latest findings from interdisciplinary theoretical studies ranging from computational algorithm development to representative applications Readers will learn how to easily tailor the techniques to accommodate their ad hoc applications To make the content as accessible as possible the book employs a clear route in each paper moving from background to motivation to quantitative development equations and lastly to case studies illustrations tutorials simulations experiences curves tables etc Though primarily intended for graduate students professors and researchers from related fields the book will also benefit engineers and scientists from industry      **Recent Advances in Sliding Modes:**

**From Control to Intelligent Mechatronics** Xinghuo Yu,Mehmet Önder Efe,2015-04-10 This volume is dedicated to Professor Okay Kaynak to commemorate his life time impactful research and scholarly achievements and outstanding services to profession The 21 invited chapters have been written by leading researchers who in the past have had association with Professor Kaynak as either his students and associates or colleagues and collaborators The focal theme of the volume is the Sliding Modes covering a broad scope of topics from theoretical investigations to their significant applications from Control to Intelligent Mechatronics      Sliding Mode Control for Synchronous Electric Drives Sergey E. Ryvkin,Eduardo

Palomar Lever,2011-11-21 This volume presents the theory of control systems with sliding mode applied to electrical motors and power converters It demonstrates the methodology of control design and the original algorithms of control and observation Practically all semiconductor devices are used in power converters that feed electrical motors as power switches A switch



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