



# Sliding Mode Control

**Yuri Shtessel, Christopher  
Edwards, Leonid Fridman, Arie Levant**



## **Sliding Mode Control:**

**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

### **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 equat

*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

**Emerging Trends in Sliding Mode Control** Axaykumar Mehta,Bijnan 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 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 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 **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

Variable-Structure Systems and Sliding-Mode Control Martin Steinberger, Martin Horn, Leonid Fridman, 2020-02-10 The book covers the latest theoretical results and sophisticated applications in the field of variable structure systems and sliding mode control This book is divided into four parts Part I discusses new higher order sliding mode algorithms including new homogeneous controllers and differentiators Part II then explores properties of continuous sliding mode algorithms such as saturated feedback control reaching time and orbital stability Part III is focused on the usage of variable structure systems VSS controllers for solving other control problems for example unmatched disturbances Finally Part IV discusses applications of VSS these include applications within power electronics and vehicle platooning Variable structure Systems and Sliding Mode Control will be of interest to academic researchers students and practising engineers

**Advances in Variable Structure Systems and Sliding Mode Control—Theory and Applications** Shihua Li, Xinghuo Yu, Leonid Fridman, Zhihong Man, Xiangyu Wang, 2017-08-10 This book reflects the latest developments in variable structure systems VSS and sliding mode control SMC highlighting advances in various branches of the VSS SMC field e g from conventional SMC to high order SMC from the continuous time domain to the discrete time domain from theories to applications etc The book consists of three parts and 16 chapters in the first part new VSS SMC algorithms are proposed and their properties are analyzed while the second focuses on the use of VSS SMC techniques to solve a variety of control problems the third part examines the applications of VSS SMC to real time systems The book introduces postgraduates and researchers to the state of the art in VSS SMC field including the theory methodology and applications Relative academic disciplines include Automation Mathematics Electrical Engineering Mechanical Engineering Instrument Science and Engineering Electronic Engineering Computer Science and Technology Transportation Engineering Energy and Power Engineering etc

*Stabilization and Control of Fractional Order Systems: A Sliding Mode Approach* Bijan Bandyopadhyay, Shyam Kamal, 2014-07-22 In the last two decades fractional differential equations have been used more frequently in physics signal processing fluid mechanics viscoelasticity mathematical biology electro chemistry and many others It opens a new and more realistic way to capture memory dependent phenomena and irregularities inside the systems by using more sophisticated mathematical analysis This monograph is based on the authors work on stabilization and control design for continuous and discrete fractional order

systems The initial two chapters and some parts of the third chapter are written in tutorial fashion presenting all the basic concepts of fractional order system and a brief overview of sliding mode control of fractional order systems The other parts contain deal with robust finite time stability of fractional order systems integral sliding mode control of fractional order systems co operative control of multi agent systems modeled as fractional differential equation robust stabilization of discrete fractional order systems high performance control using soft variable structure control and contraction analysis by integer and fractional order infinitesimal variations

**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

**Sliding Mode Control** Christopher Edwards, Sarah K. Spurgeon, 1998-08-27 In the formation of any control problem there will be discrepancies between the actual plant and the mathematical model for controller design Sliding mode control theory seeks to produce controllers to over some such mismatches This text provides the reader with a grounding in sliding mode control and is appropriate for the graduate with a basic knowledge of classical control theory and some knowledge of state space methods

**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

Control and Automation Dominik Slezak, Tai-hoon Kim, Adrian Stoica, Byeong-Ho Kang, 2009-11-24 As future generation information technology FGIT becomes specialized and fr mented it is easy to lose sight that many topics in FGIT have common threads and because of this advances in one discipline may be transmitted to others Presentation of recent results obtained in different disciplines encourages this interchange for the advancement of FGIT as a whole Of particular interest are hybrid solutions that c bine ideas taken from multiple disciplines in order to achieve something more signi cant than the sum of the individual parts Through such hybrid philosophy a new principle can be

discovered which has the propensity to propagate throughout multifaceted disciplines FGIT 2009 was the first mega conference that attempted to follow the above idea of hybridization in FGIT in a form of multiple events related to particular disciplines of IT conducted by separate scientific committees but coordinated in order to expose the most important contributions It included the following international conferences Advanced Software Engineering and Its Applications ASEA Bio Science and Bio Technology BSBT Control and Automation CA Database Theory and Application DTA Disaster Recovery and Business Continuity DRBC published independently Future Generation Communication and Networking FGCN that was combined with Advanced Communication and Networking ACN Grid and Distributed Computing GDC Multimedia Computer Graphics and Broadcasting MulGraB Security Technology SecTech Signal Processing Image Processing and Pattern Recognition SIP and e Service Science and Technology UNESST *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 **Sliding Mode Control Using Novel Sliding Surfaces**

B. Bandyopadhyay, Fulwani Deepak, Kyung-Soo Kim, 2009-09-23 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-Mode Control and Variable-Structure Systems Tiago Roux Oliveira, Leonid Fridman, Liu Hsu, 2023-10-31 This book reflects the latest developments in sliding mode control SMC and variable structure systems VSS comprising contributions by leading researchers and an international range of experts Such contributions highlight advances in various branches of the field conventional and higher order SMC with continuous and discrete time implementation and theory and applications both receive attention The book consists of six parts In the first new SMC VSS algorithms are proposed and their properties are analyzed The second part focuses on the use of observers to solve the estimation and output feedback control problems The third part discusses the discretization aspects of SMC algorithms Parts IV and V provide important insights on the use of adaptation laws for non overestimated control gains and chattering alleviation The last part examines the applications of these SMC VSS ideas to real world systems Sliding Mode Control and Variable Structure Systems introduces postgraduates and researchers to the state of the art in the field It includes theory methods and applications relevant to workers in disciplines including control automation applied mathematics electrical and mechanical engineering instrumentation electronics computer science robotics transportation and power engineering Its clear style and deep exposition help readers to keep in touch with tools that are thanks to the robustness and insensitivity to perturbations of the SMC VSS paradigm among the most efficient for dealing with uncertain systems

**Advanced Sliding Mode Control for Mechanical Systems** Jinkun Liu, Xinhua Wang, 2012-09-07 Advanced Sliding Mode Control for Mechanical Systems Design Analysis and MATLAB Simulation takes readers through the basic concepts covering the most recent research in sliding mode control The book is written from the perspective of practical engineering and examines numerous classical sliding mode controllers including continuous time sliding mode control discrete time sliding mode control fuzzy sliding mode control neural sliding mode control backstepping sliding mode control dynamic sliding mode control sliding mode control based on observer terminal sliding mode control sliding mode control for robot manipulators and sliding mode control for aircraft This book is intended for engineers and researchers working in the field of control Dr Jinkun Liu works at Beijing University of Aeronautics and Astronautics and Dr Xinhua Wang works at the National University of Singapore

Sliding Mode Thermal Control System for Space Station Furnace Facility Mark Edward Jackson, 1996

*Variable Structure Systems, Sliding Mode and Nonlinear Control* K.D. Young, Ü. Özgüner, 1999-08-18 This book comprises a selection of papers that were first presented at VSS98 5th International Workshop on Variable Structure Systems held in Sarasota Florida This workshop was the fifth in a series of VSS international workshops and the first to be held in the United States Work presented herein on theoretical developments and applications on VSS and Sliding Mode reflects how trends have advanced beyond the original ideas that are now well documented in a number of books and research monographs In particular the concepts of Sliding Sector and Second Order Sliding Mode introduced in this volume will stimulate discussions and invite further extensions Also the focus on Sampled Data systems represents a positive trend towards practical industrial

implementations of sliding mode controllers

The Top Books of the Year Sliding Mode Control The year 2023 has witnessed a remarkable surge in literary brilliance, with numerous engrossing novels captivating the hearts of readers worldwide. Lets delve into the realm of top-selling books, exploring the captivating narratives that have captivated audiences this year. The Must-Read : Colleen Hoovers "It Ends with Us" This heartfelt tale of love, loss, and resilience has captivated readers with its raw and emotional exploration of domestic abuse. Hoover expertly weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can prevail. Uncover the Best : Taylor Jenkins Reids "The Seven Husbands of Evelyn Hugo" This spellbinding historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reids captivating storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery. Sliding Mode Control : Delia Owens "Where the Crawdads Sing" This captivating coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens spins a tale of resilience, survival, and the transformative power of nature, captivating readers with its evocative prose and mesmerizing setting. These popular novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of engaging stories waiting to be discovered. The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts. The Secret History is a exceptional and suspenseful novel that will keep you guessing until the very end. The novel is a warning tale about the dangers of obsession and the power of evil.

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