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.

This book describes recent advances in the theory, properties, methods and applications of SMC, including a discussion about the advantages and disadvantages of different SMC algorithms.

This book presents few novel Discrete-time Sliding Mode (DSM) protocols for leader-following consensus of Discrete Multi-Agent Systems (DMASs). The protocols intend to achieve the consensus in finite time steps and also tackle the corresponding uncertainties. Based on the communication graph topology of multi-agent systems, the protocols are divided into two groups, namely (i) Fixed graph topology and (ii) Switching graph topology. The coverage begins with the design of Discrete-time Sliding Mode (DSM) protocols using Gao’s reaching law and power rate reaching law for the synchronization of linear DMASs by using the exchange of information between the agents and the leader to achieve a common goal. Then, in a subsequent chapter, analysis for no. of fixed-time steps required for the leader-following consensus is presented. The book also includes chapters on the design of Discrete-time Higher-order Sliding Mode (DHSM) protocols, Event-triggered DSM protocols for the leader-following consensus of DMASs. A chapter is also included on the design of DHSM protocols for leader-following consensus of heterogeneous DMASs. Special emphasis is given to the practical implementation of each proposed
DSM protocol for achieving leader-following consensus of helicopter systems, flexible joint robotic arms, and rigid joint robotic arms. This book offers a ready reference guide for graduate students and researchers working in the areas of control, automation, and communication engineering, and in particular the cooperative control of multi-agent systems. It will also benefit professional engineers working to design and implement robust controllers for power systems, autonomous vehicles, military surveillance, smartgrids/microgrids, vehicle traffic management, robotic teams, and aerial robots.

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 overcome 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. From this basis, more advanced theoretical results are developed. Two industrial case studies, which present the results of sliding mode controller implementations, are used to illustrate the successful practical application theory.

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.

Nonlinear control theory has been successfully applied to continuous, nonlinear, autonomous plant models. Implementation of these continuous control laws, using digital computers, has relied upon high sample frequencies to approximate the performance of continuous control. This thesis extends the design of continuous sliding mode control to discrete and to sampled data systems. Continuous, nonlinear, autonomous, second order dynamic plant models are discretized using an approximation to a Taylor series expansion. The discretization process accounts for the Zero Order Hold circuit, used to convert the discrete control output of the digital computer, into a piecewise continuous control input to the plant. A Discrete Sliding Mode Control is developed using Feedback Linearization to account for plant model nonlinearities, and Lyapunov Stability analysis to guarantee convergence to the sliding manifold. A five step design process systematizes the design technique. The design technique was applied to two unstable nonlinear second order plant models. Stability was confirmed by simulation studies. Comparison with the Continuous Sliding Mode Control implemented digitally, at a sample rate five times the plant model fundamental frequency, showed that the Discrete Sliding Mode Control retained asymptotic stability while the Continuous Sliding Mode Control did not.

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.

This monograph investigates the existence of higher order sliding mode in discrete-time systems and propounds a new concept of discrete-time higher order sliding mode. The authors propose a definition of discrete-time higher order sliding mode and a control law is designed by means of a concept for an uncertain linear-time invariant system, as well as the behavior of the closed-loop system is analyzed. Moreover, the book includes a thorough treatment of the probabilistic and non-deterministic case, i.e. stochastic discrete-time higher order sliding mode. The target audience primarily comprises research experts in control theory but the book may also be beneficial for graduate students alike.

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.

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 equaiton

Data driven control and learning has been developed quickly both in theory and applications recently. The deep involvement of information science in practical processes poses enormous challenges to the existing control science and engineering due to their size, distributed nature and complexity. Modeling these processes accurately using first principles or identification is almost impossible although these plants produce huge amount of operation data in every moment. The high tech hardware software and the cloud computing enable us to perform complex real time computation, which makes implementation of data driven control and method for these complex practical plants possible. It would be very significant if we can learn the systems behaviors, discover the relationship of system variables by making full use of on line or off line process data, to directly design controller, predict and assess system states, make decisions, perform real time optimization and conduct fault diagnosis.

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.

Congestion Control in Data Transmission Networks details the modeling and control of data traffic in communication networks. It shows how various networking phenomena can be represented in a consistent mathematical framework suitable for rigorous formal analysis. The monograph differentiates between fluid-flow continuous-time traffic models, discrete-time processes with constant sampling rates, and sampled-data systems with variable discretization periods. The authors address a number of difficult real-life problems, such as: optimal control of flows with disparate, time-varying delay; the existence of source and channel nonlinearities; the balancing of quality of service and fairness requirements; and the incorporation of variable rate allocation policies. Appropriate control mechanisms which can handle congestion and guarantee high throughput in various traffic scenarios (with different networking phenomena being considered) are proposed. Systematic design procedures using sound control-theoretic foundations are adopted. Since robustness issues are of major concern in providing efficient data-flow regulation in today's networks, sliding-mode control is selected as the principal technique to be applied in creating the control solutions. The controller derivation is given extensive analytical treatment and is supported with numerous realistic simulations. A comparison with existing solutions is also provided. The concepts applied are discussed in a number of illustrative examples, and supported by many figures, tables, and graphs walking the reader through the ideas and introducing their relevance in real networks. Academic researchers and graduate students working in computer networks and telecommunications and in control (especially time-delay systems and discrete-time optimal and sliding-mode control) will find this text a valuable assistance in ensuring smooth data-flow within communications networks.

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 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.

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.

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.

Gathering 20 chapters contributed by respected experts, this book reports on the latest advances in and applications of sliding mode control in science and engineering. The respective chapters address applications of sliding mode control in the broad areas of chaos theory, robotics, electrical engineering, physics, chemical engineering, memristors, mechanical engineering, environmental engineering, finance, and biology. Special emphasis has been given to papers that offer practical solutions, and which examine design and modeling involving new types of sliding mode control such as higher order sliding mode control, terminal sliding mode control, super-twisting sliding mode control, and integral sliding mode control. This book serves as a unique reference guide to sliding mode control and its recent applications for graduate students and researchers with a basic knowledge of electrical and control systems engineering.

Using numerous worked examples and problems, this book provides an introduction to the use of state space methods in control system analysis and design. It has been written for those with a very basic background in linear control theory and linear algebra. It provides physical insight into the various procedures considered as well as presenting the theoretical derivations. State Variable Methods in Automatic Control will be of interest to students and lecturers involved with courses on control engineering, specifically those involving state space methods. It will also be valuable for professional engineers involved in systems and circuit theory, as well as control system design.

Renewable energies are becoming a must to counteract the consequences of the global warming. More efficient devices and better control strategies are required in the generation, transport, and conversion of electricity. Energy is processed by power converters that are currently the key building blocks in modern power distribution systems. The associated electrical architecture is based on buses for energy distribution and uses a great number of converters for interfacing both input and output energy. This book shows that sliding-mode control is contributing to improve the performances of power converters by means of accurate theoretical analyses that result in efficient implementations. The sliding-mode control of power converters for renewable energy applications offers a panoramic view of the most recent uses of this regulation technique in practical cases. By presenting examples that range from dozens of kilowatts to only a few watts, the book covers control solutions for AC-DC and DC-AC generation, power factor correction, multilevel converters, constant-power load supply, wind energy systems,
effcient lighting, digital control implementation, multiphase converters, and energy harvesting. The selected examples developed by recognized specialists are illustrated by means of detailed simulations and experiments to help the reader to understand the theoretical approach in each case considered in the book.

A compendium of the authors’ recently published results, this book discusses sliding mode control of uncertain nonlinear systems, with a particular emphasis on advanced and optimization based algorithms. The authors survey classical sliding mode control theory and introduce four new methods of advanced sliding mode control. They analyze classical theory and advanced algorithms, with numerical results complementing the theoretical treatment. Case studies examine applications of the algorithms to complex robotics and power grid problems. Advanced and Optimization Based Sliding Mode Control: Theory and Applications is the first book to systematize the theory of optimization based higher order sliding mode control and illustrate advanced algorithms and their applications to real problems. It presents systematic treatment of event-triggered and model based event-triggered sliding mode control schemes, including schemes in combination with model predictive control, and presents adaptive algorithms as well as algorithms capable of dealing with state and input constraints. Additionally, the book includes simulations and experimental results obtained by applying the presented control strategies to real complex systems. This book is suitable for students and researchers interested in control theory. It will also be attractive to practitioners interested in implementing the illustrated strategies. It is accessible to anyone with a basic knowledge of control engineering, process physics, and applied mathematics.

"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.

This book covers a wide range of up-to-date sliding mode Variable Structure Control (VSC) and Lyapunov Control research and design techniques for the robust control of uncertain systems. In direct contrast to most adaptive controllers, these deterministic controllers employ fixed nonlinear feedback control functions, which operate effectively over a specified magnitude range of system parameter variations and disturbances. There are 18 chapters covering and discussing such topics as the theoretical and practical design of controllers for uncertain multivariable systems, novel algebraic approaches for sliding mode control, discrete-time control, and the stabilizing VSC of uncertain infinite-dimensional systems. The main areas of application include electric motor drives, robotics, flight control and space systems, as well as power electronics and chemical processes, some of which are described in the book.

Presents new, state-of-the-art sliding mode control (SMC) methodologies for uncertain parameter-switching hybrid systems Sliding Mode Control of Uncertain Parameter-Switching Hybrid Systems presents new, state-of-the-art sliding mode control (SMC) methodologies for uncertain parameter-switching hybrid systems (including Markovian jump systems, switched hybrid systems, singular systems, stochastic systems and time-delay systems). The first part of this book establishes a unified framework for SMC of Markovian jump singular systems and proposes new SMC methodologies based on the analysis results. In the second part, the problem of SMC of switched state-delayed hybrid systems is investigated, and finally the parallel theories and techniques that have been developed are extended to deal with switched stochastic hybrid systems. Solved problems with new approaches for analysis and synthesis of continuous- and discrete-time switched hybrid systems, (including stability analysis and stabilization, dynamic output feedback control,) are also included throughout. Presents new, state-of-the-art sliding mode control (SMC) methodologies for uncertain parameter-switching hybrid systems Provides a unified, systematic framework for handling SMC problems Introduces new concepts, models and techniques Includes solved problems throughout

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

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.

It is well established that the sliding mode control strategy provides an effective and robust method of controlling the deterministic system due to its well-known invariance property to a class of bounded disturbance and parameter variations. Advances in microcomputer technologies have made digital control increasingly popular among the researchers worldwide. And that led to the study of discrete-time sliding mode control design and its implementation. This brief presents, a method for multi-rate frequency shaped sliding mode controller design based on switching and non-switching type of reaching law. In this approach, the frequency dependent compensator dynamics are introduced through a frequency-shaped sliding surface by assigning frequency dependent weighing matrices in a linear quadratic regulator (LQR) design procedure. In this way, the undesired high frequency dynamics or certain frequency disturbance can be eliminated. The states are implicitly obtained by measuring the output at a faster rate than the control. It is also known that the vibration control of smart structure is a challenging problem as it has several vibratory modes. So, the frequency shaping approach is used to suppress the frequency dynamics excited during sliding mode in smart structure. The frequency content of the optimal sliding mode is shaped by using a frequency dependent compensator, such that a higher gain can be obtained at the resonance frequencies. The brief discusses the design methods of the controllers based on the proposed approach for the vibration suppression of the intelligent structure. The brief also presents a design of discrete-time reduced order observer using the duality to discrete-time sliding surface design. First, the duality between the coefficients of the discrete-time reduced order observer and the sliding surface design is established and then, the design method for the observer using Riccati equation is explained. Using the proposed method, the observer for the Power System Stabilizer (PSS) for Single Machine Infinite Bus (SMIB) system is designed and the simulation is carried out using the observed states. The discrete-time sliding mode control design method is also obtained for a laboratory experimental servo system and verified with the experimental results.

This book extrapolates many of the concepts that are well defined for discrete-time deterministic sliding-mode control for use with discrete-time stochastic systems. It details sliding-function designs for various categories of linear time-invariant systems and its application for control. The resulting sliding-mode control addresses robustness issues and the functional-observer approach reduces the observer order substantially. Sliding-mode control (SMC) is designed for discrete-time stochastic systems, extended so that states lie within a specified band, and able to deal with incomplete information. Functional-observer-based SMC is designed for various clauses of stochastic systems: discrete-time; discrete-time with delay; state time-delayed; and those with parametric uncertainty. Stability considerations arising because of parametric uncertainty are taken into account and, where necessary, the effects of unmatched uncertainties mitigated. A simulation example is used to explain the use of the functional-observer approach to SMC design. Discrete-Time Stochastic Sliding-Mode Control Using Functional Observation will interest all researchers working in sliding-mode control and will be of particular assistance to graduate students in understanding the changes in design philosophy that arise when changing from continuous- to discrete-time systems. It helps to pave the way for further progress in applications of discrete-time SMC.

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.
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.

The main purpose of control engineering is to steer the regulated plant in such a way that it operates in a required manner. The desirable performance of the plant should be obtained despite the unpredictable influence of the environment on the control system and no matter if the plant parameters are precisely known. Even though the parameters may change with time and load, still the system should preserve its nominal properties and ensure the required behavior of the plant. In other words, the principal objective of control engineering is to design systems that are robust with respect to external disturbances and modeling uncertainty. This objective may be very well achieved using the sliding mode technique, which is the subject of this book.

This volume contains the proceedings of the KKA 2017 – the 19th Polish Control Conference, organized by the Department of Automatics and Biomedical Engineering, AGH University of Science and Technology in Kraków, Poland on June 18–21, 2017, under the auspices of the Committee on Automatic Control and Robotics of the Polish Academy of Sciences, and the Commission for Engineering Sciences of the Polish Academy of Arts and Sciences. Part 1 deals with general issues of modeling and control, notably low modeling and control, sliding mode, predictive, dual, etc. control. In turn, Part 2 focuses on optimization, estimation and prediction for control. Part 3 is concerned with autonomous vehicles, while Part 4 addresses applications. Part 5 discusses computer methods in control, and Part 6 examines fractional order calculus in the modeling and control of dynamic systems. Part 7 focuses on modern robotics. Part 8 deals with modeling and identification, while Part 9 deals with problems related to security, fault detection and diagnostics. Part 10 explores intelligent systems in automatic control, and Part 11 discusses the use of control tools and techniques in biomedical engineering. Lastly, Part 12 considers engineering education and teaching with regard to automatic control and robotics.

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.

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.

This book presents novel algorithms for designing Discrete-Time Sliding Mode Controllers (DSMCs) for Networked Control Systems (NCSs) with both types of fractional delays namely deterministic delay and random delay along with different packet loss conditions such as single packet loss and multiple packet loss that occur within the sampling period. Firstly, the switching type and non-switching type algorithms developed for the deterministic type fractional delay where the delay is compensated using Thiran’s approximation technique. A modified discrete-time sliding surface is proposed to derive the discrete-time sliding mode control algorithms. The algorithm is further extended for the random fractional delay with single packet loss and multiple packet loss situations. The random fractional delay is modelled using Poisson’s distribution function and packet loss is modelled by means of Bernoulli’s function. The condition for closed loop stability in all above situations are derived using the Lyapunov function. Lastly, the efficacy of the proposed DSMC algorithms are demonstrated by extensive simulations and also experimentally validated on a servo system.

After a survey paper by Utkin in the late 1970s, sliding mode control methods 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 Emelyanov and his colleagues. The design paradigms of sliding mode control have now become a mature design technique for the design of robust control 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 invariant 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 high high value.

The book is devoted to systems with discontinuous control. The study of discontinuous dynamic systems is a multifaceted problem which embraces mathematical, control theoretic and application aspects. Times and again, this problem has been approached by mathematicians, physicists and engineers, each profession treating it from its own position. Interestingly, the results obtained by specialists in different disciplines have almost always had a significant effect upon the development of the control theory. It suffices to mention works on the theory of oscillations of discontinuous nonlinear systems, mathematical studies in ordinary differential equations with discontinuous righthand parts or variational problems in nonclassic statements. The unrelenting interest to discontinuous control systems enhanced by their effective application to solution of problems most diverse in their physical nature and functional purpose is, in the author’s opinion, a cogent argument in favour of the importance of this area of studies. It seems a useful effort to consider, from a control theoretic viewpoint, the mathematical and application aspects of the theory of discontinuous dynamic systems and determine their place within the scope of the present-day control theory. The first attempt was made by the author in 1975-1976 in his course on “The Theory of Discontinuous Dynamic Systems” and “The Theory of Variable Structure Systems” read to postgraduates at the University of Illinois, USA, and then presented in 1978-1979 at the seminars held in the Laboratory of Systems with Discontinuous Control at the Institute of Control Sciences in Moscow.

This book presents analysis and design for a class of stochastic systems with semi-Markovian jump parameters. It explores systematic analysis of semi-Markovian jump systems via sliding mode control strategy which makes up the shortages in the analysis and design of stochastic systems. This text provides a novel estimation method to deal with the stochastic stability of semi-Markovian jump systems along with design of novel integral sliding surface. Finally, Takagi-Sugeno fuzzy model approach is brought to deal with system nonlinearities and fuzzy sliding mode control laws are provided to ensure the stabilization purpose. Features: Provides systematic work on sliding mode control (SMC) of semi-Markovian jump systems. Explores SMC methods, such as fuzzy SMC, adaptive SMC, with the presence of generally uncertain transition rates. Provides novel method in dealing with stochastic systems with unknown switching information. Proposes more general theories for semi-Markovian jump systems with generally uncertain transition rates. Discusses practical examples to verify the effectiveness of SMC theory in semi-
Markovian jump systems. This book aims at graduate and postgraduate students and for researchers in all engineering disciplines, including mechanical engineering, electrical engineering and applied mathematics, control engineering, signal processing, process control, control theory and robotics.

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