

- Design Control Law for Regulator

System :  $\dot{x} = f(x, \dot{x}, u, t, \Delta)$        $\Delta < \beta$

State Space Model:  $x = x_1$

$$\dot{x} = \dot{x}_1 = x_2$$

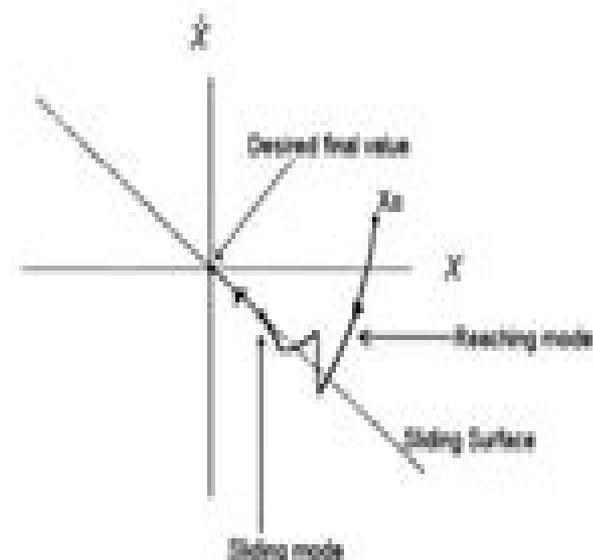
$$\dot{x} = \dot{x}_1 = \dot{x}_2 = f(x, \dot{x}, u, t, \Delta)$$

Sliding Surface:  $s = ax_1 + x_2$        $a > 0$

First Derivative of  $s \rightarrow \dot{s} = a\dot{x}_1 + \dot{x}_2 = ax_2 + f(x, \dot{x}, u, t, \Delta)$

$$\dot{s} = -k|s|^\gamma \text{sgn}(s) \quad k > 0, 0 > \gamma > 1$$

$$ax_2 + f(x, \dot{x}, u, t, \Delta) = -k|s|^\gamma \text{sgn}(s)$$



Control Law  $u = -ax_2 - f(x, \dot{x}, t, \Delta) - k|s|^\gamma \text{sgn}(s)$

# Discretetime Sliding Mode Control

**Lauren Gardner**



### **Discretetime Sliding Mode Control:**

*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

*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

### **Discrete-Time Stochastic Sliding Mode Control Using Functional Observation** Satnesh Singh, S.

Janardhanan, 2019-11-25 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

**Discrete-time Sliding Mode Control** B. Bandyopadhyay, S. Janardhanan, 2009-09-02 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

**Discrete-Time Higher Order Sliding Mode** Nalin Kumar Sharma, Janardhanan Sivaramakrishnan, 2018-09-10 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

**Discrete-time Sliding Mode Control** Govert Monsees, 2002 *Discrete-Time Sliding Mode Control for Networked Control System* Dipesh H. Shah, Axaykumar Mehta, 2018-03-16 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

**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 **Continuous and Discrete-time Sliding Mode Control Design Techniques** Ali Jafari Koshkouei,1997

**Advanced Control of Piezoelectric Micro-/Nano-Positioning Systems** Qingsong Xu,Kok Kiong Tan,2015-08-28 This book explores emerging methods and algorithms that enable precise control of micro nano positioning systems The text describes three control strategies hysteresis model based feedforward control and hysteresis model free feedback control based on and free from state observation Each paradigm receives dedicated attention within a particular part of the text Readers are shown how to design validate and apply a variety of new control approaches in micromanipulation hysteresis modelling discrete time sliding mode control and model reference adaptive control Experimental results are provided throughout and build up to a detailed treatment of practical applications in the fourth part of the book The applications focus on control of piezoelectric grippers Advanced Control of Piezoelectric Micro Nano Positioning Systems will assist academic researchers and practising control and mechatronics engineers interested in suppressing sources of nonlinearity such as hysteresis and drift when combining position and force control of precision systems with piezoelectric actuation

**Investigation of Spatial Control Strategies with Application to Advanced Heavy Water Reactor** Ravindra Munje,Balasaheb Patre,Akhilanand Tiwari,2017-10-13 This book examines the different spatial control techniques for regulation of spatial power distribution in advanced heavy water reactors AHWR It begins with a review of the literature pertinent to the modeling and control of large reactors It also offers a nodal core model based on finite difference approximation since the AHWR core is considered to be divided into 17 relatively large nodes Further it introduces a nonlinear model characterizing important thermal hydraulics parameters of AHWR and integrates it into the neutronics model to obtain a coupled neutronics thermal hydraulics model of AHWR The book also presents a vectorized nonlinear model of AHWR and implements it in MATLAB Simulink environment The model of the reactor is then linearized at the rated power and put into standard state variable form It is characterized by 90 states 5 inputs and 18 outputs Lastly it discusses control techniques for a nonlinear model of AHWR This book will prove to be a valuable resource for professional engineers and implementation specialists researchers and students [Integration of Green and Renewable Energy in Electric Power Systems](#) Ali Keyhani,Mohammad N. Marwali,Min Dai,2009-12-14 A practical application oriented text that presents analytical results for the better modeling and control of power converters in the integration of green energy in electric power systems The combined technology of power semiconductor switching devices pulse width modulation algorithms and control theories are being further developed along with the performance improvement of power semiconductors and microprocessors so that more efficient reliable and cheaper electric energy conversion can be achieved within the next decade Integration of Green

and Renewable Energy in Electric Power Systems covers the principles analysis and synthesis of closed loop control of pulse width modulated converters in power electronics systems with special application emphasis on distributed generation systems and uninterruptible power supplies The authors present two versions of a documented simulation test bed for homework problems and projects based on Matlab Simulink designed to help readers understand the content through simulations The first consists of a number of problems and projects for classroom teaching convenience and learning The second is based on the most recent work in control of power converters for the research of practicing engineers and industry researchers Addresses a combination of the latest developments in control technology of pulse width modulation algorithms and digital control methods Problems and projects have detailed mathematical modeling control design solution steps and results Uses a significant number of tables circuit and block diagrams and waveform plots with well designed class tested problems solutions and projects designed for the best teaching learning interaction Provides computer simulation programs as examples for ease of understanding and platforms for the projects Covering major power conversion applications that help professionals from a variety of industries Integration of Green and Renewable Energy in Electric Power Systems provides practical application oriented system analysis and synthesis that is instructional and inspiring for practicing electrical engineers and researchers as well as undergraduate and graduate students

Applied Electromagnetics and Computational Technology II Hajime Tsuboi, I. Vajda, 2000 The Fifth Japan Hungary Joint Seminar on Applied Electromagnetics in Materials and Computational Technology is held on September 24 26 1998 in Budapest Hungary The Seminar is organised by the Super Tech Consortium Hungary the Hungarian Society of Applied Electronics Hungary and the Japan Society of Applied Electromagnetics and Mechanics Japan The objective of the Seminar is to stimulate the exchange of creative ideas to promote new achievements by bringing together the engineers and scientists of Japan and Hungary working in the field of applied electromagnetics and related areas as well as to discuss the topics of future co operative research A special attention will be paid for the work of young scientists The scientific program covers the following topics Numerical Analysis of Electromagnetic Fields Material Modelling in Electromagnetic Fields Electromagnetic Non destructive Testing and Inverse Problems High Tc Superconducting Materials and Applications Controlled Electrical Drives This book will be published as the Proceedings of the Fifth Japan Hungary Joint Seminar including the selected papers which are presented at the Seminar

**Discrete-Time Sliding Mode Control with Outputs of Relative Degree More Than One** Sohom Chakrabarty, 2017 This work deals with sliding mode control of discrete time systems where the outputs are defined or chosen to be of relative degrees more than one The analysis brings forward important advancements in the direction of discrete time sliding mode control such as improved robustness and performance of the system It is proved that the ultimate band about the sliding surface could be greatly reduced by the choice of higher relative degree outputs thus increasing the robustness of the system Moreover finite time stability in absence of uncertainties is proved for such a choice of higher relative degree output In

presence of uncertainties the system states become finite time ultimately bounded in nature The work presents in some detail the case with relative degree two outputs deducing switching and non switching reaching laws for the same while for arbitrary relative degree outputs it shows a general formalisation of a control structure specific for a certain type of linear systems

A Minimum Function-Based Discrete Sliding Mode Control: Theory and Applications Shyam Kamal, Parijat Prasun, 2025-12-12 This monograph is driven by the ambition to thoroughly investigate and advance the field of discrete time sliding mode design based on difference equations with minima for dynamical systems The motivation behind this exploration lies in the recognition of limitations inherent in classical and conventional control techniques prompting a quest for methodologies that can effectively address the evolving demands of modern applications The overarching objective of this monograph is to introduce innovative approaches capable of enabling timely and precise control even in the presence of uncertainties and exogenous perturbations Through the development of sophisticated discrete control strategies designed to ensure finite time convergence this research aims to enhance the capabilities and operational efficiency of diverse engineering systems thereby contributing to the ongoing evolution of control methodologies in response to contemporary challenges

Advances in Neural Networks - ISSN 2006 Jun Wang, Zhang Yi, Jacek M. Zurada, Bao-Liang Lu, Yin Hujun, 2006-05-10 This is Volume II of a three volume set constituting the refereed proceedings of the Third International Symposium on Neural Networks ISSN 2006 616 revised papers are organized in topical sections on neurobiological analysis theoretical analysis neurodynamic optimization learning algorithms model design kernel methods data preprocessing pattern classification computer vision image and signal processing system modeling robotic systems transportation systems communication networks information security fault detection financial analysis bioinformatics biomedical and industrial applications and more

**Discrete Time Sliding Mode Control [microform]** Jeff K. (Jeff Kurt) Pieper, 1992

**Women in Power** Jill S. Tietjen, Marija D. Ilic, Lina Bertling Tjernberg, Noel N. Schulz, 2023-07-18 This enlightening volume examines core areas of development in electric power systems emphasizing the pivotal contributions of women engineers to the industry's evolution The authors cover a broad spectrum of key topics including generation technologies transmission and distribution progress environmental challenges worldwide electrification and workforce issues Advances in conventional and renewable energy technologies in parallel with growing environmental concerns and in conjunction with the aging of both the infrastructure itself and the workforce have led to imposing and fascinating challenges for the engineers of tomorrow This book documents the critical role of women engineers and their pioneering discoveries relates their stories of success and struggle in their own words and shares their perspectives on how these challenges will be addressed in the decades ahead

Journal of Dynamic Systems, Measurement, and Control, 2004 Publishes theoretical and applied original papers in dynamic systems Theoretical papers present new theoretical developments and knowledge for controls of dynamical systems together with clear engineering motivation for the new theory Applied papers include modeling simulation and corroboration

of theory with emphasis on demonstrated practicality      *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

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