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# Modeling and Adaptive Nonlinear Control of Electric Motors



Springer

# Modeling And Adaptive Nonlinear Control Of Electric Motors

**Chi-Keong Goh, Yew Soon Ong, Kay  
Chen Tan**



## **Modeling And Adaptive Nonlinear Control Of Electric Motors:**

**Modeling and Adaptive Nonlinear Control of Electric Motors** Farshad Khorrami, Prashanth Krishnamurthy, Hemant Melkote, 2003-05-21 In this book modeling and control design of electric motors namely step motors brushless DC motors and induction motors are considered The book focuses on recent advances on feedback control designs for various types of electric motors with a slight emphasis on stepper motors For this purpose the authors explore modeling of these devices to the extent needed to provide a high performance controller but at the same time one amenable to model based nonlinear designs The control designs focus primarily on recent robust adaptive nonlinear controllers to attain high performance It is shown that the adaptive robust nonlinear controller on its own achieves reasonably good performance without requiring the exact knowledge of motor parameters While carefully tuned classical controllers often achieve required performance in many applications it is hoped that the advocated robust and adaptive designs will lead to standard universal controllers with minimal need for fine tuning of control parameters

**AC Electric Motors Control** Fouad Giri, 2013-05-28 The complexity of AC motor control lies in the multivariable and nonlinear nature of AC machine dynamics Recent advancements in control theory now make it possible to deal with long standing problems in AC motors control This text expertly draws on these developments to apply a wide range of model based control design methods to a variety of AC motors Contributions from over thirty top researchers explain how modern control design methods can be used to achieve tight speed regulation optimal energetic efficiency and operation reliability and safety by considering online state variable estimation in the absence of mechanical sensors power factor correction machine flux optimization fault detection and isolation and fault tolerant control Describing the complete control approach both controller and observer designs are demonstrated using advanced nonlinear methods stability and performance are analysed using powerful techniques including implementation considerations using digital computing means Other key features Covers the main types of AC motors including triphase multiphase and doubly fed induction motors wound rotor permanent magnet and interior PM synchronous motors Illustrates the usefulness of the advanced control methods via industrial applications including electric vehicles high speed trains steel mills and more Includes special focus on sensorless nonlinear observers adaptive and robust nonlinear controllers output feedback controllers fault detection and isolation algorithms and fault tolerant controllers This comprehensive volume provides researchers and designers and R D engineers with a single source reference on AC motor system drives in the automotive and transportation industry It will also appeal to advanced students in automatic control electrical power systems mechanical engineering and robotics as well as mechatronic process and applied control system engineers

**Induction Motor Control Design** Riccardo Marino, Patrizio Tomei, Cristiano M. Verrelli, 2010-08-20 This book provides the most important steps and concerns in the design of estimation and control algorithms for induction motors A single notation and modern nonlinear control terminology is used to make the book accessible although a more theoretical control viewpoint is also given

Focusing on the induction motor with the concepts of stability and nonlinear control theory given in appendices this book covers speed sensorless control design of adaptive observers and parameter estimators a discussion of nonlinear adaptive controls containing parameter estimation algorithms and comparative simulations of different control algorithms The book sets out basic assumptions structural properties modelling state feedback control and estimation algorithms then moves to more complex output feedback control algorithms based on stator current measurements and modelling for speed sensorless control The induction motor exhibits many typical and unavoidable nonlinear features

**Vector Control of Three-Phase AC Machines** Nguyen Phung Quang, Jörg-Andreas Dittrich, 2015-05-14 This book addresses the vector control of three phase AC machines in particular induction motors with squirrel cage rotors IM permanent magnet synchronous motors PMSM and doubly fed induction machines DFIM from a practical design and development perspective The main focus is on the application of IM and PMSM in electrical drive systems where field orientated control has been successfully established in practice It also discusses the use of grid voltage oriented control of DFIMs in wind power plants This second enlarged edition includes new insights into flatness based nonlinear control of IM PMSM and DFIM The book is useful for practitioners as well as development engineers and designers in the area of electrical drives and wind power technology It is a valuable resource for researchers and students

Adaptive Control for Robotic Manipulators Dan Zhang, Bin Wei, 2017-02-03 The robotic mechanism and its controller make a complete system As the robotic mechanism is reconfigured the control system has to be adapted accordingly The need for the reconfiguration usually arises from the changing functional requirements This book will focus on the adaptive control of robotic manipulators to address the changed conditions The aim of the book is to summarise and introduce the state of the art technologies in the field of adaptive control of robotic manipulators in order to improve the methodologies on the adaptive control of robotic manipulators Advances made in the past decades are described in the book including adaptive control theories and design and application of adaptive control to robotic manipulators

*Discrete-Time High Order Neural Control* Edgar N. Sanchez, Alma Y. Alanís, Alexander G. Loukianov, 2008-06-24 Neural networks have become a well established methodology as exemplified by their applications to identification and control of general nonlinear and complex systems the use of high order neural networks for modeling and learning has recently increased Using neural networks control algorithms can be developed to be robust to uncertainties and modeling errors The most used NN structures are Feedforward networks and Recurrent networks The latter type offers a better suited tool to model and control of nonlinear systems There exist different training algorithms for neural networks which however normally encounter some technical problems such as local minima slow learning and high sensitivity to initial conditions among others As a viable alternative new training algorithms for example those based on Kalman filtering have been proposed There already exists publications about trajectory tracking using neural networks however most of those works were developed for continuous time systems On the other hand while extensive literature is available for linear discrete time control system

nonlinear discrete time control design techniques have not been discussed to the same degree Besides discrete time neural networks are better suited for real time implementations

*Foundations of Fuzzy Logic and Soft Computing* Patricia Melin, 2007-06-05 This book comprises a selection of papers from IFSA 2007 on new methods and theories that contribute to the foundations of fuzzy logic and soft computing Coverage includes the application of fuzzy logic and soft computing in flexible querying philosophical and human scientific aspects of soft computing search engine and information processing and retrieval as well as intelligent agents and knowledge ant colony

**Contemporary Computing** Sanjay Ranka, Arunava Banerjee, Kanad Kishore Biswas, Sumeet Dua, Prabhat Mishra, Rajat Moona, Sheung-Hung Poon, Cho-Li Wang, 2010-08-12 This book constitutes the first part of the refereed proceedings of the Third International Conference IC3 2010 held in Noida India in August 2010 The 23 revised full papers presented were carefully reviewed and selected from numerous submissions

*Multi-Objective Memetic Algorithms* Chi-Keong Goh, Yew Soon Ong, Kay Chen Tan, 2009-02-26 The application of sophisticated evolutionary computing approaches for solving complex problems with multiple conflicting objectives in science and engineering have increased steadily in the recent years Within this growing trend Memetic algorithms are perhaps one of the most successful stories having demonstrated better efficacy in dealing with multi objective problems as compared to its conventional counterparts Nonetheless researchers are only beginning to realize the vast potential of multi objective Memetic algorithm and there remain many open topics in its design This book presents a very first comprehensive collection of works written by leading researchers in the field and reflects the current state of the art in the theory and practice of multi objective Memetic algorithms Multi Objective Memetic algorithms is organized for a wide readership and will be a valuable reference for engineers researchers senior undergraduates and graduate students who are interested in the areas of Memetic algorithms and multi objective optimization

Introduction to Linear Control Systems Yazdan Bavafa-Toosi, 2017-09-19 Introduction to Linear Control Systems is designed as a standard introduction to linear control systems for all those who one way or another deal with control systems It can be used as a comprehensive up to date textbook for a one semester 3 credit undergraduate course on linear control systems as the first course on this topic at university This includes the faculties of electrical engineering mechanical engineering aerospace engineering chemical and petroleum engineering industrial engineering civil engineering bio engineering economics mathematics physics management and social sciences etc The book covers foundations of linear control systems their raison detre different types modelling representations computations stability concepts tools for time domain and frequency domain analysis and synthesis and fundamental limitations with an emphasis on frequency domain methods Every chapter includes a part on further readings where more advanced topics and pertinent references are introduced for further studies The presentation is theoretically firm contemporary and self contained Appendices cover Laplace transform and differential equations dynamics MATLAB and SIMULINK treatise on stability concepts and tools treatise on Routh Hurwitz method random optimization techniques as well

as convex and non convex problems and sample midterm and endterm exams The book is divided to the sequel 3 parts plus appendices PART I In this part of the book chapters 1 5 we present foundations of linear control systems This includes the introduction to control systems their raison detre their different types modelling of control systems different methods for their representation and fundamental computations basic stability concepts and tools for both analysis and design basic time domain analysis and design details and the root locus as a stability analysis and synthesis tool PART II In this part of the book Chapters 6 9 we present what is generally referred to as the frequency domain methods This refers to the experiment of applying a sinusoidal input to the system and studying its output There are basically three different methods for representation and studying of the data of the aforementioned frequency response experiment these are the Nyquist plot the Bode diagram and the Krohn Manger Nichols chart We study these methods in details We learn that the output is also a sinusoid with the same frequency but generally with different phase and magnitude By dividing the output by the input we obtain the so called sinusoidal or frequency transfer function of the system which is the same as the transfer function when the Laplace variable  $s$  is substituted with  $j\omega$  Finally we use the Bode diagram for the design process PART III In this part Chapter 10 we introduce some miscellaneous advanced topics under the theme fundamental limitations which should be included in this undergraduate course at least in an introductory level We make bridges between some seemingly disparate aspects of a control system and theoretically complement the previously studied subjects Appendices The book contains seven appendices Appendix A is on the Laplace transform and differential equations Appendix B is an introduction to dynamics Appendix C is an introduction to MATLAB including SIMULINK Appendix D is a survey on stability concepts and tools A glossary and road map of the available stability concepts and tests is provided which is missing even in the research literature Appendix E is a survey on the Routh Hurwitz method also missing in the literature Appendix F is an introduction to random optimization techniques and convex and non convex problems Finally appendix G presents sample midterm and endterm exams which are class tested several times

*Nonlinear Control and Filtering Using Differential Flatness Approaches* Gerasimos G. Rigatos, 2015-06-05 This monograph presents recent advances in differential flatness theory and analyzes its use for nonlinear control and estimation It shows how differential flatness theory can provide solutions to complicated control problems such as those appearing in highly nonlinear multivariable systems and distributed parameter systems Furthermore it shows that differential flatness theory makes it possible to perform filtering and state estimation for a wide class of nonlinear dynamical systems and provides several descriptive test cases The book focuses on the design of nonlinear adaptive controllers and nonlinear filters using exact linearization based on differential flatness theory The adaptive controllers obtained can be applied to a wide class of nonlinear systems with unknown dynamics and assure reliable functioning of the control loop under uncertainty and varying operating conditions The filters obtained outperform other nonlinear filters in terms of accuracy of estimation and computation speed The book presents a series of application

examples to confirm the efficiency of the proposed nonlinear filtering and adaptive control schemes for various electromechanical systems These include industrial robots mobile robots and autonomous vehicles electric power generation electric motors and actuators power electronics internal combustion engines distributed parameter systems and communication systems Differential Flatness Approaches to Nonlinear Control and Filtering will be a useful reference for academic researchers studying advanced problems in nonlinear control and nonlinear dynamics and for engineers working on control applications in electromechanical systems

**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

**Nonlinear Control of Electric Machinery** Dawson, 2019-01-22 This work presents nonlinear control algorithms for a benchmark mechanical system actuated by different types of electric machinery emphasizing system stability and robustness pivotal in the development of optimal position trajectory controllers for common motors College or university bookstores may order five or more copies at a special student price available on request from Marcel Dekker

**Learning and Collaboration Technologies. Human and Technology Ecosystems** Panayiotis Zaphiris, Andri Ioannou, 2020-07-10 This two volume set LNCS 12205 and LNCS 12206 constitutes the proceedings of the 7th International Conference on Learning and Collaboration Technologies LCT 2020 held as part of the 22nd International Conference HCI International 2020 which took place in Copenhagen Denmark in July 2020 The total of 1439 papers and 238 posters included in the 37 HCII 2020 proceedings volumes was carefully reviewed and selected from 6326 submissions The papers in this volume are organized in the following topical sections communication and conversation in learning cognition emotions and learning games and gamification in learning VR robot and IoT in learning and collaboration technology and collaborative learning As a result of the Danish Government's announcement dated April 21 2020 to ban all large events above 500 participants until September 1 2020 the HCII 2020 conference was held virtually

**Energy-Based Control of Electromechanical Systems** Victor Manuel Hernández-Guzmán, Ramón Silva-Ortigoza, Jorge Alberto Orrante-Sakanassi, 2020-12-01 This book introduces a passivity based approach which simplifies the controller design task for AC motors It presents the application of this novel approach to several classes of AC motors magnetic levitation systems microelectromechanical systems MEMS and rigid robot manipulators actuated by AC motors The novel passivity based approach exploits the fact that the natural energy exchange existing between the mechanical and the electrical subsystems allows the natural cancellation of several high order terms

during the stability analysis This allows the authors to present some of the simplest controllers proposed in scientific literature but provided with formal stability proofs These simple control laws will be of use to practitioners as they are robust with respect to numerical errors and noise amplification and are provided with tuning guidelines Energy based Control of Electromechanical Systems is intended for both theorists and practitioners Therefore the stability proofs are not based on abstract mathematical ideas but Lyapunov stability theory Several interpretations of the proofs are given along the body of the book using simple energy ideas and the complete proofs are included in appendices The complete modeling of each motor studied is also presented allowing for a thorough understanding Advances in Industrial Control reports and encourages the transfer of technology in control engineering The rapid development of control technology has an impact on all areas of the control discipline The series offers an opportunity for researchers to present an extended exposition of new work in all aspects of industrial control

**Recent Advances in Electrical and Information Technologies for Sustainable Development** Soumia El Hani, Mohamad Essaaïdi, 2019-02-08 The book includes the best extended papers which were selected from the 3rd International Conference of Electrical and Information Technologies ICEIT 2017 Morocco The book spans two inter related research domains which shaped modern societies solved many of their development problems and contributed to their unprecedented economic growth and social welfare Selected papers are based on original and high quality research They were peer reviewed by experts in the field They are grouped into five parts Part I deals with Power System and Electronics topics that include Power Electronics Energy Conversion Actuators Micro Nanotechnology etc Part II relates to Control Systems and their applications Part III concerns the topic of Information Technology that basically includes Smart Grid Information Security Cloud Computing Distributed Big Data etc Part IV discusses Telecommunications and Vehicular Technologies topics that include Green Networking and Communications Wireless Ad hoc and Sensor Networks etc Part V covers Green Applications and Interdisciplinary topics that include intelligent and Green Technologies for Transportation Systems Smart Cities etc This book offers a good opportunity for young researchers novice scholars and whole academic sphere to explore new trends in Electrical and information Technologies

**Energy Efficiency in Electric Devices, Machines and Drives** Gorazd Štumberger, Boštjan Polajžer, 2020-06-18 This Special Issue deals with improvements in the energy efficiency of electric devices machines and drives which are achieved through improvements in the design modelling control and operation of the system Properly sized and placed coils of a welding transformer can reduce the required iron core size and improve the efficiency of the welding system operation New structures of the single phase field excited flux switching machine improve its performance in terms of torque while having higher back EMF and unbalanced electromagnetic forces A properly designed rotor notch reduces the torque ripple and cogging torque of interior permanent magnet motors for the drive platform of electric vehicles resulting in lower vibrations and noise In the field of modelling the torque estimation of a Halbach array surface permanent magnet motor with a non overlapping winding layout



was improved by introducing an analytical two dimensional subdomain model A general method for determining the magnetically nonlinear two axis dynamic models of rotary and linear synchronous reluctance machines and synchronous permanent magnet machines is introduced that considers the effects of slotting mutual interaction between the slots and permanent magnets saturation cross saturation and end effects Advanced modern control solutions such as neural network based model reference adaptive control fuzzy control senseless control torque speed tracking control derived from the 3D non holonomic integrator including drift terms maximum torque per ampere and maximum efficiency characteristics are applied to improve drive performance and overall system operation

**The Industrial Electronics Handbook - Five Volume Set** Bogdan M. Wilamowski, J. David Irwin, 2011-03-04 Industrial electronics systems govern so many different functions that vary in complexity from the operation of relatively simple applications such as electric motors to that of more complicated machines and systems including robots and entire fabrication processes The Industrial Electronics Handbook Second Edition combines traditional and new *Proceedings of the ... American Control Conference*, 2005 **Electronics and Electrical Engineering** Alan Zhao, 2015-07-28 The 2014 Asia Pacific Electronics and Electrical Engineering Conference EEEEC 2014 was held on December 27 28 2014 in Shanghai China EEEEC has provided a platform for researchers engineers academicians as well as industrial professionals from all over the world to present their research results and development activities in Electroni

## Adopting the Melody of Phrase: An Emotional Symphony within **Modeling And Adaptive Nonlinear Control Of Electric Motors**

In some sort of used by screens and the ceaseless chatter of instant conversation, the melodic splendor and psychological symphony produced by the prepared term often fade into the backdrop, eclipsed by the constant noise and interruptions that permeate our lives. But, nestled within the pages of **Modeling And Adaptive Nonlinear Control Of Electric Motors** a marvelous fictional value brimming with fresh feelings, lies an immersive symphony waiting to be embraced. Constructed by an outstanding musician of language, that charming masterpiece conducts readers on a psychological journey, skillfully unraveling the hidden tunes and profound impact resonating within each cautiously crafted phrase. Within the depths of this emotional evaluation, we can investigate the book is central harmonies, analyze its enthralling publishing model, and surrender ourselves to the profound resonance that echoes in the depths of readers souls.

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