

An Adaptive Terminal Sliding Mode Control Scheme via Neural Network Approach for Path-following Control of Uncertain Nonlinear Systems

Thanh Nguyen Truong[✉], Anh Tuan Vo[✉], and Hee-Jun Kang^{*✉}

Abstract: In this paper, we design a neural network-based non-singular fast terminal sliding mode control (NFTSMC) for path tracking control of uncertain nonlinear systems (UNLSs). The major features of the proposed control algorithm are to combine merits of feed-forward neural network (FFNN) and NFTSMC, such as approximation ability, rapid convergence rate, along with strong properties to external disturbances and uncertain dynamics. A controller is derived from the above combination for high control performance and fast convergence of state variables in presence of those unknown components. Besides, a fast-reaching control law (FRCL) is also applied to obtain a faster convergence time. The new contribution of the proposed method is to propose a PI-nonsingular fast terminal sliding mode surface (PI-NFTSMS) and to use a non-singular fast terminal sliding mode-based-error filter into FFNN. The contribution of the proposed method is a PI-NFTSMS and use of a non-singular fast terminal sliding mode-based-error filter into FFNN. With this approach, the lumped uncertain dynamics (LUDs) have been quickly and fully offset. Accordingly, the proposed controller can obtain a faster convergence time, higher tracking accuracy, lesser chattering than classical NFTSMC, and avoid the glitch of state variables in reaching the sliding manifold. Consequently, the stabilization of the whole closed loop control system is then guaranteed with strong control performance. The correctness of the stability is also proven based on Lyapunov analysis. Control performance obtained from the simulation example for an uncertain 3-DOF robot and experiment for an uncertain magnetic levitation system (MLS) has verified the effectiveness and practicality of the method.

Keywords: Feed forward neural network, sliding mode control, terminal sliding mode control, tracking control methodologies, uncertain nonlinear systems.

1. INTRODUCTION

The application of automation production in systems has increased rapidly recently, which has increased the requirements for reliability, processing time, human safety, and efficient operation. Moreover, a more modern automatic system requires more complex technology, such as measurement systems, mechanical structures, and control methods. Those lead to growing uncertain parameters, including external disturbances, uncertain dynamics from structure variation of the system, friction, nonlinearity, or various real working conditions [1,2]. Therefore, obtaining good control performance and maintaining the stability of that performance is an important task for researchers. If uncertain components of a system are not computed accurately and completely, they are the reason for reducing control performance or even result into instability. Furthermore, a worthy problem is the delay of the mechanical system caused by friction. Therefore, a control

algorithm with the robust ability to compensate or counteract undesirable uncertain terms needs further research.

To obtain a high control performance, several control methods have been considered for uncertain nonlinear systems, such as intelligent control [3,4], adaptive control [5], synchronization control [6], and sliding mode control (SMC) [7–10]. They are adaptable and robust with respect to the variation of operating conditions. In comparison with the desired demands, SMC is considered due to widespread applications, simplicity, and robustness to uncertainties. However, intensive studies show that conventional SMC only gives asymptotic control errors [11]. In conventional SMC, in order to speed up convergence, the robust gains of the reaching control law should be increased to be larger than upper bound values of uncertain dynamics that lead to serious chattering behavior. As replacing method, the control methodologies called terminal sliding mode control (TSMC) or global TSMC [12,13] can handle the mentioned problem by synthesizing a nonlinear

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Adaptive Terminal Sliding Mode Control For Nonlinear

**De-Shuang Huang, Kang-Hyun
Jo, Jianqiang Li, Valeriya Gribova, Abir
Hussain**

Adaptive Terminal Sliding Mode Control For Nonlinear:

Computational Intelligence Methods for Green Technology and Sustainable Development Yo-Ping

Huang,Wen-June Wang,Hieu-Giang Le,An-Quoc Hoang,2024-12-23 This book is presented in two volumes featuring peer reviewed research papers from the 7th International Conference on Green Technology and Sustainable Development GTSD held in Ho Chi Minh City Vietnam from July 25 to 26 2024 It highlights original research by experts from both academia and industry centered on the theme of Green Technology and Sustainable Development in the Industrial Revolution 4 0 The book underscores the critical importance of sustainability in education technology and economic development while also showcasing the vital role of technological innovation in creating a greener future The papers documented in this book cover a broad range of topics including renewable energy systems smart grids artificial intelligence robotics and intelligent systems and computational intelligence all with a focus on sustainable development climate change mitigation and environmental policy These studies showcase cutting edge technologies and innovative ideas related to green technology offering actionable insights for advancing sustainable development across various sectors The authors present research based on both experimental and numerical methods offering solutions to current problems and optimizing existing methods The insights and findings provided are valuable for industry experts research institutions universities and anyone interested in advancing global sustainable development

Intelligent Computing Methodologies De-Shuang Huang,Prashan Premaratne,2020-10-15

This two volume set of LNCS 12463 and LNCS 12464 constitutes in conjunction with the volume LNAI 12465 the refereed proceedings of the 16th International Conference on Intelligent Computing ICIC 2020 held in Bari Italy in October 2020 The 162 full papers of the three proceedings volumes were carefully reviewed and selected from 457 submissions The ICIC theme unifies the picture of contemporary intelligent computing techniques as an integral concept that highlights the trends in advanced computational intelligence and bridges theoretical research with applications The theme for this conference is Advanced Intelligent Computing Methodologies and Applications Papers related to this theme are especially solicited addressing theories methodologies and applications in science and technology

Proceedings of 2016 Chinese Intelligent Systems Conference Yingmin Jia,Junping Du,Weicun Zhang,Hongbo Li,2016-09-20

These proceedings present selected research papers from CISC 16 held in Xiamen China The topics include Multi agent system Evolutionary Computation Artificial Intelligence Complex systems Computation intelligence and soft computing Intelligent control Advanced control technology Robotics and applications Intelligent information processing Iterative learning control Machine Learning and etc Engineers and researchers from academia industry and government can get an insight view of the solutions combining ideas from multiple disciplines in the field of intelligent systems

Handbook of Real-Time Computing Yu-Chu Tian,David Charles

Levy,2022-08-08 The aim of this handbook is to summarize the recent rapidly developed real time computing technologies from theories to applications This handbook benefits the readers as a full and quick technical reference with a high level

historic review of technology detailed technical descriptions and the latest practical applications In general the handbook is divided into three main parts subjected to be modified theory design and application covering different but not limited to the following topics Real time operating systems Real time scheduling Timing analysis Programming languages and run time systems Middleware systems Design and analysis tools Real time aspects of wireless sensor networks Energy aware real time methods

Intelligent Computing Theories and Application De-Shuang Huang,Kang-Hyun Jo,Jianqiang Li,Valeriya Gribova,Abir Hussain,2021-08-09 This two volume set of LNCS 12836 and LNCS 12837 constitutes in conjunction with the volume LNAI 12838 the refereed proceedings of the 17th International Conference on Intelligent Computing ICIC 2021 held in Shenzhen China in August 2021 The 192 full papers of the three proceedings volumes were carefully reviewed and selected from 458 submissions The ICIC theme unifies the picture of contemporary intelligent computing techniques as an integral concept that highlights the trends in advanced computational intelligence and bridges theoretical research with applications The theme for this conference is Advanced Intelligent Computing Methodologies and Applications The papers are organized in the following subsections Intelligent Computing in Computer Vision Intelligent Control and Automation Intelligent Modeling Technologies for Smart Cities Machine Learning and Theoretical Computational Intelligence and Applications

Telematics and Computing Miguel Félix Mata-Rivera,Roberto Zagal-Flores,Cristian Barria-Huidobro,2025-11-01 This book constitutes the proceedings of the 14th International Conference on Telematics and Computing WITCOM 2025 held in Huatulco Mexico during November 3 7 2025 The 44 full papers presented in this volume were carefully reviewed and selected from 110 submissions They are grouped into the following topics Fields of knowledge Including environmental monitoring Information systems IoT Education Artificial intelligence techniques Cybersecurity Data science

Instruments, Measurement, Electronics and Information Engineering J.Z. Ma,2013-08-08 Selected peer reviewed papers from the 2013 International Conference on Precision Mechanical Instruments and Measurement Technology ICPMIMT 2013 May 25 26 2013 Shenyang Liaoning China

Robot Control 2000 (SYROCO'00) Peter Kopacek,2001 This Proceedings contains the papers presented at the sixth IFAC Symposium on Robot Control 2000 SYROCO 00 held in Vienna Austria on 21 23 September 2000 The contributions cover the whole field of robot control starting with the classical subjects like non linear robust and hybrid control force and tracking control modelling and identification simulation and education neutral and fuzzy control But new robot applications require new robot concepts and new control tasks In consequence most of the contributions deal with mobile intelligent robots and multiple robot systems but also new applications like disassembly One of the fastest growing fields in the last three years is development and control of robots for entertainment leisure and hobby In four survey papers the state of the art in robot control and further developing trends were emphasised Because the field of robotics is growing up today in smaller countries two presentations deal with robots in Brazil and Macedonia The very important field of sensor fusion and an industrial view of future developments in robot control were also topics of survey

papers Mathematical Reviews ,2004 *Intelligent Control and Automation* De-Shuang Huang,2006-08-04 Results of the International Conference on Intelligent Computing ICIC 2006 Lecture Notes in Computer Science LNCS Lecture Notes in Artificial Intelligence LNAI Lecture Notes in Bioinformatics LNBI Lecture Notes in Control and Information Sciences LNCIS 142 revised full papers are organized in topical sections Blind Source Separation Intelligent Sensor Networks Intelligent Control and Automation and Data Fusion Knowledge Discovery and Data Mining Includes a Special Session on Smart and Intelligent Home Technology *MICAI ...* ,2004 **Machine Tool Technology, Mechatronics and Information Engineering** Zhong Min Wang,Dong Fang Yang,Kun Yang,Liang Yu Guo,Jian Ming Tan,2014-09-22 Selected peer reviewed papers from the 2014 International Conference on Machine Tool Technology and Mechatronics Engineering ICMTTME 2014 June 22 23 2014 Guilin Guangxi China **IECON '98** IEEE Industrial Electronics Society. Conference,1998 **JSME International Journal** ,1997 **2002 IEEE Region 10 Conference on Computers, Communications, Control and Power Engineering** TENCON (2002, Beijing),2002 **Journal of Dynamic Systems, Measurement, and Control** ,2001 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 *Complex Systems* Russel J. Stonier,Xing Huo Yu,1994 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 Manufacturing Technology, Electronics, Computer and Information Technology Applications Zhang Lin,Hong Ying Hu,Ya Jun Zhang,Jian Guo Qiao,Jia Min Xu,2014-11-27 Selected peer reviewed papers from the 2014 International Conference on Manufacturing Technology and Electronics Applications ICMTEA 2014 November 8 9 2014 Taiyuan Shanxi China **1995 IEEE International Conference on Neural Networks** ,1995

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