Springer Book Proposal

A Project

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Book Title: Adaptive Constrained Control for High-Order Fully Actuated Nonlinear Systems

B Short Book Description

Your book description should motivate potential audiences to read this book. Keep it concise and focused on what makes your book unique. Follow these pointers for an effective description:

- ***Subject**: Identify the book's core subject, avoid describing the topic in detail or giving definitions.*
- ***Importance**: Explain its significance to its target audience.*
- ***Content Summary**: Offer a brief overview of the book's content.*
- ***Key Points**: Highlight the most engaging methods, results, or topics.*
- ***Benefits**: State the main benefits readers will receive.*
- ***Prerequisites**: Note any required background for comprehension.*

Aim for 200-300 words, in 1-3 paragraphs; write in an active, engaging tone; integrate keywords naturally for SEO.

Subject and importance: As we know that practical engineering systems are faced with many nonlinearity, uncertainty and performance requirements, and the adaptive constrained control of nonlinear systems has been a hot and difficult problem in the control field. The high-order fully actuated system theory has been proposed to solve the control design problem of nonlinear systems and garnered significant attention in recent years, primarily due to its especially convenient and effective in dealing with control problems. This book intends to report the new results on adaptive constrained control for nonlinear systems based on the high-order fully actuated system approaches. The results in this book will no doubt advance the study of nonlinear control theory and enrich the content of the fully actuated system theory.

Content summary and key points: The book collects some novel work about adaptive constrained control for high-order fully actuated nonlinear systems, such as adaptive input-constrained control, adaptive time-constrained control and adaptive state-constrained control, provides corresponding control design strategies and demonstrates their effectiveness.

Benefits and prerequisites: People who read this book will be able to study the nonlinear control design ideas based on high-order fully actuated system approaches, and master solutions to common control problems in practical engineering systems. The reader is assumed to have some background in nonlinear system and control. Although the book is primarily intended for students and practitioners of control theory, it may be also a valuable reference for those in fields such as communication engineering and economics. Moreover, we believe that the book should be suitable for certain advanced courses or seminars.

C Table of Contents

For 'Authored Book': a detailed ToC with a second or even further hierarchy is preferred.

For 'Edited Volume': a preliminary ToC with first-level hierarchy is sufficient, however, please list the contributors' names and institutional affiliations for each chapter.

a) Please also include the objectives of each chapter and how the chapters interrelate; b) If available, please provide sample chapters that are representative of the book's level and style. If the manuscript is complete, attach the entire PDF (If applicable) for our reference.

Preface

1. Introduction

- The original model of an actual dynamic system is derived from system mechanisms or certain physical laws and is typically expressed through high-order differential equations. By employing variable expansion, the dynamic system can be represented as a state-space model. Although this model is effective for linear systems, it struggles with nonlinear issues, particularly in systems characterized by uncertainties, time delays, and time-varying properties. Fully actuated system is a system model oriented to control design, focusing on the acquisition of control variables. In this chapter, we give some overview of the fully actuated systems, adaptive control and constrained control. Also, the organization of the book is given.

2. Preliminaries

- In this chapter, basic models of fully-actuated systems are introduced, along with a method for transforming state-space strict feedback nonlinear system models into fully-actuated system models, and a brief overview of adaptive control and constrained control is given. Additionally, the relevant mathematical background is reviewed.

Part I Adaptive Input-Constrained Control of High-Order Fully Actuated Nonlinear Time-Delay System

3. Adaptive Control for a Class of High-Order Fully Actuated Nonlinear Time-Delay Systems

- Building upon the basic models of fully actuated systems introduced in the previous chapter, this chapter extends the discussion to adaptive control strategies tailored for high-order fully actuated nonlinear systems with time-delay characteristics. In this chapter, we aim to design an adaptive input-constrained controller for high-order fully actuated nonlinear systems that experience time delays. By using high-order fully actuated system theory along with

Lyapunov-Krasovskii functional methods, an adaptive control strategy is developed to handle time delays while guaranteeing system stability.

3.1 Overview

3.2 Problem Formulation of Nonlinear Time-Delay Systems

3.3 Adaptive Feedback Controller Design

3.4 Stability Analysis of Resulting Closed-Loop System

3.5 Simulation Results for Adaptive Controllers

3.6 Conclusion

References

4. Adaptive Input-Constrained Control of High-Order Fully Actuated Nonlinear Time-Delay Systems With Unmodeled Dynamics

- Building upon the adaptive control strategies in the previous chapter, this chapter extends the discussion by considering the challenges posed by input dead zones and unmodeled dynamics in high-order fully actuated nonlinear systems with time delays. Input dead zones, such as actuator saturation or physical limitations, and unmodeled dynamics, like friction or unmodeled higher-order effects, can significantly impact control performance. To address these challenges, we develop adaptive input-constrained controllers that ensure stability and robustness. By combining high-order fully actuated system theory with adaptive control techniques, we employ Lyapunov-Krasovskii functional methods to guarantee system stability and convergence while respecting input constraints.

4.1 Overview

4.2 Problem Formulation of Nonlinear Time-Delay Systems With Unmodeled Dynamics

4.3 Adaptive Input-Constrained Controller Design

4.4 Lyapunov-Based Stability Analysis for Nonlinear Time-Delay Systems

4.5 Numerical Simulations Demonstrating Controller Effectiveness

4.6 Conclusion

References

Part II Adaptive Time-Constrained Control for High-Order Fully Actuated Nonlinear Systems

5. Time-Constrained Control for High-Order Fully Actuated Nonlinear Systems

- This chapter advances to explore time-constrained control of high-order fully actuated nonlinear systems. Unlike the conventional approaches discussed earlier, prescribed-time control provides a unique mechanism where the convergence time can be explicitly predetermined. We build on the adaptive methodologies of Chapter 2 and introduce a prescribed-time control strategy that leverages the adaptive Lyapunov-based techniques and the high-order fully actuated framework. This chapter introduces a novel prescribed-time adjustment function that allows the system to achieve the desired state within a preset time.

5.1 Overview

5.2 System Formulation and Preliminaries

5.3 Prescribed-time Controller Design

5.4 Lyapunov Stability Analysis For Fully Actuated Nonlinear Systems

5.5 Simulation Results Validating Prescribed-Time Controller

5.6 Conclusion

References

6. Adaptive Time-Constrained Control for High-Order Fully Actuated Nonlinear Systems with Uncertain parameters

- Extending the prescribed-time control strategy from the previous chapter, this chapter addresses systems with uncertain parameters. In practical scenarios, parameters like mass or damping can vary, impacting system performance. We propose an adaptive control law to ensure convergence within a pre-specified time, despite these uncertainties. By integrating high-order fully actuated system theory with adaptive control, we achieve robust prescribed-time stability.

6.1 Overview

6.2 Problem Formulation of High-Order Fully Actuated Nonlinear Systems with Uncertain parameters

6.3 Design of Adaptive Prescribed-Time Controllers

6.4 Stability Analysis For Fully Actuated Nonlinear Uncertain Systems

6.5 Numerical Examples Highlighting Adaptive Prescribed-Time Controller

6.6 Conclusion

References

Part III Adaptive State-Constrained Control for High-Order Fully Actuated Nonlinear Systems

7. Adaptive Full-State Constrained Fault-Tolerant Control for High-Order Fully Actuated Nonlinear Systems

- Building on the adaptive control techniques for uncertain systems, this chapter explores full-state constrained control under actuator faults. State constraints and actuator faults are common in practical systems, requiring robust strategies to maintain performance and safety. We propose an adaptive fault-tolerant control framework that uses nonlinear transformation functions to manage constraints and compensate for faults. Leveraging high-order fully actuated system theory and Lyapunov stability analysis, the proposed method ensures stability while satisfying state constraints.

7.1 Overview

7.2 System Formulation and Preliminaries

7.3 Full-State Constrained Controller Design

7.4 Lyapunov Stability Analysis Under Fault and Constraint Scenarios

7.5 Simulation Examples Illustrating Fault-Tolerant Capabilities

7.6 Conclusion

References

8. Multi-Variable Constrained Control for High-Order Fully Actuated Nonlinear Uncertain Systems

- Expanding on the constrained control techniques from the previous chapter, this chapter addresses multi-variable high-order fully actuated nonlinear systems with uncertainties. These systems often involve multiple interacting subsystems, requiring coordinated control while respecting constraints. We introduce a novel control strategy that integrates command filtered control with high-order fully actuated system theory, managing multi-variable interactions and addressing uncertainties using radial basis function neural networks.

8.1 Overview

8.2 System Formulation and Assumptions

8.3 Controller Design Incorporating Command Filtering Techniques

8.4 Stability Analysis Under Multi-Variable Constrained

8.4 Numerical Simulations Demonstrating Multi-Variable Constrained Performance

8.5 Conclusion

References

9. Adaptive Tracking Error-Constraint Control of Fully Actuated Unmanned Underwater Vehicle System

- This chapter focuses on the adaptive trajectory tracking of unmanned underwater vehicles (UUVs) using a fully actuated system approach. UUVs face challenges such as hydrodynamic uncertainties, external disturbances, and actuator limitations. We propose an adaptive tracking error-constraint control strategy that incorporates normalized and barrier functions, combined with adaptive RBF neural networks, to handle these challenges. The proposed method ensures tracking errors remain within acceptable bounds, even under uncertainties.

9.1 Overview

9.2 Problem Formulation

9.3 Adaptive Tracking Error-Constraint Controller Design

9.4 Stability Analysis with Error-Constraint

9.5 Simulation Example of Adaptive Tracking Control Performance

9.6 Conclusion

References

10. Conclusion

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2. **Outline CVs (Authors, Editors)** – *Career notes, lists of related publications, reviews of these, etc. Please simply link to online sources, if available. In the case of edited volumes provide outline CVs of the editors only, not the chapter contributors.*

2.1 Curriculum Vitae(Career)

2.1.1 Curriculum Vitae of Prof. Changchun Hua

1) Academic qualifications

- Ph.D., School of of Electrical Engineering, Yanshan University, China, 2005

2) Previous professional experience

- 2009/02-2011/01 Research Fellow, AKS Institute, University of Duisburg-Essen, Germany
- 2007/12-2009/02 Research Fellow, Department of SCE, Carleton University, Ontario, Canada
- 2006/04-2007/10 Research Fellow, Department of ECE, National University of Singapore
- 2006/01-2009/10 Associate Professor, Institute of Electrical Engineering, Yanshan University
- 2005/07-2005/10 Senior Research Assistant, Department of MEEM, City University of Hong Kong
- 2003/01-2005/12 Lecturer, Institute of Electrical Engineering, Yanshan University

3) Present academic position

- Vice-Principal, Hebei University of Science and Technology (2023-Present)
- Professor, School of Electrical Engineering, Yanshan University (2009-Present)

2.1.2 Curriculum Vitae of Prof. Liuliu Zhang

1) Academic qualifications

- Ph.D., School of of Electrical Engineering, Yanshan University, China, 2018

2) Previous professional experience

- 2021/12-2022/12 Research Fellow, School of Electrical Engineering, Korea University, Korea
- 2018/06-2020/11 Lecturer, Institute of Electrical Engineering, Yanshan University
- 2018/06-2020/06 Postdoc, School of Mechanical Engineering, Yanshan University
- 2016/04-2016/07 Research Associate, Faculty of Science and Technology, Bournemouth University, UK

3) Present academic position

- Associate Professor, Institute of Electrical Engineering, Yanshan University (2020-Present)

2.1.3 Curriculum Vitae of Dr. Pengju Ning

1) Academic qualifications

- Ph.D., School of of Electrical Engineering, Yanshan University, China, 2023

2) Present academic position

- Postdoc, Department of Biomedical Engineering, city university of Hong Kong (2024-Present)

2.2 List of related publications

2.2.1 Closely related publications

1) Ning, PJ, Hua, CC, Meng, R, Adaptive control for a class of nonlinear time-delay system based on the fully actuated system approaches, Journal of Systems Science & Complexity, 35(2):522-534, 2022.
2) Zhu, LC, Zhang, LL, Qian, C, Hua, CC, Multi-variable constrained control for uncertain high-order strict-feedback fully actuated nonlinear systems, Journal of the Franklin Institute, 361(17): 107190, 2024.
3) Meng, R, Hua, CC, Li, K, Ning, PJ, Adaptive event-triggered control for uncertain high-order fully actuated system, IEEE Transactions on Circuits and Systems II-Express Briefs, 69(11): 4438-4442,2022.
4) Zhang, LL, Zhu, LC, Hua, CC, Practical prescribed time control based on high-order fully actuated system approach for strong interconnected nonlinear systems, Nonlinear Dynamics, 110(4): 3535-3545,2022.
5) Dong, RX, Hua, CC, Li, K, Meng, R, Adaptive fault-tolerant control for high-order fully actuated system with full-state constraints, Journal of the Franklin Institute, 360(12): 8062-8074, 2023.
6) Zhang, LL, Wang, P, Hua, CC, Adaptive control of time-delay nonlinear HOFA systems with unmodeled dynamics and unknown dead-zone input, International Journal of Robust and Nonlinear, 33(4): 2615-2628, 2023.
7) Zhang, LL, Wang, P, Qian, C, Hua, CC, Adaptive trajectory tracking error constraint control of unmanned underwater vehicle based on a fully actuated system approach, Journal of Systems Science & Complexity, 37(6): 2633-2653, 2024.
8) Ning, PJ, Hua, CC, Li, H, Global prescribed-time control fully actuated nonlinear systems, 2024 3rd Conference on Fully Actuated System Theory and Applications, Shenzhen, China, May 10-12, 2024, 141-146.
9) Wei, YQ, Hua, CC, Liu, DY, Fractional order controller design for a class of nonlinear systems by high-order fully actuated system approach, 2022 China Automation Congress, Xiamen, China, November 25-27, 2022, 2439-2443.
10) Zhang, Y, Liu, GP, Hua, CC, Yang, YN, Global prescribed performance control for nonlinear interconnected systems: A high-order fully actuated system approach, 2024 3rd Conference on Fully Actuated System Theory and Applications, Shenzhen, China, May 10-12, 2024, 945-950.

2.2.2 Other related publications

1) Hua, CC, Tian, W, Li, QD, Switching event-triggered fixed-time control for uncertain high-order nonlinear systems, IEEE Transactions on Automatic Control, 69(7): 4742-4749, 2024.
2) Hua, CC, Ning, PJ, Li, K, Adaptive prescribed-time control for a class of uncertain nonlinear systems, IEEE Transactions on Automatic Control, 67(11): 6159-6166, 2022.
3) Hua, CC, Li, QD, Li, K, Event-based finite-time control for high-order interconnected nonlinear systems with asymmetric output constraints, IEEE Transactions on Automatic Control, 67(11): 6135-6142, 2022.
4) Hua, CC, Li, Hao, Li, K, Ning, PJ, Adaptive prescribed-time stabilization of uncertain nonlinear systems with unknown control directions, IEEE Transactions on Automatic Control, 69(6): 3968-3974, 2024.
5) Ning, PJ, Hua, CC, Li, K, Meng, R, Event-triggered control for nonlinear uncertain systems via a prescribed-time approach, IEEE Transactions on Automatic Control, 68(11): 6975-6981, 2023.

6) Zhang, LL, Zhu, LC, Hua, CC, Qian, C, Adaptive decentralized control for interconnected time-delay uncertain nonlinear systems with different unknown control directions and deferred full-state constraints, IEEE Transactions on Neural Networks and Learning Systems, 34(12): 10789-10801, 2023.
7) Zhang, LL, Zhu, LC, Hua, CC, Adaptive exponential convergence state-constrained control for interconnected nonlinear systems with time-varying unknown parameters, IEEE Transactions on Systems, Man, and Cybernetics: Systems, 54(8): 4713-4725, 2024.
8) Ning, PJ, Hua, CC, Li, K, Meng, R, Adaptive fixed-time control for uncertain nonlinear cascade systems by dynamic feedback, IEEE Transactions on Systems, Man, and Cybernetics: Systems, 53(5): 2961-2970, 2023.

3. **About the Author Text** – *Please provide a brief biography that highlights the areas of your work, expertise, publication record related to the proposed book's topic, and any other relevant information such as honors, achievements, etc.*

Prof. Changchun Hua has authored or coauthored more than 400 papers in mathematical and technical journals and conferences. He is a a Fellow of IEEE and CAA. He served as the General Chair of the 2011 IEEE International Symposium on Haptic Audio Visual Environments and Games and the 2023 IEEE International Conference on CYBER Technology in Automation, Control, and Intelligent Systems. His current research interests include nonlinear control systems, renewable energy systems, and intelligent control.

Prof. Liuliu Zhang has authored or coauthored more than 50 papers in mathematical and technical journals and conferences. She was the recipient of the National Postdoctoral Innovation Talent Support Program. Her current research interests include nonlinear system control, intelligent control of networked interconnected system, and multirobot cooperative control.

Dr. Pengju Ning has authored or coauthored more than 20 papers in mathematical and technical journals and conferences. He is a reviewer of Automatica, IEEE Transactions on Automatic control, SIAM Journal on Control and Optimization, etc. His research interests include nonlinear systems, uncertain systems, adaptive control, prescribed time control, and prescribed performance control.

E Book Context

1. Type – *Is your book mainly a research monograph, undergraduate or graduate/advanced textbook, professional book, state-of-the-art survey, major reference work (>1000 pages), etc.?*

The book is a research monograph.

3. **Competing Titles** – *Please provide titles, authors, ISBNs – publisher or Amazon URLs if possible – of competing titles, and a brief comment on how your proposed book compares.*

There are currently no direct competitors in this domain. Fully actuated system approach was proposed in 2020 and 2021 as a general framework for control system analysis and design based on a newly discovered general type of fully actuated models for dynamical systems. There are no books related to the fully actuated system approach in the research of adaptive constrained control for nonlinear systems.

3. Readers – *Please select from and reorder the following list to match the expected audience share: scientists and researchers; lecturers and tutors; academic and corporate libraries; practitioners and professionals; postgraduates; undergraduates; others (specify).*

And which research areas are they from?

1) Readers: Scientists and researchers; lecturers and tutors; postgraduates; practitioners and professionals; undergraduates.

2) Research area: Control theory and applications

4. Keywords (5 -20 keywords in order of importance and relevance):

Adaptive constrained control, high-order fully actuated system approaches, nonlinear systems, dead-zone input, state-constrained control, prescribed-time stability.

5. Unique Selling Points that indicate the features and benefits (3 points, each point less than 120 characters):

1) Achieve the global stabilization of strictly feedback nonlinear time-delay systems with input constraint by using the theory of high-order fully actuated systems.

2) Explore the adaptive prescribed-time control design for fully actuated nonlinear systems with uncertainties.

3) Solve the single/multi-variable constrained control problem for uncertain high-order fully actuated nonlinear systems.

F Manuscript Plan

1. **Planned Date of Manuscript Submission:** May 30, 2025

2. Planned Pages of Manuscript (*Standard Springer book format: 155x235mm, with approx. 500 words per page***):**
The planned pages of manuscript are 210 pages.

3. Open Access option: Yes

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If interested, please discuss this with your Publishing Editor. This is an extra option that entails a processing fee, where you locate funders to provide payment to cover those costs.

G Textbook

Not applicable.

H Sample Content – *Please specify the status of any sample content accompanying this proposal.*

The sample chapter was submitted as an attachment to this proposal.

I Other Notes – *Please provide any further relevant comments or suggestions.*

Please reply to Dr.Celine Lanlan Chang, Computer Science (celine.chang@springer.com)