

# 35

## Robust Adaptive Control

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35.1	Introduction.....	35-1
	Brief History	
35.2	Identifier-Based Adaptive Control .....	35-4
	Direct and Indirect Adaptive Control • Online Parameter Estimation • Model Reference Adaptive Control • Adaptive Pole Placement Control • Instability Phenomena in Adaptive Systems • Robust Adaptive Laws	
35.3	Nonidentifier-Based Adaptive Control .....	35-13
	Switching and Multiple Models • Unfalsified Adaptive Control	
35.4	Mixed Identifier and Nonidentifier-Based Tools .....	35-19
	Adaptive Control with Mixing	
35.5	Conclusions.....	35-20
	References .....	35-21

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### 35.1 Introduction

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The design of autopilots for high-performance aircraft was one of the primary motivations for active research in adaptive control in the early 1950s. Aircrafts operate over a wide range of speeds and altitudes, and their dynamics are nonlinear and conceptually time-varying. For a given operating point, specified by the aircraft speed (Mach number) and altitude, the longitudinal nonlinear aircraft dynamics can be approximated by a linear model. As the aircraft goes through different flight conditions, the operating point changes. These changes cannot be handled by constant gain feedback control. Since the output response  $y(t)$  carries information about the state as well as the parameters, one may argue that in principle, a sophisticated feedback controller should be able to learn about the plant changes by processing the input/output (I/O) measurements  $(u, y)$  and choosing the appropriate controller from a list or design a new one in real-time. The real-time or on-the-fly selection or design of the controller is what distinguishes adaptive from nonadaptive schemes. Figure 35.1 illustrates this general adaptive control structure. The structure covers almost all classes of adaptive control. The idea is to process the I/O and possibly auxiliary measurements and decide what controller to use in real-time. Under this generic structure one can include gain scheduling where the real time controller design block is just a look-up table with a scheduler logic. In identifier-based schemes, this block includes a parameter estimator and the online calculation of the controller whereas in nonidentifier-based schemes, the block may consist of multiple models, stored controllers, and so on and an appropriate logic for selecting the right controller in real-time. Structures such as direct and indirect adaptive control also fall into this general feedback structure.

# Robust Adaptive Control Solution Manual

**Wenbin Ji**



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## **Table of Contents Robust Adaptive Control Solution Manual**

1. Understanding the eBook Robust Adaptive Control Solution Manual
  - The Rise of Digital Reading Robust Adaptive Control Solution Manual
  - Advantages of eBooks Over Traditional Books
2. Identifying Robust Adaptive Control Solution Manual
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Robust Adaptive Control Solution Manual
  - User-Friendly Interface
4. Exploring eBook Recommendations from Robust Adaptive Control Solution Manual

- Personalized Recommendations
- Robust Adaptive Control Solution Manual User Reviews and Ratings
- Robust Adaptive Control Solution Manual and Bestseller Lists
- 5. Accessing Robust Adaptive Control Solution Manual Free and Paid eBooks
  - Robust Adaptive Control Solution Manual Public Domain eBooks
  - Robust Adaptive Control Solution Manual eBook Subscription Services
  - Robust Adaptive Control Solution Manual Budget-Friendly Options
- 6. Navigating Robust Adaptive Control Solution Manual eBook Formats
  - ePub, PDF, MOBI, and More
  - Robust Adaptive Control Solution Manual Compatibility with Devices
  - Robust Adaptive Control Solution Manual Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Robust Adaptive Control Solution Manual
  - Highlighting and Note-Taking Robust Adaptive Control Solution Manual
  - Interactive Elements Robust Adaptive Control Solution Manual
- 8. Staying Engaged with Robust Adaptive Control Solution Manual
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Robust Adaptive Control Solution Manual
- 9. Balancing eBooks and Physical Books Robust Adaptive Control Solution Manual
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Robust Adaptive Control Solution Manual
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Robust Adaptive Control Solution Manual
  - Setting Reading Goals Robust Adaptive Control Solution Manual
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Robust Adaptive Control Solution Manual

- Fact-Checking eBook Content of Robust Adaptive Control Solution Manual
- Distinguishing Credible Sources

### 13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
- Exploring Educational eBooks

### 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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