Robust And Adaptive Control With Aerospace Applications 2013 Advanced Textbooks In Control And Signal Processing By Lavretsky Eugene Author 2012 Hardcover

A Class of Adaptive Controllers with Application to Robust Adaptive Control
Robust Adaptive Control of Nonlinear Systems with Guaranteed Error Bounds
Robust and Adaptive Control Strategies for Closed-loop Climate Engineering
Robust Adaptive Control and Filtering
Robust Adaptive Control
Strongly Robust Adaptive Control : the Strong Robustness Approach
Robust Adaptive Control
Robust and Adaptive Control Laws for a Mini Quad Rotor UAV
Robust Adaptive Control
Adaptive Control Systems
Nonlinear Robust and Adaptive Control with Application to Brake Control for Automated Highway Systems
Robust and Adaptive Nonlinear Control Using Dynamic Surface Controller with Applications to Intelligent Vehicle Highway Systems
L1 Adaptive Control Theory
On the Use of Robust Controllers in Adaptive Control
Certifiable L1 Adaptive Control for Helicopters
Perspectives in Robust Control
Nonlinear and Adaptive Control with Applications
Robust Adaptive Control
Robust Adaptive Control Using a Filtering Action
Robust and Adaptive Control
RISE-Based Robust and Adaptive Control of Nonlinear Systems
Adaptive Robust Control Systems
Design of Robust Adaptive Control Systems
Robust Adaptive Control
Robust Adaptive Control Schemes
Robust Adaptive Control Design Techniques
Applications of Nonlinear Control
Special Issue on Robust and Adaptive Control
Robust Adaptive Control Using a Universal Approximator with Application to Vehicle Motion Control for IVHS
Robust Adaptive Control
Robust Adaptive Control
Robust Control and Adaptive Control of Uncertain Linear Systems
Robust Adaptive Control of Switched Systems
Robust Adaptive Control for a Class of Dynamic Systems with Mismatched Uncertainties
$ C \infty $ Robust Adaptive Control
Robust Adaptive Control for Fractional-Order Systems with Disturbance and Saturation
Adaptive Robust Control Systems
Robust and Adaptive Control
Robust and adaptive control

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A Class of Adaptive Controllers with Application to Robust Adaptive Control SIAM
This dissertation describes the design of an adaptive controller for single-input single-output (SISO) systems with guaranteed bounds on the transient response, and robustness with external disturbances and unmodeled dynamics. Developed from a current approach called "L1 adaptive controller", we show that by adding two properly designed low pass filters at the input and at the estimator we can control the transient response and the sensitivity of the overall system to external disturbances and unmodeled dynamics. Global stability of the overall adaptive system is mathematically proven under the assumption that the system is minimum phase (i.e., with the zeros of the transfer function in the stable region) and bounds of the systems parameters are known to the designer. The extension of this approach to non-minimum phase systems, such as systems with flexible appendages, is also considered. We show that a non-minimum phase plant augmented with a properly designed parallel system results in a minimum phase system. The augmenting system most easily comes from the inverse of a stabilizing Proportional-Integral-Derivative (PID) controller, designed to be least sensitive to parameter uncertainties. This approach is applied to a flexible arm in a testbed at the Naval Postgraduate School, called the Flexible Spacecraft Simulator

(FSS), which emulates realistic conditions in space. Experimental results prove the effectiveness of the controller presented in this dissertation.

Robust Adaptive Control of Nonlinear Systems with Guaranteed Error Bounds Robust and Adaptive Control

Robust and Adaptive Control shows the reader how to produce consistent and accurate controllers that operate in the presence of uncertainties and unforeseen events. Driven by aerospace applications the focus of the book is primarily on continuous-dynamical systems. The text is a three-part treatment, beginning with robust and optimal linear control methods and moving on to a self-contained presentation of the design and analysis of model reference adaptive control (MRAC) for nonlinear uncertain dynamical systems. Recent extensions and modifications to MRAC design are included, as are guidelines for combining robust optimal and MRAC controllers. Features of the text include: · case studies that demonstrate the benefits of robust and adaptive control for piloted, autonomous and experimental aerial platforms; · detailed background material for each chapter to motivate theoretical developments; · realistic examples and simulation data illustrating key features of the methods described; and · problem solutions for instructors and MATLAB® code provided electronically. The theoretical content and practical applications reported address real-life aerospace problems, being based on numerous transitions of control-theoretic results into operational systems and airborne vehicles that are drawn from the authors' extensive professional experience with The Boeing Company. The systems covered are challenging, often open-loop unstable, with uncertainties in their dynamics, and thus requiring both persistently reliable control and the ability to track commands either from a pilot or a guidance computer. Readers are assumed to have a basic understanding of root locus, Bode diagrams, and Nyquist plots, as well as linear algebra, ordinary differential equations, and the use of state-space methods in analysis and modeling of dynamical systems. Robust and Adaptive Control is intended to methodically teach senior undergraduate and graduate students how to construct stable and predictable control algorithms for realistic industrial applications. Practicing engineers and academic researchers will also find the book of great instructional value.

BoD – Books on Demand

This book is based on a workshop entitled "Robust Control workshop 2000". The workshop was held in Newcastle, Australia, from the 6th to the 8th December 2000. Chapters of the book are written by some of the leading researchers in the field of Robust Control. They cover a variety of topics all related to Robust Control and analysis of uncertain systems.

Robust and Adaptive Control Strategies for Closed-loop Climate Engineering Courier Corporation

List of contributors; Preface; Adaptive internal model control; An algorithm for robust adaptive control with less prior knowledge; Adaptive variable structure control; Indirect adaptive periodic control; Adaptive stabilization of uncertain discrete-time systems via switching control: the method of localization; Adaptive nonlinear control: passivation and small gain techniques; Active identification for control of discrete-time uncertain nonlinear systems; Optimal adaptive tracking for nonlinear systems; Stable adaptive systems in the presence of nonlinear parametrization; Adaptive inverse for actuator compensation; Stable multi-input multi-output adaptive fuzzy/neural control; Adaptive robust control scheme with an application to PM synchronous motors; Index.

Robust Adaptive Control and Filtering John Wiley & Sons

Robust and Adaptive ControlSpringer Science & Business Media

Robust Adaptive Control Elsevier

This book focuses on the applications of robust and adaptive control approaches to practical systems. The proposed control systems hold two important features: (1) The system is robust with the variation in plant parameters and disturbances (2) The system adapts to parametric uncertainties even in the unknown plant structure by self-training and self-estimating the unknown factors. The various kinds of robust adaptive controls represented in this book are composed of sliding mode control, model-reference adaptive control, gain-scheduling, H-infinity, model-predictive control, fuzzy logic, neural networks, machine learning, and so on. The control objects are very abundant, from cranes, aircrafts, and wind turbines to automobile, medical and sport machines, combustion engines, and electrical machines.

Strongly Robust Adaptive Control : the Strong Robustness Approach LAP Lambert Academic Publishing

This research deals with fundamental issues in robust and adaptive control, with emphasis on performance and stability robustness under parametric uncertainty and on the potential applications of such advanced control system design methods to the control of high performance vehicles such as the supermaneuverable aircraft and bank-to-turn missiles. Keywords: Robust adaptive control; Identification in the time and frequency domains; Parametric uncertainty analysis. (edc).

Robust Adaptive Control Springer Science & Business Media

This book focuses on the applications of robust and adaptive control approaches to practical systems. The proposed control systems hold two important features: (1) The system is robust with the variation in plant parameters and disturbances (2) The system adapts to parametric uncertainties even in the unknown plant structure by self-training and self-estimating the unknown factors. The various kinds of robust adaptive controls represented in this book are composed of sliding mode control, model-reference adaptive control, gain-scheduling, H-infinity, model-predictive control, fuzzy logic, neural networks, machine learning, and so on. The control objects are very abundant, from cranes, aircrafts, and wind turbines to automobile, medical and sport machines, combustion engines, and electrical machines.

Robust and Adaptive Control Laws for a Mini Quad Rotor UAV
Springer Science & Business Media

Robust Adaptive Control of Switched Systems.

Robust Adaptive Control Newnes

Different control laws have been analyzed, from the classical theory, like PD and LQR controllers, to an innovative theory, that is represented by the L1 adaptive controller. The validation of controllers is proposed on the experimental model (derived from flight tests) and in a formation flight application. A quadrotor is a platform with fast dynamics, thus if a sudden maneuver is implemented can cause glitches on the parameters trend and the aircraft could become uncontrollable. A key aspect of this controller is the definition of control signals as the output of a low pass-filter. This feature permits to avoid high frequency oscillations due to the large adaptation gain; in systems that use electronic devices. Moreover, this controller is robust in presence of model uncertainties and unmodeled dynamics. The simple structure and the presence of less oscillations during the implementation demonstrate that this controller can be a good candidate for an autopilot. Therefore, the low pass filter is evaluated by a trial and error method. To provide a systematic method, a mixed deterministic - randomized approach for the control law design (low pass filter) is proposed.

Adaptive Control Systems IntechOpen

This thesis examines the robustness properties of various adaptive systems for control, filtering, and identification. These include the uniform boundedness or mean-square boundedness of all closed-loop signals (robust boundedness, robust ultimate boundedness), the closed-loop system tracking error performance in the presence (robust performance), and absence (nominal performance) of unmodelled dynamics, disturbances, and parameter time variations. The thesis is divided into three main parts. The first part considers the robustness of continuous-time adaptive control, the second part is concerned with robust adaptive control of discrete-time plants with time-varying parameters, and the third part deals with the robustness of stochastic adaptive algorithms that include parallel model adaptation problems such as output error identification, adaptive IIR filtering, adaptive feedforward control, and adaptive noise cancelling, and ELS (Extended Least Squares)-based adaptive control. In the first part, a continuous-time direct model reference adaptive controller (MRAC) using a gradient adaptation law based on parameter projection and "extended regressor" normalization is proposed. Based on this, boundedness of all closed-loop signals is established for a continuous-time plant of arbitrary positive relative degree, in the presence of persistent bounded disturbances and small unmodelled dynamics that depend on both input and output, in possibly nonlinear or time-varying fashion. The deterioration of output tracking error performance is shown to be a continuous function of the sizes of the disturbance and unmodelled dynamics. In the second part, a discrete-time indirect adaptive pole-zero placement controller using a gradient adaptation law based on parameter projection and "extended regressor" normalization is proposed for adaptive control of a discrete-time plant with time-varying parameters. Based on this, closed-loop boundedness and performance are established in the presence of disturbances, small unmodelled dynamics, and slow-in-the-mean parameter variations. In the third part, we consider the robustness of parameter projection-based parallel adaptation (output error-based) problems such as output error identification, adaptive IIR filtering, adaptive feedforward control, and adaptive noise cancelling, to unmodelled dynamics and to violation of statistical assumptions on the noise. We analyze vanishing gain algorithms. In the case of output error identification/adaptive IIR filtering, we also consider nonvanishing gain algorithms. It is found that the commonly imposed strict positive realness (SPR) condition can be relaxed in certain cases. We also consider the robustness of ELS-based adaptive control, which is an equation error-based approach. (Abstract shortened by UMI.)

Nonlinear Robust and Adaptive Control with Application to Brake Control for Automated Highway Systems Birkhäuser

This book presents a comprehensive overview of the recently developed L1 adaptive control theory, including detailed proofs of the main results. The key feature of the L1 adaptive control theory is the decoupling of adaptation from robustness. The architectures of L1 adaptive control theory have guaranteed transient performance and robustness in the presence of fast adaptation, without enforcing persistent excitation, applying gain-scheduling, or resorting to high-gain feedback.

Robust and Adaptive Nonlinear Control Using Dynamic Surface Controller with Applications to Intelligent Vehicle Highway Systems Springer Science & Business Media

A treatise on investigating tracking control and synchronization control of fractional-order nonlinear systems with system uncertainties, external disturbance, and input saturation Robust Adaptive Control for Fractional-Order Systems, with Disturbance and Saturation provides the reader with a good understanding on how to achieve tracking control and synchronization control of fractional-order nonlinear systems with system uncertainties, external disturbance, and input saturation. Although some texts have touched upon control of fractional-order systems, the issues of input saturation and disturbances have rarely been considered together. This book offers chapter coverage of fractional calculus and fractional-order systems; fractional-order PID controller and fractional-order disturbance observer; design of fractional-order controllers for nonlinear chaotic systems and some applications; sliding mode control for fractional-order nonlinear systems based on disturbance observer; disturbance observer based neural control for an uncertain fractional-order rotational mechanical system; adaptive neural tracking control for uncertain fractional-order chaotic systems subject to input saturation and disturbance; stabilization control of continuous-time fractional positive systems based on disturbance observer; sliding mode synchronization control for fractional-order chaotic systems with disturbance; and more. Based on the approximation ability of the neural network (NN), the adaptive neural control schemes are reported for uncertain fractional-order nonlinear systems Covers the disturbance estimation techniques that have been developed to alleviate the restriction faced by traditional feedforward control and reject the effect of external disturbances for uncertain fractional-order nonlinear systems By combining the NN with the disturbance observer, the disturbance observer based adaptive neural control schemes have been studied for uncertain fractional-order nonlinear systems with unknown disturbances Considers, together, the issue of input saturation and the disturbance for the control of fractional-order nonlinear systems in the present of system uncertainty, external disturbance, and input saturation Robust Adaptive Control for Fractional-Order Systems, with Disturbance and Saturation can be used as a reference for the academic research on fractional-order nonlinear systems or used in Ph.D. study of control theory and engineering.

L1 Adaptive Control Theory Cuvillier Verlag

In Hubschraubern kommen mitunter aufwändige regelungstechnische Verfahren zum Einsatz, um ein intuitiv steuerbares und stabiles Verhalten der Maschine zu erzeugen. Klassische Ansätze in der Entwicklung setzen dabei auf Iterationen aus Systemidentifikation und Auslegung des Systems im Frequenzbereich. In diesem Buch wird vor dem Hintergrund der nur zu gerne unterschätzten Problematik der begrenzten Bandbreiten eine robuste adaptive Regelung eingeführt. Dazu wird ein hochfrequent-aktualisierender L1-adaptiver Regler entsprechend angepasst, ein neues adaptives Gesetz der Ausgangsrückführung eingeführt, eine neue Strategie zur Auslegung der Zustandsrückführung vorgestellt, und für den sicherheitskritischen Aspekt Effekte von Ungenauigkeiten im Rechentakt und von Sensorrauschen evaluiert. Während klassische Ansätze durch nichtlineare Optimierung weitestgehend automatisierbar sind und dennoch die Notwendigkeit wiederholter Flugtests nicht verhindern können, ist der L1-adaptive Regler bei entsprechendem Systemverständnis besonders geeignet, Entwicklungszeiten zu verkürzen. Strenge mathematische Beweise untermauern die Stabilität und Robustheit der eingeführten Algorithmen, wobei die Flugeigenschaften in einem Forschungssimulator verifiziert werden. Often, very complex controller techniques are applied to helicopters for generating an intuitively controllable and stable behavior of the aircraft. In legacy controllers, a number of iterations of system identification and loop shaping methods in frequency domain have to be conducted. In this book, a robust adaptive control theory is introduced, with the often underestimated fact of only limited available bandwidths in mind. To this end, the high-frequency adapting L1-adaptive controller is adjusted, a new adaptive law for output feedback is introduced, a new strategy for defining the design of a state feedback controller is proposed, and effects of uncertainties in the processor clock rate and of sensor noise are evaluated for taking the safety critical nature of the system into account. While legacy approaches can be automated by nonlinear optimization techniques and yet cannot eliminate the necessity of repeated flight tests, the L1-adaptive controller is particularly suitable to reduce development time, provided a sufficiently deep understanding of the system is available. Rigorous mathematical proofs substantiate the stability and robustness of the algorithms as shown, while performance and handling qualities are verified in a research simulator.

On the Use of Robust Controllers in Adaptive Control

A trend of investigation of Nonlinear Control Systems has been present over the last few decades. As a result the methods for its analysis and design have improved rapidly. This book includes nonlinear design topics such as Feedback Linearization, Lyapunov Based Control, Adaptive Control, Optimal Control and Robust Control. All chapters discuss different applications that are basically independent of each other. The book will provide the reader with information on modern control techniques and results which cover a very wide application area. Each chapter attempts to demonstrate how one would apply these techniques to real-world systems through both simulations and experimental settings.

Certifiable L1 Adaptive Control for Helicopters

The following topics are dealt with: adaptive control; constrained nonlinear systems; disturbance attenuation; robust adaptive economic MPC; and discrete-time systems.

Perspectives in Robust Control

The workshop brought together international experts in the field of robust adaptive control to present recent developments in the area. These indicated that the theory of adaptive control is moving closer to applications and is beginning to give realistic guidelines useful in practical situations. The proceedings also focused on the value of such practical features as filtering, normalization, deadzones and unification of robust control and adaptation.

Nonlinear and Adaptive Control with Applications

The authors here provide a detailed treatment of the design of robust adaptive controllers for nonlinear systems with uncertainties. They employ a new tool based on the ideas of system immersion and manifold invariance. New algorithms are delivered for the construction of robust asymptotically-stabilizing and adaptive control laws for nonlinear systems. The methods proposed lead to modular schemes that are easier to tune than their counterparts obtained from Lyapunov redesign.

Robust Adaptive Control

This tutorial-style presentation of the fundamental techniques and algorithms in adaptive control is designed to meet the needs of a wide audience without sacrificing mathematical depth or rigor. The text explores the design, analysis, and application of a wide variety of algorithms that can be used to manage dynamical systems with unknown parameters. Topics include models for dynamic systems, stability, online parameter estimation, parameter identifiers, model reference adaptive control, adaptive pole placement control, and robust adaptive laws. Engineers and students interested in learning how to design, stimulate, and implement parameter estimators and adaptive control schemes will find that this treatment does not require a full understanding of the analytical and technical proofs. This volume will also serve graduate students who wish to examine the analysis of simple schemes and discover the steps involved in more complex proofs. Advanced students and researchers will find it a guide to the grasp of long and technical proofs. Numerous examples demonstrating design procedures and the techniques of basic analysis enrich the text.

Robust Adaptive Control Using a Filtering Action