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Robust Adaptive Control

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35.1 Introduction

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.

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Gary Allen McGraw



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Robust Adaptive Control Petros Ioannou, Jing Sun, 2013-09-26 Presented in a tutorial style this comprehensive treatment unifies simplifies and explains most of the techniques for designing and analyzing adaptive control systems Numerous examples clarify procedures and methods 1995 edition

Adaptive Robust Control Systems Anh Tuan Le, 2018-03-07 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 Adaptive Control Design Techniques Gary Allen McGraw, 1989

Robust Adaptive Control Morten Bach Lauritsen, 1994

Adaptive Control Tutorial Petros Ioannou, Baris Fidan, 2006-01-01 Presents the design analysis and application of a wide variety of algorithms that can be used to manage dynamical systems with unknown parameters

Robust Adaptive Control William Charles Moore, 1989

Robust Adaptive Control Z. Barota, Danmarks Tekniske Højskole. Instituttet for Matematisk Statistik og Operationsanalyse, DTH., 1990

Solutions Manual to Accompany Adaptive Control and Optimization Techniques Virgil W. Eveleigh, 1967

Robust Adaptive Control Hubert Cantalloube, Ye Fu, 1989 Compared with fixed control techniques such as H_∞ optimization the adaptive control is shown to have at least a wider range of use but lower performances

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\infty \$ Robust Adaptive Control Chujen Lin, 1996

Robust Adaptive Control Iasson Karafyllis, Miroslav Krstic, 2025-06-11 This book presents a solution to a problem in adaptive control design that had been open for 40 years robustification to disturbances without compromising asymptotic performance This original methodology builds on foundational ideas such as the use of a deadzone in the update law and nonlinear damping in the controller and advances the tools for and the theory behind designing robust adaptive controllers thus guaranteeing robustness properties stronger than previously achieved The authors present all stability notions old and new that are useful in adaptive control provide numerous examples and contrast their analysis to landmark approaches to robustification of adaptive controllers in prior literature This book develops the Deadzone Adapted Disturbance Suppression DADS control a novel adaptive control method and constructs a novel robust identifier that can work in parallel with every direct adaptive controller not only DADS it presents a wing rock instability application of DADS and provides ideas for the extension of DADS to cases not studied in the book Robust Adaptive Control Deadzone Adapted Disturbance Suppression will be of interest to mathematicians working on feedback control and stability theory and to control engineers Physicists tackling control problems and biologists with an interest in controlling population

dynamics will also find it of interest

Robust Adaptive Control in the Presence of Unmodeled Dynamics Heather Syeda Hussain, 2017 With the advent of each next generation technology demands for a rapidly reconfigurable control system yielding invariant performance under increasingly unknown or widely varying operating conditions becomes crucial Adaptive control has long been viewed as one such control method with implementation on high performance aerial vehicles providing nearly uniform performance across the flight envelope even with limited a priori knowledge on the aircraft's aerodynamic characteristics This adaptation to parametric uncertainties is achieved through a process of online measurement evaluation and compensation through the control input While the foundations of robust adaptive control theory were laid in the early 1980s obtaining quantifiable and practically meaningful robust stability margins for adaptive systems remained an open problem Successful implementation of adaptive control theory as a viable control solution can only be achieved when global robustness properties especially with respect to unmodeled dynamics are well understood This thesis proposes a solution to this long standing open problem for a class of linear time invariant plants whose states are accessible With the use of a modified adaptive update law transformation of tracking and parameter errors and sufficient conditions of a frequency domain criterion it is shown that the underlying closed loop system has globally bounded solutions That is the overall adaptive system is shown to have analytically computable robustness margins that hold for arbitrary initial conditions The proposed method and analysis utilizes several key properties of nonlinear dynamic systems first principles of real analysis and properties of strictly positive real systems to derive this fundamental result Numerical results are presented to demonstrate that the sufficient conditions for global boundedness are non conservative It is also shown that with these global properties established specific conditions can be derived under which the advantage of adaptation over non adaptive solutions for the control of uncertain systems is made clear This advantage lies in the fact parameter adaptation allows learning of the uncertainties whenever the effect of unmodeled dynamics is small leading to small tracking errors and improved robustness margins

Robust Adaptive Control, 1991

Design of Robust Adaptive Control Systems Qing Song, 1991

Safe Adaptive Control Margareta Stefanovic, Michael G. Safonov, 2011-02-04 Safe Adaptive Control gives a formal and complete algorithm for assuring the stability of a switched control system when at least one of the available candidate controllers is stabilizing The possibility of having an unstable switched system even in the presence of a stabilizing candidate controller is demonstrated by referring to several well known adaptive control approaches where the system goes unstable when a large mismatch between the unknown plant and the available models exists plant model mismatch instability Sufficient conditions for this possibility to be avoided are formulated and a recipe to be followed by the control system designer to guarantee stability and desired performance is provided The problem is placed in a standard optimization setting Unlike the finite controller sets considered elsewhere the candidate controller set is allowed to be continuously parametrized so that it can deal with plants with a very large range of uncertainties

Robust Adaptive Control Algorithms

Marimuthuswami Palaniswami,1986 Robust Adaptive Control Ahmad Sanei,2009-10 Robust Adaptive Control: Stability and Asymptotic Performance James M. Krause,Pramod P. Khargonekar,Gunter Stein,HONEYWELL SYSTEMS AND RESEARCH CENTER MINNEAPOLIS MN.,1990 Systems containing both compact real parametric uncertainty and frequency weighted bounded operator uncertainty are addressed It is shown that any parameter adaptive control system is robustly stable provided only that 1 the unknown parameters lie in a known compact convex set 2 the control design rule is Lipschitzian 3 the control design rule would produce a robust controller if given perfect parameter information and 4 a specified robust parameter estimation algorithm is applied in lieu of perfect parameter information It is also shown that the asymptotic robust performance level may be arbitrarily close to that of the non adaptive design which would result from perfect parameter information Keywords Mathematical matrices Robust adaptor control Asymptotic robust performance KT

Towards a performance theory of robust adaptive control Ahmad Sanei,2003 **Robust Adaptive Control** Aniruddha Datta,1991

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