Fault Tolerant Control Systems Design And Practical Applications

Data-driven Design of Fault Diagnosis and Fault-tolerant Control Systems presents basic statistical process monitoring, fault diagnosis, and control methods and introduces advanced data-driven schemes for the design of fault diagnosis and fault-tolerant control systems catering to the needs of dynamic industrial processes. With ever increasing demands for reliability, availability and safety in technical processes and assets, process monitoring and fault-tolerance have become important issues surrounding the design of automatic control systems. This text shows the reader how, thanks to the rapid development of information technology, key techniques of data-driven and statistical process monitoring and control can now become widely used in industrial practice to address these issues. To allow for self-contained study and facilitate implementation in real applications, important mathematical and control theoretical knowledge and tools are included in this book. Major schemes are presented in algorithm form and demonstrated on industrial case systems. Data-driven Design of Fault Diagnosis and Fault-tolerant Control Systems will be of interest to process and control engineers, engineering students and researchers with a control engineering background.

This book summarizes strategies, methods, algorithms, frameworks and systems for the fault-tolerant design and control of automated vehicles and processes. Intelligent systems may be able to accommodate inevitable faults, but this ability requires targeted design processes and advanced control systems. This book explains the respective elements involved in automated vehicles and processes. It provides detailed descriptions of fault-tolerant design, not offered in the existent scientific literature. With regard to fault-tolerant control, the focus is on innovative methods, which can accommodate not only uncertainties, but also shared and flexible redundant elements. The book is intended to present a concise guide for researchers in the field of fault-tolerant design and control, and to provide concrete insights for design and control engineers working in the field of automated vehicles and processes.

This thesis reports on novel methods for gain-scheduling and fault tolerant control (FTC). It begins by analyzing the connection between the linear parameter varying (LPV) and Takagi-Sugeno (TS) paradigms. This is then followed by a detailed description of the design of robust and shifting state-feedback controllers for these systems. Furthermore, it presents two approaches to fault-tolerant control: the first is based on a robust polytopic controller design, while the second involves a reconfiguration of the reference model and the addition of virtual actuators into the loop. Inaddition the thesis offers a thorough review of the state-of-the art in gain scheduling and fault-tolerant control, with a special emphasis on LPV and TS systems.

Data-driven and Model-based Fault Diagnosis Techniques

Fault-tolerant Control Systems

Design of Fault Tolerant Control Systems for AHS.

Diagnosis and Fault-Tolerant Control

Design of Neural Fault-tolerant Control Systems

Fault Tolerant Control System Design for Distillation Processes

The seriesAdvancesinIndustrialControl aims to report and encourage te- nologytransfer in controlengineering. The rapid development of controlte- nology has an impact on all areas of the control discipline. New theory, new controllers, actuators, sensors, new industrial processes, computer methods, new applications, new philosophies. . . , new challenges. Much of this devel- ment work resides in industrial reports, feasibility study papers, and the - ports of advanced collaborative projects. The series o?ers an opportunity for researchers to present an extended exposition of such new work in all aspects of industrial control for wider and rapid dissemination. Control system design and technology continues to develop in many d- ferent directions. One theme that the Advances in Industrial Control series is following is the application of nonlinear control design methods, and the series has some interesting new commissions in progress. However, another theme of interest is how to endow the industrial controller with the ability to overcome faults and process degradation. Fault detection and isolation is a broad ?eld with a research literature spanning several decades. This topic deals with three questions: • How is the presence of a fault detected? • What is the cause of the fault? • Where is it located? However, there has been less focus on the question of how to use the control system to accommodate and overcome the performance deterioration caused by the identi?ed sensor or actuator fault.

This Encyclopedia of Control Systems, Robotics, and Automation is a component of the global Encyclopedia of Life Support Systems EOLSS, which is an integrated compendium of twenty one Encyclopedias. This 22-volume set contains 240 chapters, each of size 5000-30000 words, with perspectives, applications and extensive illustrations. It is the only publication of its kind carrying state-of-the-art knowledge in the fields of Control Systems, Robotics, and Automation and is aimed, by virtue of the several applications, at the following five major target audiences: University and College Students, Educators, Professional Practitioners, Research Personnel and Policy Analysts, Managers, and Decision Makers and NGOs.

Linlin Li addresses the analysis and design issues of observer-based FD and FTC for nonlinear systems. The author analyses the existence conditions for the nonlinear observer-based FD systems to gain a deeper insight into the construction of FD systems. Aided by the T-S fuzzy technique, she recommends different design schemes, among them the L_inf/L_2 type of FD systems. The derived FD and FTC approaches are verified by two benchmark processes.

Design and Evaluation of Real-time Fault-tolerant Control Systems

Reliability-based Fault Tolerant Control Systems

From Fault Diagnosis to Fault-tolerant Control

Fault Tolerant Control Design for Hybrid Systems

Design of Fault Tolerant Control Systems for AHS

Fault-Tolerant Process Control

The key attribute of a Fault Tolerant Control (FTC) system is its ability to maintain overall system stability and acceptable performance in the face of faults and failures within the feedback system. In this book Integral Sliding Mode (ISM) Control Allocation (CA) schemes for FTC are described, which have the potential to maintain close to nominal fault-free performance (for the entire system response), in the face of actuator faults and even complete failures of certain actuators. Broadly an ISM controller based around a model of the plant with the aim of creating a nonlinear fault tolerant feedback controller whose closed-loop performance is established during the design process. The second approach involves retro-fitting an ISM scheme to an existing feedback controller to introduce fault tolerance. This may be advantageous from an industrial perspective, because fault tolerance can be introduced without changing the existing control loops. A high fidelity benchmark model of a large transport aircraft is used to demonstrate the efficacy of the FTC schemes. In particular a scheme based on an LPV representation has been implemented and tested on a motion flight simulator.

Fault-tolerant control theory is a well-studied topic but the use of the sets in detection, isolation and/or reconfiguration is rather tangential. The authors of this book propose a systematic analysis of the set-theoretic elements and devise approaches which exploit advanced elements within the field. The main idea is to translate fault detection and isolation conditions into those conditions involving sets. Furthermore, these are to be computed efficiently using positive invariance and reachability notions. Constraints imposed by exact fault control are used to define feasible references (which impose persistent excitation and, thus, non-convex feasible sets). Particular attention is given to the reciprocal influences between fault detection and isolation on the one hand, and control reconfiguration on the other. Contents 1. State of the Art in Fault-tolerant Control 2. Fault Detection and Isolation in Multisensor Systems 3. Residual Generation and Reference Governor Design 4. Reconfiguration of the Control Mechanism for Fault-tolerant Control 5. Related Problems and Applications About the Authors Florin Stoican received a B.E. degree from the “ Politehnica ” University of Bucharest, Romania, in 2008 and his PhD from SUPELEC, France in 2011. He held an ERCIM Postdoctoral Fellowship with NTNU Trondheim, Norway, in 2012, and is currently Assistant Professor at “ Politehnica ” University of Bucharest. His main interest is the fault tolerant control of dynamical systems through the prism of set theoretic elements. His current work involves further results in set theory and constrained optimization problems. Sorin Olaru received an M.S. degree from the “ Politehnica ” University of Bucharest, Romania, and both his PhD and Habilitation from University Paris XI, France, being awarded the European Commission Archimedes Prize in 2002. Since 2001 he has held different positions at INRIA and SUPELEC in France and visiting appointments at the University of Newcastle, Australia and NTNU Trondheim, Norway. He is currently Professor at SUPELEC, a member of the INRIA Disco team and senior member of IEEE. His research interests include optimization-based control design and the set-theoretic characterization of constrained dynamical systems.

Fault Detection and Fault-tolerant Control Using Sliding Modes is the first text dedicated to showing the latest developments in the use of sliding-mode concepts for fault detection and isolation (FDI) and fault-tolerant control in dynamical engineering systems. It begins with an introduction to the basic concepts of sliding modes to provide a background to the field. This is followed by chapters that describe the use and design of sliding-mode observers for FDI using robust fault reconstruction. The development of a class of sliding-mode observers is described from first principles through to the latest schemes that circumvent minimum-phase and relative-degree conditions. Recent developments have shown that the field of fault tolerant control is a natural application of the well-known robustness properties of sliding-mode control. A family of sliding-mode control designs incorporating control allocation, which can deal with actuator failures directly by exploiting redundancy, is presented. Various realistic case studies, specifically highlighting aircraft systems and including results from the implementation of these designs on a motion flight simulator, are described. A reference and guide for researchers in fault detection and fault-tolerant control, this book will also be of interest to graduate students working with nonlinear systems and with sliding modes in particular. Advances in Industrial Control aims to report and encourage the transfer of technology in control engineering. The rapid development of control technology has an impact on all areas of the control discipline. The series offers an opportunity for researchers to present an extended exposition of new work in all aspects of industrial control.

Fault-tolerant Control System Design

Fault-Tolerant Attitude Control of Spacecraft

Analytical and Soft Computing Approaches

Advanced methods for fault diagnosis and fault-tolerant control

Fault Tolerant Control Systems Design

An Investigation Into Reliable and Fault-tolerant Control Systems Design

This book offers a complete overview of fault-tolerant flight control techniques. Discussion covers the necessary equations for the modeling of small UAVs, a complete system based on extended Kalman filters, and a nonlinear flight control and guidance system.

Fault-Tolerant Attitude Control of Spacecraft presents the fundamentals of spacecraft fault-tolerant attitude control systems, along with the most recent research and advanced, nonlinear control techniques. This book gives researchers a self-contained guide to the complex tasks of envisaging, designing, implementing and experimenting by presenting designs for integrated modeling, dynamics, fault-tolerant attitude control, and fault reconstruction for spacecraft. Specifically, the book gives a full literature review and presents preliminaries and mathematical models, robust fault-tolerant attitude control, fault-tolerant attitude control with actuator saturation, velocity-free fault tolerant attitude control, finite-time fault-tolerant attitude tracking control, and active fault-tolerant attitude contour. Finally, the book looks at the future of this interesting topic, offering readers a one-stop solution for those working on fault-tolerant attitude control for spacecraft. Presents the fundamentals of fault-tolerant attitude control systems for spacecraft in one practical solution Gives the latest research and thinking on nonlinear attitude control, fault tolerant control, and reliable attitude control Brings together concepts in fault control theory, fault diagnosis, and attitude control for spacecraft Covers advances in theory, technological aspects, and applications in spacecraft Presents detailed numerical and simulation results to assist engineers Offers a clear, systematic reference on fault-tolerant control and attitude control for spacecraft

This book presents recent advances in fault diagnosis strategies for complex dynamic systems. Its impetus derives from the need for an overview of the challenges of the fault diagnosis technique, especially for those demanding systems that require reliability, availability, maintainability and safety to ensure efficient operations. Moreover, the need for a high degree of tolerance with respect to possible faults represents a further key point, primarily for complex systems, as modeling and control are inherently challenging, and maintenance is both expensive and safety-critical. Diagnosis and Fault-tolerant Control 1 also presents and compares different diagnosis schemes using established case studies that are widely used in related literature. The main features of this book regard the analysis, design and implementation of proper solutions for the problems of fault diagnosis in safety critical systems. The design of the considered solutions involves robust data-driven, model-based approaches.

Fault Detection and Fault-Tolerant Control Using Sliding Modes

Diagnosis and Fault-tolerant Control Volume 2

Methods and Applications

Practical Methods for Small Unmanned Aerial Vehicles

Design and Practical Applications

Insights for the Synthesis of Intelligent Systems

This book provides readers a good understanding on how to achieve Fault Tolerant Control goal of Hybrid Systems. It presents important theoretical results as well as their applications.

This book provides recent theoretical developments in and practical applications of fault diagnosis and fault tolerant control for complex dynamical systems, including uncertain systems, linear and nonlinear systems. Combining adaptive control technique with other control methodologies, it investigates the problems of fault diagnosis and fault tolerant control for uncertain dynamic systems with or without time delay. As such, the book provides readers a solid understanding of fault diagnosis and fault tolerant control based on adaptive control technology. Given its depth and breadth, it is well suited for undergraduate and graduate courses on linear system theory, nonlinear system theory, fault diagnosis and fault tolerant control techniques. Further, it can be used as a reference source for academic research on fault diagnosis and fault tolerant control, and for postgraduates in the field of control theory and engineering.

This book focuses on the fault diagnosis observer design for the switched system. Model-based fault diagnosis and fault tolerant control are one of the most popular research directions in recent decades. It contains eight chapters. Every chapter is independent in the method of observer design, but all chapters are around the same topic. Besides, in each chapter, the model description and theoretical results are firstly provided, then some practical application examples are illustrated to prove the obtained results. The advanced theoretical methodologies will benefit researchers or engineers in the area of safety engineering and the arrangement of the structure will help the readers to understand the content easily.

Fault Tolerant Flight Control

Fault Detection and Fault-Tolerant Control for Nonlinear Systems

Development of a Methodology for the Detection of System Failures and for the Design of Fault-Tolerant Control Systems

Robust Integration of Model-Based Fault Estimation and Fault-Tolerant Control

Data-driven Design of Fault Diagnosis and Fault-tolerant Control Systems

Stochastic Analysis and Synthesis

A brief description of the research on Information and Decision Systems is described. The scope of this contract is the development of an overall failure detection system design methodology and of methods for fault-tolerant control. We overview the research that has been performed in these areas during the indicated time period. A list of the papers and reports that have been and are being written as a result of research performed under this contract are included.

This thesis deals with the development of Fault-Tolerant Control Systems (FTCS). Fault-tolerant control systems are closed-loop control systems that can tolerate system component faults and maintain system stability and a certain degree of performance. They are used to enhance system reliability and are extremely important in safety-critical applications. In this thesis, the model of a system with possible component faults is first formulated mathematically. Definitions of hardware redundancy, analytical redundancy and hybrid redundancy are provided. The FTCS is classified into passive FTCS and active FTCS based on how the system utilizes the Fault Detection and Isolation (FDI) information. Existing design methods for both passive and active FTCS are reviewed, and new design methods for passive FTCS against sensor faults and active FTCS against actuator faults are proposed and verified on a lab-scale electric machine system. The test results demonstrate the effectiveness of the design. One of the important components in active FTCS is the FDI schemes that rely on so called residual signals. It is shown in this thesis that many of the existing FDI residual generation methods only work for open-loop systems or closed-loop systems without integral terms in its controller. A new method to generate the residual signal for closed-loop systems is proposed based on the results from the sensitivity analysis once the characteristics of a closed-loop control system are known. The original contributions of this thesis are: (i) to determine the limitations of the existing FDI schemes for closed-loop systems and to propose a new way to generate the FDI residual signal; (ii) to apply the FDI and FTCS theories to the design of a passive FTCS for a DC motor speed control system and an active FTCS for a synchronous generator excitation control system. The proposed design methods can readily be extended to other applications.

This book presents model-based analysis and design methods for fault diagnosis and fault-tolerant control. Architectural and structural models are used to analyse the propagation of the fault through the process, test fault detectability and reveal redundancies that can be used to ensure fault tolerance. Case studies demonstrate the methods presented. The second edition includes new material on reconfigurable control, diagnosis of nonlinear systems, and remote diagnosis, plus new examples and updated bibliography.

Analysis and Design of Decentralized Fault-tolerant Control Systems Based on the Passivity Theorem

Fault Tolerant Control System Design Using Dynamic Neural Networks

Advances in Gain-Scheduling and Fault Tolerant Control Techniques

Design Principles of Active Robust Fault Tolerant Control Systems

Analysis and Synthesis of Fault-Tolerant Control Systems

Diagnosis and Fault-tolerant Control 1

Written by leading experts in the field, this book provides the state-of-the-art in terms of fault tolerant control applicable to civil aircraft. The book consists of five parts and includes online material.

Modern technological systems rely on sophisticated control functions to meet increased performance requirements. For such systems, Fault Tolerant Control Systems (FTCS) need to be developed. Active FTCS are dependent on a Fault Detection and Identification (FDI) process to monitor system performance and to detect and isolate faults in the systems. The main objective of this book is to study and to validate some important issues in real-time Active FTCS by means of theoretical analysis and simulation. Several models are presented to achieve this objective, taking into consideration practical aspects of the system to be controlled, performance deterioration in FDI algorithms, and limitations in reconfigurable control laws.

Robust Integration of Model-Based Fault Estimation and Fault-Tolerant Control is a systematic examination of methods used to overcome the inevitable system uncertainties arising when a fault estimation (FE) function and a fault-tolerant controller interact as they are employed together to compensate for system faults and maintain robustly acceptable system performance. It covers the important subject of robust integration of FE and FTC with the aim of guaranteeing closed-loop stability. The reader’s understanding of the theory is supported by the extensive use of tutorial examples, including some MATLAB®-based material available from the Springer website and by industrial-applications-based material. The text is structured into three parts: Part I examines the basic concepts of FE and FTC, providing extensive insight into the importance of and challenges involved in their integration; Part II describes five effective strategies for the integration of FE and FTC: sequential, iterative, simultaneous, adaptive-decoupling, and robust decoupling; and Part III begins to extend the proposed strategies to nonlinear and large-scale systems and covers their application in the fields of renewable energy, robotics and networked systems. The strategies presented are applicable to a broad range of control problems, because in the absence of faults the FE-based FTC naturally reverts to conventional observer-based control. The book is a useful resource for researchers and engineers working in the area of fault-tolerant control systems, and supplementary material for a graduate- or postgraduate-level course on fault diagnosis and FTC. Advances in Industrial Control reports and encourages the transfer of technology in control engineering. The rapid development of control technology has an impact on all areas of the control discipline. The series offers an opportunity for researchers to present an extended exposition of new work in all aspects of industrial control.

Fault Diagnosis and Fault-Tolerant Control Based on Adaptive Control Approach

Fault-Tolerant Design and Control of Automated Vehicles and Processes

Fault Diagnosis and Fault-Tolerant Control Strategies for Non-Linear Systems

Fault-tolerant Flight Control and Guidance Systems

Fault Analysis and Control

Observer-Based Fault Diagnosis and Fault-Tolerant Control for Switched Systems

The major objective of this book is to introduce advanced design and (online) optimization methods for fault diagnosis and fault-tolerant control from different aspects. Under the aspect of system types, fault diagnosis and fault-tolerant issues are dealt with for linear time-invariant and time-varying systems as well as for nonlinear and distributed (including networked) systems. From the methodological point of view, both model-based and data-driven schemes are investigated.To allow for a self-contained study and enable an easy implementation in real applications, the necessary knowledge as well as tools in mathematics and control theory are included in this book. The main results with the fault diagnosis and fault-tolerant schemes are presented in form of algorithms and demonstrated by means of benchmark case studies. The intended audience of this book are process and control engineers, engineering students and researchers with control engineering background.

Fault-Tolerant Process Control focuses on the development of general, yet practical, methods for the design of advanced fault-tolerant control systems; these ensure an efficient fault detection and a timely response to enhance fault recovery, prevent faults from propagating or developing into total failures, and reduce the risk of safety hazards. To this end, methods are presented for the design of advanced fault-tolerant control systems for chemical processes which explicitly deal with actuator/controller failures and sensor faults and data losses. Specifically, the book puts forward: · A framework for detection, isolation and diagnosis of actuator and sensor faults for nonlinear systems; · Controller reconfiguration and safe-parking-based fault-handling methodologies; · Integrated-data- and model-based fault-detection and isolation and fault-tolerant control methods; · Methods for handling sensor faults and data losses; and · Methods for monitoring the performance of low-level PID loops. The methodologies proposed employ nonlinear systems analysis, Lyapunov techniques, optimization, statistical methods and hybrid systems theory and are predicated upon the idea of integrating fault-detection, local feedback control, and supervisory control. The applicability and performance of the methods are demonstrated through a number of chemical process examples. Fault-Tolerant Process Control is a valuable resource for academic researchers, industrial practitioners as well as graduate students pursuing research in this area.

In recent years, control systems have become more sophisticatedin order to meet increased performance and safety requirements formodern technological systems. Engineers are becoming more awarethat conventional feedback control design for a complex system mayresult in unsatisfactory performance, or even instability, in theevent of malfunctions in actuators, sensors or other systemcomponents. In order to circumvent such weaknesses, new approachesto control system design have emerged which can tolerate componentmalfunctions while maintaining acceptable stability andperformance. These types of control systems are often known asfault-tolerant control systems (FTCS). More precisely, FTCS arecontrol systems which possess the ability to accommodate componentfailure automatically. Analysis and Synthesis of Fault-Tolerant Control Systemscomprehensively covers the analysis and synthesis methods of faulttolerant control systems. It unifies the methods for developingcontrollers and filters for a wide class of dynamical systems andreports on the recent technical advances in design methodologies.MATLAB® is used throughout the book, to demonstrate methods ofanalysis and design. Key features: • Provides advanced theoretical methods and typicalpractical applications • Provides access to a spectrum of control design methodsapplied to industrial systems • Includes case studies and illustrative examples • Contains end-of-chapter problems Analysis and Synthesis of Fault-Tolerant Control Systemsis a comprehensive reference for researchers and practitionersworking in this area, and is also a valuable source of informationfor graduates and senior undergraduates in control, mechanical,aerospace, electrical and mechatronics engineering departments.

Annual Report for MOU 288

Design, Analysis and Implementation of Fault-tolerant Control Systems with Application to Electric Machines [microform]

Fault Tolerant Control Schemes Using Integral Sliding Modes

A Benchmark Challenge

Active Fault-Tolerant Control Systems

A Behavioral System Theoretic Perspective

This book presents recent advances in fault diagnosis and fault-tolerant control of dynamic processes. Its impetus derives from the need for an overview of the challenges of the fault diagnosis technique and sustainable control, especially for those demanding systems that require reliability, availability, maintainability, and safety to ensure efficient operations. Moreover, the need for a high degree of tolerance with respect to possible faults represents a further key point, primarily for complex systems, as modeling and control are inherently challenging, and maintenance is both expensive and safety-critical. Diagnosis and Fault-tolerant Control 2 also presents and compares different fault diagnosis and fault-tolerant schemes, using well established, innovative strategies for modeling the behavior of the dynamic process under investigation. An updated treatise of diagnosis and fault-tolerant control is addressed with the use of essential and advanced methods including signal-based, model-based and data-driven techniques. Another key feature is the application of these methods for dealing with robustness and reliability.

The book introduces novel algorithms for designing fault-tolerant control (FTC) systems using the behavioral system theoretic approach, and presents a demonstration of successful novel FTC mechanisms on several benchmark examples. The authors also discuss a new transient management scheme, which is an essential requirement for the implementation of active FTC systems, and two data-driven methodologies that are broadly classified as active FTC systems: the projection-based approach and the online-redesign approach. These algorithms do not require much a priori information about the plant in real-time, and in addition this novel implementation of active FTC systems circumvents various weaknesses induced by using a diagnostic module in real-time. The book provides graduate students taking masters and doctoral courses in mathematics, control, and electrical engineering an excellent stepping-stone for their research. It also appeals to practitioners interested to apply innovative fail-safe control techniques.

This book presents selected fault diagnosis and fault-tolerant control strategies for non-linear systems in a unified framework. In particular, starting from advanced state estimation strategies up to modern soft computing, the discrete-time description of the system is employed Part I of the book presents original research results regarding state estimation and neural networks for robust fault diagnosis. Part II is devoted to the presentation of integrated fault diagnosis and fault-tolerant systems. It starts with a general fault-tolerant control framework, which is then extended by introducing robustness with respect to various uncertainties. Finally, it is shown how to implement the proposed framework for fuzzy systems described by the well-known Takagi—Sugeno models. This research monograph is intended for researchers, engineers, and advanced postgraduate students in control and electrical engineering, computer science, as well as mechanical and chemical engineering.

Active Fault Tolerant Control Systems

Control Systems, Robotics and AutomatioN — Volume XVI

Analysis and Design

Set-theoretic Fault-tolerant Control in Multisensor Systems