

Data Driven Methods For Fault Detection And Diagnosis In Chemical Processes Advances In Industrial Control

Mass production companies have become obliged to reduce their production costs and sell more products with lower profit margins in order to survive in competitive market conditions. The complexity and automation level of machinery are continuously growing. This development calls for some of the most critical issues that are reliability and dependability of automatic systems. In the future, machines will be monitored remotely, and computer-aided techniques will be employed to detect faults in the future, and also there will be unmanned factories where machines and systems communicate to each other, detect their own faults, and can remotely intercept their faults. The pioneer studies of such systems are fault diagnosis studies. Thus, we hope that this book will contribute to the literature in this regard.

Data-Driven and Model-Based Methods for Fault Detection and Diagnosis covers techniques that improve the quality of fault detection and enhance monitoring through chemical and environmental processes. The book provides both the theoretical framework and technical solutions. It starts with a review of relevant literature, proceeds with a detailed description of developed methodologies, and then discusses the results of developed methodologies, and ends with major conclusions reached from the analysis of simulation and experimental studies. The book is an indispensable resource for researchers in academia and industry and practitioners working in chemical and environmental engineering to do their work safely. Outlines latent variable based hypothesis testing fault detection techniques to enhance monitoring processes represented by linear or nonlinear input-space models (such as PCA) or input-output models (such as PLS)

Explains multiscale latent variable based hypothesis testing fault detection techniques using multiscale representation to help deal with uncertainty in the data and minimize its effect on fault detection Includes interval PCA (IPCA) and interval PLS (IPLS) fault detection methods to enhance the quality of fault detection Provides model-based detection techniques for the improvement of monitoring processes using state estimation-based fault detection approaches Demonstrates the effectiveness of the proposed strategies by conducting simulation and experimental studies on synthetic data

This unique text/reference describes in detail the latest advances in unsupervised process monitoring and fault diagnosis with machine learning methods. Abundant case studies throughout the text demonstrate the efficacy of each method in real-world settings. The broad coverage examines such cutting-edge topics as the use of information theory to enhance unsupervised learning in tree-based methods, the extension of kernel methods to multiple kernel learning for feature extraction from data, and the incremental training of multilayer perceptrons to construct deep architectures for enhanced

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data projections. Topics and features: discusses machine learning frameworks based on artificial neural networks, statistical learning theory and kernel-based methods, and tree-based methods; examines the application of machine learning to steady state and dynamic operations, with a focus on unsupervised learning; describes the use of spectral methods in process fault diagnosis.

Intelligent Fault Diagnosis and Remaining Useful Life Prediction of Rotating Machinery provides a comprehensive introduction of intelligent fault diagnosis and RUL prediction based on the current achievements of the author's research group. The main contents include multi-domain signal processing and feature extraction, intelligent diagnosis models, clustering algorithms, hybrid intelligent diagnosis strategies, and RUL prediction approaches, etc. This book presents fundamental theories and advanced methods of identifying the occurrence, locations, and degrees of faults, and also includes information on how to predict the RUL of rotating machinery. Besides experimental demonstrations, many application cases are presented and illustrated to test the methods mentioned in the book. This valuable reference provides an essential guide on machinery fault diagnosis that helps readers understand basic concepts and fundamental theories. Academic researchers with mechanical engineering or computer science backgrounds, and engineers or practitioners who are in charge of machine safety, operation, and maintenance will find this book very useful. Provides a detailed background and roadmap of intelligent diagnosis and RUL prediction of rotating machinery, involving fault mechanisms, vibration characteristics, health indicators, and diagnosis and prognostics Presents basic theories, advanced methods, and the latest contributions in the field of intelligent fault diagnosis and RUL prediction Includes numerous application cases, and the methods, algorithms, and models introduced in the book are demonstrated by industrial experiences

In the current age of information explosion, newly invented technological sensors and software are now tightly integrated with our everyday lives. Many sensor processing algorithms have incorporated some forms of computational intelligence as part of their core framework in problem solving. These algorithms have the capacity to generalize and discover knowledge for themselves and learn new information whenever unseen data are captured. The primary aim of sensor processing is to develop techniques to interpret, understand, and act on information contained in the data. The interest of this book is in developing intelligent signal processing in order to pave the way for smart sensors. This involves mathematical advancement of nonlinear signal processing theory and its applications that extend far beyond traditional techniques. It bridges the boundary between theory and application, developing novel theoretically inspired methodologies targeting both longstanding and emergent signal processing applications. The topic ranges from phishing detection to integration of terrestrial laser scanning, and from fault diagnosis to bio-inspiring filtering. The book will appeal

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to established practitioners, along with researchers and students in the emerging field of smart sensors processing. Zhiwen Chen aims to develop advanced fault detection (FD) methods for the monitoring of industrial processes. With the ever increasing demands on reliability and safety in industrial processes, fault detection has become an important issue. Although the model-based fault detection theory has been well studied in the past decades, its applications are limited to large-scale industrial processes because it is difficult to build accurate models. Furthermore, motivated by the limitations of existing data-driven FD methods, novel canonical correlation analysis (CCA) and projection-based methods are proposed from the perspectives of process input and output data, less engineering effort and wide application scope. For performance evaluation of FD methods, a new index is also developed.

Control systems at production plants consist of a large number of process variables. When detecting abnormal behavior, these variables generate an alarm. Due to the interconnection of the plant's devices the fault can lead to an alarm flood. This again hides the original location of the causing device. In this work several data-driven approaches for root cause localization are proposed, compared and combined. All methods analyze disturbed process data for backtracking the propagation path. This work was published by Saint Philip Street Press pursuant to a Creative Commons license permitting commercial use. All rights not granted by the work's license are retained by the author or authors.

This book provides a complete picture of several decision support tools for predictive maintenance. These include embedding early anomaly/fault detection, diagnosis and reasoning, remaining useful life prediction (fault prognostics), quality prediction and self-reaction, as well as optimization, control and self-healing techniques. It shows recent applications of these techniques within various types of industrial (production/utilities/equipment/plants/smart devices, etc.) systems addressing several challenges in Industry 4.0 and different tasks dealing with Big Data Streams, Internet of Things, specific infrastructures and tools, high system dynamics and non-stationary environments . Applications discussed include production and manufacturing systems, renewable energy production and management, maritime systems, power plants and turbines, conditioning systems, compressor valves, induction motors, flight simulators, railway infrastructures, mobile robots, cyber security and Internet of Things. The contributors go beyond state of the art by placing a specific focus on dynamic systems, where it is of utmost importance to update system and maintenance models on the fly to maintain their predictive power.

Modern industrial processes are becoming more complex, and consequently monitoring them has become a challenging task. Fault Detection and Diagnosis (F01) as a key element of process monitoring, needs to be investigated because of its essential role in decision making processes. Among available F01 methods, data driven approaches are currently receiving increasing attention because of their relative simplicity in implementation. Regardless of F01 types, one of the main traits of reliable F01 systems is their ability of being updated while new conditions that were not considered at their initial training appear in the process. These new conditions would emerge either gradually or abruptly, but they have the same level of importance as in both cases they lead

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to F01 poor performance. For addressing updating tasks, some methods have been proposed, but mainly not in research area of chemical engineering. They could be categorized to those that are dedicated to managing Concept Drift (CD) (that appear gradually), and those that deal with novel classes (that appear abruptly). The available methods, mainly, in addition to the lack of clear strategies for updating, suffer from performance weaknesses and inefficient required time of training, as reported. Accordingly, this thesis is mainly dedicated to data driven F01 updating in chemical processes. The proposed schemes for handling novel classes of faults are based on unsupervised methods, while for coping with CD both supervised and unsupervised updating frameworks have been investigated. Furthermore, for enhancing the functionality of F01 systems, some major methods of data processing, including imputation of missing values, feature selection, and feature extension have been investigated. The suggested algorithms and frameworks for F01 updating have been evaluated through different benchmarks and scenarios. As a part of the results, the suggested algorithms for supervised handling CD surpass the performance of the traditional incremental learning in regard to MGM score (defined dimensionless score based on weighted F1 score and training time) even up to 50% improvement. This improvement is achieved by proposed algorithms that detect and forget redundant information as well as properly adjusting the data window for timely updating and retraining the fault detection system. Moreover, the proposed unsupervised F01 updating framework for dealing with novel faults in static and dynamic process conditions achieves up to 90% in terms of the NPP score (defined dimensionless score based on number of the correct predicted class of samples). This result relies on an innovative framework that is able to assign samples either to new classes or to available classes by exploiting one class classification techniques and clustering approaches.

Data-driven Methods for Fault Detection and Diagnosis in Chemical Processes Springer Science & Business Media

Early and accurate fault detection and diagnosis for modern chemical plants can minimise downtime, increase the safety of plant operations, and reduce manufacturing costs. The process-monitoring techniques that have been most effective in practice are based on models constructed almost entirely from process data. The goal of the book is to present the theoretical background and practical techniques for data-driven process monitoring. Process-monitoring techniques presented include: Principal component analysis; Fisher discriminant analysis; Partial least squares; Canonical variate analysis. The text demonstrates the application of all of the data-driven process monitoring techniques to the Tennessee Eastman plant simulator - demonstrating the strengths and weaknesses of each approach in detail. This aids the reader in selecting the right method for his process application. Plant simulator and homework problems in which students apply the process-monitoring techniques to a nontrivial simulated process, and can compare their performance with that obtained in the case studies in the text are included. A number of additional homework problems encourage the reader to implement and obtain a deeper understanding of the techniques. The reader will obtain a background in data-driven techniques for fault detection and diagnosis, including the ability to implement the techniques and to know how to select the right technique for a particular application.

This volume presents state-of-the-art tools and techniques for automatically detecting, diagnosing, and predicting the effects of

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adverse events in an engineered system. It emphasizes the importance of these techniques in managing the intricate interactions within and between engineering systems to maintain a high degree of reliability. Reflecting the interdisciplinary nature of the field, the book explains how the fundamental algorithms and methods of both physics-based and data-driven approaches effectively address systems health management in application areas such as data centers, aircraft, and software systems.

This book assesses the potential of data-driven methods in industrial process monitoring engineering. The process modeling, fault detection, classification, isolation, and reasoning are studied in detail. These methods can be used to improve the safety and reliability of industrial processes. Fault diagnosis, including fault detection and reasoning, has attracted engineers and scientists from various fields such as control, machinery, mathematics, and automation engineering. Combining the diagnosis algorithms and application cases, this book establishes a basic framework for this topic and implements various statistical analysis methods for process monitoring. This book is intended for senior undergraduate and graduate students who are interested in fault diagnosis technology, researchers investigating automation and industrial security, professional practitioners and engineers working on engineering modeling and data processing applications.

Guaranteeing a high system performance over a wide operating range is an important issue surrounding the design of automatic control systems with successively increasing complexity. As a key technology in the search for a solution, advanced fault detection and identification (FDI) is receiving considerable attention. This book introduces basic model-based FDI schemes, advanced analysis and design algorithms, and mathematical and control-theoretic tools. This second edition of Model-Based Fault Diagnosis Techniques contains: • new material on fault isolation and identification and alarm management; • extended and revised treatment of systematic threshold determination for systems with both deterministic unknown inputs and stochastic noises; • addition of the continuously-stirred tank heater as a representative process-industrial benchmark; and • enhanced discussion of residual evaluation which now deals with stochastic processes. Model-based Fault Diagnosis Techniques will interest academic researchers working in fault identification and diagnosis and as a text it is suitable for graduate students in a formal university-based course or as a self-study aid for practising engineers working with automatic control or mechatronic systems from backgrounds as diverse as chemical process and power engineering.

Statistical Process Monitoring Using Advanced Data-Driven and Deep Learning Approaches tackles multivariate challenges in process monitoring by merging the advantages of univariate and traditional multivariate techniques to enhance their performance and widen their practical applicability. The book proceeds with merging the desirable properties of shallow learning approaches – such as a one-class support vector machine and k-nearest neighbours and unsupervised deep learning approaches – to develop more sophisticated and efficient monitoring techniques. Finally, the developed approaches are applied to monitor many processes, such as waste-water treatment plants, detection of obstacles in driving environments for autonomous robots and vehicles, robot swarm, chemical processes (continuous stirred tank reactor, plug flow reactor, and distillation columns), ozone pollution, road traffic congestion, and solar photovoltaic systems. Uses a data-driven based approach to fault detection and attribution Provides an in-

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depth understanding of fault detection and attribution in complex and multivariate systems Familiarises you with the most suitable data-driven based techniques including multivariate statistical techniques and deep learning-based methods Includes case studies and comparison of different methods

Fault Diagnosis of Dynamic Systems provides readers with a glimpse into the fundamental issues and techniques of fault diagnosis used by Automatic Control (FDI) and Artificial Intelligence (DX) research communities. The book reviews the standard techniques and approaches widely used in both communities. It also contains benchmark examples and case studies that demonstrate how the same problem can be solved using the presented approaches. The book also introduces advanced fault diagnosis approaches that are currently still being researched, including methods for non-linear, hybrid, discrete-event and software/business systems, as well as, an introduction to prognosis. Fault Diagnosis of Dynamic Systems is valuable source of information for researchers and engineers starting to work on fault diagnosis and willing to have a reference guide on the main concepts and standard approaches on fault diagnosis. Readers with experience on one of the two main communities will also find it useful to learn the fundamental concepts of the other community and the synergies between them. The book is also open to researchers or academics who are already familiar with the standard approaches, since they will find a collection of advanced approaches with more specific and advanced topics or with application to different domains. Finally, engineers and researchers looking for transferable fault diagnosis methods will also find useful insights in the book.

Reliability Analysis and Asset Management of Engineering Systems explains methods that can be used to evaluate reliability and availability of complex systems, including simulation-based methods. The increasing digitization of mechanical processes driven by Industry 4.0 increases the interaction between machines and monitoring and control systems, leading to increases in system complexity. For those systems the reliability and availability analyses are increasingly challenging, as the interaction between machines has become more complex, and the analysis of the flexibility of the production systems to respond to machinery failure may require advanced simulation techniques. This book fills a gap on how to deal with such complex systems by linking the concepts of systems reliability and asset management, and then making these solutions more accessible to industry by explaining the availability analysis of complex systems based on simulation methods that emphasise Petri nets. Explains how to use a monitoring database to perform important tasks including an update of complex systems reliability Shows how to diagnose probable machinery-based causes of system performance degradation by using a monitoring database and reliability estimates in an integrated way Describes practical techniques for the application of AI and machine learning methods to fault detection and diagnosis problems

In the oil and gas industries, large companies are endeavoring to find and utilize efficient structural health monitoring methods in order to reduce maintenance costs and time. Through an examination of the vibration-based techniques, this title addresses theoretical, computational and experimental methods used within this trend. By providing comprehensive and up-to-date coverage of established and emerging processes, this book enables the reader to draw their own conclusions about the field of vibration-

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controlled damage detection in comparison with other available techniques. The chapters offer a balance between laboratory and practical applications, in addition to detailed case studies, strengths and weakness are drawn from a broad spectrum of information. Contents: Machine Learning Algorithms for Damage Detection (Eloi Figueiredo and Adam Santos) Data-Driven Methods for Vibration-Based Monitoring Based on the Singular Spectrum Analysis (Irina Trendafilova, David Garcia and Hussein Al-Bugharbee) Experimental Investigation of Delamination Effects on Modal Damping of a CFRP Laminate, Using a Statistical Rationalization Approach (Majid Khazaee, Ali Salehzadeh Nobari and M H Ferri Aliabadi) Problem of Detecting Damage Through Natural Frequency Changes (Gilbert-Rainer Gillich, Nuno N N Maia and Ion Cornel Mituletu) Damage Localization Based on Modal Response Measured with Shearography (J V Araújo dos Santos and H Lopes) Novel Techniques for Damage Detection Based on Mode Shape Analysis (Wieslaw Ostachowicz, Maciej Radzie?ski, Maosen Cao and Wei Xu) Damage Identification Based on Response Functions in Time and Frequency Domains (R P C Sampaio, T A N Silva, N M M Maia and S Zhong) Readership: Engineers, technicians, researchers working in the field of vibration-based techniques. Keywords: Structural Health Monitoring; SHM; Vibration-based SHM; Machine Learning; Time Domain Data Analysis; Frequency Domain Data Analysis; Damage Index Review: Key Features: The 1st book to address theoretical, computational and experimental methods The book provides an up to date and comprehensive coverage of established and emerging techniques within the field of vibration-controlled damage detection Excellent balance between laboratory and practical applications Many case studies in various chapters that help the reader to identify weak and strong points of various techniques

Fault Diagnosis and Sustainable Control of Wind Turbines: Robust Data-Driven and Model-Based Strategies discusses the development of reliable and robust fault diagnosis and fault-tolerant ('sustainable') control schemes by means of data-driven and model-based approaches. These strategies are able to cope with unknown nonlinear systems and noisy measurements. The book also discusses simpler solutions relying on data-driven and model-based methodologies, which are key when on-line implementations are considered for the proposed schemes. The book targets both professional engineers working in industry and researchers in academic and scientific institutions. In order to improve the safety, reliability and efficiency of wind turbine systems, thus avoiding expensive unplanned maintenance, the accommodation of faults in their early occurrence is fundamental. To highlight the potential of the proposed methods in real applications, hardware-in-the-loop test facilities (representing realistic wind turbine systems) are considered to analyze the digital implementation of the designed solutions. The achieved results show that the developed schemes are able to maintain the desired performances, thus validating their reliability and viability in real-time implementations. Different groups of readers—ranging from industrial engineers wishing to gain insight into the applications' potential of new fault diagnosis and sustainable control methods, to the academic control community looking for new problems to tackle—will find much to learn from this work. Provides wind turbine models with varying complexity, as well as the solutions proposed and developed by the authors Addresses in detail the design, development and realistic implementation of fault diagnosis and fault tolerant control strategies for wind turbine systems Addresses the development of sustainable control solutions

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that, in general, do not require the introduction of further or redundant measurements Proposes active fault tolerant ('sustainable') solutions that are able to maintain the wind turbine working conditions with gracefully degraded performance before required maintenance can occur Presents full coverage of the diagnosis and fault tolerant control problem, starting from the modeling and identification and finishing with diagnosis and fault tolerant control approaches Provides MATLAB and Simulink codes for the solutions proposed

The main objective of Data-Driven and Model-Based Methods for Fault Detection and Diagnosis is to develop techniques that improve the quality of fault detection and then utilize these developed techniques to enhance monitoring various chemical and environmental processes. The book provides both the theoretical framework and technical solutions. It starts with reviewing relevant literature, proceeds with a detailed description of developed methodologies, followed by a discussion of the results of developed methodologies, and ends with major conclusions reached from the analysis of simulation and experimental studies. The book is an indispensable resource for researchers in academia and industry and practitioners working in chemical and environmental engineering to do their work safely. Outlines latent variable based hypothesis testing fault detection techniques to enhance monitoring processes represented by linear or nonlinear input-space models (such as PCA) or input-output models (such as PLS) Explains multiscale latent variable based hypothesis testing fault detection techniques using multiscale representation to help deal with uncertainty in the data and minimize its effect on fault detection Includes interval PCA (IPCA) and interval PLS (IPLS) fault detection methods to enhance the quality of fault detection Provides model-based detection techniques for improvement of monitoring processes using state estimation-based fault detection approaches Demonstrates the effectiveness of the proposed strategies by conducting simulation and experimental studies on synthetic data

This book examines recent methods for data-driven fault diagnosis of multimode continuous processes. It formalizes, generalizes, and systematically presents the main concepts, and approaches required to design fault diagnosis methods for multimode continuous processes. The book provides both theoretical and practical tools to help readers address the fault diagnosis problem by drawing data-driven methods from at least three different areas: statistics, unsupervised, and supervised learning.

This book constitutes the refereed proceedings of the Second International Conference on Data Mining and Big Data, DMBD 2017, held in Fukuoka, Japan, in July/August 2017. The 53 papers presented in this volume were carefully reviewed and selected from 96 submissions. They were organized in topical sections named: association analysis; clustering; prediction; classification; schedule and sequence analysis; big data; data analysis; data mining; text mining; deep learning; high performance computing; knowledge base and its framework; and fuzzy control.

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

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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 gathers the proceedings of the 1st International Conference on Engineering, Applied Sciences and System Modeling (ICEASSM), a four-day event (18th–21st April 2017) held in Accra, Ghana. It focuses on research work promoting a better understanding of engineering problems through applied sciences and modeling, and on solutions generated in an African setting but with relevance to the world as a whole. The book provides a holistic overview of challenges facing Africa, and addresses various areas from research and development perspectives. Presenting contributions by scientists, engineers and experts hailing from a host of international institutions, the book offers original approaches and technological solutions to help solve real-world problems through research and knowledge sharing. Further, it explores promising opportunities for collaborative research on issues of scientific, economic and social development, making it of interest to researchers, scientists and practitioners looking to conduct research in disciplines such as water supply, control, civil engineering, statistical modeling, renewable energy and sustainable urban development.

This thesis develops a systematic, data-based dynamic modeling framework for industrial processes in keeping with the slowness principle. Using said framework as a point of departure, it then proposes novel strategies for dealing with control monitoring and quality prediction problems in industrial production contexts. The thesis reveals the slowly varying nature of industrial production processes under feedback control, and integrates it with process data analytics to offer powerful prior knowledge that gives rise to statistical methods tailored to industrial data. It addresses several issues of immediate interest in industrial practice, including process monitoring, control performance assessment and diagnosis, monitoring system design, and product quality prediction. In particular, it proposes a holistic and pragmatic design framework for industrial monitoring systems, which delivers effective elimination of false alarms, as well as intelligent self-running by fully utilizing the information underlying the data. One of the strengths of this thesis is its integration of insights from statistics, machine learning, control theory and engineering to provide a new scheme for industrial process modeling in the era of big data.

With pressure increasing to utilise wastes and residues effectively and sustainably, the production of biogas represents one of the most important routes towards reaching national and international renewable energy targets. The biogas handbook: Science, production and applications provides a comprehensive and systematic guide to the development and deployment of biogas supply chains and technology. Following a concise overview of biogas as an energy option, part one explores biomass resources and fundamental science and engineering of biogas production, including feedstock characterisation, storage and pre-treatment, and yield optimisation. Plant design, engineering, process optimisation and digestate utilisation are the focus of part two. Topics considered include the engineering and process control of biogas plants, methane emissions in biogas production, and biogas digestate quality, utilisation and land application. Finally, part three discusses international experience and best practice in biogas utilisation. Biogas cleaning and upgrading to biomethane, biomethane use as transport fuel and the generation of heat and power from biogas for stationery applications are all discussed. The book concludes with a review of market development and biomethane certification schemes. With its distinguished editors and international team of expert contributors, The biogas handbook: Science, production and applications is a practical reference to biogas technology for process engineers,

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manufacturers, industrial chemists and biochemists, scientists, researchers and academics working in this field. Provides a concise overview of biogas as an energy option Explores biomass resources for production Examines plant design and engineering and process optimisation This book addresses the needs of researchers and practitioners in the field of high-speed trains, especially those whose work involves safety and reliability issues in traction systems. It will appeal to researchers and graduate students at institutions of higher learning, research labs, and in the industrial R&D sector, catering to a readership from a broad range of disciplines including intelligent transportation, electrical engineering, mechanical engineering, chemical engineering, the biological sciences and engineering, economics, ecology, and the mathematical sciences.

In many industrial applications early detection and diagnosis of abnormal behavior of the plant is of great importance. During the last decades, the complexity of process plants has been drastically increased, which imposes great challenges in development of model-based monitoring approaches and it sometimes becomes unrealistic for modern large-scale processes. The main objective of Adel Haghani Abandan Sari is to study efficient fault diagnosis techniques for complex industrial systems using process historical data and considering the nonlinear behavior of the process. To this end, different methods are presented to solve the fault diagnosis problem based on the overall behavior of the process and its dynamics. Moreover, a novel technique is proposed for fault isolation and determination of the root-cause of the faults in the system, based on the fault impacts on the process measurements.

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.

Early and accurate fault detection and diagnosis for modern chemical plants can minimize downtime, increase the safety of plant operations, and reduce manufacturing costs. This book presents the theoretical background and practical techniques for data-driven process monitoring. It demonstrates the application of all the data-driven process monitoring techniques to the Tennessee Eastman plant simulator, and looks at the strengths and weaknesses of each approach in detail. A plant simulator and problems allow readers to apply process monitoring techniques.

Modern scientific computational methods are undergoing a transformative change; big data and statistical learning methods now have the potential to outperform the classical first-principles modeling paradigm. This book bridges this transition, connecting the theory of probability, stochastic processes, functional analysis, numerical analysis, and differential geometry. It describes two classes of computational methods to leverage data for modeling dynamical systems. The first is concerned with data fitting algorithms to estimate parameters in parametric models that are postulated on the basis of physical or dynamical laws. The second is on operator estimation, which uses the data to nonparametrically approximate the operator generated by the transition function of the underlying dynamical systems. This self-contained book is suitable for graduate studies in applied mathematics, statistics, and engineering. Carefully chosen elementary examples with

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supplementary MATLAB® codes and appendices covering the relevant prerequisite materials are provided, making it suitable for self-study.

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