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

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Trends in Advanced Intelligent Control, Optimization and Automation
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A Proceedings Volume from the 6th IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes
Data-Driven Technology for Engineering Systems Health Management
Theory and Practical Applications

JAIDYN MOYER

Fault Diagnosis and Sustainable Control of Wind Turbines Springer
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.
Data Driven Methods for Updating Fault Detection and Diagnosis System in Chemical Processes Springer Nature
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.
Data-driven Whole Building Fault Detection and Diagnosis MDPI
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.
Advanced methods for fault diagnosis and fault-tolerant control Springer Science & Business Media
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.

Data-driven Fault Detection and Reasoning for Industrial Monitoring Elsevier

This open access 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.

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

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

Fault-Diagnosis Systems Springer

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-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 Radzieński, 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 IndexReview: Key Features: The 1st book to address theoretical, computational and experimental methodsThe book provides an up to date and comprehensive coverage of established and emerging techniques within the field of vibration-controlled damage detectionExcellent balance between laboratory and practical applicationsMany case studies in various chapters that help the reader to identify weak and strong points of various techniques

Data-Driven and Model-Based Methods for Fault Detection and Diagnosis Springer Science & Business Media

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.

Data-driven Methods for Fault Localization in Process Technology Elsevier

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.

Data-Driven Design of Fault Diagnosis Systems KIT Scientific Publishing

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.

Data-driven Methods for Fault Localization in Process Technology World Scientific

The safe and reliable operation of technical systems is of great significance for the protection of human life and health, the environment, and of the vested economic value. The correct functioning of those systems has a profound impact also on production cost and product quality. The early detection of faults is critical in avoiding performance degradation and damage to the machinery or human life. Accurate diagnosis then helps to make the right decisions on emergency actions and repairs. Fault detection and diagnosis (FDD) has developed into a major area of research, at the intersection of systems and control engineering, artificial intelligence, applied mathematics and statistics, and such application fields as chemical, electrical, mechanical and aerospace engineering. IFAC has recognized the significance of FDD by launching a triennial symposium series dedicated to the subject. The SAFEPROCESS Symposium is organized every three years since the first symposium held in Baden-Baden in 1991. SAFEPROCESS 2006, the 6th IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes was held in Beijing, PR China. The program included three plenary papers, two semi-plenary papers, two industrial talks by internationally recognized experts and 258 regular papers, which have been selected out of a total of 387 regular and invited papers submitted. * Discusses the developments and future challenges in all aspects of fault diagnosis and fault tolerant control * 8 invited and 36 contributed sessions included with a special session on the demonstration of process monitoring and diagnostic software tools

Advanced methods for fault diagnosis and fault-tolerant control Springer Science & Business Media

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 to established practitioners, along with researchers and students in the emerging field of smart sensors processing.

Model- and Data-driven Approaches to Fault Detection and Isolation in Complex Systems Butterworth-Heinemann

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.

Nonlinear Multimode Processes Springer Science & Business Media

This volume contains the proceedings of the KKA 2017 – the 19th Polish Control Conference, organized by the Department of Automatics and Biomedical Engineering, AGH University of Science and Technology in Kraków, Poland on June 18–21, 2017, under the auspices of the Committee on Automatic Control and Robotics of the Polish Academy of Sciences, and the Commission for Engineering Sciences of the Polish Academy of Arts and Sciences. Part 1 deals with general issues of modeling and control, notably flow modeling and control, sliding mode, predictive, dual, etc. control. In turn, Part 2 focuses on optimization, estimation and prediction for control. Part 3 is concerned with autonomous vehicles, while Part 4 addresses applications. Part 5 discusses computer methods in control, and Part 6 examines fractional order calculus in the modeling and control of dynamic systems. Part 7 focuses on modern robotics. Part 8 deals with modeling and identification, while Part 9 deals with problems related to security, fault detection and diagnostics. Part 10 explores intelligent systems in automatic control, and Part 11 discusses the use of control tools and techniques in biomedical engineering. Lastly, Part 12 considers engineering education and teaching with regard to automatic control and robotics.

Data-Driven Computational Methods Springer Nature

Methods in Chemical Process Safety, Volume 1, publishes fully commissioned reviews across the field of process safety, risk assessment and management and loss prevention. It aims to serve as an informative tool and user manual for process safety for both engineering researchers and practitioners. Publishing one themed volume a year, the publication provides a resource detailing the latest methods in the field of chemical process safety. Helps acquaint the reader/researcher with the fundamentals of process safety Provides the most recent advancements and contributions on the topic from a practical point-of-view Presents users with the views/opinions of experts in each topic Includes a selection of the author(s) of each chapter from among the leading researchers and/or practitioners for each given topic

Fault Detection and Diagnosis in Industrial Systems Elsevier

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 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.

Proceedings of KKA 2017—The 19th Polish Control Conference, Kraków, Poland, June 18–21, 2017 Springer Nature

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 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.

Sensor Signal and Information Processing II Springer Nature

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.

Model-Based Fault Diagnosis Techniques John Wiley & Sons

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.

Fault Detection, Supervision and Safety of Technical Processes 2006 Cambridge University Press

Residential and commercial buildings are responsible for more than 40% of the primary energy consumption in the United States. Energy wastes are estimated to reach 15% to 30% of total energy consumption due to malfunctioning sensors, components, and control systems, as well as degrading components in Heating, Ventilation, Air-conditioning (HVAC) systems and lighting systems in commercial buildings in the U.S. Studies have demonstrated that a large energy saving can be achieved by automated fault detection and diagnosis (AFDD) followed by corrections. Field studies have shown that, AFDD tools can help to reach energy savings by 5-30% from different systems such as HVAC systems, lighting systems, and refrigeration systems. At the same time, the deployment of AFDD tools can also significantly improve indoor air quality, reduce peak demand, and lower pollution. In buildings, many components or equipment are closely coupled in a HVAC system. Because of the coupling, a fault happening in one component might propagate and affect other components or subsystems. In this study, a whole building fault (WBF) is defined as a fault that occurs in one component or equipment but causes fault impacts (abnormalities) on other components and subsystems, or causes significant impacts on energy consumption and/or indoor air quality. Over the past decades, extensive research have been conducted on the development of component AFDD methods and tools. However, whole building AFDD methods, which can detect and diagnose a WBF, have not been well studied. Existing component level AFDD solutions often fail to detect a WBF or generate a high false alarm rate. Isolating a WBF is also very challenging by using component level AFDD solutions. Even with the extensive research, cost-effectiveness and scalability of existing AFDD methods are still not satisfactory. Therefore, the focus of this research is to develop cost-effective and scalable solutions for WBF AFDD. This research attempts to integrate data-driven methods with expert knowledge/rules to overcome the above-mentioned challenges. A suite of WBF AFDD methods have hence been developed, which include: 1) a weather and schedule based pattern matching method and feature based Principal Component Analysis (WPM-FPCA) method for whole building fault detection. The developed WPM-FPCA method successfully overcome the challenges such as the generation of accurate and dynamic baseline and data dimensionality reduction. And 2) a data-driven and expert knowledge/rule based method using both Bayesian Network (BN) and WPM for WBF diagnosis. The developed WPM-BN method includes a two-layer BN structure model and BN parameter model which are either learned from baseline data or developed from expert knowledge. Various WBFs have been artificially implemented in a real demo building. Building operation data which include baseline data, data that contain naturally-occurred faults and artificially implemented faults are collected and analyzed. Using the collected real building data, the developed methods are evaluated. The evaluation demonstrates the efficacy of the developed methods to detect and diagnose a WBF, as well as their implementation cost-effectiveness.