Hindawi
Journal of Control Science and Engineering
Volume 2018, Article ID 8460541, 3 pages
https://doi.org/10.1155/2018/8460541

Editorial

Fault Diagnosis and Application to Modern Systems 2018

Xiao He,[1] **Zidong Wang**,[2] **Zhijie Zhou**,[3] **Youqing Wang**,[4] **and Qiang Liu**[5]

[1] *Department of Automation, Beijing National Research Center for Information Science and Technology (BNRist), Tsinghua University, Beijing 100084, China*
[2] *Department of Computer Science, Brunel University London, London UB8 3PH, UK*
[3] *Xi'an High-Tech Institute, Xi'an 710025, China*
[4] *College of Electrical Engineering and Automation, Shandong University of Science and Technology, Qingdao 266590, China*
[5] *State Key Laboratory of Synthetical Automation for Process Industries, Northeastern University, Shenyang, Liaoning 110819, China*

Correspondence should be addressed to Xiao He; hexiao@tsinghua.edu.cn

Received 2 September 2018; Accepted 2 September 2018; Published 2 December 2018

Fault diagnosis (FD) is a powerful means to guarantee the continuously increasing requirements from the modern industrial systems on better performance, more reliability, and higher safety. Therefore, the field of research on FD has been keeping vitality for the past several decades. FD utilized the analytical redundancy relationship of the control system to provide the whole system with useful and accurate information about the faults, to make further decisions such as recovering or compensating the influence of faults, predicting the residual life and so forth. A residual signal needs to be constructed and then to be compared with a preset limit for detecting the occurrence of fault. The exact location of the fault should be ensured to avoid the propagation of the fault to other components. The amplitude and emerging time of the fault also need to be estimated. All aforementioned procedures are the three basic units involved in a typical FD process, which are fault detection, fault isolation, and fault estimation. The precise investigation and comprehension of the fault achieved by the FD techniques bring a significant impact on the further process of fault accommodation.

The current available FD methodologies can be generally categorized as the model-based method and the data-driven approach. With a mathematical model, the model-based method can furnish the factors beyond the objective faults with the precise decoupling or maximum attenuation. In the case that the mathematical model is not available, however, the historical data are sufficient, and the data-driven approach reveals its superiority. The theoretical challenges as well as practical applications brought by the modern sophisticated real-time control systems propel the research on FD. Consequently, the abundant results for the topics of FD have recently come up. To this end, we have organized a special issue Fault Diagnosis and Application to Modern Systems in 2017. Based on the success of the 2017's special issue, the editorial office has made this special issue into one of the annual special issues, which simply means it becomes the first issue in a series of special issues which will be published each year. In this special issue of the year 2018, we have received 19 manuscripts from all over the world. With careful and rigorous peer-review, seven papers have been selected and accepted to be finally published in this special issue. These seven papers included in this special issue which reflect the development in FD of modern systems will be overviewed in the following.

Some work in this special issue addresses challenges experienced in the data-driven FD techniques. In "Fault Diagnosis Method Based on Gap Metric Data Preprocessing and Principal Component Analysis", Z. Wang et al. study the use of Gap metric as a method to improve the data preprocessing in the Principal Component Analysis (PCA) approach and propose a novel PCA method for fault diagnosis. The Gap metric is capable of measuring the distance between two linear systems and reflecting the correlation of different variables of the system in high-dimensional Riemannian space. With the adoption of the Gap metric data preprocessing method, the variable data in the system can be emphasized with small absolute change and fairly large variation. Therefore, the principal component can be accurately extracted for further calculating the T^2 and SPE statistical limits so as to detect the occurrence of fault. The results of the numerical simulation show that the proposed PCA method based on the Gap metric has better performance in omissive judgement of fault, compared with the traditional PCA method and the one in European space. Furthermore, the proposed solution is feasible even on detection of micro faults.

Another paper "Data Preprocessing Method and Fault Diagnosis Based on Evaluation Function of Information Contribution Degree" by S. Ji and C. Wen introduces the evaluation function to adaptively update the network parameters and proposes a novel method for evaluating the parameters of the function. Their proposed method uses Kalman filter to real time update the hidden layer output weights of BP neural network and adjust the output of BP neural network hidden layer, which increases the accuracy of the obtained evaluation function and avoids the waste of resources caused by the unnecessary retraining of the network. This paper further employs the Mean Impact Value (MIV) algorithm to calculate the weight of the feature, whose main purpose is to bring the weighted data into the established fault diagnosis model for FD. Their proposed FD method is further utilized in the data collected by a Combined Cyber Power Plant over 6 years. The experimental results demonstrate that the proposed method can effectively detect the faults by improving the performance of algorithm and reducing the wasteful time-consuming of retraining.

Some work focuses on the model-based FD techniques and considers the system recovery and further prediction. In the paper entitled "Detection of Two-Level Inverter Open-Circuit Fault Using a Combined DWT-NN Approach" by B. D. E. Cherif and A. Bendiabdellah, a novel diagnostic method is proposed for detecting an inverter IGBT open-circuit switch fault, based on the discrete wavelet transforms (DWT) algorithm and the approach of neural network (NN). The Coiflet algorithm is applied in the DWT, and then the stator current signal is decomposed into approximations and details that can respectively represent the slow and fast variations of the signal. In order to realize the automatic fault diagnosis, this paper further introduces the NN approach whose construction is established via the Lunemberg algorithm. The experimental results of a built voltage inverter fed induction motor illustrate the feasibility and effectiveness of the proposed diagnosis method.

The accurate residual life prediction at the beginning of performance degradation can prevent the complex systems from suffering the serious fault or major damage emerging. The paper "A New Residual Life Prediction Method for Complex Systems Based on Wiener Process and Evidential Reasoning" by X. Zhang et al. presents a novel residual life prediction method for complex systems through using Wiener process and evidential reasoning. Based on Wiener process, a degradation model is built whose parameters are estimated and updated by maximum likelihood method and Bayesian method, separately. The evidential reasoning rule is applied to establish the residual life prediction model and is further integrated with the prediction results of Wiener process to obtain more accurate prediction results. The results of the case study of the residual life of gyroscope demonstrate that the proposed prediction method is more feasible and effective compared with the method based on fuzzy theory.

The demands for the reliability of short-term traffic flow prediction grow up with the pervasive coordination of various kinds of traffic equipment. Unfortunately, the serious fluctuation in the traffic data can deteriorate the prediction accuracy. The paper "A New Synergistic Forecasting Method for Short-term Traffic Flow with Event-triggered Strong Fluctuation" by D. Huang et al. proposes a novel short-term traffic forecasting method to solve the aforementioned problem. The traditional grey Verhulst model is improved by introducing the Markov chain. Then the authors employ the first order difference exponential smoothing technique to improve the prediction smoothness with accuracy. Finally the improved grey Verhulst prediction method and the first order difference exponential smoothing technique are synthesized by the dynamic weighting factors to achieve the goal of accurately and effectively forecasting short-term traffic flow. The proposed method is verified through a case study of the urban expressway under a strong fluctuation environment, where the comparative analysis indicated its feasibility.

Some work pays attention to the application of FD and Fault-Tolerant Control (FTC) techniques for some specific real-time systems. In "Deep Sparse Auto Encoder for Feature Extraction and Diagnosis of Locomotive Adhesion Status" by C. Zhang et al., a sparse auto-encoder deep neural with dropout is presented to tackle the FD problem of the wheel–rail adhesion state of a locomotive. Adhesion is a phenomenon caused by the rolling wheel pair subjected to a tangential traction, where the rolling pressure leads to deformation between the wheel and the rail as well as the continuous and stable contact surface between the wheel and the rail. This paper refines the adhesion features as four categories for wheel skid warning. This paper further applies an unsupervised learning algorithm that is the spare auto-encoder and stacks it into a deep structure, which constructs a model for effectively extracting data features and making classification easier. Then, the adhesion state of the locomotive can be diagnosed based on the inherent characteristics of the sample data of the sparse auto-encoder deep neural network. The experimental results indicate that the proposed method can achieve a 99.3% diagnosis accuracy and simultaneously meet the actual engineering monitoring requirements.

The paper entitled "Neural Back-stepping Control of Hypersonic Flight Vehicle with Actuator Fault" by Q. Wu and Y. Guo addresses the FTC problem of hypersonic flight vehicle, based on a back-stepping control law with neural networks and adaptive method. The neural networks approach is utilized in the controller design so as to estimate the unknown function in flight dynamics. Considering the aspect of eliminating the influence of the actuator dead-zone fault, this paper introduces an adaptive signal in the controller design to estimate the unknown fault parameters. Moreover, the stability analysis and simulation are provided to indicate the good performance of proposed adaptive fault tolerant method.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Acknowledgments

This editorial was partially supported by the National Key Research and Development Program under Grant 2017YFA0700300, the NSFC under Grants 61473163, 61522309, and 61733009, and the R&D Project of Intelligent Ship 1.0 from the Ministry of Industry and Information Technology of China under Grant [2016]544.

Xiao He
Zidong Wang
Zhijie Zhou
Youqing Wang
Qiang Liu