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Editorial

Special issue on recent advances on control and diagnosis via process measurements

The recent increasing amounts of process measurements produced in various complex applications have demonstrated a “data driven” epoch of modern industrial processes. With the rapid developments of information science and technology, both the advanced data storage devices and the fast data transmission equipments have promoted the efficient processing of big data into realization. As a result, available process measurements can be applied to improving the effectiveness of current methodologies or practical techniques related to various subjects of modern industrial application research. Compared to the well-established model based techniques in the last few decades, the recent developments on control and diagnosis via available process measurements have received more attention both from academic and practical domains. The common object of data driven approaches is the effective utilization of considerable amounts of measured or stored data to achieve regular running and desired performance of modern industrial applications.

The primary objective of this special issue is to provide an international forum for researchers and practitioners to exchange their latest achievements and to identify critical issues, challenges and emerging trends for future investigation of data based techniques. This special issue presents high-quality articles describing: modeling and key parameter identification for complicated systems, data based fault diagnosis and fault tolerant control, recent advances on filtering and control via process measurement. We received a total of 23 submissions, and all submitted papers have been carefully reviewed after a rigorous review process. We selected 11 articles covering the subject from different perspectives, i.e., 47.8% of all the submitted papers.

The first contribution, entitled “Bearing fault diagnosis with morphological gradient wavelet” by Mohammad H Khakipour, Ali A Safavi and Peyman Setoodeh, focuses on morphological wavelet transform for bearing fault diagnosis. This paper proposes a morphological gradient wavelet scheme in order to extract impulsive features and perform noise reduction in the vibration signals of defective bearings. Vibration signals of two defective bearings are investigated, one with an inner race fault and the other with an outer race fault. The proposed morphological gradient wavelet algorithm owns advantaged speed and simplicity of implementation. Therefore, it is suitable for real-time signal processing aimed at online condition monitoring.

The second paper “Stochastic degradation process modeling and remaining useful life estimation with flexible random-effects” by Zhengxin Zhang, Changhua Hu and Xiao-Sheng Si

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et al., proposes a degradation model with flexible random-effects, which makes it flexible to choose distributions to portray the unit-to-unit variability according to the available information. In this paper, an analytical approximated probability density function of the remaining useful life is derived under the concept of first passage time. This work makes the random-effects flexible by identifying parameters in both the degradation model and the mixture of normal distributions based on available degradation data through stochastic expectation maximization algorithm.

In the third paper "Robust finite-time fault estimation for stochastic nonlinear systems with Brownian motions" by Xiaoxu Liu and David Gao, fault estimation for stochastic nonlinear systems subject to partially decoupled unknown input disturbances and Brownian motions is discussed. In this paper, stochastic input-to-state stability and finite-time stochastic input-to-state stability of stochastic nonlinear systems are firstly investigated based on Lyapunov theory. By integrating augmented system approach, unknown input observer technique, finite-time stochastic input-to-state stability theory, a highly-novel fault estimation technique is proposed. The convergence of the estimation error with respect to un-decoupled unknown inputs and Brownian perturbation is proven by using the derived stochastic input-to-state stability and finite-time stochastic input-to-state stability theorems.

The forth paper, "Actuator and sensor faults estimation based on proportional integral observer for TS fuzzy model" by Tewfik Youssef, Mohammed Chadli and Hamid Reza Karimi et al., also focuses on the topic of fault estimation. This paper presents a novel method to address a Proportional Integral observer design for the actuator and sensor faults estimation based on Takagi–Sugeno fuzzy model with unmeasurable premise variables. The faults are assumed as time-varying signals whose k-th time derivatives are bounded. Using Lyapunov stability theory and L2 performance analysis, sufficient design conditions are developed for simultaneous estimation of states and time-varying actuator and sensor faults. The proportional integral observer gains are computed by solving the proposed conditions under Linear Matrix Inequalities constraints.

Model based fault diagnosis is also discussed in the fifth paper "Adaptive fault detection and diagnosis using parsimonious Gaussian mixture models trained with distributed computing techniques" by Thiago Akio Nakamura, Reinaldo M Palhares and Walmir M Caminhas et al. This work proposes a batch-incremental adaptive methodology for fault detection and diagnosis based on mixture models trained in a distributed computing environment. The models used are from a family of Parsimonious Gaussian Mixture Models, in which the reduced number of parameters of the model brings important advantages when there are few data available, an expected scenario of faulty conditions.

The sixth manuscript, "Fault diagnosis of non-Gaussian process based on FKICA" by Wenyou Du, Yunpeng Fan and Yingwei Zhang et al. revolves around the fact that certain fault data can be pre-separated from the normal data manually in some industrial processes. In order to utilize this part of data, fault-related kernel independent component analysis is put forward as an improvement to kernel independent component analysis in this paper. Fault-related kernel independent component analysis can make full use of the historical fault data by decomposing the data space into four subspaces and making the algorithm more sensitive to certain fault. The proposed methods are applied to monitoring of fused magnesia furnace smelting processes. The experiment result shows that the proposed methods are more sensitive to the known faults.

The seventh paper “Fault isolation based on residual evaluation and contribution analysis” by Jing Wang, Wenshuang Ge and Jinglin Zhou et al. focuses on the topic of fault isolation strategy for industrial processes. A new fault isolation strategy for industrial processes is presented based on residual evaluation and contribution plot analysis. Based on the space projection, the residual evaluation and contribution plot are unified into a framework. A new contribution index is calculated according to the average value of the current and previous residuals. The smearing effect can be eliminated, and the fault evolution can be acquired based on this index. This would be helpful for engineers to find out the fault roots and then eliminate them.

In the eighth paper “Multimode process monitoring based on data-driven method” by Wenyou Du, Yunpeng Fan and Yingwei Zhang, a new data-driven method and its application to process monitoring is proposed for handling the multimode process monitoring problem in the electro fused magnesia furnace. This paper defines a new similarity between different modes with weighted norm distance which can extract common and special features of all modes respectively. The multi-mode modeling method is proposed based on the defined similarity and the fault detection indices are applied with the multi-mode model.

In the ninth paper “Data-driven model reference control design by prediction error identification” by Luciola Campestrini, Diego Eckhard and Alexandre Bazanella et al., data-driven control design in a model reference framework is concerned. This paper presents a new one-shot data-driven method based on the prediction error approach and the reference model control design. The method allows for some design choices, which can be used to shape bias and variance error based on different levels of prior information. Exploring these design choices and the resulting statistical properties for each one also provides a framework that allows a meaningful comparison of data-driven design with model-based design.

The tenth contribution, entitled "Fault tolerant control using adaptive output integral-type sliding mode" by Zhengen Zhao, Ying Yang and Yong Zhang, focuses on the fault tolerant control for linear systems with unknown bounded uncertainty and time-varying faults. In this paper, a fault detection unit is embedded in the fault estimation block, which is used to detect faults and trigger the adaptive law for fault estimation, and the adaptive output integral-type sliding mode is designed to attenuate unknown bounded uncertainty and tolerate time-varying faults. Lyapunov stability theory is also applied to synthesizing the design of the observer and nominal controller.

The last manuscript, “Improved one-cycle control algorithm for diagnosis and optimization in low-voltage SVG device” by Zujun Ding, revolves around current PWM control of low voltage SVG (Static Var Generator). Taking the three-phase four-leg inverter as the research object, this paper designs the current controller based on one-cycle control algorithm and derives the control equation in detail. This improved control unit could realize reactive power, harmonics, and negative sequence imbalance current comprehensive compensation function, and duty cycle stability are improved. Control performance and response time of the control unit were significantly optimized.

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