Guest Editorial: Special Section on Smart Process Manufacturing Driven by Artificial Intelligence

AS A fundamental industry, process industry mainly involves elementary raw material industries, such as petroleum, chemical, steel, nonferrous metal, and building. However, there are a series of problems existing in the process industry such as the inaccurate perception of industrial data, low production efficiency, high materials consumption, and limitations in safety and environment protection. In order to solve these restriction problems, we must pursue the goal of efficient, green, and smart processes in manufacturing and marketing. On the other hand, artificial intelligence (AI) has powerful strengths in perception, knowledge representation, learning, reasoning, and planning, so that it has been successfully utilized in diverse areas, such as autonomous vehicles and so on. It is promising to have deep and tight integration between artificial intelligence and process industry, to achieve "smart process industry." Based on artificial intelligence, technological process optimization and plant-wide optimization will be realized for production, management, and marketing in the process industry, which will then achieve smart, optimal, green, and high-end manufacturing. With the advent of new developments in artificial intelligence, it has become possible to present new algorithms/strategies for decision-making, production operation, efficiency and safety, information integration, and so forth, which thereby further promotes AI applications in the process industry.

This special section is dedicated to facilitating the research and development of AI in the field of smart process manufacturing. Through a rigorous and careful review process, we have selected 11 papers for publication. A summary of the accepted papers is provided as follows.

Due to several reasons including the extreme working environment or the requirement of high maintenance cost to operate online, physical sensing devices may fail to measure the quality variables of interest in the process industry. Hence, it is necessary to develop virtual sensing techniques like soft sensors to estimate those unavailable key variables by utilizing easy-to-measure process variables.

In order to guarantee the high-efficiency and safe operation for the process industry, model predictive control (MPC) has received increasing attention and has succeeded in applications to the control of processes such as oil, paper and pulp, and mining. To comply with the effluent standards and growing demands for safety and reliability of the operation of wastewater treatment processes (WWTPs), the first paper entitled "Data-Driven Multiobjective Predictive Control for Wastewater Treatment Process" by Han *et al.* proposes a data-driven multiobjective predictive control (MOPC) method, in which a multiobjective control strategy is developed to design MOPC, and an adaptive fuzzy neural network identifier is designed to catch the nonlinear behaviors of WWTPs.

The assessment of operating performance for industrial processes is critical to guarantee high productivity and low cost. In this context, the second paper entitled "Concurrent assessment of process operating performance with joint static and dynamic analysis" by Zou *et al.* presents a concurrent static and dynamic assessment method for operating performance in terms of industrial processes under closed-loop control. Compared with some traditional researches, this paper combines canonical variate analysis and slowfeature analysis to extract the static and dynamic features of a process, so that the proposed method can establish a more accurate assessment of operating performance. Aiming to maintain a high product quality, preventing fatal accidents, and identifying root causes of failures in processes, timely fault detection plays a critical role in the process industry. In order to effectively deal with both process nonlinearities and time-varying characteristics in industrial soft sensing, the third paper entitled "Bayesian Just-in-time Learning and Its Application to Industrial Soft Sensing" by Shao *et al.* establishes a Bayesian just-in-time learning to achieve higher predictive accuracy of just-in-time learning-based soft sensor by improving its relevant sample selection strategy and base learner training algorithm. As a type of soft sensor, near-infrared (NIR) plays a critical role in the online analysis of difficult-to-measure properties of petrochemicals. However, since industrial data present strong non-Gaussian and uncertainty characteristics, it is challenging to obtain a precise NIR model in petrochemical processes.

To this end, the fourth paper entitled "Biased Minimax Probability Machine-based Adaptive Regression for Online Analysis of Gasoline Property" by He *et al.* proposes a biased minimax probability machine, which has the superior capability in dealing with uncertainties and variations.

Under the guidance of a well-designed production scheduling, the industrial processes can operate in an efficient way, which is beneficial to guarantee high economic benefit. However, due to unpredictable delays and disturbances on the scheduling, random variations in processing times are inevitable. Focusing on the hot strip mill, the fifth paper entitled "Robust Scheduling of Hot Rolling Production by Local Search Enhanced Ant Colony

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Optimization Algorithm" by Zhang *et al.* proposes a robust optimization approach to make the scheduling, which can deal with the uncertainty in processing times.

As a deep neural network, autoencoder has been widely utilized in soft sensor framework, owing to superior abilities of feature extraction and data reconstruction. Considering the missing data situation in process industries, the sixth paper entitled "Supervised Variational Autoencoders for Soft Sensor Modeling with Missing Data" by Xie *et al.* develops two novel submodels based on deep variational autoencoder to establish a soft sensor framework. Moreover, the effectiveness of the proposed method is demonstrated via an industrial polymerization dataset. With only a limited amount of labeled data available, soft-sensors may be unable to capture the underlying physics of the process, so that the model may not be reasonably extrapolated.

To this end, the seventh paper entitled "Physically Consistent Soft-sensor Development Using Sequence-to-Sequence Neural Networks" by Chou *et al.* proposes a sequence-to-sequence model in the form of a nonlinear state-observer/encoder and predictor/ decoder, which is evaluated in the application to impurity predictions of an industrial column. Considering dynamics and nonlinearity existed in time and batch directions for batch processes, the eighth paper entitled "Data-Driven Two-Dimensional Deep Correlated Representation Learning for Nonlinear Batch Process Monitoring" by Jiang *et al.* proposes a two-dimensional deep correlated representation learning method to achieve efficient fault detection and isolation of nonlinear batch processes.

With the aid of machine learning techniques, the ninth paper entitled "Performance Supervised Fault Detection Schemes for Industrial Feedback Control Systems and their Data-Driven Implementation" by Li *et al.* utilizes the performance degradation prediction method to address the performance supervised fault detection issues for industrial feedback control systems and investigates its implementation based on the data-driven approach.

To control an industrial paste thickener, the tenth paper entitled "Neural Network-Based Model Predictive Control of a Paste Thickener over an Industrial Internet Platform" by Núñez *et al.* presents a real implementation of a neural-network-based model predictive control scheme (NNMPC), in which modeling is achieved using an encoder.decoder with attention recurrent neural network and MPC search is done by using particle swarm optimization.

Since the acquisition of labeled data is costly and laborious in practice, the 11th paper entitled "Fault Classification in High-dimensional Complex Processes using Semi-supervised Deep Convolutional Generative Models" by Ko *et al.* proposes a new approach using semi-supervised deep generative models to make an effective use of a large amount of unlabeled data for fault classification. By incorporating convolutional neural networks, the proposed method can further handle the temporal correlation and intervariable correlation in multivariate time series process data collected from multiple sensors.

We would like to thank all the authors who submitted their work to this special section. We also would like to express our thanks to the experts in the field who voluntarily participated in the review process on a very tight schedule. Finally, we want to give our sincere thanks to the Editor-in-Chief, Prof. R. Luo, for providing us with timely guidance and support.

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