Guest Editorial: Advanced Intelligent Manufacturing System: Theory, Algorithms, and Industrial Applications

INTELLIGENT manufacturing has promoted the development of Industry 4.0 and enabled the manufacturing industry to gradually move into the stage of intelligence with the rapid development of the Internet of Things and the Industrial Internet. An intelligent manufacturing system is a manufacturing system that can automatically adapt to changing environments and varying process requirements with minimal supervision and assistance from operators. Therefore, intelligent manufacturing has become a recognized core high technology to enhance the overall competitiveness of the manufacturing industry. The goal of intelligent manufacturing is to make production resources form a circular network with the characteristics of autonomy, adjustability, and configurability, to develop production processes flexibly, and to realize the efficiency of individual customization. For example, by analyzing the factory floor data, equipment monitored data, and the enterprise manufacturing database, it could help to store, explore, and make complex decisions for the manufacturing system. To achieve this goal, modern information technologies, such as artificial intelligence, big data, cloud computing, and mobile Internet, modeling, control, and optimization need to be integrated and collaborated with the physical resources of the manufacturing process, which triggers new theory, solution algorithms, and application scenarios.

This Special Section presents the latest developments on advanced intelligent manufacturing: theory, algorithms, and applications. Through a rigorous peer-review process, eight articles have been accepted, which are summarized below.

In [A1], Chen et al. propose a multichannel domain adaptation graph convolutional network method for intelligent fault diagnosis of the complex systems in view of the diversity of working conditions and the lack of sufficient fault samples. In the established network, a feature mapping layer based on convolutional neural network is used to extract features from input data, which then are transmitted to the graph generator to construct two association graphs. Three distributed graph convolutional networks are thereafter used to extract the specific and common embeddings from two association graphs and their combination. An attention mechanism is used to learn importance weights and a domain discriminator is leveraged to reduce the distribution discrepancy of different data domains for fault diagnosis. Two experimental studies show that the proposed method can effectively extract domain-invariant features for cross-domain under varying working conditions.

In [A2], Zhou et al. design a time-varying online transfer learning (TVOTL) model for intelligent fault diagnosis of rolling bearings. The proposed model can not only construct the transfer diagnosis model with incomplete unlabeled target data offline, but also achieve online update. In the offline stage, the initial feature transformation matrix is obtained using limited interdomain data and the raw data are mapped to the corresponding feature space to get new representations. In the online stage, data distribution discrepancies between domains are reduced with online collected target instances and the transfer diagnosis model is updated. The proposed TVOTL model is verified on ten transfer diagnosis tasks to illustrate the outstanding performance.

In [A3], Li et al. develop an accurate model for the accelerated degradation testing with considering the unreliable signals under the influence of external environment and stresses. Based on the proposed model, a closed-form expression for the useful life analysis is derived. The M-H sampling method is used to estimate the unknown parameters. The results using the electrical connectors' dataset demonstrate that the proposed model is more accurate in the useful life analysis than the traditional models by considering the unreliable signals.

In [A4], Alfarizi et al. propose a new data-driven prediction framework for bearing remaining useful life (RUL) utilizing an integration of empirical mode decomposition, random forest, and Bayesian optimization. The proposed framework consists of two main phases: feature extraction and RUL prediction. The first phase of this framework focused on decomposing the empirical input signals using empirical mode decomposition into distinct frequency bands to filter out irrelevant frequencies and determine the fault characteristics of the signals. In the second phase, the RUL prediction is then carried out by an RF-based model with its hyperparameters tuned by Bayesian optimization. The proposed approach is validated using datasets obtained from an actual run-to-failure experiment of roller bearings. The experiment results significantly improved compared to the standard data-driven and stochastic approaches.

In [A5], Cheng et al. introduce an industrial noisy label semisupervised learning (INL-SSL) fault diagnosis approach, addressing the problem that a certain number of samples in an industrial dataset are mislabeled. The proposed INL-SSL architecture simultaneously trains two deep neural networks (DNNs), which cross-train on each other to filter noisy label errors. In particular, a fitted Gaussian mixture model divides

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time series samples of each DNN flow into an unlabeled set with samples likely to be noisy and a labeled set with samples likely to be clean. Given the labeled and unlabeled data, the authors propose a time series MixMatch semisupervised learning strategy to train the diagnostic model. Ablation study verifies the benefit of the proposed time series augmentation techniques for semisupervised training. Extensive experiments on a benchmark industrial dataset of rolling element bearings (REB) reveal that the INL-SSL outperforms state-of-the-art approaches. On another self-collected REB dataset, the proposed approach also exceeds other comparison methods under noise ratios.

In [A6], Shen et al. propose a new adaptive unscented Kalman filter (AUKF) to deal with the parameter estimation problem for a class of nonlinear unmanned surface vessel (USV) models with unknown statistical characteristics of process noises. Specifically, the considered parameter estimation problem is first transformed into the state estimation problem by extending 18 parameters and three unknown inputs into augmented states for the USVs. With the help of such a transformation, the unknown inputs including disturbances and modeling errors are estimated effectively, and employed to construct the estimators such that the effect of these unknown inputs on parameter estimation can be significantly suppressed. Under the condition that the structure of the covariance matrix of the process noise is available, an adaptive law is further designed to estimate such a high-dimensional covariance matrix where the covariance estimation errors can be reduced. Finally, the proposed estimation approach is verified via performing the practical experiment as well as numerical simulations.

In [A7], Wang et al. propose an explainable multitask Shapley explanation networks (EMSEN), which performs real-time diagnosis on video results of colonoscopy with multimodal inputs from two different light sources. Multiple tasks such as position detection, classification, and diagnosis are completed in the form of multiple outputs. The efficient channel attention (ECA) mechanism-based network is introduced, which only needs to add some parameters to achieve local cross-channel interaction without dimensionality reduction, so as to improve feature extraction and efficiency. In addition, a Shapley explanation networks (ShapNet) structure is used to explain model-important pixel features during inference process. A detection network module finally outputs the multitask results. The simulation experiment results verify the technical soundness and performance of the proposed method. The explainable feature extraction in videos has the potential of application in object detection and operational condition identification in the field of intelligent manufacturing.

In [A8], Li et al. design a dynamic automated guided vehicles (AGV) scheduling model. The established model consists of three parts: the real-time task list for updating real-time tasks, the aperiodic departure method for calculating the scheduling schemes, and the dynamic AGV scheduling model responsible for generating the scheduling schemes. The three parts carry out information interaction and cooperation to improve the self-adaptive ability of AGV in the scheduling stage when facing the complex dynamic environment. Considering the shortcomings of the traditional fixed parameter optimization algorithm and the limitation of the number of calculations within the cycle, the discrete invasive weed optimization algorithm as well as the aperiodic departure method and the real-time task list updating method is proposed, in order to optimize the calculation process and performance and reduce the cost waste. A case from Foxconn factory verifies the validity of the proposed model and algorithm. The experimental cases in actual production workshops show the response ability of the model in dealing with complex and special situations.

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APPENDIX: RELATED ARTICLES

[A1] Z. Chen, H. Ke, J. Xu, T. Peng, and C. Yang, “Multi-channel domain adaptation graph convolutional networks-based fault diagnosis method and with its application,” *IEEE Trans. Ind. Informat.*, doi: 10.1109/TII.2022.3224988.

[A2] Y. Zhou, Y. Dong, and G. Tang, “Time-varying online transfer learning for intelligent bearing fault diagnosis with incomplete unlabeled target data,” *IEEE Trans. Ind. Informat.*, doi: 10.1109/TII.2022.3230669.

[A3] Y. Li, S. Xu, H. Chen, L. Jia, and K. Ma, "A general degradation process of useful life analysis under unreliable signals for accelerated degradation testing," *IEEE Trans. Ind. Informat.*, doi: 10.1109/TII.2022.3224960.

[A4] M. G. Alfarizi, B. Tajiani, J. Vatn, and S. Yin, "Optimized random forest model for remaining useful life prediction of experimental bearings," *IEEE Trans. Ind. Informat.*, doi: 10.1109/TII.2022.3206339.

[A5] C. Cheng, X. Liu, B. Zhou, and Y. Yuan, "Intelligent fault diagnosis with noisy labels via semi-supervised learning on industrial time series," *IEEE Trans. Ind. Informat.*, doi: 10.1109/TII.2022.3229130.

[A6] H. Shen, G. Wen, Y. Lv, J. Zhou, and L. Wang, "USV parameter estimation: Adaptive unscented Kalman filter-based approach," *IEEE Trans. Ind. Informat.*, doi: 10.1109/TII.2022.3202521.

[A7] D. Wang, X. Wang, S. Wang, and Y. Yin, "Explainable multitask Shapely explanation networks for real-time Polyp diagnosis in videos," *IEEE Trans. Ind. Informat.*, doi: 10.1109/TII.2022.3208364.

[A8] Z. Li, H. Sang, Q. Pan, K. Gao, Y. Han, and J. Li, "Dynamic AGV scheduling model with special cases in matrix production workshop," *IEEE Trans. Ind. Informat.*, doi: 10.1109/TII.2022.3211507.

Qiang Liu (Senior Member, IEEE) received the B.S., M.S., and Ph.D. degrees in control theory and engineering from Northeastern University, Shenyang, China, in 2003, 2006, and 2012, respectively.

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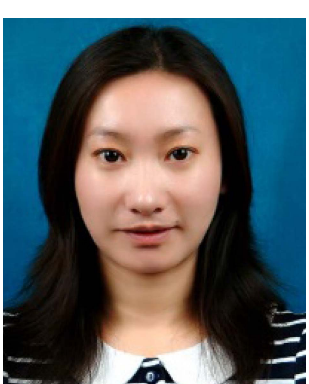

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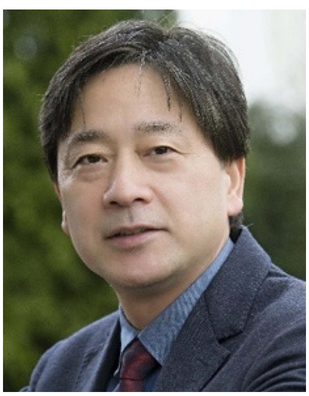

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