Autonomous Intelligent
Systems

EDITORIAL

Recent advances of AI for engineering service and maintenance

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In the context of Industry 4.0, the development of intelligent manufacturing gave birth to a new generation of industrial systems which is expected to be operative under a high level of functionality, reliability, and resilience, to meet the high-quality engineering service and maintenance demands from the systems operators and end-users. As envisioned by Industry 4.0, the next generation of engineering service and maintenance will highly depend on artificial intelligence (AI). Engineering service and maintenance are the cores of operation management, which helps to maximize not only availability, productivity and profitability but even the asset lifetime. This Special Section aims to harvest the latest efforts in fundamental methodologies as well as their applications in AI for engineering services and maintenance. Below is provided with a summary of the nine papers in this issue following the previously mentioned subgrouping of the topics.

"A dynamic customer requirement mining method for continuous product improvement" reported by Zhao et al. proposes a novel dynamic customer requirement mining method to analyze the dynamic changes of customer satisfaction with product attributes based on sentiment and attention expressed in online reviews, aiming to better meet customer requirements and provide the direction and content of future product improvement. Specifically, this method is divided into three parts. Firstly, text mining is adopted to collect online review data of multi-generation products and identify product attributes. Secondly, the attention and sentiment scores of product attributes are calculated with a natural language processing tool, and further integrated into the corresponding satisfaction scores. Finally, the improvement direction for next-generation products is determined based on the changing satisfaction scores of multi-generation product attributes. In ad-

dition, a case study on multi-generation phone products based on online reviews was conducted to illustrate the effectiveness and practicality of the proposed methodology. Our research completes the field of requirements analysis and provides a new dynamic approach to requirements analysis for continuous improvement of multi-generation products, which can help enterprises accurately understand customer requirements and improve the effectiveness and efficiency of continuous product improvement.

"Collaboration effectiveness-based complex operations allocation strategy towards to human-robot interaction" by Zhang et al. researches a human-robot collaborative operation framework based on CNC (Computer Number Control) machine tool, which is divided into three stages: pre-machining, machining and post-processing. Then, an action-based granularity decomposition method was used to construct the human-robot interaction hierarchical model. Further, a collaboration effectiveness-based operations allocation function is established through normalizing the time, cost, efficiency, accuracy and complexity of human-robot interaction. Finally, a simulated annealing algorithm is adopted to solve the preferable collaboration scheme; a case is used to verify the feasibility and effectiveness of the proposed method.

"A service-oriented energy assessment system based on BPMN and machine learning" presented by Yan et al. designed a service-oriented energy assessment system and developed it to assist managers in clarifying the energy consumption of machining in this paper. Firstly, the operational requirements of the serviced-oriented energy assessment system are analyzed from the perspective of enterprises. Then, based on the establishment of system architecture, three key technologies, namely data integration, process integration, and energy evaluation, are studied in this paper. In this section, the energy characteristics of machine tools and the energy relationships are studied through the working states of machine tools, machining features of parts and process activities of processes, and

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the relational database, BPMN 2.0 specification, and machine learning approaches are employed to implement the above function respectively. Finally, a case study of machine tool centre stands base machining in a manufacturing enterprise was applied to verify the effectiveness and practicality of the proposed approach and system.

"Forecasting the yield of wafer by using improved genetic algorithm, high dimensional alternating feature selection and SVM with uneven distribution and high-dimensional data" by Xu et al. proposes a novel wafer yield prediction method, in which the improved genetic algorithm (IGA) is an under-sampling method, which is used to solve the problem of data overlap between finished products and defective products caused by the similarity of manufacturing processes between finished products and defective products in the wafer manufacturing process, and the problem of data imbalance caused by too few defective samples, that is, the problem of uneven distribution of data. In addition, the high-dimensional alternating feature selection method (HAFS) is used to select key influencing processes, that is, key parameters to avoid overfitting in the prediction model caused by many input parameters. Finally, SVM is used to predict the yield. Furthermore, experiments are conducted on a public wafer yield prediction dataset collected from an actual wafer manufacturer. IGA-HAFS-SVM achieves state-of-the-art results on this dataset, which confirms the effectiveness of IGA-HAFS-SVM. Additionally, on this dataset, the proposed method improves the AUC score, G-Mean and F1-score by 21.6%, 34.6% and 0.6%, respectively, compared with the conventional method. Moreover, the experimental results prove the influence of data characteristics on wafer yield prediction.

The paper by Fu and Liu entitled "A deep learning-based approach for electrical equipment remaining useful life prediction" proposes a data-driven approach to predict the remaining useful life (RUL) of electrical equipment. Firstly, the three-phase alternating voltage and the current records of the life of electrical equipment through the number of use times are collected. Secondly, the failure-relevant features are extracted by using the time domain, frequency domain, and wavelet methods. Then, a CNN-LSTM network is designed and used to train an electrical equipment RUL prediction model based on the extracted features. An experimental study based on ten datasets collected from low-voltage AC contactors reveals that the proposed method shows merits in comparison with the prevailing deep learning algorithms in terms of MAE and RMSE.

"An attention enhanced dilated CNN approach for cross-axis industrial robotics fault diagnosis" by Liu et al. proposes an attention-enhanced dilated convolutional neural network (D-CNN) approach for the cross-axis industrial robotics fault diagnosis method. Firstly, key feature extraction and sliding window are adopted to pre-process the monitoring data of industrial robots before D-CNN is introduced to extract data features. And self-attention is used to enhance feature attention capability. Finally, the pre-trained model is used for transfer learning, and a small number of the dataset from another axis of the multi-axis industrial robot are used for fine-tuning experiments. The experimental results show that the proposed method can reach satisfactory fault diagnosis accuracy in both the source domain and target domain.

The paper by Lu et al. entitled "Fault diagnosis of the industrial robot based on dual-module attention convolutional neural network" investigates a data-driven method for the fault diagnosis of industrial robot reducers, that is, a dual-module attention convolutional neural network (DMA-CNN). This method aims to diagnose the fault state of industrial robot reducer. It establishes two parallel convolutional neural networks with two different attentions to capture the different features related to the fault. Finally, the features are fused to obtain the fault diagnosis results (normal or abnormal). The fault diagnosis effect of the DMA-CNN method and other attention models are compared and analyzed. The effectiveness of the method is verified on a dataset of real industrial robots.

Zhang et al. focus on the time between failures (TBF) prediction of the products to realize early detection and maintenance. The main purpose of this paper is to establish an intelligent TBF prediction model for complex mechanical products. The reliability information conversion method is used to solve the problems of reliability information collection difficulty, high collection cost and small data samples in the process of TBF prediction based on reliability information for complex mechanical products. The product reliability information is fully mined and enriched to obtain more reliable and accurate TBF prediction results. Firstly, the Fisher algorithm is employed to convert the reliability information to expand the sample, and the compatibility test is also discussed. Secondly, the BP neural network is used to realize the final prediction of TBF, and the PSO algorithm is used to optimize the initial weight and threshold of BP neural network to avoid falling into local extreme values and improve the convergence speed. Thirdly, the mean-absolute-percentage-error and the Coefficient of determination are selected to evaluate the performance of the proposed model and method. Finally, a case study of TBF prediction for a remanufactured CNC milling machine tool (XK6032-01) is studied in this paper, and the results show the feasibility and superiority of the proposed TBF prediction method.

The paper entitled 'Enhanced pothole detection system using YOLOX algorithm', by Mohan Prakash and Sriharipriya presents research for detecting road potholes using YOLOX algorithm. The YOLOX model is trained with a pothole dataset and the obtained results are analysed

by calculating the Precision, Recall and size of the model and are compared with other YOLO algorithms. The experimental results produced in this paper show that the YOLOX-nano model predicts potholes at higher precision compared to other models while having low computation costs. We were able to achieve an Average Precision (AP) value of 85.6% from training the model and the total size of the model is 7.22 MB. The newly developed YOLOX algorithm seems to have increased in its accuracy compared to its predecessors but its potholes detecting capabilities haven't been tested before and this paper is one of the first to detect pot-holes with the YOLOX object detection algorithm. The research done in this paper will help in reducing the cost and increase the speed of identifying potholes and greatly help in the maintenance of the roads.

This collection of articles represents the active and diverse research occurring within the engineering service and maintenance. The guest editors would like to take this opportunity to thank all contributing authors for their excellent work. We are also very grateful to the reviewers for offering their precious time and efforts and for providing constructive comments promptly. Finally, we wish to acknowledge the great support rendered by the editorial office without that this special issue won't be a success.

Declarations

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