PURDUE UNIVERSITY | Environmental and Ecological Engineering

EEE Research Seminar

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Enhancing Interpretability and Adaptability of Manufacturing Equipment Health Models and Establishment of Cost Models for Maintenance Decisions

Abstract

The integration of Industry 4.0 technologies such as cyber-physical systems (CPSs), the internet of things (IoTs), and artificial intelligence (AI) has revolutionized the traditional manufacturing systems, making them ever smart and digitalized. Maintenance, a critical component of manufacturing, has been incorporated with data-driven strategies such as prognostic and health management (PHM) to improve production efficiency and reliability. This is achieved by real-time sensing and AI-based modeling, which monitor the health condition of operational equipment for fault detection or failure prediction. The results generated by these models provide crucial support for decision-making processes in manufacturing, ranging from maintenance scheduling to production management.

This research focuses on data-driven machine health models based on deep learning in manufacturing systems and explores three directions towards the practical implementation of PHM: model interpretation, model adaptability and robustness enhancement, and cost-benefit analysis of maintenance strategies. In terms of model interpretation, the RNN-LSTM-based model prediction on bearing health estimation was analyzed, and the relationship between the model input and output was investigated. The adoption of the LRP technique improves the explainability of the LSTM model, and has potentials beyond predictive maintenance applications. To enhance model adaptability and robustness, a Transformer-based method was developed for fault diagnosis and novel fault detection, which achieved superior performance compared to conventional fault classification AI-based models. The decision-making aspect of PHM was addressed by conducting a cost-benefit analysis on different maintenance strategies, which provided a new perspective for decision-makers in maintenance management.

Bio

Mr. Haiyue Wu received his Bachelor's degree in Mechanical Engineering at Zhejiang University, China. In 2018, he joined the Laboratory of Sustainable Manufacturing (LSM) for his Ph.D. at Purdue under Professor John W. Sutherland's supervision. He worked as a research assistant in the Wabash Heartland Innovation Network (WHIN) project for next generation manufacturing. Haiyue's research field includes smart and sustainable manufacturing, prognostic and machine health management, and predictive maintenance. His research focuses on developing efficient machine learning (deep learning) methods to perform diagnostic or prognostic analysis related to machine health conditions, including anomaly detection, faults classification, and remaining useful life prediction. In addition, improving machine learning model's interpretability and decision making process is also within his research interest.