MIM 2025 Special Session Proposal

Title: Data Science and Generative AI for Complex Manufacturing Systems

Description:

Nowadays, manufacturing systems are becoming more intelligent and also facing a growing complexity. Complex manufacturing systems are characterized by large scale, numerous factors, and coupling relationships, posing a significant challenge for controlling and improving their performances, such as safety, quality, efficiency and economy.

For example, in steel manufacturing, over 100 chemical reactions occur in harsh high-temperature environments, with constant transformations of solid, liquid, and gaseous fluids, resulting in unobservable dynamics and uncontrollable operations. Aerospace manufacturing faces complex impacts from interacting workstations, high-dimensional parameters, and uncertainties. Semiconductor manufacturing struggles with balancing quality, capacity, and efficiency amidst numerous products, equipment, and re-entrant process. Confronted with intricate complexity, how do we effectively analyze, regulate, and enhance them?

Moreover, data has become an essential production factor. Massive data are collected and stored, which demands more attentions to release its value. However, complex manufacturing systems present considerable difficulties to existing data analysis methods due to their ambiguous mechanisms, abundance of data with limited valuable information, and the coexistence of both structured and unstructured multimodal data. Recently, advanced and interpretable models, such as explainable machine learning, causal analysis, complex networks, and transformer networks, report breakthroughs. Particularly, large language models have sharply risen. In this context, Data Science and Generative AI for Research have become the fourth and fifth paradigms of modern scientific research, bringing dawn to addressing these challenges.

Hence, this special session aims to disseminate recent research developments and significant industrial applications on Data Science and Generative AI for Complex Manufacturing Systems. Original, high-quality theoretical and empirical research papers are invited in topics include, but not limited to,

- Advances in data science and generative AI theories
- Machine learning, cognitive science, causal inference, knowledge engineering for complex manufacturing systems
- Large language models for complex manufacturing systems
- Digital twin and metaverse for complex manufacturing systems
- Data science and generative AI for fault diagnosis, process monitoring, quality control and production scheduling
- Data science and generative AI for human-robot cooperation

- Complex network for the modeling of complex manufacturing systems
- Operations research for the optimization of complex manufacturing systems
- Innovative applications of data science and generative AI for complex manufacturing systems

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