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MACHINE LEARNING-BASED MODELING, PREDICTION, AND OPTIMIZATION IN ADVANCED MANUFACTURING AND MULTIPHYSICAL PROPERTIES OF MATERIALS

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MINISYMPOSIUM

Materials that exhibit multiphysical properties open new avenues for enhancing functionality, while they are highly sensitive to microstructures and internal stress/strain fields, which are vulnerable to key parameters in the manufacturing process. The complex interactions, dynamic environments, rapid modulation of material structures during manufacturing, and intricate coupling among multiphysical phenomena demand multidisciplinary, intelligent, and adaptive solutions for modeling, predicting, and optimizing the process-structure-property paradigm. By leveraging machine learning (ML) approaches in combination with theoretical models, numerical simulations, and experiments, researchers have discovered new methods to address these challenges, thereby improving efficiency, precision, and innovation in manufacturing systems and accelerating the design and optimization processes for multiphysical applications of materials and structures.

This minisymposium aims to solicit and disseminate original research on the cutting-edge integration of ML techniques in the modeling, prediction, and optimization of advanced manufacturing processes and multiphysical material behaviors. Key topics of interest may include (but are not limited to):

- **ML in Process Modeling and Material Characterization**: Using ML to model complex structures and interactions in polymers, metals, ceramics, and composites; accelerating physics-based simulations with ML-based surrogates; and calibrating ML models with high-fidelity data and using ML models to achieve fast characterization, especially under dynamic and nonlinear conditions.
- **ML in Process Design and Control of Advanced Manufacturing**: Implementing ML for offline/online data analysis and ML-based design and control systems that enable smart manufacturing and closed-loop control, where process parameters are continuously adjusted and optimized to maximize performance and efficiency while synthesizing new material systems across multiple time and length scales.
- **ML in Complex Fluid-Structure Interaction**: Using ML to bridge high-fidelity multiphysics modeling and high-resolution in-situ experiments to understand the underlying mechanisms in manufacturing involving fluid-structure interactions.
- **Inverse Design and Optimization of Multiphysical Phenomena**: ML-driven solutions for inverse design and optimization problems in materials and structures, where desired multiphysical material

properties (e.g., heat transfer, complex flow, mechanical deformation, chemical segregation, band structures) inform the design of manufacturing parameters or material composition.

This minisymposium will showcase innovative ML approaches in manufacturing, materials science, and engineering, fostering collaborations that lead to practical implementations and novel research directions. We aim to invite renowned researchers to deliver plenary talks and provide a platform for early-career investigators to exchange ideas and guide future research. In addition to attracting talented minds in academia, this symposium will also appeal to industry partners eager to integrate ML techniques into manufacturing and product property predictions.