Digital Twins in Engineering, DTE 2027
March 8-12, 2027, Yokohama, Japan

MULTISCALE MODELING, ROM AND AI-ENHANCED SIMULATION FOR DIGITAL TWINS

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ABSTRACT

Multiscale simulation and material modeling have become essential tools for understanding, predicting, and designing the nonlinear behavior of materials, structures, and engineering systems across a wide range of spatial and temporal scales. By linking microstructural features, mesoscale mechanisms, and macroscopic responses, these approaches provide a rigorous basis for computational materials design, structural performance assessment, manufacturing-process simulation, and lifecycle prediction.

In the context of digital twins, multiscale modeling is a key enabling technology because digital twins require models that are physically reliable, computationally efficient, continuously updatable, and capable of integrating heterogeneous data from simulations, experiments, sensors, manufacturing records, and operational environments. Reduced-order modeling, surrogate modeling, scientific machine learning, physics-informed neural network and hybrid physics-data methods can transform high-fidelity multiscale simulations into fast, adaptive, and predictive digital-twin components.

The aim of this minisymposium is to bring together researchers and engineers working on multiscale modeling, computational mechanics, materials modeling, model reduction, AI-enhanced simulation, and digital twin technologies. Contributions are welcome on theoretical developments, numerical algorithms, data-driven and hybrid approaches, experimental integration, software implementation, benchmark studies, and industrial applications.

MS topics include computational homogenization, micromechanics, ROM/POD/DMD/operator inference, physics-informed neural networks, data-driven material modeling, uncertainty quantification, model validation, topology optimization, additive manufacturing, composites, architected materials, biomechanics and trustworthy digital twins for engineering decision support.