

MULTIMETHOD COMPUTATIONAL MECHANICS FOR PHYSICS-INFORMED DIGITAL TWINS

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ABSTRACT

Digital twin technologies require the seamless integration of physics-based simulation, data-driven modeling, uncertainty quantification, and real-time computational workflows. However, complex engineering systems often involve multiscale and multiphysics phenomena, including fluid-structure interaction, fracture, impact, manufacturing processes, infrastructure systems, and coupled thermo-mechanical behavior. No single numerical method is sufficient to address all aspects of such problems with the robustness, accuracy, and computational efficiency required for practical digital twins.

This minisymposium focuses on multimethod computational mechanics as a methodological foundation for next-generation physics-informed digital twins. Topics of interest include, but are not limited to, finite element, finite volume, finite difference, particle, meshfree, lattice Boltzmann, immersed boundary, Eulerian, Lagrangian, and hybrid numerical methods; coupling strategies for multiphysics and multiscale problems; model order reduction and surrogate modeling; data assimilation and sensor-informed simulation; physics-informed and hybrid AI models; uncertainty quantification; generative AI and generative design for engineering systems; and high-performance computing platforms for real-time or near-real-time digital twin applications.

The objective of this minisymposium is to bring together researchers working on computational mechanics, numerical methods, AI for science, and digital twin applications, and to discuss how diverse numerical and data-driven approaches can be integrated into reliable, interpretable, and deployable digital twin frameworks. Particular emphasis will be placed on cross-method comparison, method coupling, practical limitations, validation, and the development of new computational paradigms beyond conventional disciplinary boundaries. MS Topics include technologies enabling digital twins, hybrid models, informed AI, data assimilation, model order reduction, uncertainty quantification, generative AI and generative design, engineering applications, and AI-HPC integration.