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DIGITAL TWINS FOR MULTISCALE DESIGN: INTEGRATING AI AND HIGH-FIDELITY SIMULATIONS

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ABSTRACT

Digital twins have emerged as a transformative paradigm in engineering, driven by the rapid advancement of computational power and data-driven methodologies. A digital twin represents a dynamic, high-fidelity virtual counterpart of a physical system, enabling real-time monitoring, predictive maintenance, and accelerated design cycles. In this context, the high-fidelity numerical simulations and artificial intelligence (AI) frameworks that underpin these twins play a pivotal role in establishing the foundation for robust digital twin technology.

This mini-symposium aims to explore the synergistic integration of AI and physics-based simulations for the development of effective, efficient, and trustworthy digital twins in multiscale design. We specifically seek to address the computational bottlenecks inherent in high-fidelity models through the incorporation of machine learning surrogate modeling, physics-informed neural networks (PINNs), verification and validation (V&V), uncertainty quantification (UQ), and advanced optimization frameworks.

We invite contributions focusing on the development and application of digital twin technologies, as well as their foundational methodologies. We are particularly interested in research that bridges multiple scales, ranging from microscale material behavior to macroscale structural performance and manufacturing processes. By fostering a dialogue between domain experts in computational mechanics and data science, this session aims to define the future of predictive engineering.

REFERENCES

[1] Zheng, X., Zhang, X., Chen, T., Watanabe, I., *Deep Learning in Mechanical Metamaterials: From Prediction and Generation to Inverse Design*, Advanced Materials 35 (2023) 2302530.

[2] Li, J., Zheng, X., Watanabe, I., Ochiai, Y., *A Systematic Review of Digital Transformation Technologies in Museum Exhibition*, Computers in Human Behavior 161 (2024) 108407.