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ADVANCED METHODS FOR HIGH-FIDELITY DIGITAL TWINS

700 - DIGITAL TWINS

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ABSTRACT

Throughout their life cycle, physical systems experience evolving behaviors and properties due to factors such as wear, environmental exposure, and operational stress. With the advancement of sensor technologies and computational modeling, the creation of High-Fidelity Digital Twins (HFDTs), virtual replicas of physical systems, has become increasingly feasible across a wide range of engineering applications. A cornerstone of HFDT development is system identification, which involves assessing the current state of a system and detecting areas of degradation or vulnerability. This typically requires solving inverse problems through effective parametrization, often framed as complex optimization tasks. Strategic sensor placement further enhances this process, making optimal sensor deployment a critical component in the development of HFDTs.

This mini-symposium will explore cutting-edge techniques in system identification, optimization, sensor placement, feedback, as well as hybrid approaches that integrate machine learning with traditional physics-based numerical methods in the creation of HFDTs. Applications can be from (but are not limited to) civil engineering, bio-medical engineering, aerospace engineering, and mechanical engineering. The topics will include advanced optimization strategies such as gradient-based algorithms, genetic algorithms, Bayesian optimization, and data-driven methods that improve the accuracy, robustness, and computational efficiency of digital twin approaches.

We also encourage discussions on case studies that demonstrate the practical application of these methodologies. Our goal is to foster interdisciplinary collaboration and drive innovation in the use of HFDTs to enhance system performance, safety, and sustainability. By examining current challenges, best practices, and emerging technologies, including AI-enhanced predictive maintenance and decision-making tools, we aim to empower participants with actionable insights for building more resilient and intelligent engineering systems.

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