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ADVANCED NUMERICAL METHODS FOR PREDICTIVE DIGITAL TWINS

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ABSTRACT

Computational models provide nowadays ubiquitous tools in engineering, despite their practical insights highly depend on the capability to accurately reflect the underlying physical system. Numerical simulation is therefore moving from being powerful analysis and development tools towards having increased roles in contexts like, e.g., operational monitoring, control, predictive maintenance, and decision support, in which models of specific entities are continually updated in the form of a digital twin. The digital twin paradigm aims to overcome the limitation of *static* models by providing adaptive and comprehensive models that can be tailored to the physical setting at hand. This is made possible by acquiring observational data from the physical system (usually in the form of sensor data) and assimilating them to continually update the model in order to reflect the evolving physical system. A synergistic coupling between physical systems, data collection, computational models, and decision-making processes, is therefore required to address today's industrial challenges, by enhancing computational efficiency. From a mathematical standpoint, this translates into a combined use of tools from scientific computing, statistics, dynamical systems, and control theory.

In particular, being able to design and calibrate computational models that are reliable, accurate and predictive when dealing with complex systems is of paramount importance, and can nowadays take advantage of either physics-based or data-driven methodologies, both representing the focus of this session.

Starting from real-life problems of interest in engineering and applied sciences (like, e.g., structural health monitoring or the generation of virtual patients) the goal of this session is to discuss the most recent strategies for the design of computational techniques aimed at describing physics-based systems and embedding information from real data. These techniques might include – but are not restricted to – data-driven discovery of dynamical systems, optimal control, uncertainty quantification, data assimilation for parameter and state estimation – like, e.g., filtering techniques and dynamic decision networks – as well as reduced order modeling strategies, surrogate models – like, e.g., gaussian process and neural network regression – and multi-fidelity techniques.