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DIGITAL TWINS FOR PREDICTIVE INTELLIGENCE IN ENGINEERING SYSTEMS

MATTEO TORZONI[*], MARCO TEZZELE[†], GIANLUIGI ROZZA[‡], AND ANDREA MANZONI[§]

[*] Department of Civil and Environmental Engineering, Politecnico di Milano
Piazza L. da Vinci 32, 20133 Milano, Italy
E-mail: matteo.torzoni@polimi.it

[†] Department of Mathematics, Emory University,
400 Dowman Drive, Atlanta, GA 30322, USA
E-mail: marco.tezzele@emory.edu

[‡] Mathematics Area, mathlab, SISSA (International School for Advanced Studies),
Via Bonomea 265, 34136 Trieste, Italy
E-mail: grozza@sissa.it

[§] MOX – Department of Mathematics, Politecnico di Milano,
Piazza L. da Vinci 32, 20133 Milano, Italy
E-mail: andrea1.manzoni@polimi.it

ABSTRACT

Digital twins are rapidly evolving from descriptive and predictive tools into intelligent, adaptive systems that integrate data, models, and decision-making across the lifecycle of engineering systems. Recent advances point to a paradigm shift from reactive digital representations toward autonomous, agentic twins capable of learning, reasoning, and acting within a closed loop between the physical and virtual domains. In this emerging landscape, digital twins are no longer passive mirrors of reality, but active computational entities that enable discovery, optimization, and control under uncertainty.

Positioned at the interface of computational mechanics, uncertainty quantification, and scientific machine learning, this mini-symposium aims to explore the foundations and enabling technologies required to equip engineering systems with predictive and adaptive capabilities through digital twins. This session seeks contributions advancing next-generation digital twins, with emphasis on: model order reduction and surrogate modelling for real-time applications; uncertainty quantification, propagation, and management; physics-enhanced machine learning; and autonomous, agent-based digital twin frameworks. Particular attention is given to approaches that enable adaptive model updating, automated knowledge extraction, and self-learning digital twins that actively seek information and optimize their interaction with the physical environment.