

DIGITAL TWINS IN MEDICINE AND HEALTHCARE: MODELING, SIMULATION, AND CLINICAL APPLICATIONS

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ABSTRACT

Digital twin technology is emerging as a unifying paradigm across engineering and biomedical domains, enabling virtual representations of complex systems. In healthcare, digital twins extend core engineering principles—such as multiphysics modeling, system identification, and control—toward patient-specific applications, including disease progression modelling, therapy optimization, treatment planning and optimization of clinical decision-making.

Minisymposia will highlight how methodologies traditionally developed in computational engineering—such as high performance computing, model order reduction, physics informed AI and hybrid AI–physics modeling—are being translated and adapted to biomedical and healthcare applications. Digital twins integrate multimodal data sources such as imaging, multi-omics, wearable sensors, and electronic health records. Multiphysics modeling plays a central role in advancing digital twins for biomedical applications by enabling the integration of interacting physical, chemical, and biological processes within a unified computational framework. Advances in high performance computing allow treatment planning, including real time simulations.

In silico modeling is rapidly reshaping drug discovery by enabling the construction of high-fidelity digital representations of biological systems and disease processes. Within a digital twins framework, patient-specific or population-level virtual models can integrate multi-omics data, pharmacokinetics/pharmacodynamics (PK/PD), and mechanistic pathway simulations to predict therapeutic response and optimize candidate selection.

The session will feature contributions spanning multiple scales, from cellular and organ-level simulations (e.g., brain, liver, cardiovascular, oncology, and infectious disease models), applications of high performance computing and AI for treatment planning. Application of in silico models for drug discovery will be also discussed.