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ADVANCED AND HYBRID COMPUTATIONAL MODELLING TOWARDS DIGITAL TWINS FOR HEALTH

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ABSTRACT

The convergence of advanced computational modelling and digital twin technology is revolutionizing healthcare, enabling unprecedented precision, personalization, and predictive capabilities. Digital twins—virtual replicas of physical entities or systems—are increasingly leveraged in medicine to simulate physiological processes, optimize treatments, and enhance decision-making.

The objectives of the mini-symposium will address the state-of-art of biomechanical modelling and simulation studies using finite element method (FEM) and their combination with artificial intelligence (AI) and mixed reality (MR) for evidence-based diagnosis, clinical decision in Healthcare.

Advanced modelling techniques, such as physics-based simulations, machine learning (ML), and deep learning, are integrated to capture the complexity of biological systems. Hybrid models, which combine mechanistic and data-driven approaches, offer a powerful solution to address the limitations of traditional methods. For instance, physics-informed neural networks (PINNs) merge differential equations with neural networks to improve the accuracy of simulations, while ensemble models aggregate multiple algorithms to enhance robustness. These advancements enable the creation of patient-specific digital twins, which can simulate organ-level interactions, predict disease progression, and evaluate treatment outcomes in silico.

In healthcare, digital twins are applied across a spectrum of domains: from personalized medicine, where patient-specific models predict disease progression, to surgical planning, where virtual replicas guide interventions.

However, challenges persist, including the need for high-quality, interoperable data, computational efficiency, and ethical considerations and translational research (integration of digital twins into routine clinical practice).