CONTINUUM BIOMECHANICS OF LIVING ACTIVE SYSTEMS AND DIGITAL ORGAN TWINS

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ABSTRACT

Computational biomechanics and robust numerical methods support the investigation of disease mechanisms and treatment strategies in living active systems [1]. Multiphysics and multiscale models combine mechanics with biochemistry, electrophysiology and transport processes to support predictive simulations. These models connect subcellular activity with macroscopic continuum mechanics and account for tissue responses to mechanical stimuli, growth and remodelling. Interactions between functional units must also be considered to explain tissue and organ behaviour.

This minisymposium focuses on these challenges and extends its scope to patient-specific digital twins of individual organs and coupled organ systems. The emphasis is on representing biological mechanisms, synchronizing models with longitudinal observations, and establishing the credibility of physiological predictions. Digital twins repeatedly update states, parameters, and, where necessary, model structure from individual data and assess predictions against subsequent observations [2]. This requires handling heterogeneous, incomplete and asynchronous measurements while maintaining consistent model states and physiological coupling conditions. Representative applications include the heart, brain, lungs, liver, and kidneys and their functional interactions.

Topics of interest include:

- Active tissue mechanics, mechanobiology, growth and remodelling
- Multiscale and multiphysics modelling
- Multimodal data assimilation, personalisation and identifiability
- Conservative organ coupling and adaptive multifidelity co-simulation
- Scalable solvers, model reduction and physics-informed surrogates
- Verification, independent validation and uncertainty propagation
- Reproducible benchmarks, interoperable software and FAIR data and models

We welcome interdisciplinary contributions, combining mechanical modelling, numerical methods, data science, and clinical applications. Contributions from experimental biomechanics are also welcome, since they provide data for mechanistic understanding, parameterisation and validation. The objective is to compare approaches for efficient and physiologically consistent predictions, including quantified aleatoric and epistemic uncertainties and explicit limits of applicability.

REFERENCES

[1] Suditsch, M., Wagner, A. and Ricken, T. (2025). Onco*: An umbrella Python framework for modelling and simulation of oncological scenarios. Journal of Computational Science, 85, 102533. DOI: 10.1016/j.jocs.2025.102533.

[2] Sel, K. et al. (2025). Survey and perspective on verification, validation, and uncertainty quantification of digital twins for precision medicine. npj Digital Medicine, 8, 40. DOI: 10.1038/s41746-025-01447-y.