Identifying Dominant Parameters in PV-based Fitting of a Paediatric Cardiac Digital Twin

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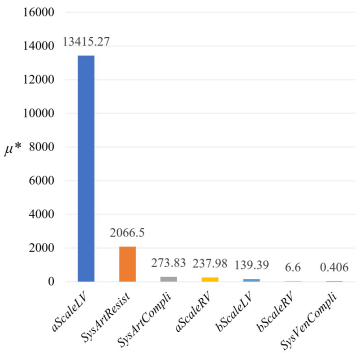
Aims: Closed-loop cardiac electromechanical models are increasingly used to support *in silico* experimentation and digital twins by coupling myocardial mechanics with circulatory dynamics. However, their personalization remains challenging under limited clinical data, particularly in paediatric applications. In this setting, the inverse problem becomes underdetermined, as multiple parameter combinations can reproduce similar pressure-volume (PV). In this work, we aim to identify which parameters influence the model to reproduce physiologically PV loops for developing a closed-loop electromechanical paediatric digital twins.

Methods: We consider a whole-heart patient-specific closed-loop cardiac electromechanical model derived from the MRI scan of a 9-year-old subject. Personalization is performed through myocardial material parameters, governed by a Usyk-type constitutive formulation, including ventricular parameters controlling the stiffness of the passive properties of the myocardium (*aScaleLV*, *bScaleLV*, *aScaleRV*, *bScaleRV*), and circulatory parameters including systemic arterial resistance and compliance (*SysArtResist*, *SysArtCompli*) and venous compliance (*SysVenCompli*). A parameter screening study is conducted on a set of available simulations, and parameter influence is quantified using Morris elementary effects, with the mean absolute effect used for ranking.

Results: As is observed in the figure, the PV screening revealed a clear dominance of left ventricular parameters. *aScaleLV* showed the largest influence across all observations, with a Morris index value of 13415.27, followed by *SysArtResist* (2066.5) and *SysArtCompli* (273.83).

Conclusion: PV calibration overemphasizes left ventricular parameters, with reduced sensitivity to vascular and right ventricular parameters.



Morris sensitivity indices (μ^*)