Parameter Estimation in cardiac biomechanical models with physics-informed neural networks

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Abstract: Due to their predictive potential and their role in aiding clinical data interpretation and optimising tailored diagnosis, biophysical models of the cardiovascular system have seen increased development in the scientific community [1]. However, high-resolution, accurate multi-physics mathematical models are computationally intensive and demand fine-tuning of numerous parameters, hindering their clinical application. To address this challenge, this presentation introduces a novel approach that integrates physics-informed neural network methods [2] with detailed 3D cardiac biomechanical models. The learning algorithm leverages a mathematical model based on partial differential equations to represent the physics of the problem, and it combines this with clinical displacement and strain data to enhance the convergence properties of the method. Several benchmarks are showcased to highlight the method's accuracy, robustness, and potential for efficiently determining patient-specific biophysical properties.

References: [1] A. Quarteroni, L. Dedè, A. Manzoni and C. Vergara, Mathematical modelling of the human cardiovascular system: data, numerical approximation, clinical applications, Cambridge Monographs on Applied and Computational Mathematics, Cambridge Uni- versity Press, 2019.

[2] M. Raissi, P. Perdikaris, and G.E. Karniadakis, Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations. J. Comp. Phys., (2019). 378: 686707.