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MONOLITHIC AND SEGREGATED ALGORITHMS FOR THE NUMERICAL SIMULATION OF CARDIAC ELECTROMECHANICS

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We consider in this work the numerical solution of the integrated electromechanics problem in the human heart, specifically for the left ventricle. We focus on the mathematical and numerical coupling of the single core models contributing to the cardiac function, namely electrophysiology, ionic activity, mechanical activation at the cellular level, and passive and active mechanics at the tissue level. Distinguishing features in our model are the active strain approach for the determining active muscle contraction and relaxation, as well as the Holzapfel–Ogden constitutive law for the passive mechanics of the tissue.

Our main contribution lays in the numerical coupling strategy of the above mentioned core models. After having introduced suitable discretization schemes for the space and time discretizations – namely the Finite Element method and Backward Differentiation Formulas, respectively – we consider both monolithic and staggered algorithms for their integration. We extensively discuss the properties of the coupling schemes, both in terms of computational efficiency and accuracy, by numerically solving the electromechanics problem in the high performance computing framework.

We finally apply the algorithms to solve the electromechanics problem in a subject–specific geometry of the human left ventricle and we reproduce the typical pressure–volume diagram characterizing the cardiac cycle.

REFERENCES

[1] A. Gerbi, L. Dede', and A. Quarteroni, A monolithic algorithm for the simulation of cardiac electromechanics in the human left ventricle. *MOX report*, 2017.

[2] A. Quarteroni, T. Lassila, S. Rossi, and R. Ruiz-Baier, Integrated heart – Coupling multiscale and multiphysics models for the simulation of the cardiac function. *Comput. Meth. Appl. Mech. Engng.*, Vol. **314**, pp. 345–407, 2017.