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COUPLED *CSFE* - ORD NUMERICAL MODEL FOR HEART ELECTRO-MECHANICS

Vladimir Geroski[1,2], Miljan Milosevic[2,3], Nenad Filipovic[1,2], Milos Kojic[3,4]

[1] Faculty of Engineering, University of Kragujevac, Sestre Janjic 6, 34000 Kragujevac, Serbia, vlada.geroski@gmail.com, fica@kg.ac.rs
[2] Bioengineering Research and Development Center BioIRC Kragujevac, Prvoslava Stojanovica 6, 34000 Kragujevac, Serbia.
[3] Belgrade Metropolitan University, Tadeuša Košćuška 63, 11000 Belgrade, Serbia, miljan.m@kg.ac.rs
[4] Houston Methodist Research Institute, The Department of Nanomedicine, 6670 Bertner Ave., R7 117, Houston, TX 77030, mkojic42@gmail.com

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It is of enormous importance to have accurate electro-mechanical models for better understanding of various heart diseases such as heart failure, cardiac arrhythmia, and cardiomyopathy. Muscles in the body are activated by electrical signals, transmitted from the nervous system to muscle cells, affecting the cell membranes potentials. Current flow through cell membrane contains ion currents of molecules such as sodium (Na^+), potassium (K) and calcium (Ca^{2+}), which are critically important for muscle function and must be adequately formulated within mathematical models for electrophysiology simulations. Additionally, calcium current and concentration inside the cell are the main cause of generating active stress within muscle fibers.

Modelling such complex system is a huge challenge for computational methodology. In order to make computational models feasible for applications, we introduced a smeared concept for modelling physical fields, by formulating a composite smeared finite element (CSFE) for electrophysiology [1]. In order to calculate calcium current and concentration within the cell, we coupled the CSFE and the OHara-Rudy (oRD) membrane model [2]. In the oRD model of human ventricle, action potential (AP) is formulated using undiseased human data which determine accurate myocyte electrophysiology and Ca^{2+} cycling validation over the entire range of physiological frequencies. Electrophysiology module is further coupled with muscle mechanics by widely used relation for heart muscle that connects calcium concentration and active stress along muscle fibers [3].

Presented methodology is applied to various 2D and 3D geometries of the heart wall tissue to compute mechanical response of the system. Using this approach it is possible to efficiently solve coupled fluid-electro-mechanical heart behaviour, and provide accurate predictions of the heart beat.

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