MATHEMATICAL AND NUMERICAL MODELING OF CARDIAC FIBER GENERATION AND ELECTROMECHANICAL FUNCTION: TOWARDS A REALISTIC SIMULATION OF THE WHOLE HEART

ROBERTO PIERSANTI

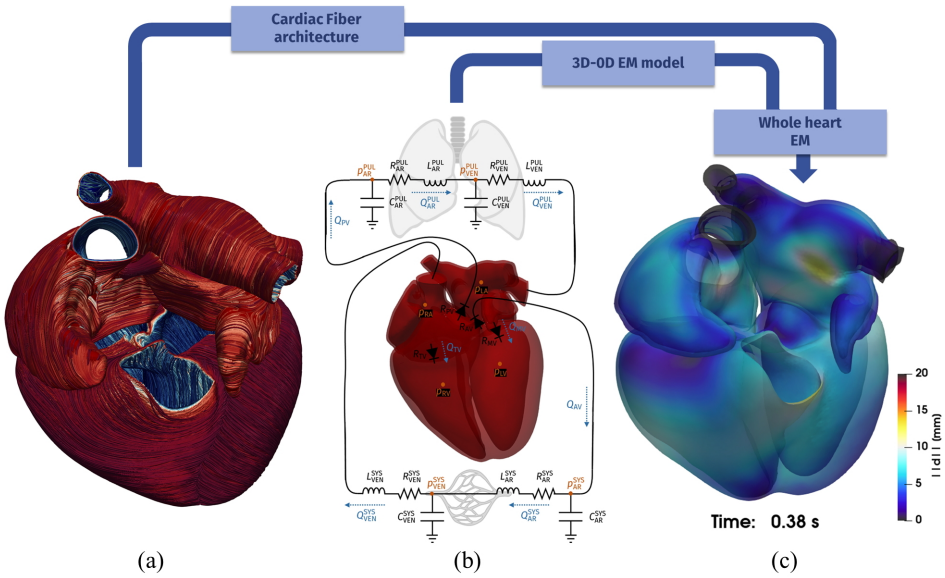

FIGURE 1. Graphical abstract: a) cardiac muscular fiber architecture; b) 3D-0D whole heart model; c) full heart electromechanical simulation.

Even though some area of heart modeling reached a certain level of maturity, whole heart models are a far reaching endeavour and are still in their infancy. This work provides a detailed fully coupled multiscale mathematical and numerical model of cardiac electromechanics (EM) of the whole human heart. Two crucial factors for accurate numerical simulations of cardiac EM are: reconstructing the muscular fiber architecture; accounting for the interaction between the heart and the circulatory system. With the aim of facing the challenges formerly described, the main contributions in this work move along two strands. On the one hand, we developed a unified mathematical framework to prescribe myocardial fibers orientation in computational four chamber heart geometries, see Figure 1(a) [1]. On the other hand, we provide a biophysically detailed cardiac 3D EM model coupled with a 0D closed-loop lumped parameters model of the whole circulatory system, see Figure 1(b) [2]. The validity of the whole heart 3D-0D model was demonstrated through EM simulations with physiological activation sites in realistic cardiac computational domain, see Figure 1(c).

REFERENCES

[1] R. PIERSANTI, P.C. AFRICA, M. FEDELE, C. VERGARA, L. DEDE', A.F. CORNO, AND A. QUARTERONI, *Modeling cardiac muscle fibers in ventricular and atrial electrophysiology simulations*, Computer Methods in Applied Mechanics and Engineering, 373, p. 113468, 2021.

[2] R. PIERSANTI, F. REGAZZONI, M. SALVADOR, A.F. CORNO, L. DEDE', C. VERGARA, AND A. QUARTERONI, *3D-0D closed-loop model for the simulation of cardiac biventricular electromechanics*, Computer Methods in Applied Mechanics and Engineering, 391, pp. 114607, 2022.

MOX, DEPARTMENT OF MATHEMATICS, POLITECNICO DI MILANO, MILAN, ITALY
Email address: roberto.piersanti@polimi.it