# A Coupled Heart-Torso Framework for Cardiac Electrocardiographic Simulation

Hongda Mao*, Linwei Wang, Ken Wong, Huafeng Liu and Pengcheng Shi

A physiological meaningful heart model is helpful for understanding the heart. The existing works either adopt a static heart model or a so-called one-way electromechanical coupling model that does not contain mechanoelectrical feedback. However, electrophysiological and mechanical functions of the heart are inter-dependent, and realistic electrocardiographic simulations can only be achieved when such electromechanic relationship is considered. In this paper, we propose an electromechanical-coupled heart model which contains both electromechanical coupling and mechanoelectrical feedback, and incorporate it into a coupled heart-torso framework for cardiac electrocardiographic simulation.

Our proposed heart model contains four components: cardiac electrophysiological model which describes the spatiotemporal dynamics of electrical activation of the heart; cardiac electromechanical coupling which determines the active contraction stresses generated in response to the electrical activation; cardiac mechanics which describes the heart material properties and deformation related to the active contraction stresses; cardiac mechanoelectrical feedback which describes the effect of heart motion to electrophysiology. To build the coupled heart-torso framework, we adopt a meshfree-BEM (boundary element method) strategy. The hearts transmembrane potentials (TMPs) along with its motion are solved by meshfree method, while the body surface potentials maps (BSPs) are calculated by BEM. Under this framework, a direct 3D TMPs-to-BSPs mapping can be achieved where the body-surface electrographic simulation reflects the underlying electrophysiology as well as motion of the heart.

We first present a simulation of our realistic heart model, which shows spatiotemporal evolution of 3D TMPs along with the heart motion. Second, we test our heart-torso framework with realistic heart and torso geometries. The simulation exhibits a beating heart as well as spatiotemporal evolution of BSPs on the torso. At last, a comparison is made between our simulated ECG signals and that from a static heart model, through which we find T wave shift is found in our simulated signals.