Mathematical Modelling of the electrical wave in the heart from ion-channels to the body surface: Direct and inverse problems.

Nejib Zemzemi

CARMEN team, Inria Bordeaux Sud-Ouest
200 avenue de la vieille tour, 33405 Talence Cedex.

Electrocardiographic Imaging (ECGI) is a new imaging technique that noninvasively images cardiac electrical activity on the heart surface. In ECGI, a multi-electrode vest records body-surface potential maps (BSPMs); then, using geometrical information from CT-scans and a mathematical algorithm, electrical potentials, electrograms and isochrones are reconstructed on the heart surface. The reconstruction of cardiac activity from BSPMs is an ill-posed inverse problem. Regularization techniques are used in order to solve this problem.

We developed a 3D computational model of the electrical wave in the heart. This multi-scale mathematical model is heavy in terms of computational cost. Different numerical schemes are used in order to reduce the computational cost: We use domain decomposition methods combined with different time decoupling schemes. We also use reduced order methods allowing reducing the degrees of freedom in the linear system.

We present a 3D anatomically based model of the whole human with a biophysically detailed representation of human membrane kinetics, realistic cardiac geometry, fibre orientation and heterogeneity in electrophysiological properties of cardiac ventricles. The 3D multi-scale model is used to simulate different heart conditions in order to test different method introduced to solve the inverse problem in electrocardiography.

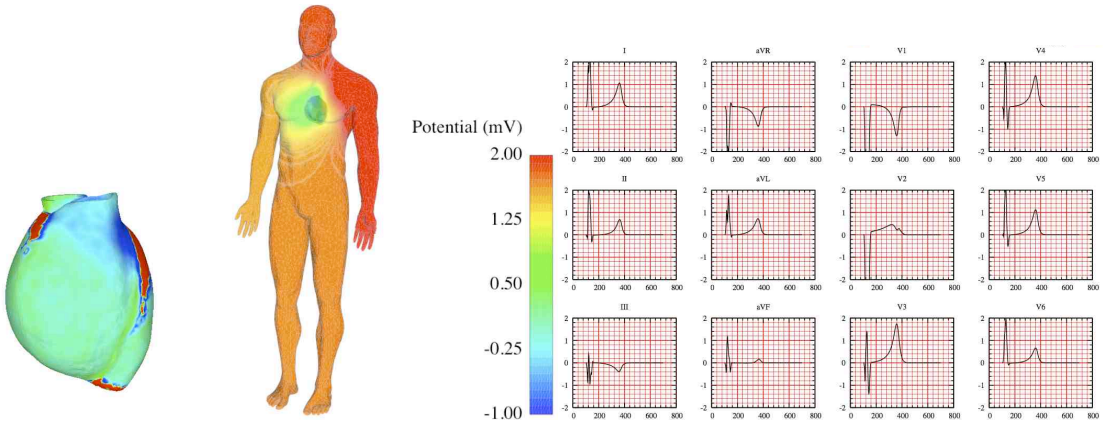

Figure: Body surface potential distribution (left) and 12-leads of the ECG (right)