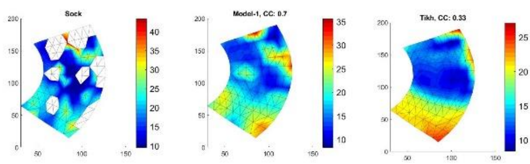
Electrocardiographic Imaging of Sinus Rhythm in Pig Hearts using Bayesian Maximum A Posteriori Estimation

Yesim S Dogrusoz[1], Remi Dubois[2], Emma Abell[2], Matthijs Cluitmans[3], Laura Bear[2]

[1]Middle East Technical University, Ankara, Turkey
[2]IHU-LIRYC, Université de Bordeaux, Bordeaux, France
[2]Maastricht University, Maastricht, Netherlands

Electrocardiographic imaging (ECGI) has the potential to guide physicians to plan treatment strategies. Previously, Bayesian maximum a posteriori (MAP) estimation has been successfully applied to solve this ill-posed inverse problem and localize pacing sites for simulated data. In this study, we evaluate its effectiveness using experimental data in reconstructing sinus rhythm, a rhythm known to result in artifacts using standard ECGI methods.

Four datasets from Langendorff-perfused pig hearts suspended in a human-shaped torso-tank were used. Each experiment included 3-5 simultaneous electrogram (EGM) and body surface potential (BSP) recordings of 10 beats, in baseline and under dofetilide and pinacidil perfusion (drugs that alter action potential duration). MAP estimation, assuming jointly Gaussian EGM and BSPs, and Tikhonov regularization were used to solve the inverse problem. Measurement noise was assumed to be Gaussian, independent, and identically distributed (iid). The prior models were generated using beats from the same experiment and drug state, but excluding the test beat (i.e., leave-one-beat-out). Pearson's correlation was used to evaluate EGM reconstructions (temporal) and activation time (AT) maps, which were estimated using a spatio-temporal approach.



Sample AT maps for one beat; left to right: ground truth, MAP, Tikhonov.

There was 8% (from 0.70 to 0.76) - 27% (from 0.63 to 0.80 and from 0.51 to 0.65) increase in median CC-EGM, and 8% (from 0.90 to 0.97 and from 0.75 to 0.81) - 94% (from 0.33 to 0.64) increase in median CC-AT in the MAP results compared to Tikhonov. In one case only, median CC-AT of MAP dropped by 16% (from 0.78 to 0.65).

MAP outperforms Tikhonov regularization for all datasets and test beats with the leave-one-beat-out prior model for reconstructing the sinus rhythm beats. We will continue our evaluations on the localization and the number of epicardial breakthroughs and repolarization time estimates, as well as incorporating more realistic prior model scenarios.