Use of Simulated Data for the Estimation of Prior Models in Kalman Filter-Based ECGI

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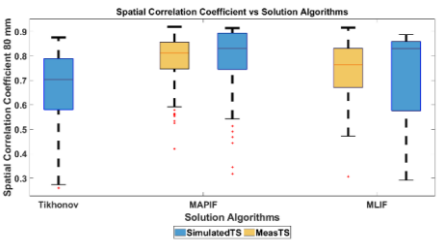
Background: Kalman filtering has been succesfully applied to electrocardiographic imaging (ECGI) to improve the estimation accuracy, especially when a 'good' training set of epicardial potentials is available to estimate the prior statistics. Most methods in the literature use previously measured experimental data to obtain these training sets, which would not be feasible in a clinical application. In this study we explored the effectiveness of using simulated epicardial potentials for obtaining the prior models.

Methods: Body surface potential measurements at 30 dB SNR were simulated from LV-paced epicardial potential recordings obtained from University of Utah. Kalman filter was used to solve the inverse problem. The Kalman filter prior model parameters were estimated using the maximum likelihood (MLIF) and maximum a posteriori (MAPIF) estimation methods from two different training sets. The first training set (M-TS) included epicardial measurements from similar experiments, but not the test data for which we solve the inverse problem. The second training set (S-TS) included simulated epicardial potentials. First, 3D transmembrane potentials were simulated in an anisotropic heart using the Aliev-Panfilov model. The correponding epicardial potentials were obtained by solving the forward problem using the bidomain model. Both training sets included beats that were paced from an 80mm-neighbourhood of the pacing location of the test beat. Reconstructed electrograms were evaluated using the spatial (sCC) and temporal (tCC) correlation coefficients, and pacing site localization accuracy was assessed based on the localization error (LE-mm).



Boxplot distribution of spatial CC values over all time instances. Tikhonov regularization results are also included for comparison.

Results: MAPIF had the best performance even with S-TS (M-TS/S-TS – average sCC: 0.79/0.80; average tCC: 0.79/0.82; LE: 8.94/6.36mm). MLIF also yielded comparable results with S-TS (M-TS/S-TS – average sCC: 0.74/0.72; average tCC: 0.76/0.77; LE: 8.94/4.46mm).

Conclusions: Even using a simple simulation method, and large margin in the initial pacing location range (80mm here), simulated data can be used for defining the prior models in the Kalman filter-based-ECGI.