A Learning Based Statistical Approach for Combining Multiple Measurements in Electrocardiographic Imaging

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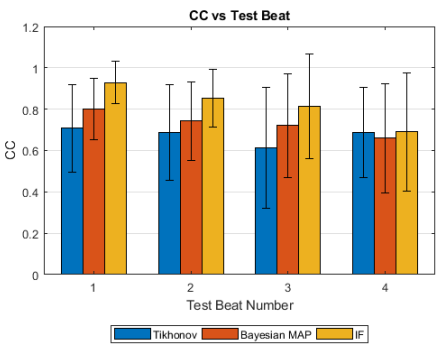
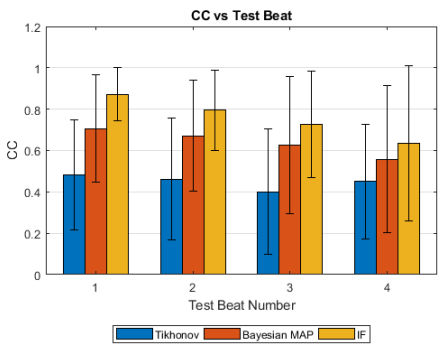
Aim: In experimental and simulation studies of non-invasive electrocardiographic imaging (ECGI), multiple measurements of the body surface and epicardial potentials are available. However, the best way to utilize all available measurements still remains an open question. We proposed a learning based statistical approach to incorporate multiple measurements.
Methods: We used four beats of experimental epicardial potentials, paced from nearby LV locations, obtained from University of Utah. Body surface measurements were simulated from these potentials. We modeled the ECGI problem by using state-space equations assuming zero mean, independent Gaussian noise. Inverse problem is solved by using a learning based approach, called as Inference and Filtering (IF). In the learning step, we used Maximum Likelihood estimation under independent observations and Markovian assumption to estimate the initial state's mean and covariance, measurement and process noise covariances, and the state transition matrix. After this learning step, Kalman filter and smoother were applied to solve the ECGI problem. We used leave-one-beat-out protocol to utilize available data for test and training. Two different levels of noise (10 dB and 30 dB SNR) were used while simulating the body surface potentials. We compared the IF method with Bayesian MAP estimation, where the same training set was used to estimate the prior probability density function, and zero-order Tikhonov regularization.
Results: For the 30 dB case, correlation coefficient (CC) value ranges are 0.61 to 0.70, 0.65 to 0.80, and 0.69 to 0.93 for Tikhonov regularization, MAP, and IF, respectively. For the 10 dB case, CC value ranges are 0.4 to 0.46, 0.55 to 0.70, and 0.63 to 0.87 for Tikhonov regularization, MAP and IF, respectively.
Conclusion: IF algorithm outperforms the other methods when the test beat and the training set beats distributions are fairly similar to each other.



SNR = 30 dB



SNR = 10 dB