Compensation of Model Errors in Electrocardiographic Imaging using Bayesian Estimation

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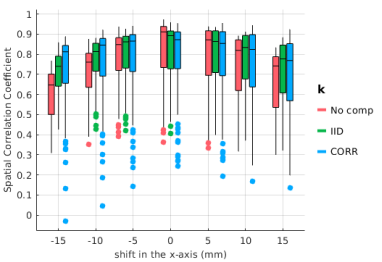
Bayesian Maximum a Posteriori (MAP) estimation has been successfully applied to electrocardiographic imaging (ECGI). However, in most studies, MAP deals only with the measurement noise and ignores the forward model errors. In this study, we incorporate model uncertainty in the MAP formulation to improve the inverse reconstructions.

Measured electrograms (EGM) from the University of Utah were used to form training and test datasets. Body surface potential (BSP) measurements were simulated at 30 dB SNR. EGMs were reconstructed using MAP estimation, assuming jointly Gaussian EGM and BSPs. The training dataset was used to define the prior probability function (pdf). Both the measurement noise and model error were assumed to be uncorrelated with the EGMs. Measurement noise was assumed to be Gaussian, independent, and identically distributed (iid). Model error was introduced as -15 to +15 mm shift of the heart position in x, y, and z directions. Three model error pdf's were considered: no compensation (model error is assumed as zero in the solution); model error is modeled as iid (IID); model error is correlated across leads (CORR). For IID and CORR, pdf was estimated based on all geometry disturbances. Results were evaluated using spatial (sCC) and temporal (tCC) correlation coefficients.

Median sCC values increased up to 25% (from 0.65 to 0.81) with CORR and 15% (from 0.66 to 0.76) with IID compared to 'no compensation'. Medi-an tCC values were comparable in most cases, but increased up to 8% (from 0.78 to 0.84) with IID and 12% (from 0.78 to 0.87) with CORR in some cases. Improvements were mostly observed for larger geometric errors.



Spatial CC boxplot distributions for shift error in the x-direction.

Including model errors in the MAP formulation, even in a simple form such as the IID, improved results. Future work will include considering other types of model errors and incorporating the correlation of these model errors with the EGMs.