A Sliding Window Approach to Regularization in Electrocardiographic Imaging

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Introduction: Electrocardiographic imaging (ECGI) is a technique used to noninvasively reconstruct the electrical signals from the heart. The inverse problem of ECGI is ill-posed, so regularization must be applied to constrain the solution. Regularization is typically applied to each individual time point (instantaneous) or to the beat as a whole (global). These techniques often lead to over or under regularization. We aimed to develop an inverse formulation that strikes a balance between these two approaches that would realize the benefits of both by implementing a sliding window regularization.

Methods: We formulated our sliding window regularization using the boundary element method with Tikhonov 0 and 2^{nd} order regularization. This sliding window utilized a time window of the body surface potentials around each sample. We compared reconstructed potentials from the sliding window, instantaneous, and global regularization techniques to ground truth potentials for 10 heart beats paced from the ventricle in a large-animal model.

Results: The sliding window technique provided smoother transitions of regularization weights than instantaneous regularization while improving spatial correlation over global regularization. The sliding window technique accomplishes this while maintaining low regularization weights across the QRS complex.

Discussion: While the differences in regularization weight were nuanced, smoother transitions provided by the sliding window regularization have the ability to eliminate discontinuities in potential caused by instantaneous regularization.

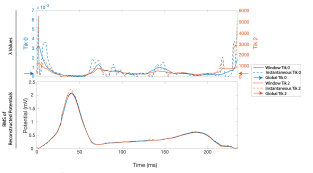

Figure 1. Reguarization weights throughout a representative beat. The regularization weights are show in the upper plot for the instantaneous and sliding window regularization methods with Tikhonov 0 and 2^{nd} order regularization. The lower plot shows the root mean square (RMS) of the solutions from each regularization technique.