Delay-Based Regularization for ECG Imaging of Transmembrane Voltages

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We suggest a novel regularization method for reconstruction of cardiac transmembrane voltages (TMV) from body surface potentials (BSP) that is based on imposing similarity between time-aligned TMVs of nearby nodes. Theoretical considerations show that this constraint links space and time in a way that allows to recover spatially constant components of TMVs that are in the null-space of the lead field matrix. An iterative scheme is proposed to update the inter-node delays needed for time-alignment.

Evaluation of the method using simulated ventricular pacings showed a clear improvement over second order Tikhonov (SOT) in terms of correlation and absolute error of activation times (AT) and spatial and temporal correlation of TMVs. For an RV septal pacing, the Pearson correlation coefficient of ATs increased from 0.656 to 0.936 and, in contrast to SOT, the excitation origin was indicated at the correct location.

In conclusion, the delay-based constraint offers a regularization that is particularly effective for TMVs, while supporting their physiological properties.