Impact of Noise on ECGI Resolution with Zero Order Tikhonov Regularization and L-Curve Optimization

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Introduction. Electrocardiographic Imaging (ECGI) allows computing the electrical activity in the epicardium by inverting the electrical propagation matrix, which can be solved by regularizing this ill-posed problem. The objective of this study is to evaluate the effects of noise on the signals in the selection of the regularization parameter (λ) by means of zero-order Tikhonov and L-curve optimization.

Methods. Fourteen atrial fibrillation (AF) simulations were used for computing the ECGI with different noise levels (3, 10, 20, 30, and 40dB). Signals of different real cardiac rhythms were also used to compute the ECGI (3 AF, 2 atrial flutters, 3 atrial pacing, 3 sinus rhythm and 3 ventricular tachycardia). For simulations and patients, maximum L-curve curvature and λ were extracted and compared.

Results. The maximum curvature of the L-curve, noise level and the obtained λ were directly correlated for AF simulations. Higher levels of noise resulted in smaller curvatures of the L-curve and the selection of higher values of λ and, thus reducing the amplification of noise when computing ECGI. Real cardiac signals of AF presented similar results in curvature and λ as the higher values of noise explored in simulations (3dB, $\lambda > 10^{-6}$, curvature < 1). Non-fibrillating rhythms presented higher curvatures and lower values of λ.

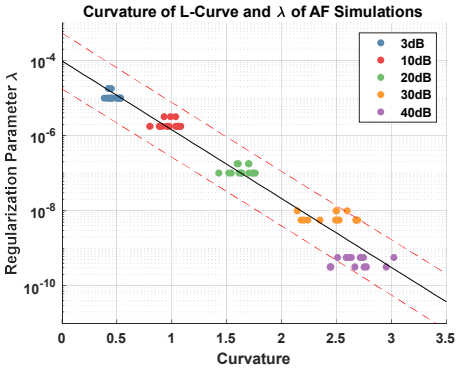

Figure 1. Curvature and regularization parameter λ resultant from the inverse problem calculation of atrial fibrillation simulations with different levels of noise added.

Conclusion. The noise of the signal proportionally affects to the reconstruction of ECGI. The given results show a methodology to obtain trustable solutions of ECGI maps based on the shape of the L-curve optimization.