Improved Performance of Data-Adaptive Regression Framework Based on Multivariate Adaptive Regression Splines for Electrocardiographic Imaging

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Aims: Noninvasive electrocardiographic imaging (ECGI) is used to map cardiac electrical activity from body surface ECG. This study aims to optimize how we used in-vivo experimental data for training and improve a nonparametric regression framework based on multivariate adaptive regression splines (MARS), for ECGI.

Method: A regression model was trained with body surface potentials (184 electrodes) and corresponding electrograms (239 unipolar electrodes) recorded from four anesthetized closed-chest pigs during pacing from various sites (n=5 to 21 depending on the animal). A comparative analysis of four different training set compositions was performed on the MARS-based method using: i) one beat, ii) five beats, iii) all available beats and iv) a signal-averaged beat. The results were compared with the standard ECGI Tikhonov regularisation method. The performances of these methods were measured using two indicators: i) the Relative Error (RE), ii) the Correlation Coefficient (CC) between the estimated and true EGM and Activation Time (AT).

Results: The CC of EGM reconstructed with the MARS-based method increased with an increasing number of training beats (CC of 0.64±0.19, 0.69±0.20, 0.70±0.19 for 1, 5 and all beats respectively), as does the computation time (130±20, 629±107, 3370±622s). This was also seen with accuracy of AT (CC of 0.53±0.19, 0.57±0.19, 0.60±0.18). Using a single-averaged beat was as accurate as using all beats (CC=0.71±0.20 for EGMs and 0.59±0.16 for ATs), and more accurate than Tikhonov (CC=0.56±0.08; $p \leq 0.0001$ and 0.63±0.15) while keeping computation low (401 ± 30s), seven-fold lower than training with all beats.

Conclusion: The MARS-based method had better fidelity to the original EGMs compared to Tikhonov regularization when the amount of training data available was sufficient, both in number of beats and number of different stimulus sites. Signal averaging for model training drastically reduced computing time without significantly affecting performance.