Improving Localizing Cardiac Geometry Using ECGI

Jake A Bergquist, Jaume Coll-Font, Brian Zenger, Lindsay C Rupp, Wilson W Good, Dana H Brooks, Rob S MacLeod

Introduction: Electrocardiographic Imaging (ECGI) is a promising tool for noninvasive diagnosis of cardiac dysfunction using body surface potentials (BSPs). ECGI requires a model of the torso, and one source of error is inaccuracy in the position of the heart within the torso, for example from respiratory movement. In previous work we presented a method to localize the heart from BSPs when the heart surface potentials are known. The goal of this study is to extend this approach to ECGI, when the heart potentials are not known.

Methods: We parameterize the position of the heart with 6 degrees of freedom. We assume that consecutive heartbeats have the same cardiac source and the primary source of ECGI error is cardiac geometry localization. We use an iterative coordinate descent optimization. In each iteration, a single inverse solution is computed with current per-beat estimates of cardiac location using BSPs from multiple beats. This solution is then used to estimate new cardiac positions for each beat by minimizing forward solution error. The method was tested using data synthesized using measurements from a torso tank phantom with a suspended canine heart. We simulated moving the heart to 100 different locations within a 40 x 40 x 90 mm bounding box and computing torso surface measurements at each location and adding noise. Improvement was evaluated in terms of both localization and ECGI accuracy.

Results: Figure 1 shows the reconstructed (red) vs ground truth (black) parameters for all 100 beats. The mean per-electrode localization error was 8.4±0.2 mm. ECGI accuracy increased using the corrected geometry. Spatial and temporal correlation increased from 53±27% to 94±0.08%, and 52±27% to 94±0.7% respectively, and RMSE decreased from 1.1 ±0.6 mV to 0.33 ± 0.0087 mV.

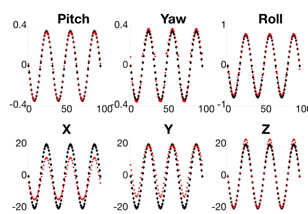

Figure 1. Ground truth (black diamonds) and reconstructed (red dots) cardiac position parameters for each parameterized degree of freedom/ Pitch, yaws, and roll are defined (in radians) around a septal axis, x, y, and z are in mm's.

Discussion: Our geometric correction method dramatically improved ECGI accuracy by reducing cardiac geometry localization error. Future studies will extend to more realistic animal models and then human subjects Success could impact clinical ECGI by reducing errors from respiratory movement and perhaps dramatically reduce imaging requirements and thus both cost and difficulty of use, widening clinical applicability.