An Adaptive Laplacian Based Interpolation Algorithm for Noise Reduction in Body Surface Potential Maps

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Body surface potential maps (BSPMs) are typically recorded from a large number of ECG leads that cover the entire thorax. This increased spatial sampling has been shown to improve diagnostic accuracy and is required in Electrocardiographic imaging (ECGi). One the challenges of BSPM recording is the management of the large number of recording leads/electrodes during the acquisition process. And, often BSPMs recorded in the clinical setting may have a number of leads that are noisy due to poor skin electrode contact.

Several methods have been proposed that can be used in the denoising of BSPMs. These include the use of the Karhunen-Loeve transform and various interpolation based methods. In this study we report on an algorithm that detects and adaptively interpolates contaminated BSPM leads using the Laplacian method to allow accurate reconstruction of BSPM potential distributions.

We analyzed 117 lead BSPMs recorded from 360 subjects. The dataset was made up of one third normal, one third MI and one third LVH. We successively simulated the removal of ECG leads at various locations and tested the ability of our algorithm to accurately reconstruct the missing information. Performance was measured by comparing the actual BSPM distributions with those where missing leads had been reconstructed using the algorithm. Comparisons were expressed as RMS error (RMSE) and correlation coefficient (CC).

When just one electrode was removed the algorithm could reconstruct BSPM patterns of QRS segment with median RMSE of between 0.30-7.71 μV and CC of between 0.998-1.000. Of all the scenarios tested the algorithm performed worst when 4 electrodes in close proximity were removed in the posterior inferior region. In this scenario the observed RMSE was 11.84 μV and CC was 0.993.

This work shows that noisy BSPM leads, which often manifest in the clinical setting, can be accurately reconstructed using our Laplacian based interpolation algorithm.