Model Based Relevance of Measuring Electrodes for the Inverse Solution with a Single Dipole

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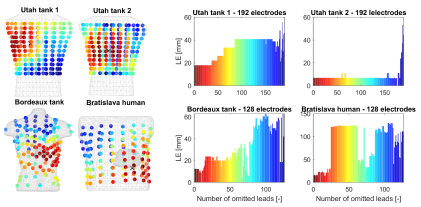
The importance of electrodes positioning for body surface potential mapping (BSPM) is usually evaluated in terms of the signal power or signal-to-noise ratio. In this study, the effect of the electrodes is investigated with respect to the heart-torso model. The worst-case scenario when the information from the most relevant electrodes is missing in computing the inverse solution with a single dipole was explored.

BSPM data from three torso-tank ventricular pacing experiments (Utah1, Utah2, Bordeaux) and measurement on a human (Bratislava) obtained via the EDGAR database were used for the identification of the stimulation position using the inverse solution with a single dipole. The boundary element method was used to compute the transfer matrices for homogeneous volume conductor. The relevance of electrodes was determined by the singular value decomposition of transfer matrices for the given position of the stimulation electrode. First, the inverse solution was computed using all electrodes, then electrodes were gradually removed from the BSPM according to their relevance. The sensitivity of the inverse method was assessed through the localization error (LE) calculated as the Euclidean distance between the known stimulation and the reconstructed pacing site.

For Utah1, LE started to increase from 18.0mm after removing 36 significant electrodes and continued to increase with further electrode removal up to 55.7mm. In Utah2 experiment, we observed robustness to electrode removal. LE increased only when 92% of electrodes were removed. For Bordeaux tank, LE increased after removing 12 electrodes from 12.5mm gradually increasing to 62.9mm. For human data, LE increased from 16.0mm after the removal of just 6 electrodes and worsened rapidly after removing 24 electrodes to 121.2mm.

The observed differences in LE sensitivities to electrode removal can be most likely attributed to different positions of pacing site in the experiments and complex torso model in human data.



Left: Relevance of electrodes on the torso (the most/least, red/blue), Right: LE in dependence of the number of omitted electrodes.