Multiobjective Optimization Approach to Localization of Ectopic Beats by Single Dipole

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One of the possible methods for localization of the origin of an undesired ventricular activation from body surface potential maps (BSPMs) is the inverse solution using a single dipole representing the early activated myocardial volume. Up to date the criterion for the ñoptimalò solution has been the minimal value of the relative residual error (RRE) between the measured BSPM and the map computed by the estimated dipole. The method was presented/verified mainly on simulated data or on individual/separate ECG cycles from measurements.

In this study, the BSPMs measurements lasting several minutes were performed on patients with premature ventricular contractions (PVCs). The measured signal was segmented into ECG beats that were further clustered according to their morphology. A prototypical beat was computed for each cluster. Other properties of the clusters were also determined, such as cluster cardinalities, within cluster signal distribution and cluster-based correlations between signals in different leads on the torso at a given time instant.

From such information a reliability score (RS) for the single dipole localization can be derived from the posterior distribution over dipole moments, given the BSPM. We suggest to determine the ñoptimalò inverse solution (dipole) in the multi-objective optimization setting through simultaneous optimization of both the RRE and reliability scores.

The method was applied on BSPMs measured on patient with cardiostimulator during 5 minutes of imposed pacing, 498 beats together (Figure left). The torso model and the position of stimulating electrode were obtained from CT scan. The balance between the optimized scores was determined as the knee-point on the Pareto front calculated from the first 20ms of ventricular activation (Figure right). The inclusion of the reliability score led to improvement of the localization error from 16mm (RRE only) to 11mm (RRE+RS) and from 13mm to 9mm for homogeneous and inhomogeneous torso, respectively.