

Assessment of Number of Lesions from Integral Body Surface Potential Maps

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Aim

- Identification of the number of ischemic lesions based on exploitation of morphological and statistical properties of difference integral body surface potential maps.

Purpose

- Patients with ischemic heart disease and atherosclerosis may suffer from one or more simultaneously occluded coronary arteries.
- Information about the number of lesions is desired in order to improve treatment decisions.

Relevance

- In our previous work [1] the method for recognition of the cases with two or one lesions from features derived from inverse solutions was suggested, however the approach has appeared to be too complicated for use in clinical praxis.
- New procedure avoids rather demanding step of computing inverse solution and extracts characteristics for discrimination analysis directly from modelled DI BSPMs.

Methods and analysis

- One or two lesions in different positions in the ventricular myocardium were modelled and corresponding BSPMs (body surface potential maps) were calculated on the surface of an inhomogeneous torso model using the multiple dipole cardiac generator [2]. Twelve combinations of two ischemic lesions were adopted, each with eight variations in size and shape. Together 96 pairs and 48 single lesions were modelled. BSPMs were computed using boundary element method.
- DI (difference integral) BSPMs from STT interval [3] were computed by subtracting the normal integral BSPM from an integral BSPM computed from the heart with one or two modelled lesions.
- Scalar and vector field operations were applied to normalized potential maps: gradient (difference of neighbouring map values), divergence (subsequently from gradient field), and laplacian (representing second derivative).
- Map projections in vertical and horizontal direction were processed in a form of mean values obtained from columns and rows.
- Statistical properties of the maps and their projections: number of peaks (local extremes), minimum, maximum, mean, standard deviation, and central moments (extension of standard deviation into higher orders).
- Distribution properties of map values were extracted from histogram shape and represented by a histogram based entropy and a length of histogram envelope.
- Mutual combinations of maps, projections, and statistical properties resulted in 112 different features.
- Two classes corresponding to one and two lesions were used in quadratic variant of Fisher discriminant analysis [4]. Cross-validation technique was applied in a form of repeated random sub-sampling validation. In 1000 trials 80% of available data was randomly chosen for training and remaining 20% for validation. A feature selection was applied in order to reduce the data dimensionality and to simplify the data evaluation. Greedy forward selection algorithm was used by adding the best feature at each round [5].

Results

- Single best performing feature was *gradStdev* (standard deviation from gradient field map) with 25.2 % overall error rate.
- Combination with the second feature *projCurveA* (length of curves created by vertical and horizontal projections - Fig.1) yielded error rate of 17.9 % (Fig.2 left).
- The best performance in 12 dimensions (Fig.2 right) with the overall error rate 4.1 % and partial errors 9.6 % and 1.2 % for misclassification of single and double lesions.

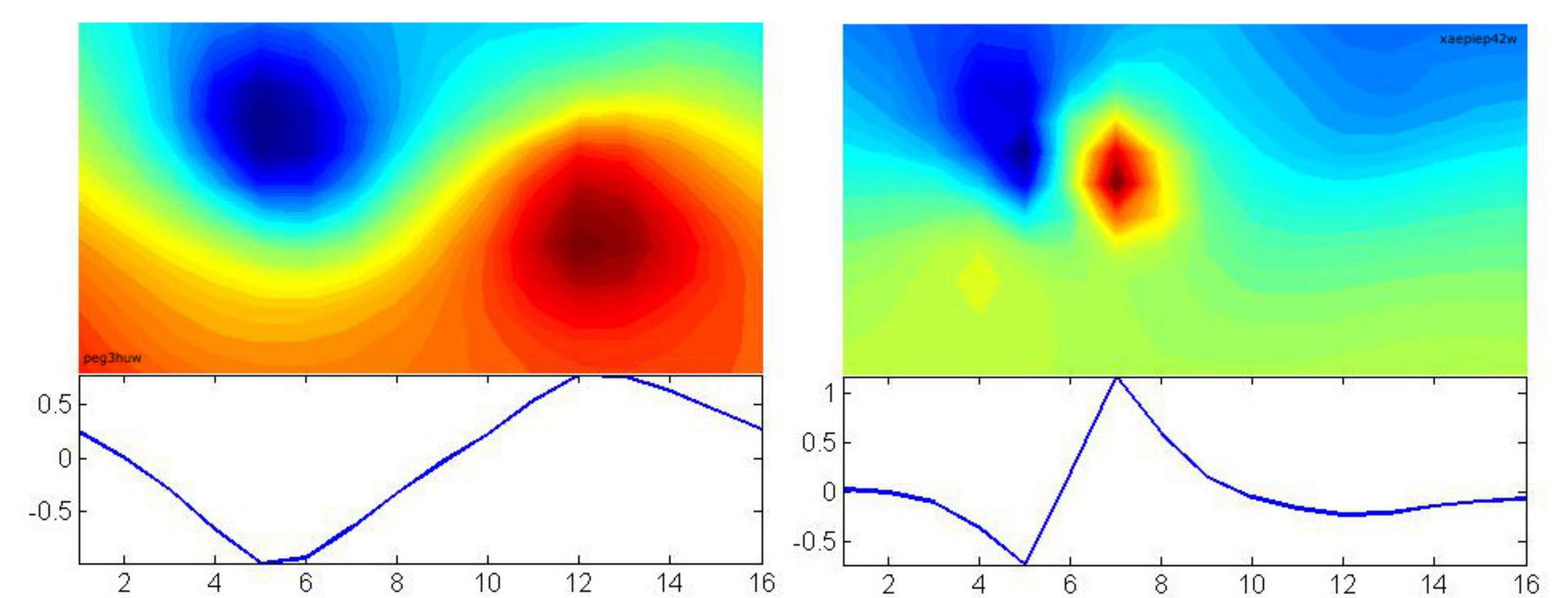


Fig.1: Typical sample of single (left) and double (right) lesion normalized DI BSPM together with their vertical projections (mean values from columns). Double lesions might have higher number of local extremes in both maps (here 3 vs. 2) and projections (here again 3 vs. 2), higher mean gradient and mean laplacian in maps, and higher length of curves created by projection either in horizontal or vertical direction.

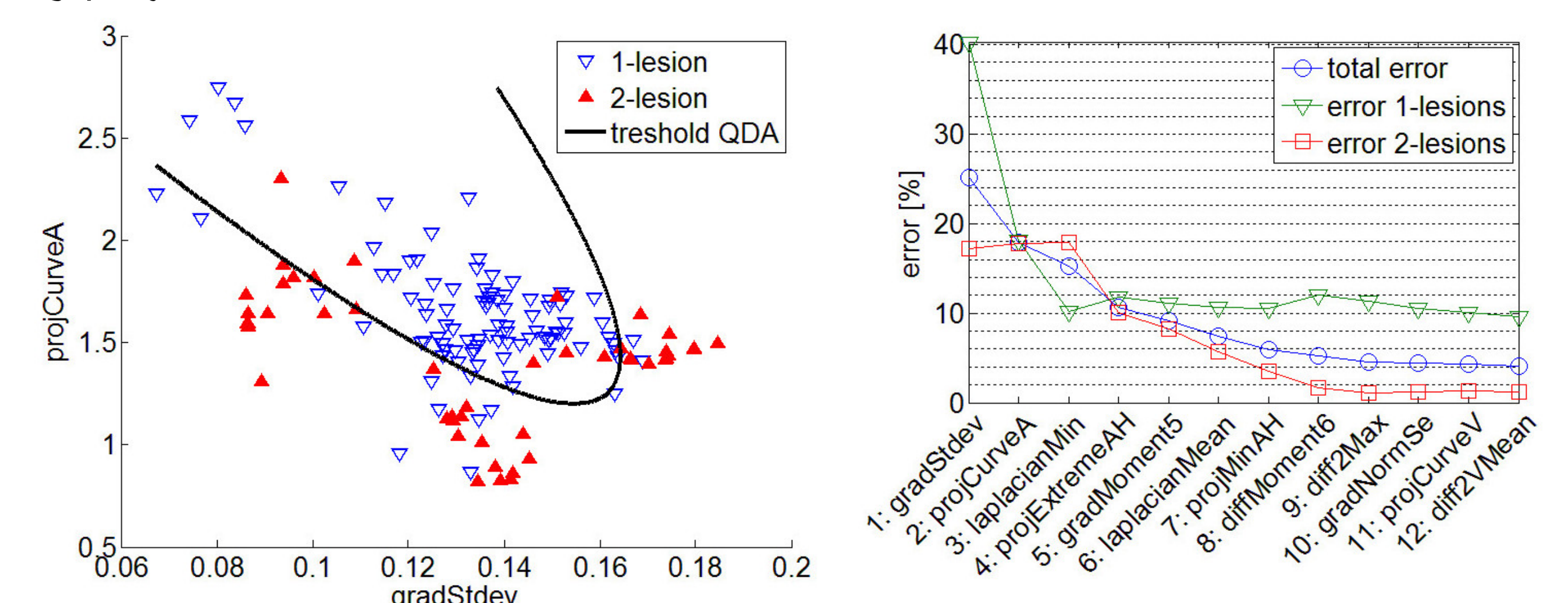


Fig.2: Quadratic discriminant analyses. Left: Two best performing features in 2 dimension feature space with overall error 17.9 %. Right: Performance of the most effective set of features according to the number of features used.

Conclusions

- Newly proposed method overperformed our previous more complicated inverse solution approach [3]: While for a set of 7 features both approaches obtained the same error rate of 5.9 %, here accuracy further increased and achieved 4.1 % error for 12 selected features.
- For our future analysis we intent to apply different types of noise, namely noise derived from electrode position uncertainties and from dipole moments that represent the lesions.
- Discriminant analysis based on exploitation of morphological and statistical properties of integral BSPMs may be helpful in successful identification of the number of ischemic lesions.

References:

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