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Comparing D-bar and Regularization-based reconstruction

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Abstract: EIT reconstruction algorithms based on D-bar methods offer various advantages. One limitation to wider use of these algorithms has been a lack of comparisons of algorithm performance on reconstruction metrics. We show some initial results comparing D-bar and regularization-based reconstructions for phantom data.

1 Introduction

Reconstruction of EIT images is a challenging non-linear problem which needs to overcome the poor sensitivity to changes at depth. Over the years, many EIT reconstruction algorithms have been proposed for 2D and 3D geometries, and for difference and absolute reconstructions.

One relatively novel approach to image reconstruction is D-bar, a non-iterative absolute approach [2]. The D-bar literature is rich, but there is little direct comparison of performance to traditional (iterative, regularized) approaches. Comparison of algorithms is challenging, because there are multiple comparison criteria: resolution, ability to suppress noise, ability to maintain sharp edges, resistance to electrode movement and other artefacts.

Our goal is to present initial results comparing D-bar with two popular regularized algorithms, iterative Gauss-Newton (with a smoothing prior) and GREIT [1], all for reconstruction of difference images with small contrasts.

2 Results and Discussion

Two simulation phantoms were used, shown in fig. 1. One is a shape – “Pac-Man” – with sharp edges and holes, while the other moves a small target from centre to the side. Small (0.1× background) contrasts were used. All algorithms were set to calculate difference 32×32 pixel EIT images assuming a circular 2D body with 32 equally spaced electrodes of the indicated width. Stimulation patterns were “skip 4” with monopolar voltage measurements on all electrodes (including driven ones).

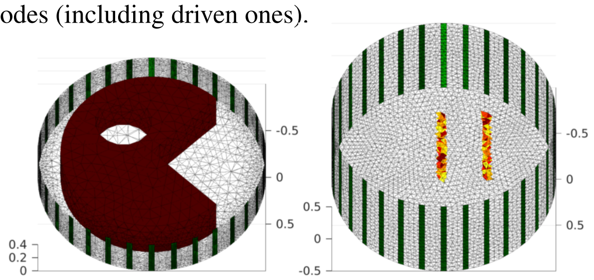

Figure 1: Phantoms: “Pac-Man” shape, and point targets

Most algorithms have parameters to control the trade-off between resolution and noise performance. D-bar uses a radius (r), GN uses a hyperparameter (λ) and GREIT uses a noise figure (NF). We wanted to first select parameters which for which the noise performance is equal, and then subsequently evaluate other characteristics. Fig. 2 reconstructs the phantom with added Gaussian noise for comparison of parmeter settings. We observe that D-bar shows a different pattern (lower spatial frequency) for the reconstructed noise compared GN and GREIT.

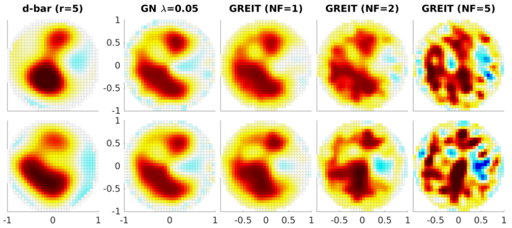

Figure 2: Reconstructions of data with added Gaussian noise (noise sample per row) for algorithms and parameter settings.

Next, we analysed the “point spread function” versus radial position (fig. 3). D-bar has more uniform resolution, compared to improving resolution near the boundary.

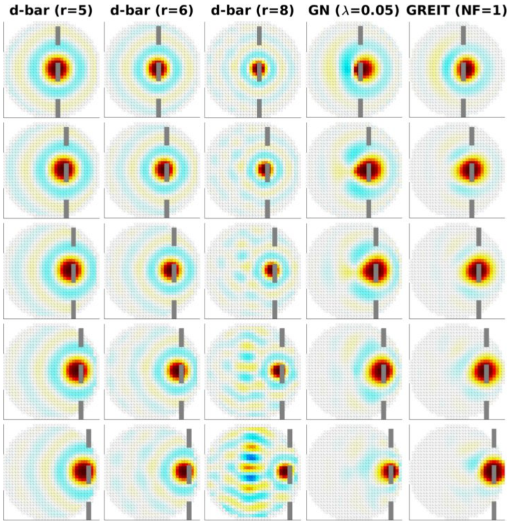

Figure 3: Reconstructions of points (at grey dotted line)

Last, we explore the ability to reconstruct difference images where electrodes move between measurements. Here the right centre electrode moves by the indicated amount (in degrees). Results show D-bar is least affected.

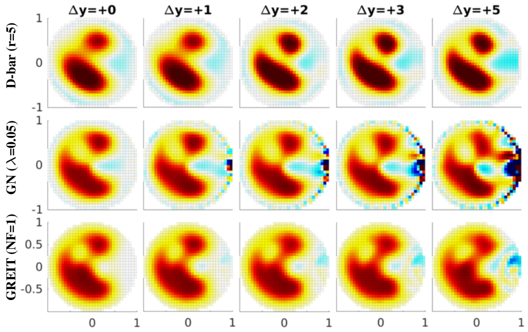

Figure 4: Reconstructions of moving electrode near “mouth”

Our results show that D-bar: 1) has position invariant point-spread function, 2) projects noise into images very differently, and 3) appears much less sensitive to electrode position errors than regularized reconstructions. There is clearly plenty of work needed to understand these effects.

References

[1] A Adler *et al*, *Physiol Meas*, 30:S35–S55, 2009
[2] Isaacson *et al.*, *IEEE TMI*, 23:7, 821-828 2004.