Separation of 3D EIT electrode planes

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Abstract: Using multiple planes of electrodes, EIT can reconstruct three-dimensional images. For thoracic imaging, such a configuration appears to offer useful advantages, such as better slice specificity and reduced off-plane sensitivity. We describe a simulation study to determine recommendations for separation of the electrode planes.

1 Introduction

Most thoracic EIT studies have used a single plane of electrodes to reconstruct 2D images, which are sensitive to conductivity changes above and below the plane. Using two planes, it is possible to better control the vertical sensitivity of EIT [2], even if the goal is to reconstruct a better 2D slice [1]. Practically, however, it is important to have specific recommended configurations for two-plane EIT. Here we seek to understand the influence of the separation distance (s) between the electrode planes.

2 Methods and Results

Fig. 1 shows the configuration. The body is an elliptical cylinder with minor diameter 1.0. Small sagittal-plane contrasts simulated at height h above the centre of the planes.

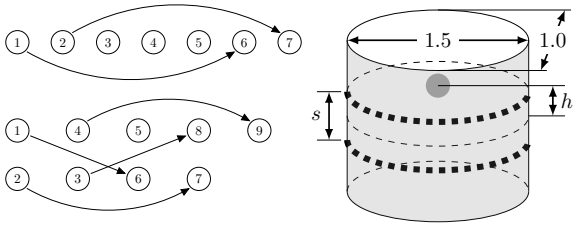

Figure 1: *Left:* One- and two-plane electrode configuration using the *square* pattern and *skip*=4; *Right:* Simulation geometry with electrode planes separated by s and a target h above the centre.

Reconstructions are shown for a single target position (fig. 2) for values of s, *skip* and Noise Figure (NF).

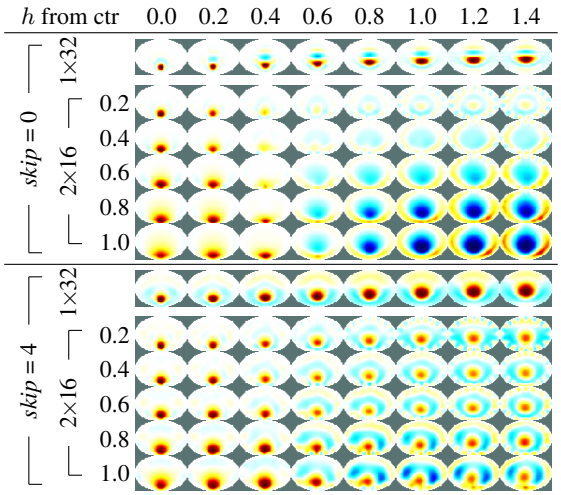

Figure 2: Reconstructed centre-slice images for an off-centre target moving vertically away from the centre plane, for NF=1 and the indicated plane separation. Image amplitude is normalized to the 1×32 reconstruction at each h.

For 1×32 there is a severe position error with increasing h; targets above the plane are "pushed" to the centre. 2×16 shows less position error, but produces artefacts, especially for *skip*=0. For $s > 0.4$ resolution gets significantly worse.

To quantify the off-plane contribution, fig. 3 shows the normalized amplitude response for various algorithm parameters. We note that 1×32 shows poor off-plane sensitivity. There is a compromise between slice uniformity and slice thickness, which is worse at lower NF.

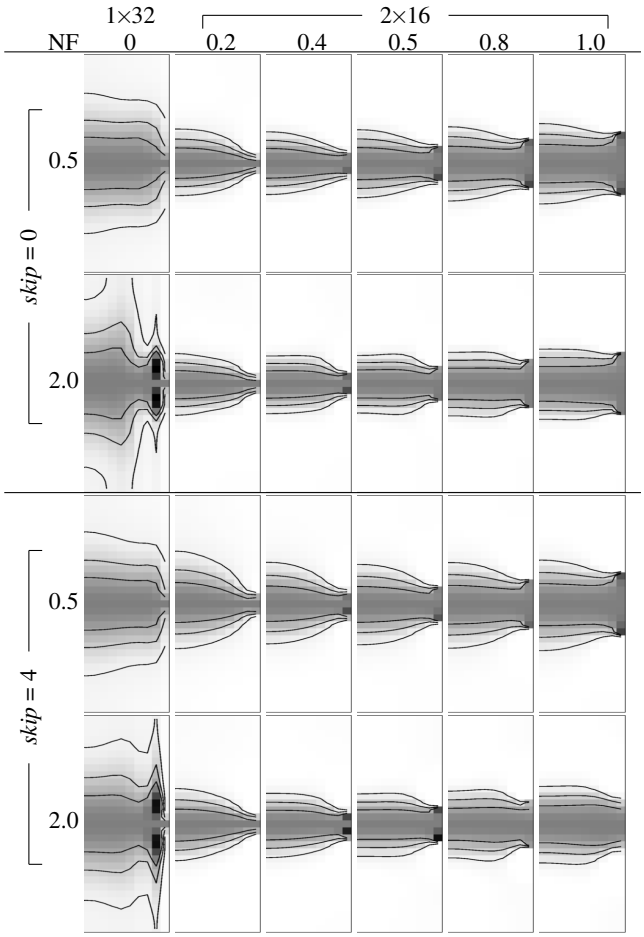

Figure 3: Normalized amplitude response (sum of in-plane image pixels divided by the value on the centre slice) for targets in the central sagittal plane. Each image has horizontal axis from centre to minor-axis side and vertical axis from $h = -1.5$ to 1.5. Contours at 75%, 50% and 25% and only positive values shown.

3 Discussion

For thoracic EIT with two electrode planes, we study the choice of plane separation, s as a function of minimum thoracic diameter. We recommend a value between $s = 0.4$ and 0.6 (about 10 cm, adult) as the best compromise between off-plane rejection, thin imaging slice, in-plane resolution, and rejection of off-plane contrasts.

References

[1] B Grychtol *et al*, Conf EIT 2017, Dartmouth, USA, p.7, 2017.
[2] B Grychtol, B Müller, A Adler *Physiol Meas* 37:785–800, 2016.