An Approach to Extend GREIT Image Reconstruction to 3D

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Abstract: This paper presents a new image reconstruction technique for 3D EIT based on the extension of the 2D GREIT method. Key aspects include the expansion of optimization targets and set of desired images to cover multiple planes. Results show the reduction off-plane interference seen in 2D reconstruction. The selection of target planes is also found to be highly significant to the image.

1 Introduction

There is strong potential in the use of 3D imaging in Electrical Impedance Tomography (EIT) applications, [1,2] despite challenges with accuracy, evaluation, and processing requirements. This paper presents a new method for 3D EIT image reconstruction. The method is compared with the 2D GREIT method to analyze the influence of off-plane targets.

2 Methodology

2.1 GREIT Method

The 3D reconstruction approach is an extension of the 2D GREIT method, which is described in [3]. The 2D method consists of a forward model, a noise model, and a set of desired performance metrics. A training set of conductivity target images is created based on the performance metrics. The reconstruction matrix R is then calculated as follows:

$$R = DY^{-1}(YY^{-1} + \Sigma_n)^{-1} \tag{1}$$

where D is a point spread function based on the desired target features, Y is the set of simulated target measurements, and Σ_n is the noise covariance term.

In order to extend this algorithm to 3D, a three dimensional set of targets is created. A set of target planes must be selected according to the region of interest, as well as speed and memory concerns.

The calculation of matrix D is expanded to cover the n target planes, giving diagonal matrix $D_{n,n}$. A matrix $D_{i,i}$ is solved for each target plane i based on the desired performance metrics. This approach assumes that the target radius is smaller than the target plane separation.

2.2 Simulation

The proposed 3D GREIT method is compared to the 2D GREIT method to examine the effects of off-plane targets on image quality. The forward model is built using a cylindrical finite element model (FEM) using 35 089 elements. The 2D model includes one ring of 16 circular electrodes and the 3D model uses 2 rings of 16 electrodes. Measurements are simulated using the adjacent pattern. The 2D method solves each plane individually while the 3D method uses a single reconstruction matrix.

3 Results and Discussion

The reconstructed images, overlaid onto the FEM model, are shown in Fig. 1. The 2D GREIT image shows strong off-plane influence. For each slice, the image extends towards the off-plane sphere, resulting in a wide column. The 3D GREIT image is better constrained to the object regions for both the on- and off-plane objects.

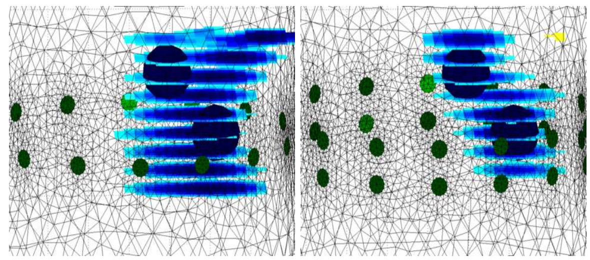

Figure 1: Reconstructed images using 2D GREIT method `left` and 3D GREIT method `right` for one on-plane sphere and one off-plane sphere. Images generated using `EIDORS`.

The 3D GREIT method provides better resolution and lower position error, as illustrated in Fig. 2. This suggests that the 3D method has improved immunity to off-plane effects while also providing useful information concerning regions outside the electrode planes.

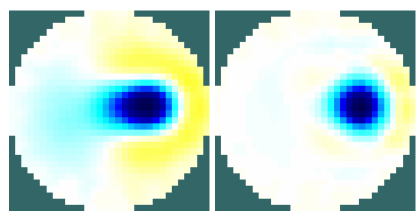

Figure 2: Centre image slice from 2D GREIT method `left` and 3D GREIT method `right`. Images generated using `EIDORS`.

Although 2D GREIT allows the specification of the position of the desired image plane, since a single image must explain all the data, it necessarily conflates the two targets. By simultaneously reconstructing images at multiple planes, 3D GREIT allows to distinguish changes occurring at different levels, resulting in reduced off-plane influence. Consequently, the selection of the target planes has high significance in the 3D GREIT method.

4 Conclusions

The 3D GREIT method proposed in this paper has been demonstrated against the 2D GREIT method. Results indicate that the 3D GREIT method reduces off-plane effects and allows for the imaging of off-plane objects, while improving resolution and position error. In addition, the selection of target planes will have a significant impact on the image.

References

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