Using real data to train GREIT improves image quality

Pascal Gaggero[1], Andy Adler[2] and Bartłomiej Grychtol[3]

[1]Bern University of Applied Sciences, Bienne, Switzerland
[2]Carleton University, Ottawa, Canada
[3]German Cancer Research Center, Heidelberg, Germany

Abstract: Image reconstruction in electrical impedance tomography is sensitive to errors in the (forward) model of the measurement system. We propose a new approach, based on the GREIT algorithm, where the reconstruction matrix is trained on real rather than simulated data, obviating the need for an accurate numerical forward model. We observe a substantial improvement in image quality, particularly for changes close to the boundary.

1 Introduction

Traditional approaches to image reconstruction in electrical impedance tomography (EIT) require knowledge of the geometry of the studied domain and characteristics of the measurement system. However, accurate hardware modelling, including all of its imperfections and the interface between the electrodes and the studied domain, is a very difficult task. We present an approach that bypasses the need for an accurate model of the hardware by using real measurement data to calculate a reconstruction matrix based on the GREIT approach [1]. The motivation of the present work is to customize the reconstruction method for a particular configuration of a particular EIT system to improve the accuracy of the reconstructed images.

2 Methods

GREIT is a linear reconstruction algorithm for difference EIT, where the reconstruction matrix is calculated based on a data set of sample measurements from small single-target perturbations and the corresponding desired images [1]. To date, this training data set was generated using numerical simulations. Here, we use a recently developed robotic testing platform for EIT systems [3] to create the training perturbations and record the corresponding measurements in a saline tank. We compare reconstructions of a testing data set (recorded by the same system) obtained with GREIT trained on real data with that trained on equivalent simulated data.

Measurements were acquired on a saline tank (∅ 290 mm, σ=1.6 S/m) with the Pioneer Set (Swisstom, Landquart, Switzerland) with its 32 active electrodes [2] in a single ring around the tank and default settings. Training data were acquired by placing a non-conductive POM ball (∅ 25 mm) in 770 different positions in the plane of the electrodes. Equivalent simulated data were obtained with the `mk_GREIT_model` function in EIDORS using a best-effort FEM model of the tank. Testing data were acquired in 250 positions with a ∅ 45 mm ball.

To compare the reconstructions obtained with GREIT trained on measurements (GREITm) and simulations (GREITs), we used figures of merit adopted from [1]: position error (PE), deformation (DEF), amplitude response (AR) and ringing (RNG).

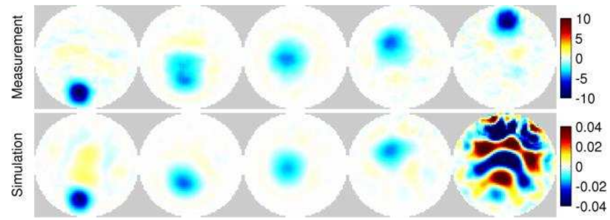

Figure 1: Sample reconstructions with GREIT trained on measurements (top) and simulations (bottom).

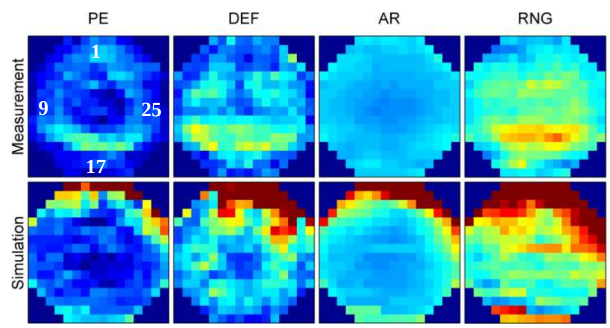

Figure 2: Figure of merit maps. The color scale for both images in a single column is fixed; very high values (red) are cropped.

3 Results

Sample reconstructions of the test data with GREITm and GREITs are presented in Fig. 1. Neither algorithm reconstructs the correct value of the conductivity contrast (about -1.6 S/m). For most target positions, the algorithms show comparable performance. However, for targets in the region delimited by electrodes 5 and 25 (top part of the image), GREITs shows much worse performance. This is reflected in the figure of merit maps (Fig. 2), where GREITs shows deterioration in that region. GREITm is characterised by a more uniform amplitude response and less ringing.

4 Conclusions

Our results support the notion that real measurement data can successfully replace the forward used to calculate the GREIT reconstruction matrix. We interpret the non-uniform performance of GREITs as resulting from hardware setup imperfections, since greatest deterioration was observed for target locations near the end of the electrode belt (electrodes 25 to 32) or where measurement and current stimulation are performed across the belt's ends (electrodes 5 to 25). Future work will address the extent to which tank measurements are helpful in training a GREIT reconstruction matrix for human thorax imaging.

References

[1] A. Adler et al., Phys Meas **30**, S35-S55, 2009
[2] P. O. Gaggero et al., Phys Meas **33**:831-847, 2012
[3] P. O. Gaggero et al. In XIVth Int Conf EIT. 2013