EIT Electrode Quality Assessment and Data Rejection

Mark Campbell[1] and Andy Adler[1]

[1]Department of Systems and Computer Engineering, Carleton University, Ottawa, Canada, markacampbell@sce.carleton.ca

Abstract: EIT images are often impaired by low-quality data due to poor electrode connections. We present an electrode quality assessment and data rejection (EQADR) algorithm to allow automatic detection and removal of the contribution of noisy measurements based on user-specified parameters.

1 Introduction

Sophisticated methods for removing the contribution of noisy measurements to the image reconstruction matrix have been developed [1] and optimized [2], which are effective at artifact removal. However, identifying which electrodes or measurements need to be removed remains a manual and time-consuming process. This paper presents an automated approach for electrode quality assessment, followed by the data rejection method developed by Adler and Mamatjan. This algorithm is designed to be used with data acquired by Sentec EIT systems.

Measurement quality is judged using the in-phase (I) and quadrature (Q) components of the EIT voltage measurements. A measurement is deemed erroneous if it exceeds the measuring capacity of the EIT hardware (falling on the boundary of the IQ plot), or if it has a negative I component (figure 1). Each electrode and measurement pair is given a score based on the proportion of total measurements that were erroneous, ranging from 0 - 1. The reciprocity of EIT measurements can lead to a single faulty electrode causing the other two electrodes with which it pairs (its "partners") to also appear faulty. The contribution of electrode reciprocity to the scores is resolved to yield the final data quality scores by the method shown in this pseudocode:

```
for each of the i electrodes:
    find the electrodes p1 and p2 that pair with electrode i.
    for each of the pi partners of i:
        find the partner pip of pi that is not i.
        if the score of i >= to the combined scores of pi and pip,
            pi is not noisy. Set the score of pi to that of pip.
```

The user may specify whether rejection is performed on a per-electrode or per-measurement basis, what the maximum acceptable number of rejected electrodes or measurement is, and the maximum acceptable score an accepted electrode or measurement may have. Rejection starts with the worst measurement or electrode, then proceeds until no more data groupings are higher than threshold, or until the maximum number of rejections occurs. The threshold parameter allows the user to tune the true positive and false positive rates for data rejection. The EQADR source code ia available here: sf.net/p/eidors3d/code/HEAD/tree/trunk/dev/eqadr.

2 Methods

3D EIT data was collected from a human subject with 2 rings of 16 electrodes separated by 6 cm with a skip-4 measurement and stimulation pattern. Tidal images were reconstructed with EIDORS[3] using the GREIT algorithm[4] for the plane at 3 cm with and without EQADR, and a noise factor of 2. EQADR was set to the electrode rejection mode, with a maximum number of 6 rejected electrodes, and a rejection score of 0.2 or higher.

3 Results and Discussion

EQADR identified and rejected 5 electrodes, whose measurements are shown by the red markers in figure 1.

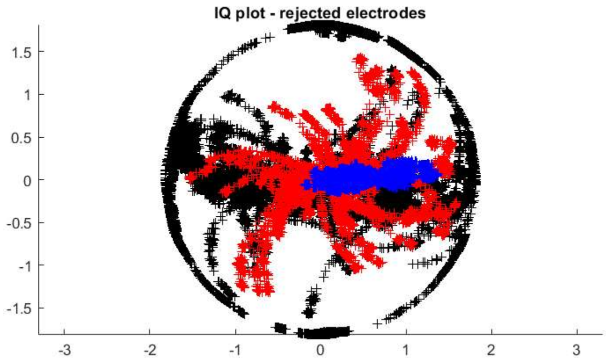

Figure 1: IQ plot of EIT measurements for the sample recording. All data was plotted in black. Noisy measurements identified by EQADR was plotted in red. Measurements from electrodes more than 2 positions away from the simulating electrodes were then plotted in blue.

The reconstructed images in figure 2 show that EQADR was effetive at reducing the appearance of artifacts in the center and boundary of the image and produced lung boundaries that were more defined than without compensation.

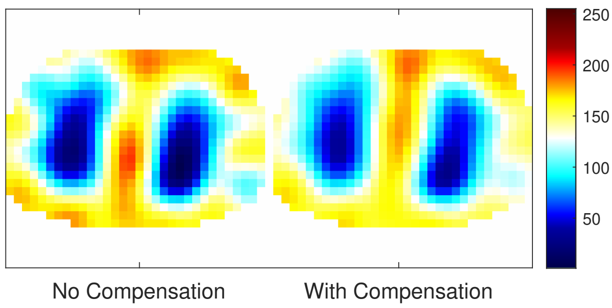

Figure 2: Reconstructed images without EQADR (left) and with EQADR (right)

References

[1] A Adler *Physiol Meas*, 25:227–238, 2004

[2] Y Mamatjan, P Gaggero, B Müller, B Grychtol, A Adler *Conf 36th CMBES*, 2013

[3] A Adler, WRB Lionheart *Physiol Meas*, 27:S25–S42, 2006

[4] B Grychtol, B Müller, A Adler *Physiol Meas*, 37:785–800, 2016