Title	Bi-Frequency Symmetry Difference (BFSD) EIT in stroke diagnosis
Author(s)	McDermott, Barry; O'Halloran, Martin; Porter, Emily
Publication Date	2019-07-01
Publication Information	McDermott, Barry, O'Halloran, Martin, & Porter, Emily. (2019). Bi-Frequency Symmetry Difference (BFSD) EIT in stroke diagnosis. Paper presented at the 20th International Conference on Biomedical Applications of Electrical Impedance Tomography London, UK, 01-03 July.
Publisher	EIT2019
Link to publisher's version	https://eit2019.co.uk/eit2019.pdf
Item record	http://hdl.handle.net/10379/15267
DOI	http://dx.doi.org/10.5281/zenodo.2691705

Bi-Frequency Symmetry Difference (BFSD) EIT in Stroke Diagnosis

Barry McDermott[1], Martin O'Halloran[1] and Emily Porter[1]

[1]Translational Medical Device Lab, National University of Ireland, Galway, b.mcdermott3@nuigalway.ie

Abstract: BFSD-EIT can detect deviations in the inherent normal symmetry of the head due to, for example, the presence of a bleed or clot in stroke. We assess the potential of BFSD-EIT to robustly detect lesions under a series of modelling errors and calculate tolerable error levels before lesion detection is confounded.

1 Introduction

Detection of static lesions, such as is the case for an intracranial bleed or clot in stroke, is an ongoing challenge for EIT [1], [2]. We present a novel technique (described in [3]) based on the symmetrical nature of the head across the sagittal plane. The presence of a lesion results in deviations in this symmetry. Identification of these deviations enables detection of the lesion, with subsequent determination of the nature of the lesion achieved using *a priori* knowledge of conductivity (and contrast) changes of tissues between frequency points. In this numerical study, an anatomically accurate 4-layer model was used with or without either a bleed or clot at different locations within the brain. Measurement frames from two symmetrically equal but opposite injection/ measurement protocols (taken at carefully selected frequency points) are differenced to detect deviations in symmetry (if present). The performance is assessed using images and metrics. Next, the model is exposed to a battery of modelling errors with performance assessed at different levels of error. The proposed Global Left Hand Side (LHS) & Right Hand Side (RHS) Mean Intensity (GMI) metric is particularly robust to modelling errors, and can be used to detect, identify and locate lesions as well as describe the effect of errors.

2 Methods

Models were generated with various levels of error assessing the impact of noise, errors in electrode positioning, contact impedance, assumed conductivity of tissues, the assumed anatomy of the head, and a frequency dependent background. The metric used to assess performance was the GMI: The average intensity over all the voxels on each side (LHS & RHS) of the sagittal plane.

The performance of the BFSD-EIT technique and the GMI metric were compared with those of an error-free model. The results are summarised as follows.

∗The SNR of the system used to record measurements should be at or above a rating of 80 dB.

∗Errors in electrode positioning have a severe effect on performance but a high degree of tolerance is seen if symmetry is maintained between symmetric partner electrodes (up to ± 30 mm).

∗Errors in contact impedance of electrodes (up to ± 50% of the assumed impedance) have little or no effect on performance.

∗Errors in the assumed conductivity of the tissue voxels (up to ± 50% of the reference value) have little or no effect on performance.

∗Errors in the assumed anatomy of the head affect performance. Asymmetrical anatomy can mask the presence of lesions. If the tissues have a frequency dependent change in conductivity this challenge may be overcome. Errors in the assumed geometry of the head (i.e. the boundary) with a variance of 10% cause only a slight decrease in performance.

∗A frequency dependent background has the potential to confound disambiguation if frequency points *f* are not carefully chosen. The pattern of contrast change at the selected *f* points between lesion and background must differ for bleed and clot.

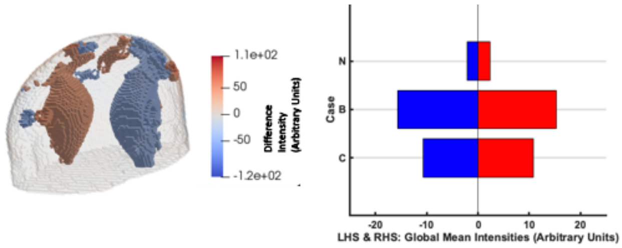

Figure 1: Left: A BFSD-EIT image for a 10 ml LHS bleed. Right: GMI metric results for no lesion (N); 10 ml LHS bleed (B); 50 ml LHS clot (C) (all at 25 Hz).

3 Conclusions

This set of numerical studies point to BFSD-EIT being feasible for use in the stroke diagnosis problem, provided potential error sources are respected and within parameters of tolerance. The technique is potentially applicable to other domains where symmetry may be exploited, stroke representing a particularly challenging problem and perhaps a "hardest case" for the algorithm. Future work is planned where the algorithm will be applied to both phantom and human data, with the hope that strong numerical performance is carried into more realistic scenarios.

4 Acknowledgements

The research leading to these results has received funding from the European Research Council under the European Union's Horizon 2020 Programme/ ERC Grant Agreement BioElecPro n.637780, and from the Hardiman Research Scholarship, NUIG.

References

[1] A Adler, A Boyle, *IEEE Transactions on Biomedical Engineering* 64(11):2494–2504,2017

[2] A Romsauerova, A McEwan, L Horesh, *Physiological Measurement* 27(5):S147-S161,2006

[3] B McDermott, M O'Halloran, E Porter, *Physiological Measurement* 39(4): 044007,2018