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STATIC LESION DETECTION IN SYMMETRIC SCENES USING DUAL-FREQUENCY ELECTRICAL IMPEDANCE TOMOGRAPHY

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INTRODUCTION

Tissues have characteristic frequency dependent impendence to electrical current. This property is exploited by Electrical Impedance Tomography (EIT), an emerging biomedical imaging technique. In EIT, electrical conductivity maps of the interior of a body of interest can be reconstructed from voltage measurements collected from electrodes placed on the boundary in response to a prescribed pattern of injected electrical current. The ill-posed, poorly conditioned nature of the reconstruction problem has resulted in EIT having most success applied to time difference imaging, while simultaneously challenged by static scenes. Stroke is a biomedical imaging problem featuring a static lesion (a bleed or a clot), with effective treatment only possible once the aetiology is known. It is an application where the low-cost, portable, cheap and hazard free nature of EIT could be used to accelerate the patient treatment path and improve outcomes without the delay for CT or equivalent imaging. Here we present a novel algorithm for lesion detection, identification and location in numerical models of stroke using EIT measurements from two symmetrically equivalent electrode arrays, taken at two different frequencies of current stimulation.

MATERIALS AND METHODS

An anatomically realistic 3-layer numerical model of the head is generated with a scalp, skull and brain layer and are assigned conductivities of 0.1 S/m, 0.0069 – 0.0129 S/m and 0.1 S/m respectively. Lesions are modelled as spheres of 10 ml and 50 ml volume and classified as bleed or clot. A total of 32 EIT electrodes are arranged at the boundary as two symmetrically equivalent arrays. Measurements are generated from each array at two frequency points (f_1 and f_2) where the conductivity of the tissues is remains constant for scalp, skull, brain and bleed (0.7 S/m) but changes from 0.08 S/m to 0.02 S/m for clot. At each f point the measurements from the two symmetric arrays are differenced and used to generate an image with associated quantitative metrics applied to the overall image and detected regions of interest (ROIs) which are candidate lesions. The results from a single f point detects a lesion (if present and if not on the sagittal plane) but also detects a confounding anti-lesion (seen as a high intensity and low intensity ROI). Comparison of the results (images and metrics) from both f points allows disambiguation, identification and localisation of the lesion.

RESULTS

The algorithm performs well for lesions that are away from the sagittal plane, larger and with measurements taken with a higher signal-to-noise ratio. A sample set of results from a case of a 50 ml clot positioned on the left side in a rostro-caudal location is shown in Figure 1. The associated metrics are:
(A) Global LHS : RHS Mean Intensity: The average intensity over all voxels on either side of the sagittal plane (ideally equal but opposite).
(B) Difference in Centroid Location: The difference in the centroid locations between the high and low intensity ROIs for a given image (ideally zero).
(C) Intensity per m^3: The intensity value (arbitrary units) of the overall region of interest per unit volume. The value is (+) for an increase in conductivity, (-) for a decrease. Reported for both ROIs. Ideally follows the trend of (A).
In this example the quantitative metrics are given in Table 1. The enhanced contrast between clot and brain at f_2 compared to f_1 identifies the lesion as a clot with larger values for (A), (C) and smaller value for (B) at f_2 compared to f_1.

Table 1: Quantitative Metrics

Metric:	f_1	f_2
A	+382 : -365	+1293 : -1183
B	2.7 mm	1.3 mm
C	+2002 : -1953	+7217 : - 6564

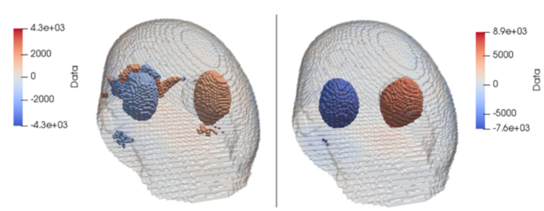

Figure 1 Reconstructed images for a 50 ml clot. Left: The image at f_1. Right: The image at f_2. The enhanced contrast of lesion to brain at f_2 identifies the lesion as a clot, on the left.

DISCUSSION

This novel modality of EIT is shown in simulation to detect, identify and locate static lesions in scenarios where a plane of symmetry is present. It has exciting potential for important applications such as stroke.

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