Effects of modelling layers and realistic geometry in reconstruction algorithms for EIT of brain function

Adam D. Liston†, Andrew P. Bagshaw‡, Richard H. Bayford†, Andrew Tizzard†, A. Thomas Tidswell§, Hamid Dehghani# and David S. Holder§

†School of Health and Social Sciences, Middlesex University, London.
‡Montreal Neurological Insititute, Montreal, Canada.
§Department of Clinical Neurophysiology, University College Hospital, London, UK
Thayer School of Engineering, Dartmouth College, Hanover, USA

Electrical impedance tomography of brain function has the potential to provide a rapid portable bedside neuroimaging device. Recently, our group published the first ever EIT images of evoked activity recorded with scalp electrodes. While the raw data showed encouraging reproducible changes of a few per cent, the images were noisy. The poor image quality was due in part to the use of a simplified reconstruction algorithm which modelled the head as a homogeneous sphere. The purpose of this work has been to develop new algorithms in which the model incorporates extracerebral layers and realistic geometry, and to assess their effect on image quality.

We considered algorithms incorporating four different forward models of the head: two analytical models i) a homogeneous sphere and ii) concentric spheres in which the brain, skull and scalp were modelled analytically and two numerical (FEM) models iii) a homogeneous, head-shaped volume and iv) a head-shaped volume with internal compartments of contrasting resistivity.

The two analytical sphere algorithms were tested on a) a computer-simulation using the four, concentric spheres model; b) a spherical, electrolyte-filled tank containing a concentric Plaster of Paris shell to mimic the skull. Mean localisation errors for 38 simulated perturbations were 5.82.1mm and 15.96.3mm respectively for four-shell and homogeneous reconstruction. For movement of Perspex along the same axes in the tank, mean localisation errors were 13.7 ± 5.8mm and 20.7 ± 10.1mm. Incorporating shells in the algorithm resulted in peak impedance changes localised more accurately and less centrally than when shells were not included.

All four algorithms were tested on 8 human subjects during between 6 and 12 epochs of exposure to a visual stimulus. Images of visual evoked responses showed no more consistency across subjects with the new algorithms though some individual examples were improved.