# Fusion of electrical impedance tomography data with MRI

Ross A Little[1], John L Davidson[2], Josephine H Naish[1], Paul Wright[2], Ron Kikinis[3], Hugh McCann[2], and Geoff J Parker[1]

[1]Imaging Sciences, Manchester Academic Health Sciences Centre, University of Manchester, Manchester, United Kingdom, [2]School of Electrical and Electronic Engineering, University of Manchester, United Kingdom, [3]Surgical Planning Laboratory, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, United States

Background Patient care often requires knowledge of both detailed anatomical information and organ functionality. Imaging modalities capable of very rapid scanning, such as Electrical Impedance Tomography (EIT), typically lack good spatial resolution compared with lower speed acquisitions such as MRI.
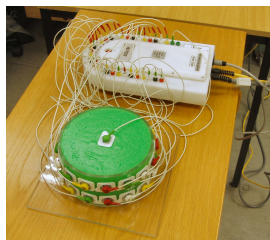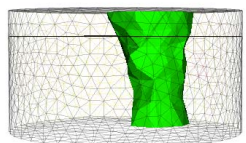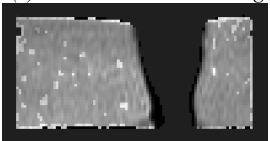

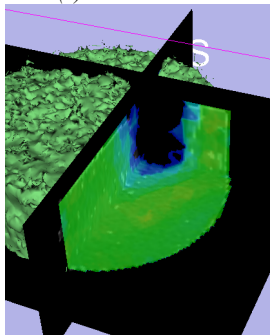*(a) phantom and EIT headbox*

(b) TX151 inhomogeneity

Fig 1: TX151 phantom

(a) tetrahedral EIT rendering

(b) axial MRI slice

(c) joint EIT and MRI dataset

Fig 2: data visualisation

Objectives Our aim is to robustly fuse EIT and MRI data streams to give temporally and anatomically resolved functional lung imaging. Presently we are progressing the fusion of EIT and MRI data from gel-based phantoms using the *Confeitir* (CONverter of Functional Electrical Impedance Tomography Images for Registration) software [1] and the *3D Slicer* medical image visualisation package [2].

Data acquisition A phantom of diameter 170 mm and height 85 mm was constructed using TX151 polysaccharide gel (Oil Center Research, La Fayette, LA). This is a tissue realistic material previously used in both EIT and MRI [3]. To every 1 L of deionised water, 120 g TX151 was added and the result was thoroughly blended before setting in a Perspex mould. Apertures at heights of 25 mm and 65 mm in the mould allowed two rings of sixteen Ag/AgCl EEG electrodes to be affixed for EIT measurements. An additional reference electrode was attached top-centre of the phantom. EIT data were captured using fEITER (functional Electrical Impedence Tomography of Evoked Responses) [4], a biomedical EIT instrument operating at 100 frames per second (the headbox is shown fig 1(a)). Data were acquired for a homogeneous reference condition (fig 1(a)) and after the creation of an air-hole inhomogeneity (fig 1(b)). Following the EIT, the electrodes were removed and a 3D T_1-weighted structural MR image was acquired on a 1.5 T Philips Achieva scanner using a FFE (fast field echo) sequence with a flip angle of 20°, TR/TE 4.5/1.1 ms, matrix size 144×144×57, voxel dimensions 1.74 mm × 1.74 mm × 2.06 mm. The EIT reconstruction used a tetrahedral mesh model of 12966 elements constructed using NetGen [5], following the EIDORS 3D [6] and the linear conjugate gradients method of [7], and is shown in fig 1(c).

Mapping to voxel space *Confeitir* [1] was used to convert the reconstructed EIT data from the irregular tetrahedral mesh into a regular matrix with 2 mm isotropic voxels. This software iterates over a large number of irregularly sized simplexes and sets voxel values to be equal to the value of the simplex that surrounds the centre of the voxel. This is a more accurate solution than finding the nearest neighbour centroid, which may assign incorrect voxel values where, for example, a short and fat simplex is located next to a long and thin simplex.

Data visualisation The open source platform *3D Slicer* was used to manipulate and visualise the images. This package provides a flexible and extendable platform from which to view and analyse medical images. The MRI-derived DICOM structural reference images and the EIT-derived conductivity change measurements, after conversion to Analyze format, were imported into *3D Slicer* and manually aligned. The grow-cut module was used to create a model of the phantom from the MRI volume to aid visualisation. Fig 2 shows some of the resulting images: (a) is the EIT reconstruction in tetrahedral space, (b) shows a structural MRI slice for comparison and (c) shows a visualisation of the EIT data aligned with the MRI structural image. A visual inspection of the images suggests good correspondence between the two modalities, even showing the top-to-bottom tapering which was physically present in the original phantom.

Summary and future work EIT and MRI data fusion has been successfully demonstrated in a phantom. Further work will enable quantitative measurement of EIT spatial fidelity under several standard acquisition and reconstruction methods, including the acquisition and registration of human data. Such data fusion is an essential step in the development of combined dynamic lung function imaging with human EIT and MRI data.

References [1] McCormick, D, et al (2007) Proc of 8th Conf on EIT, Graz, Austria, pp. 384-387; [2] Pieper, S, et al (2004) Proc of 1st IEEE Int Symp on Biomed Im, pp. 632-635; [3] Mazzara, GP, et al (1996) MRI 14:639-648; [4] Davidson, JL, et al (2010) Proc of 11th Conf on Biomed Apps of EIT, Florida, USA; [5] Schöberl, J (1997) Comput Visual Sci 1:41-52; [6] Polydorides and Lionheart (2002) Meas Sci Technol 13:1871-1883; [7] Polydorides, N (2002) PhD Thesis, UMIST, UK.