Reconstruction of Conductivity Changes Using an Advanced Compensation Method in Electrical Impedance Tomography

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Abstract: Element displacement and contact impedance changes are compensated in the reconstruction approach. Images have been reconstructed using the proposed method with the data from numerical simulation, saline phantom and in vivo human measurement.

1 Introduction

One of the key difficulties of Electrical impedance tomography (EIT) imaging is the modelling error, such as shape deformation and contact impedance changes. When a deformable medium is investigated, not only boundary elements (including electrodes) but also internal elements displace. Moreover, when the voltages are measured on the electrodes, the contact impedance that exists in the interface causes a voltage drop. If difference imaging techniques are involved, these difficulties can be partly solved [1-3], but in order to obtain a better imaging quality, element displacement and contact impedance changes have to be taken into account.

2 Methods

An augmented Jacobian $\mathbf{J} = [\mathbf{J_c}\ \mathbf{J_d}\ \mathbf{J_t}]$ is obtained by concatenating conductivity change Jacobian $\mathbf{J_c}$, element displacement Jacobian $\mathbf{J_d}$ and contact impedance changes Jacobian $\mathbf{J_t}$. A modified NOSER prior $[\mathbf{R}]_{i,i} = \left[\mathbf{J'}^T \mathbf{J'}\right]_{i,i}^{p}$ is established, where $\mathbf{J'} = [\mathbf{J_c}\ \mu^2\mathbf{J_d}\ \tau^2\mathbf{J_t}]$, we define μ and τ as the model hyperparameters to represent the different weights. The one-step linear Gauss-Newton (GN) method is implemented to solve the inverse problem.

2.1 Numerical Simulation
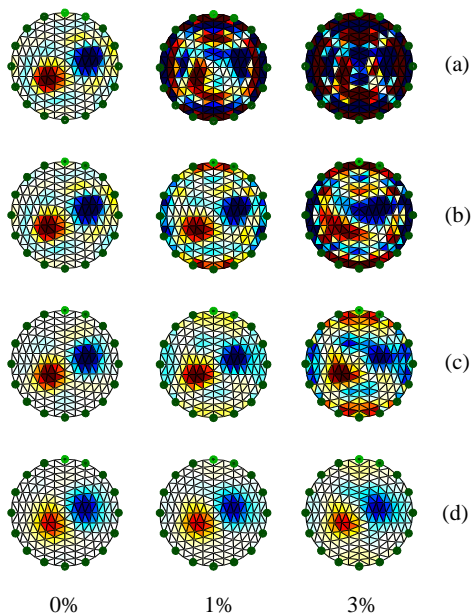

0%   1%   3%

Figure 1: Image reconstructions. (a) Standard GN method; (b) Electrode movement model; (c) Proposed method with $\mu = 1$ and $\tau = 1$; (d) Proposed method with $\mu = \sqrt{0.1}$ and $\tau = 0.1$. From left to right, distortion amplitude increases from 0%, 1% to 3% of model diameter respectively.

2.2 Saline Phantom Measurement

The saline phantom is a plastic cylindrical tank with 14cm diameter and 12cm height, being filled with 0.9% saline solution. A small non-conductive spherical object of 1cm diameter was statically suspended. The proposed method successfully obtained the inhomogeneous target without introducing any artefacts.

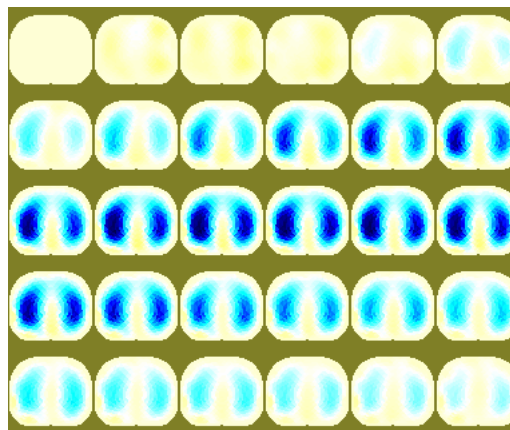### 2.3 In vivo Human Measurement

Figure 2: Images of lung ventilation. The breathing cycle from end inspiration to end expiration was approximately 5 seconds. Each second was shown in the same row.

3 Conclusions

An advanced compensation method which is more robust to shape distortion is proposed in this paper by an improved version of the electrode movement model [1]. The algorithm performed well and showed significant improvements of artefact resistance. One key advantage is that, once pre-calculations are completed, images can be reconstructed by a single regularized inverse, and it requires little additional time over traditional methods. Considering the reconstructed images from in vivo human measurement, this method shows potential to be applied in real time monitoring of lung ventilation and may be useful to increase the accuracy and reliability of EIT technique in routine clinical applications.

References

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