Evaluating Deformation Corrections in Electrical Impedance Tomography

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The Boundary Movement Problem

- Long suspected: errors in the knowledge of the boundary shape are an important factor in the inaccuracy of reconstruction.

Uncorrected
Introduction: Chest EIT

- Boundary shape changes with breathing, desirable to correct the boundary shape using the EIT data so that a consistent isotropic conductivity can be fitted to the data.
- Should result in a distorted image due to the anisotropic nature of chest muscle, yet still preserve useful features of the lungs.
Introduction: Isotropy

- Boundary deformations do not preserve assumed isotropy of the domain.
- Thus, (for the isotropic case) data contains information about conductivity & boundary deformation.
Introduction: Previous Work

• Previous work to address shape changes in EIT has shown that:
  – theoretically, for an infinite number of electrodes, non-conformal changes in boundary shapes and electrode locations can be uniquely determined (Lionheart, 1998);
  – in some cases, conductivity and shape changes can be recovered using a combined image reconstruction model of both conductivity and shape changes (Soleimani et al, 2006).
However

- Not all deformations lead to these anisotropic conductivities.
- The exception is exactly the distortions that are conformal maps.
- In 2-D, an infinite number of conformal maps.
Conformal Vector Field
(in two dimensions)

• Also known as:
  – infinitesimal conformal motion,
  – conformal Killing field.

• Preserves the angle between vectors.
Simulation

Source

Non-Conformal

Conformal

Combined

Without correction

With correction

(a) (d) (g)

(b) (e) (h)

(c) (f) (i)
Phantom

- Plastic pan
- Deformable rubber gasket
- Saline solution
- 16 stainless-steel electrodes
2-D Experimental Deformations

(a) 2 points
(b) 3 points
(c)
Experimental Reconstruction

No Deformation
Experimental Reconstruction

2 & 3 points, Without Deformation Correction
Experimental Reconstruction

2 points

3 points
Conclusion & Discussion

- Conformal and non-conformal vector fields as applied to EIT.
- Reconstruction of non-conformal electrode movement from conductivity change: simulation and experimental results show reduced artifacts.
Conclusion & Discussion

- One limitation is assumption of isotropy.
  - Further investigation with respect to known anisotropic domains (muscle tissue & flowing blood) would be interesting.

- Linear approximation of forward problem used,
  - holds out the hope that, with the correction of the boundary shape and electrode positions, using the EIT data will be sufficient for non-linear and accurate absolute EIT reconstruction of clinical data.
Thank you.

Questions?

Acknowledgement: This work was supported by a grant from NSERC Canada.