Evaluating Deformation Corrections in Electrical Impedance Tomography

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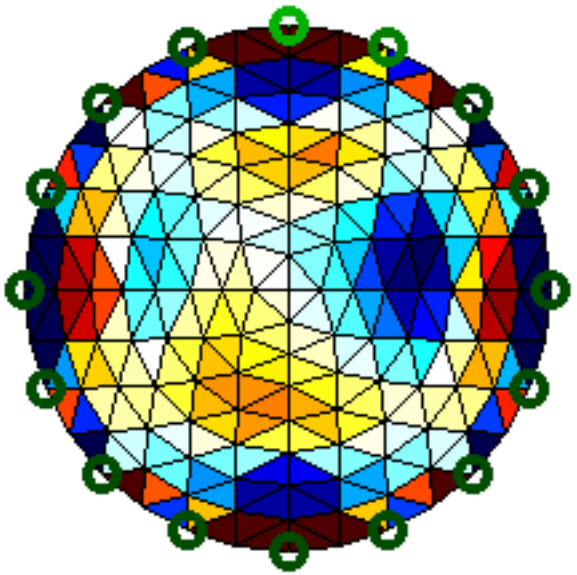
The Boundary Movement Problem



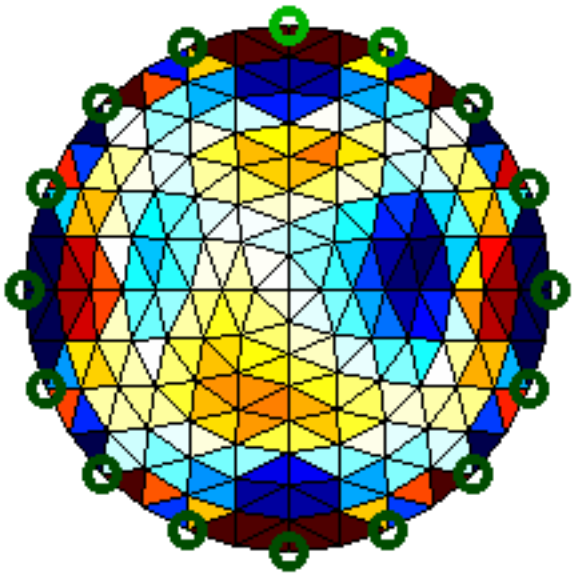
Uncorrected

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

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



Uncorrected

- 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).

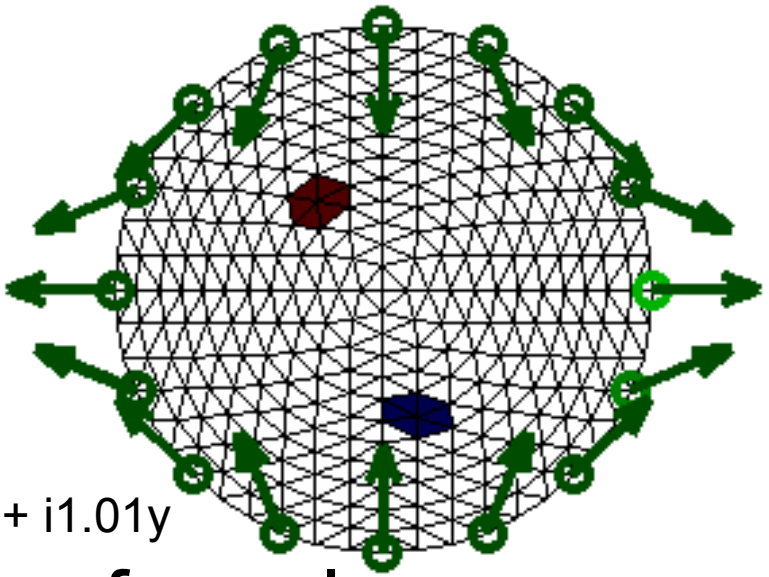
However

- 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

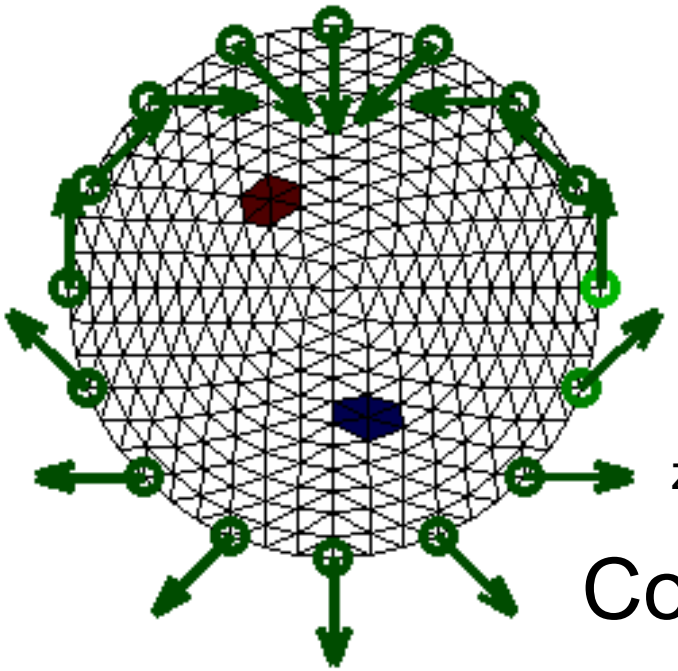
(in two dimensions)

- Also known as:
  - infinitesimal conformal motion,
  - conformal Killing field.
- Preserves the angle between vectors.



z -> 0.99x + i1.01y

Non-Conformal

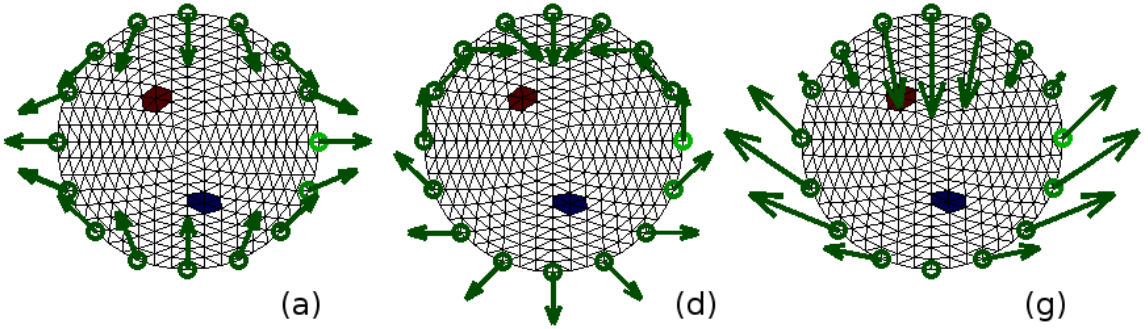


$z \to z + 0.01z^2$

Conformal

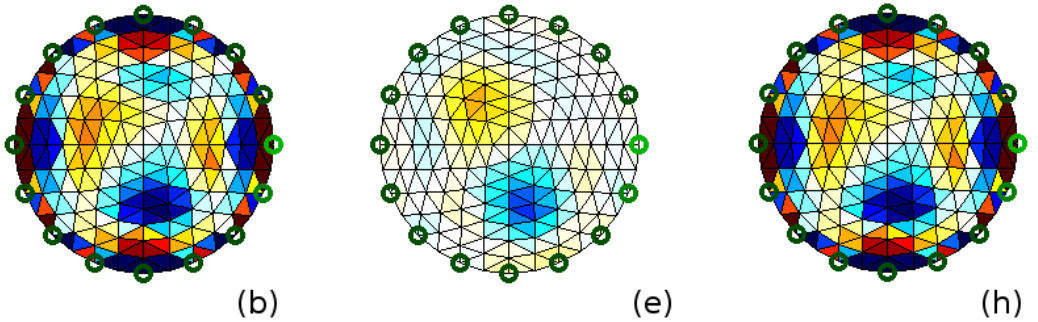
Simulation

source

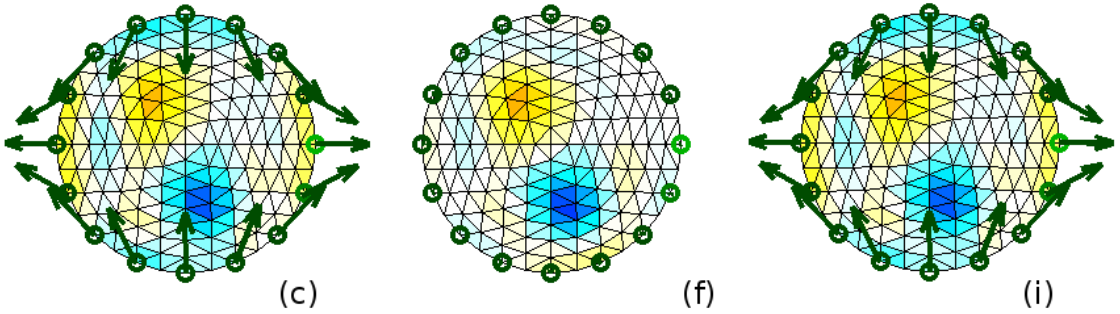


Non-Conformal Conformal Combined

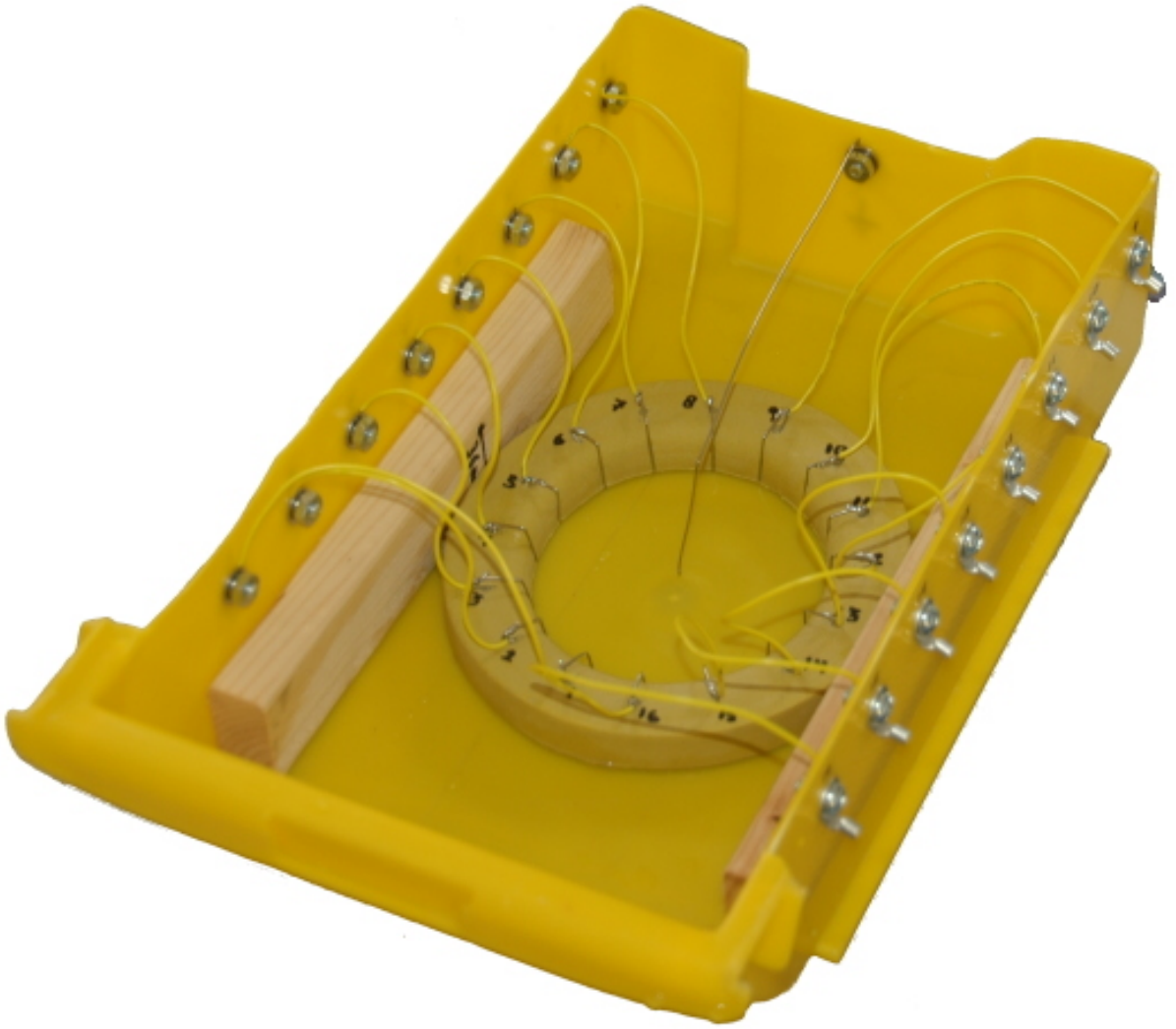
without correction



with correction

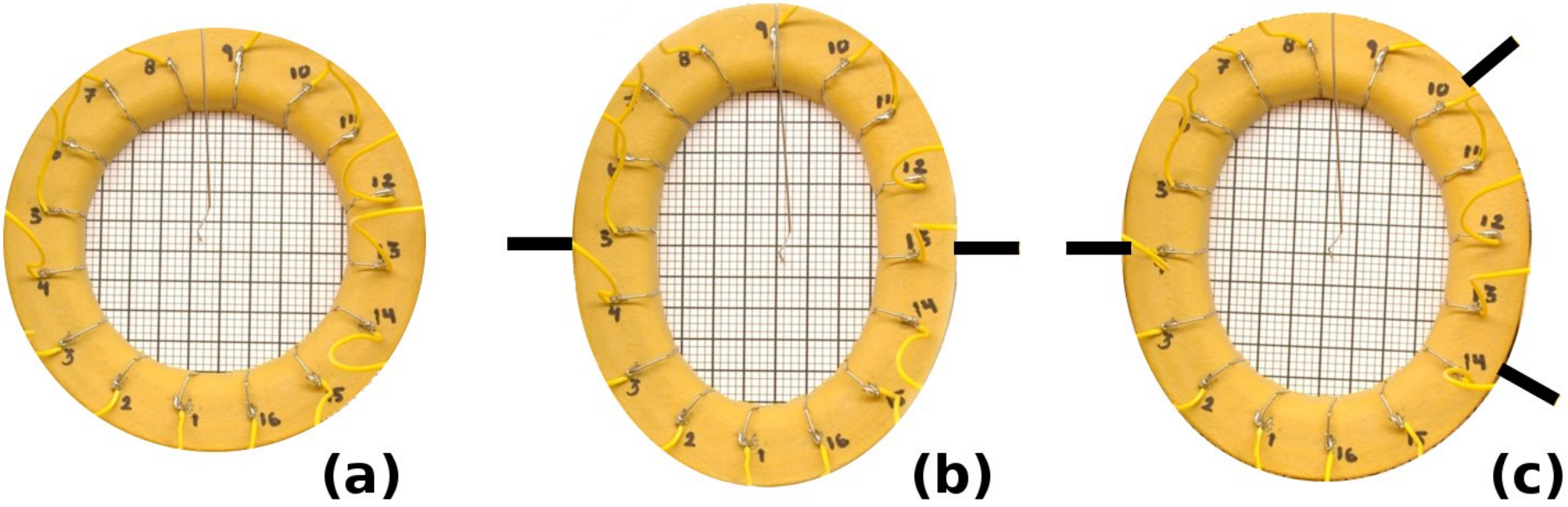


Phantom



- Plastic pan
- Deformable rubber gasket
- Saline solution
- 16 stainless-steel electrodes

2-D Experimental Deformations

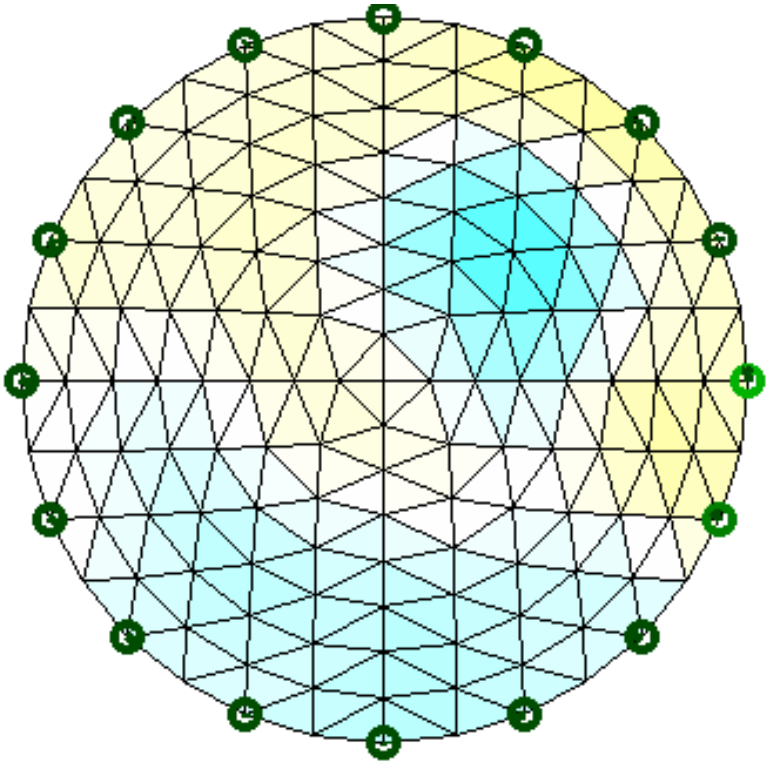


2 points

3 points

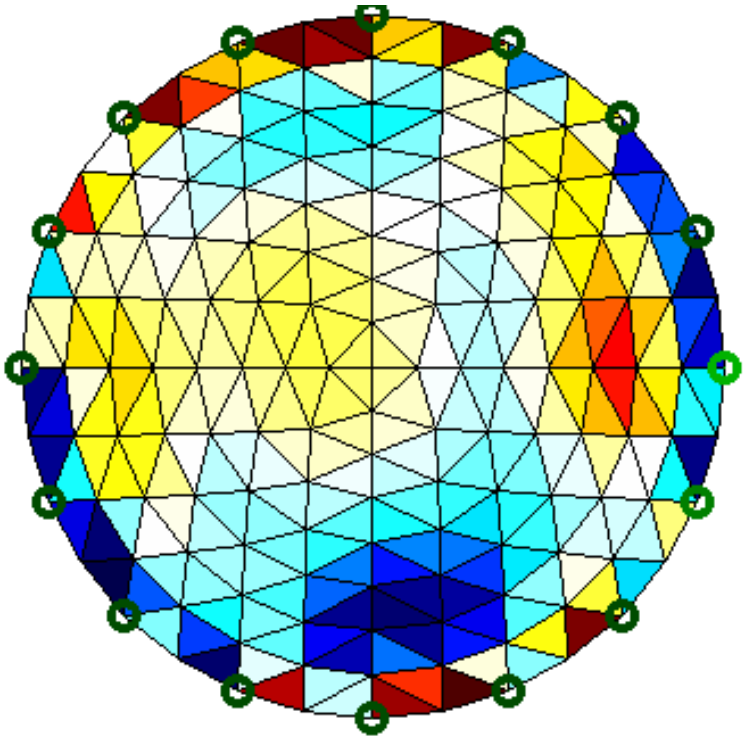
Experimental Reconstruction

No
Deformation



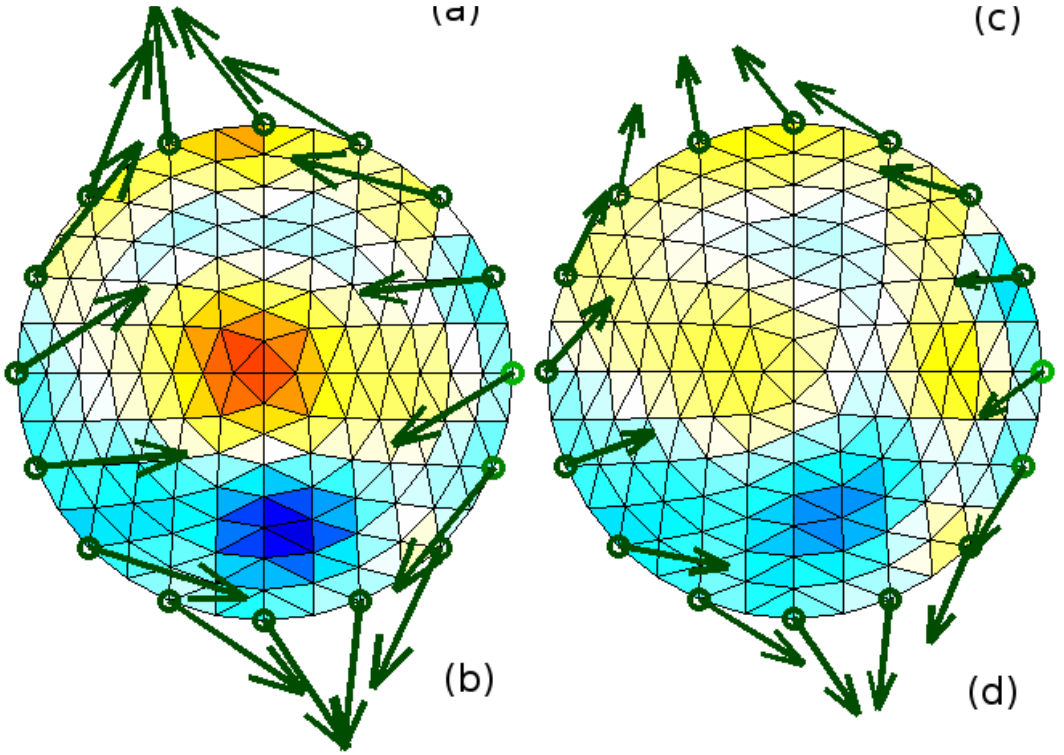
Experimental Reconstruction

2 & 3 points, Without Deformation Correction

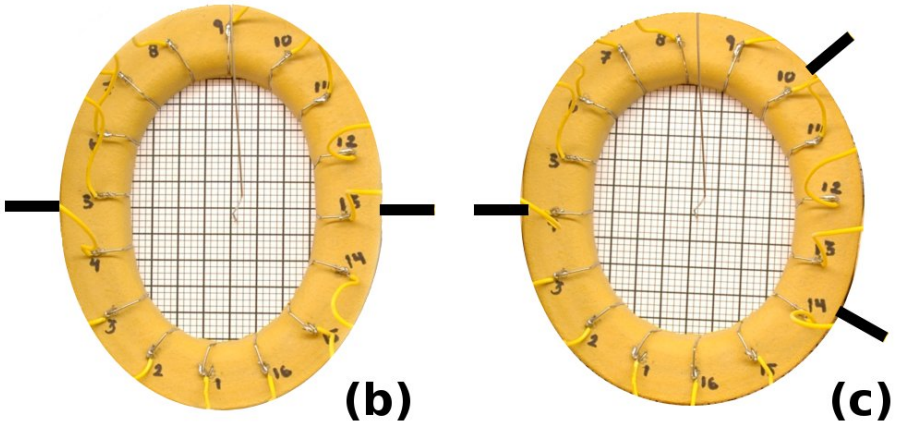


Experimental Reconstruction

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?

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