Electrode Models under Shape Deformation
in Electrical Impedance Tomography

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Motivation

- Using Difference EIT, most unknowns do not affect image quality as long as they are not changing:

  - e.g. contact impedance,

  - electrode area, or

  - electrode location [1]

- ... but what happens when the body *is* deforming?

[1] Barber & Brown, *Errors in reconstruction of resistivity images using a linear reconstruction technique*, 1988, Clin. Phys. Physiol. Meas

Motivation

- Many shape deformations result in artifacts[2]

- Why are conformal changes interesting?

    – Isotropic conductivities remain isotropic and do not introduce artifacts [3]

- ... but is this true for all electrode models?

    – We compare electrode model behaviour when the body is deforming, in simulation
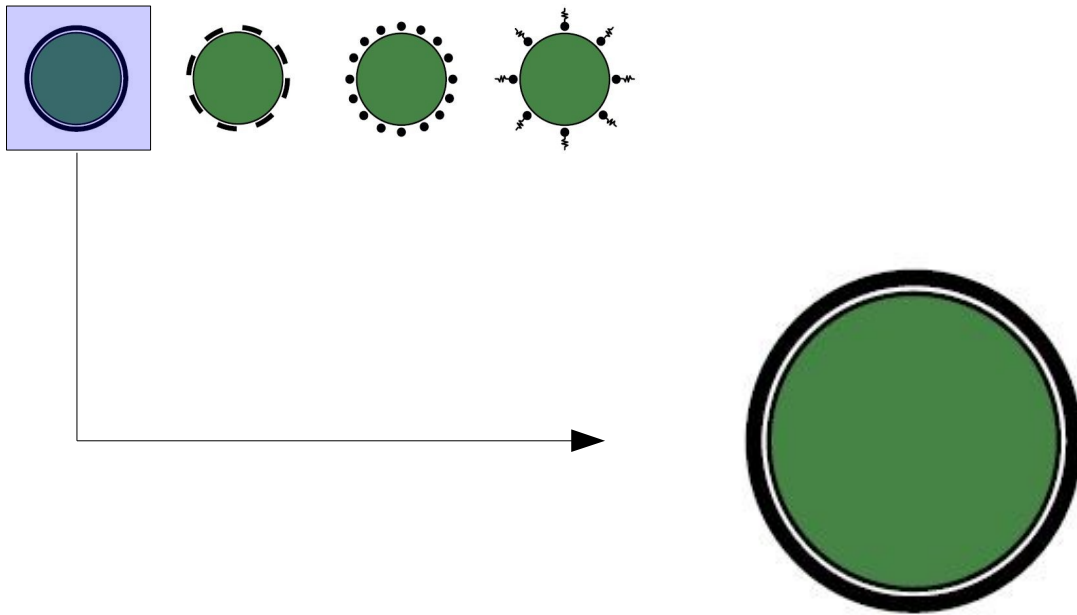
[2] A Adler et al, *Impedance imaging of lung ventilation: do we need to account for chest expansion?*, 1996, IEEE BME
[3] WRB Lionheart, *Boundary Shape and Electrical Impedance Tomography*, 1998, IOP Journal Inv. Problems
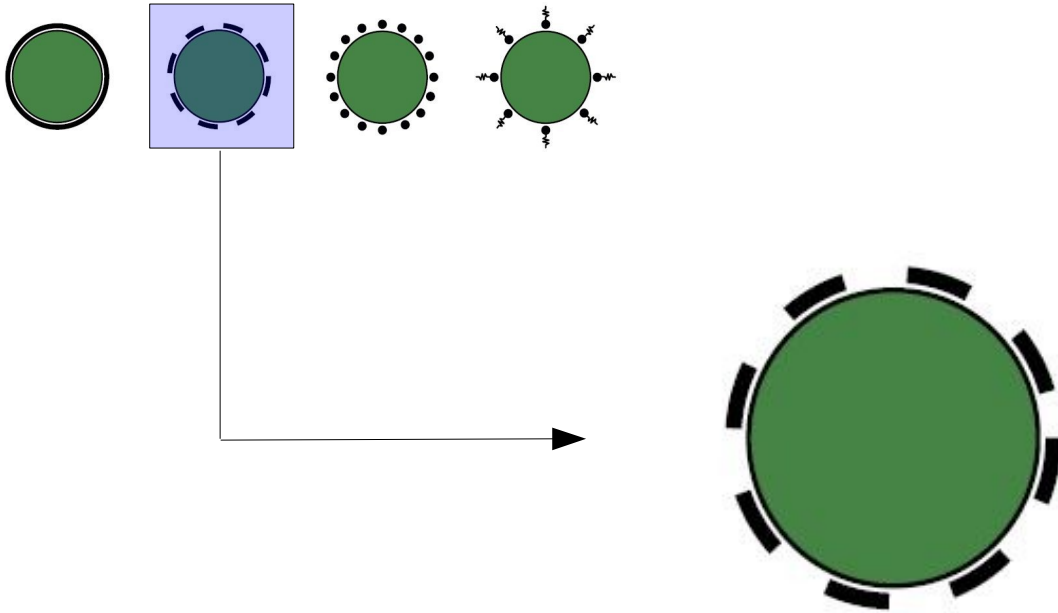
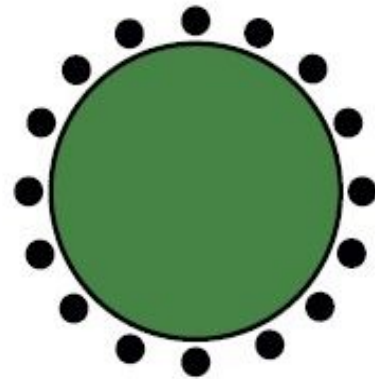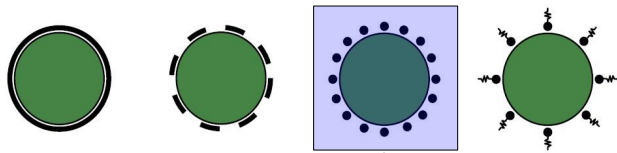# Mathematical Electrode Models
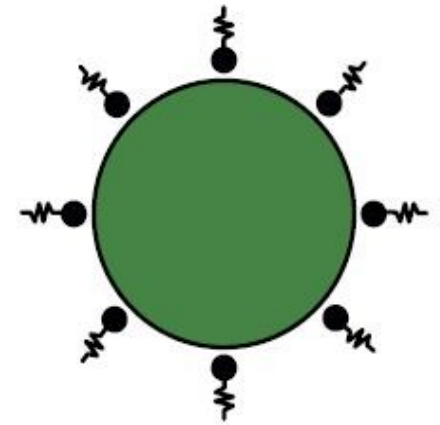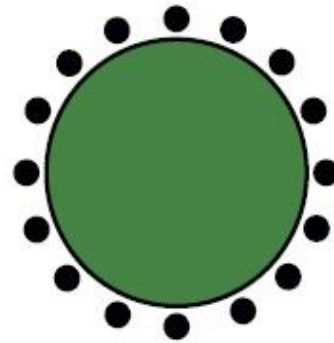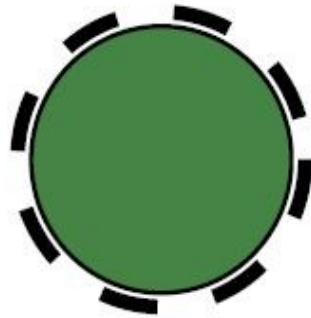
Mathematical Electrode Models

Continuous Model
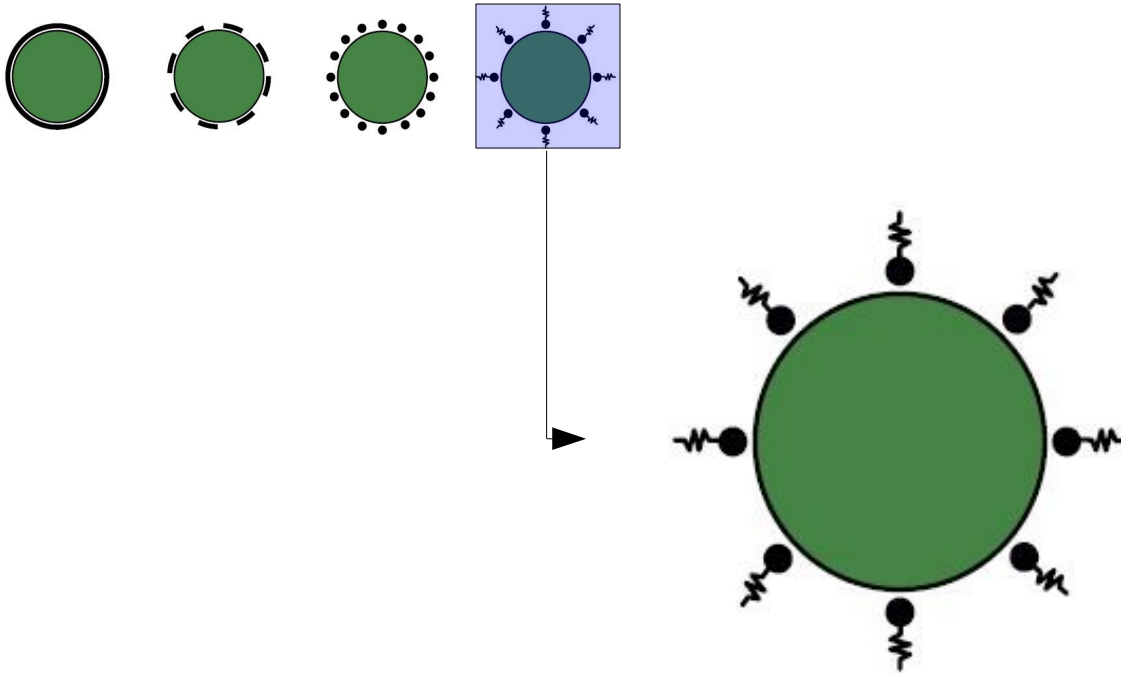
Mathematical Electrode Models

Gap Model

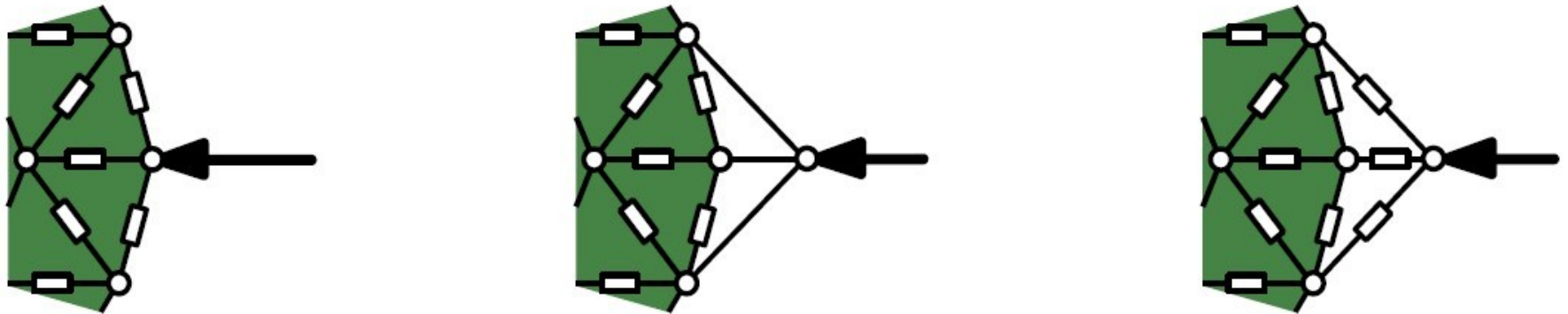# Mathematical Electrode Models

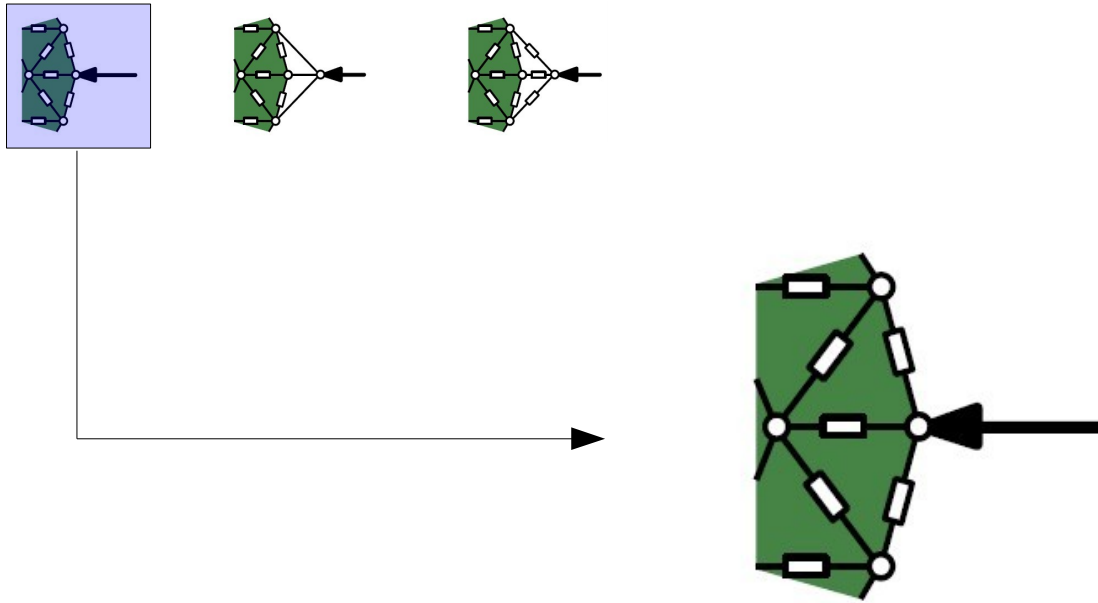Shunt Model

Mathematical Electrode Models

Complete Electrode Model

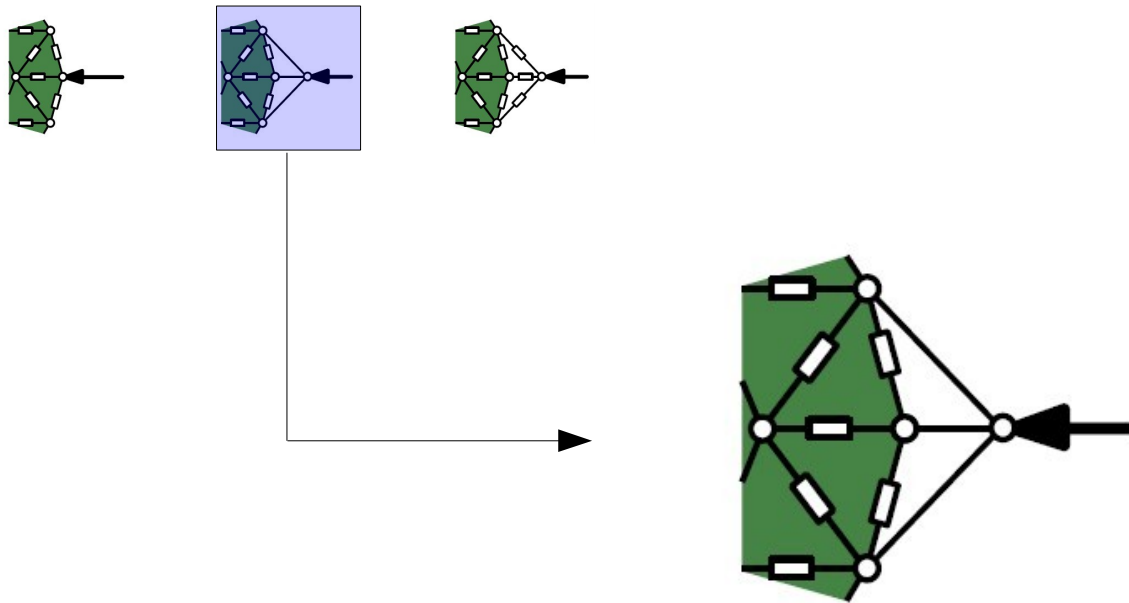# Finite Element Method Electrode Models

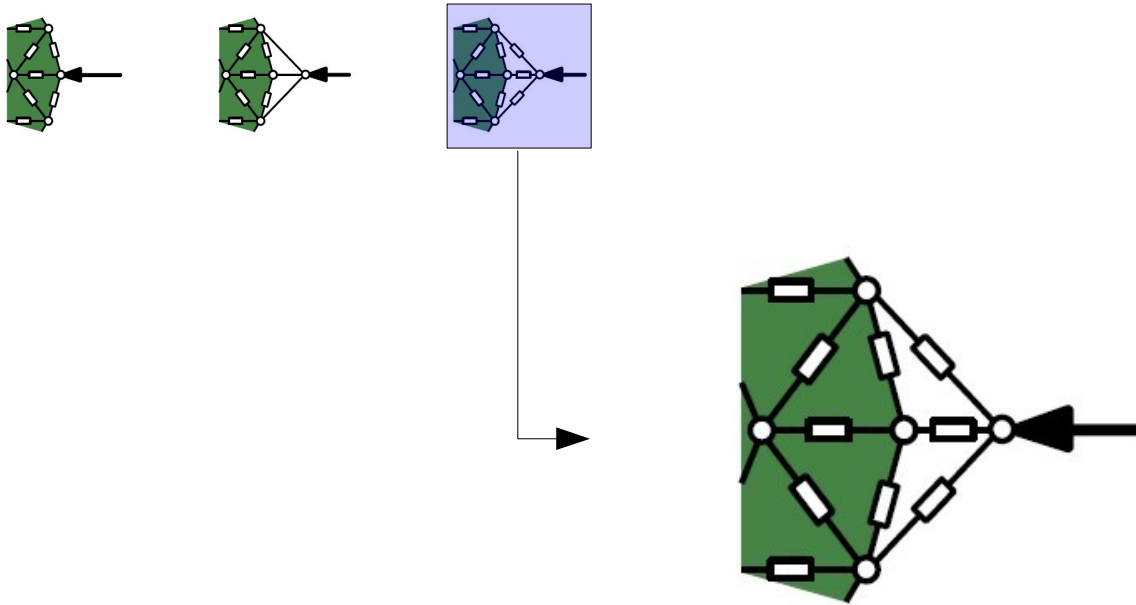# Finite Element Method Electrode Models

Point Electrode Model

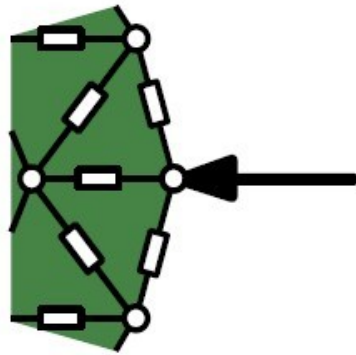# Finite Element Method Electrode Models

Shunt Electrode Model

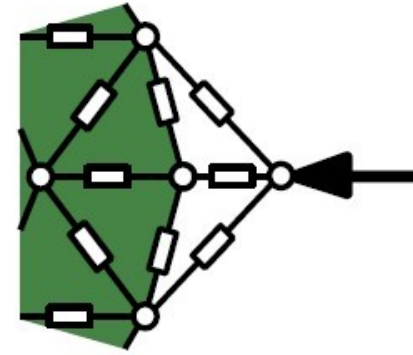# Finite Element Method Electrode Models
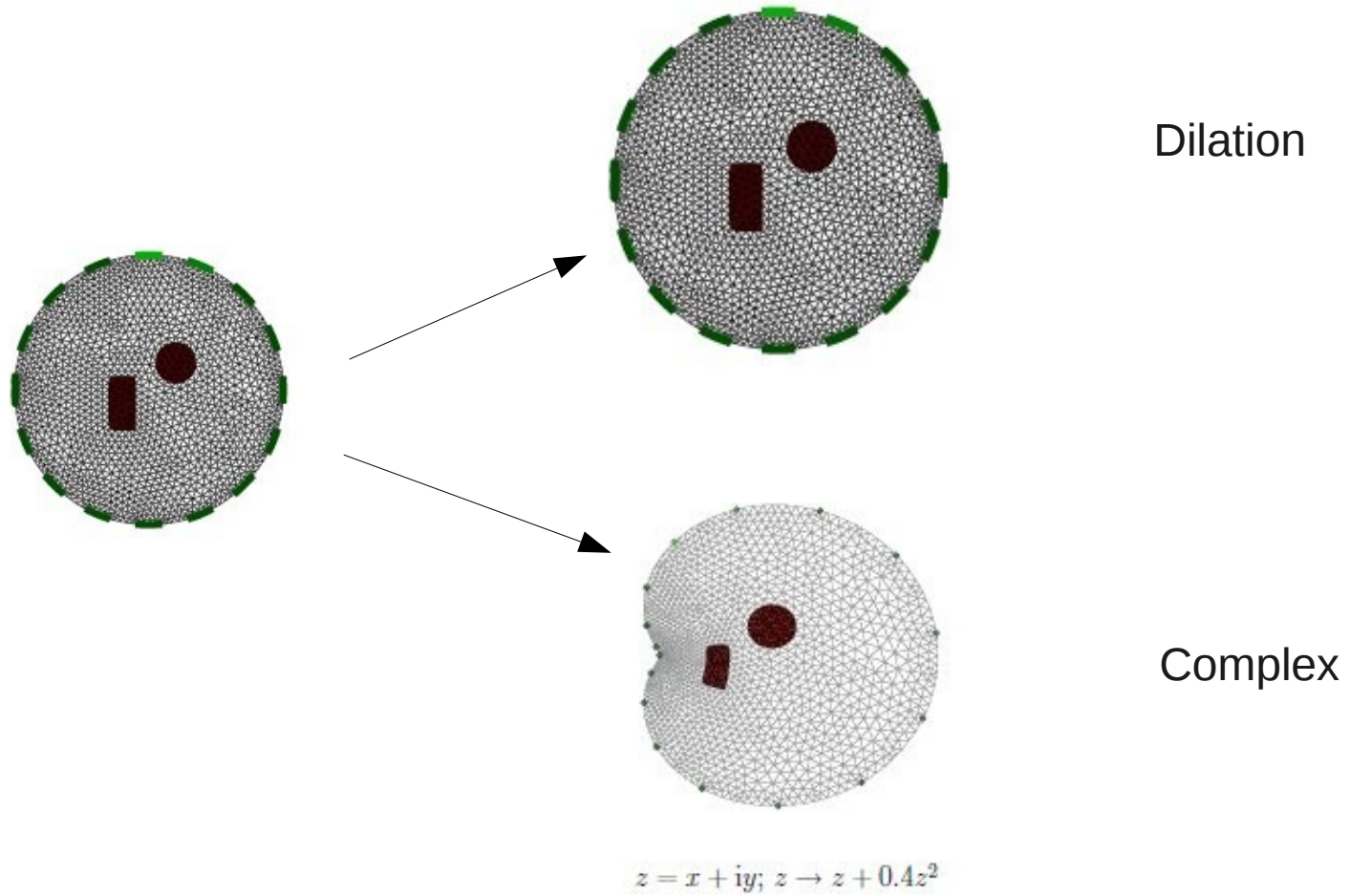

Complete Electrode Model

Focus

Point
Electrode Model
(PEM)

Complete
Electrode Model
(CEM)

- With respect to conformal deformations:
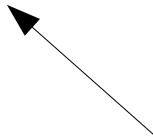   – PEM does not introduce artifacts.
        What about CEM?

Conformal Deformations

Dilation

Complex

$$z = x + iy; \; z \rightarrow z + 0.4z^2$$

Electrode Deformation

Table 1 :   Electrode Model Behaviour under Deformation

| Model | Deformation | | AAM_n | Comment |
	Domain	Electrode		
PEM	dilation	matching	0	
	complex		0.0807	
	dilation	fixed	0	
CEM	dilation	matching	0.0010	
	complex		2.013	artifacts (deformed)
	dilation	fixed	5.5	artifacts (ringing)

$$\text{AAM}_n = \sum \left[\frac{c_1 - c_0}{c_0} \right]^2$$
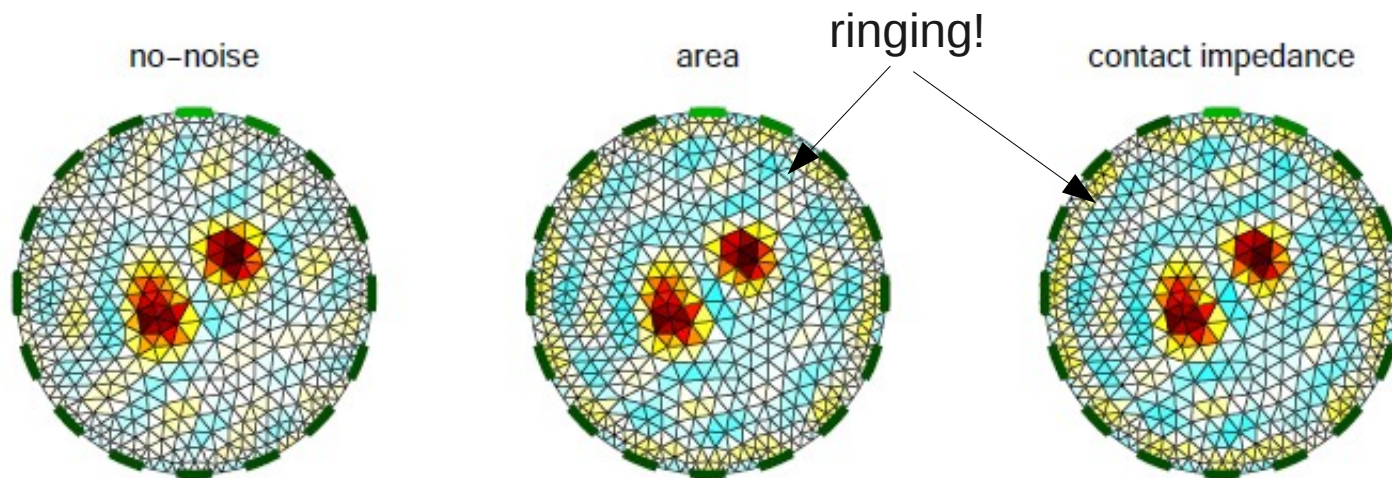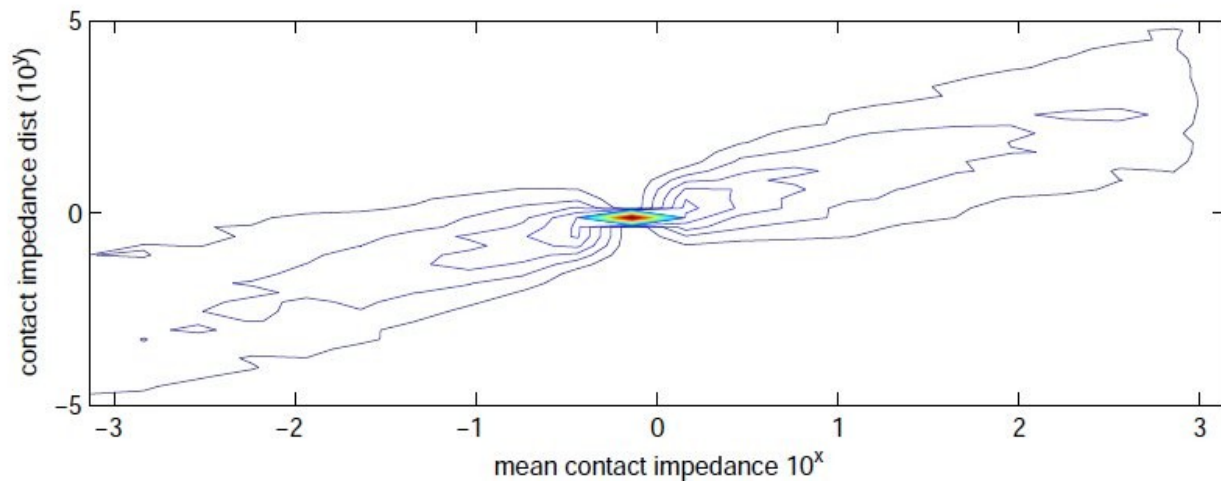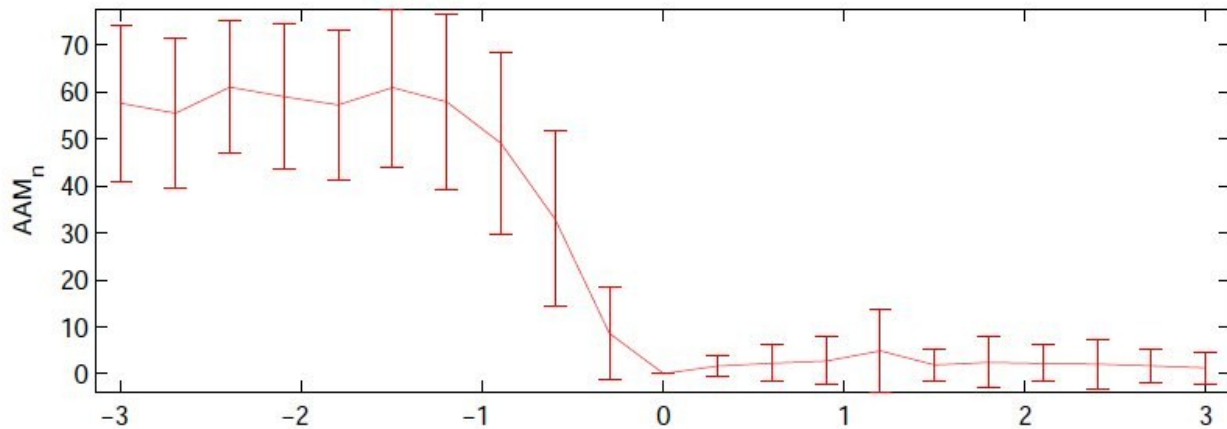
Electrode Deformation and Contact Impedance

Figure 10.4: Electrode area versus contact impedance artifacts: (left) reconstruction, no noise; (middle) reconstruction, electrode areas reduced to $1/4$, $AAM_n = 5.5$; (right) reconstruction, contact impedances reduced to $1/16$, $AAM_n = 7.04$
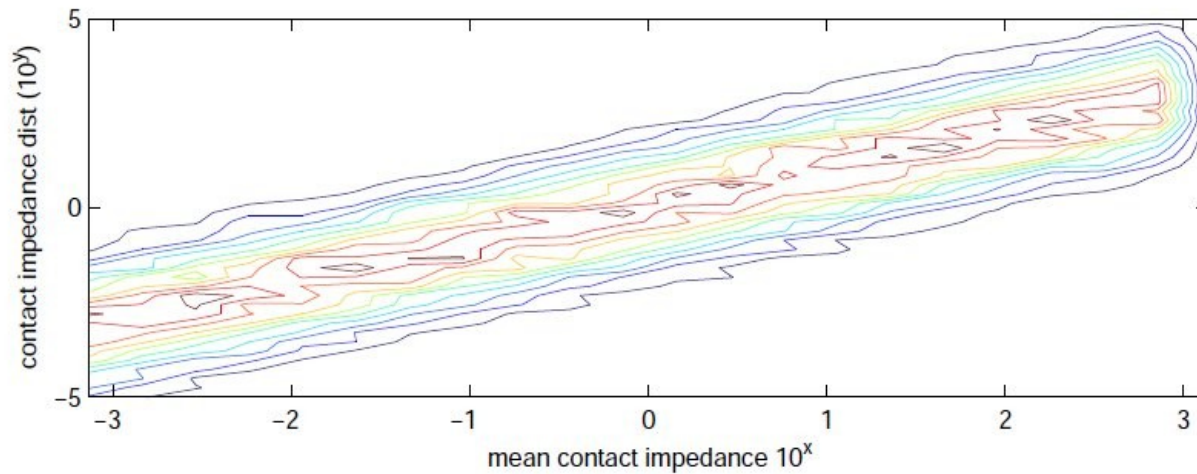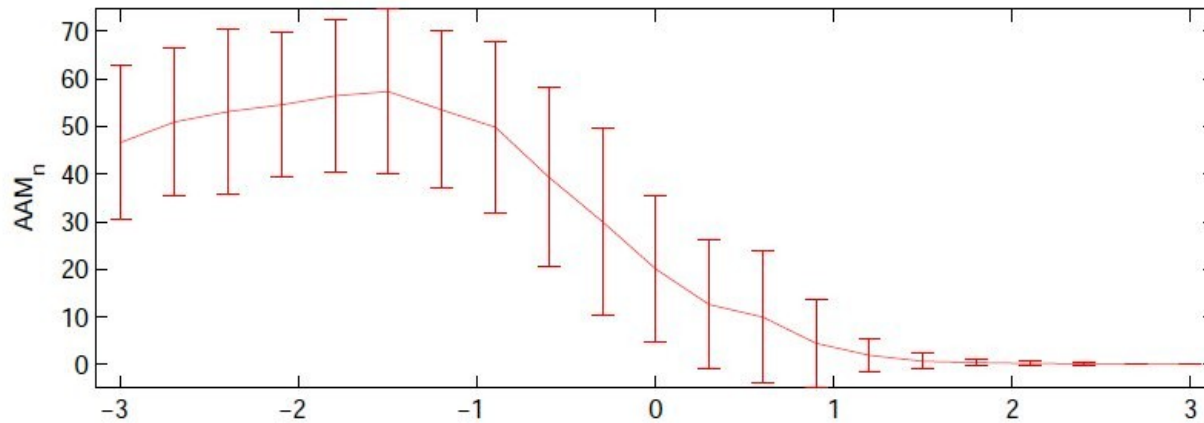
Electrode Contact Impedance

$$z_c = 10^{\mathcal{N}(\mu, \sigma^2)}$$

$$3 \leq \mu \leq 3$$

$$\sigma^2 = |\mu|$$

Electrode Contact Impedance

$$z_c = 10^{\mathcal{N}(\mu, \sigma^2)}$$

$$3 \leq \mu \leq 3$$

$$\sigma^2 = 1$$

Discussion:

Electrode Models under Shape Deformation

- Using the CEM, reconstructions of conformal deformations can result in artifacts

- Changes in contact impedance and electrode area can result in similar artifacts

- Increases in contact impedance do not result in reconstruction artifacts

Thank You

Questions?