1. Evaluating Spatial Resolution of Cortical Stimulation

**Goal:** Optimization of current injection using electrocorticographic (ECoG) arrays and evaluation of stimulation resolution for 3 ROIs

**Approach:**
- 16/256 channel ECoG arrays, inter-electrode distance (1 cm/2.5 mm) [1]
- 7/34 million test nodes/elements.
- ROIs located in the gyri wall of the motor cortex
- Isotropic conductivities in S/m: scalp = 0.43, skull=0.33, CSF=1.79, Brain=0.33, ECoG/Air= 1e-6 are
- Optimization for different cortical depth ROIs radial to cortex.

2. Avoiding Current Density “Hot-spots”

**Goal:** Optimization of injected current patterns for control of both targeting and safety and maximizing current density in target area.

**Approach:**
- Use 48 channel ECoG arrays without creating “hot-spots”
- Optimize stimulus pattern with no local density constraints; Orange: Potential hot-spots
- Find hot-spots and impose constraints on hot-spots.
- Iteratively locate hot-spots and impose local density constraints until no hot-spot occurs.

**Conclusion:**
- Simulation suggests that it is possible to control hot-spots. Our algorithm efficiently controls hot-spots

3. Validation

a. Evaluation of FEM modeling accuracy:

**Goal:** The accuracy of the FEM model is evaluated by comparing the simulated ECoG measurements with experimental recordings. The human experimental ECoG measurements are conducted by University of Washington.

**Approach:**
- 2 ECoG sheets (1 mm thickness): 32 electrode array (including stimulation electrode pair) and 16 electrode array.
- Sampling frequency: 12 kHz; 10 biphasic pulses (1.2 ms pulse width), amplitude +/-1 mA.
- Average the 10 pulses for each electrode and compare value for each channel to FEM.

**Conclusion:**
- Initial result: reasonable correspondence between simulation and measurements.
- Correlation coefficient: 0.8748.

b. Translation of simulations to phantom and in vivo models:

**Goal:** Transfer of computational models to experimental settings, investigation of contact size and distance for targeted safe cortical stimulation

**Approach:**
- Vary electrode spacing and contact diameter.
- Validate models using phantoms.
- Validate models in chronic implanted sheep.

**Open questions:**
- How much can we gain by optimized targeting with different arrays?
- How do contact size and number of electrodes impact targeting?
- How can we validate deeper in the cortex?
- How do stimulation parameters such as pulse shape, width and rate affect current flow and hot-spot distribution in living cortex?

**Conclusion:**
- Initial result: reasonable correspondence between simulation and measurements.
- Correlation coefficient: 0.8748.

**Iteration 3:** 2802 hot-spots

**Iteration 1:** 4042 hot-spots

**Iteration 5:** No hot-spots

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