ROAST- An Open-Source Platform for Modeling Transcranial Electrical Stimulation & its Validation

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ISMRM ONE COMMUNITY FOR CLINICIANS AND SCIENTISTS

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Disclosures

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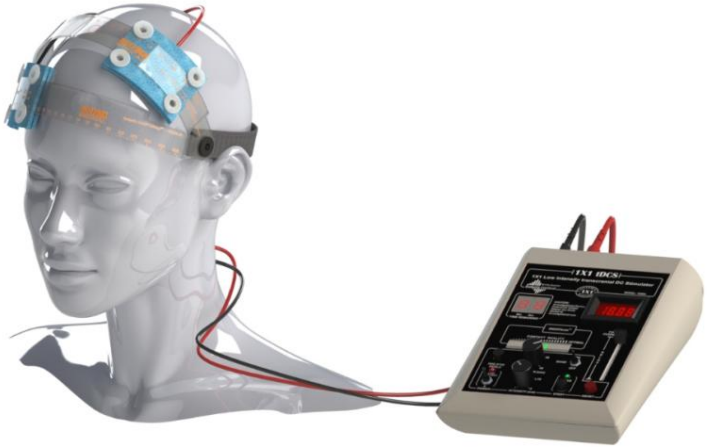
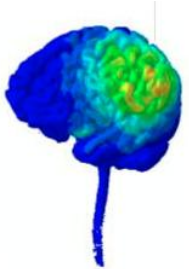
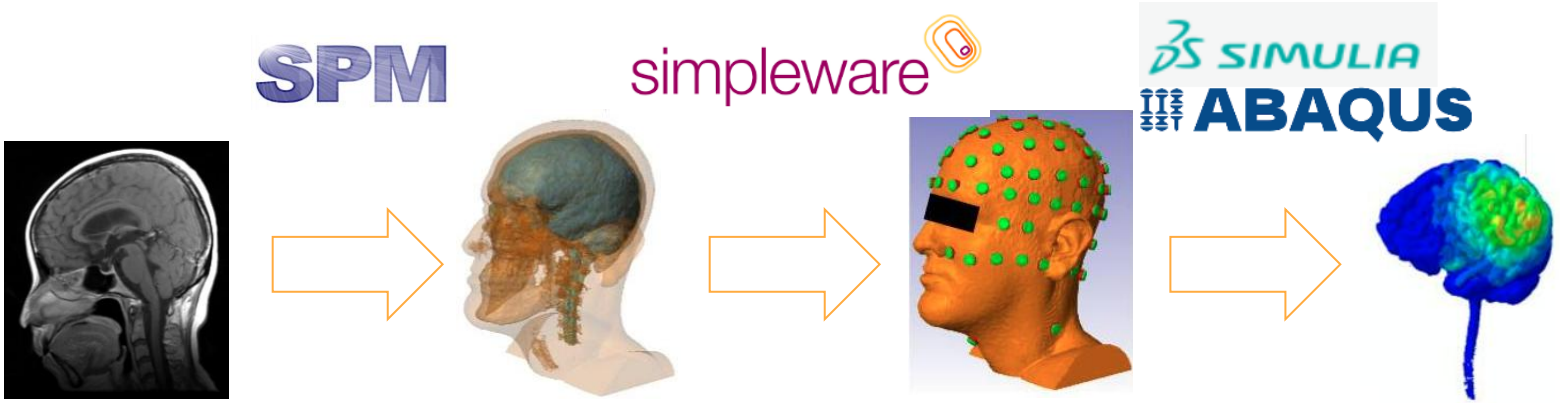
Transcranial electrical stimulation (TES)



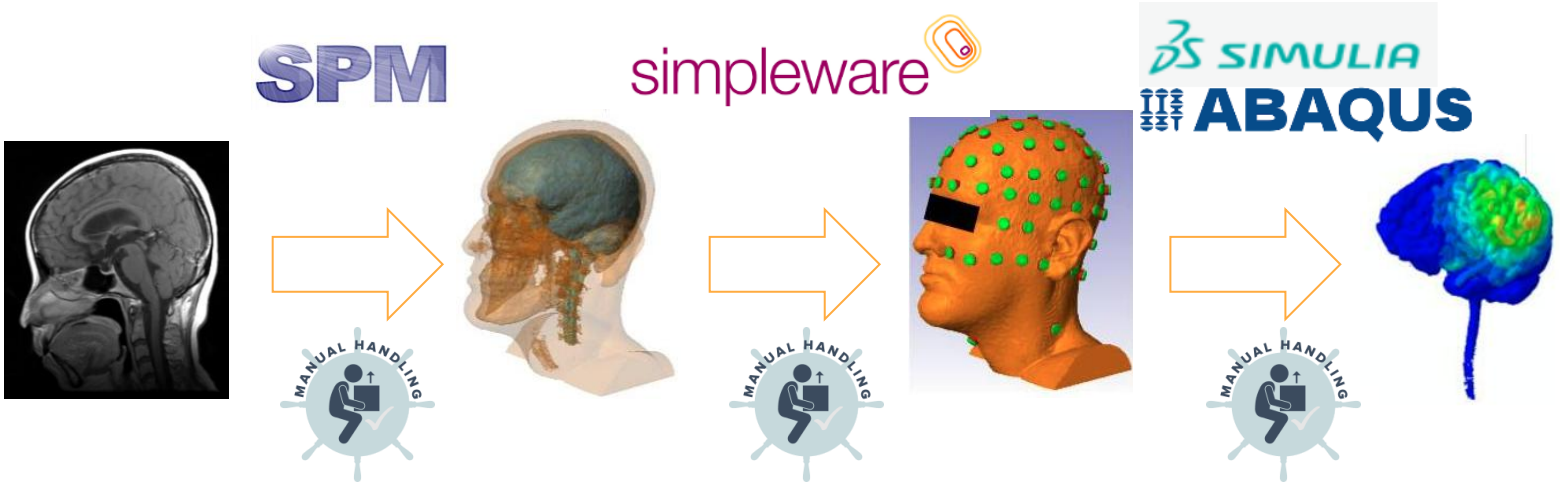


Workflow of image-guided TES modeling (from 2010)



Huang et al., 2013

Workflow of image-guided TES modeling (from 2010)



1~2 weeks

Huang et al., 2013

ROAST (from Nov. 11, 2017)

ROAST

MATLAB

20~30 minutes

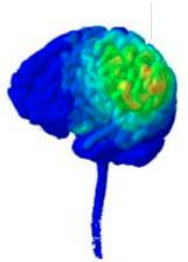
https://github.com/andypotatohy/roast

Huang et al., 2019

Example uses

- Basic simulation:

  roast('example/subject1.nii', {'F1',0.3,'P2',0.7,'C5',-0.6,'O2',-0.4},'simulationTag','basicDemo')



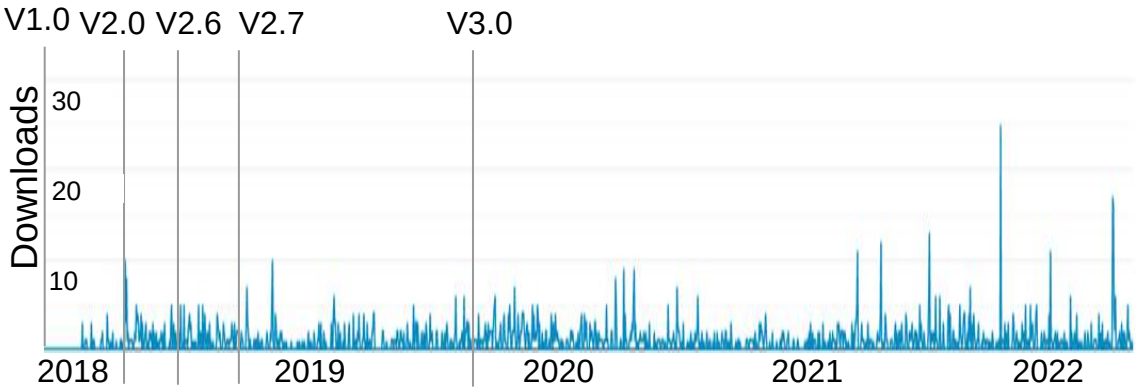
- Generate lead field

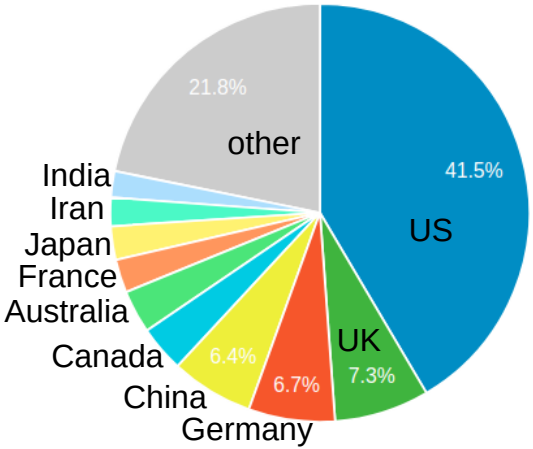
  roast('example/MNI152_T1_1mm.nii','leadField','simulationTag','MNI152leadField')

- Targeted stimulation

  roast_target(‘example/MNI152_T1_1mm.nii’,'MNI152leadField',[-48 -8 50],’targetingTag’,’basicDemo’)

Adoptions of ROAST





Nasimova & Huang, 2022

Adoptions of ROAST

Table 1
Clinical studies that used ROAST to model individual heads under different research contexts. Use purposes include: (I) ROI analysis of E-field against clinical outcomes; (II) Visualization of the E-field at ROI; (III) Voxel-based morphometry; (IV) Optimization of the stimulation; (V) Dose control; (VI) Visualization of electrode placement.

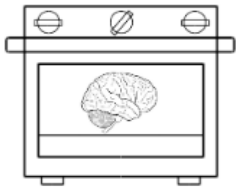
Applications	Number of Subjects Modeled (References)	Use Purposes
Aging effects	N = 587 [22]	(I), (III)
	N = 130 [23]	(I), (II), (V)
	N = 54 [24]	(I), (II), (III)
Alzheimer/Dementia	N = 2 [25]	(II), (III)
	N = 60 [26]	(II), (III), (VI)
Brain tumor/lesion	N = 2 [27]	(I), (II)
	N = 2 [28]	(II), (VI)
	N = 8 [29]	(I), (II), (VI)
Cerebellar stimulation	N = 4 [30]	(I), (II), (VI)
	N = 12 [31]	(I), (II), (VI)
	N = 18 [32]	(I), (III), (IV)
	N = 10 [33]	(I), (III), (IV)
	N = 12 [34]	(I), (III), (IV)
	N = 25 [35]	(I), (III), (IV)
Cognition	N = 16 [36]	(I), (II), (VI)
Depression	N = 151 [37]	(I)
Epilepsy	N = 2 [38]	(I)
	N = 12 [39]	(I), (II), (VI)
Functional connectivity	N = 10 [40]	(I), (II)
Inter-individual variability	N = 57 [41]	(I), (II), (IV), (V) (VI)
	N = 50 [42]	(I), (II), (V), (VI)
	N = 14 [43]	(I), (II), (VI)
	N = 2 [44]	(I), (IV)
	N = 32 [45]	(II)
	N = 47 [46]	(I)
	N = 60 [47]	(I)
	N = 240 [48]	(I), (II), (III), (VI)
	N = 29 [49]	(I), (V)
	N = 47 [50]	(I), (V)
	N = 15 [51]	(II), (VI)
	N = 90 [52]	(II), (V), (VI)
Schizophrenia	N = 21 [53]	(I), (II), (VI)
	N = 17 [54]	(I)
Substance use disorder	N = 5 [55,56]	(II), (IV), (V), (VI)
Working memory and attention	N = 15 [57]	(I), (II)
Total	N = 1858	

- 225 articles reviewed
- 94 clinical TES studies used ROAST
- 1800+ individual heads modeled for 30+ clinical applications
- 1800+ weeks of time saved
- Similar E-field found across studies at the same brain area under same or similar stimulation montages

Nasimova & Huang, 2022

Why ROAST?

ROAST



Realistic vOlumetric Approach to Simulate TES

Why vOlumetric?

SimNIBS V1
by Axel Thielscher
2011

BET → gmsh →

ROAST
2017

SPM → ISO2MESH →

getDP

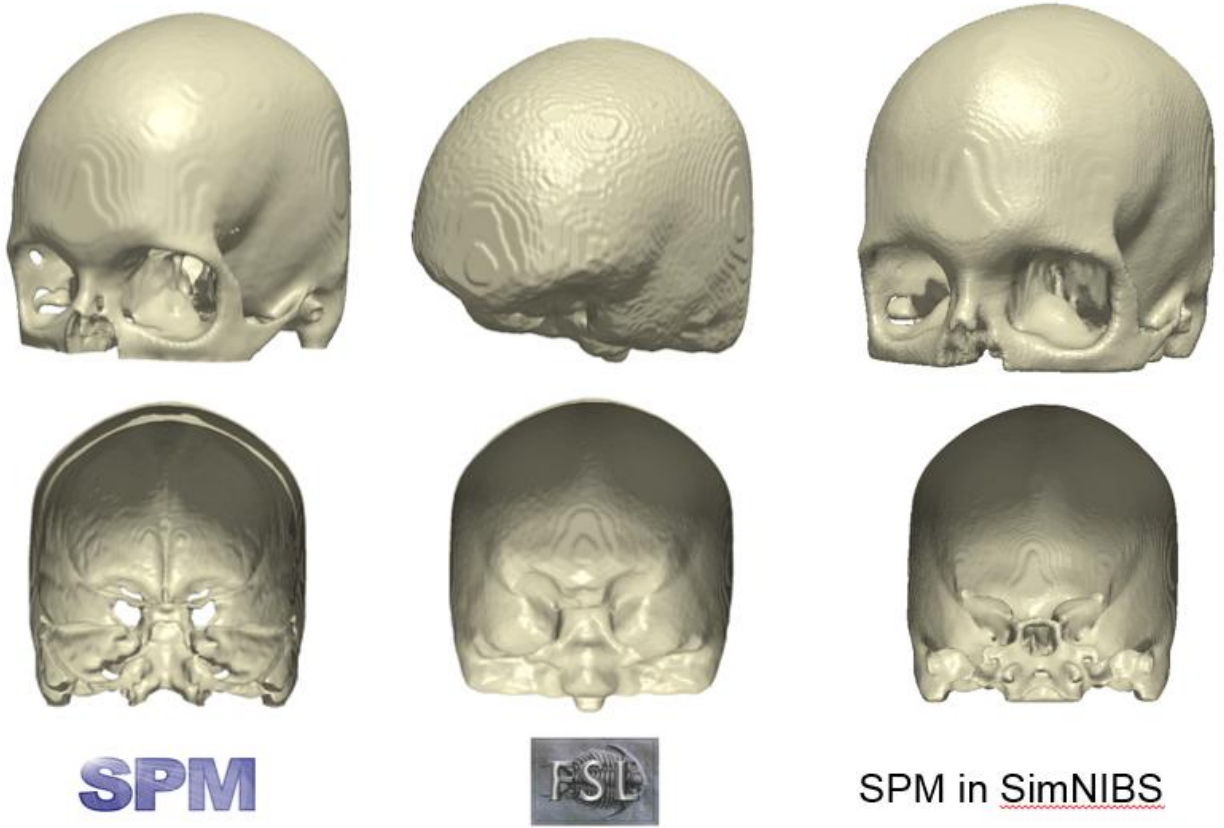
SimNIBS V2
2018

SPM →

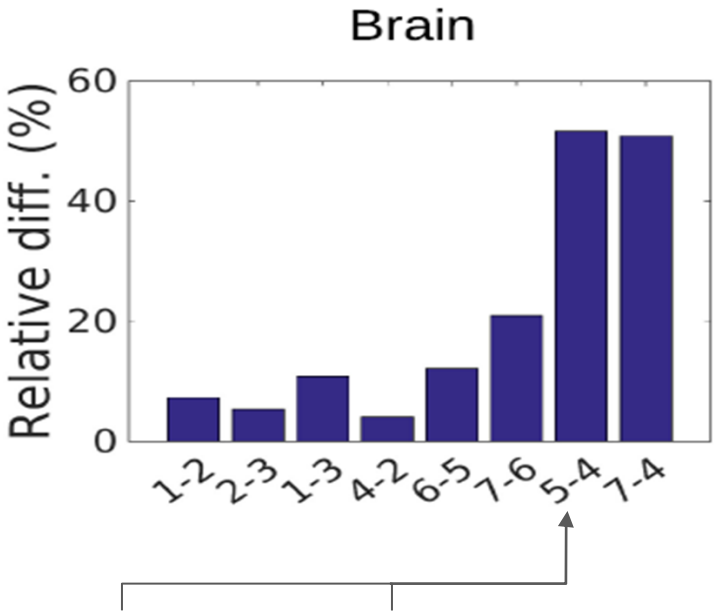
gmsh →

getDP

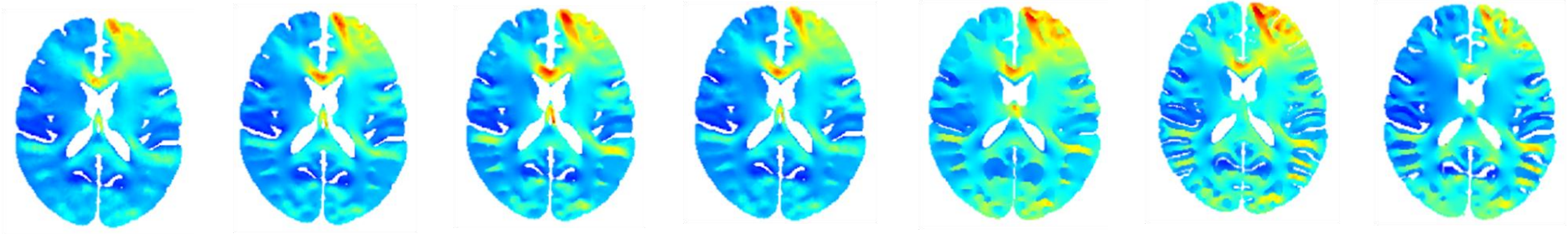
Why Realistic?



Difference from two approaches



(1) ROAST (2) ROAST-sg (3) ROAST-sa (4) ROAST-gg (5) SimNIBS-hr (6) SimNIBS-hrE (7) SimNIBS-mm



Huang et al., 2019

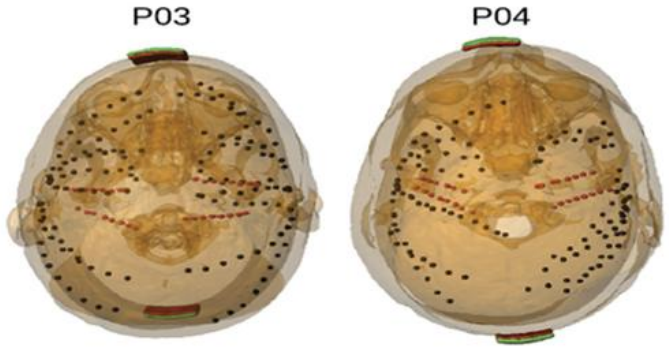
Can we trust all these models?

Model validation

NYU School of Medicine
NYU LANGONE MEDICAL CENTER

Anli Liu

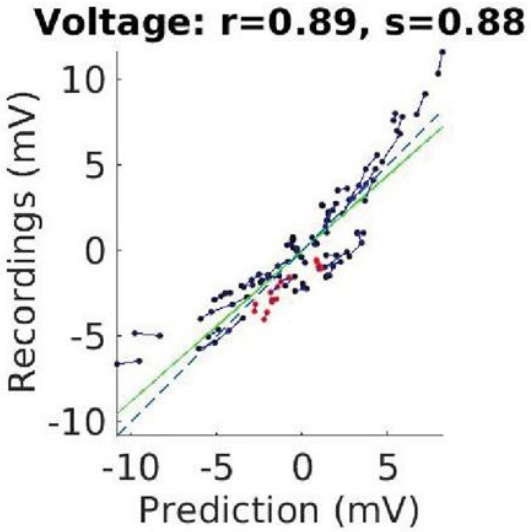
Daniel Friedman

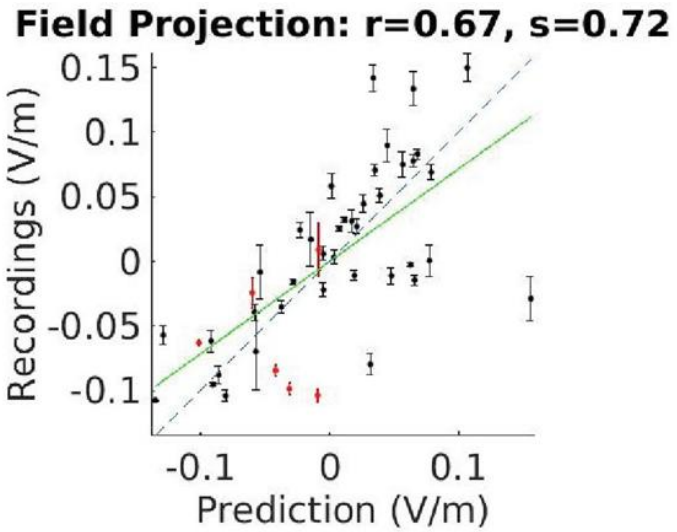


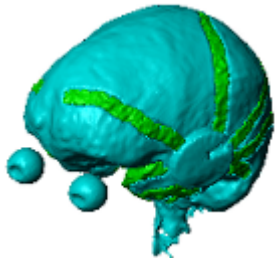
- 10 patients under iEEG
- ~130 recording electrodes per patient

Huang, Liu, et al, *eLife*, 2017

Validation results





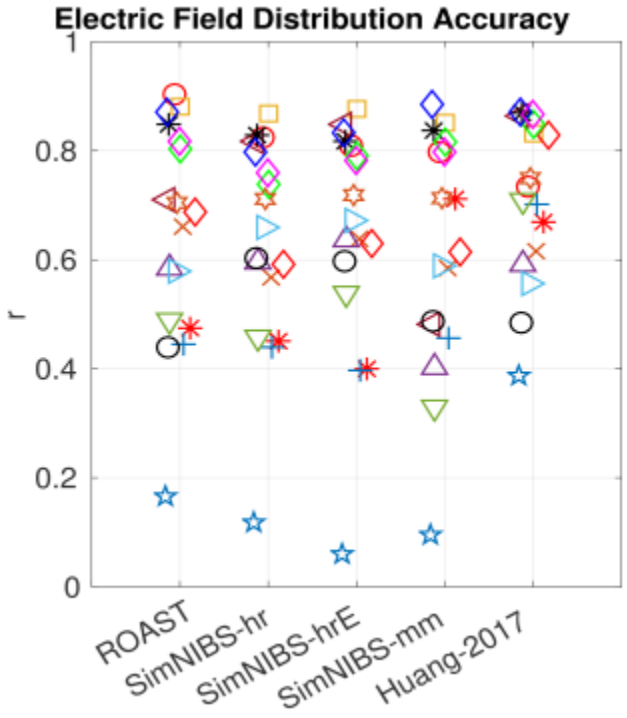


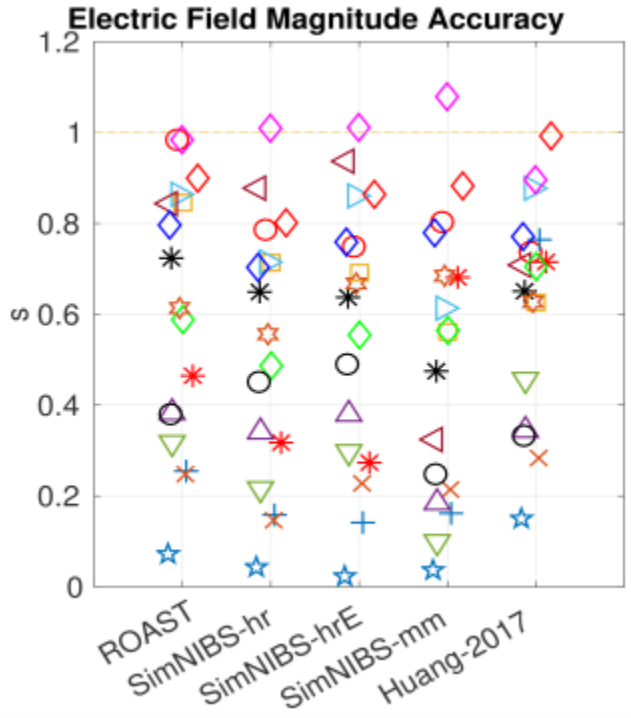
Relative distribution patterns well predicted (correlation “r”);
Absolute magnitudes roughly estimated by model (slope “s”)

First time validation of TES models!

Huang, Liu, *et al*, eLife, 2017

ROAST vs. SimNIBS





Huang et al., 2019

Future directions

- ROI analysis
- Interface with other open-source software: Brainstorm, Freesurfer
- Interface for importing customized segmentation
- Integration of modern deep-learning engine
- Development of a platform that allows calibration of tissue conductivities

Resources

Code repo: https://github.com/andypotatohy/roast

Documentation: https://github.com/andypotatohy/roast#1-getting-started

Mailing list: https://groups.google.com/group/roast-users/subscribe

Tutorial video: https://www.youtube.com/watch?v=-Yr53o4Sw2Y

Tutorial slides: https://neuromodec.org/nyc-neuromodulation-online-2020/Neuromod2020_ROASTtutorial.pdf

Q & A