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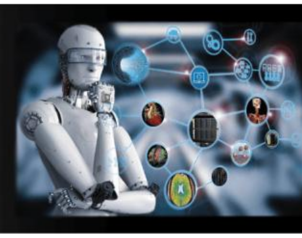

Title

ROAST: an open-source, fully-automated, Realistic vOlumetric-Approach-based Simulator for TES

Authors & Affiliations

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Introduction

Research in the area of transcranial electrical stimulation (TES) often relies on computational models of current flow in the brain. To build such a model, the magnetic resonance images (MRI) of the human head have to be segmented, electrodes have to be placed, the volume is then meshed into a finite element model and solved numerically to estimate the current flow. Various software tools are available for each step, and processing pipelines that connect these tools for batch processing. However, existing pipelines are either not fully automated or difficult to use. Recently SimNIBS (Thielscher et al., 2015) becomes popular for its ease of use, but it's based on the surface approach to represent the anatomy, which is limited to capture detailed structures such as the skull. Here we propose a new software, ROAST, to provide an easy end-to-end solution.

Methods & Results

We put together the segmentation algorithm in SPM8 (Ashburner and Friston, 2005), our in-house Matlab script for segmentation touch-up and automatic electrode placement (Huang et al., 2013), the open-source finite element mesh generator iso2mesh (Fang and Boas, 2009) and solver getDP (Dular et al., 1998). The complete pipeline is a Realistic vOlumetric Approach to Simulate Transcranial electric stimulation and has therefore been named ROAST. We tested it on the MNI-152 standard head (Grabner et al., 2006) and compared the results with those obtained with a commercial mesher and solver (ScanIP and Abaqus), and with SimNIBS. Figure 1 shows an axial brain slice of the electric field distribution from different modeling pipelines. It is evident that the distributions of electric fields are visually quite similar across different pipelines. The quantitative differences for the electric field distributions between these methods are shown in Figure 2. Relative differences in electric fields from using open-source versus commercial meshers and solvers are an average of 20% (Figure 2A–D), with differences in the CSF shooting up over 100% when getDP is used instead of Abaqus (Figure 2B). SimNIBS-generated segmentation gives higher deviations (average 67%, Figure 2E) compared to those from SPM8-generated segmentation.

Conclusion

We release a new, fully-automated TES simulator based on free software (except Matlab). It only gives a 9% difference in predicted electric field distribution in the brain compared to commercial software. The difference is higher (47%) when comparing with SimNIBS, mainly because SimNIBS builds the model based on the surface segmentation of the MRI, as opposed to the volumetric segmentation generated by SPM. We release ROAST at https://www.parralab.org/roast/

Clinical Relevance

Due to its simplicity to use (no need to install any package, just download and run) and fast speed (20 minutes to get a model from MRI of 1mm resolution), it'll allow clinicians to run TES simulations on their own easily and efficiently, compared to using other tools (e.g., SimNIBS and SCIRun).

Presentation category, please mark your preference: [ ]Cancer [ ]Cardiac [ ]Nano [**X**]Neuro

Figures and tables

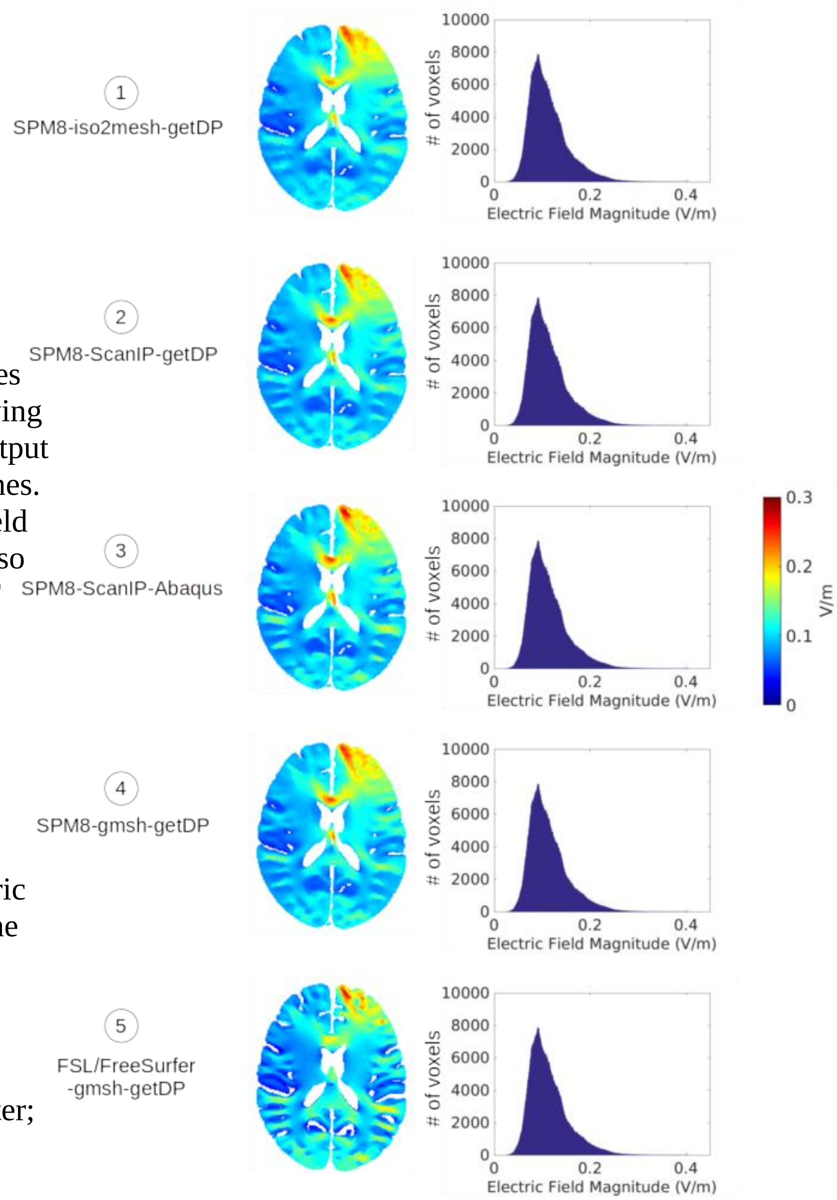

Figure 1: Example brain slices from the MNI152 head showing electric field distributions output by different modeling pipelines. Histograms of the electric field magnitude in the brain are also shown. Pipeline 1 is ROAST and Pipeline 5 is SimNIBS.

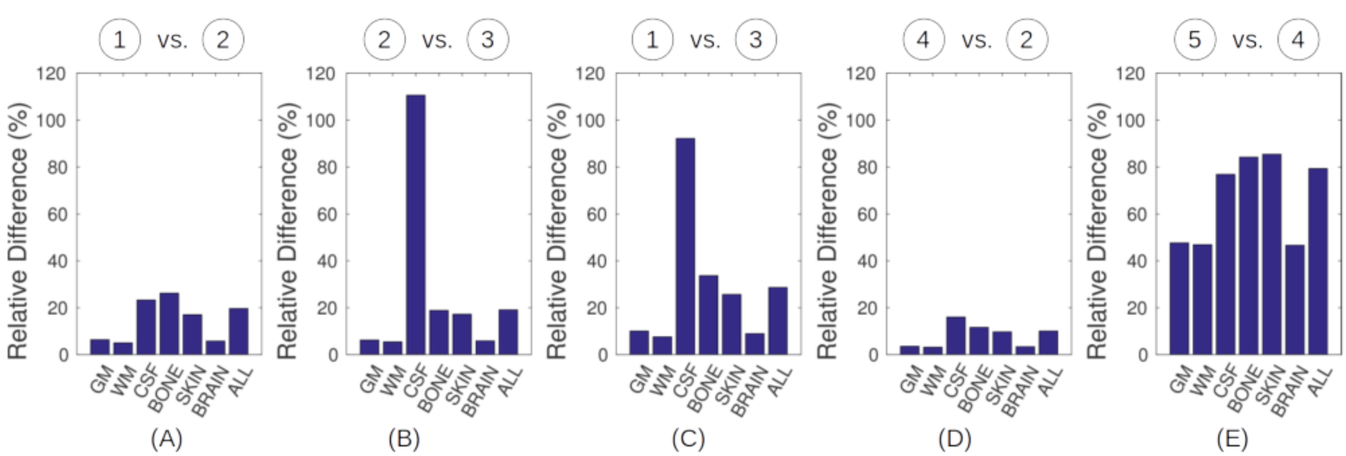

Figure 2: Difference in electric field distributions between the pipelines in Figure 1.
GM: gray matter; WM: white matter; CSF: cerebrospinal fluid; BRAIN: gray and white matter; ALL: all the tissues.