ROAST-target: An open-source software tool for targeting transcranial electric stimulation

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Synopsis

Several optimization algorithms have been published for the spatial targeting of transcranial electric stimulation (TES), and multi-electrode high-definition TES (HD-TES). Here we release for the first time the implementation of our various targeting algorithms [1-3] as part of ROAST, an easy-to use, freely available, open-source software package [4]. With a single function, “roast_target”, users can determine an electrode montage that will optimally target a desired location in the brain with a desired optimality criterion. ROAST can now also generate the lead field matrix required for targeting in a fully-automated fashion. We believe this code release will make individualized TES montages more broadly available and promote rational clinical trial design using multi-electrode montages.

Background

Transcranial electric stimulation (TES) delivers weak electric current into the brain with the aim of modulating neural activity. Electrode placement provides substantial flexibility for targeting specific brain areas, in particular if arrays of electrodes are used. Significant efforts have been invested to computationally optimize where to place those electrodes and how much current to apply to each [1-3,5-8]. While the algorithms for targeted TES have been designed, implemented and tested extensively with robust results, to the best of our knowledge, they have not yet been publicly released. Currently TES researchers use commercial software solutions [9] or have to implement the algorithms on their own, which requires significant computational know-how.

Methods

Here we release our implementation of computational targeting following our work of the past several years [1-3]. The targeting algorithms are fully integrated in our existing open-source software package ROAST [4]. We put optimization criteria such as maximal-intensity and maximal-focality into a single function called “roast_target”. Users can also provide other advanced options to this function such as the desired direction of optimized current flow at the target, and specific algorithms for optimizing electrode montages. They can also ask “roast_target” to guide the current flow to either single-site target or multi-site targets, or determine the field orientation that achieves maximal intensity at the target. Moreover, to generate the model necessary for algorithmic optimization, a new feature was added to ROAST that can automatically generate the prerequisite lead-field matrix. This matrix contains the electric field distribution generated by each electrode of an array relative to a common reference [10]. The lead-field can now be readily generated for individual heads starting with their anatomical MRI.

Results

The targeting code is released into ROAST Version 3, available at https://www.parralab.org/roast/. In the process of segmentation ROAST aligns the individual head anatomy to the standard MNI coordinate space. All that is required for individual targeting is the desired MNI coordinate and an anatomical MRI of the individual subject. Therefore, it is now feasible to perform individual targeting across large number of individuals.

Discussion

We believe this code release will make individualized TES montages more broadly available. This should allow investigators to more readily deploy high-definition multi-electrode arrays into their studies (e.g. HD-tDCS) and thus promote rational clinical trial design.

Acknowledgments:
This work was supported by NIH grants R44-NS092144, R01-MH111896, R01-NS095123 and Soterix Medical, Inc.

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