Optimization of Electrode Positions for Multi-Electrodes tES for Deep Brain Stimulations

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Transcranial electrical stimulation (tES), which modulates neural activity by applying a weak direct current by a pair of electrodes attached to the head [1], has been widely applied to a treatments well as neuroscience in recent years. The tES can stimulate not only a brain surface surrounding the electrodes but also deep brain regions because the current is distributed over a head [2]. To improve focalization in tES, multi-electrodes tES, in which multiple electrode pairs are attached to the head, has been investigated [3]. However, there are numerous combinations of electrode pairs and current ratios, and thus to find the optimal solution with a brute-force method required a huge computational costs and time. Therefore, optimization algorithms to overcome this difficulty is required [4].

In this study, we proposed a fast optimization for electrode current ratio targeted deep brain regions (Fig. 1a) for 19 patterns of electrode attachment based on the international 10-20 system, using the restricted least squares method. Our proposal for optization is based on surface data of the electric field as input values in the lilmited least squares method to explore all combinations. Head models for twenty healthy subjects are used and the target area was chosen as the right accumubens as an example in this study. First, the electric field distribution for each electrode pair is computed using the scalar-potential finite-difference (SPFD) method [5]. Then, the above proposal is applied for optimizaton. The optimization results were confirmed at a group level. The distributions of normalized electric field strength (Fig. 1b) shows that higher EF is focused on the target in the optimization using the surface data as input. The box chart (Fig. 1c) shows optimization using the surface data has less variability and a higher mean value. Thus, we consider that the surface data as input for optimization is more suitable for stimulating a target in deep brain region.

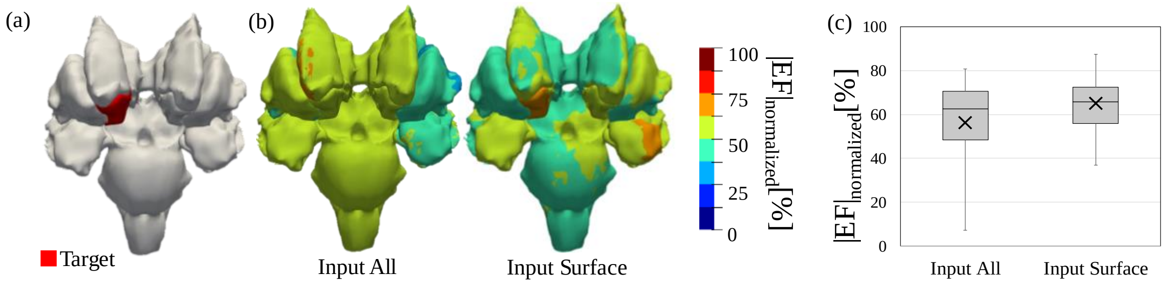

Figure 1. (a) Target in deep brain regions, (b) distribution of normalized electric field strength in deep brain regions and (c) box plot of normalized electric field in target area averaged over head models for twenty subjects.

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References

[1] M. A. Nitsche and W. Paulu, "Excitability changes induced in the human motor cortex by weak transcranial direct current stimulation", *J Physiol*, 527, 3, Septenver 2000, pp.633–639

[2] J. Gomes-Tames, A. Asai and A. Hirata et al, "Significant group-level hotspots found in deep brain regions during transcranial direct current stimulation (tDCS): A computational analysis of electric fields", *Clinical Neurophysiology*, 131, 3, February 2020, pp.755-765.

[3] J. P. Dmochowski1, A. Datta and M. Bikson, "Optimized multi-electrode stimulation increases focality and intensity at target" Journal of Neural Engineering. 8, 4, June 2011, pp.16-639.

[4] Y. Huang, C. Thomas and A. Datta, et al., " Optimized tDCS for Targeting Multiple Brain Regions: An Integrated Implementation ", *2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, July 2018, pp.3545-3548.

[5] T. W. Dawson et al., "Analytic validation of a three-dimensional scalar-potential finite-difference code for low-frequency magnetic induction", *Applied Computational Electromagnetics Society Journal*, 11, 3, November 1996, pp.72–81.