Representation and Deep Learning on Brain Surface Data for Transcranial Magnetic Stimulation

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The results of this project could enable real-time targeted transcranial magnetic stimulation (TMS) to become a clinical reality, improving outcomes for patients with depression, schizophrenia, and other neurological disorders. I propose two novel pipelines for TMS field prediction by learning on brain surface data. Previous methods used for this type of modeling, including finite element modeling (FEM)-based approaches, can take many hours to converge to a solution, rendering them unusable in real time clinical settings. The methods I have developed have clear advantages, including increased processing and prediction speed, with marginal tradeoff in accuracy. Specifically, my methods run in real-time (on the scale of milliseconds) with a normalized error of 0.31% relative to the gold standard. TMS has emerged as a promising noninvasive therapy for many neurological disorders. A magnetic coil induces electrical currents in the brain, which in turn stimulates brain activity. For TMS therapy to be more effective, it needs to be highly targeted to the region of interest (ROI) and personalized with adjustments able to be made on the spot. Current methods to simulate the electrical field induced by TMS magnetic coil position are inefficient. A few months ago, the first paper that used 3D convolutional neural networks (CNN) to predict TMS fields was published. However, that method remains inefficient and inaccurate due to the difficulty of working with brain volumetric data. My methods, by using brain surface data, circumvent these weaknesses and enable the potential of more effectively targeted TMS to become a reality.