Contrast Source Electromagnetics Solver for Neurostimulation

M.J.R.A. van Rossum, R.M.C. Mestrom, A.G. Tijhuis, R.M.H. Besseling.

Eindhoven University of Technology

January 31, 2017

Transcranal Magnetic Stimulation (TMS) is a type of neurostimulation that equips a loop antenna to generate a magnetic field that penetrates the skull. In practice, TMS is used to treat patients with a depressive disorder. Additionally, clinical trials are being conducted to explore the benefits for other mental health conditions. Even though TMS is used in practice, the underlying neuronal activation mechanism(s) are unclear. Detailed knowledge of how the electromagnetic fields generated by TMS couple into the nervous tissue is vital to enhance our understanding and improve the clinical efficacy.

A computational electromagnetic model for these fields inside the human head is a first step to do this. To achieve an accurate computation of the electromagnetic field, a contrast source approach is used. This can be seen as the effect an object (e.g. a human head) has on an electromagnetic field distribution in free space (e.g. that was generated by a TMS antenna). The object is considered as the source of the perturbation in the electromagnetic field in free space. The difference in material properties between free space and the object may then be considered as the contrast.
The electromagnetic fields are computed iteratively by means of a conjugate gradient scheme. Starting from the solution in vacuum (which is determined analytically) we quickly converge to solution using the electromagnetic contrast in material parameters.

The result is a voxel-based computational model for the electromagnetic fields. In addition, the model includes the option of "marching on in anything". With this method we quickly compute the new electromagnetic field after a small update in simulation parameters. Currently, we are working on an efficient implementation of the field excitation.