Collection of Sixteen High-Quality Human Head CAD Models Generated with SimNIBS 2.1 Using Connectome Subject Data within MATLAB Platform

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Introduction: For all neurostimulation modalities, numerical computation of the electric fields within a head model is the major and often only way to foster spatial targeting and obtain a quantitative measure of the required stimulation dose [1]. Several open-source software packages currently exist [2] that allow for automatic and semiautomatic generation of realistic CAD head models from individual MRI datasets. At the same time, generic computational cranium models continue to remain important for population-based studies as well as for testing accuracy, speed, and performance of numerical algorithms and software packages. The goal of this study is to present a collection of sixteen high-resolution, 2-manifold, CAD compatible head models available to all interested parties for electromagnetic and acoustic simulations. Each model contains high-resolution skin, skull, CSF, GM, cerebellum, WM, and ventricles compartments and is available via MATLAB Central at https://www.mathworks.com/matlabcentral/fileexchange/69517-collection-of-sixteen-high-quality-human-head-cad-models.

Materials and Methods: The MRI data were kindly provided by the Human Connectome Project [3], WU-Minn Consortium (PIs: David Van Essen and Kamil Ugurbil; 1U54MH091657) funded by the NIH Blueprint for Neuroscience Research; and by the McDonnell Center for Systems Neuroscience at Washington University. The T1 and T2 image files of the Connectome database were used as input for the automatic SimNIB 2.1.1 segmentation pipeline. After independently segmenting all fifty subjects used in the Population Head Repository (PHR) [4], a visual inspection of the skull segmentation quality has been performed and sixteen “acceptable” models have been retained. Figure 1 shows examples of acceptable and unacceptable outer skull shells. In contrast to the PHR, we did not perform any mesh postprocessing with MeshMixer. The postprocessing conducted as part of the PHR was focused on the skin (reducing mesh resolution) and the skull, and resulted in the appearance of some undesirable non-manifold features for both objects.

Results and Discussion: The average total number of facets per head dataset is 866,000. The average mesh quality over all compartments of all datasets is remarkably high and equal to 0.25. The average edge length over all compartments of all datasets is 1.5 mm. The average mesh resolution in points/mm² over all compartments of all datasets is 0.6 points per mm². To ensure CAD criteria were met, the mesh checker of the commercial FEM software ANSYS Electronics Desktop 2018.1 using the “strict” check level was applied. Each head compartment of every dataset has been checked and all the surface meshes passed the ANSYS check without errors.

Translational Impact: Compared to the PHR, we have doubled the resolution and increased triangle quality for the skin surface. Also, all present CAD meshes are 2-manifold. Our data are accompanied by a MATLAB code generating head cross-sections in any plane. Application examples pertinent to neurostimulation will be presented.

References:


