Realistic Human Head Model for Simulating the Effect of Electrical Stimulation

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Introduction: Using a Realistic Human Head model to simulate the effect of electrical stimulation. This can be useful in understanding field distribution in the brain and therefore, the actual point of stimulation before doing it on human subject. With the help of this model, parameters like the stimulus strength as well as electrode placement and its effect can be tested much more easily while targeting a specific location in the brain model.
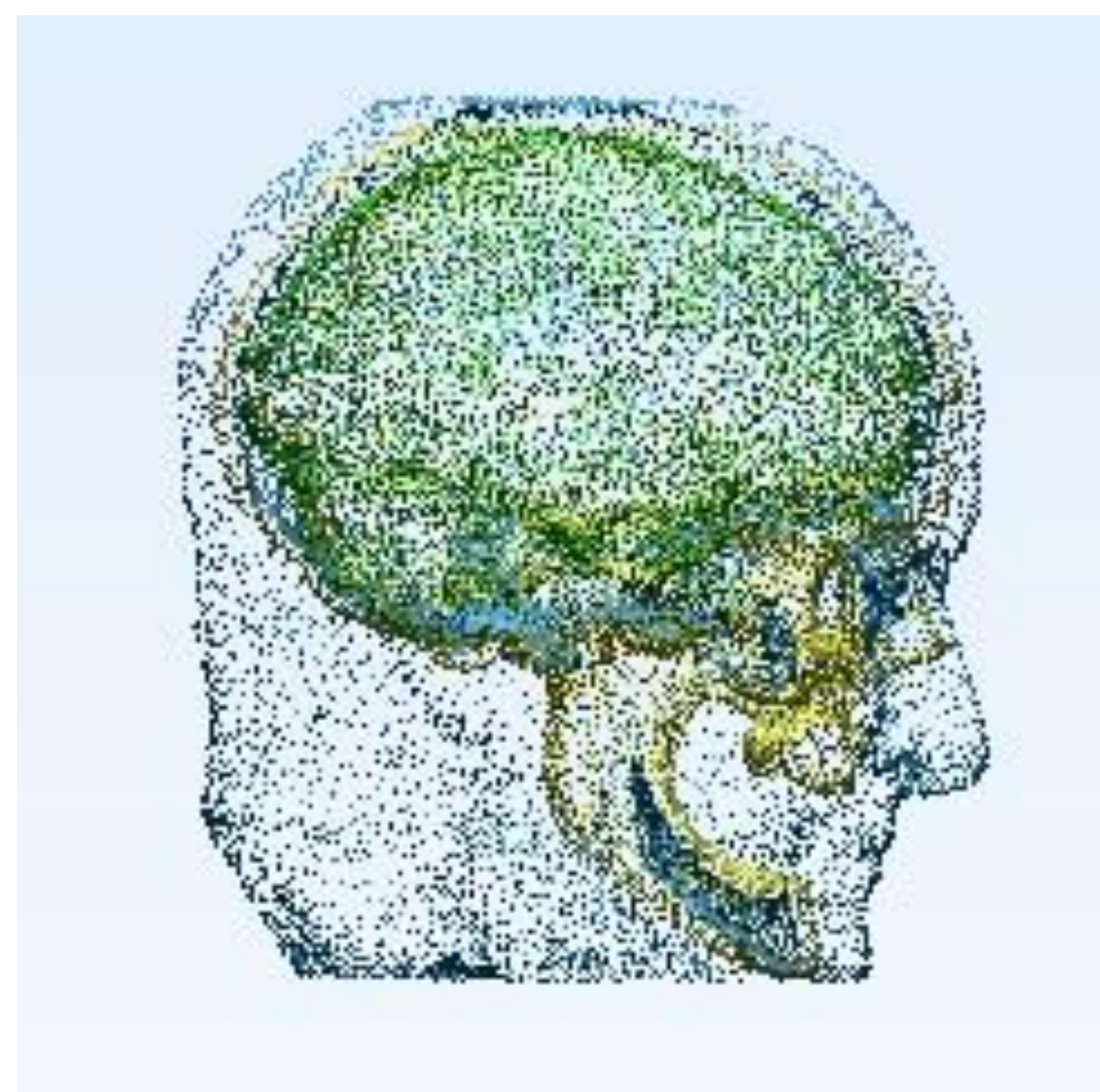

Figure 1. Side view of the model

Computational Methods: Development of this model requires two software – ITK SNAP and COMSOL. ITK SNAP along with Meshlab is used for creating Volume meshes from MRI/CT images. Obtained Volume meshes are imported into COMSOL for simulation and analysis. Electrical current and Electrical circuit interfaces of AC/DC module and a Time dependent study has been used for this model.

Two electrodes were used for generating the required pulse waveform. Then depending upon the part of the brain to be stimulated, the Electrodes position and waveform properties were optimized so as to get accurate information.

$$\nabla \cdot \mathbf{J} = Q_j$$

$$\mathbf{J} = \sigma \mathbf{E} + \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J_e}$$

$$\mathbf{E} = -\nabla V$$

In this study, Human head was divided into three parts namely Brain, Bone and the remaining part as a whole. 3D assembly of Head was successfully built and used for simulation and analysis.
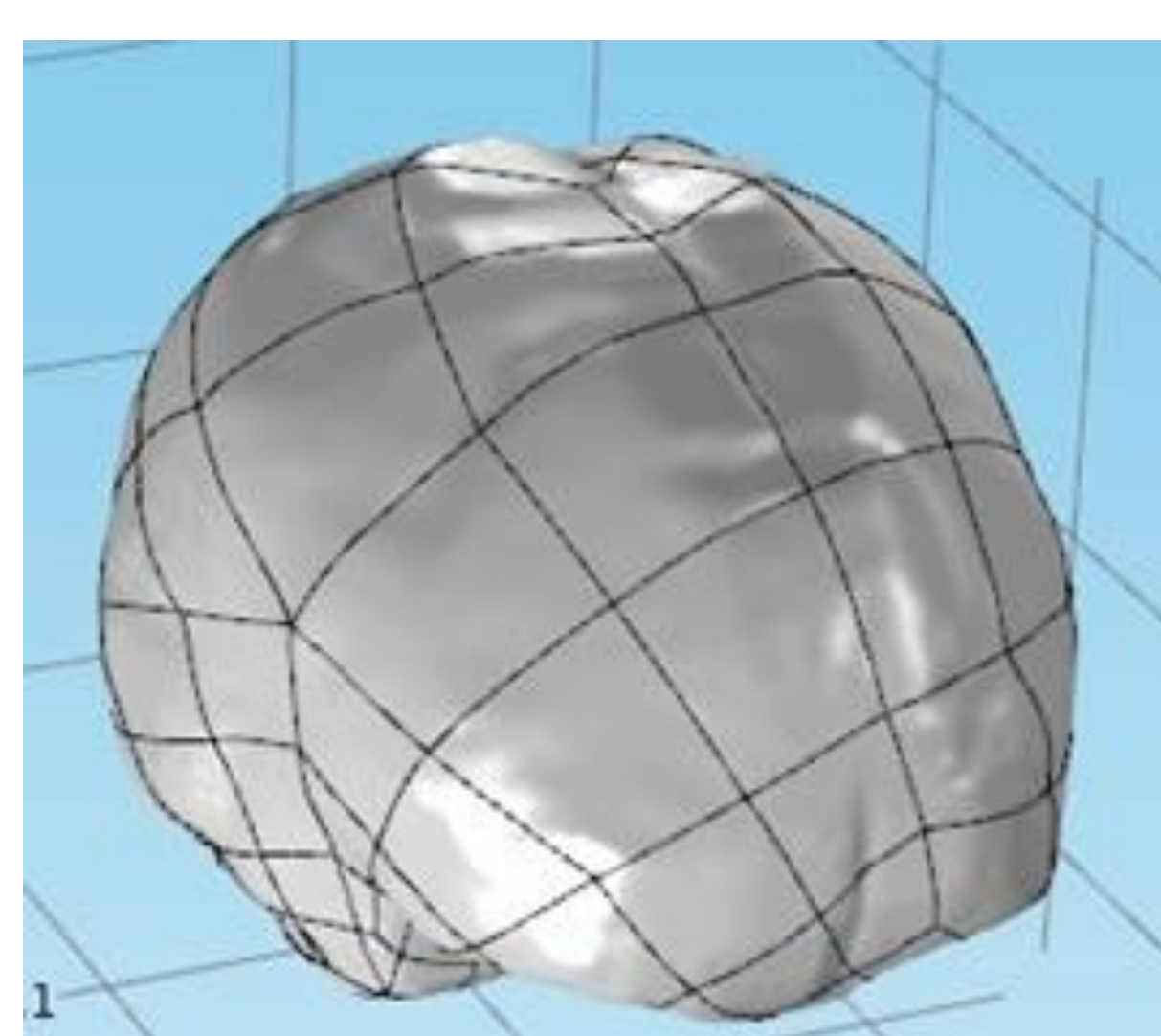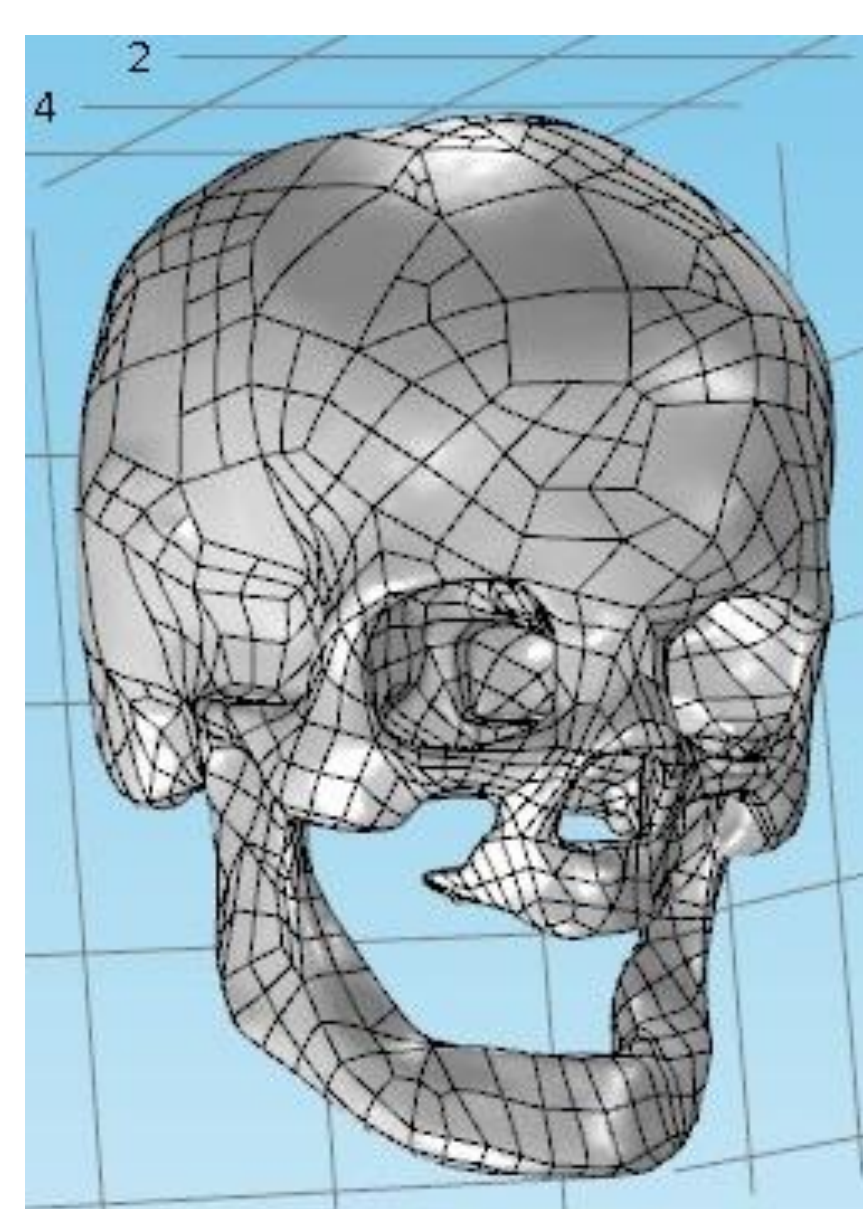
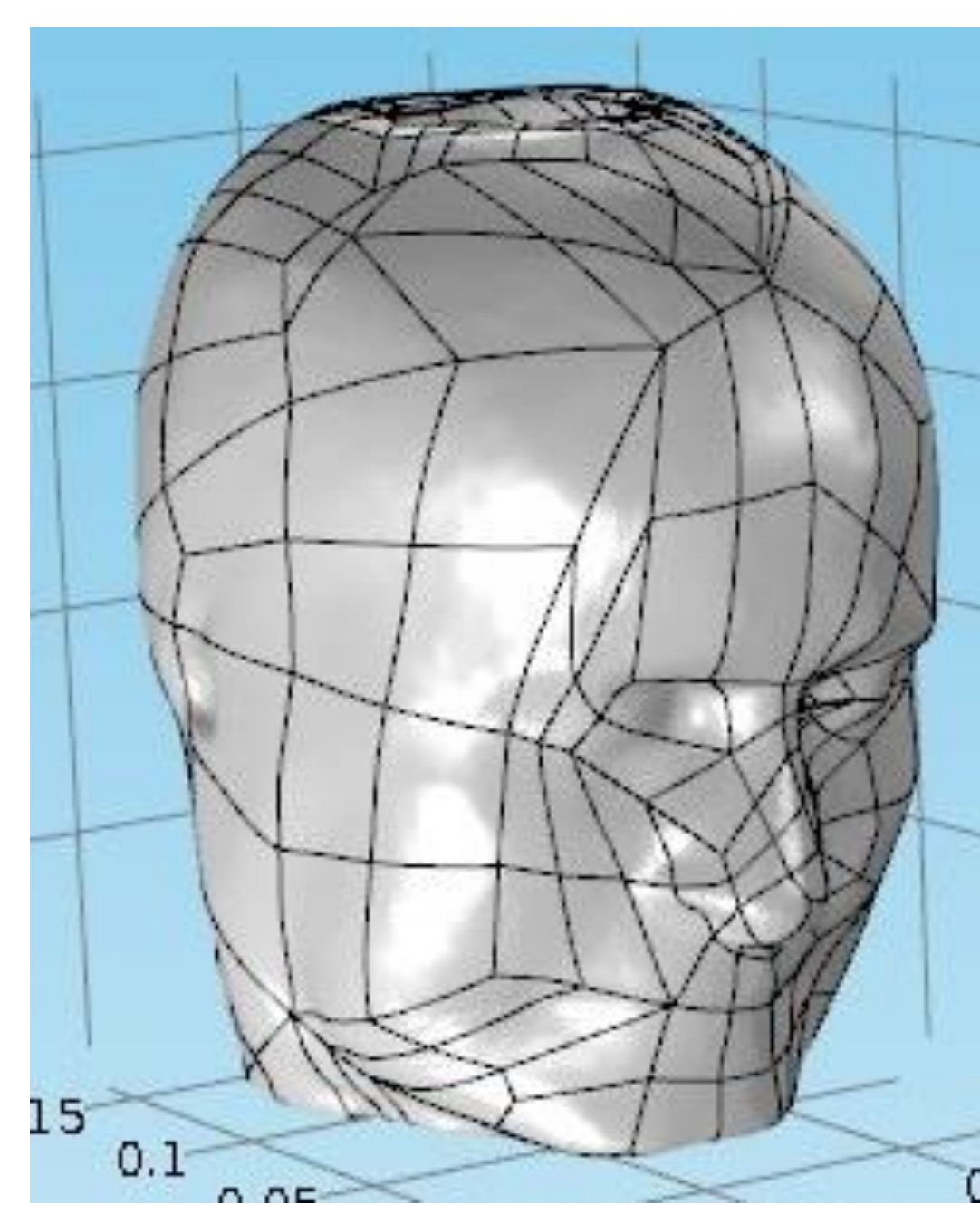

Figure 2. Brain

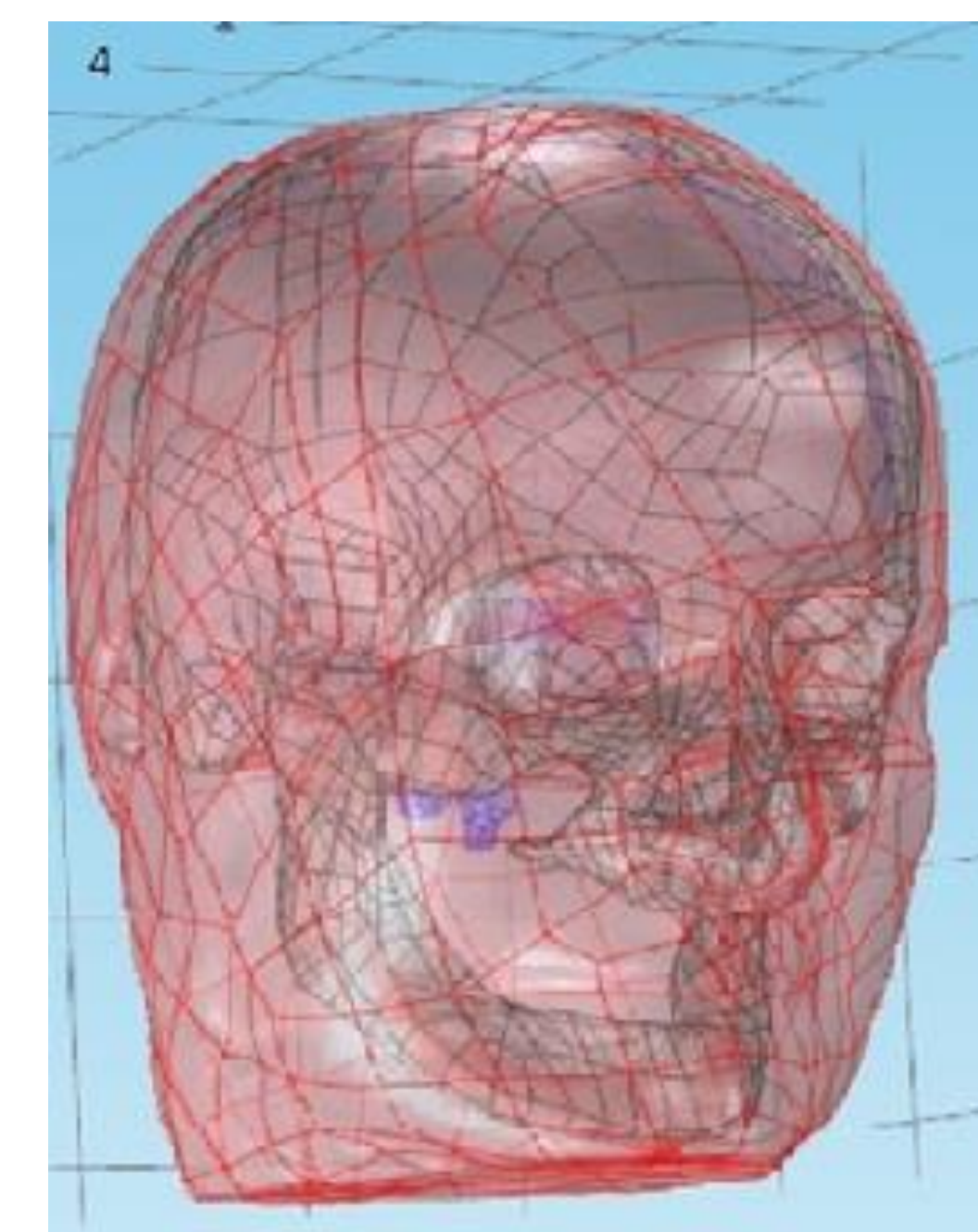**Figure 3**. Bone

Figure 4. Remaining part

Figure 5. Final Assembly

Results: Sample simulations of the models are shown below. Electrical Current interface from AC/DC module was used for simulation purpose. The simulations were successful and error free except for the simulation of the entire assembly which requires extensive computation. The models from this research can be very helpful in the medical field as an aid before stimulating patient
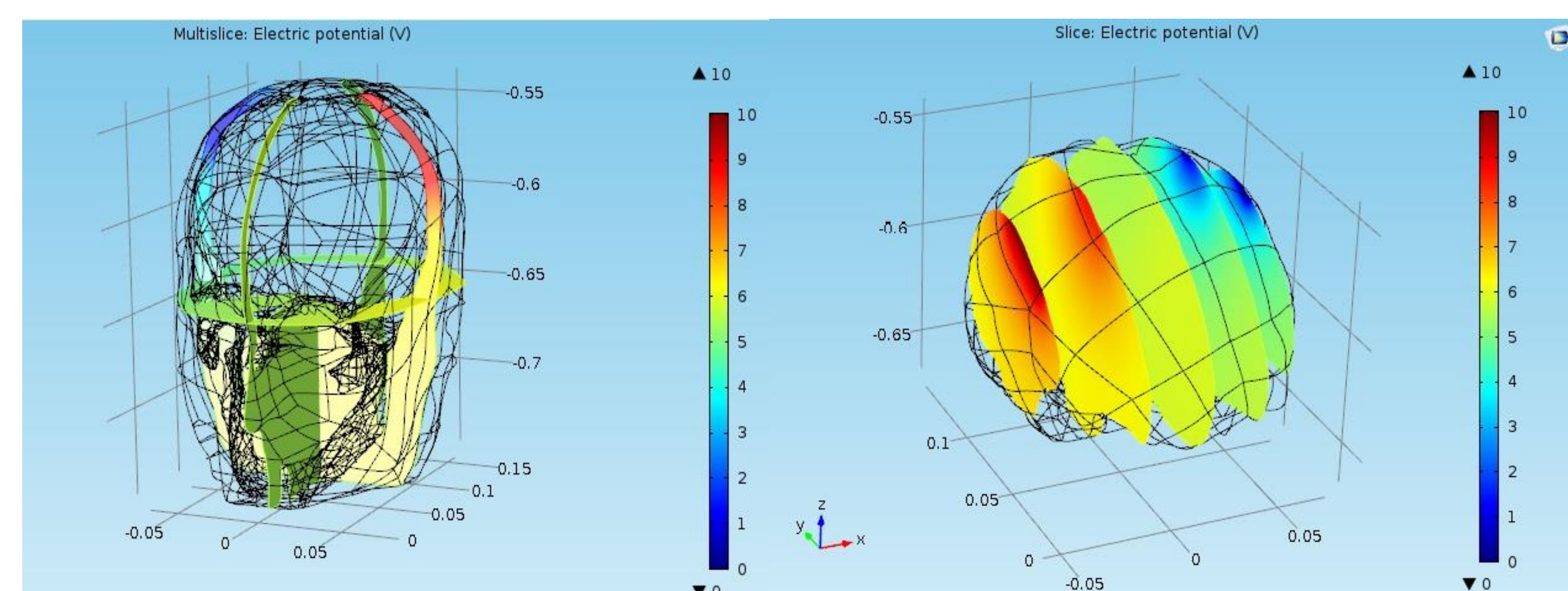

Figure 6 Sample simulation of Head without brain

Figure 7. Sample simulation of brain

Conclusions: This model provides useful insight about the effect of electrical stimulation. This model can also be used in Magnetic stimulation and Radio Frequency applications, as COMSOL has specific Physics defined for those purposes.

References:

1. http://hpc.mtech.edu/comsol/pdf/ACDC_Module/ACDCModuleUsersGuide.pdf
2. http://www.lmn.pub.ro/~daniel/ElectromagneticModelingDoctoral/Books/COMSOL4.3/acdc/IntroductionToACDCModule.pdf
3. http://www.lmn.pub.ro/~daniel/ElectromagneticModelingDoctoral/Books/COMSOL4.3/mph/PhysicsInterfaceBuilderUsersGuide.pdf
4. http://plato.fab.hs-rm.de/web-mathematik/mathematik/semester7/modellierung/COMSOLMultiphysicsReferenceGuide.pdf