Numerical Evaluation of the Polarizability Tensors of Stem Cells with Realistic 3D Shapes

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Abstract

Most of the reported studies on the electrical characteristics of biological cells assume that they have simple shapes like spheres or ellipsoids due to the lack of information about their accurate 3D shape. However, the actual shape of a cell can be quite fractal and it must be taken into consideration when trying to accurately predict the response of a cell to an electric stimulus. With the recent advancement of microscopic imaging technique, cell culture engineering and segmentation algorithm, it is now possible to accurately reconstruct the 3D shape of a biological cell. In this study, we are computationally studying the electrical properties of stem cells obtained from a database of three-dimensional (3D) stem cell shapes developed by the National Institute of Standards and Technology. Since the cell shapes in the database are quite complex, there are no closed form equations for their electrical properties. Therefore, we use the COMSOL Multiphysics® software to calculate the polarizability tensors of these cell shapes and compare with an independent numerical technique to validate the accuracy of the results. We performed this numerical evaluation using the Electrostatics physics interface within the AC/DC module. The results and the approach presented in this study can be used to shed the light on the electrical properties of biological cells in a wide range of applications.

Figures used in the abstract

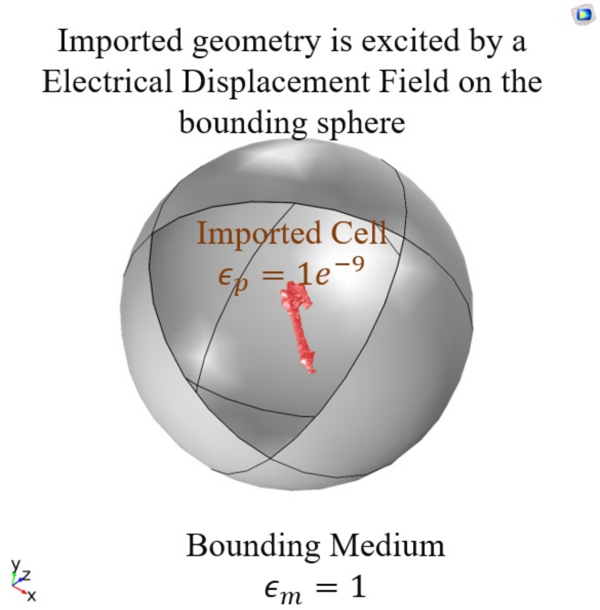

Figure 1: Pictorial depiction of the simulation setup (figure not drawn to scale). The imported cell geometry is bounded in a sphere of at least 25 times larger than the size of the cell to replicate free space condition. The excitation is provided by simulating an "Electric Displacement Field" on the bounding sphere.