

## Generating Realistic Meshes of Neuron Models

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Brain cells, known as neurons, transmit electrical signals upon receiving sufficient stimulation. These signals can be modulated using device electric fields (E-fields) for therapeutic benefit. Treatments such as transcranial magnetic stimulation (TMS) rely on coils and electrodes to stimulate the brain, treating depression, smoking addiction, and obsessive-compulsive disorder. *In silico* models relying on our in-house adjoint boundary element method (BEM) solver can be used to fully couple membrane electric currents with device E-fields (Czerwonky *et al*, "Integral Equation for Analyzing Neuron Response to Non-invasive Electromagnetic Brain Stimulation," *ACES 2023*). However, it requires watertight meshes of neuron geometry. We present several algorithms for generating meshes of realistic neuron morphologies and stimulating them using BEM.

First, we present a method for converting filamentary compartment neuron models into triangle meshes using an algorithm that adds thicknesses to the neuron compartments. The algorithm meshes each compartment individually and then the compartments are merged to generate a watertight mesh with no overlapping triangles (G. W. Hart, "Sculptural forms from hyperbolic tessellations," *2008 IEEE International Conference on Shape Modeling and Applications*, Stony Brook, NY, USA, 2008, pp. 155-161).

Second, we present a method for generating realistic soma meshes. The method creates realistic cell bodies (i.e. somas) by deforming a unit sphere mesh (K. Erleben, J. Sporring, K. Henriksen, and H. Dohlmann, "The finite element method," in *Physics-based Animation*, Charles River Media, 2005, pp. 335–368) and (J. J. Garcia-Cantero, J. P. Brito, S. Mata, S. Bayona, and L. Pastor, "NeuroTessMesh: A tool for the generation and visualization of neuron meshes and adaptive on-the-fly refinement," *Frontiers in Neuroinformatics*, vol. 11, p. 38, 2017). We define points along the surface where axons (cell branches) will be connected, then define vectors from the origin to the specified points. We multiply the vectors by a scalar to define the extent of which we wish to stretch the surface, then compute the element stiffness matrix to stretch the mesh along the specified radius and vector. Finally, we present a method to incorporate dendritic spines into the cell, as well as considering non-cylindrical cross-section.

We present results of how the geometric factors affect the effects E-fields have on neurons. We consider the amount of E-field required to activate a neuron (i.e., activation threshold) as a function of geometric complexity of the neuron. Ultimately, the new framework enables us to determine the important geometrical factors that are determinant of stimulation of a neuron cell by an impinging E-field.