Simulation of Bioelectromagnetic Variation Caused by Variability in Tissue Properties Using the Stochastic FDTD (S-FDTD) Method

Lecturer: Cynthia Furse (Acknowledgment: Khadijeh Masumnia-Bisheh)
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Abstract
Bioelectromagnetic simulations typically use average tissue properties (relative permittivity and permeability) and determine average electromagnetic fields in and around the body, head, etc. from various electromagnetic sources. However, tissue properties vary depending on the individual (age, gender, health, hydration, etc.) and at different locations within the body or organ, and their measurements are subject to various types of potential errors and uncertainty. Uncertainty and variability of the tissue properties leads to uncertainty and variability in the electromagnetic fields, which can be substantial. The traditional method for assessing uncertainty is the Monte Carlo method, which performs numerous (often thousands) of simulations, each with a combination of varying tissue properties, and yields the fields from each combination, which can then be used to determine the mean and standard deviation of these fields. For bioelectromagnetic simulations, which often take hours to run a single high resolution simulation, this method can be untenable. The stochastic finite difference time domain (S-FDTD) method was developed to estimate the variation in fields from the variability and uncertainty in the tissue properties from a single simulation, which is orders of magnitude faster than the Monte Carlo method. In this tutorial, we'll discuss how this method is derived and applied in bioelectromagnetic simulations, and also give a brief summary of some of the other applications of this method.

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Cynthia M. Furse is a Distinguished Professor of Electrical and Computer Engineering at the University of Utah. She applies electromagnetics to sensing and communication in complex lossy media such as the human body, geophysics, ionospheric plasma, and aircraft wiring. She is a Fellow of the IEEE, the National Academy of Inventors, and the Applied Computational Electromagnetics Society and has received numerous teaching and research awards including the 2020 IEEE Chen To Tai Distinguished Educator Award.

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