From Cell Phone Interactions to Implantable Neurostimulators: A Journey Through the Field of Bioelectromagnetics in the past 20 years

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Over the past 20 years, progress in biolectromagnetics research has been remarkable. Numerical methods in electromagnetics, capable only of handling very coarse models of the human body two decades ago, have reached the point of allowing us to handle heterogeneuous tissues modeled at μm resolution. Human body model of resolution of several mm, used to simulate the propagation of electromagnetic fields induced in the human body by cell-phones or other wireless devices, have been gradually replaced by ultra-high resolution models, which include details of cell bodies and neural structures. This capability has greatly enhanced our opportunities to gain an insight on the interaction between currents and fields induced by neural implants, for example, and neural structures. The sophistication of the models and the computational methods, enabled by very high resolution imaging techniques, opened exciting opportunities in the field of neuroimplants, neurostimulators, neurorecording systems, and wireless implantable devices.

In this presentation, we will cover some of the recent computational methods and computational models that are proving to be instrumental toward the design of current and future implantable systems. We will discuss recent progress in multiscale computational methods and how the interface between different computational methods operating at different spatial and temporal scales can be implemented to handle models inclusive of detailed features of the neurostimulators and the neural tissue. Application of these techniques to an artificial retina to restore partial vision to the blind, an hippocampus implant, and magnetic implantable stimulators are discussed. Further, we will discuss applications of these methods to the development of wireless telemetry systems for implantable devices and briefly touch on some enabling technologies that may have significant impact on the future development of neurostimulators.