FEM Modeling of Magnetic Stimulation of Neural Tissue by Bidomain

Robert Szmurło, Jacek Starzyński, Bartosz Chaber, Zuzanna Krawczyk
Warsaw University of Technology
robert.szmurlo@ee.pw.edu.pl, jstar@ee.pw.edu.pl,
bartosz.chaber@ee.pw.edu.pl, krawczyz@ee.pw.edu.pl

Abstract

The bidomain model is very well established for modeling cardiac tissue [1,2]. There have been several attempts to adapt the concept of overlaying intra and extracellular tissues to modeling of neural tissue [3,4,5]. Most of the papers focus although on electrical stimulation, which can be directly adapted from heart models. In our research we develop a magnetic FEM model of stimulation. Such stimulation can be for example applied externally during the surgeries in the neighbourhood of the spine to verify if the spine connectivity has not been damaged.

The magnetic stimulation is commonly modeled with vector potential A with Lorentz or Coulomb gauge to find specific solution [6]. These numerical techniques does not work for nonlinear bidomain and for magnetic stimulation we don't have a physiologically or technically justified Dirichlet boundary condition. This results in an ill posed problem. To find a solution we propose to apply a similar to the PML (perfectly matching layer) approach used for solving waves equation. We propose to introduce a Dirichlet boundary condition separated from the tissue by a specially crafted layer preventing current leakage from the model. The bidomain modeling of magnetic stimulation requires additional numerical techniques to converge nonlinear solvers (e.g. operator splitting [2]). In the paper an implementation of the proposed approach using FENICS Project as a basis will be presented.

References

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