SEMINAR NOTICE

Department of Electrical and Systems Engineering

Modeling and Detection of Uterine Contractions using Magnetomyography

PhD Dissertation Defense

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Abstract

We present a novel mathematical framework for modeling and analyzing uterine contractions using magnetomyography (MMG). Uterine MMG uses an array of magnetometers to non-invasively sense, with high spatio-temporal resolution, the magnetic field generated by the contractions. We develop an electromagnetic forward model of myometrial contractions, derive statistical algorithms for automatically detecting uterine contractions from MMG measurements obtained using a clinical magnetic sensor array, and compute performance bounds on the class of unbiased model-based segmentation algorithms used in our detection method.

We introduce a four-compartment volume conductor geometry and use a bidomain approach to model the propagation of the myometrium transmembrane potential. We consider a modified version of the Fitzhugh-Nagumo (FHN) equation for modeling ionic currents in each myocyte, assuming a plateau-type transmembrane potential, and we incorporate the anisotropic nature of the uterus by designing conductivity-tensor fields. We estimate the conductivity tensor values in the extracellular domain using an analytical expression of the transmembrane potential propagation speed, as a function of the model parameters, and Archie's law. We use finite element methods (FEM) to solve our model and present several numerical examples. Our numerical results are in good agreement with experimental values reported in the technical literature.

Our research results are potentially useful for monitoring and characterizing uterine contractions during pregnancy, thus safeguarding the health of the mother and fetus.

Dissertation advisor:
Professor Arye Nehorai

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of the Doctor of Philosophy degree

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Washington University in St. Louis
School of Engineering & Applied Science