Universität Basel

Research Project

Multilevel Methods and Uncertainty Quantification in Cardiac Electrophysiology

Third-party funded project

Project title Multilevel Methods and Uncertainty Quantification in Cardiac Electrophysiology
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Departement Mathematik und Informatik / Computational Mathematics (Harbrecht)
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Computational models and numerical analysis play an increasingly important role in many medical and biomedical applications. As a matter of fact, mathematical modeling and numerical simulations allow for the creation of – prototypical or patient-specific – models, which can be used to study, e.g., the function of organs such as the human heart, or to evaluate and plan for individualized therapies. Using established forward models, different studies have been carried out, providing sensitivity analysis on the basis of forward simulations and a more or less straightforward sampling of the parameter spaces. However, the newly developed ideas and mathematical insights from Uncertainty Quantification (UQ) do allow for a much more precise and efficient quantification of important sensitivities in cardiac simulations. It is therefore the goal of this proposal to exploit ideas and techniques from UQ for simulations in cardiology, in particular electrophysiology, and to develop simulation tools, which in the very end will provide reliable estimates of parameter sensitivities to the clinician for patient-specific simulations in electrophysiology. More precisely, we plan to consider the equations modeling the bioelectrical activity of the cardiac tissue, which are parametrized by conductivity tensor fields that, in practice, are not known exactly. This motivates to model them as random fields which, in turn, yields a solution that is a random field. By combining the expertise of the two PIs in the fields of uncertainty quantification and large-scale parallel computations and model development for electrophysiology, the project will reach the following goals: (i) new theoretical results on the solution's stochastic regularity will be derived for the rigorous foundation of multilevel adaptive stochastic techniques; (ii) these new techniques will be integrated into existing, deterministic large-scale solvers in order to provide efficient software for reliable and realistic stochastic simulations in cardiac electrophysiology.

Keywords uncertainty quantification, multigrid methods, cardiac electrophysiology
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Add publication

Published results

3815443, Harbrecht, Helmut; Peters, Michael; Schmidlin, Marc, Uncertainty quantification for PDEs with anisotropic random diffusion, 0036-1429 ; 1095-7170, SIAM Journal on Numerical Analysis, Publication: JournalArticle (Originalarbeit in einer wissenschaftlichen Zeitschrift)

4529076, Harbrecht, Helmut; Schmidlin, Marc, Multilevel methods for uncertainty quantification of elliptic PDEs with random anisotropic diffusion, 2194-0401 ; 2194-041X, Stochastics and Partial Differential Equations, Publication: JournalArticle (Originalarbeit in einer wissenschaftlichen Zeitschrift)

4650851, Harbrecht, Helmut; Schmidlin, Marc, Multilevel quadrature for elliptic problems on random domains by the coupling of FEM and BEM, 2194-0401 ; 2194-041X, Stochastics and Partial Differential Equations, Publication: JournalArticle (Originalarbeit in einer wissenschaftlichen Zeitschrift)

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