# Dissertation Defense

## *Patient-Specific Modeling in Cardiac Electrophysiology: Parameter Estimation and Personalization*


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**Abstract:** Computational modeling in cardiac electrophysiology (EP) has long played a central role in the study of physio-pathological dynamics of electrical propagation. One of the most significant challenges to face is the translation process of numerical (in silico) investigations to clinical practice. In silico simulations can potentially impact the quality of cardiac arrhythmia therapy, reducing the risk of in vivo testing. However, the clinical use of virtual experiments is hindered by the need of customization of mathematical models to patient-specific data. The personalization process involves the fine tuning of many model parameters, that cannot be measured directly, via accurate and efficient data assimilation techniques. This work is particularly focused on the estimation of cardiac conductivities, crucial parameters of the Bidomain and Monodomain models  currently the most used mathematical descriptions of cardiac electrical behavior. This Thesis addresses the challenge described above yielding four main contributions. (1) We perform an extensive and thorough synthetic and experimental validation of the deterministic variational data assimilation method proposed by Yang and Veneziani in 2015 to retrieve conductivities from potential recordings. The results demonstrate that the procedure provides accurate space-dependent conductivity estimates that reproduce most of the observed dynamics. (2) The Proper Generalized Decomposition (PGD) reduced-order model technique is investigated for the first time in EP to improve the efficiency of the variational technique. Relying on the off-line/on-line paradigm and without the need of any preliminary knowledge of the high-fidelity solution, we show in 2D and 3D settings that the strategy enables nearly real-time estimation preserving reasonable accuracy. (3) With the goal of assessing the robustness of the results, we propose a statistical formulation of the estimation problem for Monodomain conductivities. Exploiting the computational convenience of the on-line PGD solution, the methodology allows a reliable quantification of the uncertainty of two-dimensional estimates. (4) Using a virtual personalized heart model efficiently reconstructed from high resolution MRI images and ECG data via a physics-based reduced-order model approach, we perform a preliminary study of the induction of ventricular electrical anomalies with respect to different conduction properties in view of optimizing arrhythmia treatments in silico.


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