Towards Reduced Order Modelling of Cardiac Electroanatomical Mapping

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Context : Ventricular tachycardia (VT) is a lethal heart rhythm disorder responsible for 80% of sudden cardiac deaths. Radiofrequency ablation (RFA) of VT is minimally invasive and potentially curative but target identification using cardiac electroanatomical mapping (EAM) is challenging. Personalized computer heart models are a promising tool that may provide deeper insight of patient electrophysiology (EP). Personalization can be achieved by adjusting models to match measured ECGs or EAMs, a viable option for determining patient tissue properties. However, this approach requires short simulation times, that state-of-the-art reaction-diffusion models do not offer.

Aims : This study aimed to assess the accuracy of fast cardiac EP reduced order models (ROMs) built through machine-learning (ML) of computer simulation data.

Methods : Simulations were run on a left-ventricle reaction-diffusion EP model constructed with a single patient dataset from the CHU Rennes, France. The model contained anatomical features such as infarct scar, scar boundary zone, Purkinje network, transmural heterogeneity and general orthotropy. A batch of 150 simulations was run with varying orthotropy and myocardium conduction parameters. Resulting data was reduced through singular value decomposition then interpolated to obtain a 2-parameter-ROM that estimated endocardial activation maps for given orthotropy and conduction parameters.

Results : Simulation results were compared to patient endocardial EAMs in sinus rhythm, with a mean error of $28\,\mathrm{ms}$. Mean ROM error with respect to simulated validation data was $0.09\,\mathrm{ms}$ using as low as 15 learning scenarios. Error was below $1\,\mathrm{ms}$ in at least 97% of non-scar endocardium nodes for all ROM estimations.

Conclusion : Although our computer model must be improved to better match patient EAMs, our ML algorithm can handle the anatomical features present in the simulations and yield fast and accurate 2-parameter-ROMs with limited learning data. Larger parameter sets will be explored to extend personalization possibilities.