Bayesian Calibration of Artificial Pacemaker Models with Device–Tissue Interactions

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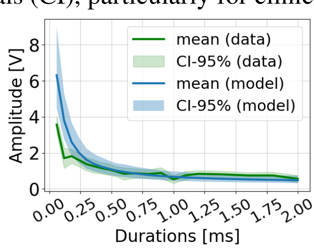
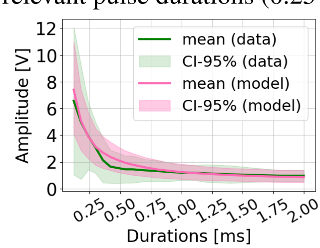
Aim. An artificial cardiac pacemaker delivers electrical stimuli to the myocardium as voltage pulses of controlled duration via implanted pacing leads. The objective is to induce cardiac depolarization, called *capture*, while minimizing energy consumption. This leads to operating near the stimulation threshold separating capture from non-capture in the voltage–duration plane, defined by the *Lapicque curve*. We aim to validate a coupled cardiac electrophysiology–pacemaker model through Bayesian calibration using experimental data, contributing to the robust, reliable, and uncertainty-aware use of computational models for medical device design.

Method. We consider a non-dimensional computational model of pacemaker–heart interaction, where the myocardium is represented by two cardiac membranes coupled through intra- and extracellular resistances and connected to the pacing electrodes. Model parameter distributions are estimated using a Metropolis–Hastings random walk algorithm, enabling sampling from intractable posterior distributions. Experimental data are obtained from ventricular wedge preparations of sheep aged 1–2 years. Two pacemakers are evaluated under healthy and fibrotic tissue conditions, with stimulation applied at diverse right ventricle sites. A total of 20 and 19 durations are used to construct the *Lapicque curves* for 10 healthy and 4 fibrotic implantation sites, respectively.

Results. The results show that the model accurately reproduces stimulation capture of healthy (blue) and fibrotic (pink) tissue, with 95% confidence intervals (CI), particularly for clinically relevant pulse durations (0.25–2 ms).





Conclusion. These results highlight the relevance of Bayesian calibration for integrating experimental data into cardiac stimulation models. This work provides a probabilistic characterization of model parameters and uncertainties, paving the way for robust/reliable design based on computer simulation.