

An algorithm to sample an anatomy with uncertainty

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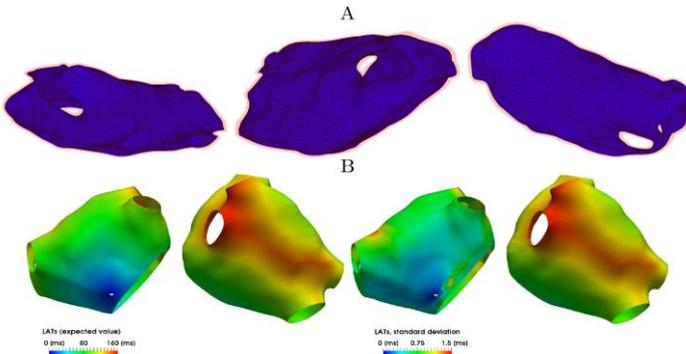
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Introduction: Patient-specific models of the heart are gaining importance in the treatment of the heart diseases. Quantify how the uncertainty on clinical data affects the model is an important step in communicating the confidence of model predictions to cardiologists. In this work, we want to quantify the uncertainty on simulated local activation times (LATs) in presence of uncertainty on the anatomy.

Methods: We represent the left atrium (LA) as a 2D manifold immersed in a 3D space and discretized with a linear triangulation. We consider the mesh point coordinates affected by uncertainty, normally distributed and with isotropic variance (v^2). We then characterise the LA through a set of principal components (PC), evaluated on a training set of 17 anatomies obtained with an electro-anatomical Mapping System. We then evaluate the expected value (μ_{LAT}) and the standard deviation (σ_{LAT}) of the LATs at each mesh vertex with a Monte Carlo (MC). We draw samples from the anatomy probability distribution by sampling the PC latent variables from their posterior distribution and then reconstructing the LA shape. We computed LATs with an eikonal model; we fixed the location of activation on one node of the mesh.

Results: We applied the procedure on 4 LA anatomies that do not belong to the training set. For each anatomy we draw 12,000 samples; on each sample, we solved the eikonal model with a source located in the proximity of the coronary sinus. Finally, for each node of the mesh, we evaluated μ_{LAT} and σ_{LAT} with MC. We investigated the effect of uncertainty on measurements by repeating the procedure for 5 v values.

Conclusions: We introduced a computationally efficient method to draw samples from an anatomy distribution and to infer model uncertainty.



A: Example of shape posterior distribution samples (red) and shape expected value (blue). B: Example of expected value (left) and standard deviation (right) of local activation times. The grey sphere represents the initial point for the eikonal equation.