A Comparison of Methods for Examining the Effect of Uncertainty in the Conductivities in a Model of Partial Thickness Ischaemia

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Aims: This work compares three different methods that examine how sensitive epicardial potentials are to uncertainty in the conductivity inputs to a bidomain model of partial thickness ischaemia in the left ventricle.

Methods: Simulations of acute partial thickness (50% of the wall thickness) ischaemia are conducted in a half-ellipsoidal model of the left ventricle to produce epicardial potential distributions (EPDs), while simultaneously varying each of the six bidomain conductivity values. From these, emulators are produced using three different methods: Gaussian Process emulators (GPE), Partial Least Squares (PLS), and generalised polynomial chaos expansion (PCE). Indices are then calculated that quantify the sensitivity of the EPDs to uncertainty in the input conductivities.

Results: All three approaches indicate that the EPDs are most sensitive to uncertainty in the longitudinal conductivities and the extracellular normal conductivity, and that variation in these conductivities has a significant effect on the epicardial potentials that are produced. This effect is of a similar magnitude to the effect that uncertainty in fibre rotation angle through the tissue has on the EPDs. Varying the depth of the ischaemic region within the ventricular wall does not change the conductivities to which the main EPD features (a maximum and two flanking minima) are sensitive.

Conclusions: For this work, the PCE approach has the advantage, over the GPE and PLS approaches, that it provides more information (that is, sensitivity over the whole ventricular surface, rather than just at the main features). However, GPE and PLS are able to supply information about the sensitivity of the position of the features that PCE is not. Finally, PLS and PCE can be performed using fewer points than for GPE.