Comparing different methods of sensitivity analysis for computational modelling of magnesium-based implant biodegradation

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Background

- Degradation of magnesium is a multiphysics process that is complex and computationally expensive to model.
- Model key parameters (e.g., reaction rate constants, diffusion coefficients, etc.) cannot be found in literature and some cannot be measured using experiments.
- Sensitivity analysis approaches are computationally expensive and limited in the case of complex models.
- The surrogate models reduce the complexity of the degradation models without compromising their accuracy.
- Model predictions are strongly influenced by parameter uncertainty.

Methodology

- Creating the surrogate model required a mininum of observations of the original model (≡ 2Np) (steps 1 and 2).
  * Np: Number of Parameters
- After creating a surrogate model (steps 3–5) and validating it, further analysis and testing can be performed; e.g., uncertainty propagation and sensitivity analysis (step 6).
- The surrogate model is able to cover the entire input distribution of parameters (step 4).
- The sensitivity analysis reflect the impact of each parameter over the model output.

Results

- Surrogate modelling approach reduces the computation time and simplifies the simulation of the degradation process without compromising the accuracy of the complex degradation model.
- A PCE–Surrogate model enables us to carry out the sensitivity analysis for the full range of input parameter distributions.
- We implemented global sensitivity analyses in order to quantify the influence of the variation in model key parameters kdeg and tinit on the estimations of the degradation rate for magnesium-based implants.
- Sample-based and linearization methods provide an overview of the system especially in the case of limited computing power.

Conclusions

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- We implemented global sensitivity analyses in order to quantify the influence of the variation in model key parameters kdeg and tinit on the estimations of the degradation rate for magnesium-based implants.
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References