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The Construction and Application of Surrogate Models for Sensitivity Analysis

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In the field of environmental modelling, especially modelling problems in the water resources sector, the acquisition of observation data is usually expensive, and/or the underlying model representations are incredibly complex. The spatially distributed models typically used for water quantity and quality prediction yield significant uncertainties even after being carefully calibrated, and they tend to have a high computational cost with long runtimes. These issues profoundly affect the performance of the models and impact the efficiencies of sensitivity and uncertainty analysis; ultimately, achieving robust decision making is very difficult for end-users who need knowledge of the behaviour of such models and the credibility of their predictions.

Machine learning can provide a means for the practical construction of surrogate models of the original response surface by learning from data, and this dramatically helps with computational efficiency and performance. Currently, several machine learning techniques such as Gaussian processes and polynomial chaos expansions have been widely used for generating surrogate models, but a gap still exists on how to efficiently combine the surrogate model construction and sensitivity analysis.

Sensitivity analysis relies heavily on the sampling choices and model runtimes. How can different sampling methods be designed to more efficiently explore the behaviour of surrogate models, and how to best construct surrogate models to assist the convergence of sensitivity analysis metrics? These are still challenging problems. Machine learning techniques will be explored as a potential solution to these challenging problems.

Keywords: Machine Learning; Environmental Modelling; Hydrological Modelling; Sensitivity Analysis; Surrogate Model; Uncertainty

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