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Efficient Uncertainty Quantification via Sparse Representation

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Most mathematical/computational models of real world phenomena involve uncertainties in their data. We assume here that these uncertainties are modelled with probabilistic/stochastic methods. This makes it possible to quantify the effect of the uncertainty on output quantities and functionals thereof.

Very often the underlying "deterministic" model is already very complex and computationally demanding. After a brief introduction into the mathematical setting we focus on the computational challenges implied by adding the stochastic description. The problems become huge, both from storage and computational demands.

With the assumption that the "interesting" part of the stochastic response lives on a relatively "low-dimensional" manifold we start by compressing/sparsifying the stochastic input data. The task then is to design algorithms which will only operate on this sparse representation and present the output quantities also in a sparse representation. These algorithms will be the main focus. In this way the uncertainty quantification may again become computationally manageable.

Having such algorithms then also helps in even more computationally demanding tasks like, for example, stochastic optimisation of Bayesian uncertainty updating. The challenge here is to construct algorithms which take advantage of the sparse representation at all stages.