Uncertainty Quantification and Numerical Accuracy

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Abstract:

Floating-point numbers represent only a subset of real numbers. As such, floating-point arithmetic introduces approximations that can compound and have a significant impact on numerical simulations.

Numerical error is usually considered negligible compared to other types of error such as uncertainties, an hypothesis that is rarely tested. Furthermore, uncertainty quantification methods are, by themselves, non-trivial numerical applications that might suffer from numerical inaccuracies.

In this context it seems important to empirically validate the numerical stability of our uncertainty quantification methods but, to the best of our knowledge, it has never been done. This is partly due to the fact that current approaches to measure numerical error are both very slow and complex to use, making their combination with uncertainty quantification techniques difficult.

In this work we propose the use of a newly introduced method to measure numerical error, showing that it is fast, very direct and accurate. Using this method we study the numerical behavior of various uncertainty quantification techniques (from straight-forward Monte-Carlo to metamodels such as Gaussian process and non-intrusive Chaos polynomials) applied to an application with non-negligible numerical error.

Based on our experimental results, we hypothesize that the more information efficient a method is and the more likely it is to be severely impacted by numerical errors contaminating its inputs. Meaning that methods that are often privileged, because they require fewer samples, are also the ones that are more likely to give unreliable results in the presence of numerically unstable computations.

Short biography – Nestor Demeure has a Master's degree in software and knowledge engineering from the university of Strasbourg (2017) and an Engineering degree in Computer science and applied Mathematics from the École nationale supérieure d'informatique pour l'industrie et l'entreprise (2017).
He is currently pursuing a PhD on precision and performance problems related to the use of floating-point arithmetic in high-performance computing with the École normale supérieure Paris-Saclay (University Paris-Saclay) in partnership with the French Commission for Atomic Energy.