# Towards High-Dimensional Uncertainty Quantification: A Tensor Perspective

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**Abstract**

Uncertainty quantification based on stochastic spectral methods has become an emerging topic in many engineering fields including computational electromagnetics and electronic design automation. Such techniques are extremely powerful for low-dimensional stochastic simulations, since they can characterize accurately and efficiently the stochastic behavior by using a small number of basis functions and parameter samples. However, their efficiency can significantly degrade as the parameter dimensionality increases, due to the huge number of basis functions required to approximate a solution of interest.

In this talk, we present efficient numerical techniques to solve high-dimensional uncertainty quantification problems. Different from most existing techniques (such as compressed sensing and analysis of variance) that exploit the underlying sparse property of a generalized polynomial-chaos expansion, our techniques exploit the low-rank property by tensor (which is a high-dimensional generalization of matrix). We first show how tensor decomposition can be applied to enable high-dimensional hierarchical uncertainty quantification. Then, we show how to obtain high-dimensional generalized polynomial-chaos expansion by tensor recovery when only a small number of simulation samples are available.

High-dimensional engineering examples from nano-scale integrated circuits, MEMS, photonics and power systems will be presented to show the application of our techniques.

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## References

Technical details of this abstract can be found in the following publications:

1) Z. Zhang, X. Yang, I. Oseledets, G. E. Karniadakis and L. Daniel, “Enabling high-dimensional hierarchical uncertainty quantification by ANOVA and tensor-train decomposition,” *IEEE Trans. Computer-Aided Design of Integrated Circuits and Systems*, vol.34, no. 1, pp. 63-76, Jan. 2015. (arXiv:1407.3023v4).
2) Z. Zhang, H. D. Nguyen, K. Turitsyn and L. Daniel, “Probabilistic power flow computation via low-rank and sparse tensor recovery,” submitted to *IEEE Trans. Power systems* (arXiv:1508.02489v1).