

**Surrogates models for uncertainty quantification and design optimization**

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**Abstract**

Nowadays computational models are used in virtually all fields of applied sciences and engineering to predict the behavior of complex natural or man-made systems. Also known as *simulators*, they allow the engineer to assess the performance of a system *in-silico*, and then optimize its design or operating.

Realistic models (e.g. finite element models) usually feature tens of parameters and are costly to run, even when taking full advantage of the available computer power. In parallel, the more complex the system, the more uncertainty in its governing parameters, environmental and operating conditions. In this respect, uncertainty quantification methods used to solve reliability, sensitivity or optimal design problems may require thousands to millions of model runs when using brute force techniques such as Monte Carlo simulation, which is not affordable with high-fidelity simulators.

In contrast, *surrogate models* allow one to tackle the problem by constructing an accurate approximation of the simulator's response from a limited number of runs at selected values (the so-called *experimental design*) and some learning algorithm. In this lecture, two types of efficient surrogate models will be presented in details, namely *polynomial chaos expansions* (including sparse approaches for high-dimensional problems) and Kriging (a.k.a. Gaussian process modelling). Recent extensions to dynamics and supervised learning will be addressed. Various applications in sensitivity and reliability analysis as well as model calibration (Bayesian inversion) and reliability-based design optimization will be shown as an illustration.