Uncertainty Quantification – examples, challenges and perspectives

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Abstract

Uncertainty quantification (UQ) is generally defined as a set of methods and tools for the characterization of uncertainties, variabilities, and errors in models, as well as their effects on results. It is an essential step for evaluation of the reliability of the predictions made by models. Since its historical origins, Uncertainty Quantification has also sought to open up to other areas, such as epidemiology, economics and computer science.

In this lecture, we will present a historical introduction, examples of these new applications and discuss some of the challenges and perspectives of this area. Indeed, UQ traditionally adopts a probabilistic point of view and seeks to determine probability distributions. This point of view has historical roots in Civil and Mechanical Engineering and makes that probabilistic and statistical methods are actually in the core of UQ approaches.

One of the future challenges for UQ is the integration of other points of view, in a collaborative or complementary way. For instance:

- The unification of the epistemic and random viewpoints;

- The integration methods for categorical and qualitative variables;

Other challenges concern:

- Efficient methods for small data situations;

- Approaches for systems with hidden variables;

- Creation of efficient methods of extrapolation;

- The development of an "Inverse UQ";

- Efficient methods for UQ in infinitely dimensional spaces;

- Take into account the effects of time (aging and wear);

- Extension to non Hilbertian situations;

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