UNIVERSITÀ DI PISA
DOTTORATO DI RICERCA IN INGEGNERIA INDUSTRIALE

Doctoral Course

Introduction to uncertainty quantification and stochastic sensitivity analysis

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Contents

Many uncertain parameters are often present in the set-up of experiments and/or numerical simulations in engineering. The evaluation of the effect of these uncertainties on the variability of the output quantities is of fundamental importance. The classical engineering approach in this framework is based on the realization of deterministic response surfaces starting from a high number of tests. This procedure becomes not affordable when the cost of a single realization of the numerical/experimental test is very expensive in terms of time or cost. Recently, stochastic approaches to the problem proved to be very efficient in minimizing the number of deterministic numerical/experimental tests required to obtain accurate stochastic response surfaces of the output quantities and, hence, their variability with the uncertain parameters. In particular, it is possible to single out the significance of the contribution of each of the uncertain input parameters to the overall variability of the results. These methodologies are based on different techniques, such as generalized polynomial chaos or stochastic collocation.

The course will present the main stochastic approaches (in the non-intrusive form) for the evaluation of the propagation of uncertainties in the input data to the output quantities of interest, viz. generalized polynomial chaos and stochastic collocation. Some practical examples of the application of these techniques in engineering will be given and, at the end of the course, students will be able to set-up an uncertainty quantification analysis for a problem of interest.

Schedule

The course is made up of four three-hour lectures, which will be held twice a week. More details on the topics of each lecture can be found here below.

1. **Introduction to the general concept of uncertainty quantification**, definition and motivation, classification of the various techniques and application fields. Generalities of non-intrusive stochastic approaches (Monte-Carlo). Comparison between deterministic and stochastic approach to highlight the main advantages/disadvantages (3 hours)
2. Description of surrogate models for response surface generation: **generalized polynomial chaos**, stochastic collocation (sparse grid and multi-level). Stochastic quantification of the variability of the output quantities. (3 hours)
3. Description of surrogate models for response surface generation: **stochastic collocation** (sparse grid and multi-level). (3 hours)
4. **Examples** of stochastic sensitivity analyses applied to different problems. **Practical exercise**: uncertainty quantification analysis carried out by using an open-source code (3 hours)

Timetable

All lectures will be held in room "DIA", Dipartimento di Ingegneria Civile e Industriale – sede di Ingegneria Aerospaziale, via G. Caruso 8, Pisa, and will be scheduled as follows.

Lecture number	Date	Time	Lecturer
1	2/12/2019 (Monday)	14:30–17:30	Alessandro Mariotti
2	3/12/2019 (Tuesday)	13:30–16:30	Alessandro Mariotti
3	12/12/2019 (Thursday)	10:30–13:30	Alessandro Mariotti
4	13/12/2019 (Friday)	10:30–13:30	Alessandro Mariotti

About the lecturer

Alessandro Mariotti currently is Assistant Professor of Fluid dynamics at the Department of Civil and Industrial Engineering, University of Pisa. His main research field is the experimental and numerical study of complex flows. The main activities he carried out concern the experimental and numerical analysis and control of the flow separation around bluff bodies and the development of methods for drag reduction; the experimental and numerical study of the flow in micro-reactors; uncertainty quantification applied to fluid dynamic problems; simulation of hemodynamics problems; numerical evaluation of coastal erosion; wind-tunnel tests and aerodynamics optimization. (e-mail: alessandro.mariotti@unipi.it).