Course offered for the PhD program
in Civil, Chemical and Environmental Engineering
Curriculum in Structural and Geotechnical Engineering, Mechanics and Materials
Curriculum in Wind Science and Engineering
A.Y. 2019/2020 (XXXV cycle)

(possibility of participation for students in other PhD cycles or other PhD courses)

1. Title

Introduction to uncertainty quantification and stochastic sensitivity analysis

2. Course description

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.

3. Course Organization

- 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 (2 hour)
- 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. (6 hours)
- Examples of stochastic sensitivity analyses applied to fluid dynamics problems. In particular, stochastic sensitivity analyses to experimental/numerical set-up parameters and to boundary conditions in wind-engineering application (2 hours)
- Practical exercise: uncertainty quantification analysis carried out by using an open-source code (2 hour)

4. Lecturer

Alessandro Mariotti, PhD
Department of Civil and Industrial Engineering
University of Pisa, Italy
alessandro.mariotti@unipi.it

5. Duration and credits

12 hours + final test (2.5 credits)

6. Activation mode and teaching period

2-3 days in the following periods:

- 28/10/2019-19/11/2019
- 4/12/2019-11/12/2019
- 18/12/2019-20/12/2019

7. Deadline for registration

The deadline for applications is XXXXX. Please, send an e-mail confirmation to Alessandro Mariotti, alessandro.mariotti@unipi.it.

8. Final exam

Test examination at the end of the course

9. Recommended references

Class slides provided by A. Mariotti