Chair for Reliability Engineering

dortmund university

Interval Analysis using Simulation

Prof. Matthias Faes[1], Dr. Marcos Valdebenito[2]

[1]Supervisor, matthias.faes@tu-dortmund.de

[2]Co-supervisor, marcos.valdebenito@tu-dortmund.de

Context

Numerical models that emulate the behaviour of engineering systems depend on a number of input parameters that describe material properties, loading and boundary conditions (among others). Often there is uncertainty about the precise value of such input parameters. A means for characterizing their uncertainty is resorting to intervals, which are particularly useful whenever there is little information available. As the input parameters of the numerical model are characterized as intervals, it is evident that the output responses become intervals as well. Determining the intervals associated with the output responses is usually a demanding task, as it comprises solving optimization problems.

A popular approach for performing analysis with intervals consists of assigning a uniform distribution to each input parameter and then, perform Monte Carlo simulation to obtain samples of the output responses. Then, the interval associated with the response is assumed to be described by the minimum and maximum simulated response. Unfortunately, such procedure may severely underestimate the interval of the response, leading to unconservative results.

Objectives

The purpose of this project is to develop a numerical strategy based on simulation that allows estimating the bounds of the output response of a numerical model whose input parameters are modelled as intervals. To achieve this broad goal, the following specific objectives must be fulfilled:

- Understand and implement basic methods for uncertainty propagation considering intervals [1].
- Examine existing alternatives that allow estimating output bounds with sufficient accuracy through simulation methods [2].
- Apply the previous developments to a case study pertinent to mechanical engineering.

Required Skills

To develop this project, the following skills are considered a plus.

- Strong mathematical background.
- Knowledge of software for numerical analysis (e.g. Matlab) and simulation (e.g. Abaqus).
- Reading and writing skills in English.

Application

In case that you are interested in this project, please follow these steps.

1. Read the associated bibliography (see below).
2. Prepare a short motivation letter addressing the following issues:
    a. Your interest in developing this project.
    b. The reasons that make you a good candidate for developing this project.
    c. Intended dates for working in the project.
3. Send the motivation letter to the supervisors via E-mail and ask for an exploratory meeting.

Bibliography

1. M. Faes and D. Moens, “Recent Trends in the Modeling and Quantification of Non-probabilistic Uncertainty,” Archives of Computational Methods in Engineering, vol. 27, Art. no. 3, Jul. 2020.
2. R. R. P. Callens, M. G. R. Faess, and D. Moens, “Multilevel Quasi-Monte Carlo for Interval Analysis,” International Journal for Uncertainty Quantification, vol. 12, Art. no. 4, 2022.