6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

Combined Uncertainties in the Numerical Simulation of Acoustics

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Key Words: *Uncertainty, Combined Uncertainty, Numerical Acoustics, BEM*

With constantly increasing computational power and advanced numerical simulation techniques the solution of more and more complex physical systems becomes possible with growing precision. In most cases, such simulations are based on purely deterministic computational models, whereas in real life situations no absolute knowledge of the modelled system exists. Parameter uncertainties, model assumptions, and numerical errors induce uncertainties to the simulation results.
Due to the broad range of relevant frequencies, acoustic simulations can show intensive sensitivity to uncertainties in the model parameters. Within the last decades, acoustics have become more and more important due to noise restrictions and an increasing relevance in aspects of comfort. Therefore, there is an increasing need of well-suited techniques to model uncertainties in acoustical simulation.

In many cases, different sources of uncertainty with individual characteristics occur. In general, the research community of uncertainty modelling categorizes uncertainty by two different types which are denoted as aleatoric and epistemic. The first describes uncertainties which cannot be influenced or reduced by the modeller and usually have random character. Therefore stochastic methods like Monte Carlo Simulations are mostly used to model such quantities.

Epistemic uncertainties arise from a lack of knowledge of the modelled system. Due to not exactly known parameters or model assumptions, not enough information is at hand to find a proper probabilistic description of the uncertain parameter. Therefore, different techniques like interval or fuzzy arithmetic can be used to propagate the uncertainties through the simulation. In real life scenarios, the two types cannot always be strictly separated or do appear both within the same system. Modelling these combined uncertainties requires a special treatment in the simulations.

Numerical acoustics is a rather untouched field of application for uncertainty handling. Therefore, the primary intend of this paper is to give an overview of how well-established techniques for uncertainty modelling perform in acoustic problems. For this purpose, a rather simple boundary element model of an interior problem is set up to include multiple uncertain parameters with different characteristics. The general influence of imprecise data for acoustical properties is shown and the suitability of different modelling techniques for the uncertainties is assessed. Special emphasis is placed on possibilities to incorporate combined uncertainties of both aleatoric and epistemic type.