Fuzzy-Bayesian Quantification of rare and Imprecise Information

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Abstract

Engineering information frequently contains components of different character. Statistical data may be rare, measurements may be imprecise, sample elements may have been generated under inconsistent environmental conditions, the conditions on the construction site may deviate from the conditions under which the tests have been performed, subjective expert knowledge and experience may be available whereby different opinions exist. This type of inconsistent information requires a generalized uncertainty model to derive proper decisions.

In this paper the model fuzzy randomness is selected to reflect stochastic uncertainty and imprecision of the underlying information simultaneously and separately. For a proper quantification, the available information is classified into uncertainty and imprecision. Uncertainty is taken into account with probabilistic models. These include both traditional statistical probabilities and subjective probabilities. For a combination of subjective probabilistic information with data the BAYES'ian theorem is employed. Imprecision is quantified with the aid of fuzzy sets, which include an interval modeling as a special case. Both imprecision of data and imprecision in expert assessments are considered. The entire variety of possible combinations of uncertainty and imprecision is brought together in one quantification concept as fuzzy BAYES'ian approach. In dependence on the available statistical and expert information, estimations are performed and BAYES'ian models are formulated. Inherent imprecision is simultaneously incorporated in the data description, in prior distributions, in the statistical estimations, and in the BAYES'ian updating processes. The specific procedures are discussed for selected situations.

The proposed quantification covers a set of possible stochastic models over a range of imprecision. Various intensities of imprecision are considered simultaneously in the subsequent structural or reliability analysis. This is particularly useful to identify sensitivities of a structural response or of a safety level with respect to input imprecision and probabilistic model choice. A maximum allowable imprecision in the input information can be identified, which is associated with a minimum amount of information – representing an economical optimum to derive decisions.