Technische Universität Braunschweig

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Uncovering a World of Possibilities: Quantifying Uncertainty with Possibility Theory

Lecture of

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seminar room, ground floor

In the engineering sciences, there is a need for accurately addressing and faithfully quantifying uncertainties of various origin. This talk aims to motivate the use of imprecise probabilities for uncertainty quantification, emphasizing the vital distinction between aleatory uncertainties, which are random and unavoidable, and epistemic uncertainties, which stem from limited data or a lack of knowledge. Epistemic uncertainty, in particular, presents a significant challenge in engineering, necessitating innovative approaches for appropriate quantification and effective propagation, where the classical probabilistic framework often turns out to be inadequate.

A potential solution to this challenge lies in the domain of imprecise probabilities, which encompass methodologies like p-boxes and Dempster-Shafer theory among others. These methods provide a robust framework for dealing with incomplete information, thereby aiming at a preferably high precision of uncertainty quantification.

This talk advocates the concept of possibility theory as a theory of imprecise probabilities. Possibility theory offers a robust and surprisingly trivial approach to quantifying uncertainties, where the dual possibility and necessity measures serve as probability bounds. The theory stands out for its ability to handle polymorphic uncertainty effectively, while ensuring reliable and inclusive results in engineering analyses as well as in decision-making. A key advantage of the here presented view of possibility theory is its close relation to the theory of fuzzy arithmetic, which by dint of some specific adjustments provides a solid basis for the efficient implementation in engineering applications.

Novel developments over the last few years extend the applicability of possibility theory to various practical scenarios, providing a robust methodological framework for data inference and transformation. The so-called Imprecise-Probability-to-Possibility-Transform facilitates the integration of different types of information, ranging from expert knowledge via sparse data to precise probability distributions, into a cohesive analytical model and actionable insights.

The field of possibility theory and imprecise probabilities is, however, not without its challenges. Future research directions include remaining computational challenges and further pursuit into the idea of partial priors as a promising advancement of the practical applicability of possibility theory.