香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

土木及環境工程學系
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

SEMINAR

EFFICIENT ROBUST RELIABILITY ANALYSIS: DECISION MAKING UNDER INCOMPLETE KNOWLEDGE

Speaker

Prof. Matthias Faes

TU Dortmund University

Abstract

Numerical tools to approximate the solution of (sets of) differential equations have become indispensable in the design of engineering components from the micro-scale to complete structures. Thanks to these tools, an engineer is now able to design, test and optimize designs long before a first prototype is built. However, despite the highly detailed numerical predictions that can be obtained, the results of these calculations often show a non-negligible discrepancy with the actual physical behavior of the structure. At the core of this discrepancy lies uncertainty in the description of the model physics, as well as the governing parameters.

Uncertainties are for instance commonly encountered in the context of structural dynamics, where for instance the effect natural phenomena such as earthquakes or wind loads on structures has to be considered. Indeed, due to the sheer complexity of the underlying physics, the corresponding dynamical loads that act on the system often cannot be described in a crisp way. Stochastic processes provide a rigorous framework to deal with the uncertainties and space/time correlations of uncertain loads by resorting to the well-documented framework of probability theory. However, in practice, the analyst is often confronted with limited, incomplete or conflicting sources of data (i.e., epistemic uncertainty) due to limitations in time, budget and/or measurement resolution. In this case, there might be simply not enough information to warrant the computational cost of performing extremely detailed reliability analyses with very small failure probabilities. This begs the question: where should we invest our resources – in making our reliability analyses more accurate or in making them more robust?

In this talk, I will present some philosophical, theoretical and very practical numerical calculation schemes that are aimed at contributing to answering this question. The presentation will draw from recent work we performed in the field of reliability sensitivity and imprecise reliability analysis, highlighting recent advances in surrogate modelling (functional dimensionality reduction, Bayesian active learning, polynomial chaos expansions), decoupling schemes (operator norm theory) and efficient sampling schemes (multi-domain line sampling, directional importance sampling).

Biography

Matthias Faes became a full Professor in Reliability Engineering at TU Dortmund at the age of 30, since February 2022. Before, he was a post-doctoral fellow of the Research Foundation Flanders (FWO) working at the Department of Mechanical Engineering of KU Leuven and was also affiliated to the Institute for Risk and Reliability at the University of Hannover as an Alexander von Humboldt Fellow. He graduated summa cum laude as Master of Science in Engineering Technology in 2013 and obtained his PhD in Engineering Technology from KU Leuven in 2017. Since then, he works on theoretical and numerical methods to perform efficient uncertainty quantification and reliability analysis under scarce data and information, including inverse and data-driven methods, surrogate modeling schemes, stochastic fields and imprecise probabilities.

Matthias Faes is the 2nd Laureate of the 2017 PhD award of the Belgian National Committee for Applied and Theoretical Mechanics, winner of the 2017 ECCOMAS European PhD award for best PhD thesis in 2017 on computational methods in applied sciences and engineering in Europe, winner of the 2019 ISIPTA - IJAR Young Researcher Award for outstanding contributions to research on imprecise probabilities and winner of the 2023 EASD Junior Research Prize for his contribution to the development of methodologies for structural dynamics, among other national and international awards and honours. He is Associate Editor at Mechanical Systems and Signal Processing and Reliability Engineering and System Safety, as well as Associate Managing Editor of the ASCE-ASME Journal of Risk and Uncertainty in Engineering system parts A and B, among other journals. On top, he serves on the excecutive boards of the European Association for Structural Dynamics (EASD), and the International Association for Reliability Engineering and Risk Management (IARERM. Finally, he is the chairman of the Committee on Probability and Statistics in the Physical Sciences of the Bernouilli Society, as well as Chairman of several technical committees of both the European Safety and Reliability Association (ESRA), as the International Association for Structural Satety and Reliability (IASSAR). Matthias Faes is author of more than 125 journal papers and more than 100 conference contributions and he has a Google Scholar H-index of 31 (3600+ citations) since 2016.

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