Efficient Numerical Methods for Uncertainty Quantification in Dynamic Systems: Applications to Earthquake Engineering

Prof. Matthias Faes

TU Dortmund University, Chair for Reliability Engineering

Numerical methods for solving differential equations are crucial in engineering, enabling simulations of structural behavior under dynamic loads, especially in earthquake-prone regions. These simulations provide engineers with valuable insights into structural resilience before construction, guiding safer designs for seismic events. However, discrepancies between simulated and actual structural responses often arise due to inherent uncertainties in material properties, loading conditions, and environmental variables.

In dynamic systems subjected to seismic forces, these uncertainties—such as variability in soil conditions, seismic fault behavior, and ground motion characteristics—are critical for assessing structural reliability. Standard probabilistic methods may fall short in efficiently handling these complexities, particularly when computational resources or detailed data are limited. Consequently, there is a pressing need for efficient reliability calculation methods that can incorporate diverse uncertainties to provide accurate predictions of structural safety.

This research seminar will explore advanced techniques for reliability calculations in the context of earthquake engineering, focusing on methods that efficiently propagate uncertainties in dynamic simulations. I will present approaches that streamline reliability assessments while maintaining accuracy, applied to earthquake-resilient design for high-rise buildings and critical infrastructure. By advancing efficient reliability modeling in dynamic systems, these methodologies aim to enhance the resilience and safety of structures subjected to seismic risks.

Speaker Bio

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 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 is working on advanced methodologies for non-probabilistic uncertainty quantification under scarce data and information, including inverse and data-driven methods, stochastic fields and interval techniques. He is a 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 the 2023 EASD Junior Research Prize for his contribution to the development of methodologies for structural dynamics, among other awards. He is editor at Mechanical Systems and Signal Processing and Associate Managing Editor of the ASCE-ASME Journal of Risk and Uncertainty in Engineering system parts A and B, among other journals. Matthias Faes is author of more than 85 journal papers and more than 80 conference contributions and he has a Google Scholar H-index of 26 (2300+ citations) since 2016.