VANDERBILT
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DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

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FGH 298

"PREDICTING WITH MODEL ENSEMBLES & UNCERTAIN PARAMETERS, FROM PDES TO INFERRED OPERATORS"

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ABSTRACT

In this talk, we discuss the construction of admissible, identifiable stochastic models to represent and quantify the impact of parametric and model-form uncertainties in computational science and engineering.

We first consider the case of parametric uncertainties defining systems of partial differential equations. We focus on the infinite-dimensional setting (i.e., random fields) and focus on variables (i) taking values in constrained spaces described by smooth manifolds, and (ii) indexed by nonconvex domains. We present theoretical results and computational algorithms based on fractional stochastic differential equations. We discuss validation on various applications involving physical experiments, including the modeling of as-built additively manufactured structures, phase-field modeling, and multiscale analysis.

We next address the case of model-form uncertainties and consider the multimodel setting where different model candidates exhibit high plausibility with respect to data. Typical examples include atomistic simulations, constitutive modeling in nonlinear elasticity, and phase-field methods. We present recent advances to build measures describing such uncertainties, leveraging concepts and tools from optimization on Riemannian manifolds. We propose an efficient propagation technique that adaptively partitions the underlying sample space to capture discontinuities in the approximation space. We show that the proposed framework can be used to address the following question, related to optimal design of experiments and resource allocation, in an informed (quantitative) manner: what matters the most, models or parameters?

Time permitting, we will finally show how the developed methods can be leveraged to assess robustness in operator learning frameworks.

BIOGRAPHY

Johann Guilleminot is the Paul Ruffin Scarborough Associate Professor of Engineering and an Associate Professor of Mechanical Engineering and Materials Science at Duke University. He received his MS (2005) and PhD (2008) degrees in Theoretical Mechanics from the University of Lille 1 Science and Technology (France), and received his Habilitation (2014) from Universit´e Paris-Est, with certifications in Applied Mathematics and Mechanics.

Dr. Guilleminot's research focuses on probabilistic methods, computational mechanics and materials science, as well as on topics at the interface between these fields, with a broad range of applications ranging from the modeling of engineered materials and structures to patient-specific simulations on biological tissues. He is the recipient of various accolades, including student awards (Best MS Thesis, Best PhD Thesis), the French Early Career Award (2012), and the NSF CAREER Award (2020). He currently serves as Editor-in-Chief for Finite Elements in Analysis and Design (Elsevier), and Associate Editor for the Journal of Engineering Mechanics (ASCE) and the Journal of Computing and Information Science in Engineering (ASME). He is the Chair of the USACM TTA on Uncertainty Quantification and Probabilistic Modeling and an active member of EMI, IACM, SIAM, and USACM.