



Data-driven and Physics-informed Modeling of Infrastructure Systems: From Low-emission Mobility to Resilience Analytics

Development of sustainable and resilient infrastructure systems requires innovative frameworks that leverage the explosion of data available through advances in sensors, internet, mobility as well as computational models to design for and respond to the challenges of the climate change era. I will demonstrate how physics-constrained data-driven modeling enables development of quantitative platforms for identification, monitoring and projection of infrastructure performance. In the first part of the presentation, I will showcase a citizen-enabled framework to monitor, in real-time, road surface condition, vehicle excess energy consumption, and the related environmental impact at network scale. Unlike the widely used approaches for road infrastructure monitoring that rely solely on data and empirical models, this framework integrates physics-compatible models of road-vehicle interaction with crowdsourced data to characterize the parameters of system. The proposed data-centric platform has the potential to not only help transportation authorities make optimal decisions in the allocation of resources for road maintenance but also guide route selection by individual drivers or fleet owners. This will be a key player in a rapidly evolving world where an accelerating climate change is pressing for dramatic measures to reduce carbon footprint and GHG emissions. The second part of this talk will be focused on modeling damage using an energy-based formulation of lattice element method (LEM). I will describe the potential of mean force (PMF) approach, widely used in statistical physics and introduce a hybrid PMF formulation of LEM to efficiently model fracture and crack growth in heterogeneous media. The hybrid approach is shown to be a viable choice due to its flexibility in modeling complex failure mechanisms and its computational efficiency and reliable results. Finally, I will discuss our efforts to leverage the versatility of this framework and adapt the formulation as a means for devising a systematic bottom-up approach for efficient characterization of failure and damage in structural systems to establish an effective quantitative tool for resilience analytics.



Dr. Arghavan Louhghalam is an assistant professor in the department of Civil and Environmental Engineering with a joint appointment in Mechanical Engineering Department at University of Massachusetts, Dartmouth. She also holds a research affiliate position in the department of Civil and Environmental Engineering at MIT. Prior to that she was a postdoctoral research associate at Massachusetts Institute of Technology. She earned her PhD from the Department of Civil and Systems Engineering at the Johns Hopkins University. Her research interests lie in the area of engineering mechanics, physics-constrained data-driven modeling, and applied statistics with particular emphasis on development of smart solutions for resilient and sustainable built environment. Dr. Louhghalam is a recipient of NSF early CAREER development award and her research on citizen-enabled crowdsourced monitoring of transportation infrastructure has been recognized nationally and featured in media outlets such as the New York Times.

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