CRUNCH Seminars at Brown, Division of Applied Mathematics

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Solving high-dimensional stochastic partial differential equations with physics-informed neural networks

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I will start with an overview of the research activities carried out in the Predictive Science Laboratory (PSL) at Purdue. In particular, I will use our work at the Resilient Extra-Terrestrial Habitats Institute (NASA) to motivate the need for physics-informed neural networks (PINNs)for high-dimensional uncertainty quantification (UQ), automated discovery of physical laws, and complex planning. The current state of these three problems ranges from manageable to challenging to open, respectively. The rest of the talk will focus on PINNs for high-dimensional UQ and, in particular, on stochastic PDEs. I will argue that for such problems, the squared integrated residual is not always the right choice. Using a stochastic elliptic PDE, I will derive a suitable variational loss function by extending the Dirichlet principle. This loss function exhibits (in the appropriate Hilbert space) a unique minimum that provably solves the desired stochastic PDE. Then, I will show how one can parameterize the solution using DNNs and construct a stochastic gradient descent algorithm that converges. Subsequently, I will present numerical evidence illustrating this approach's benefits to the squared integrated residual, and I will highlight its capabilities and limitations, including some of the remaining open. Finally, I will outline the current PINNs-related research activities at PSL and solicit your interest in potential collaborations.