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Accelerating Numerical Simulations by Model Reduction with Scientific and Physics-Informed Machine Learning

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Partial differential equations (PDEs) are invaluable tools for modeling complex physical phenomena. However, only a limited number of PDEs can be solved analytically, leaving the majority of them requiring computationally expensive numerical approximations. To address this challenge, reduced order models (ROMs) have emerged as a promising field in computational sciences, offering efficient computational tools for real-time simulations. In recent years, deep learning techniques have played a pivotal role in advancing efficient ROM methods with exceptional generalization capabilities and reduced computational costs. In this talk we explore how classical ROM techniques can be elevated through the integration of deep learning models.

Our discussion encompasses a review of existing approaches to enhancing ROM, from graph neural network to multifidelity models by means of neural operators. We will introduce Physics-Informed Neural Networks (PINNs), highlighting their recent advancements in inverse modeling, discretive PINNs, and multiphase modeling and application to fluid dynamics.