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Dictionary-based operator learning for nonlinear partial differential equations

The study of turbulent flows is computationally intensive due to the intrinsic multi-scale behavior of their nonlinear dynamics. Thus, it requires relatively high-resolution grids to capture their complexity fully. For instance, imagine the range of length and time scales in the numerical study of a hurricane passing over a city. The field of fluid mechanics traditionally deals with massive amounts of data. However, methods to precisely quantify complex and multi-scale phenomena of fluid flows remain unresolved to a large extent. More specifically, turbulent fluid data require algorithms capable of addressing nonlinearities and multi-scale phenomena that may not be available in classical machine learning methods. This talk presents a dictionary-based operator learning method as a reduced-order data-driven model of the chaotic behavior of turbulent flows. First, I will outline the convergence criteria for extracting the governing operator from noisy measurements underlying a nonlinear dynamical system. I will then show numerical results comparing dictionary-based and neural network-based methods. Finally, I will discuss the dictionary-based reduced-order representation of the Naiver-Stokes operator. The current findings indicate the potential extension of wavelet methods in dictionary-based operator learning for chaotic systems.