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Dynamic Mode Decomposition for model reduction of flow and transport in porous media

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Reduced-order models (ROMs) can be used in place of a high-fidelity model (HFM) to alleviate the computational cost associated with HFM simulations. Emulators or surrogates are a class of ROMs whose aim is to reduce the complexity of a given HFM by learning the dynamics of the state variables directly from the model' s output, i.e. they are trained on a dataset generated by running the HFM multiple times. As such, the number of simulations required to train a ROM is a measure of its effectiveness. Here, we use dynamic mode decomposition (DMD), a powerful data-driven method to construct ROMs of complex dynamical systems [1,2]. DMD employs singular value decomposition (SVD) and pursues the computation of the best-fit linear operator to approximate the relationship between time-shifted snapshots in time of the state variable [2]. Variants of the standard DMD algorithm exist, including the residual, generalized, and extended DMD [2,3]. In this study, we assess the accuracy of different DMD algorithms when mimicking flow and transport in porous media. We consider both interpolation and extrapolation (i.e. to get short-time future prediction) scenarios. The DMD has proven its utility in approximating systems of partial differential equations (PDEs); however, it doesn' t handle the possible variability in model parameters. As such, we explore how to combine DMD with the Polynomial Chaos Expansion (PCE), a family of ROMs used to approximate the response surface of a HFM in the random parameter space; this allows to obtain a ROM in terms of a polynomial relationship explaining the model response of interest as a function of the uncertain parameters, properly represented as independent random variables [4,5].

Participation

In-Person

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Primary authors: CIRIELLO, Valentina (University of Bologna); LIBERO, Giulia (University of Bologna); TARTAKOVSKY, Daniel (Stanford University)

Presenter: CIRIELLO, Valentina (University of Bologna)

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