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Fast Physics Informed Surrogate Models for Fluid Flow in Porous Media: Learning Operators using DeepONets

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Simulating fluid flow in reservoir models is an expensive and time-consuming task. Given the inherent uncertainty in most measurements used as inputs for these models, it is customary to perform stochastic modeling in order to reduce and quantify the uncertainty. Recently, a new class of machine learning algorithms referred to as operator learning has been developed. These algorithms, such as DeepONets and Fourier Neural Operators, can learn mappings between two infinite-dimensional spaces. However, these approaches suffer from data inefficiency as they require thousands of training observation pairs in the input and output domains which is computationally prohibitive. Physics-informed DeepONet has been proposed as a remedy to this problem. In this paradigm, DeepONets are regularized by underlying physical laws in a manner similar to Physics Informed Neural Networks (PINNs), hence the name. Physics-informed DeepONets can learn the solution operator mapping between a set of initial and boundary conditions to the full spatio-temporal solution making it a powerful tool for parametric PDE learning. Here, we investigate the applicability of Physics-informed DeepONets to an immiscible two-phase fluid flow problem through a 1D porous medium. We provide two test cases. First, we attempt to learn the solution operator mapping of an initial condition to the entire spatio-temporal solution of all possible initial conditions. Second, we test Physics-informed DeepONets to learn the solution operator mapping of a boundary condition to the entire spatio-temporal solution of all possible boundary conditions. Our results show that with a small sacrifice in accuracy, enormous gains in speed can be achieved, as this approach can solve thousands of PDEs in a fraction of a second.

Participation

In-Person

References

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