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CA multifidelity deep operator network approach to closure for multiscale systems

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Projection-based reduced order models (PROMs) have shown promise in representing the behavior of multiscale systems using a small set of generalized (or latent) variables. Despite their success, PROMs can be susceptible to inaccuracies, even instabilities, due to the improper accounting of the interaction between the resolved and unresolved scales of the multiscale system (known as the closure problem). In the current work, we interpret closure as a multifidelity problem and use a multifidelity deep operator network (DeepONet) framework to address it. In addition, to enhance the stability and/or accuracy of the multifidelity-based closure, we employ the recently developed "in-the-loop" training approach from the literature on coupling physics and machine learning models. The resulting approach is tested on shock advection for the one-dimensional viscous Burgers equation and vortex merging for the two-dimensional Navier-Stokes equations. The numerical experiments show significant improvement of the predictive ability of the closure-corrected PROM over the un-corrected one both in the interpolative and the extrapolative regimes.