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Reduced order modeling with Barlow Twins self-supervised learning: Navigating the space between linear and nonlinear solution manifolds

Wednesday, 1 June 2022 10:45 (15 minutes)

We propose a unified data-driven reduced order model (ROM) that bridges the performance gap between linear and nonlinear manifold approaches. Deep learning ROM (DL-ROM) using autoencoders has been shown to capture non-linear solution manifolds but fails to perform adequately when linear subspace approaches such as proper orthogonal decomposition (POD) would be optimal [1]. Specifically, the proposed framework relies on the combination of an autoencoder and Barlow Twins self-supervised learning as first introduced in Zbontar et al. (2021) [2]. The framework is data-driven and can operate on unstructured meshes, which provides flexibility in its application for various cases including standard finite element solvers, observation data, or a combination of these sources. Through multiple benchmark problems regarding natural convection in porous media, we show that our framework provides a speed-up of 7 × 106 times compared to a finite element solver and achieves a relative error of 4%in the worst case scenario. Moreover, this framework mitigates the limitation of the previous DLROM framework by providing comparable results to POD-based approaches for problems where the solution lies within a linear subspace, as well as DL-ROM autoencoder-based approaches where the solution lies on a nonlinear manifold. Hence, it would bridge the gap between linear and nonlinear reduced manifolds. We have illustrated that our framework achieves these results due to a proficient construction of the latent space. Hence, it is easier to map these latent spaces using regression models. SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525.

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References

[1] Kadeethum, T., Ballarin, F., O'Malley, D., Choi, Y., Bouklas N., Yoon, H. Non-intrusive reduced order modeling of natural convection in porous media using convolutional autoencoders: comparison with linear subspace techniques. Adv. Water Resour. 104098 (2022).
[2] Zbontar, J., Jing, L., Misra, I., LeCun, Y., Deny, S. Barlow twins: Self-supervised learning via redundancy reduction. arXiv preprint arXiv:2103.03230 (2021).

Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

Online

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