

Nonlinear manifold ROM with Convolutional Autoencoders and Reduced Over-Collocation method

Francesco Romor, Giovanni Stabile* and Gianluigi Rozza

International School for Advanced Studies (SISSA), mathLab, mathematics, Via Bonomea 265, 34136, Trieste, Italy e-mail: fromor@sissa.it, gstabile@sissa.it, grozza@sissa.it

Keywords: *Nonlinear manifold projection, hyper reduction, autoencoders*

Non-affine parametric dependencies, nonlinearities and advection-dominated regimes of the model of interest can result in a slow Kolmogorov n -width decay, which precludes the realization of efficient reduced-order models based on Proper Orthogonal Decomposition. Among the possible solutions, there are purely data-driven methods that leverage nonlinear approximation techniques such as autoencoders and their variants to learn a latent representation of the dynamical system, and then evolve it in time with another architecture. Despite their success in many applications where standard linear techniques fail, more has to be done to increase the interpretability of the results, especially outside the training range and not in regimes characterized by an abundance of data. Not to mention that none of the knowledge on the physics of the model is exploited during the predictive phase. In this talk, in order to overcome these weaknesses, we implement a variant of the nonlinear manifold method introduced by Lee et al [1] with hyper-reduction [2] achieved through reduced over-collocation and teacher-student training of a reduced decoder [3]. We test the methodology on a 2d nonlinear conservation law model and compare the results we would obtain with a purely data-driven method for which the dynamics is evolved in time with a long-short term memory network.

REFERENCES

- [1] K. Lee and K. T. Carlberg, *Model reduction of dynamical systems on nonlinear manifolds using deep convolutional autoencoders*, Journal of Computational Physics, vol. 404, p. 108973, Mar. 2020, doi: 10.1016/j.jcp.2019.108973.
- [2] Y. Kim, Y. Choi, D. Widemann, and T. Zohdi, *A fast and accurate physics-informed neural network reduced order model with shallow masked autoencoder*, Journal of Computational Physics, p. 110841, Nov. 2021, doi: 10.1016/j.jcp.2021.110841.
- [3] F. Romor, G. Stabile, G. Rozza *Nonlinear manifold ROM with Convolutional Autoencoders and Reduced Over-Collocation method*, 2021, in preparation.