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Artificial neural network for bifurcating phenomena modelled by nonlinear parametrized PDEs

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The aim of this work is to show the applicability of the Reduced Basis (RB) model reduction and Artificial Neural Network (ANN) dealing with parametrized Partial Differential Equations (PDEs) in nonlinear systems undergoing bifurcations.

Bifurcation analysis, i.e., following the different bifurcating branches due to the non-uniqueness of the solution, as well as determining the bifurcation points themselves, are complex computational tasks. Reduced Order Models (ROM) and Machine Learning (ML) techniques can potentially reduce the computational burden by several orders of magnitude.

Models describing bifurcating phenomena arising in several fields with interesting applications, from continuum to quantum mechanics passing through fluid dynamics [4,5,6].

Following the approach in [1, 2], we analyzed different bifurcating test cases where both physical and geometrical parameters were considered. In particular, we studied the Navier-Stokes equations for a viscous, steady and incompressible flow in a planar straight channel with a narrow inlet.
We reconstructed the branching solutions and explored a new empirical strategy in order to employ the RB and ANN for an efficient detection of the critical points.

All the simulations were performed within the open source software FEniCS and RBniCS [7] for the ROM, while we chose PyTorch to construct the neural network.

References

[1] M. Guo and J. S. Hesthaven. Data-driven reduced order modeling for time-dependent problems. Computer methods in applied mechanics and engineering, 345:75–99, 2019.

[2] J. S. Hesthaven and S. Ubbiali. Non-intrusive reduced order modeling of nonlinear problems using neural networks. Journal of Computational Physics, 363:55–78, 2018.

[3] F. Pichi, F. Ballarin, J. S. Hesthaven, and G. Rozza. Artificial neural network for bifurcating phe- nomena modelled by nonlinear parametrized PDEs. In preparation, 2020.

[4] F. Pichi, A. Quaini, and G. Rozza. A reduced order technique to study bifurcating phenomena: application to the Gross-Pitaevskii equation. ArXiv preprint https://arxiv.org/abs/1912.06089, 2019.

[5] F. Pichi and G. Rozza. Reduced basis approaches for parametrized bifurcation problems held by non-linear Von Kármán equations. Journal of Scientific Computing, 339:667–672, 2019.

[6] M. Pintore, F. Pichi, M. Hess, G. Rozza, and C. Canuto. Efficient computation of bifurcation diagrams with a deflated approach to reduced basis spectral element method. ArXiv preprint arXiv:1907.07082, 2019.

[7] RBniCS. http://mathlab.sissa.it/rbnics.

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