



SLING Efficient algorithms for sustainable machine learning

Mon, January 24th, 2022, 3:00 p.m., DIBRIS - Conference Hall III floor, via Dodecaneso 35, Genova.

Analysis and Learning

Deep learning-based reduced order models for the real-time numerical approximation of PDEs

Abstract.

Conventional reduced order modeling techniques such as the reduced basis method (relying, e.g., on proper orthogonal decomposition (POD)) may incur in severe limitations when dealing with nonlinear time-dependent parametrized PDEs, as these are strongly anchored to the assumption of modal linear superimposition. To overcome them, we have recently proposed a new, nonlinear approach to set reduced order models (ROMs) by exploiting deep learning (DL) algorithms. In the resulting DL-ROMs, both the nonlinear trial manifold and the nonlinear reduced dynamics are learned in a non-intrusive way, by relying on deep (e.g., feedforward, convolutional, autoencoder) neural networks; these latter are trained on a set of full order model solutions obtained for different parameter values. Although extremely efficient at testing time, when evaluating the PDE solution for any new testing-parameter instance, DL-ROMs might still require an expensive training stage, because of the extremely large number of network parameters to be estimated. A substantial speed up in the training stage of DL-ROMs can be achieved by (i) performing a prior dimensionality reduction through POD, and (ii) relying on a multi-fidelity pretraining stage, where different physical models can be efficiently combined. The resulting POD-DL-ROM strategy is thus easy to train, and enables real-time solutions of nonlinear time-dependent parametrized PDEs. Numerical results dealing with a variety of problems - such as, e.g., nonlinear diffusion-reaction, nonlinear elastodynamics, unsteady Navier-Stokes equations and fluid-structure interaction problems will show the generality of this approach and its remarkable computational savings.

Speaker

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Andrea Manzoni is an associate professor of numerical analysis at Politecnico of Milan. He is the author of 3 books and of approximately 60 papers. He got his Ph.D. in Mathematics from EPFL, Lausanne. He won in 2012 the ECCOMAS Award for the best PhD thesis in Europe about computational methods in applied sciences and engineering and the Biannual SIMAI prize (Italian Society of Applied and Industrial Mathematics) in 2017. His research interests include the development of reduced-order modeling techniques for PDEs, PDE-constrained optimization, uncertainty quantification, computational statistics, and machine/deep learning.