DEEP LEARNING COMPUTING

TRACK NUMBER 1700

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Key words: Deep Learning, Partial Differential Equations, Computing.

ABSTRACT

Deep learning, i.e., using deep neural networks for regression and classification, has been very successful in many different contexts in science and engineering. These include image analysis, natural language understanding, game intelligence, and protein folding. As deep neural networks are universal function approximators, employing them as ansatz spaces for solutions of ordinary and partial differential equations is natural, paving the way for their successful use in scientific computing. An incomplete list of examples where deep learning is used for the numerical solutions of differential equations includes the solution of high-dimensional linear and semi-linear parabolic partial differential equations and many-query problems such as those arising in uncertainty quantification (UQ), PDE constrained optimization, and (Bayesian) inverse problems.

Another interesting use of deep learning is data-driven computing, that is to combine available data with existing physical laws to more accurately predict events as diverse as the spread of pandemics, the weather forecast, the behavior of a vehicle, a structure, or a drug, among others. Deep learning algorithms can be used to solve all these problems. Moreover, they have been the best performers in the last decade and are being massively adopted by various industries and institutions.

Previous problems can be recast as parametric partial differential equations, and the use of deep neural networks in their solution is explored for elliptic and parabolic PDEs, transport PDEs, and hyperbolic and related PDEs, and as operator learning frameworks. All the aforementioned

methods are of the supervised learning type, i.e., the underlying deep neural networks have to be trained on data, either available from measurements or generated by numerical simulations.

Another interesting application of deep learning algorithms is the so-called Physics Informed Neural Networks (PINNs) which collocate the PDE residual on training points of the approximating deep neural network. PINNs have been successfully applied to simulate various forward and inverse PDE problems.

This mini-symposium accepts contributions that employ deep learning techniques to predict the result of physical systems often governed by ordinary and/or partial differential equations and are possibly complemented with measured data. We encourage works ranging from the mathematical analysis of these methods to their industrial applications.