Solving Partial Differential Equations with Deep Learning

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Partial differential equations (PDEs) are ubiquitous in nearly all fields of applied physics and engineering, encompassing a wide range of physical and phenomenological models and conservation laws for problems related to reaction-diffusion-convection systems, electromagnetism, quantum mechanical systems, and kinetics, to name a few. In particular, many physical phenomena of interest can be described as a system of parameterized, time-dependent, nonlinear PDEs. With the advent of spatial discretization schemes such as finite-difference, finite-volume, finite-element, or spectral methods, many such problems are now solved routinely, utilizing the high-performance computing paradigm of distributed parallelism on large clusters of networked CPUs or GPUs. While a large body of work exists in the literature dedicated to these numerical methods, important challenges remain regarding the solution accuracy, convergence, and computational cost for various problems with significant model complexity. Recently, machine learning techniques have been proposed as a promising alternative to conventional numerical methods. These techniques make use of the universal approximation capacity of artificial neural networks to represent the solution of PDEs, with no spatial discretization required. In this presentation, we will demonstrate the state-of-the-art in solving PDEs with deep learning using TensorFlow and comment on the some challenges and outlook for this field in the near future.

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