AI for Data-driven simulations in Physics

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Abstract

Partial Differential Equations (PDEs) are often described as the language of Physics as they describe a wide array of physical phenomena over a vast range of scales. Despite their remarkable success over many decades, numerical methods for approximating PDEs can incur a very high computational cost. This limitation has provided the impetus for the design of fast and accurate Machine Learning/AI based neural PDE surrogates which can learn the PDE solution operator from data. In this talk, we review some latest developments in the field of Neural Operators, which are widely used as an ML paradigm for PDEs and discuss state of the art neural operators based on convolutions or attention. We will discuss graph and transformer based architectures for PDEs on arbitrary domains and conditional Diffusion models for PDEs with chaotic multiscale solutions. Finally, the issue of sample complexity is addressed by the design of general purpose Foundation models for PDEs.