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Tensor Networks in Machine Learning and PDEs

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Abstract

Tensor networks were initially developed to classically simulate interacting quantum systems and are currently the state-of-the-art method in the field. Their success stems from their capability to efficiently and controllably compress large vectors by adjusting the size of tensors within the network. More recently, TNs have been explored in a variety of classical settings, such as machine learning (ML) and the integration of partial differential equations (PDEs). In ML, TN-based methods have demonstrated performance on par with optimized neural networks in tasks like computer vision and offer a powerful compression strategy that can significantly reduce energy costs during both training and inference. For PDE integration, TNs provide a robust framework for handling problems with multiple length scales, producing extremely large state vectors that are otherwise difficult to store and process. Early studies on turbulent flows governed by the Navier–Stokes equations have already shown superior scaling compared to direct numerical simulations.

With ongoing improvements in TN-based algorithms, these methods hold great promise for solving complex industrial challenges in areas such as aerodynamics, climate modelling and computer vision. In this presentation, we provide a pedagogical overview of TN methodologies and discuss their current applications and future prospects for a range of classical problems.

Keywords: Quantum inspired methods, Tensor Networks, Partial differential equations, Machine learning