Machine Learning-aided enhancement and acceleration techniques for Polyhedral Finite Element methods

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Abstract

The new paradigm of Polygonal Finite Element Methods (PolyFEMs) has been introduced in the last years. PolyFEMs are Galerkin-type projection methods where the finite-dimensional discretization space is built by employing a computational grid of arbitrarily shaped polygonal/polyhedral (polytopal, for short) elements. This talk discusses how to enhance PolyFEMs' accuracy and performance based on designing suitable Machine Learning-aided numerical algorithms. More specifically, we propose new strategies to handle polytopal grid refinement, to be employed within an adaptive framework. Specifically, Convolutional Neural Networks (CNNs) are employed to classify the "shape" of an element so as to apply "ad-hoc" refinement criteria or to enhance existing refinement strategies at a low online computational cost. The k-means clustering algorithm is used to refine polytopes with unknown shapes in a robust manner. We test the proposed algorithms considering two families of finite element methods that support arbitrarily shaped polytopal elements, namely the Virtual Element method and the Polytopal Discontinuous Galerkin method. We demonstrate that the proposed strategies do preserve the structure and the quality of the underlying grids, reducing the overall computational cost and mesh complexity. Some recent results on ML-aided grid agglomeration techniques to be employed within multigrid iterative solvers will also be discussed.

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