Advances in mesh adaptation for large-scale simulations: from adaptive methods to AI

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Abstract

The increasing complexity of computational models in engineering and science demands numerical methods that can efficiently resolve multiscale and evolving physical phenomena while controlling computational cost. Mesh adaptation provides a fundamental mechanism for achieving this by dynamically allocating computational resources where they are most needed. This mini-symposium will bring together researchers working on h-, p-, and r-adaptation, covering both low- and high-order discretisations, mesh motion, and emerging data-driven approaches for adaptive simulation.

The symposium will address recent advances in adaptive mesh generation and simulation, including anisotropic and goal-oriented adaptation, high-order and curved meshes, dynamic mesh motion, and combined $h/p/r$ strategies. Particular attention will be given to challenges arising in large-scale and high-performance computing, including parallel mesh adaptation, load balancing, scalability to very large meshes, and adaptation for complex geometries and multiphysics applications.

A further focus will be the emerging role of artificial intelligence and machine learning in mesh adaptation. Topics of interest include learning-based error and feature indicators, data-driven prediction of optimal mesh resolution and polynomial degree, reinforcement learning for adaptive strategies, transfer learning between simulations, and physics-informed or physics-aware approaches. The symposium will explore how AI can complement established adaptation techniques while addressing challenges of robustness, interpretability, computational cost, and generalisation.

Contributions are invited that advance the state of the art in theory, algorithms, software, and applications of mesh adaptation. The symposium aims to provide a forum for interaction between researchers developing numerical methods, mesh-generation technologies, high-performance computing approaches, and AI-based techniques, with the goal of identifying new directions towards automated, efficient, scalable, and intelligent adaptive computational simulations.