Scalability, Determinism, and State-of-the-Art Methods: Key Features of the Omega_h Open-Source Mesh Adaptation Library

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ABSTRACT

This abstract is aimed at MS 14.

Omega_h is a new open-source library for adapting tetrahedral and triangle meshes to conform to a given metric field under various constraints. In order to ensure robustness during development and best results for users, Omega_h has three unique features: excellent scalability on supercomputers including MPI+OpenMP and MPI+CUDA environments, algorithms that are fully ordering-independent, partition-independent, and deterministic, and the incorporation of the latest methods in adaptation research.

We present the independent set paradigm which forms the basis for parallelization of mesh adaptation, and the key transformations that form the building blocks for parallelizing a wide variety of unstructured mesh operations. MPI scalability has been demonstrated by generating billions of elements on up to 16,000 cores of an IBM Blue Gene/Q computer, and million-element problems can be handled efficiently by a single GPU device.

Given the typically local nature of most unstructured mesh operations, we present an upward adjacency sorting and "pull-based" model for performing operations in a way that gives the same result regardless of partitioning, ordering, and parallelism. An efficient fixed-point algorithm for parallel reductions is presented as the final key to ordering-independent results.

Finally, Omega_h brings together many of the latest methods from mesh adaptation research. Some of the most important developments incorporated include full topology-preserving edge collapses [1], edge swaps with efficient selection [2], Log-Euclidean metric tensor interpolation [3], metric tensor intersection [4], and metric field gradation control [5].

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