

PROCEEDINGS

A Scalable Geometric Acceleration Algorithm for 3D Non-Conforming Embedded Discrete Fracture Models

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ABSTRACT

In numerical simulations of Enhanced Geothermal Systems (EGS) and unconventional reservoirs, accurate modeling of flow in discrete fracture networks and matrix–fracture interactions is essential for engineering safety and thermal recovery. The non-conforming Embedded Discrete Fracture Model (EDFM) has been widely adopted to balance physical resolution and computational efficiency on unstructured meshes. However, for dense, intersecting, and highly non-planar three-dimensional fracture networks, geometric intersection detection between fracture elements and heterogeneous matrix grids becomes a severe computational bottleneck.

To address this issue, a highly efficient intersection detection algorithm for three-dimensional non-conforming EDFM is proposed based on a voxelization–14-DOP acceleration framework. A uniform background voxel grid is constructed, and conservative three-dimensional rasterization of fracture micro-elements is performed using an exact triangle–voxel intersection test based on the Separating Axis Theorem (SAT), ensuring completeness in the broad-phase search while extracting optimal candidate matrix cells. In the narrow phase, tight 14-Discrete Oriented Polytope (14-DOP) bounding volumes are employed to further cull invalid mesh pairs, significantly reducing unnecessary exact geometric evaluations. A dedicated sub-triangulation strategy is additionally incorporated to robustly handle non-coplanar intersections induced by complex fracture geometries.

Benchmark tests on a complex three-dimensional fracture network with fifteen interleaved fractures demonstrate that, compared with exhaustive search and Octree-accelerated approaches, the proposed method reduces exact geometric intersection checks by approximately 99.9% and 75.0%, respectively, and achieves up to three orders of magnitude speedup in overall processing time, while preserving fully consistent topological reconstruction.

KEYWORDS

Non-conforming EDFM; voxelization-based acceleration; separating axis theorem; 14-DOP bounding volume; enhanced geothermal systems

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