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Guaranteed Element Quality Overlay Tetrahedral Mesh Generation With CAD Feature Capture

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Many variations of overlay grid approaches to tetrahedral mesh generation have been published [1]. They are particularly popular with level set data to capture iso-surface type geometries. However, difficulties using overlay grid approaches to mesh CAD models are documented in literature due to difficulties capturing the CAD curves and vertices without sacrificing element quality. We present a new approach to overlay grid tetrahedral mesh generation with element quality guarantees and captures most CAD surface, curves and vertices.

Overlay grid approaches start from an overlay grid with excellent quality, followed by either snapping overlay nodes, or cutting overlay cells to geometry intersections. Our design principle is capture as much geometry as possible without sacrificing element quality. We accomplish this design principle with snapping only (i.e. no element cutting) by iterating between first, moving overlay grid nodes towards their target locations on CAD features but only to the point of maintaining a user specified element quality threshold, and second, tetrahedral topology changes to improve the quality of tetrahedra in the neighbor of the moving nodes, which will enable nodes to move closer to their targets in subsequent iterations. While there is no guarantee that all nodes will ever reach their target locations, in practice, greater than 99.9% of overlay nodes do reach their targets. This guarantees the resulting element quality at the expense of geometry capture. The higher the requested guaranteed element quality, the lower the geometric fidelity and vice versa.

We couple this guaranteed element quality with the target location identification described by Staten et. al. [2] to capture CAD features with tetrahedral meshes in distributed memory parallel. Updates on the latest progress of this approach will be presented.

[1] F. Labelle, J. R. Shewchuk. ”Isosurface Stuffing: Fast Tetrahedral Meshes with Good Dihedral Angles.” ACM Transactions on Graphics, 26(3):57.1-57.10, July 2007. Special issue on Proceedings of SIGGRAPH 2007.

[2] M. L. Staten, D. R. Noble, C. R. Wilson, C. L. McBride, M. K. Bhardwaj. “Massively Parallel Tet Meshing With Size-Dependent Feature Capture on CAD Models, Proceedings 27th International Meshing Roundtable, 2018.

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