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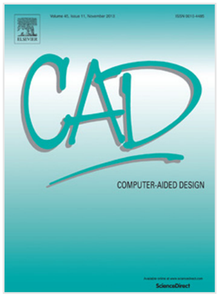

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All-Quad Meshing without Cleanup

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Abstract

We present an all-quad meshing algorithm for general domains. We start with a strongly balanced quadtree. In contrast to snapping the quadtree corners onto the geometric domain boundaries, we move them away from the geometry. Then we intersect the moved grid with the geometry. The resulting polygons are converted into quads with midpoint subdivision. Moving away avoids creating any flat angles, either at a quadtree corner or at a geometry–quadtree intersection. We are able to handle two-sided domains, and more complex topologies than prior methods. The algorithm is provably correct and robust in practice. It is cleanup-free, meaning we have angle and edge length bounds without the use of any pillowing, swapping, or smoothing. Thus, our simple algorithm is fast and predictable. This paper has better quality bounds, and the algorithm is demonstrated over more complex domains, than our prior version.

Keywords: All-Quadrilateral Meshing, Guaranteed Quality, Sharp Features

1. Introduction

Generating good quality meshes is a challenging problem with many engineering applications: e.g., Finite Element Analysis (FEA) [1, 2, 3] and Computer-Aided Design (CAD) [4, 5]. The quality of the mesh plays a significant role in the accuracy and stability of the numerical computation. It is difficult to determine if a mesh possesses even the minimal quality necessary to undertake a computational analysis without concrete metrics. Since the necessary criteria are often application specific, the community has gravitated toward quality metrics based on geometric criteria that are usually sufficient. For example, angle minimum and maximum bounds are commonly used, along with element size, aspect ratio, skew, stretching, and orientation.

Many algorithms for triangular meshing are robust and provide guaranteed quality, and are readily available. In that sense triangular meshing is well-developed, but quad meshing is not. Prior quad methods often have difficulty in achieving angles in $[45°, 135°]$. Indeed, sharp features of the input domain may make this impossible. However, even without sharp input features, many prior methods create flat elements that require post-processing to achieve good angles. Another shortcoming is that many methods only work on restricted classes of input domains, such as meshing only one side of a geometric boundary, or vertices must have four or fewer curves. Ideally, one would like a provably good algorithm (i.e., with quality bounds) guaranteed to work on arbitrary topology, including point sets, two-sided domains, and embedded curves.

1.1. Related Work

Unstructured all-quad meshing algorithms are usually categorized into two main categories: *indirect* and *direct*. A classical indirect approach starts with a triangular mesh, and then transforms the triangular elements into quadrilateral elements, via optimization [6, 7], refinement and coarsening [8], or simplification [9]. A class of indirect methods start with a triangular mesh and applies the mid-point subdivision rule [10, 11] to

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