Atomic Volumes for Mesh Completion

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Problem Statement

- Given a surface mesh with holes, create polygonal patches to close the holes in a topologically correct way.
  - User constraints may be added

Definition of a “correct” solution

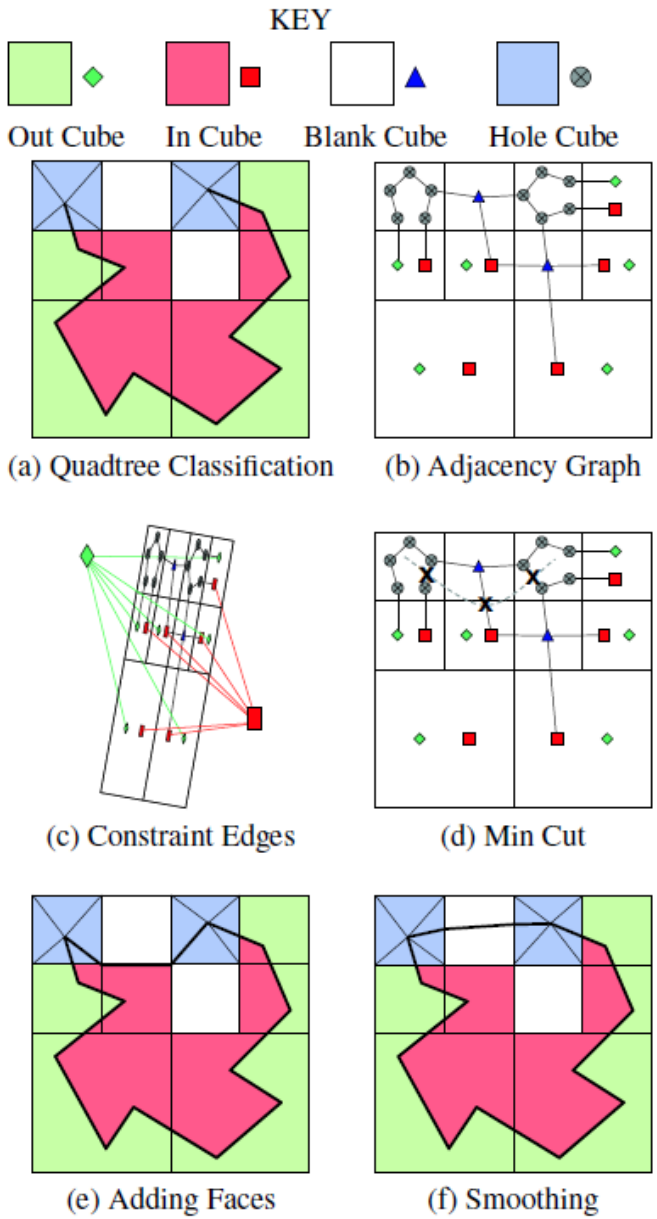
- Produce a non-self-intersecting watertight mesh.
- Process arbitrary holes in complex meshes.
- Avoid changing, approximating or re-sampling the original data away from the holes.
- Incorporate user-provided constraints to allow the selection of multiple topologically differing solutions,
- Process large scanned meshes with a running time proportional to the size of the holes, rather than that of the input mesh.

Algorithm outline

- Subdivide space into an octree of “atomic volumes”
- Create a graph that spans connected “inside” and “outside” regions in space
- Compute a min-cut on the graph to find edges that cross a hypothesized boundary in “hole cells”. Add the boundary faces to the mesh to fill the hole
- Smooth the new faces

Example of subdivision

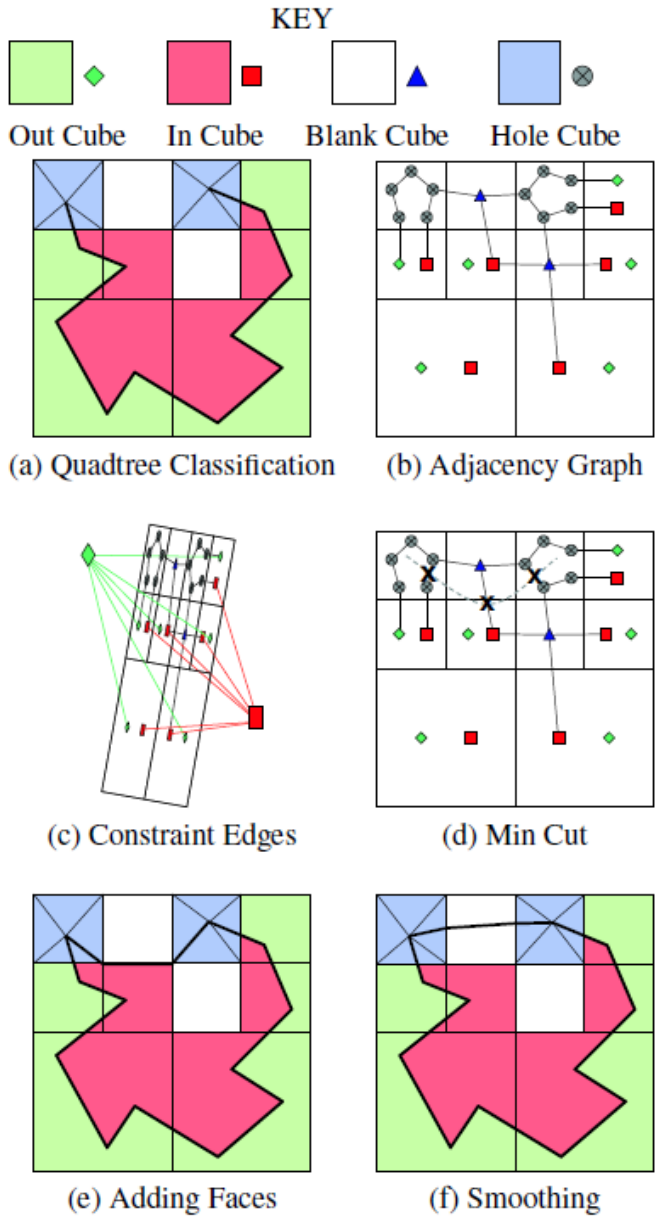
- IO cubes: part green and part red.
  - Note: The labels in the Figure do not represent the labels in the paper
- Blank cubes: not intersected by mesh faces
- Hole cubes: contain a single boundary vertex or a single boundary edge



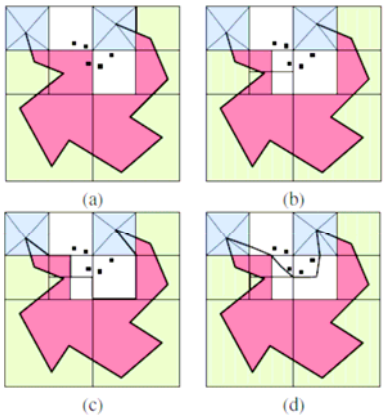
Hole cubes

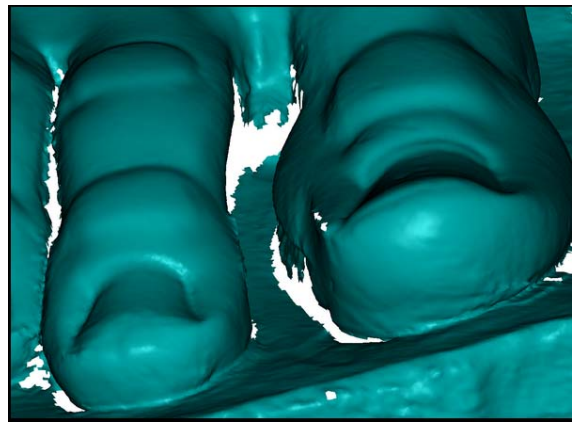
Notes about paper text

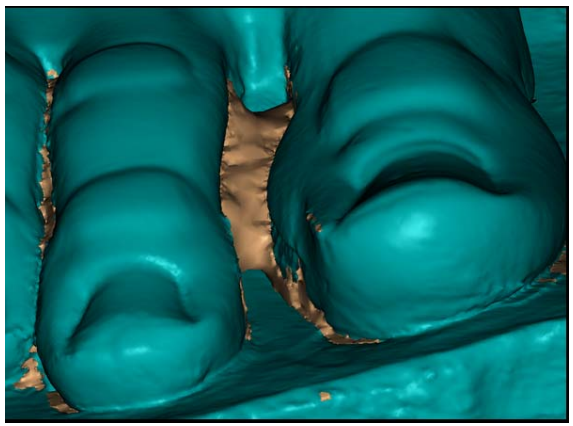
- "**Boundary Edges** are edges with a finite edge-weight, placed between any two nodes with adjacent atomic volumes. If the boundary between two volumes is intersected by a face of the input surface then no edge is needed. In such a case, both volumes must be IO cubes, and therefore the boundary between those two cubes is pre-defined. In all other cases, an edge is added."
  - This is NOT illustrated in the Figure.
- "the boundary between an atomic volume and an IO cube is always a polygon that does not intersect any input triangles"

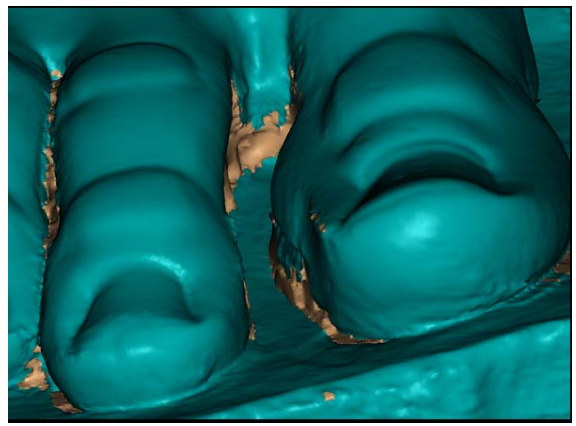


Adding user constraints









Smoothing

- Laplacian smoothing of mesh: Each vertex is moved to the mean location of its immediate neighbors.
- Mesh topology must be preserved
- “Vertices may be moved as long as each remains within its own area, defined by the centers of the neighboring atomic volume.”
  - Could use Voronoi cells?

Strengths and weaknesses of the method

Strengths

- Produces a watertight model
- Does not change existing polygons
- Adaptive subdivision near holes
- Uses a “logical” inference to separate inside and outside
- Can be extended to patch holes in volumetric scans

Weaknesses

- Octree structure defines shapes of patch polygons
- The authors could have done a better writing job
- The smoothing method seems to be ad-hoc