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Watertight Planar Surface Meshing of Indoor Point-Clouds with Voxel Carving

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Goal

Create triangulated meshes that represents the geometry of a point-cloud.

- Watertight representation
- Memory efficient processing and representation
- Handle large point-clouds (over 100 million points)
- Generate planar models
- Ensure high-quality triangles
- Preserve fine detail

Motivation

- Virtual walkthroughs
- Indoor navigation
- Augmented reality
- Energy simulation applications

Input Data

Input point-cloud created using ambulatory scanning system, mounted on a human operator as a backpack.

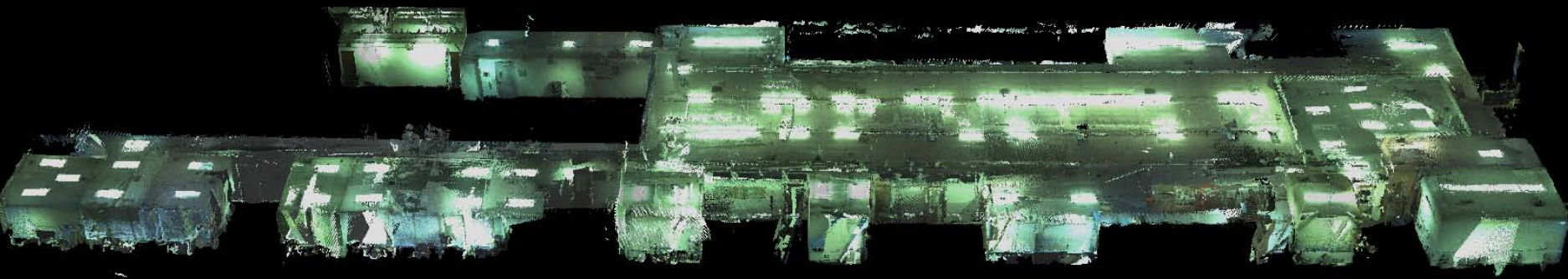


Localizing system during data collection enables tracking the path of the backpack to generate a point-cloud from the collected LiDAR scans.

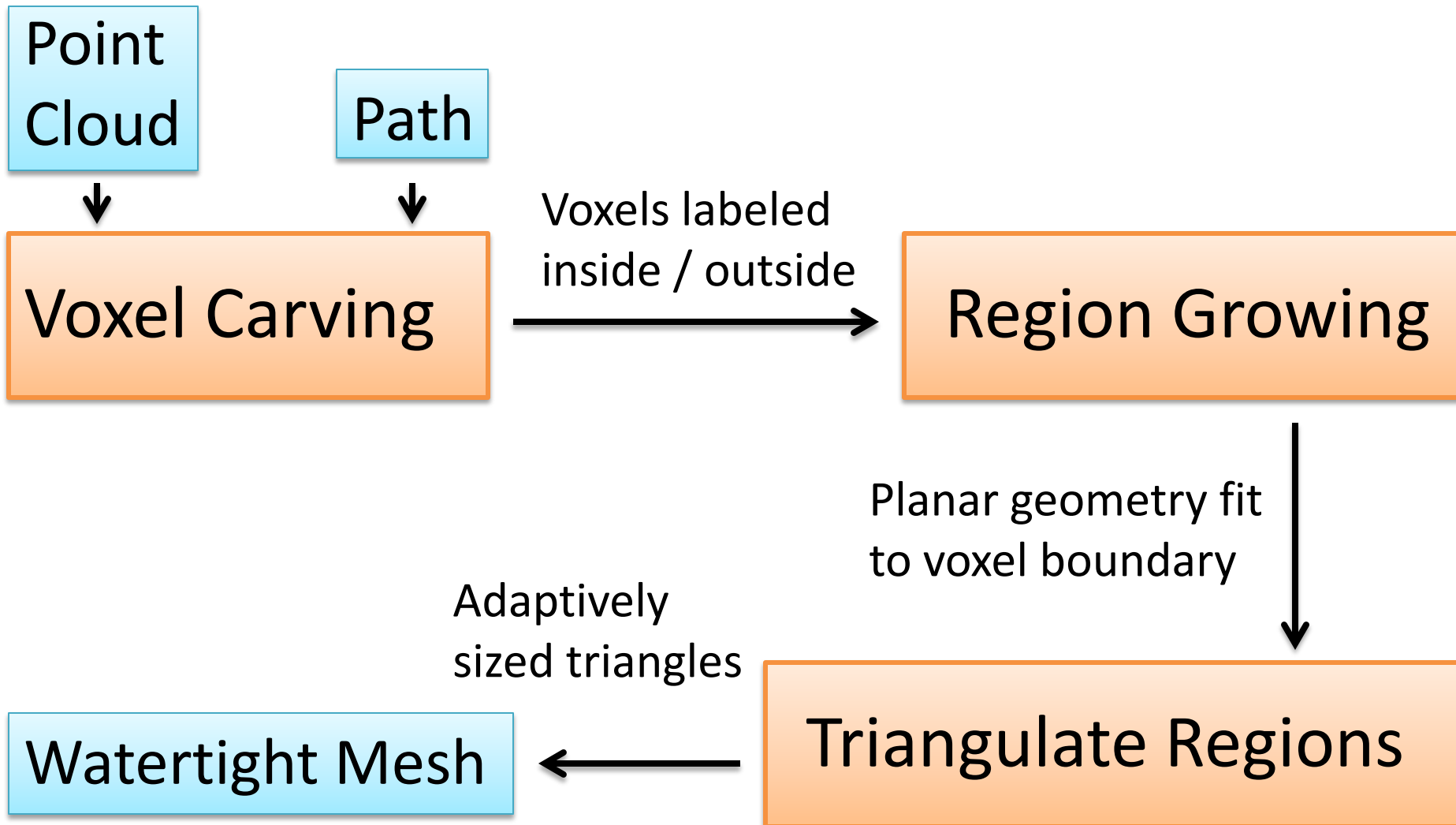
Path walked by Operator



Resulting point-cloud

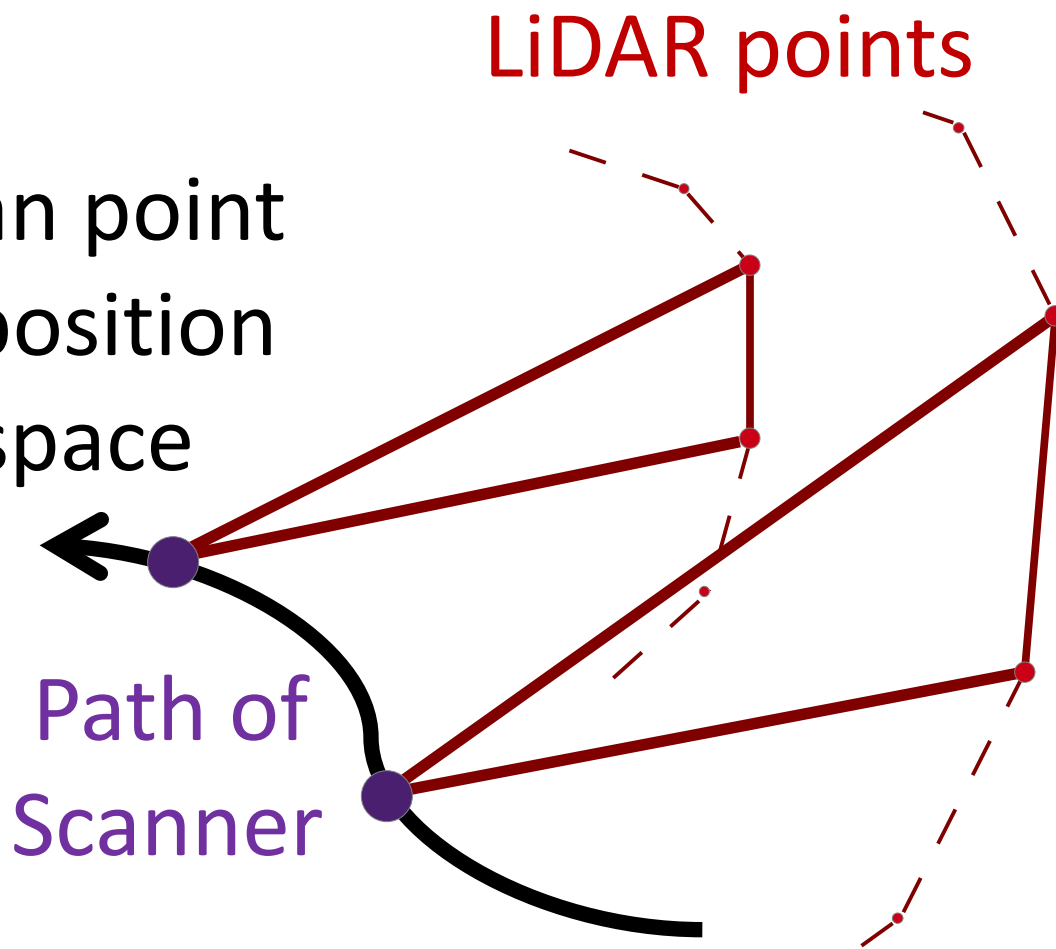


Surface Meshing System Diagram



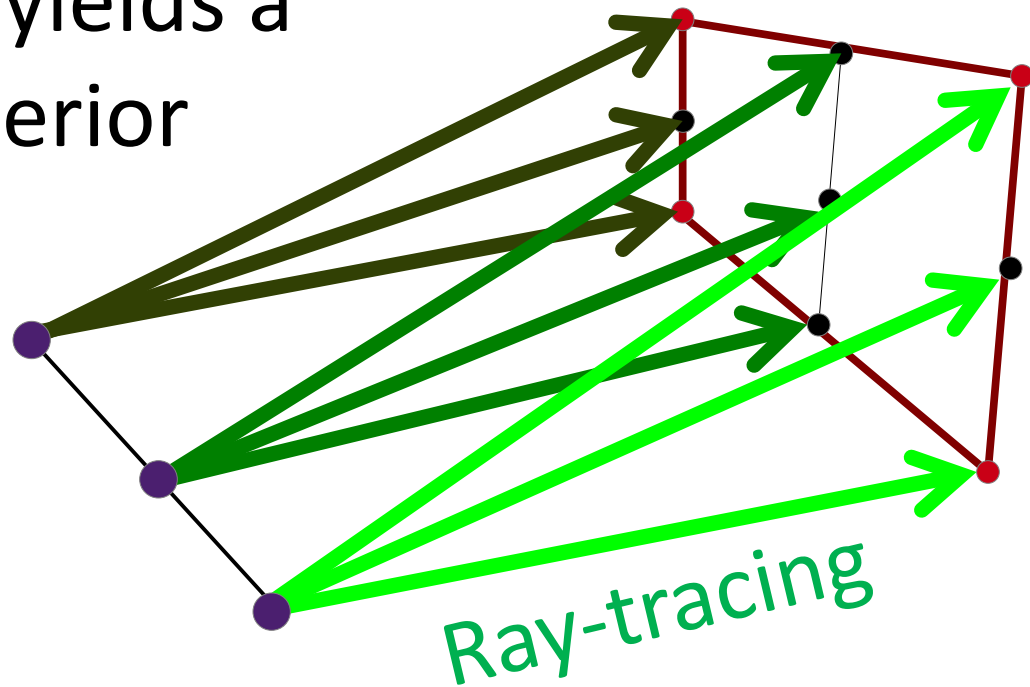
Carving

The line segment between each scan point and the scanner position represents open space



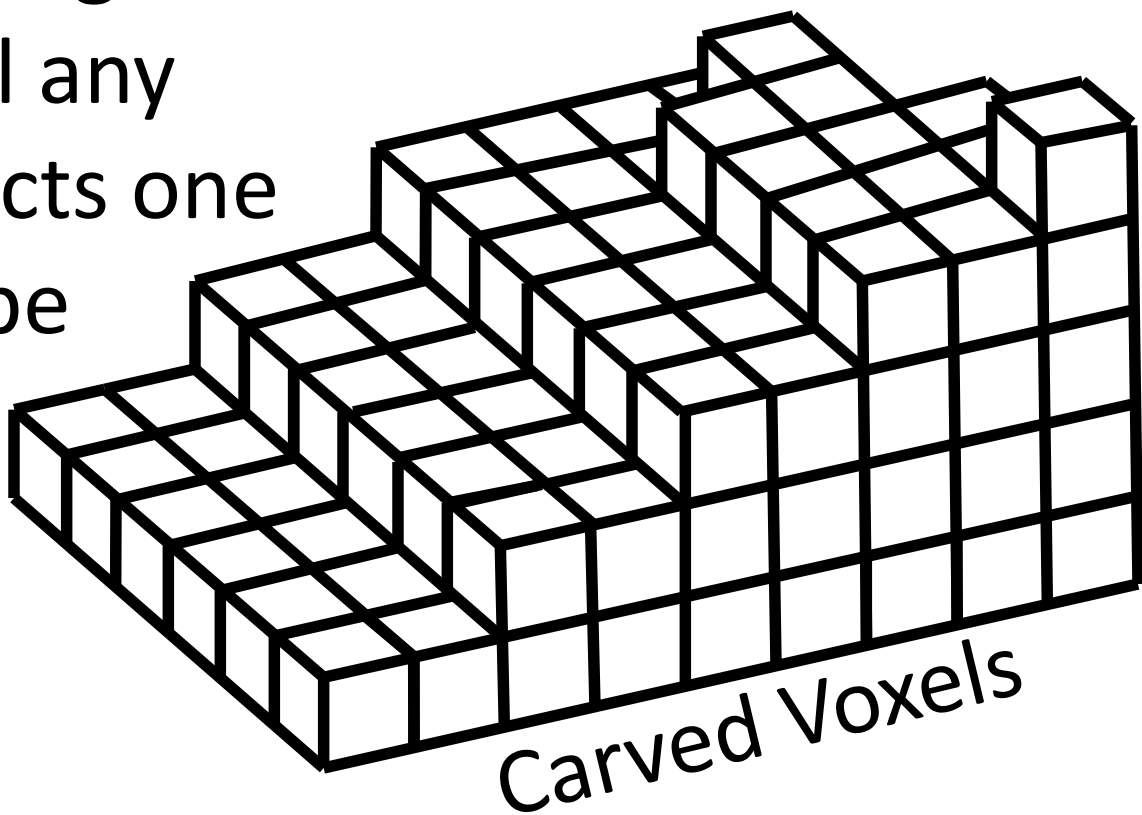
Carving

Interpolating a solid volume between these lines yields a representation of interior space



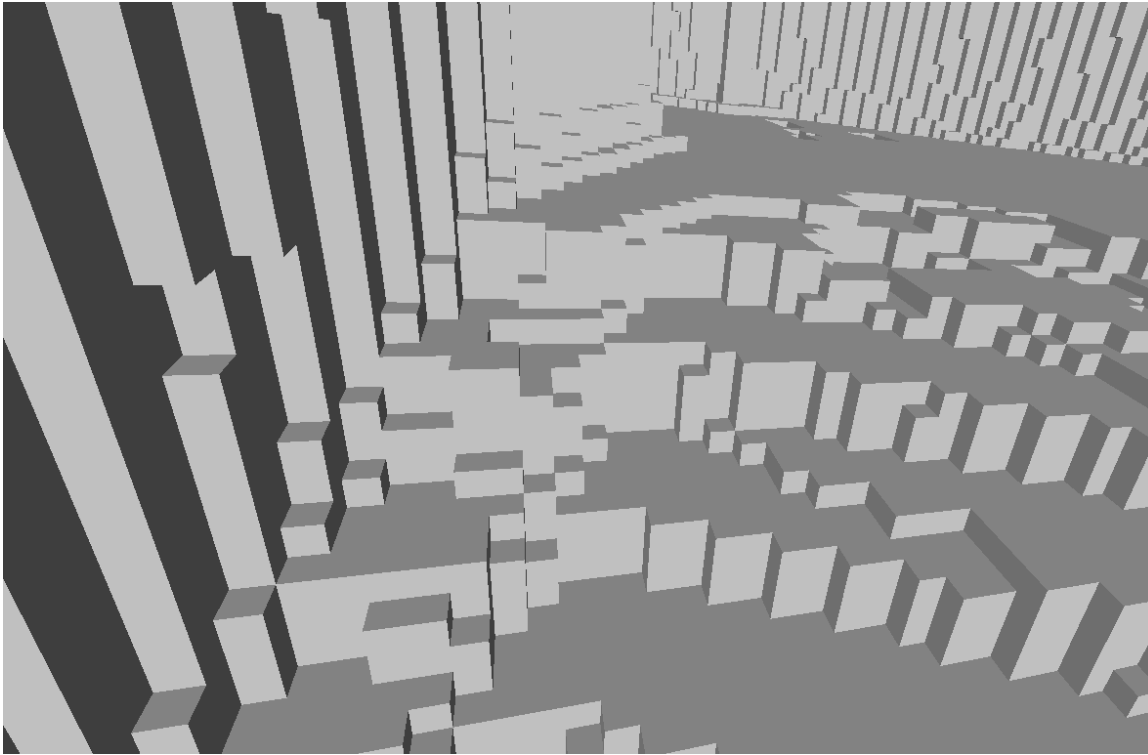
Carving

By defining a voxel grid in space, we label any voxel that intersects one of these lines to be *interior*, and the rest are *exterior*



Plane Fitting

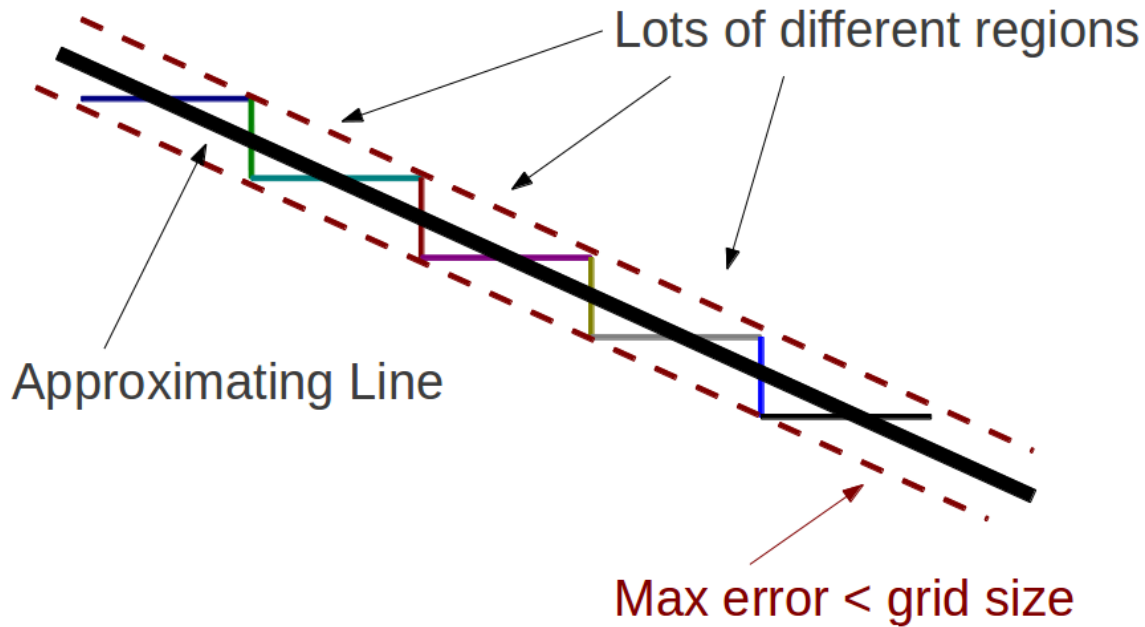
Carved voxels of staircase



Surface of voxels is discretized.

Want to fit planes to remove “zig-zag” artifacts

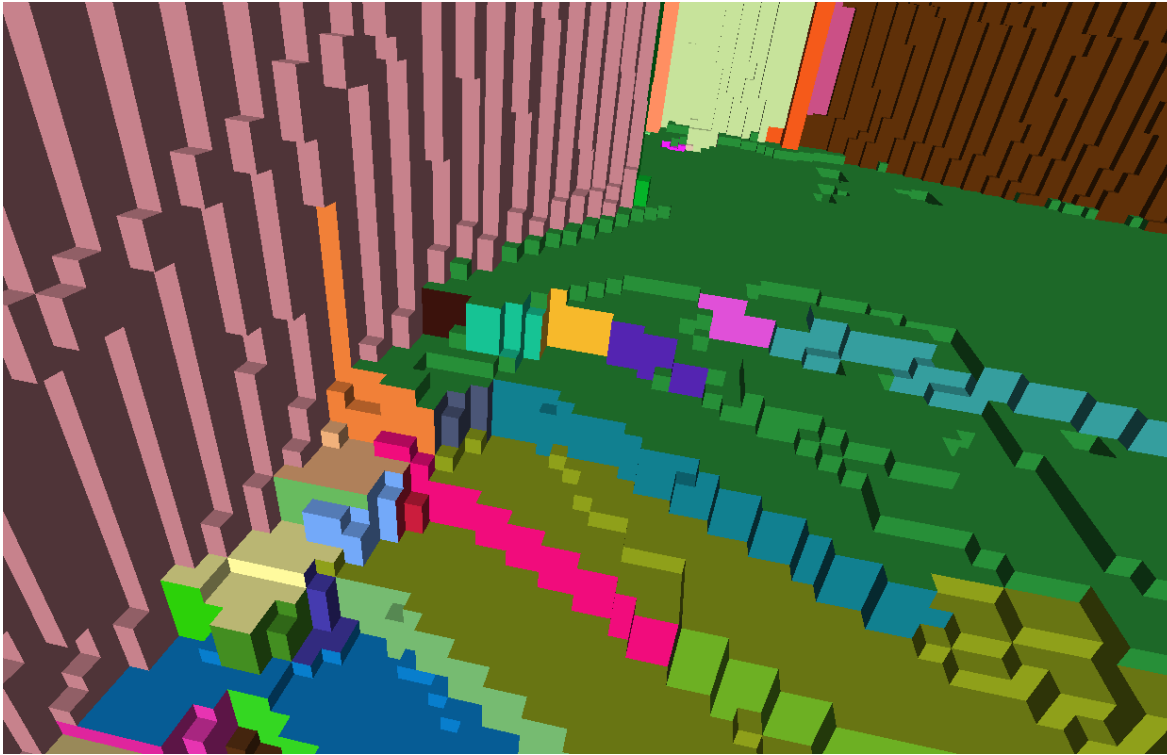
Plane Fitting



Iteratively group regions that well-represent planes

Plane Fitting

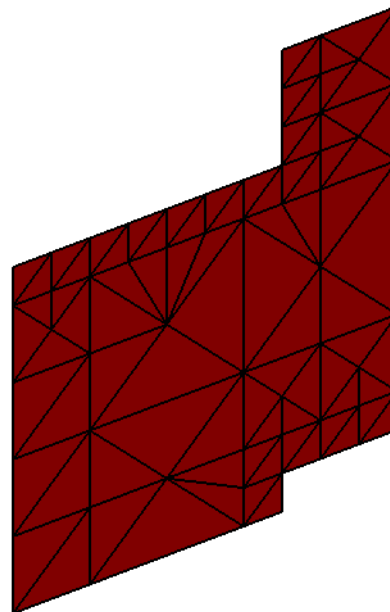
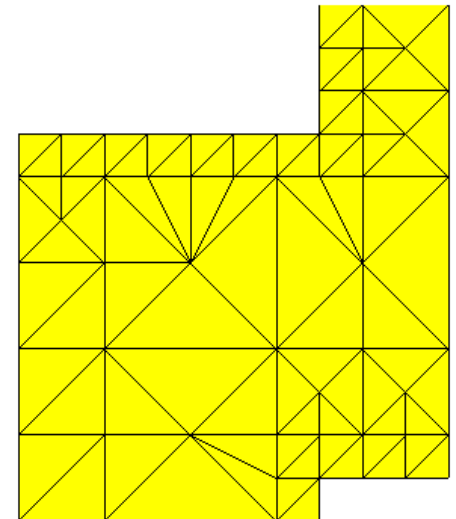
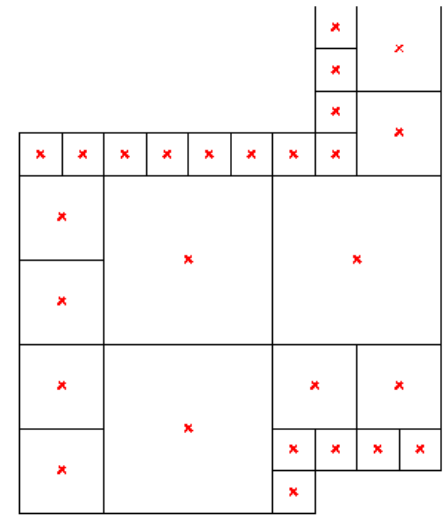
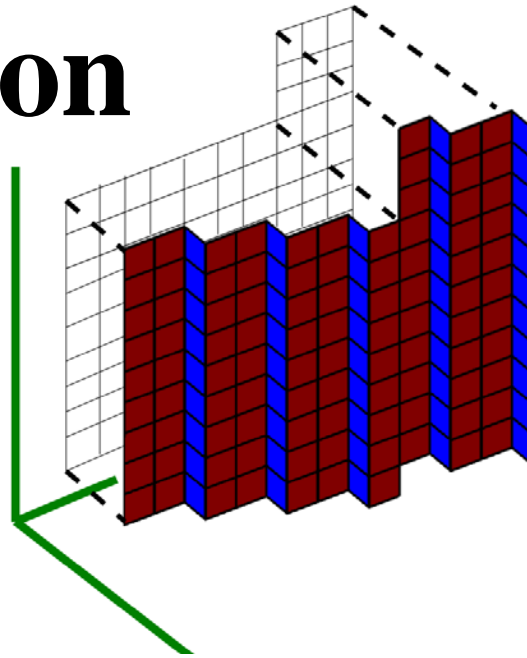
Grown planar regions



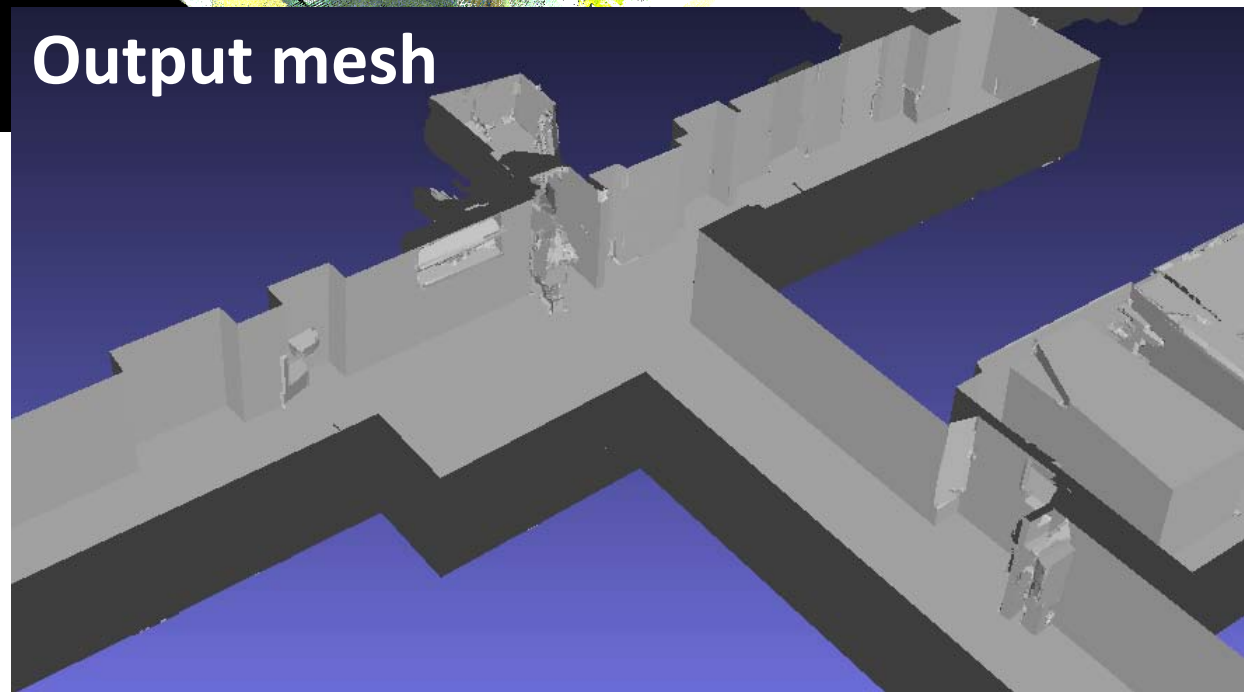
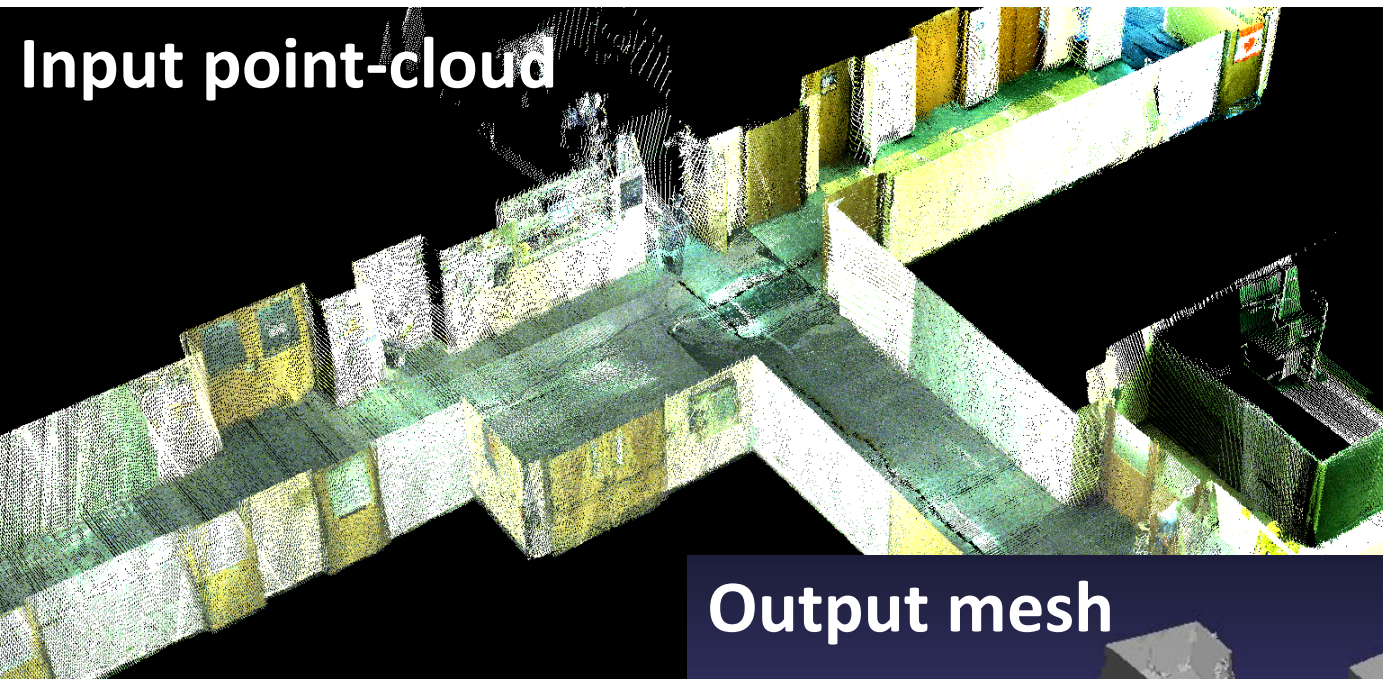
Voxel faces are grouped into regions that are approximately planar

Triangulation

- Voxel faces grouped into regions, but still discretized
- Each region is triangulated along its dominant axis
- Triangulation uses a quadtree structure to adaptively mesh each region, so larger regions use larger triangles
- The triangulations are merged into a 3D mesh so the seams are watertight

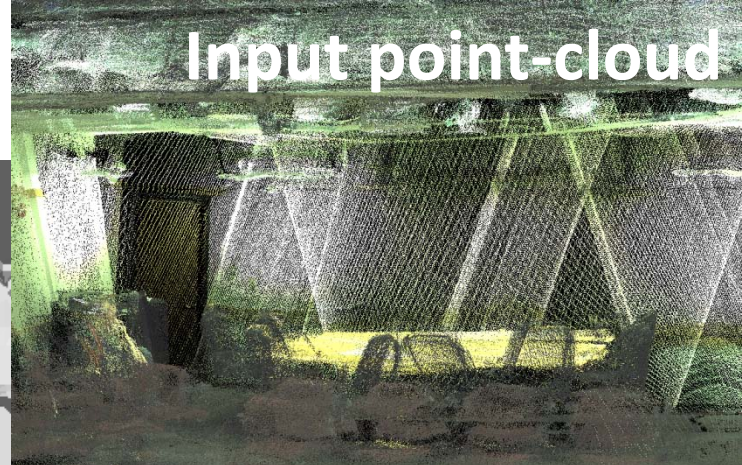
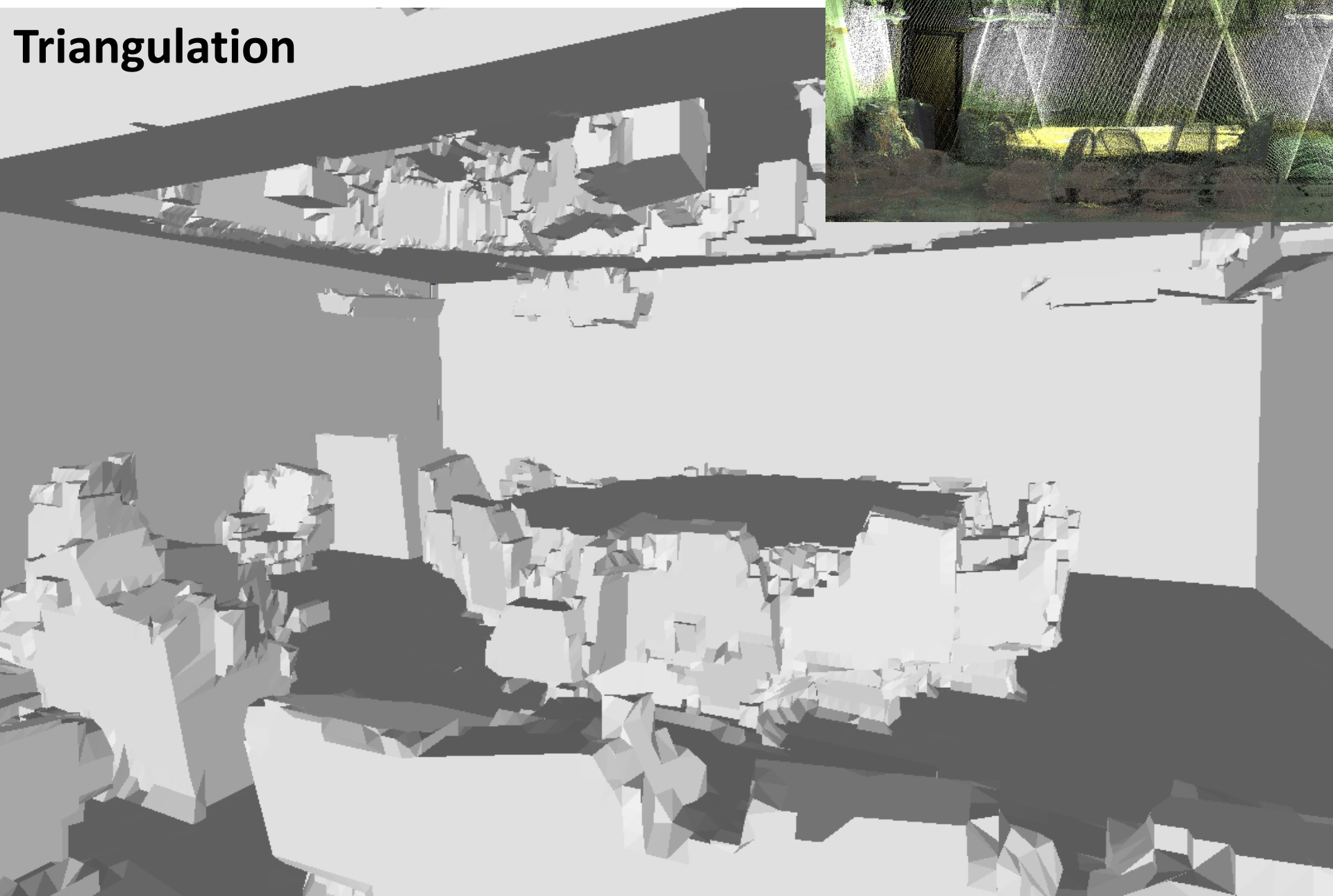


Results

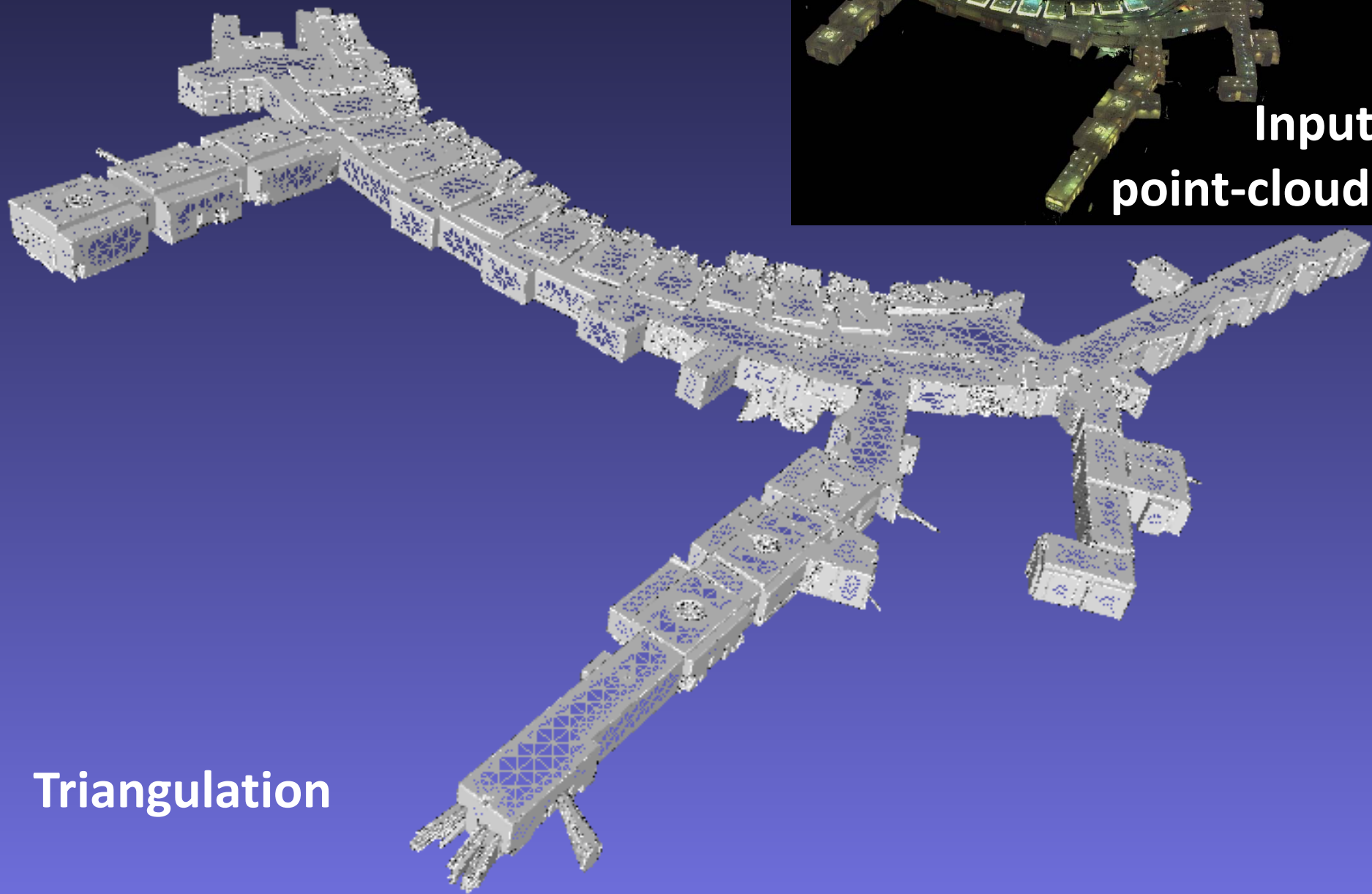
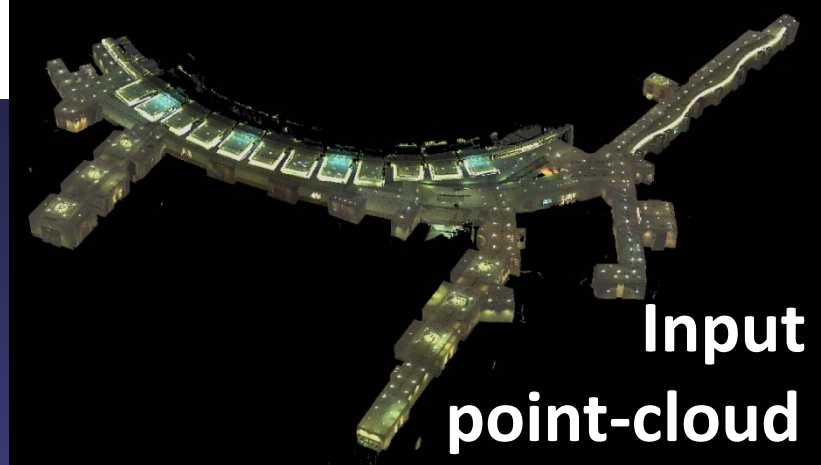


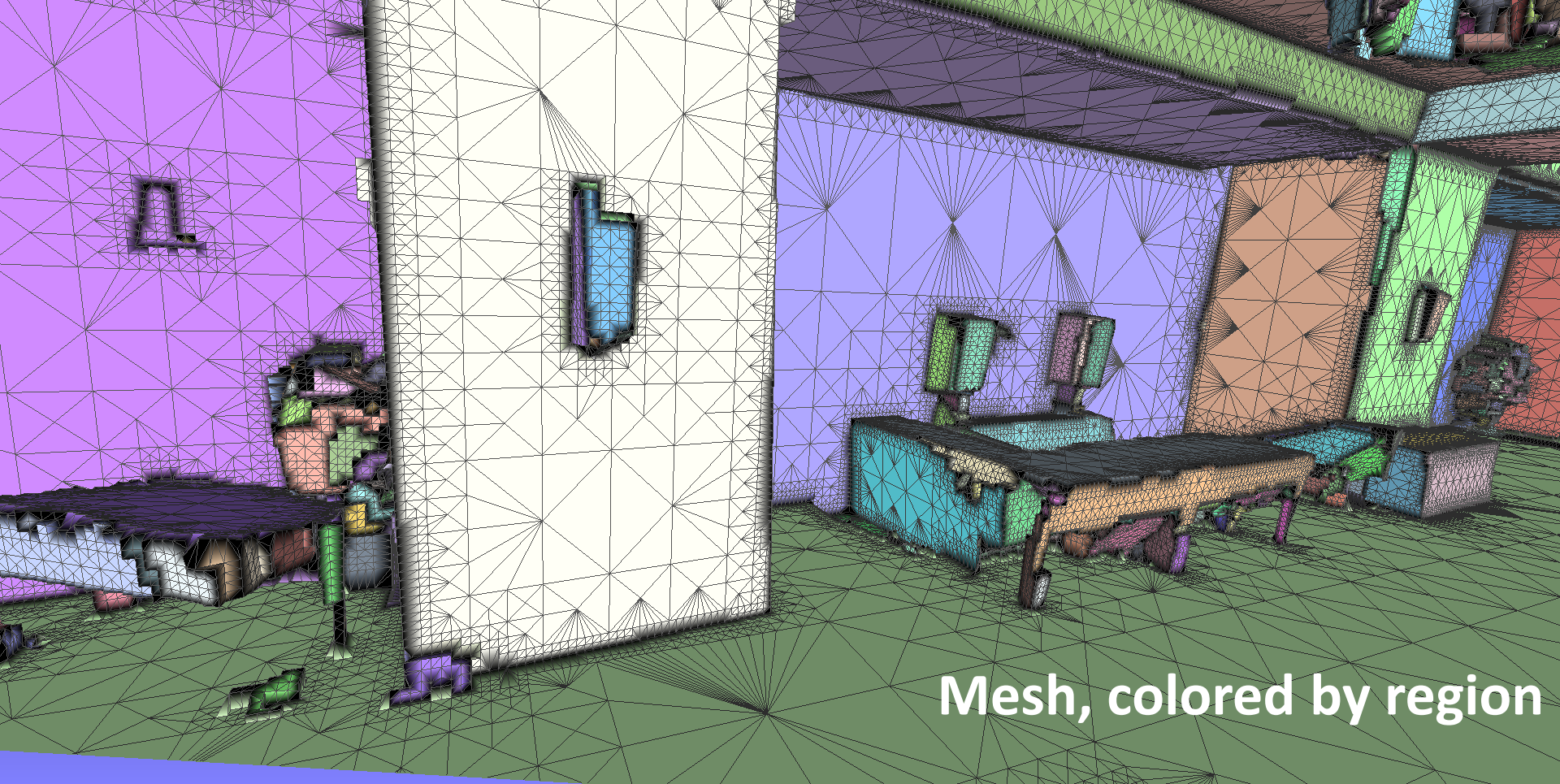
Model of conference room

Triangulation



Model of hotel hallways

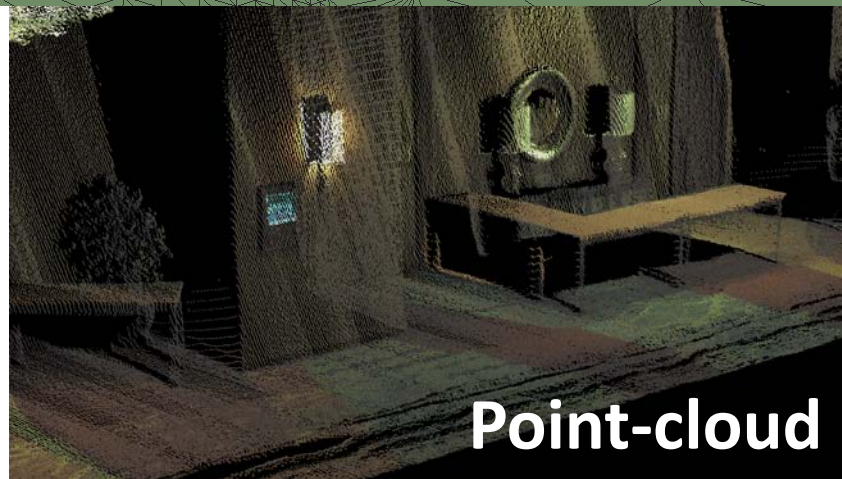




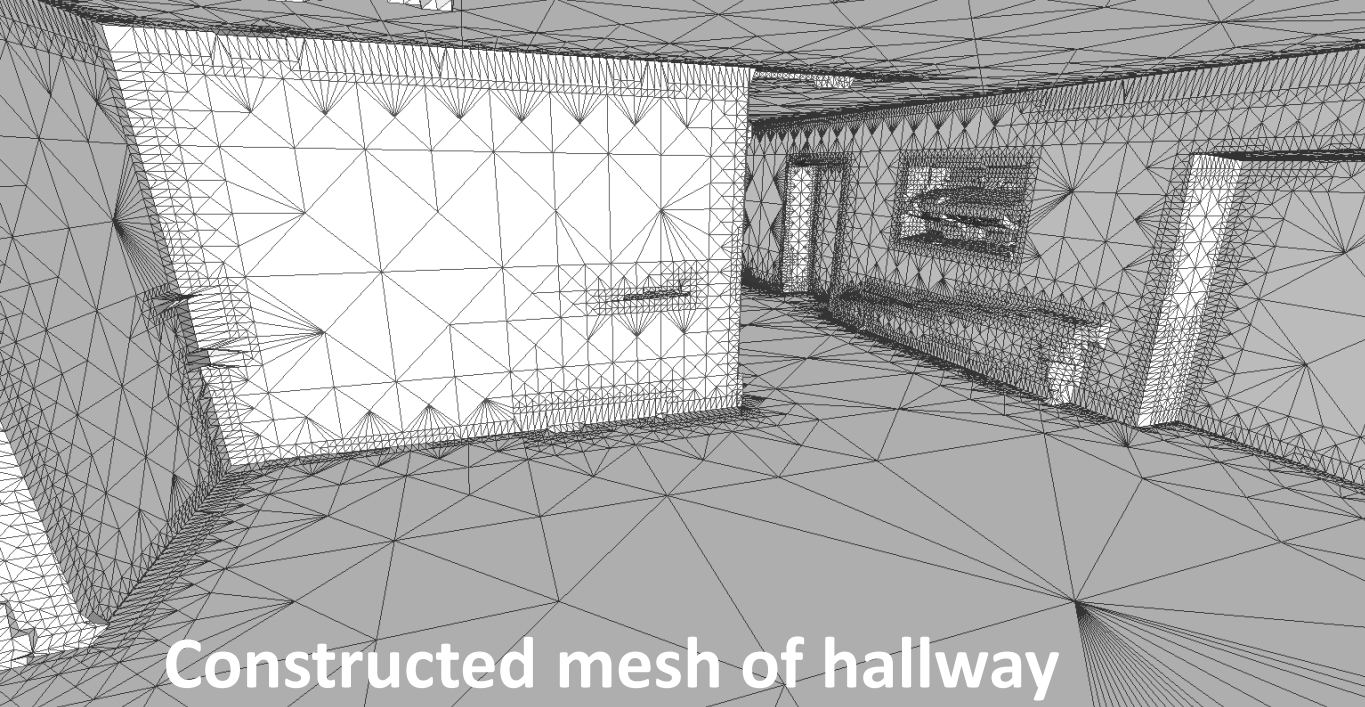
Mesh, colored by region

Close up of hotel hallway

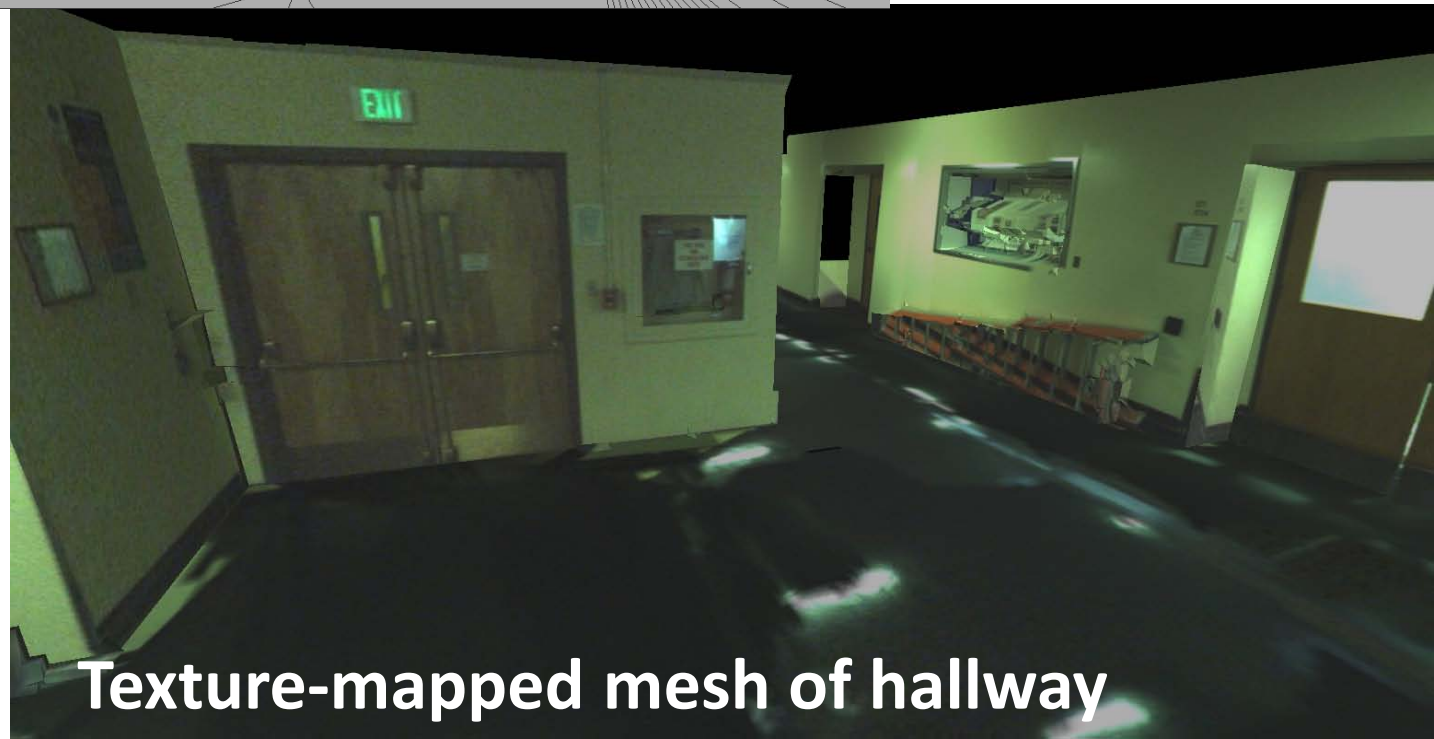
Viewing triangulation and planar regions



Point-cloud



Constructed mesh of hallway



Texture-mapped mesh of hallway