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

3DV - June 29, 2013

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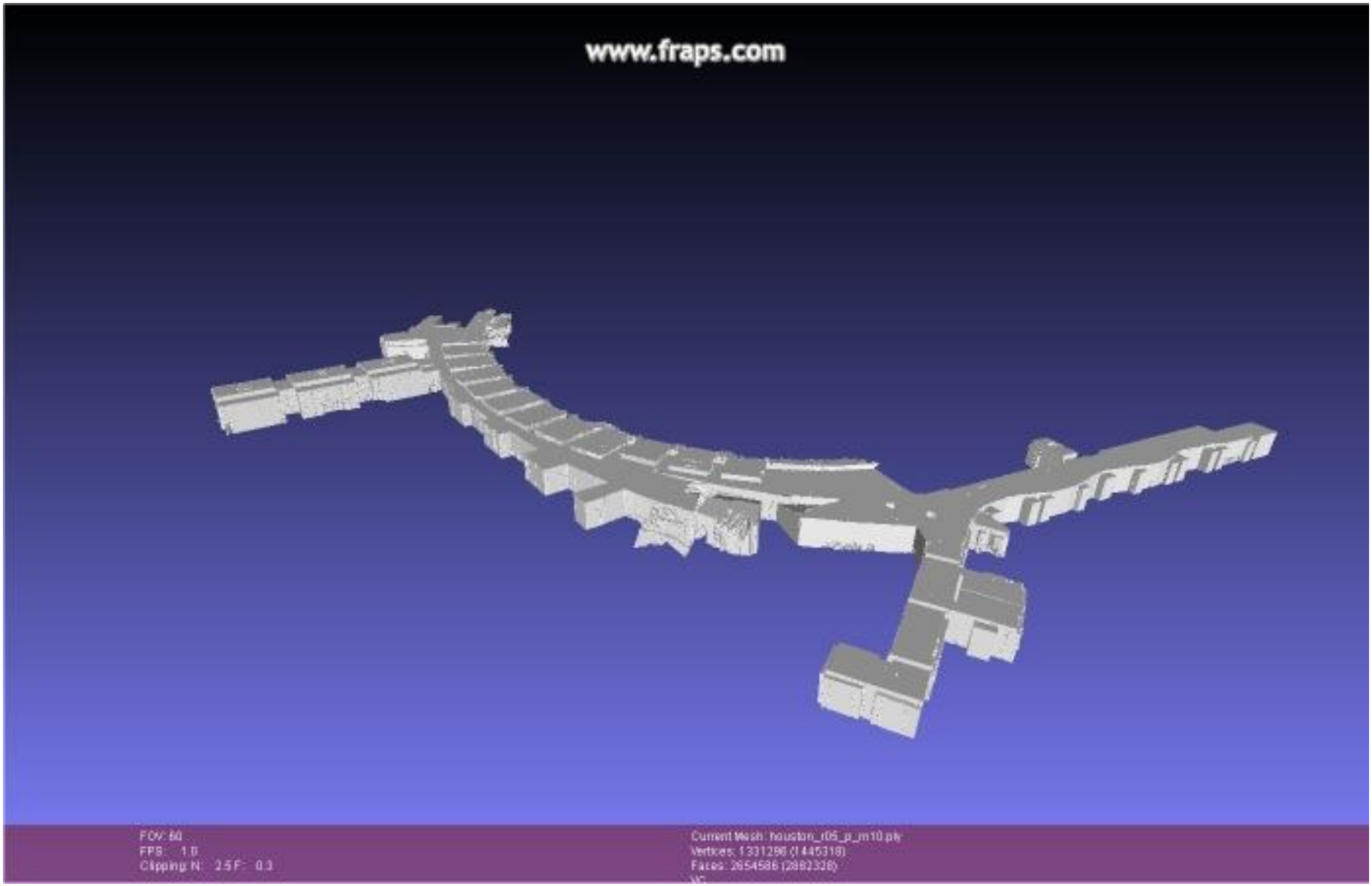
Surface Meshing of Buildings

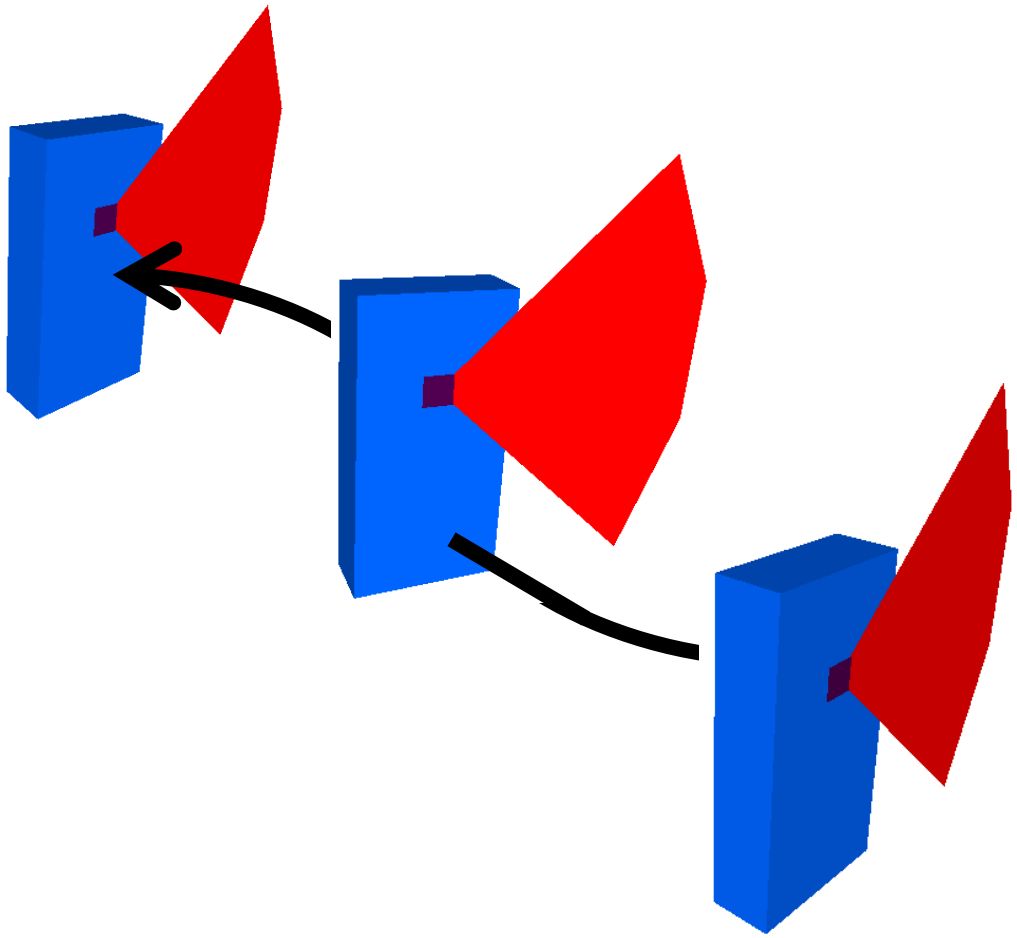


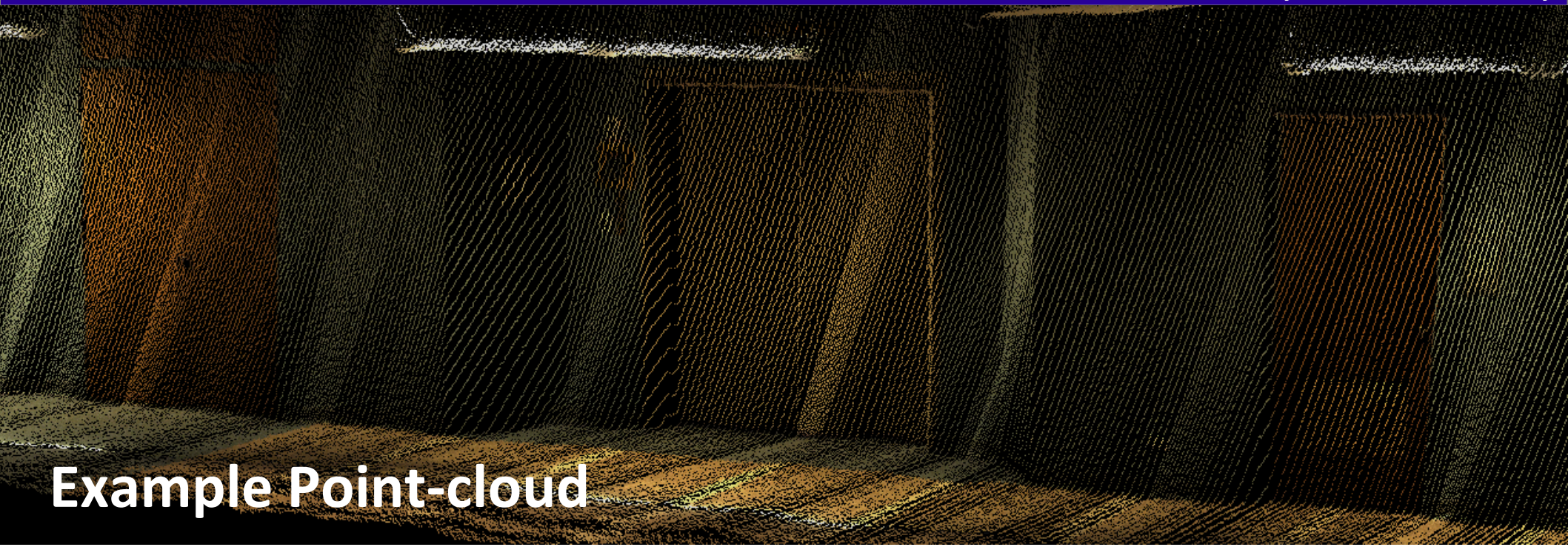
Indoor Modeling

- Acquisition System

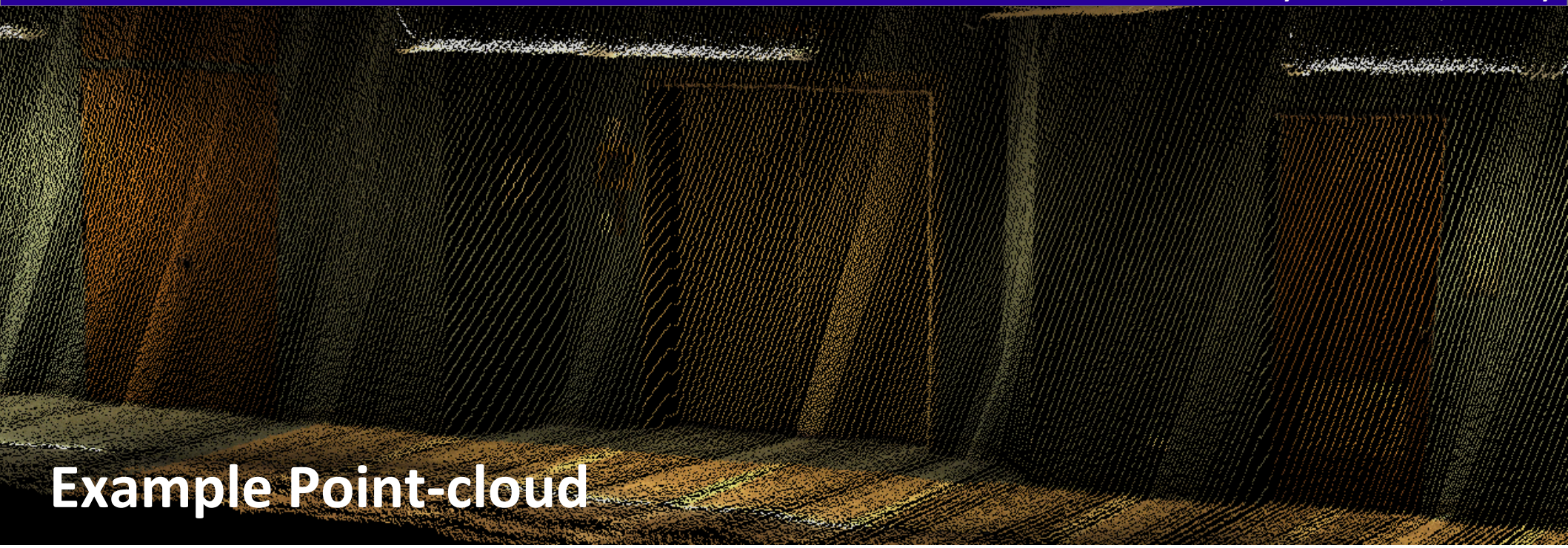
Indoor Modeling

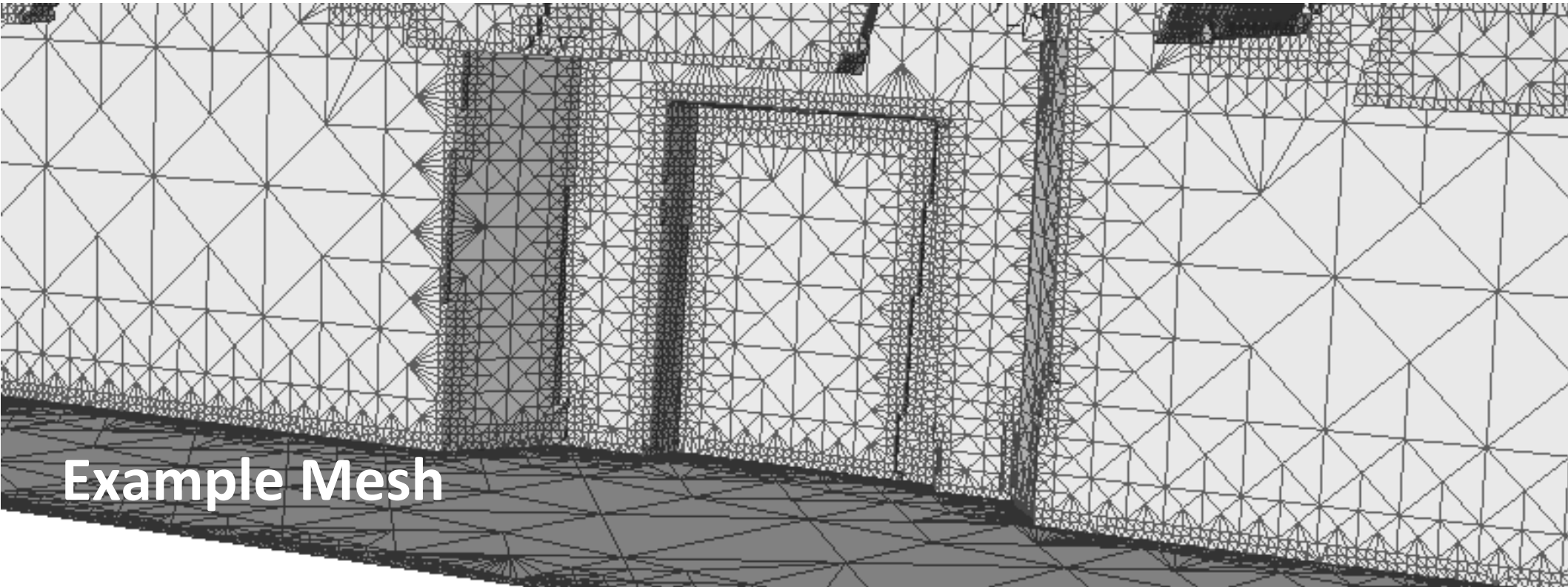
- Point-cloud Generation





Example Point-cloud


Example Point-cloud


Example Mesh

Motivation

- Why is meshing useful?
- Why do we want it to be planar?
- Why do we want it to be watertight?

Motivation

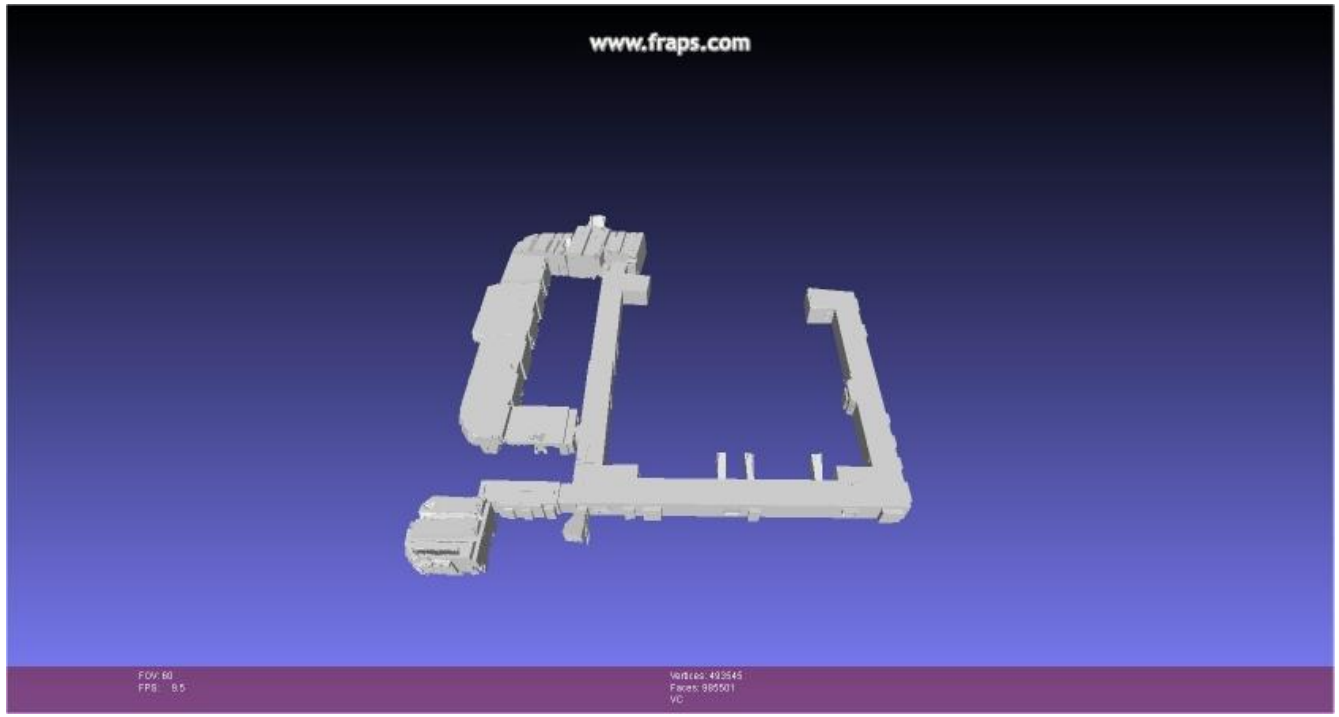
- Why is meshing useful?

Example Point-cloud

- **45 Million Pts**
- **3.5 GB on disk**

Motivation

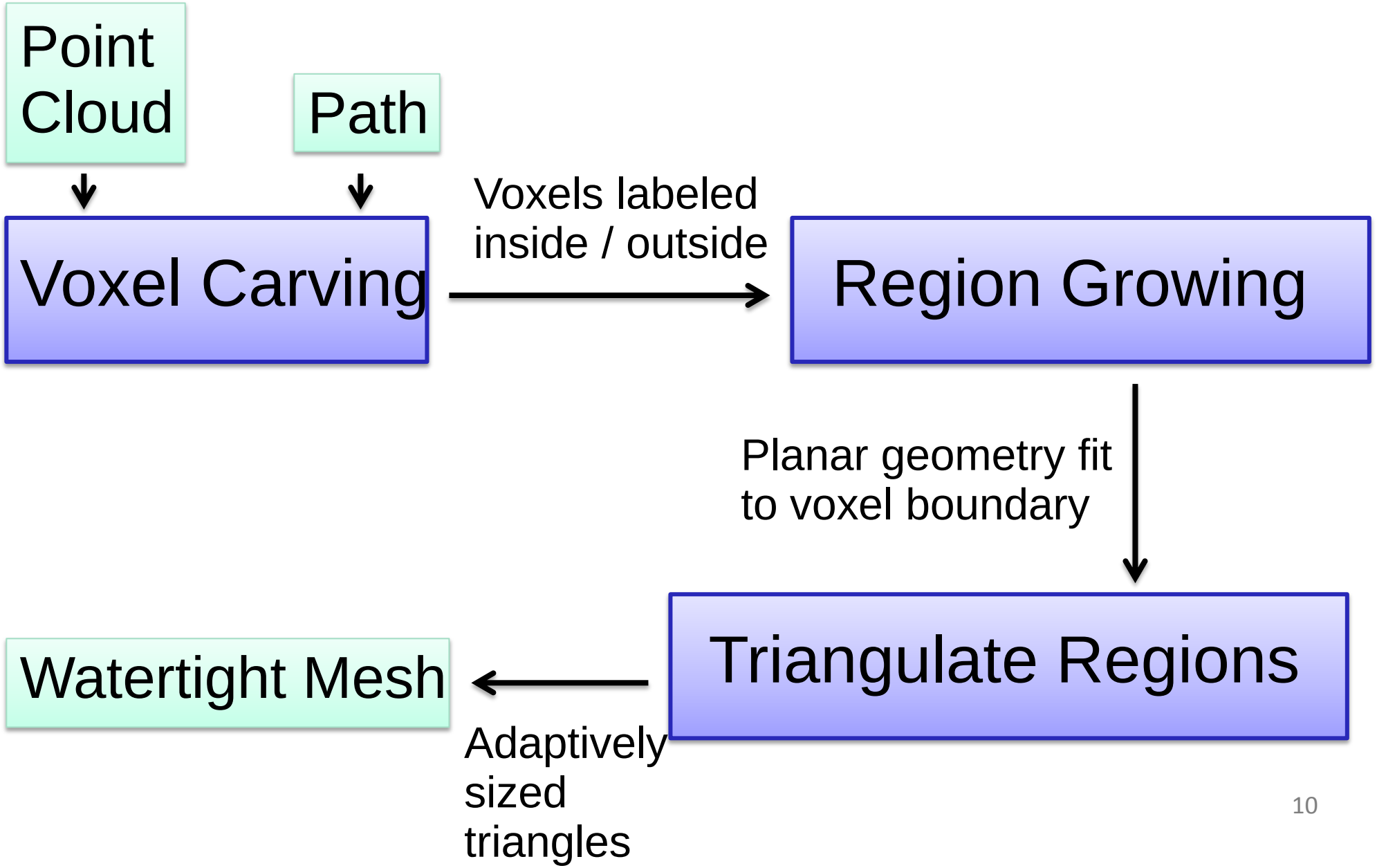
- Why is meshing useful?



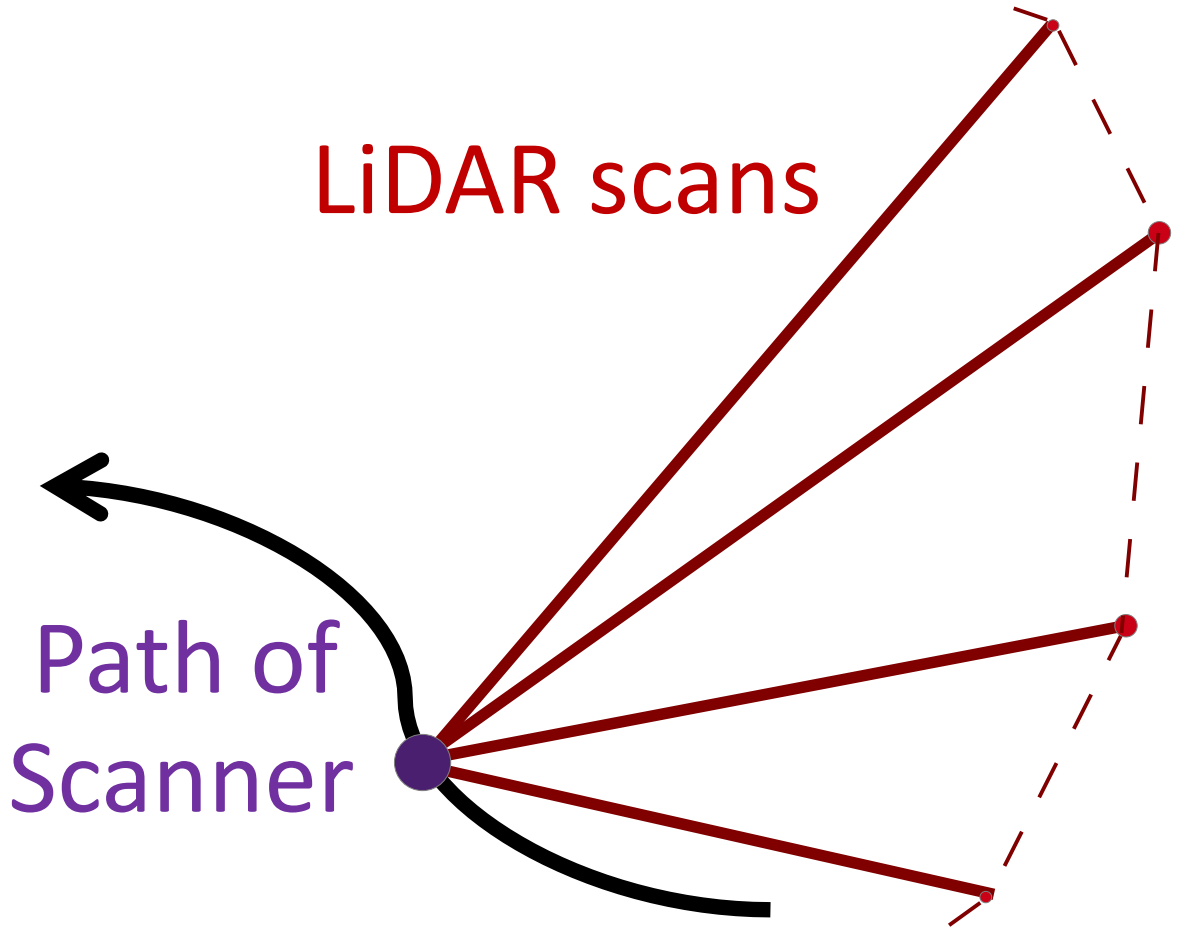
Example Mesh

- 985,000 Tris
- 20 MB on disk

Approach

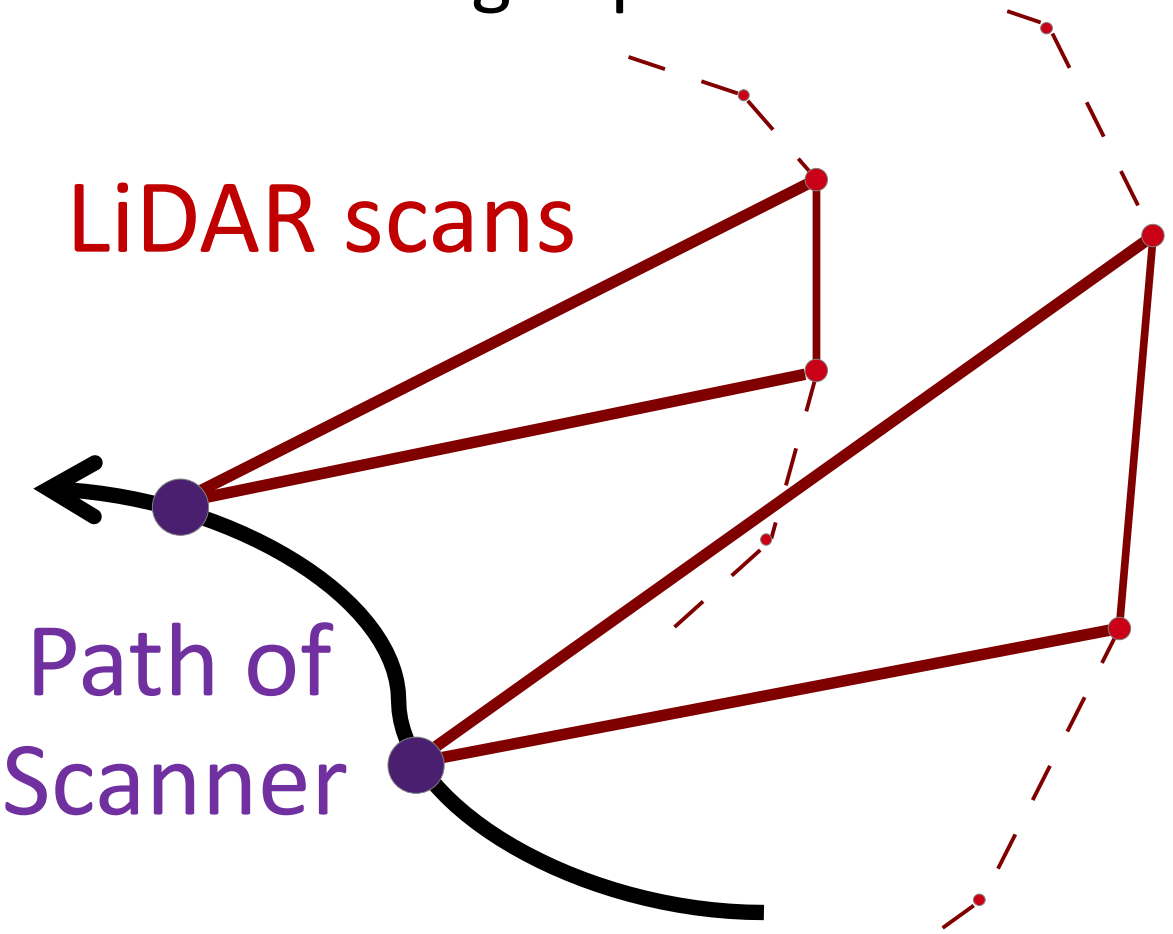

Point Cloud
Path
Voxel Carving
Voxels labeled inside / outside
Region Growing
Planar geometry fit to voxel boundary
Triangulate Regions
Watertight Mesh
Adaptively sized triangles

Voxel Carving



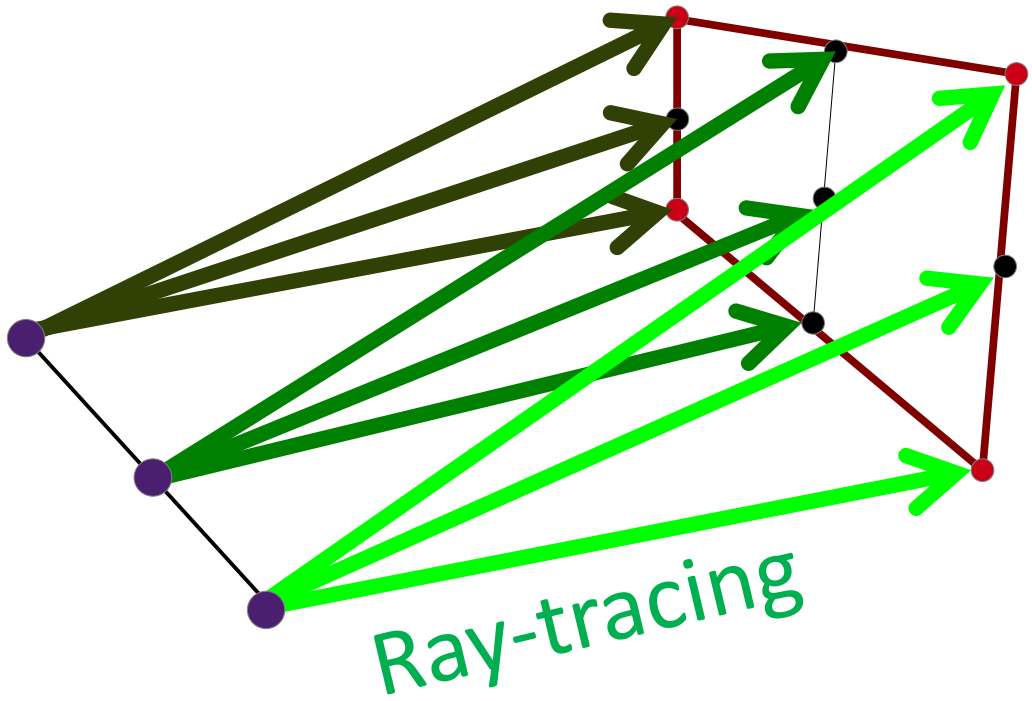
Voxel Carving

- Trace path of laser through space



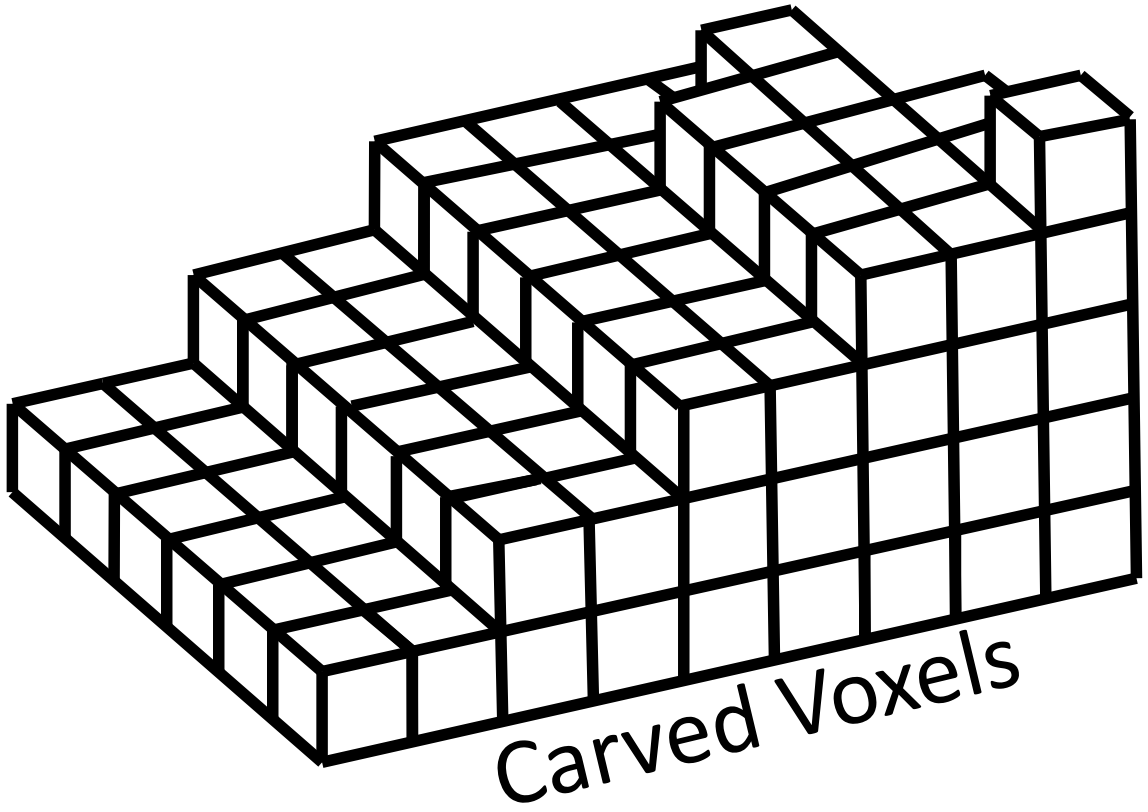
Voxel Carving

- Interpolate neighboring scans to define volume



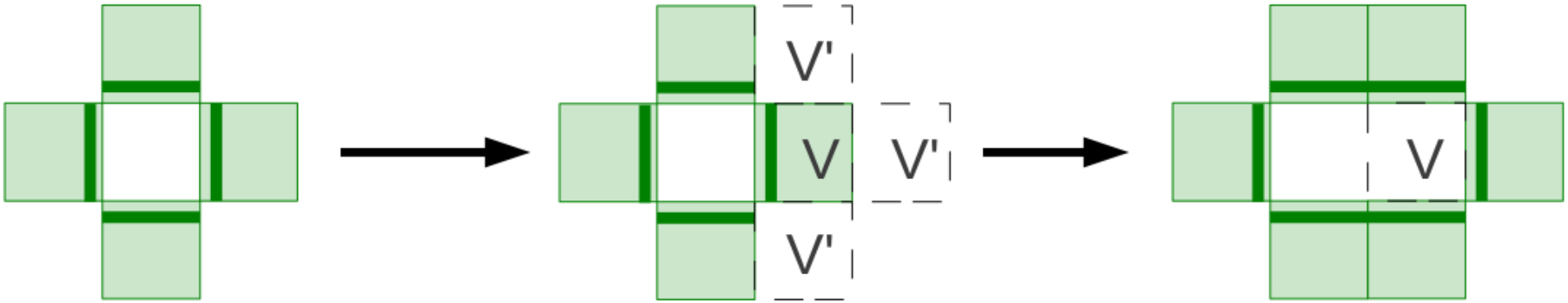
Voxel Carving

- Define volume with voxels

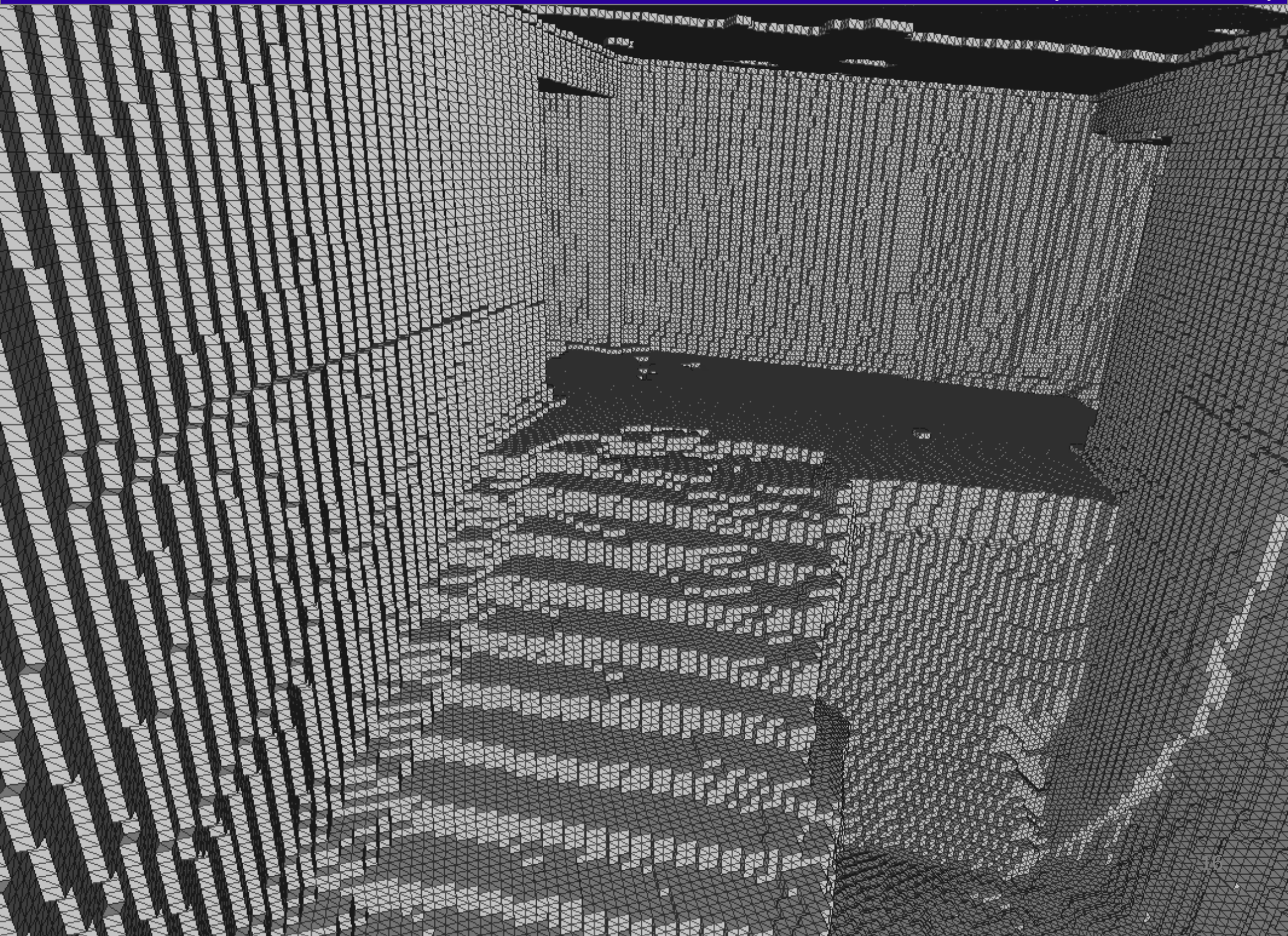


Voxel Data Structure

- Only boundary voxels explicitly stored

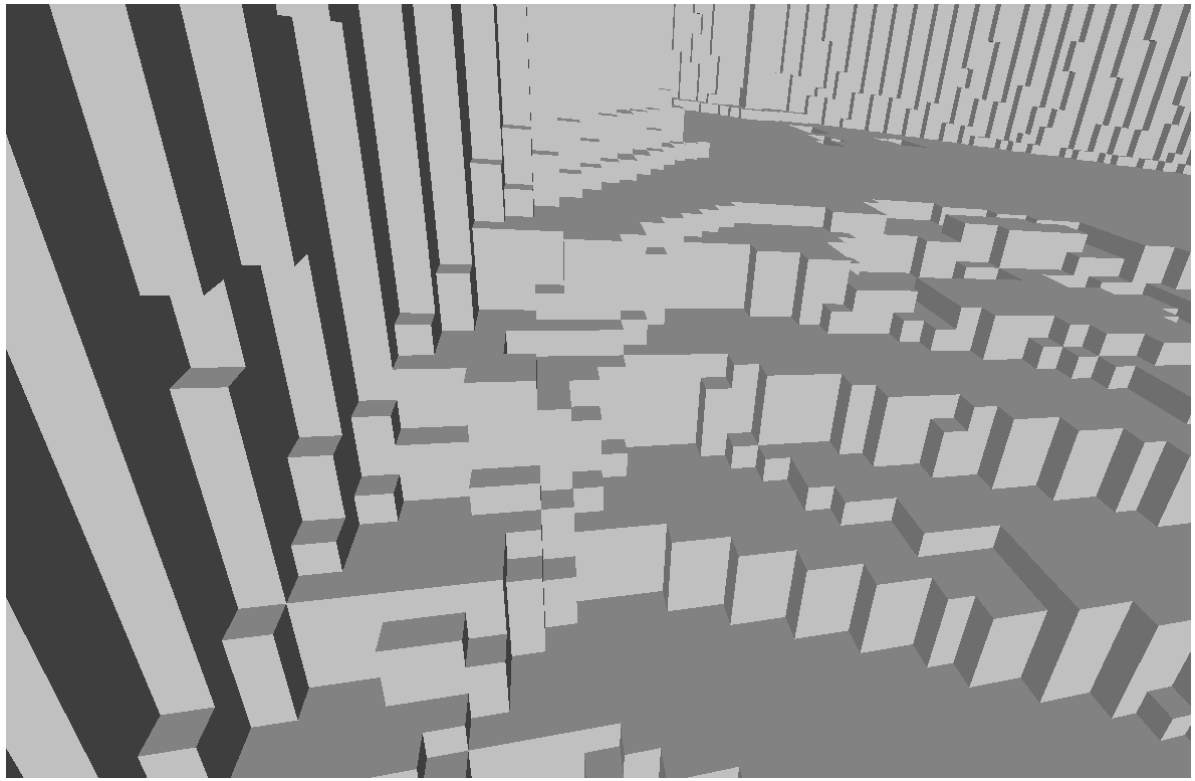


- Carving preserves watertightness of volume



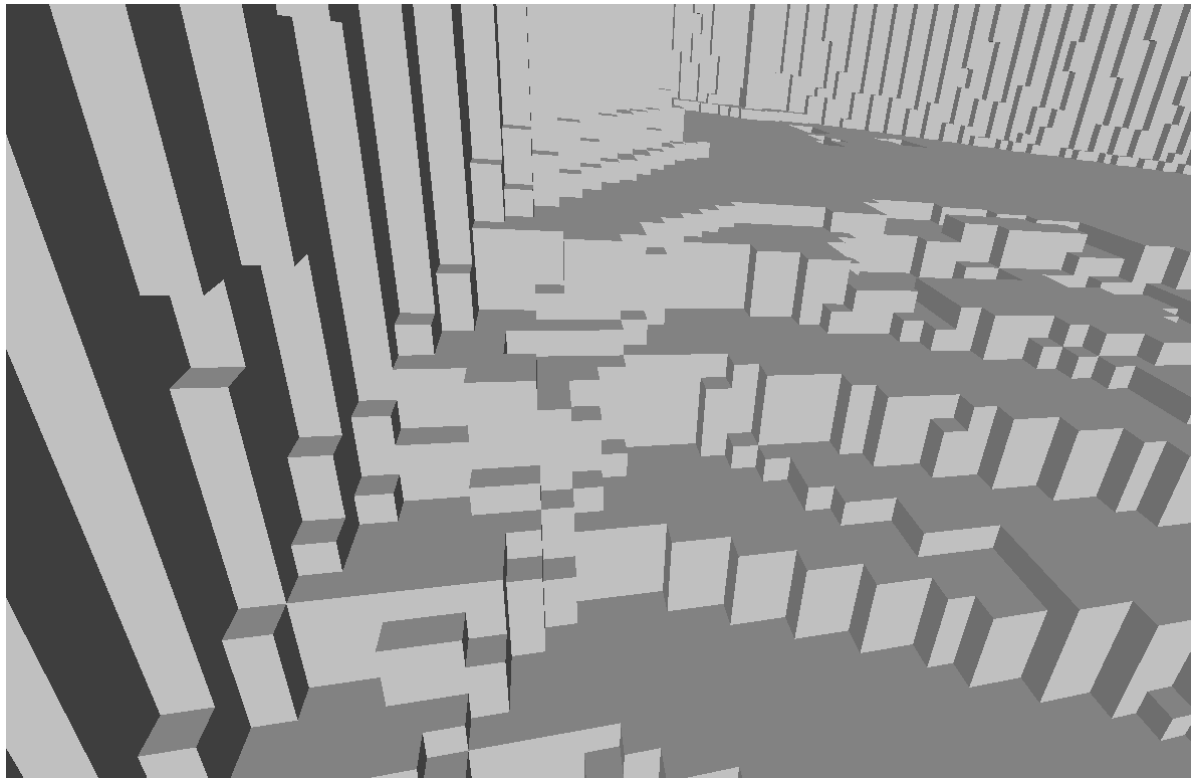
Plane Fitting

- **Goal**: remove discretization artifacts on surface



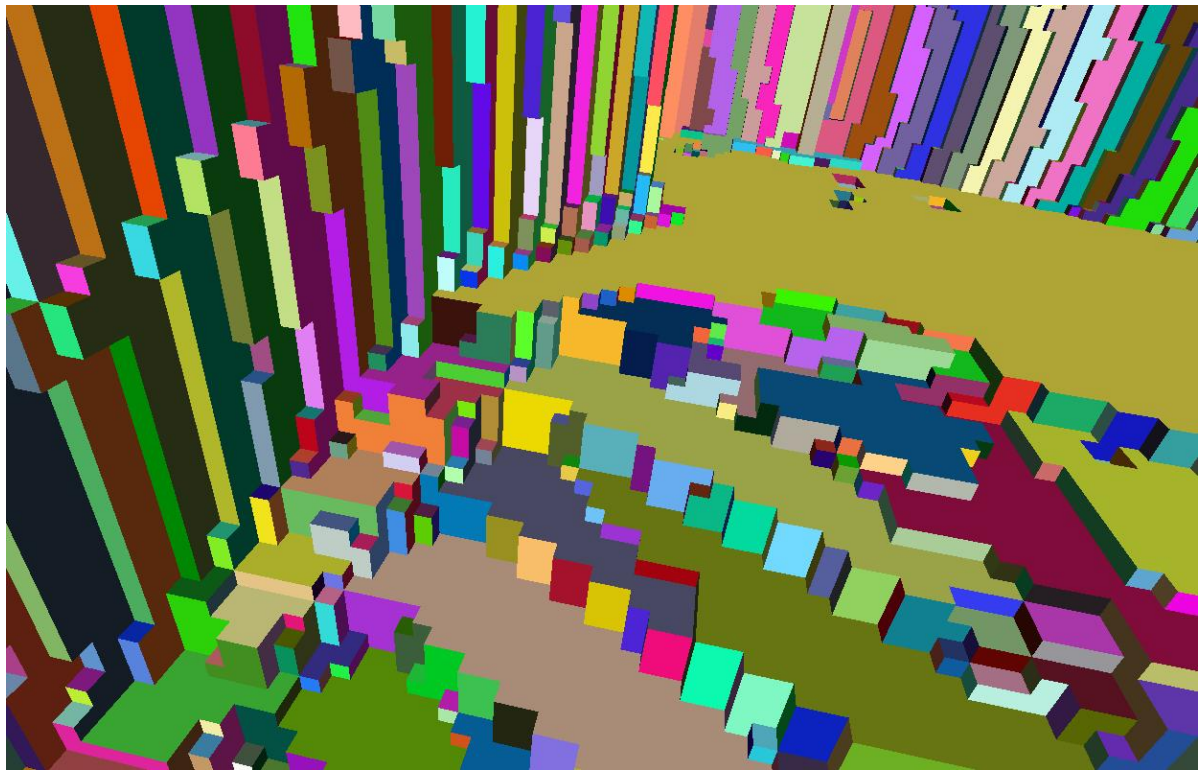
Plane Fitting

- **Goal**: remove discretization artifacts on surface
- Combine voxel faces into **planar regions**



Plane Fitting

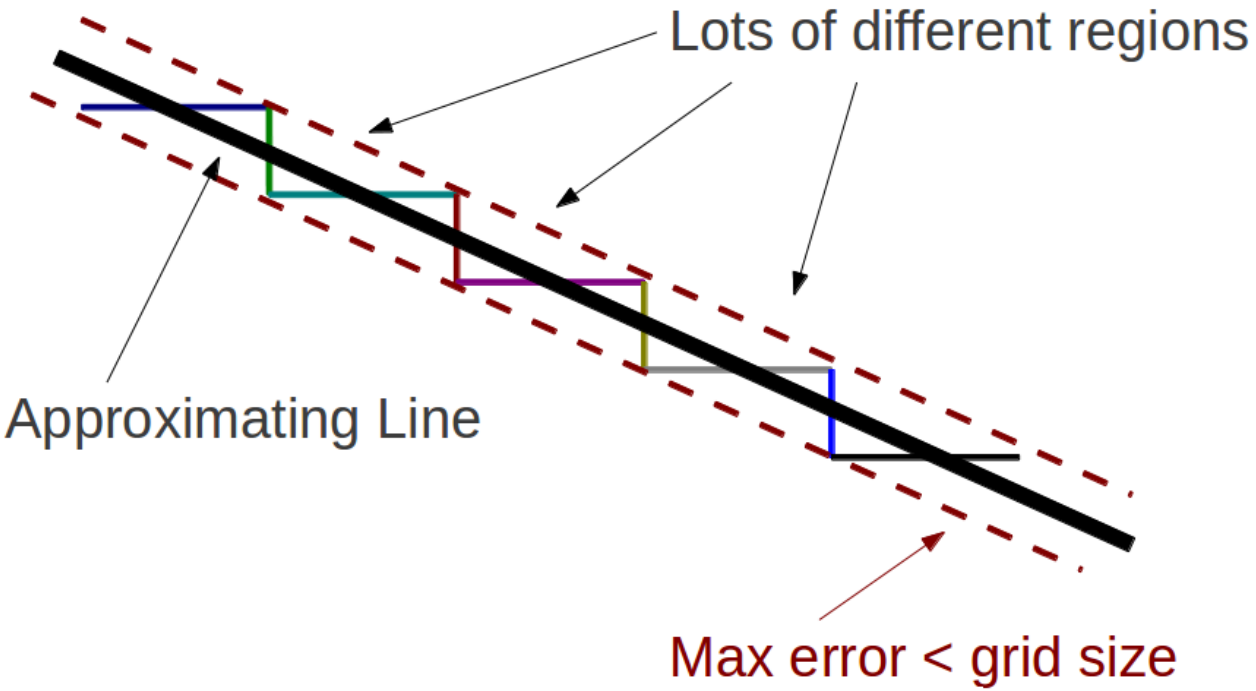
- **Goal**: remove discretization artifacts on surface
- Combine voxel faces into **planar regions**



Initialize via flood-fill

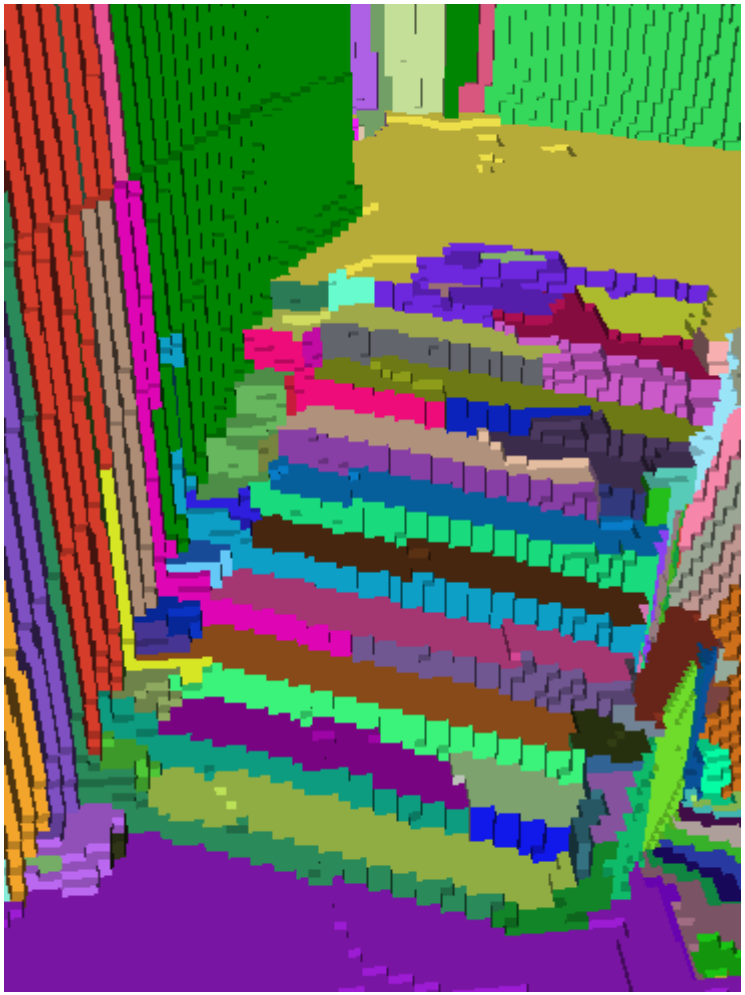
Plane Fitting

- Merge regions by computing best-fit plane



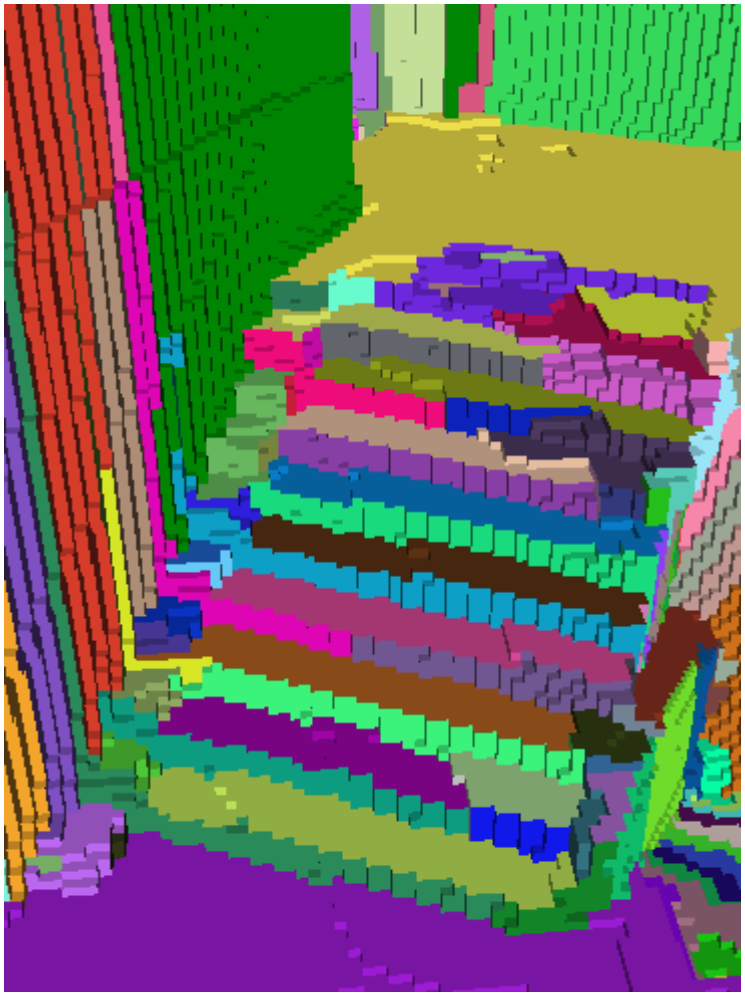
Plane Fitting

- Final merged regions



Plane Fitting

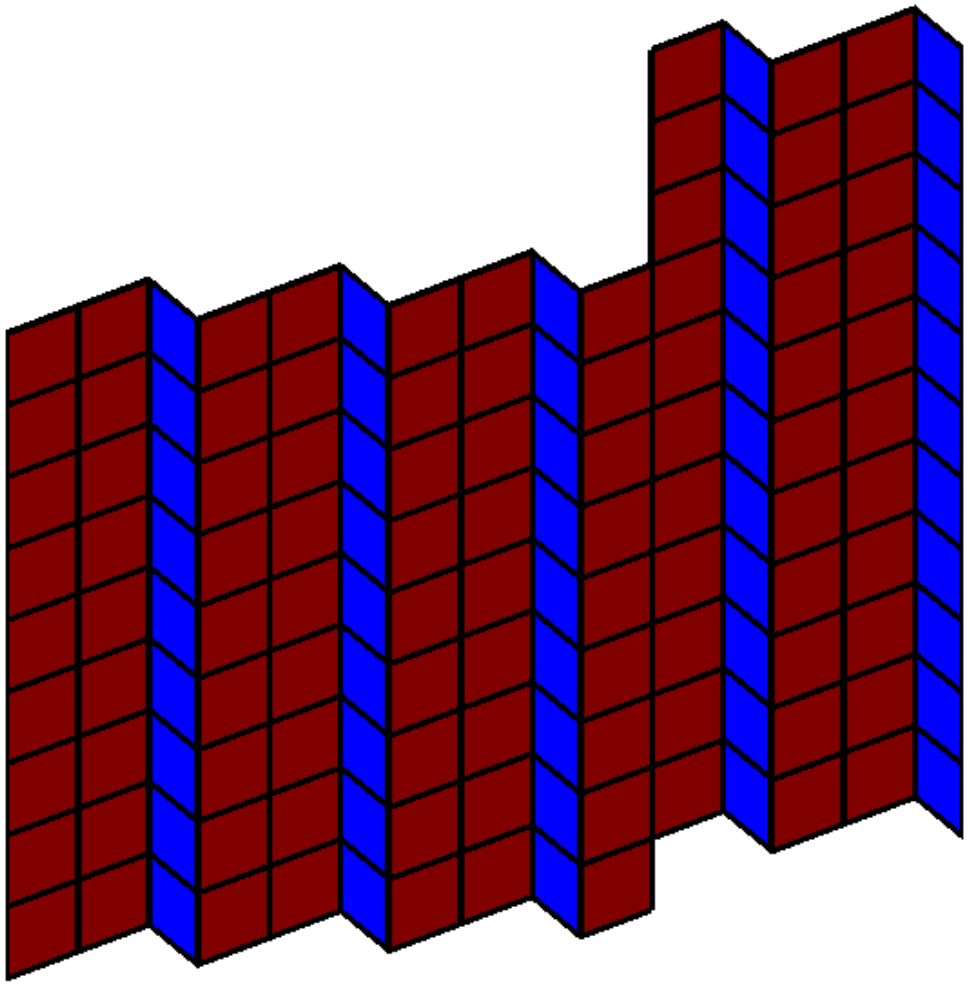
- Final merged regions



- Identified **locations** of planar regions
- Now need to **mesh**

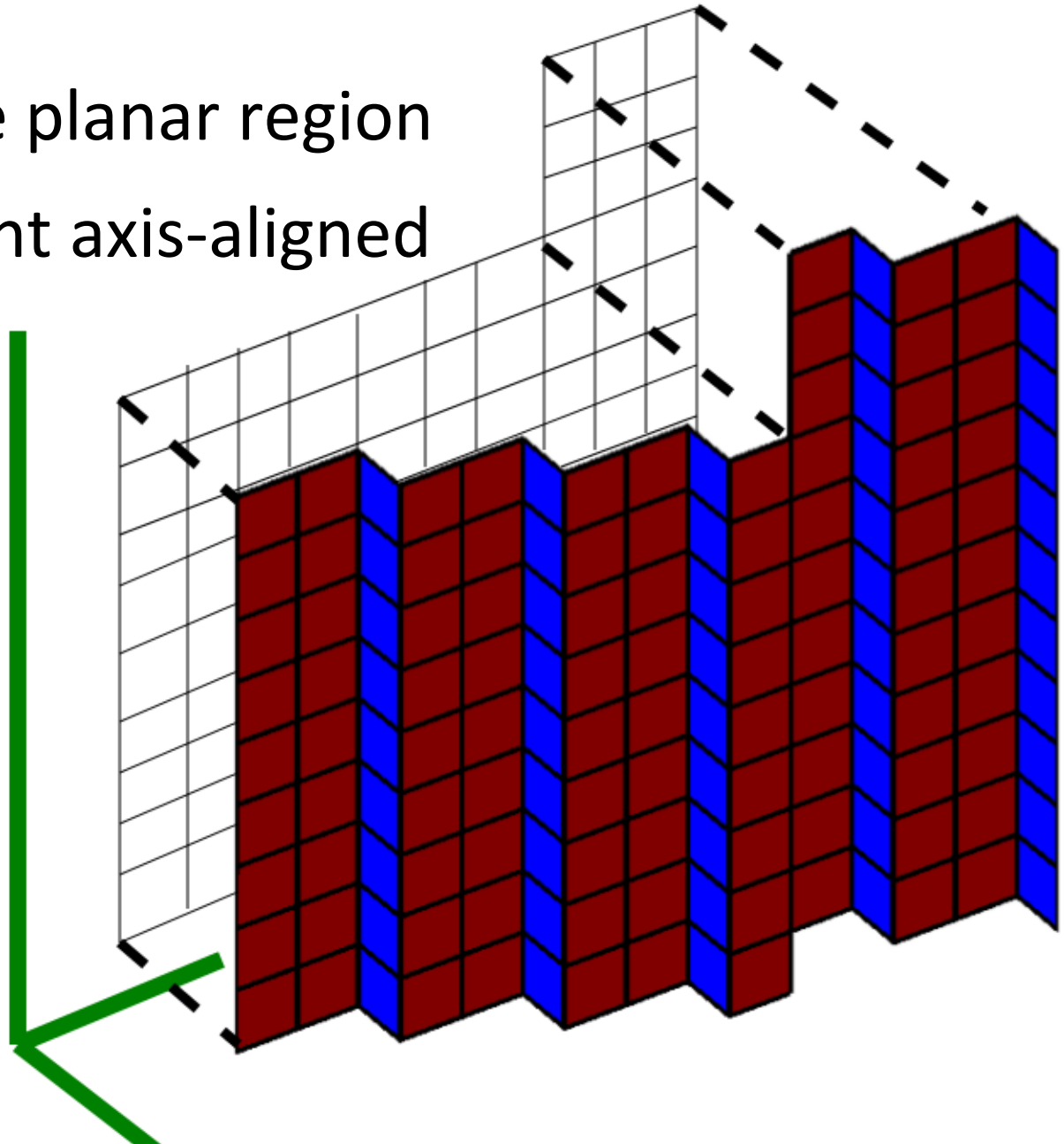
Triangulation of Regions

- Example planar region



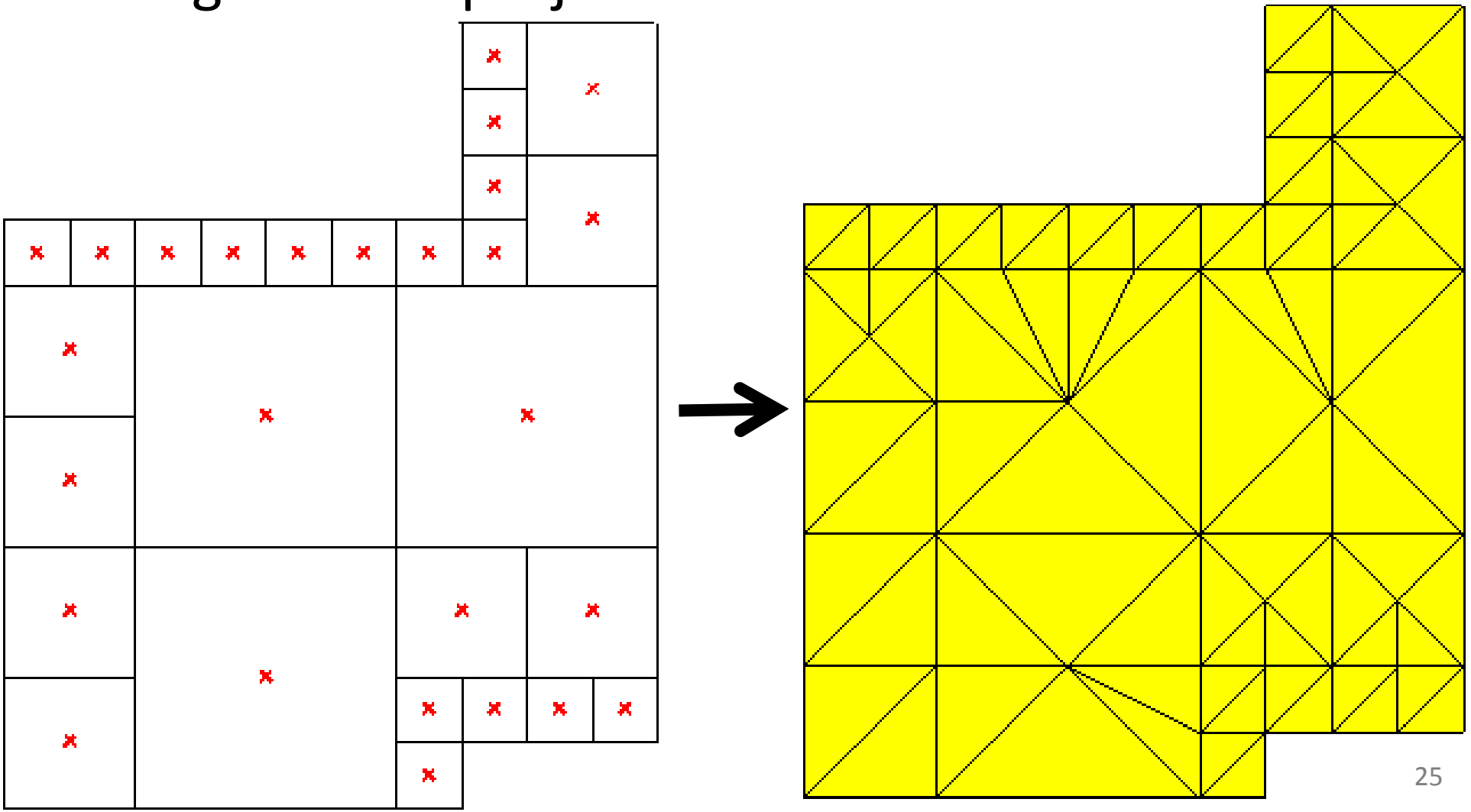
Triangulation of Regions

- Example planar region
- Dominant axis-aligned plane



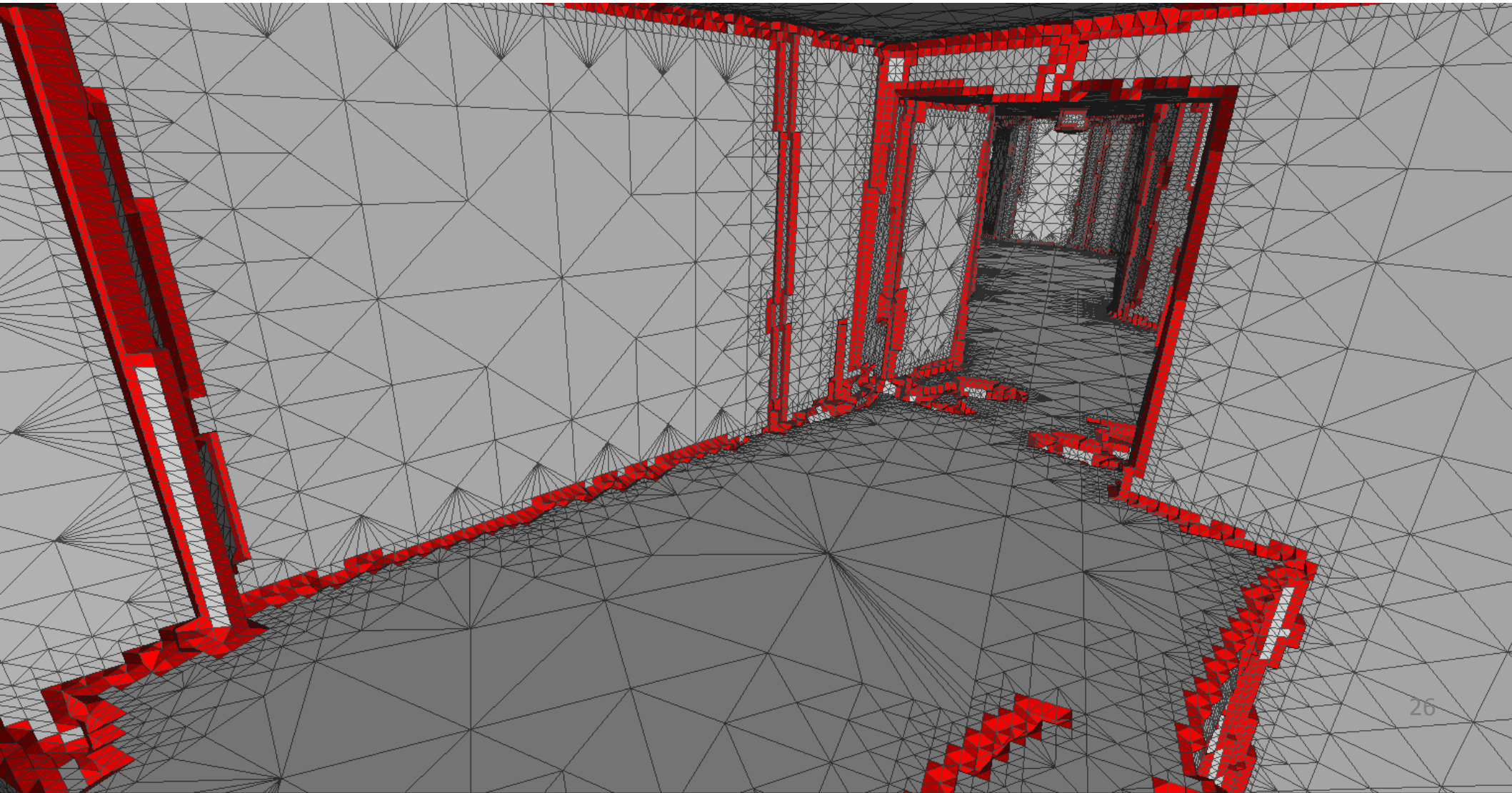
Triangulation of Regions

- Triangulate 2D projection



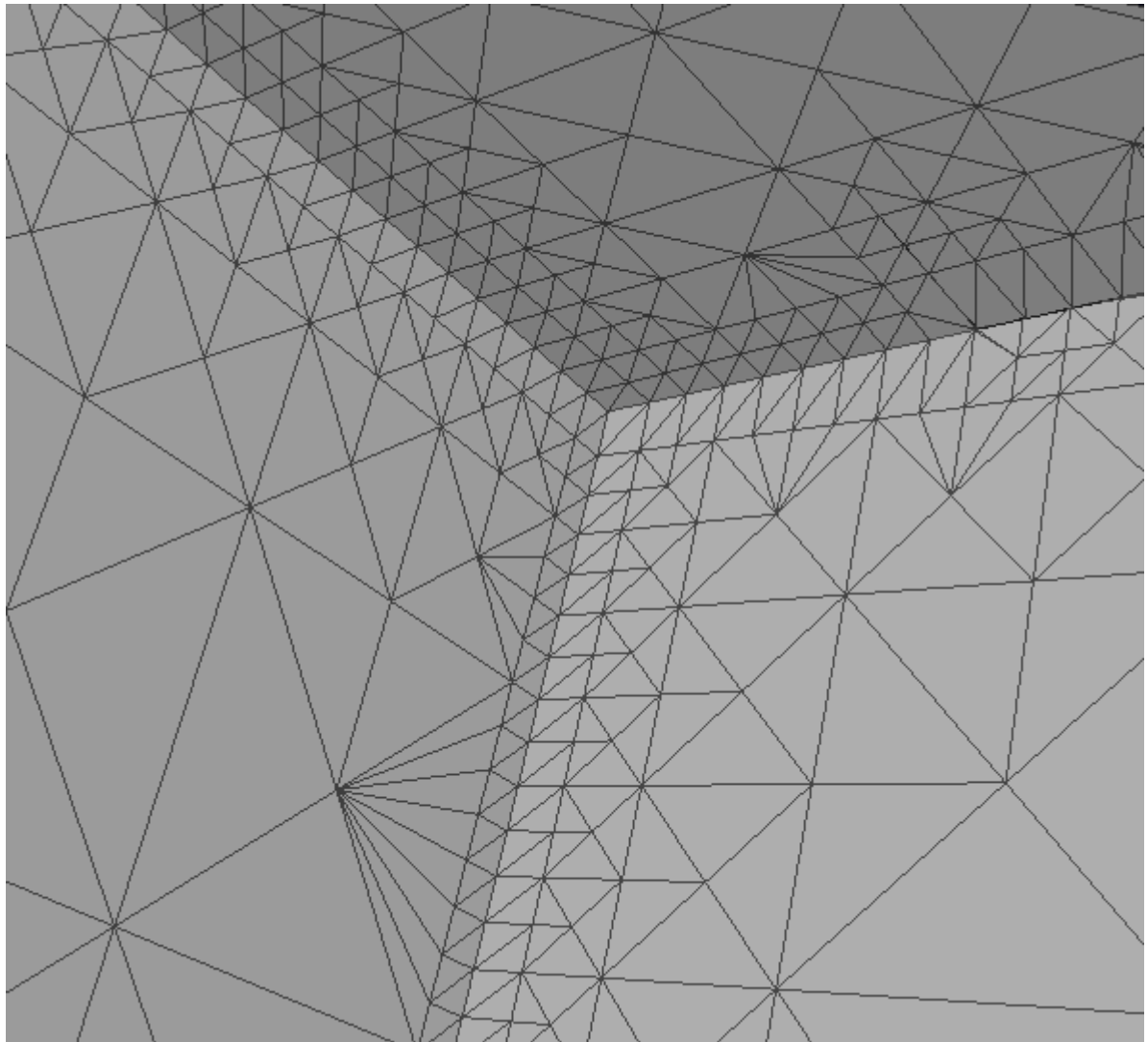
Triangulation of Regions

- Example



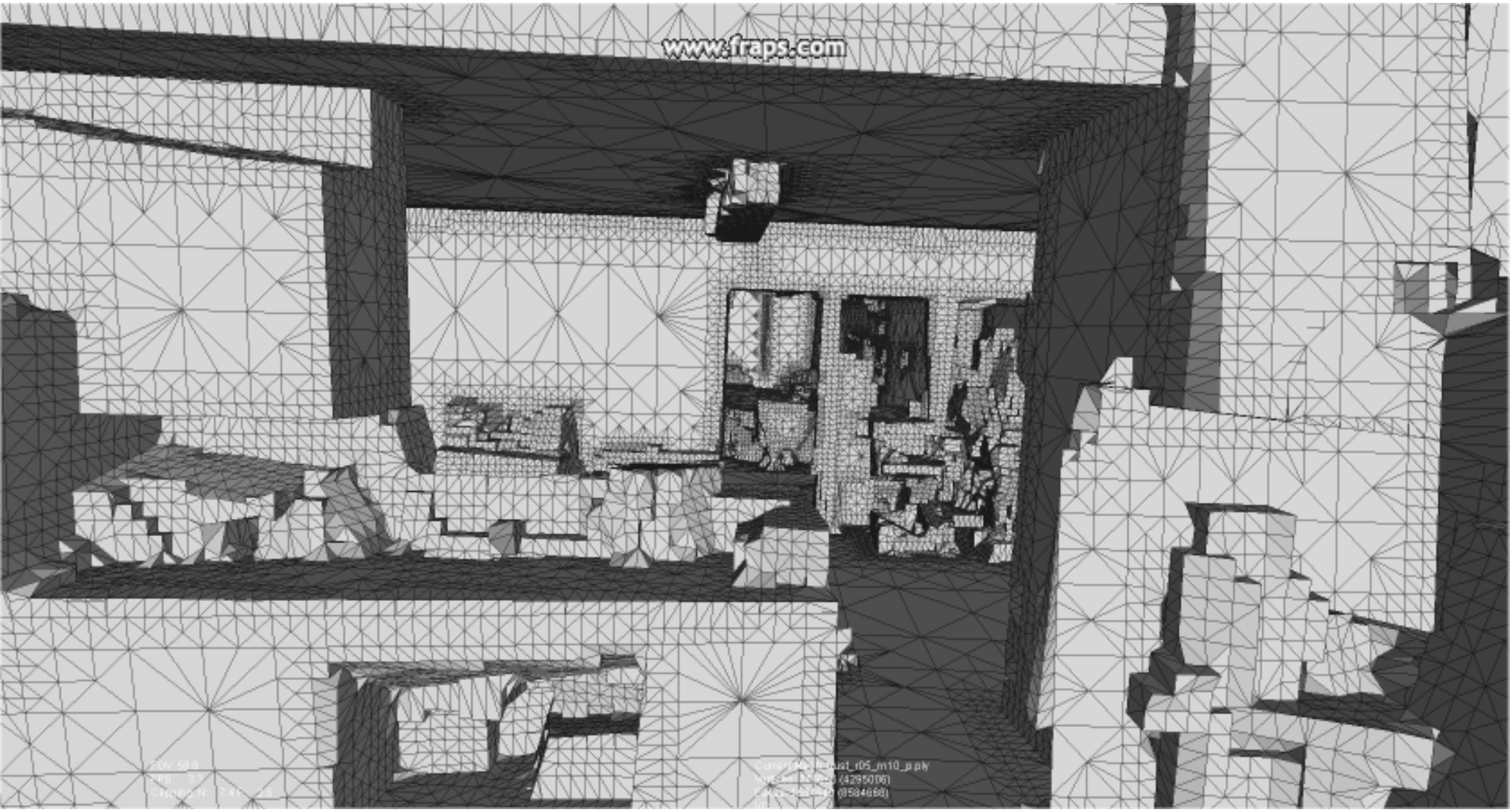
Triangulation of Regions

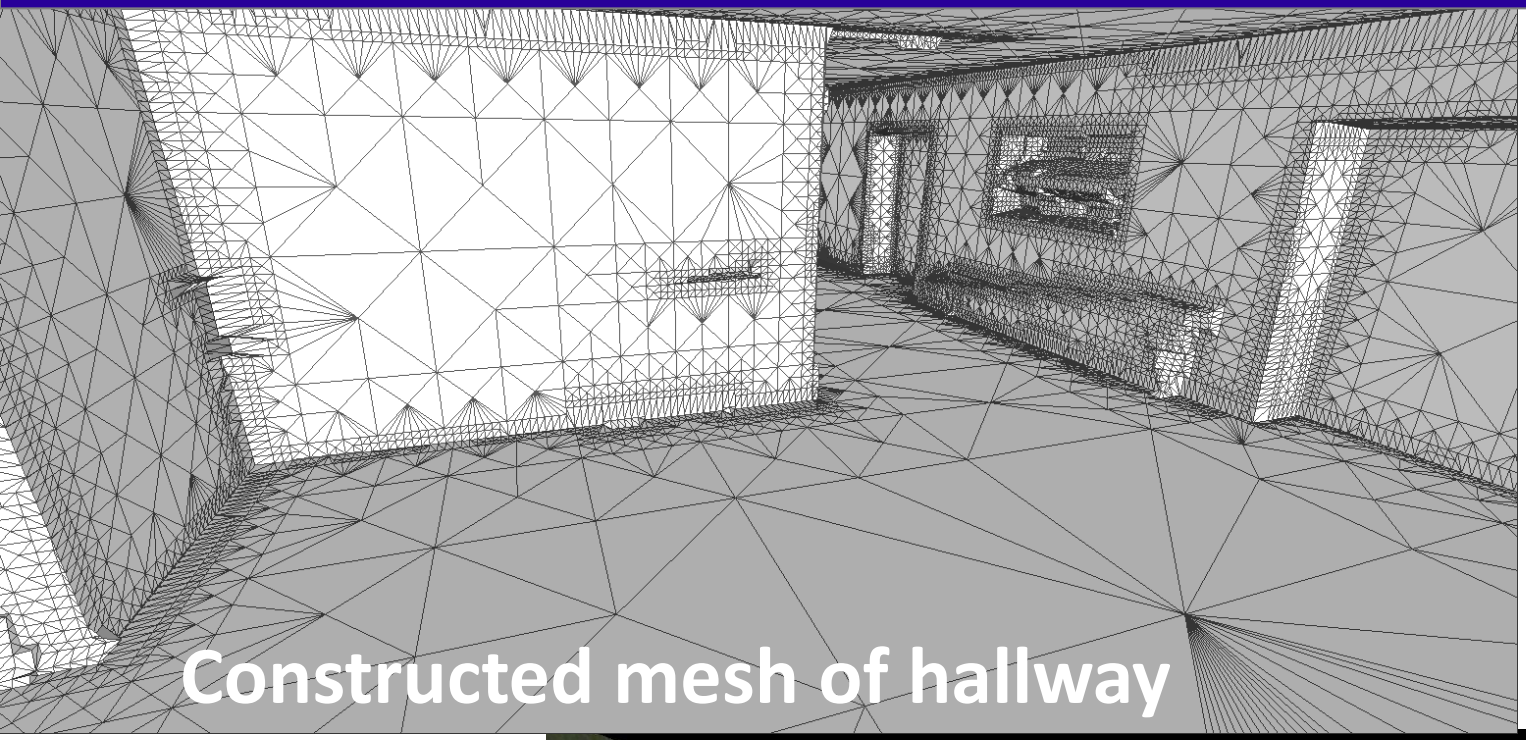
- Boundaries snapped to plane intersections



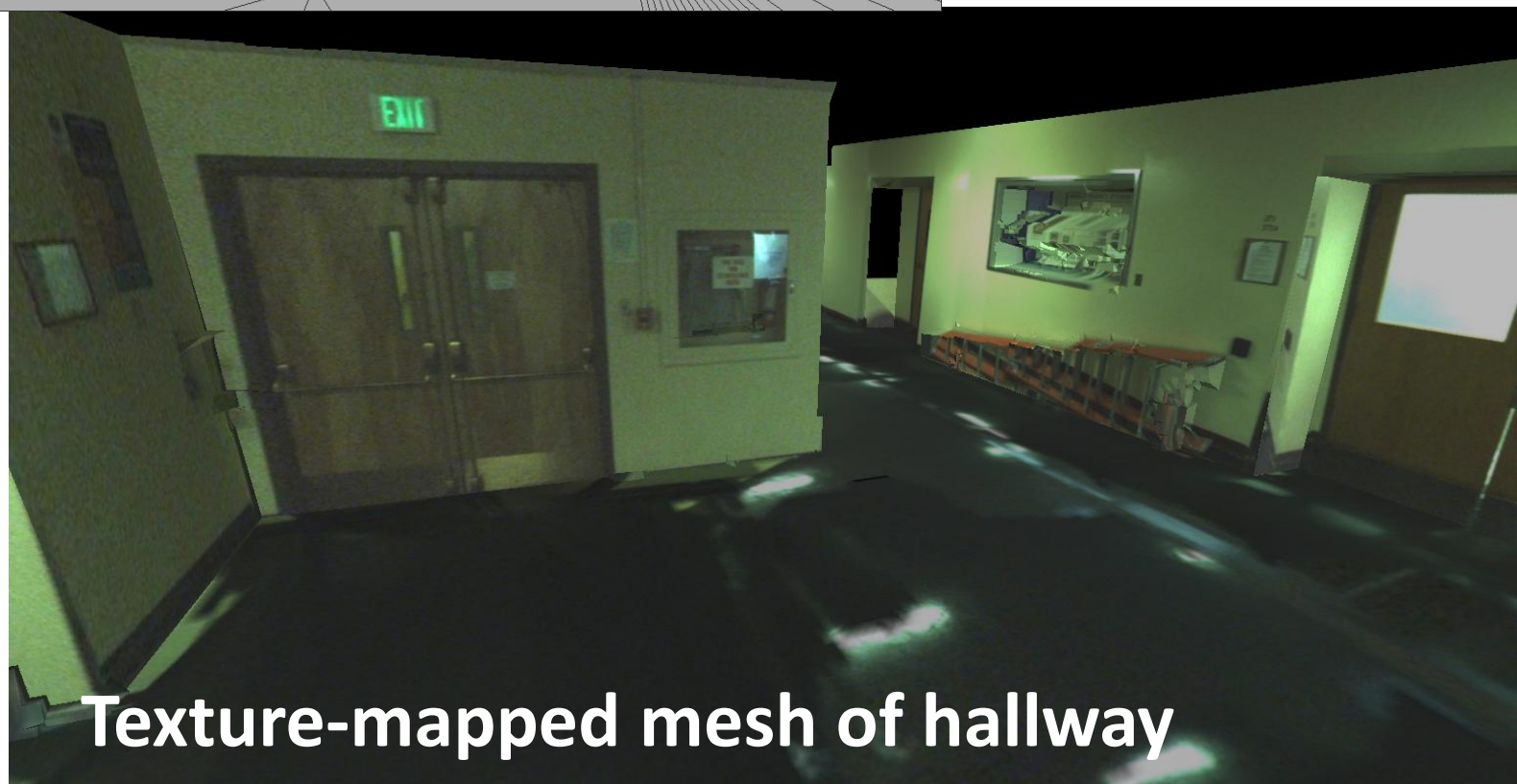
Results

Results

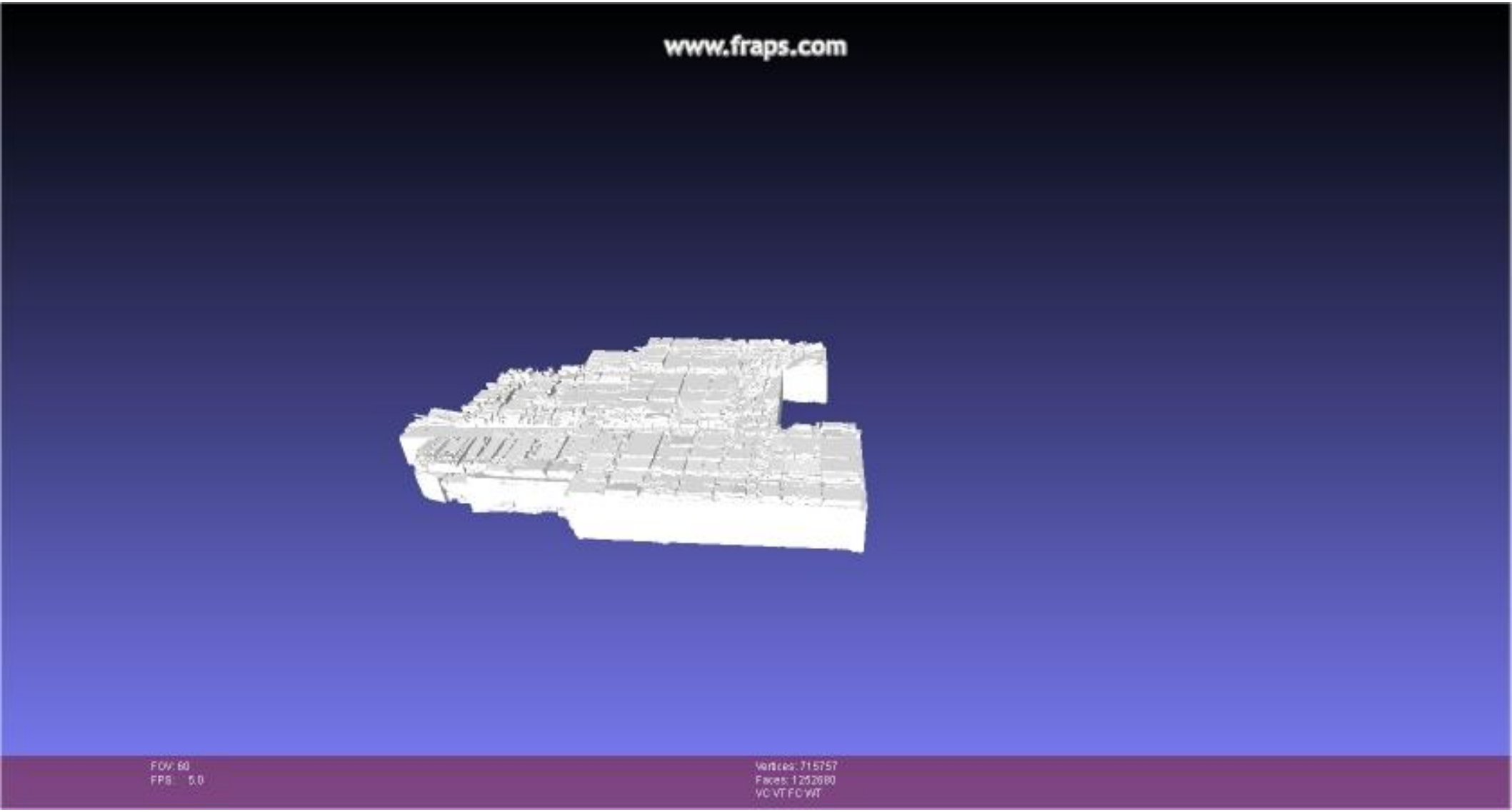


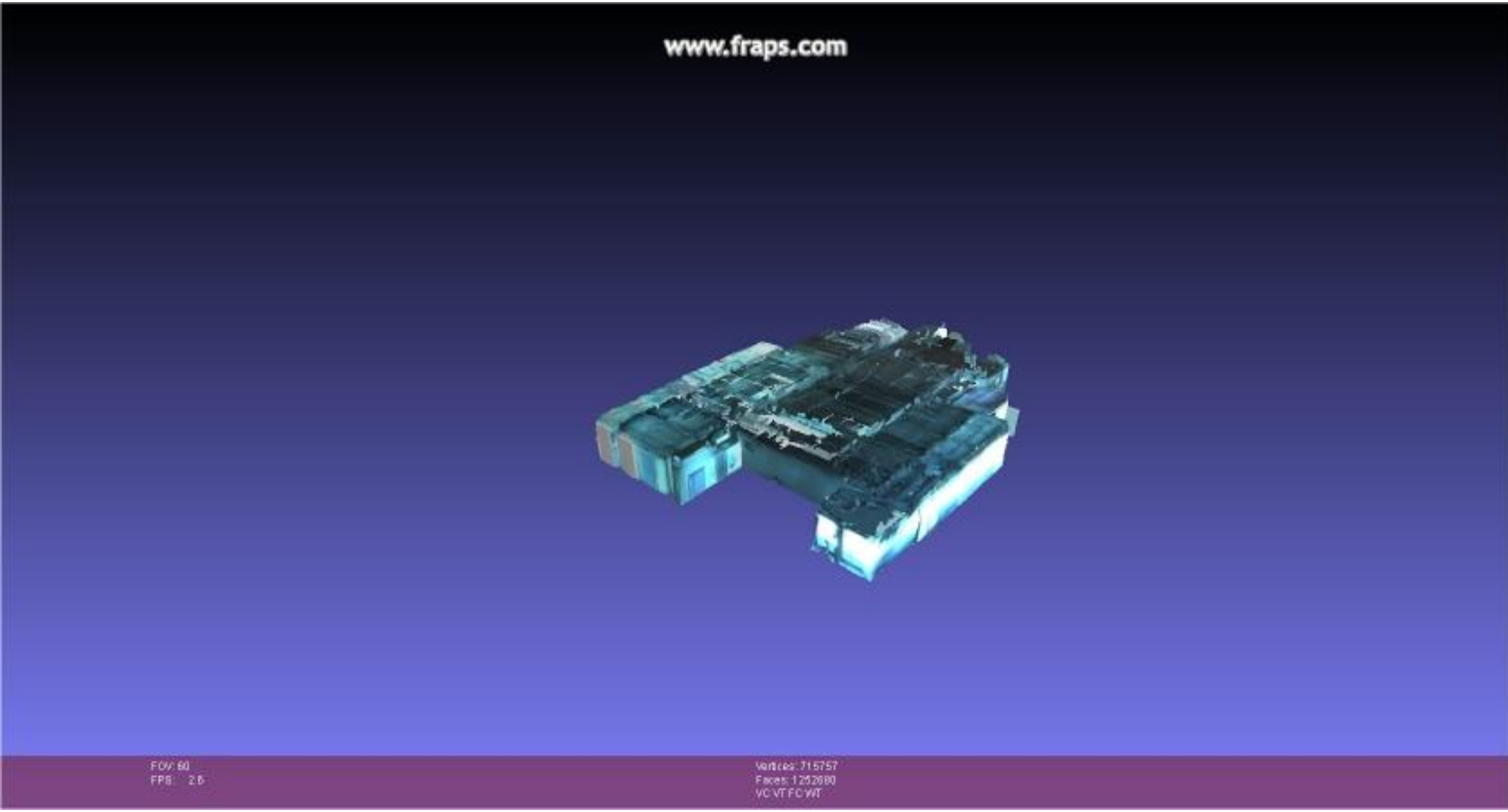


Constructed mesh of hallway



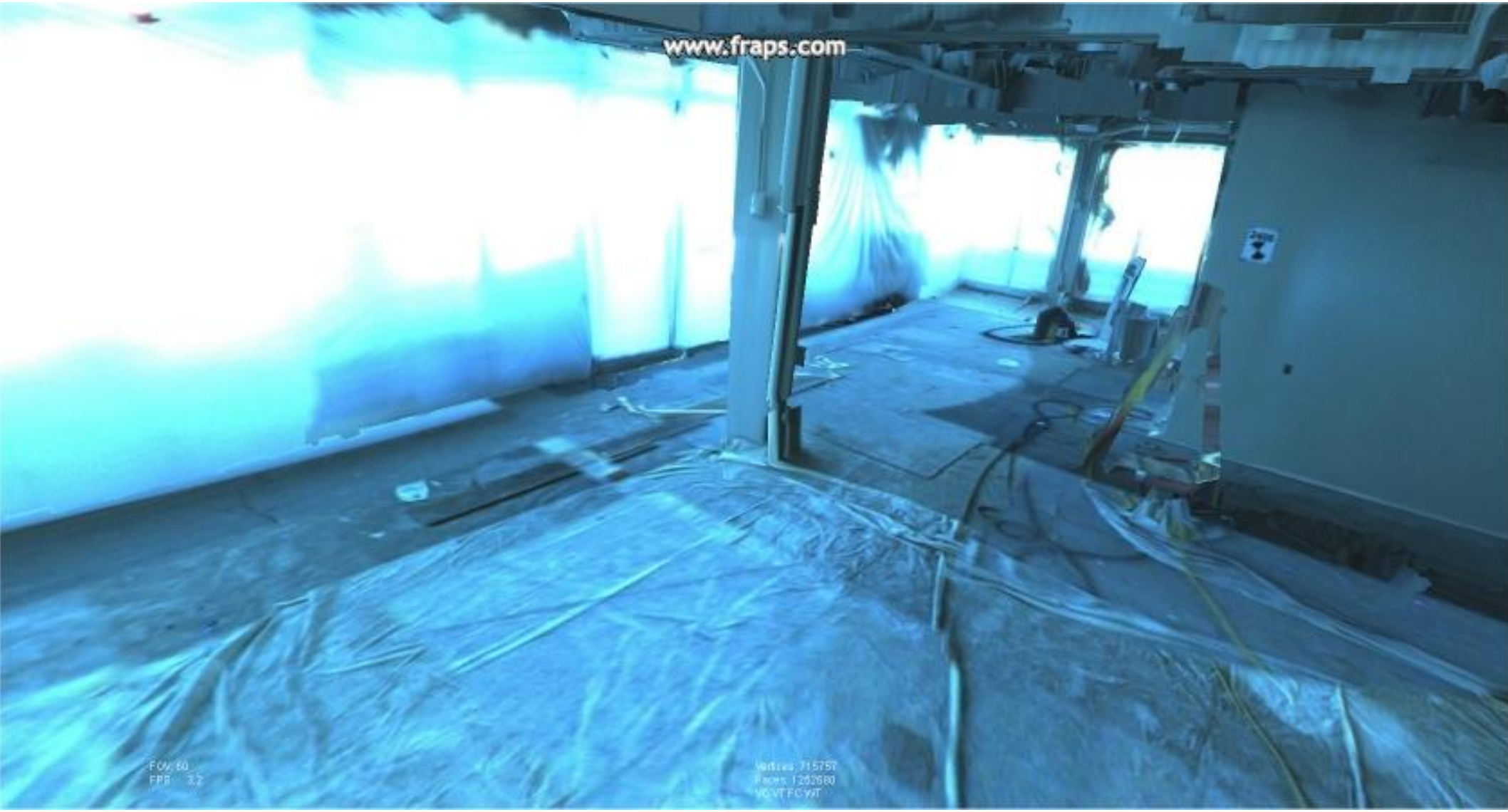
Texture-mapped mesh of hallway

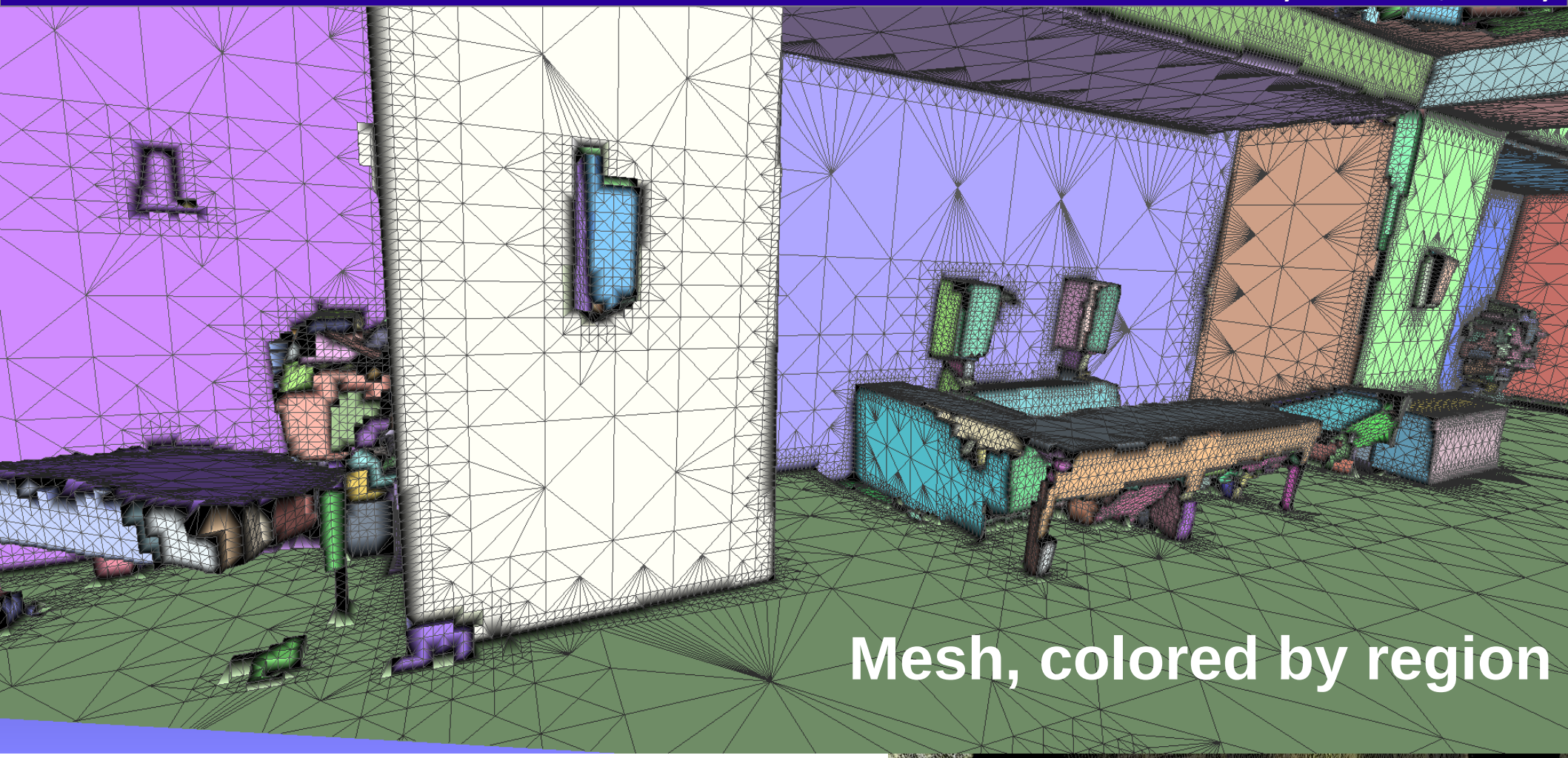

www.fraps.com
FOV: 60
FPS: 5.0
Vertices: 715757
Faces: 1252680
VC VT FC WT


www.fraps.com
FOV: 60
FPS: 2.6
Vertices: 715757
Faces: 1252680
VC VT FC WT


www.fraps.com
2416
FOV: 60
FPS: 3.3
Vertices: 715757
Faces: 1202680
VC VT FC WT

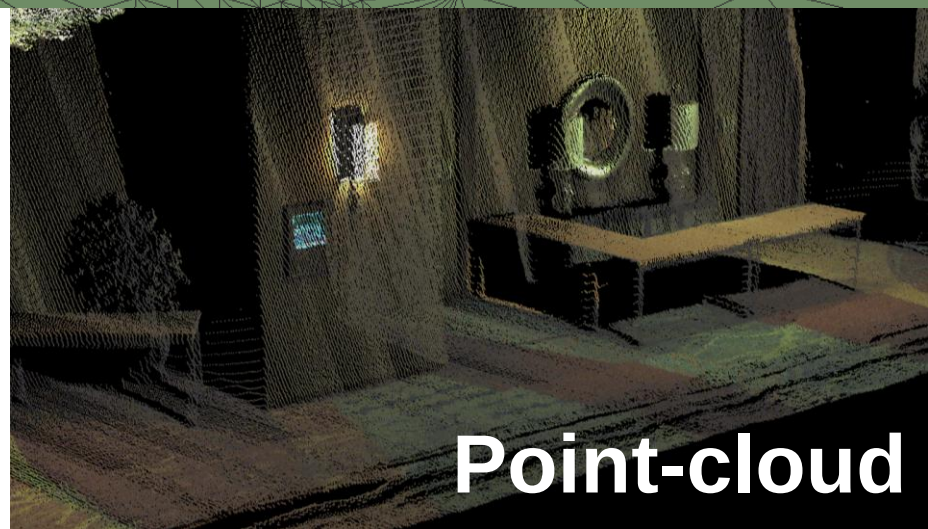

www.fraps.com
2416
FOV: 80
FPS: 21
Vertices: 715757
Faces: 1252680
VC VT FC WT


www.fraps.com

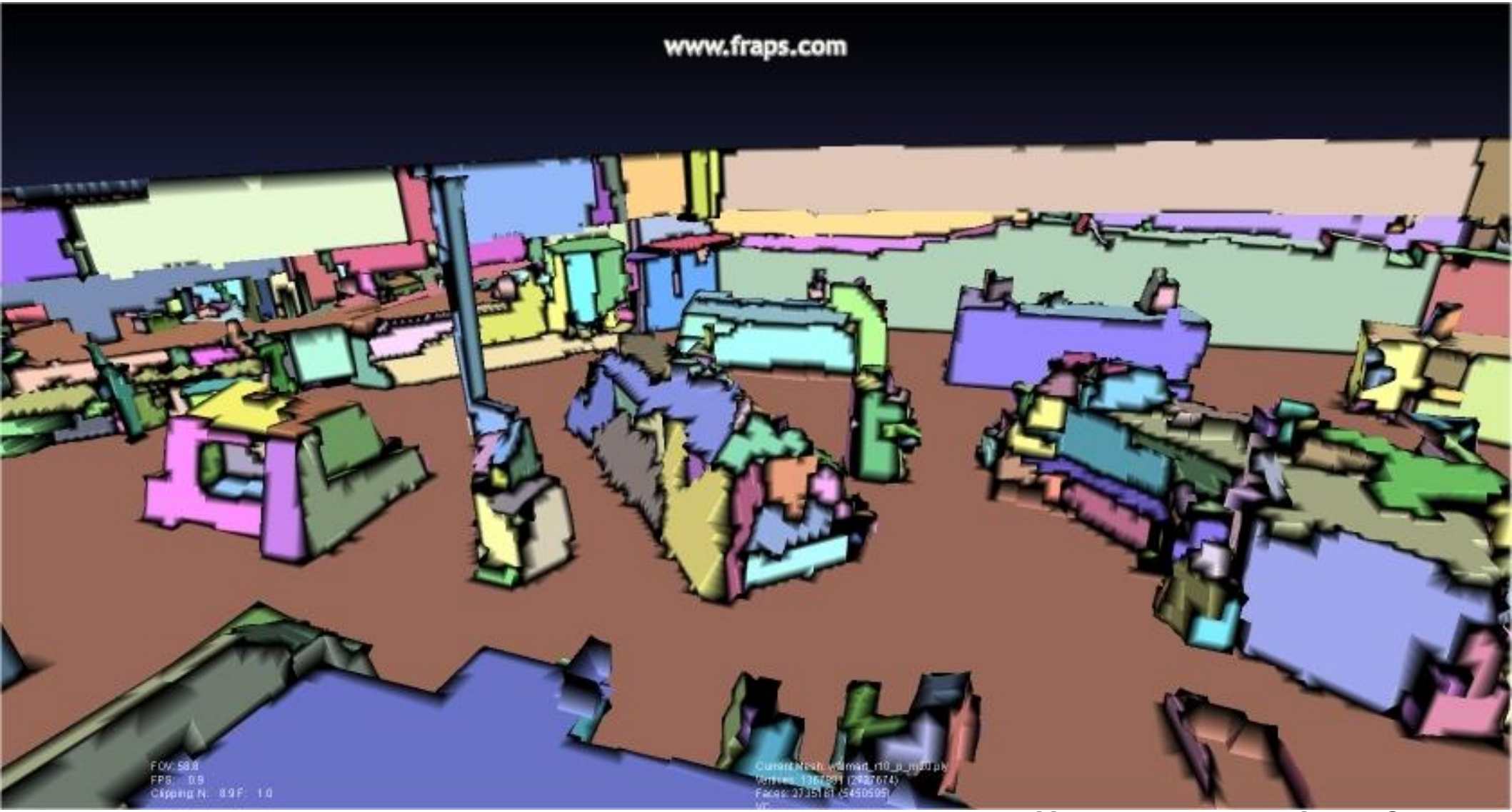


Close up of hotel hallway

Viewing triangulation and planar regions



Large Retail Shopping Center

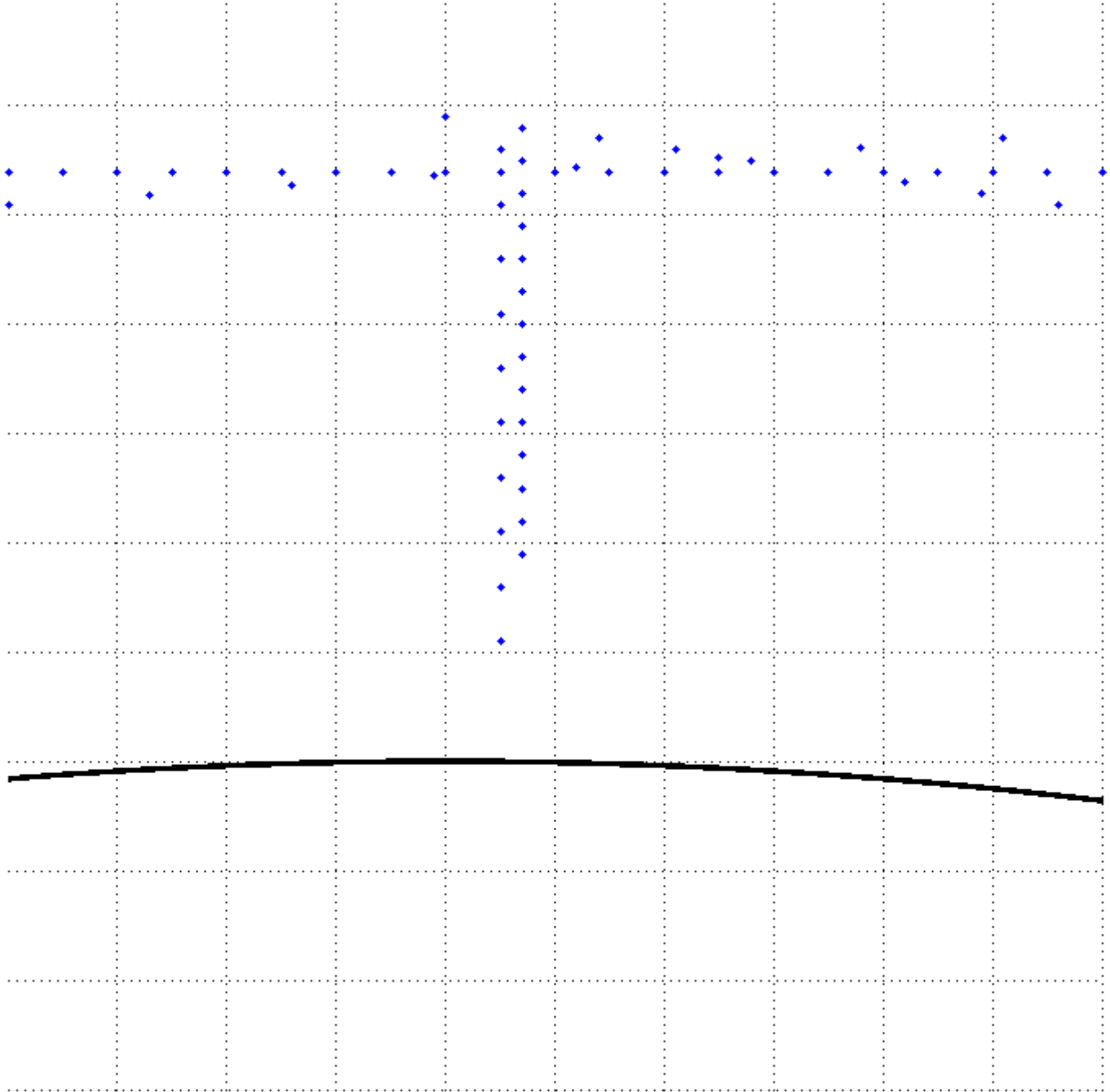


112 m x 78 m

2.7 million triangles from
220 million points

Supplemental

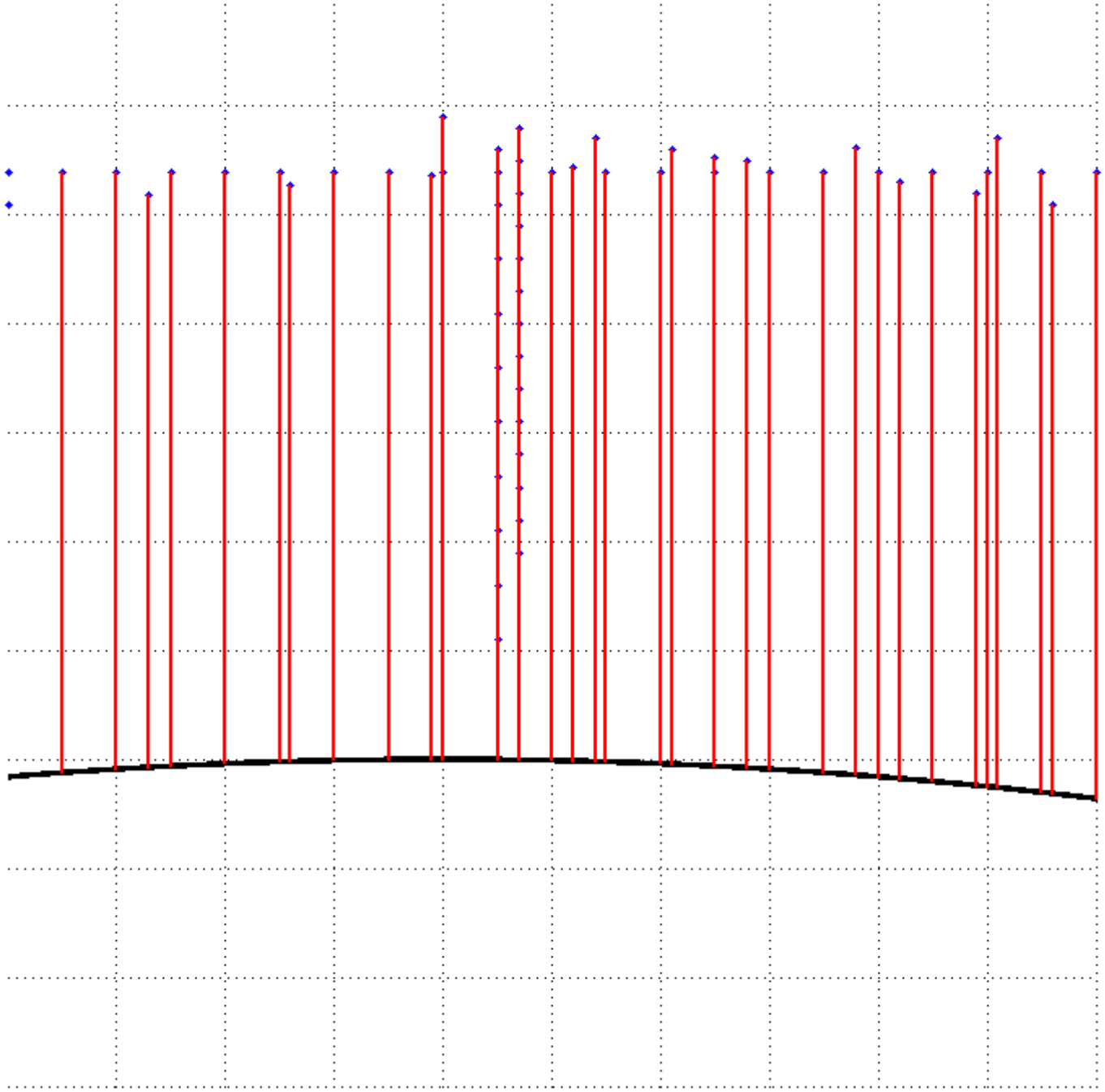
Preserving Fine Detail in Voxels



Scan points

Path of scanner

Preserving Fine Detail in Voxels

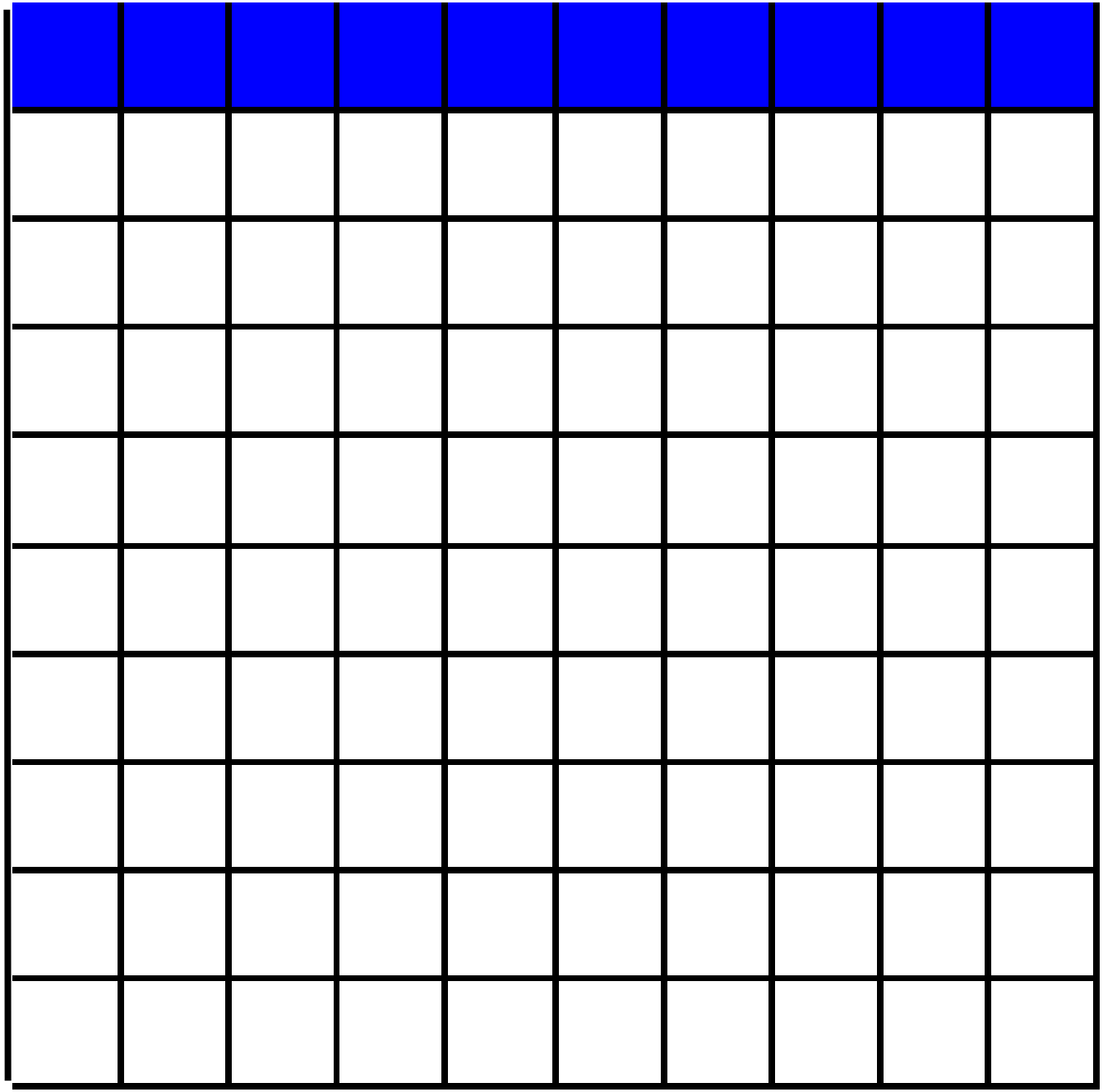


Scan points

Lasers

Path of scanner

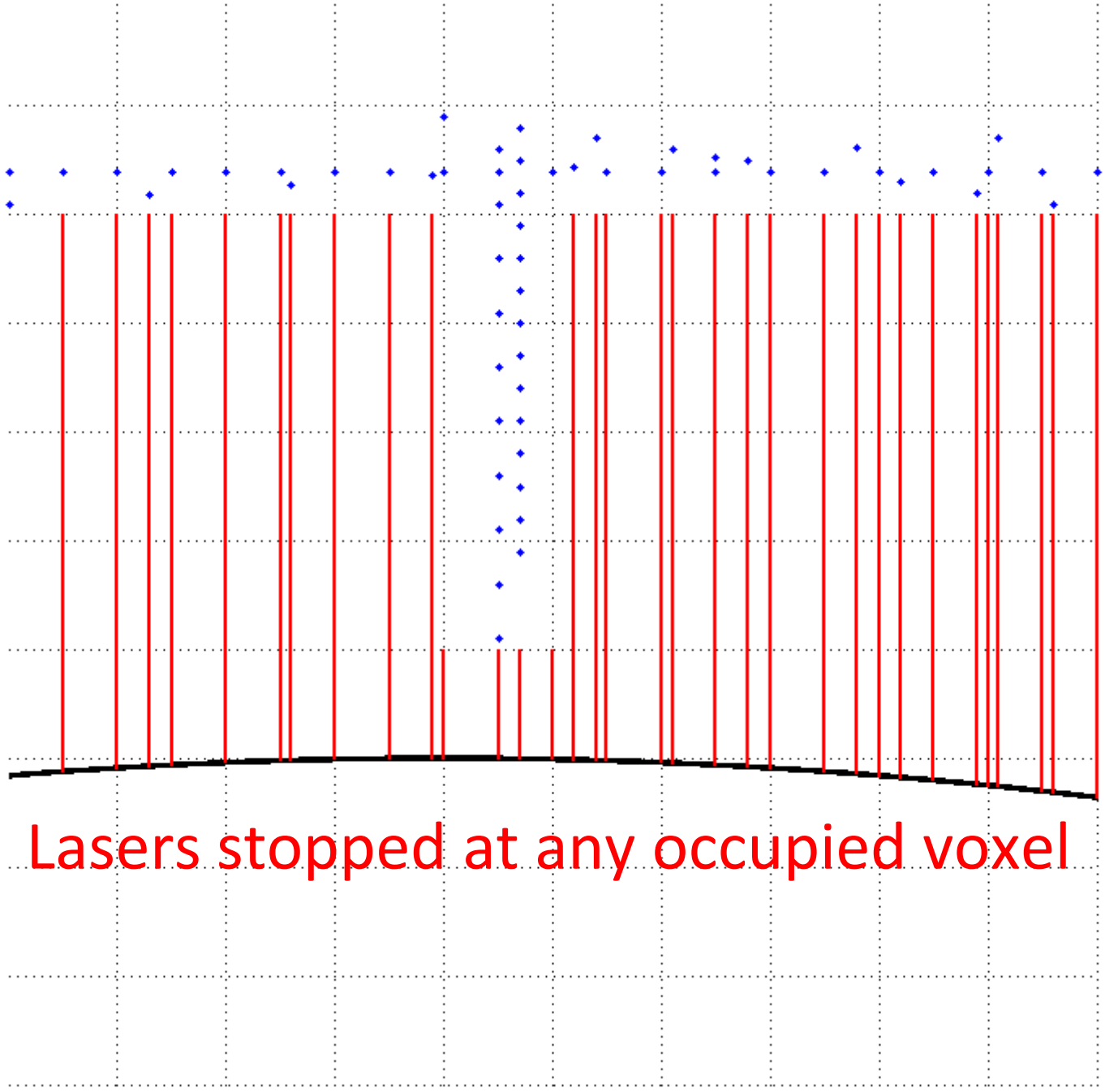
Preserving Fine Detail in Voxels



Exterior Space

Interior Space

Preserving Fine Detail in Voxels

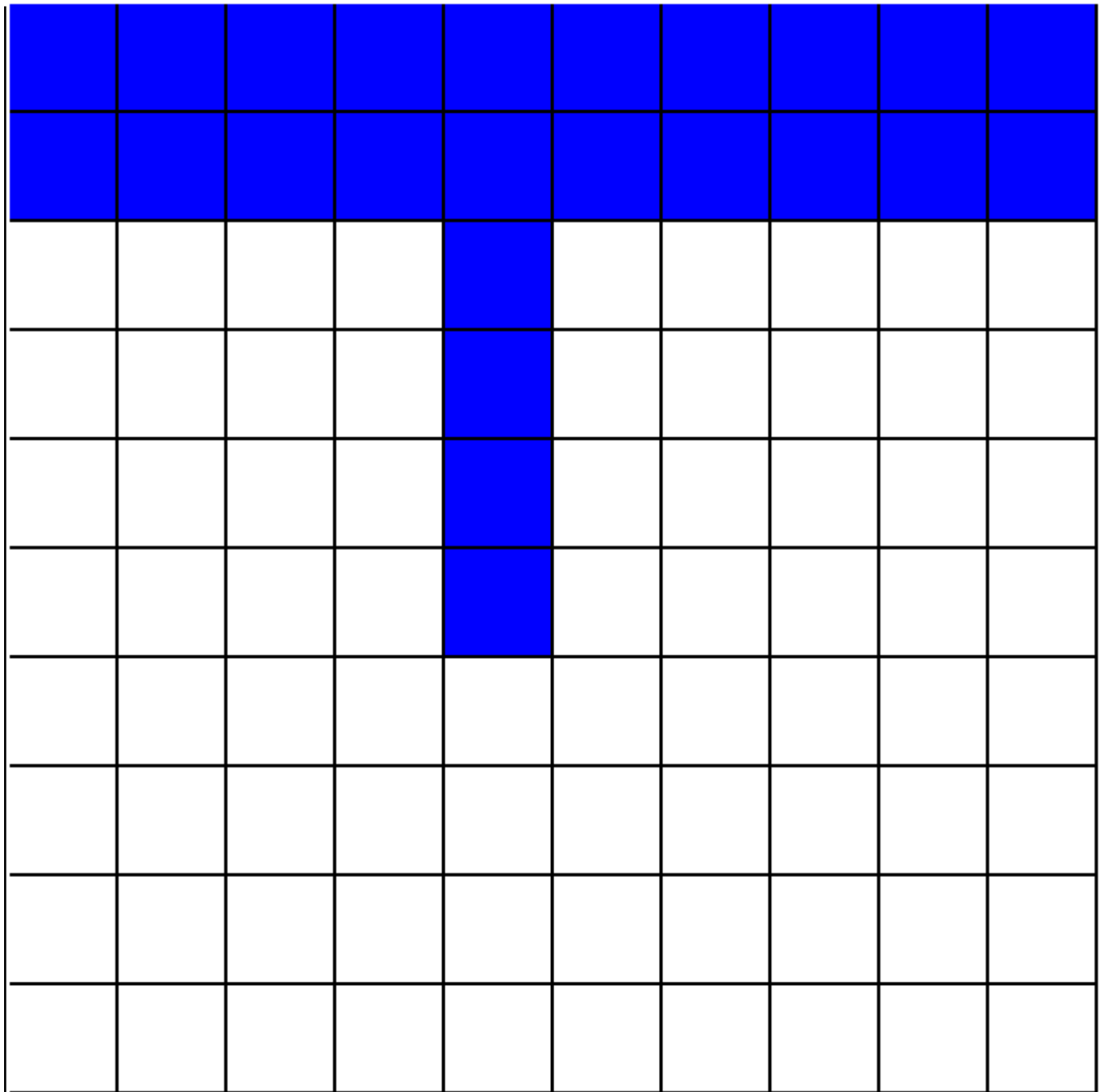


Scan points

Path of scanner

Lasers stopped at any occupied voxel

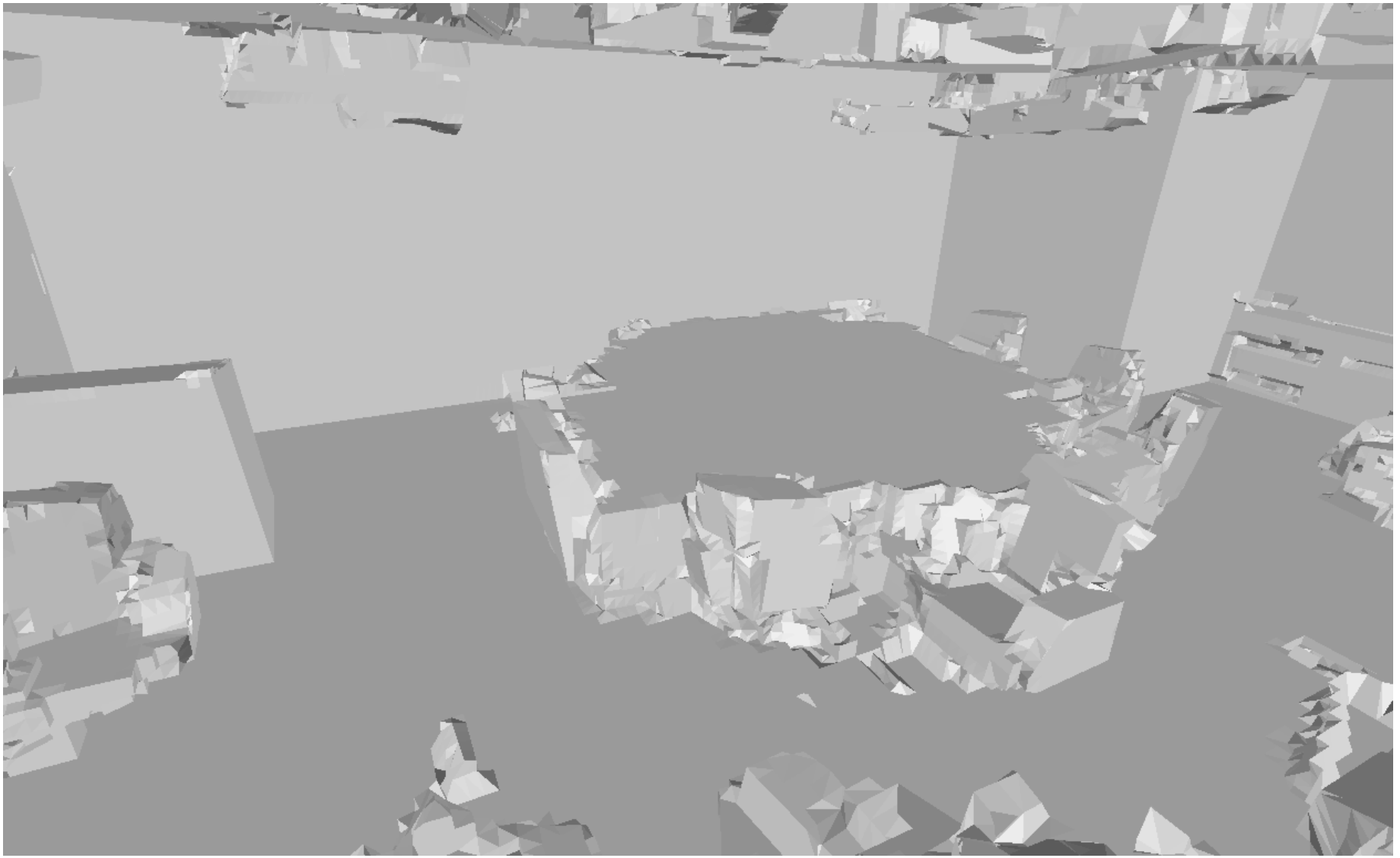
Preserving Fine Detail in Voxels



Exterior Space

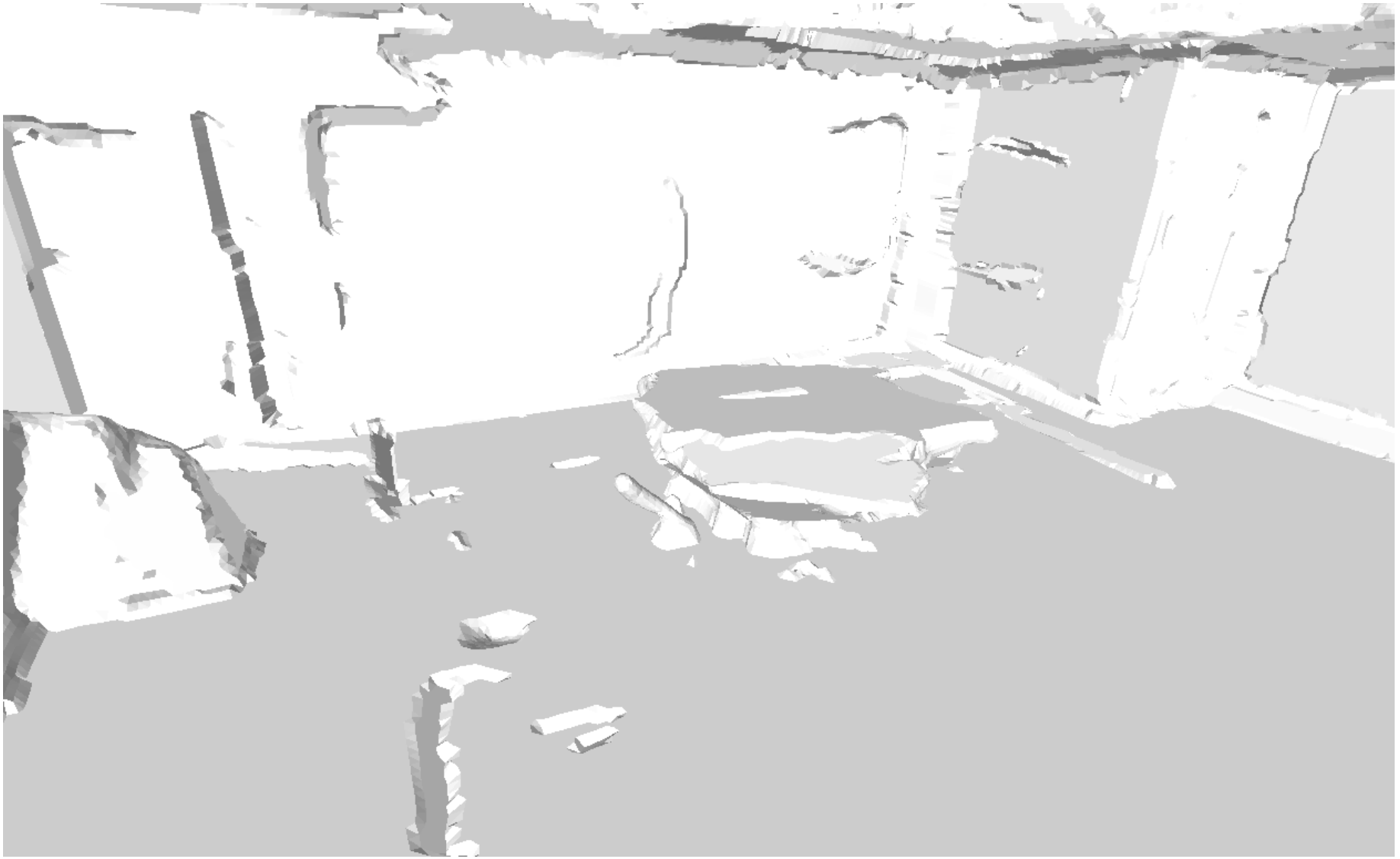
Interior Space

Preserving Fine Detail in Voxels



Preserving fine detail

Preserving Fine Detail in Voxels



Without preserving fine detail