

# Floor Plan Generation and Room Labeling of Indoor Environments from Laser Range Data

GRAPP 2014

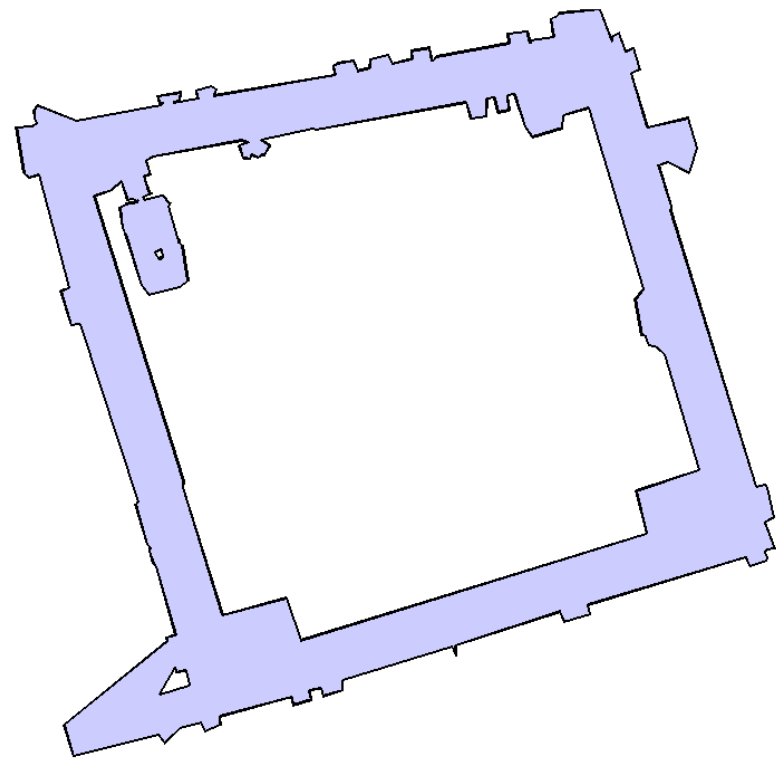
January 5, 2014

Eric Turner

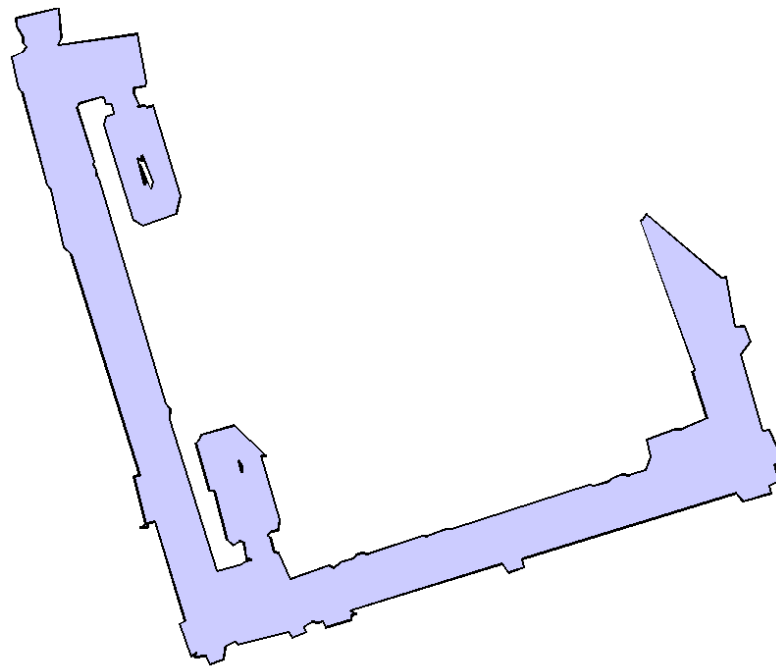
Avideh Zakhor

# Floor Plans

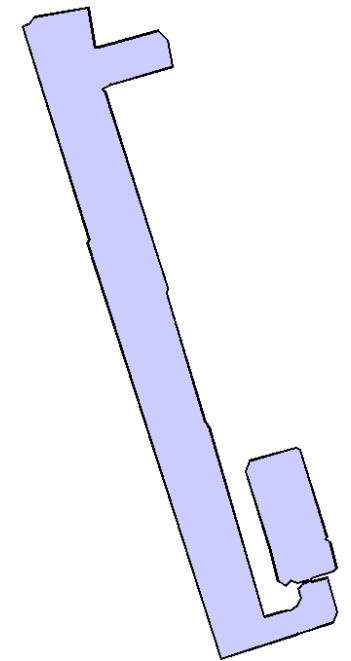
- Interior hallways



Level 1

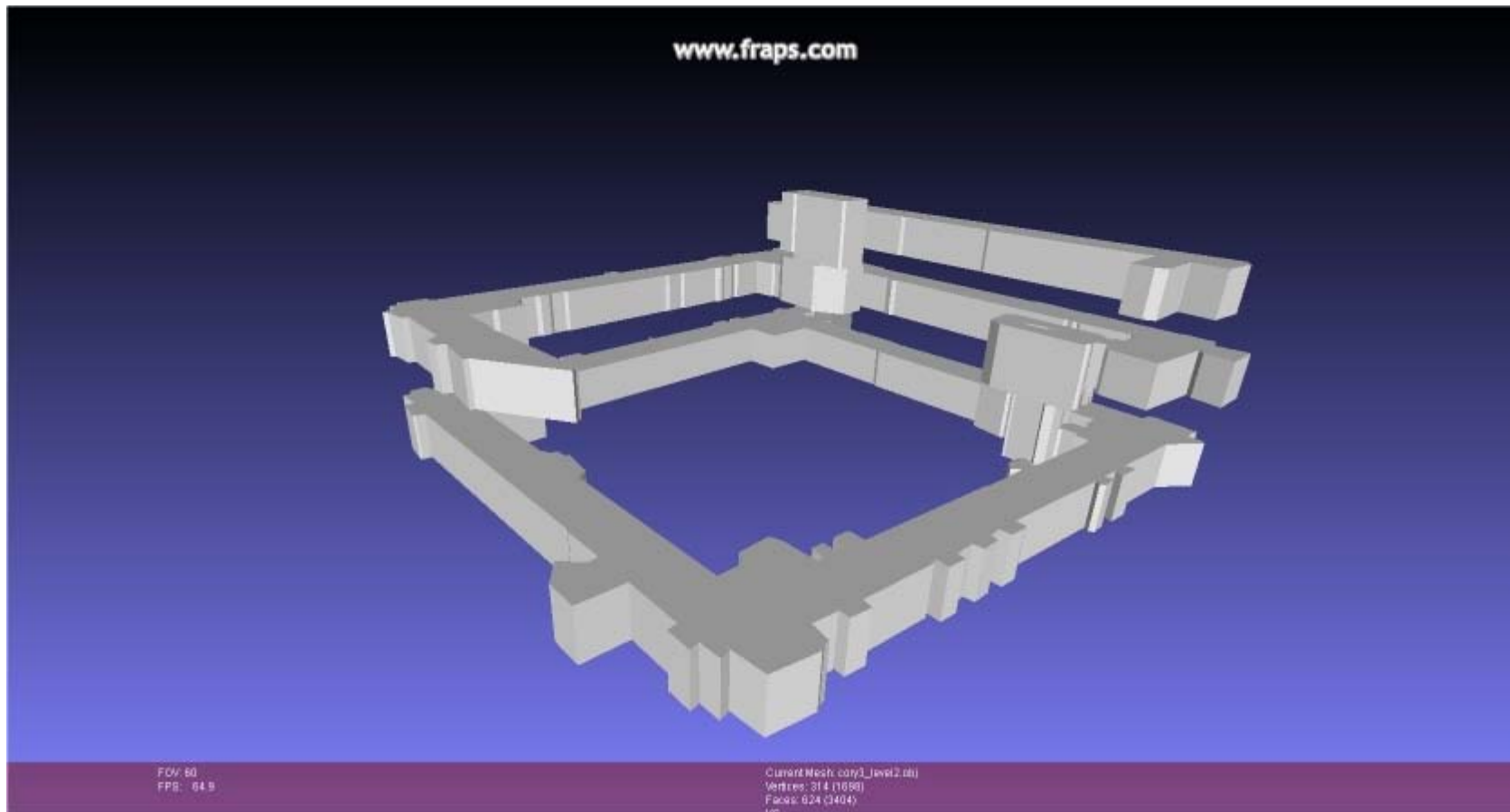


Level 2



Level 3

# Floor Plans → 3D Models of Buildings



- Indoor Navigation
- Energy Simulation
- Texture Mapping
  - *Virtual Reality*
  - *Augmented Reality*
  - *Video Games*

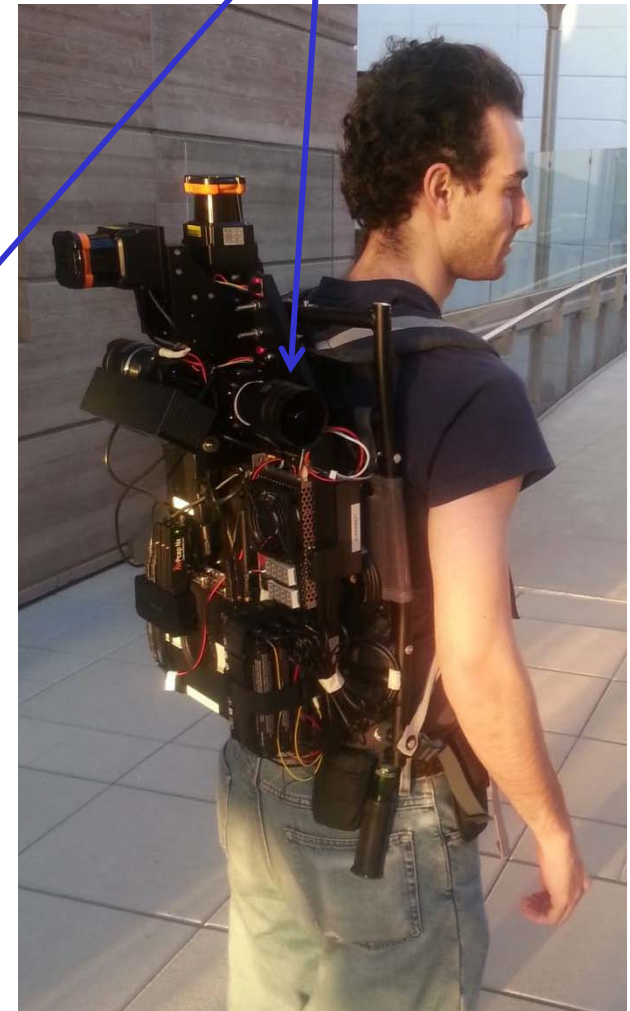
# Indoor Modeling

- Acquisition System



# Indoor Modeling

## ■ Acquisition System

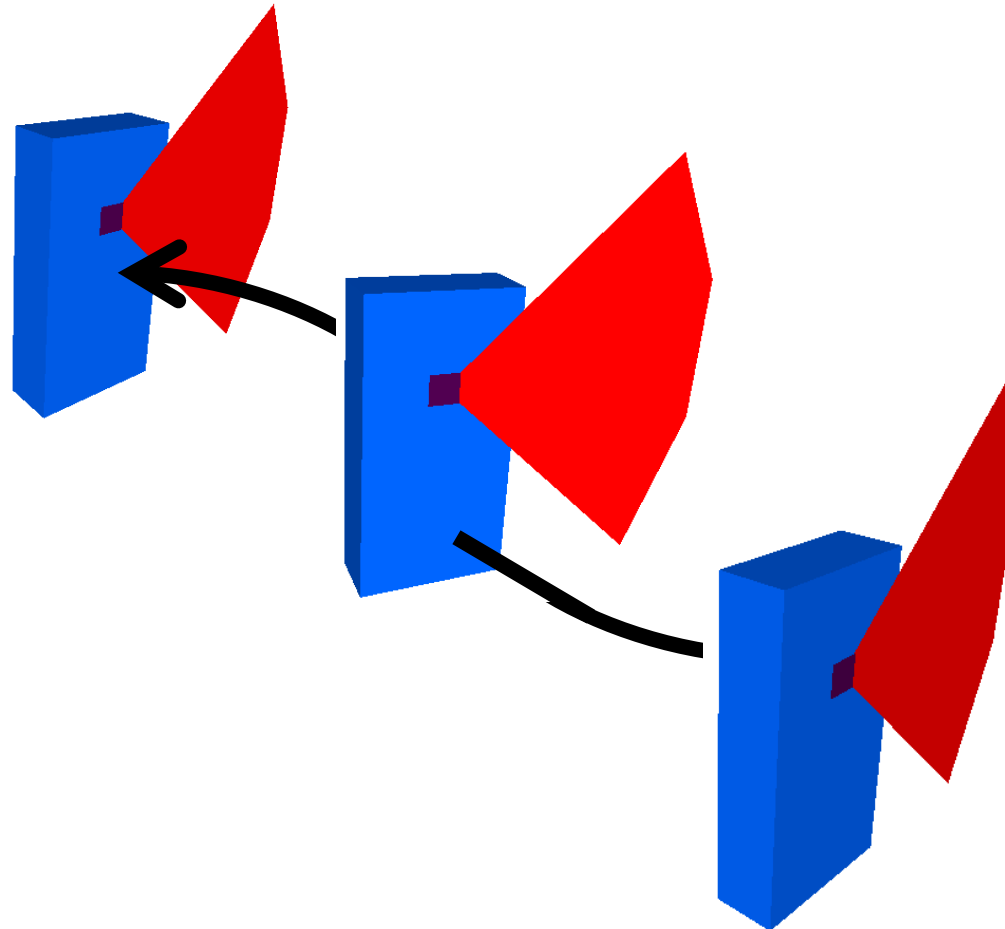


Laser Scanners

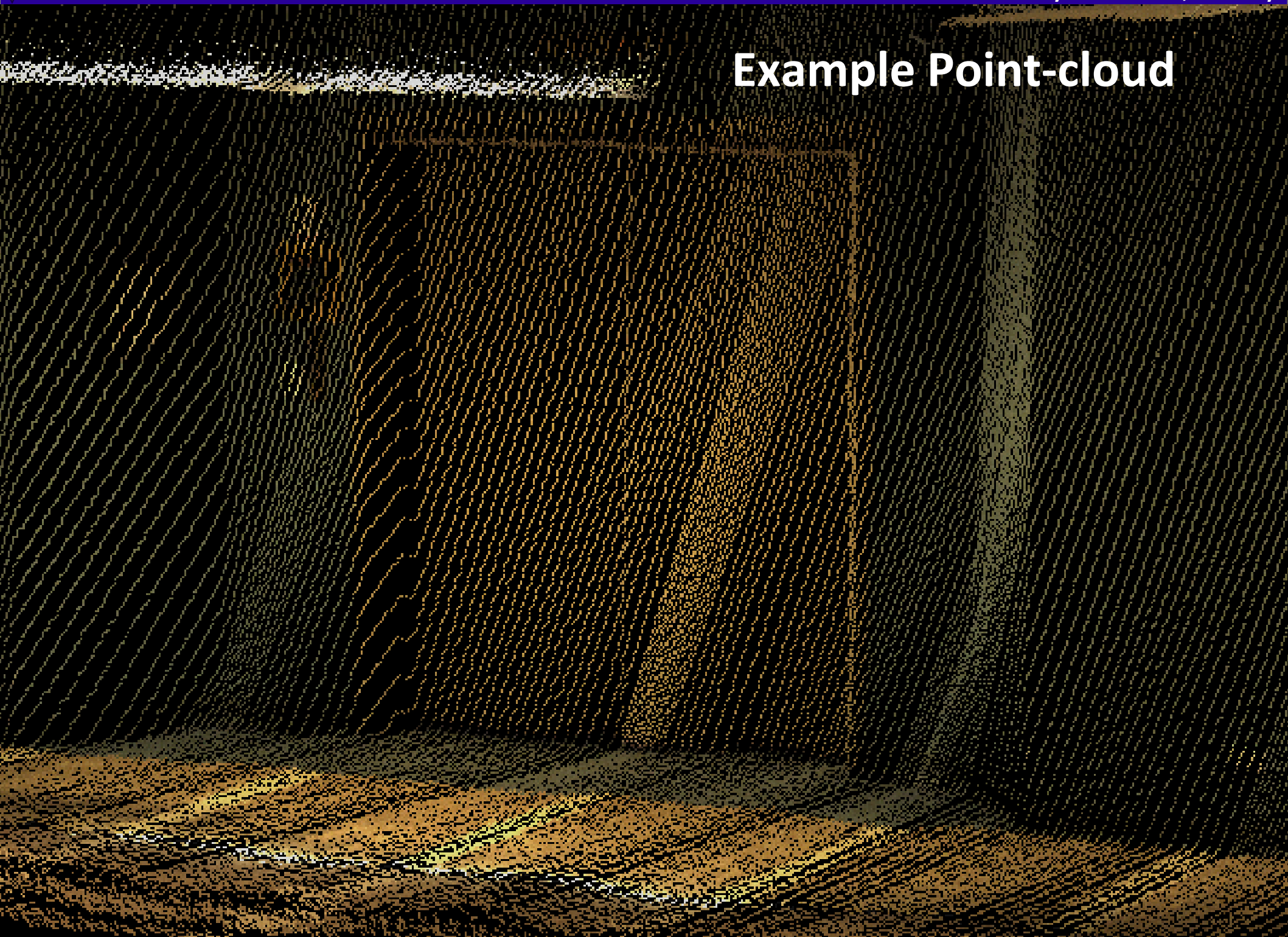
Cameras

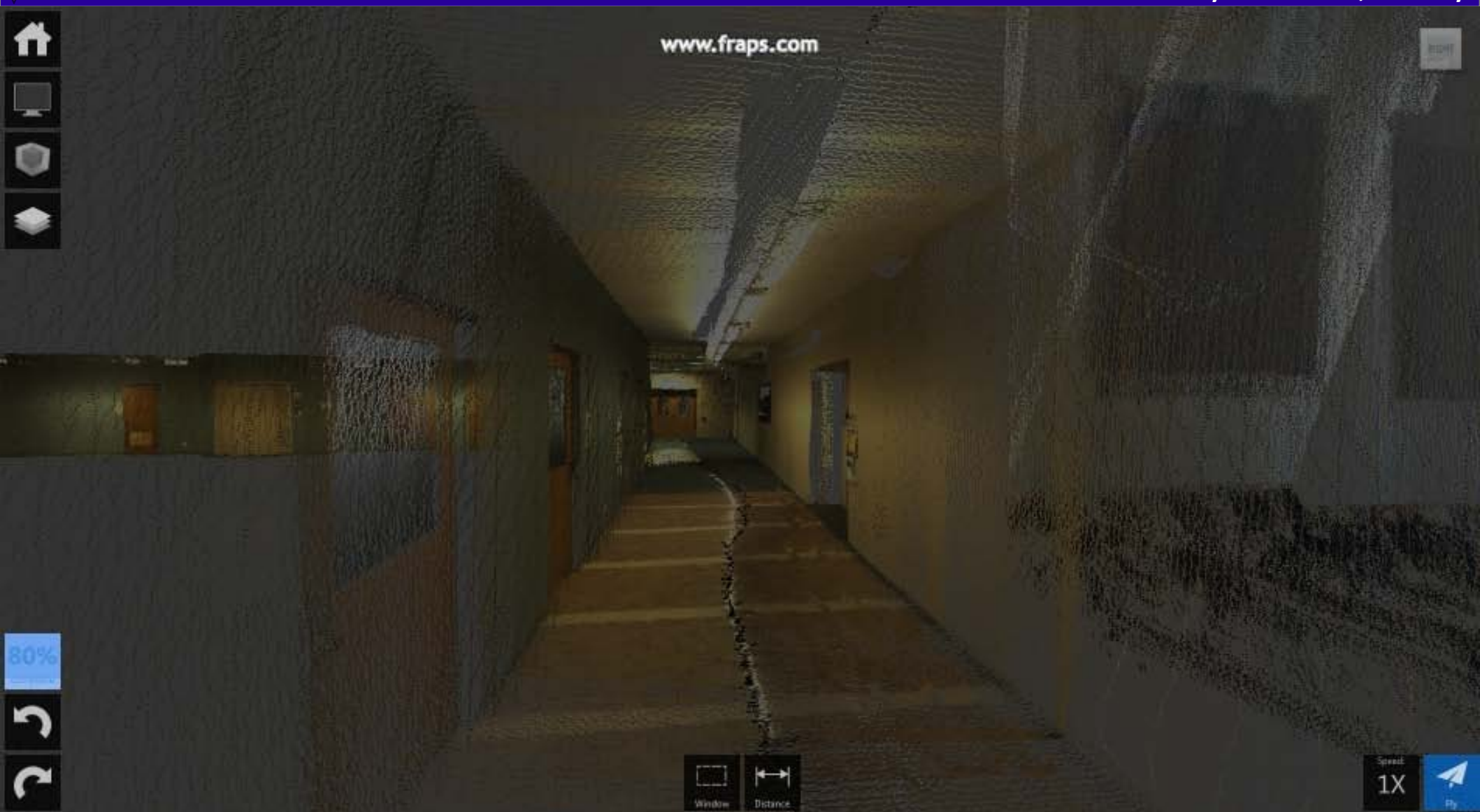
# Indoor Modeling

- Point-cloud Generation



# Example Point-cloud





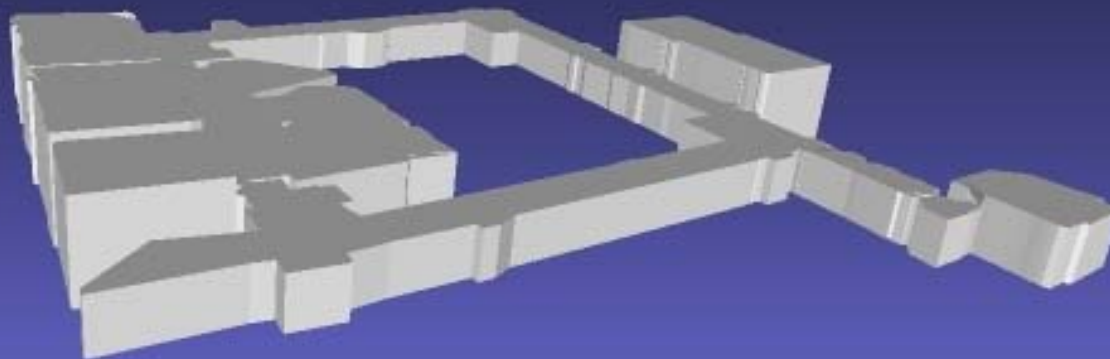
- 45 Million Points
- 3.4 GB on disk

Good for visualization,  
but **unwieldy**



# Motivation for Meshing

www.fraps.com



FCV: 60  
FPS: 100.0

Vertices: 1882  
Faces: 3432  
VC:

**2,644 Triangles**

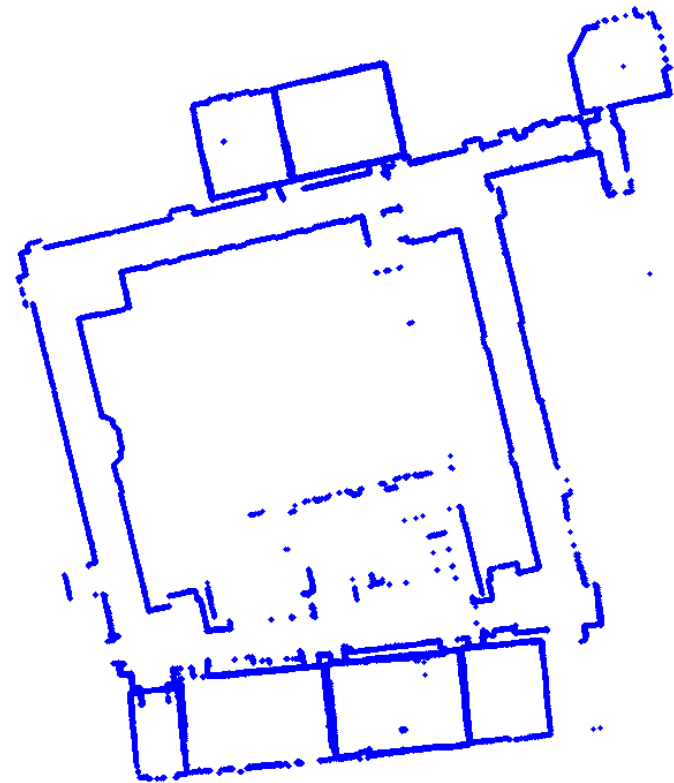
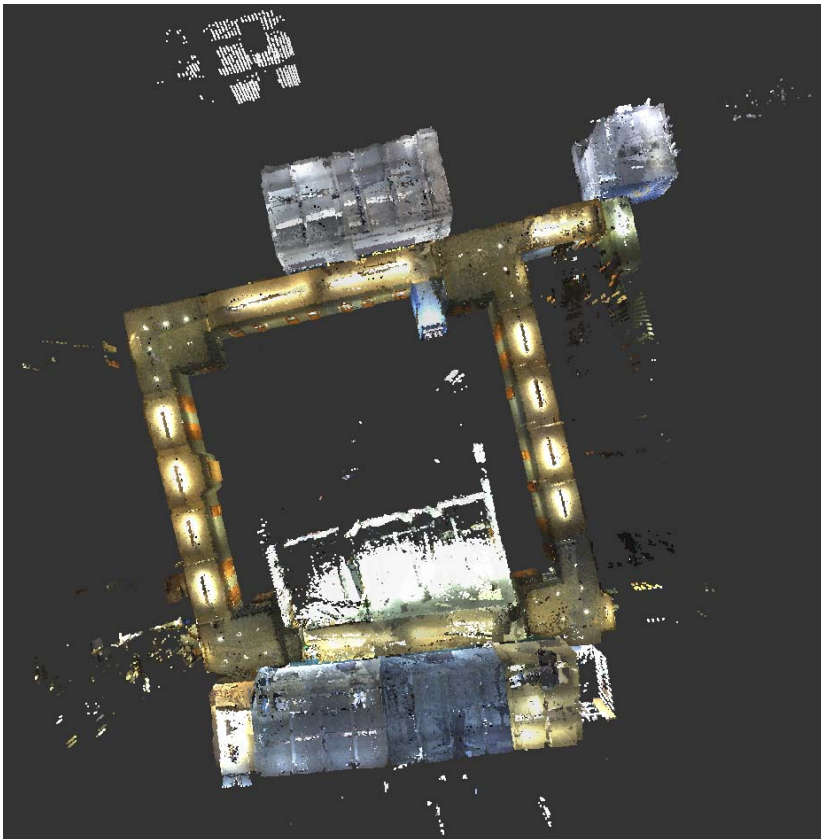
**81 KB on disk**

**Watertight**

**Models floors, walls, ceilings**

# Generating Floor Plans

- For 3D information, **point clouds** can be used

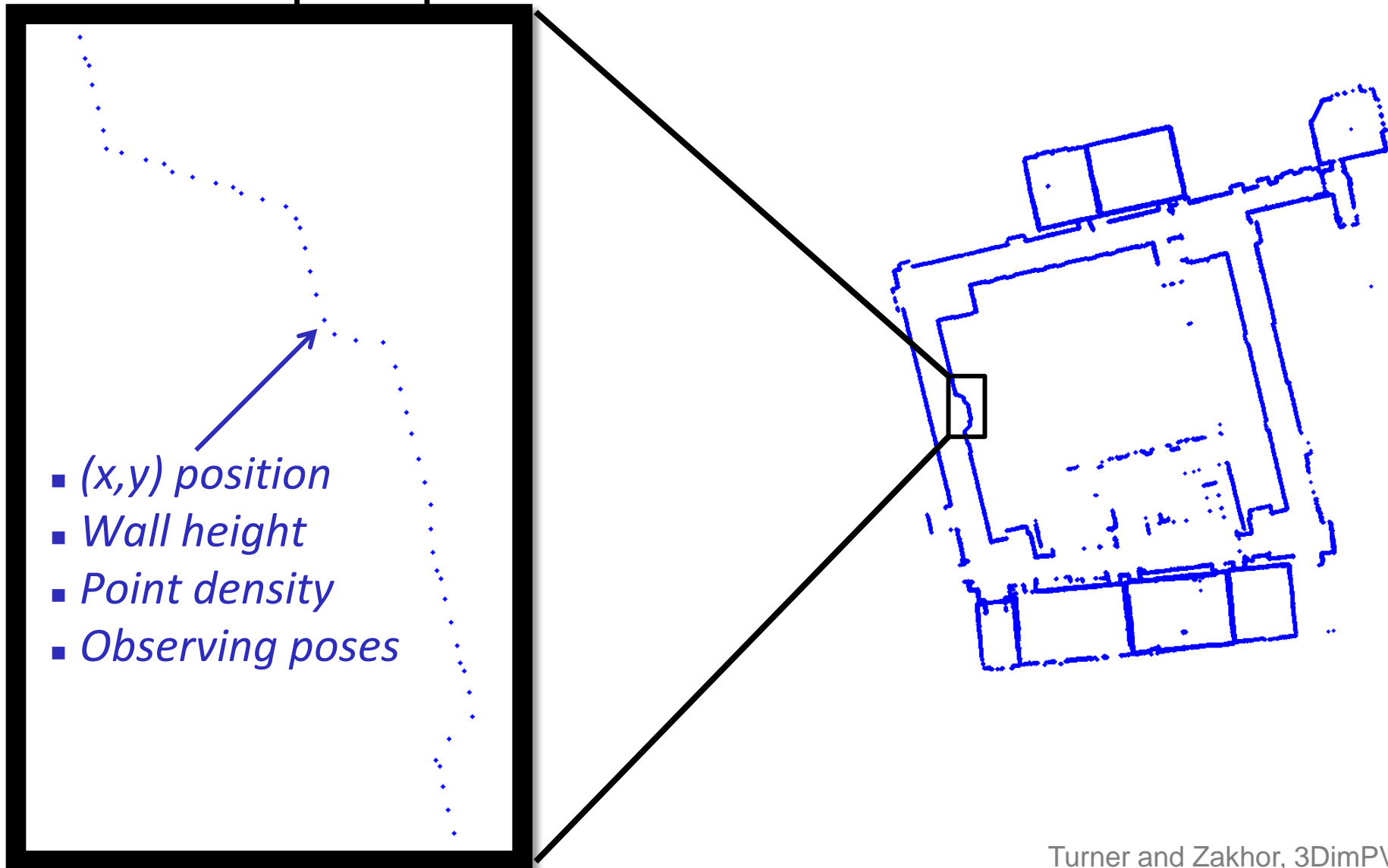


**45 Million Points**

**19,000 Wall Samples**<sup>10</sup>

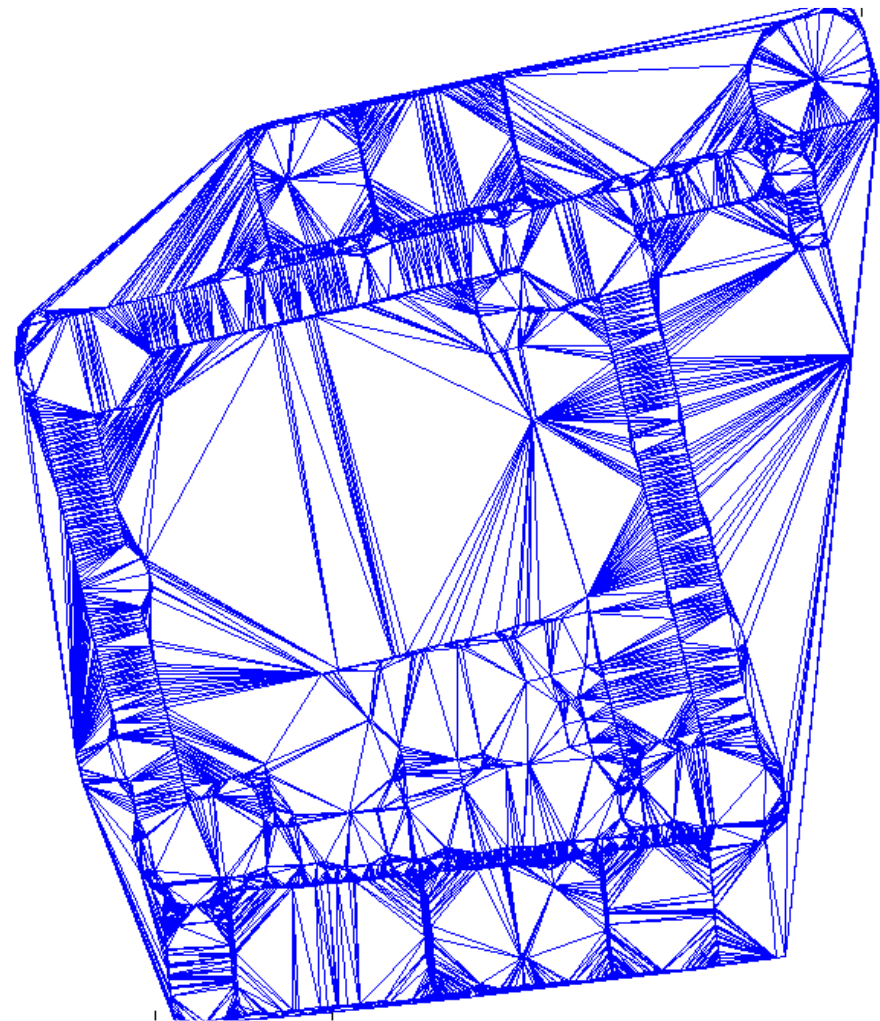
# Generating Floor Plans

- Each sampled position contains wall information



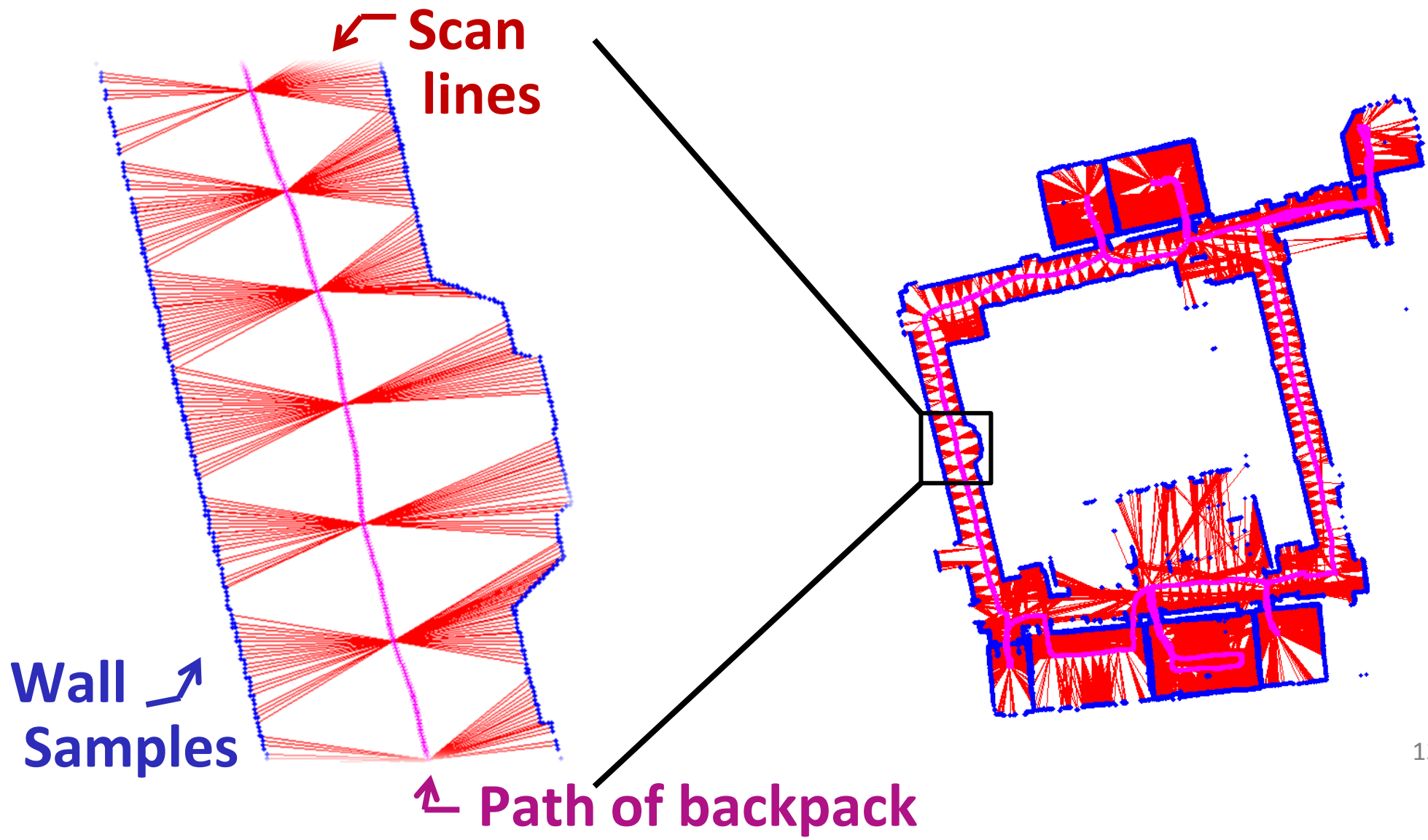
# Delaunay Triangulation

- Triangulate samples to represent Floor Plan area
- Each triangle is either **Inside** or **Outside**



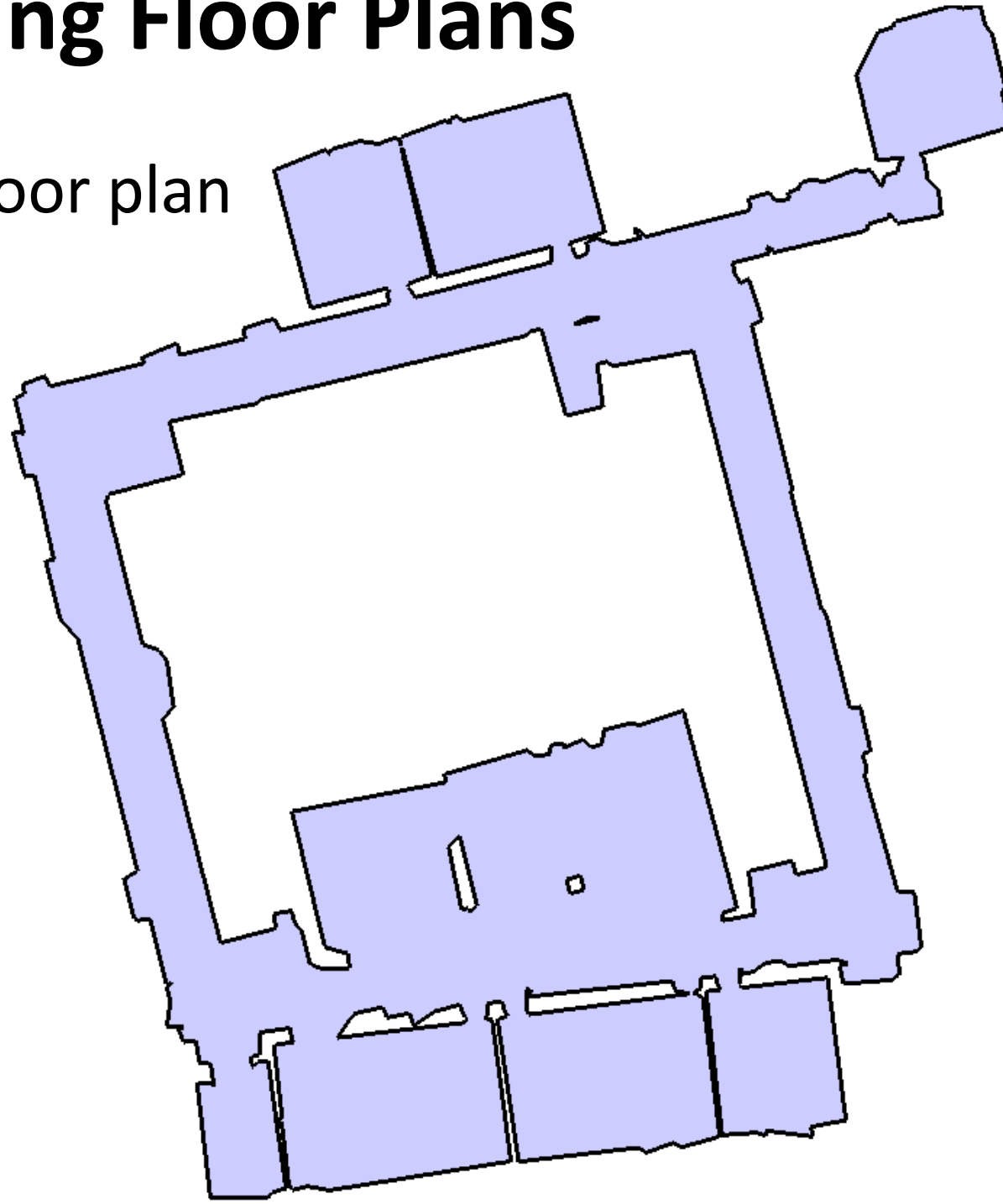
# Generating Floor Plans

- Labeling interior volume

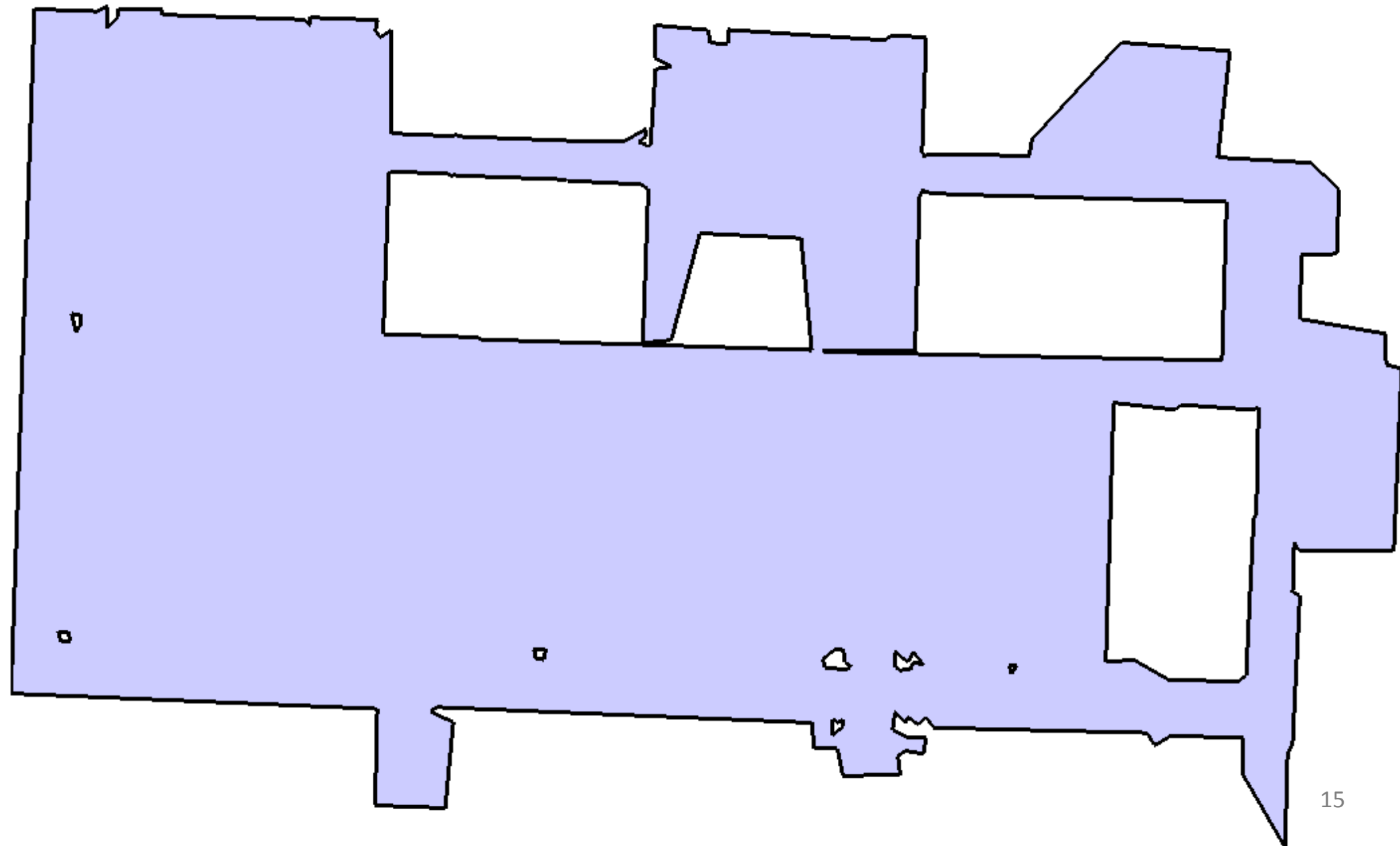


# Generating Floor Plans

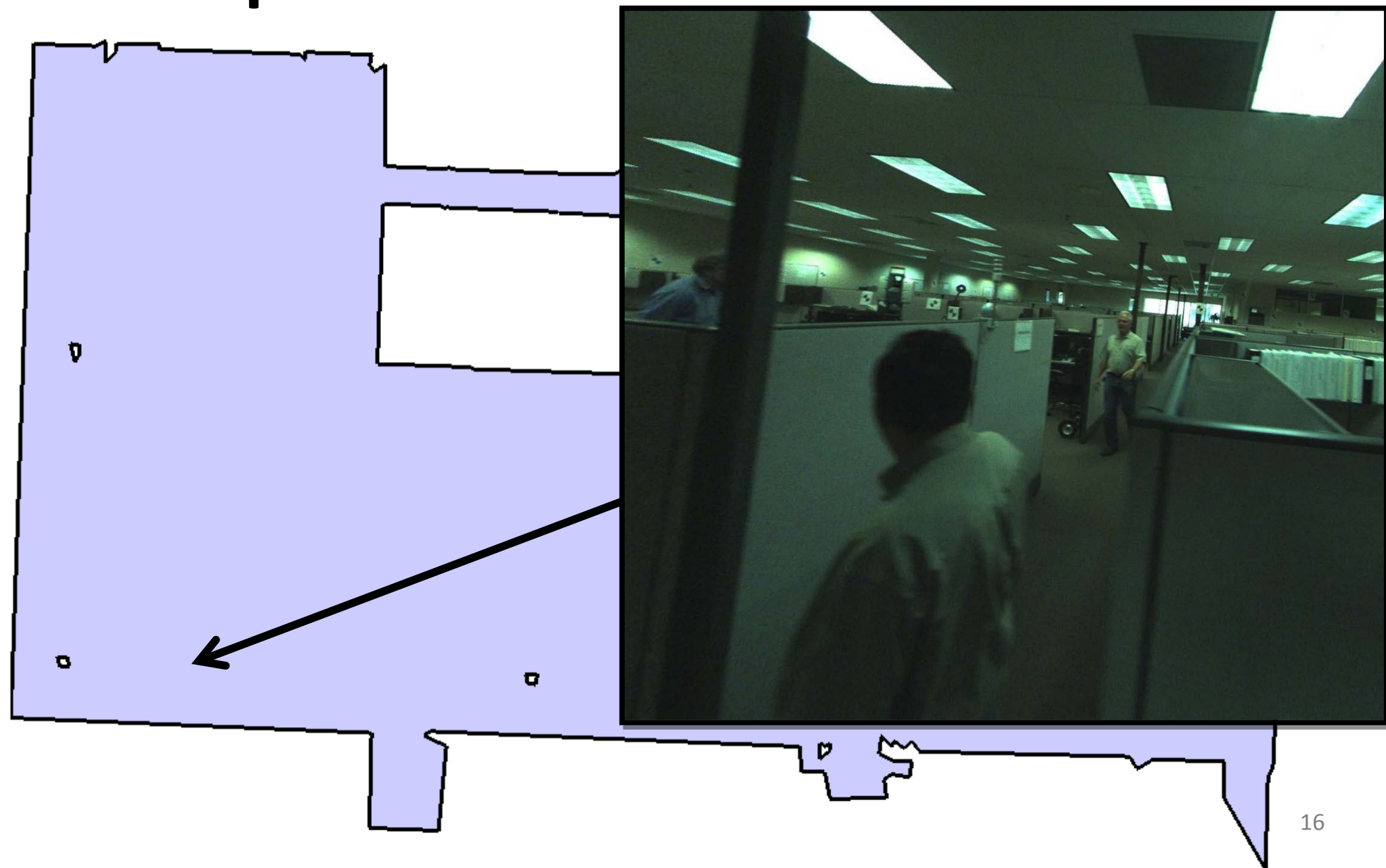
- Example floor plan



# Example Floor Plans

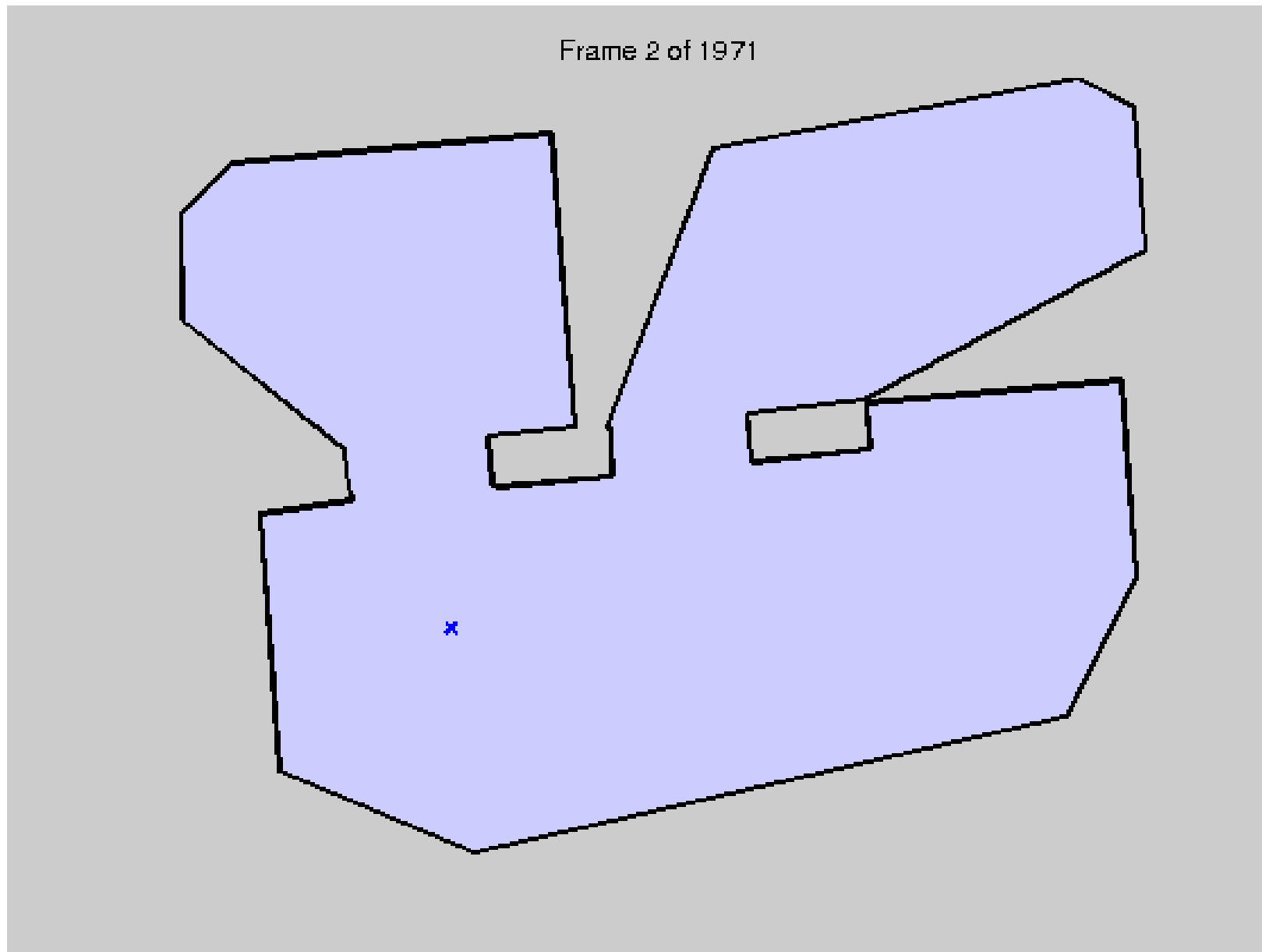


# Example Floor Plans

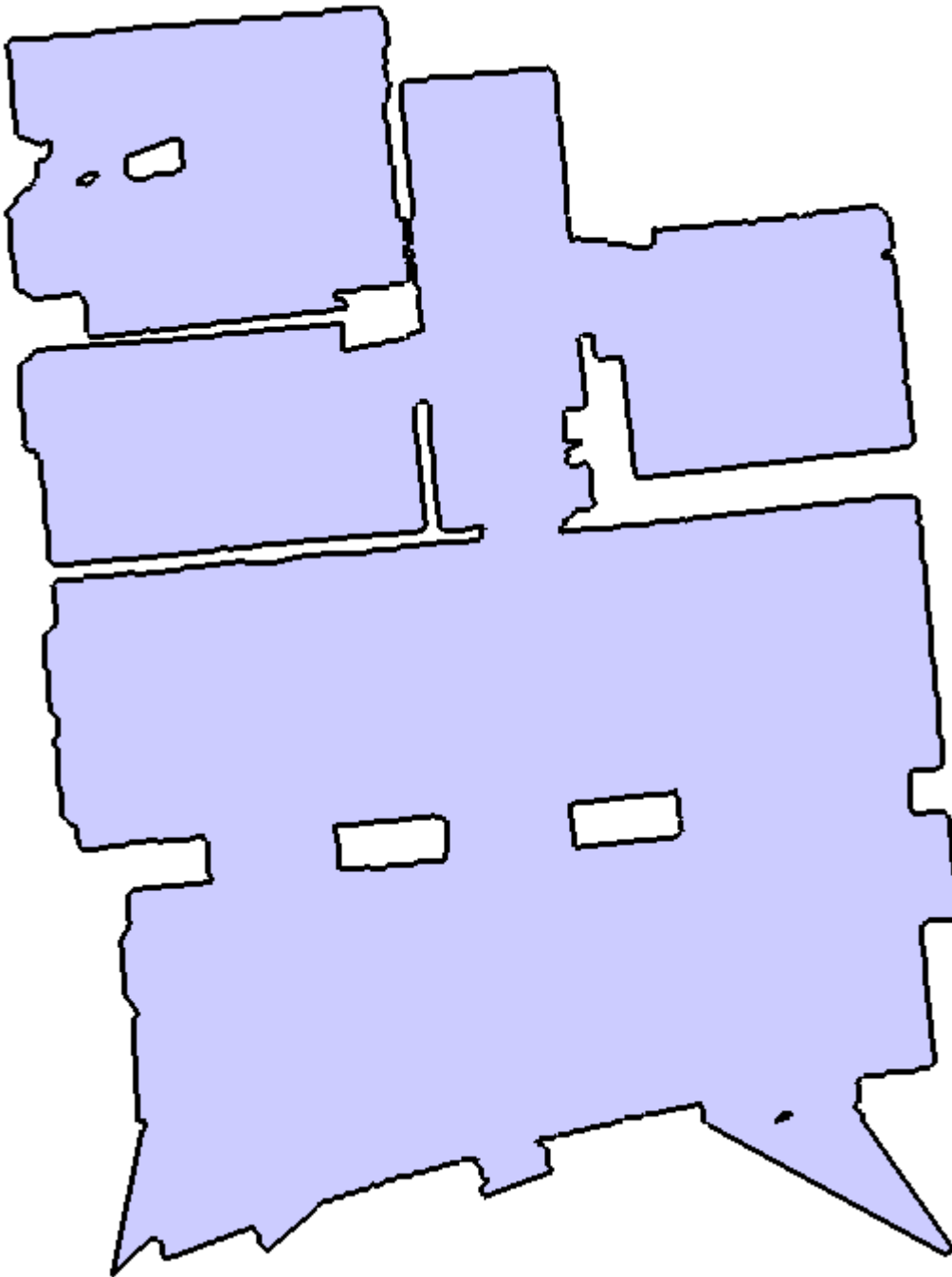




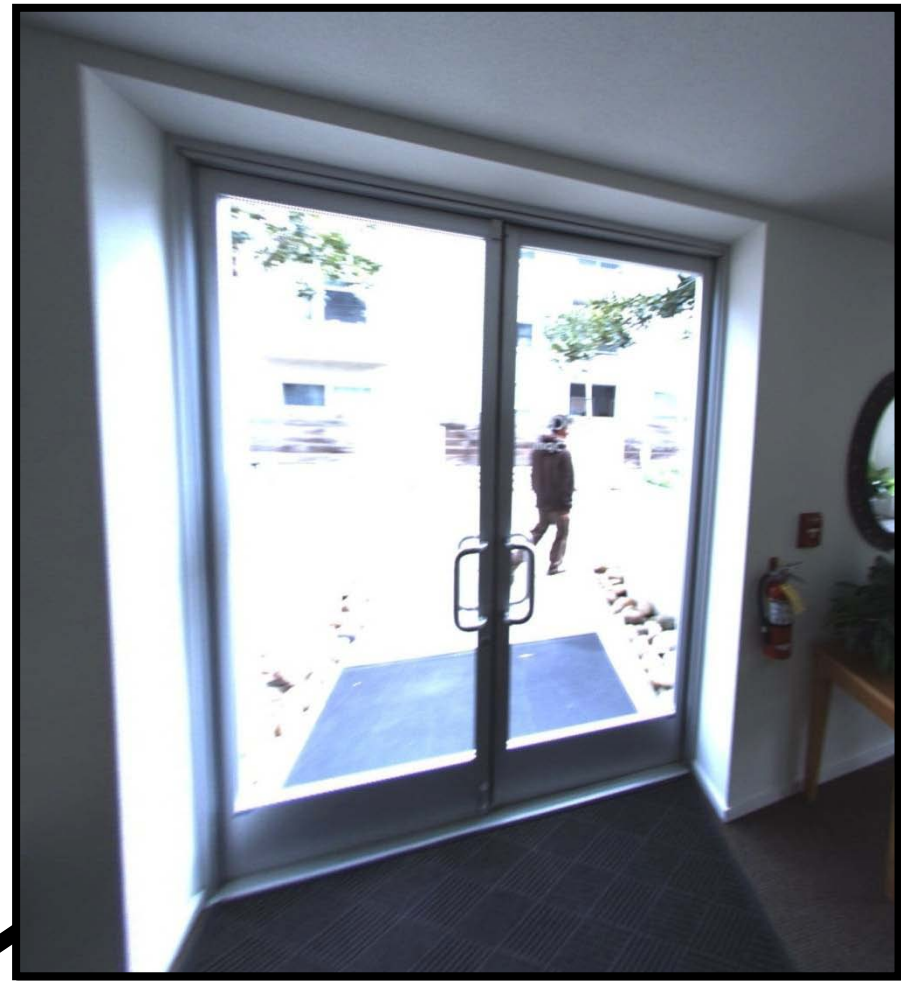
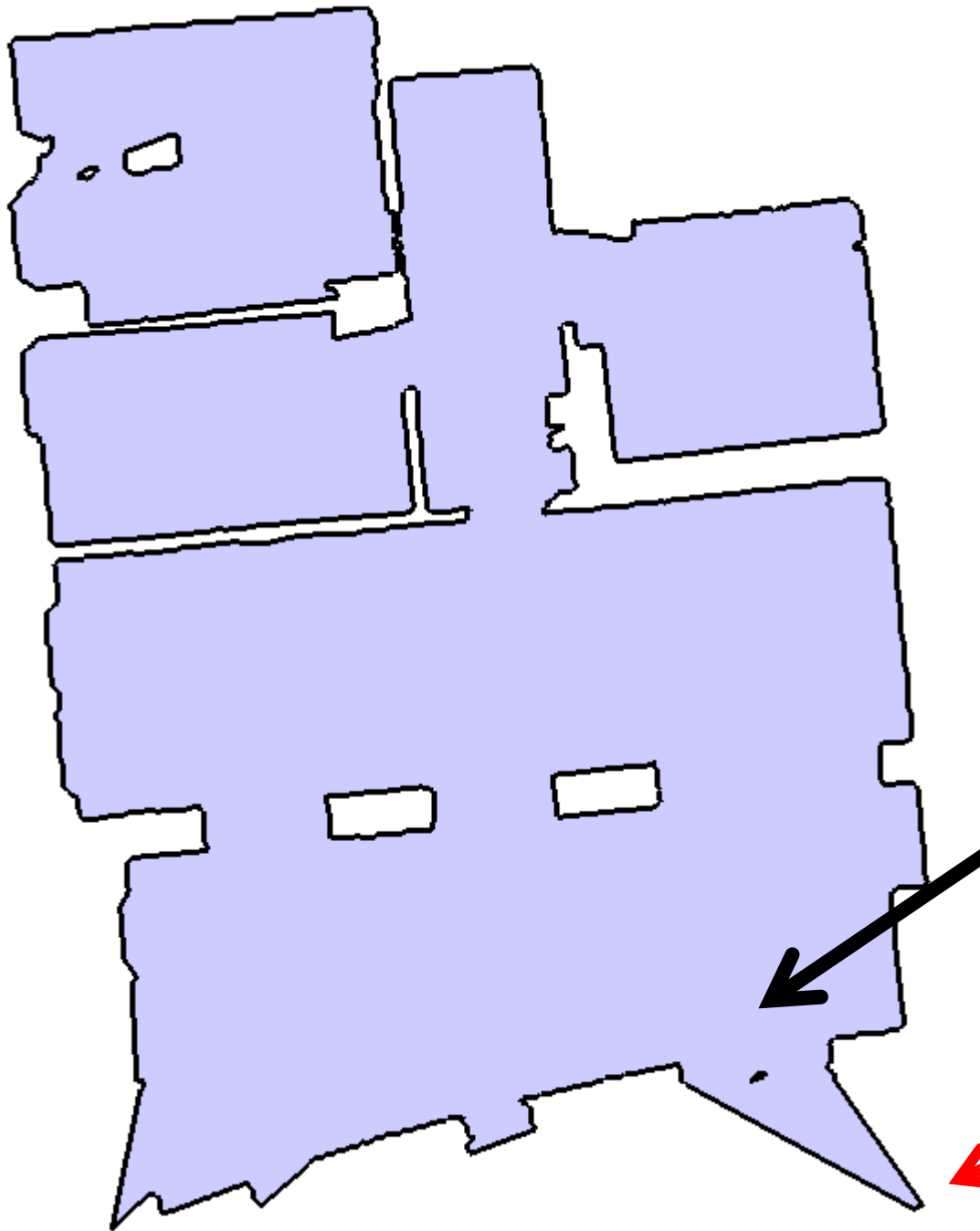
# Example Floor Plans



# Example Floor Plans from 2D System

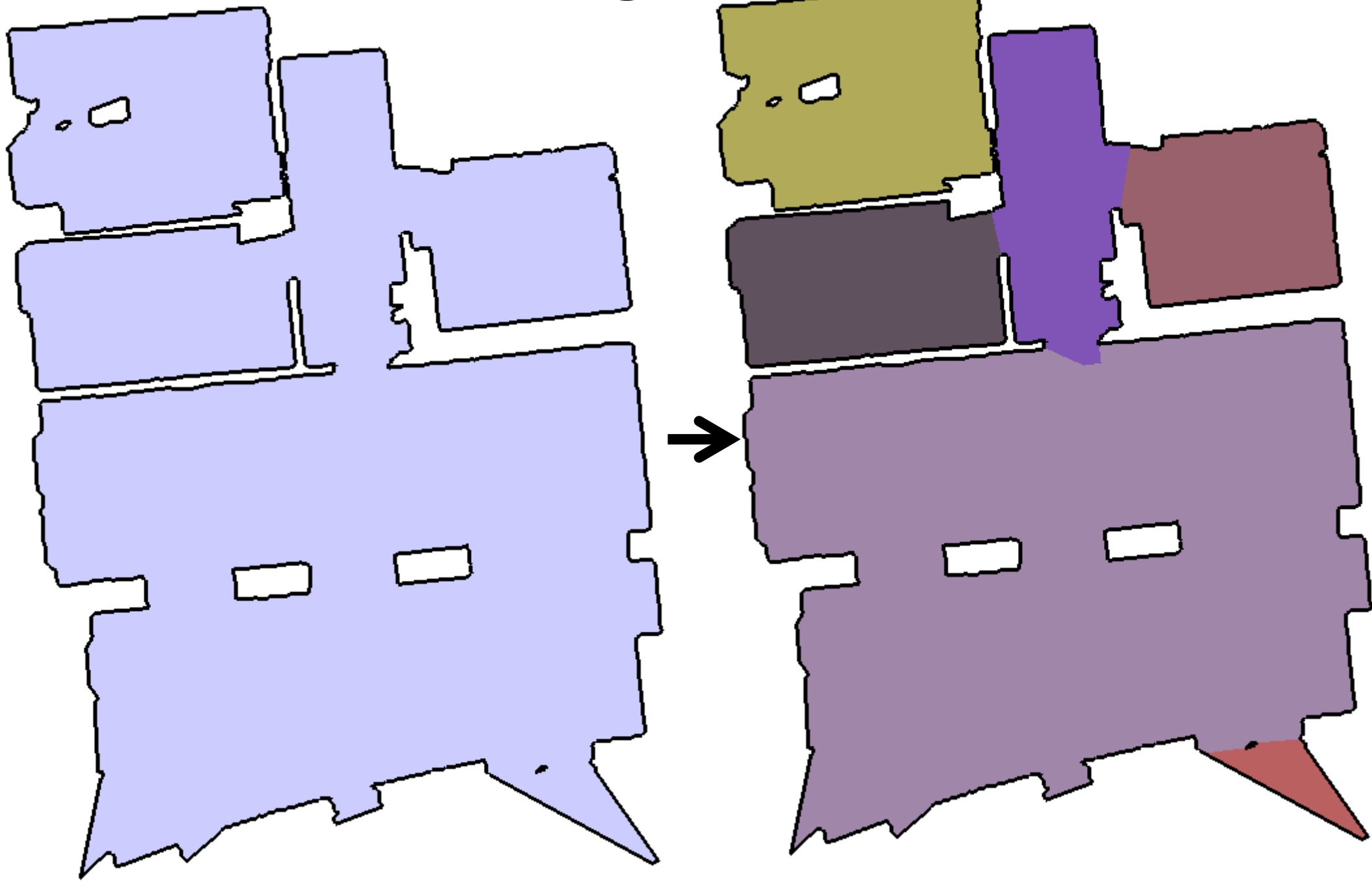


# Example Floor Plans from 2D System



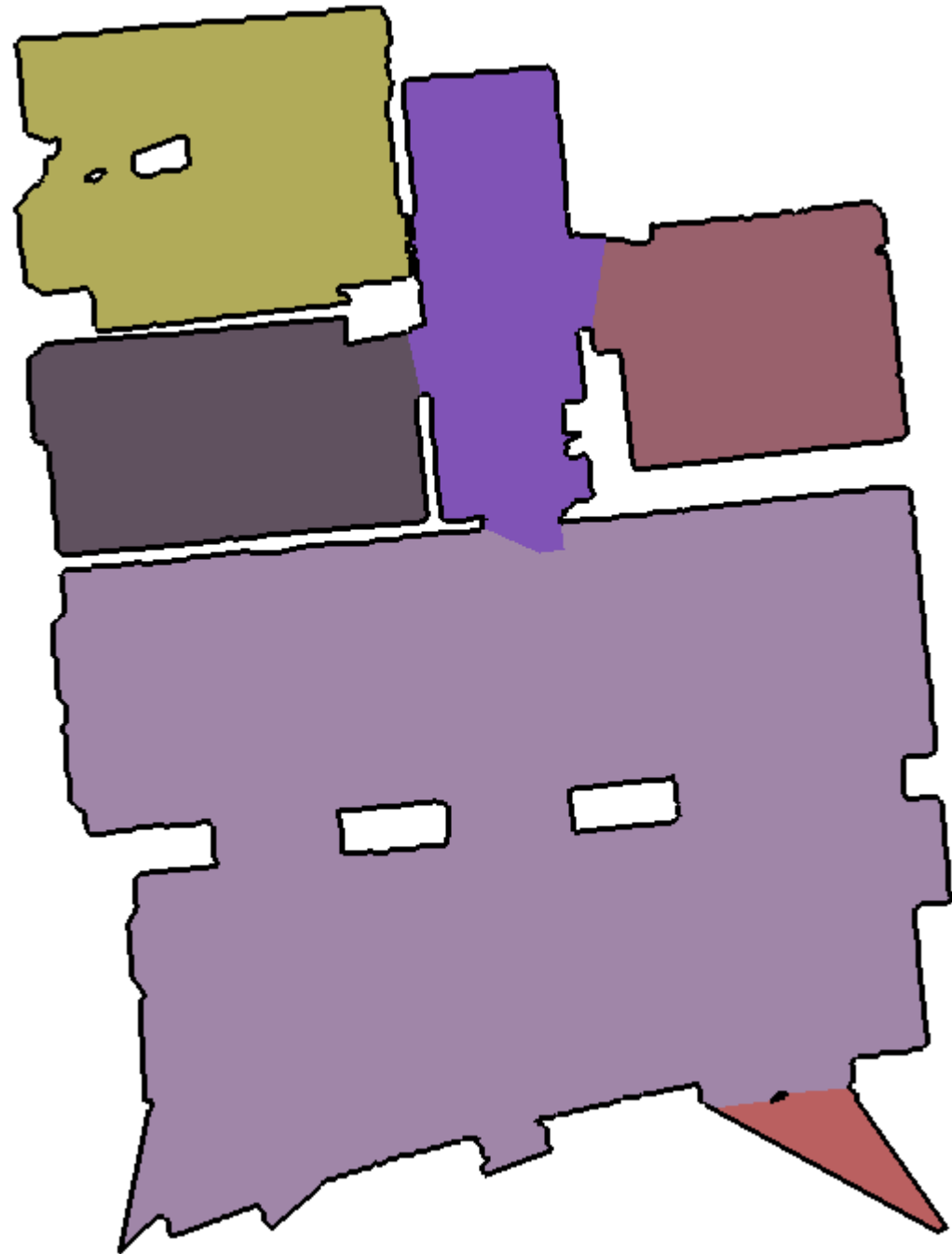
**Outside area  
partially scanned**

# Room Partitioning

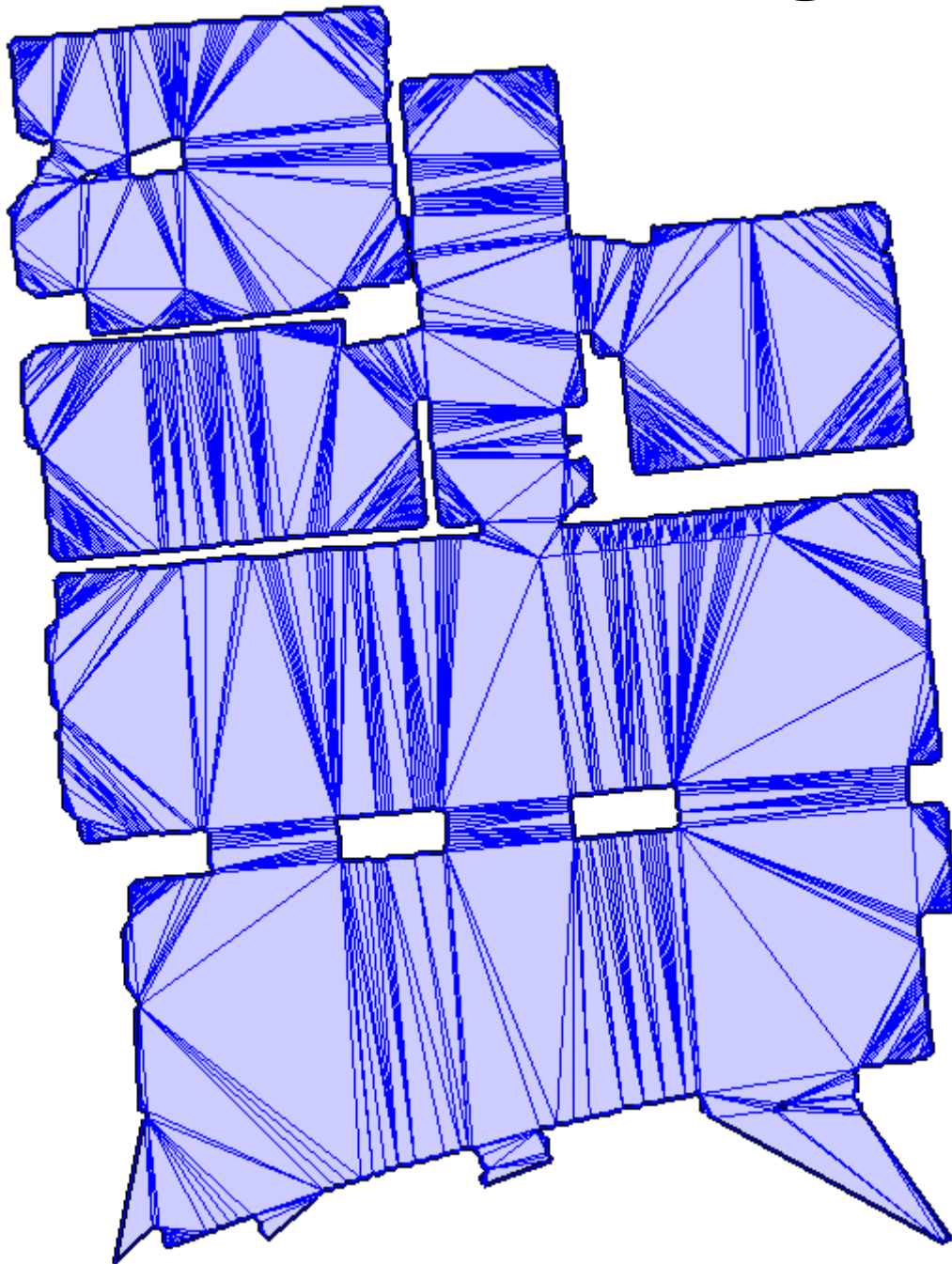


# Room Partitioning

- Find **seed locations** for each **room**
- **Graph cut** to partition all space in floorplan into rooms
- **Refine** room labels

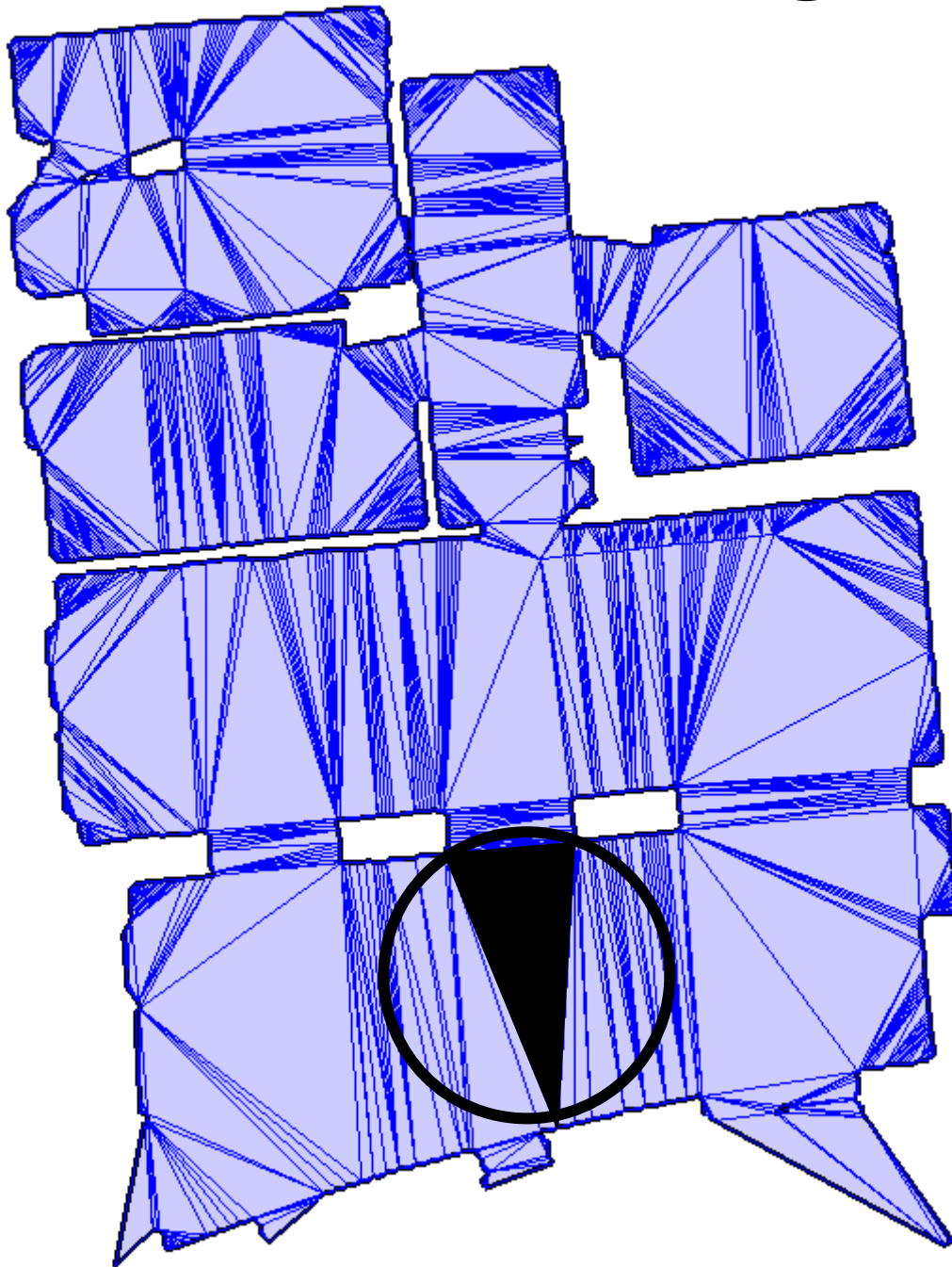


# Room Partitioning



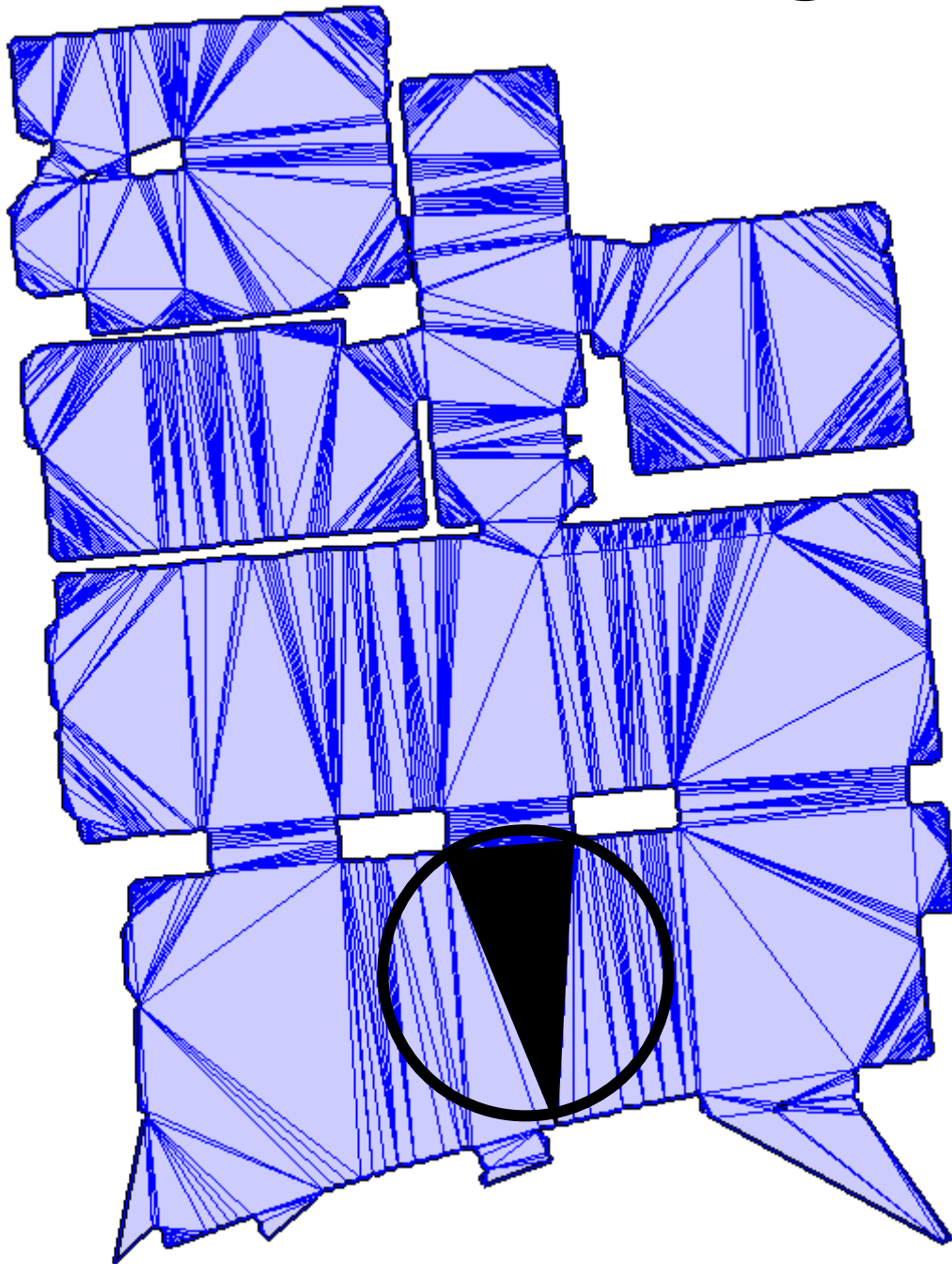
- Delaunay Triangulation
- Dense Wall Samples

# Room Partitioning



- Delaunay Triangulation
- Dense Wall Samples
- **Circumcircles** typically contained in interior

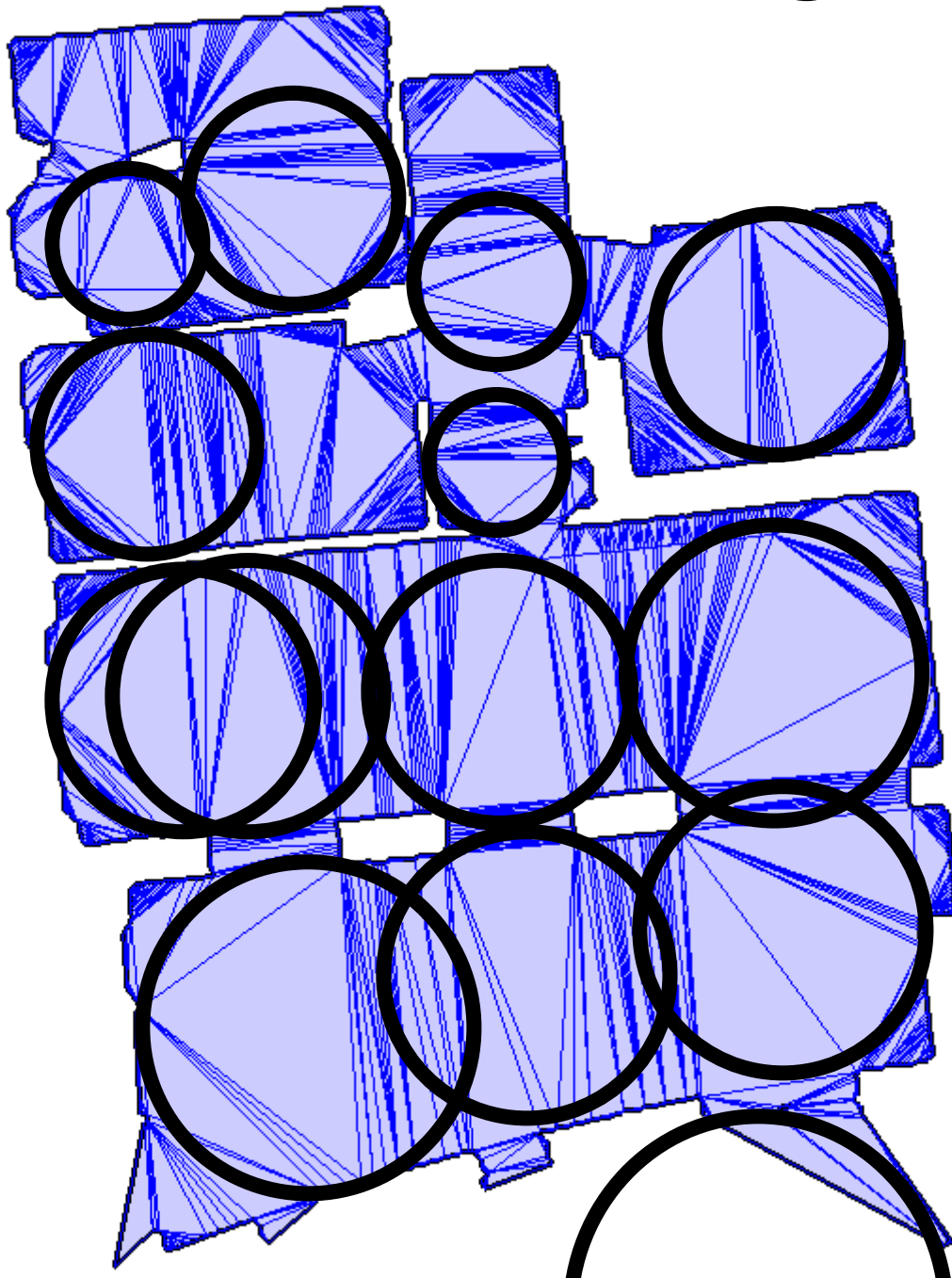
# Room Partitioning



- Delaunay Triangulation
- Dense Wall Samples
- **Circumcircles** typically contained in interior
- **Circumcircles** good proxy for room size

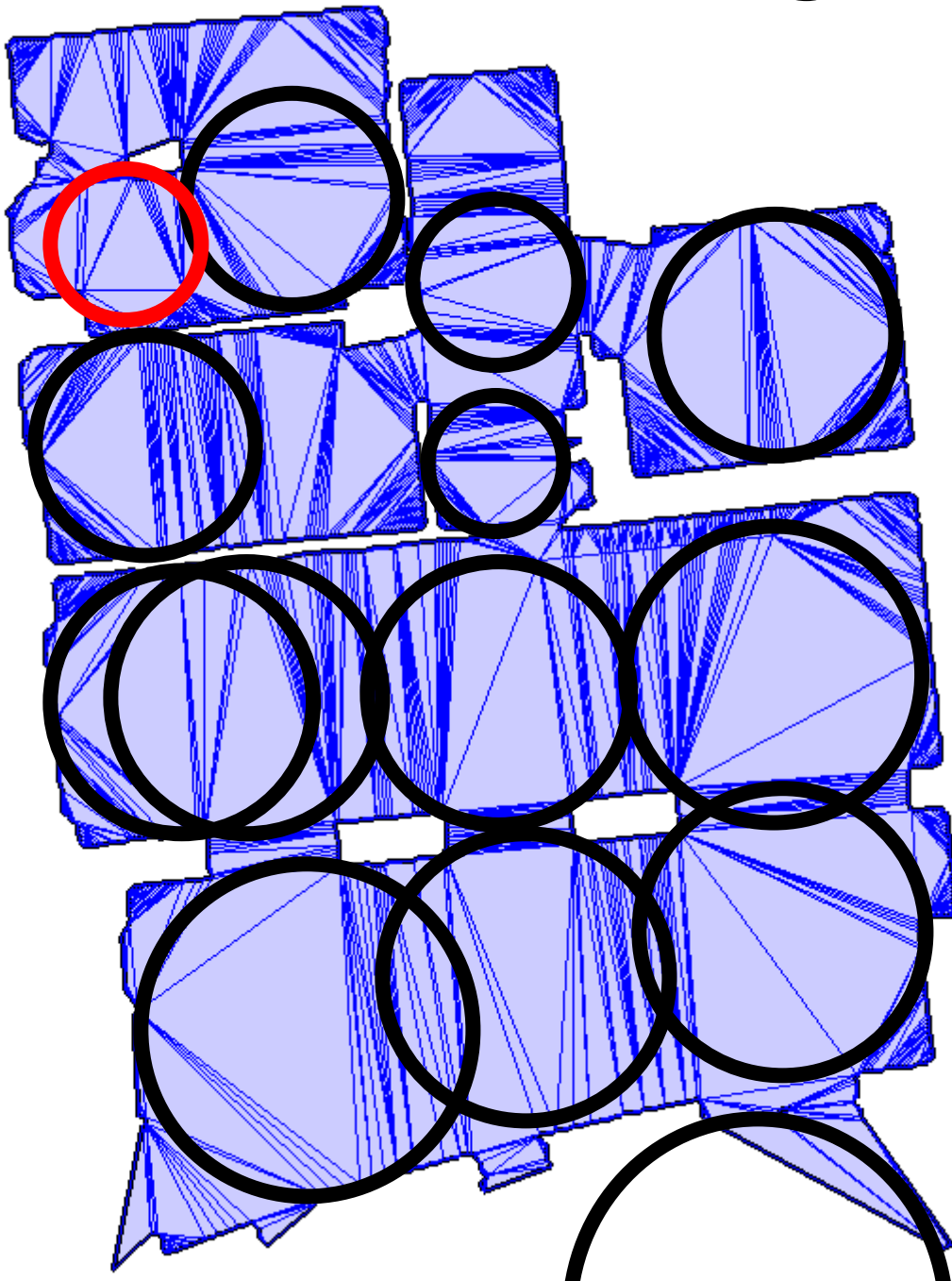


# Room Partitioning



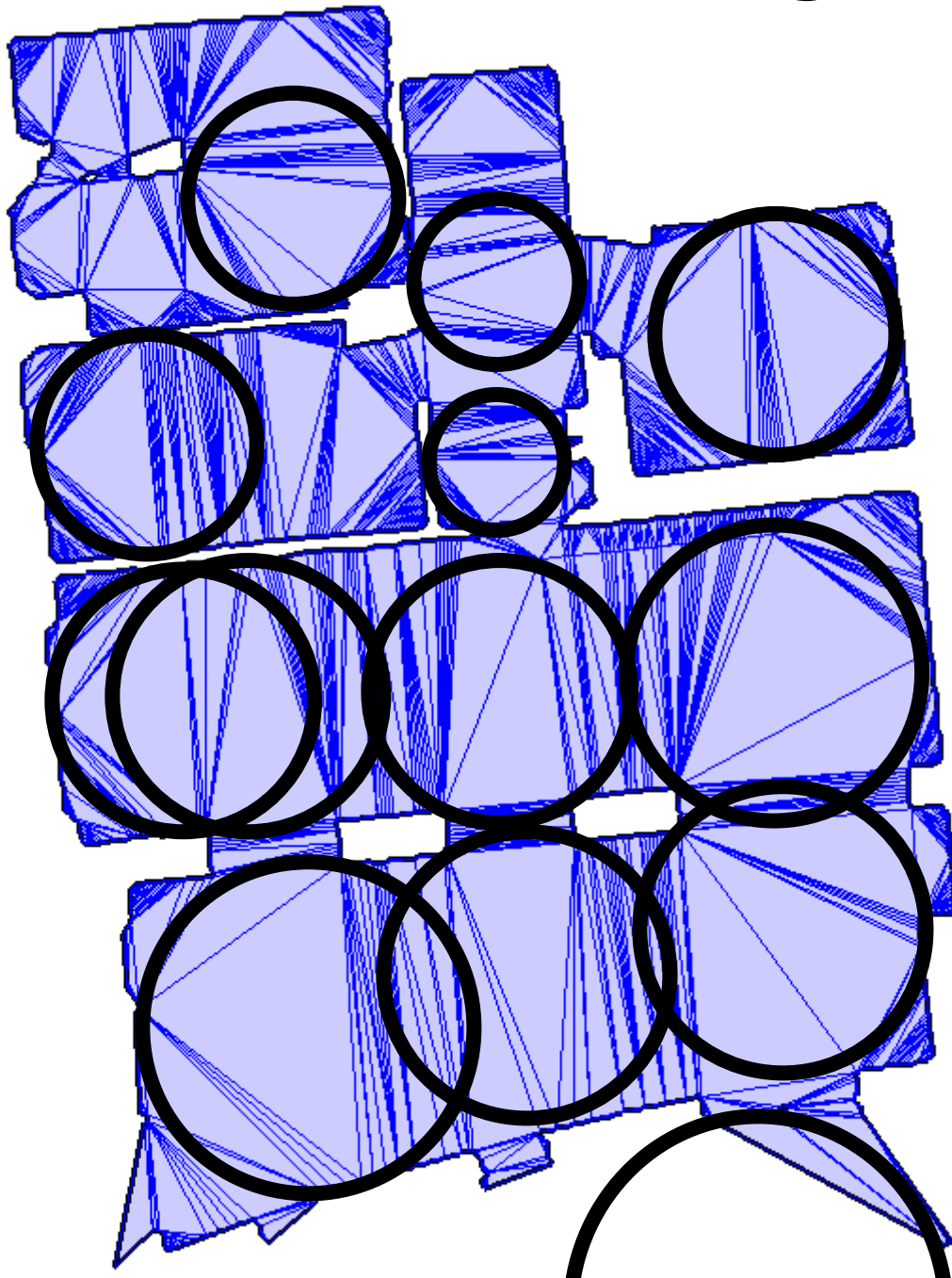
- Find **local maxima** of circumradii

# Room Partitioning



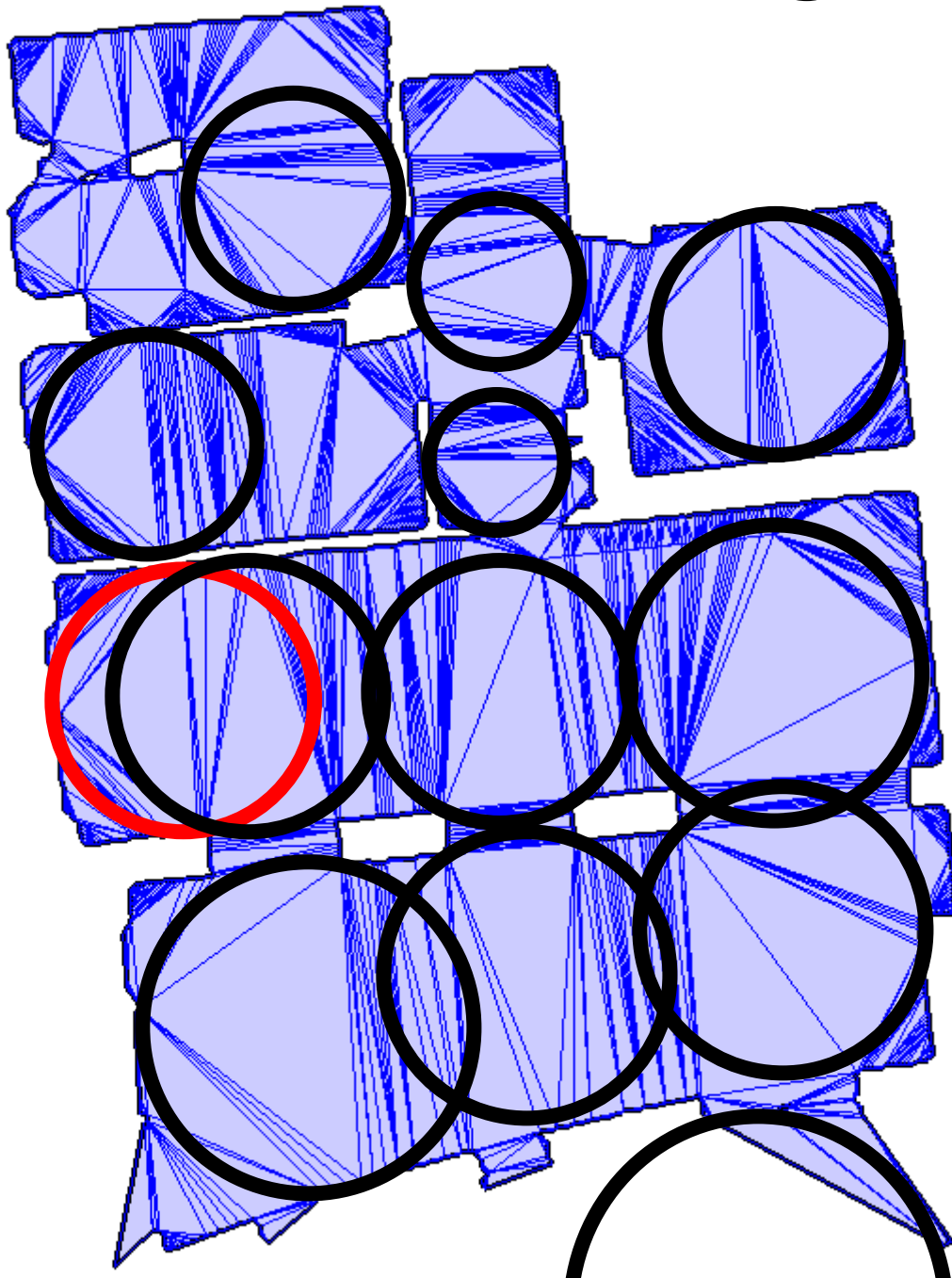
- Find **local maxima** of circumradii
- The circumcircles who are larger than all other **intersecting** circumcircles

# Room Partitioning



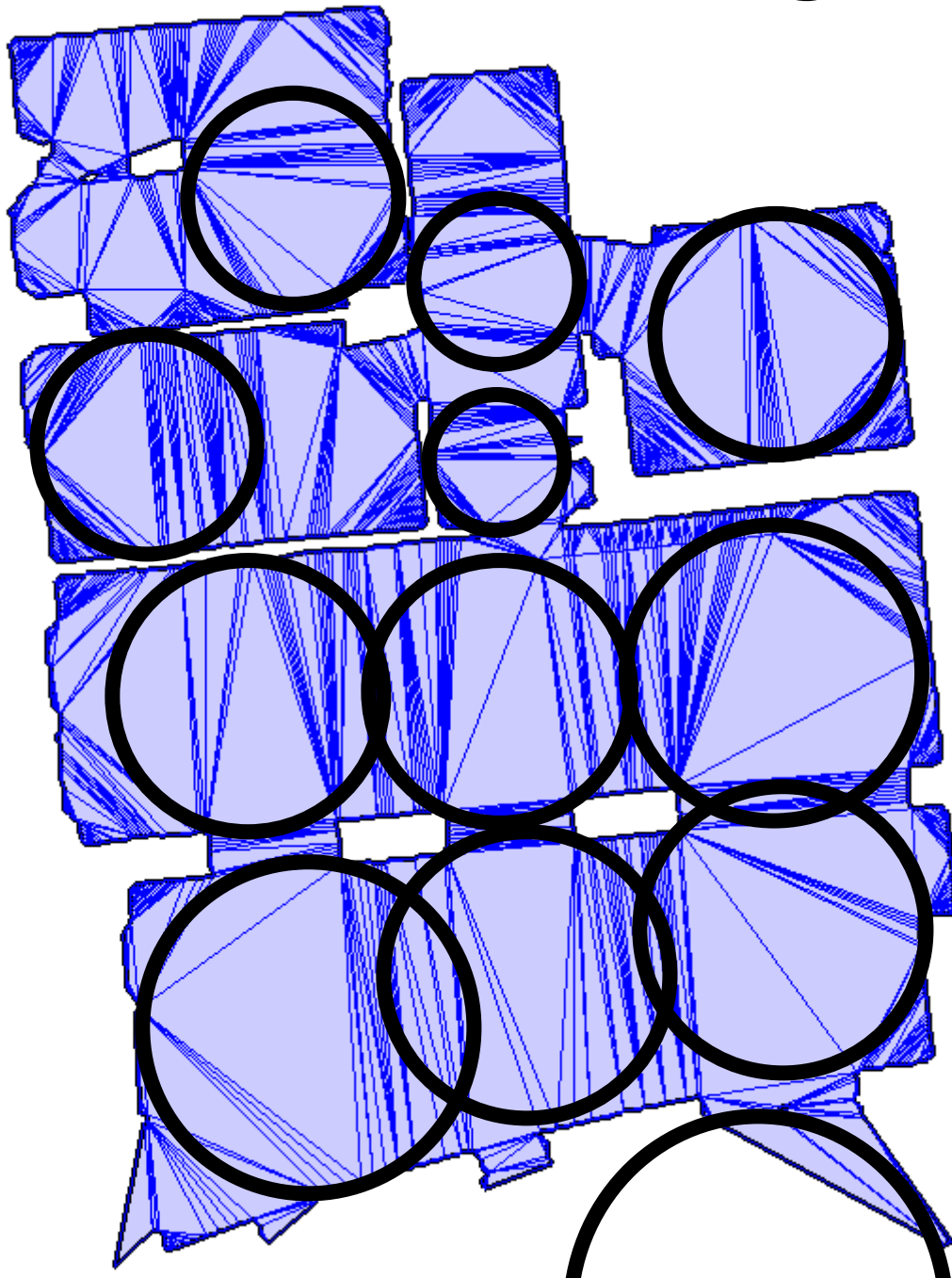
- Find **local maxima** of circumradii
- The circumcircles who are larger than all other **intersecting** circumcircles

# Room Partitioning



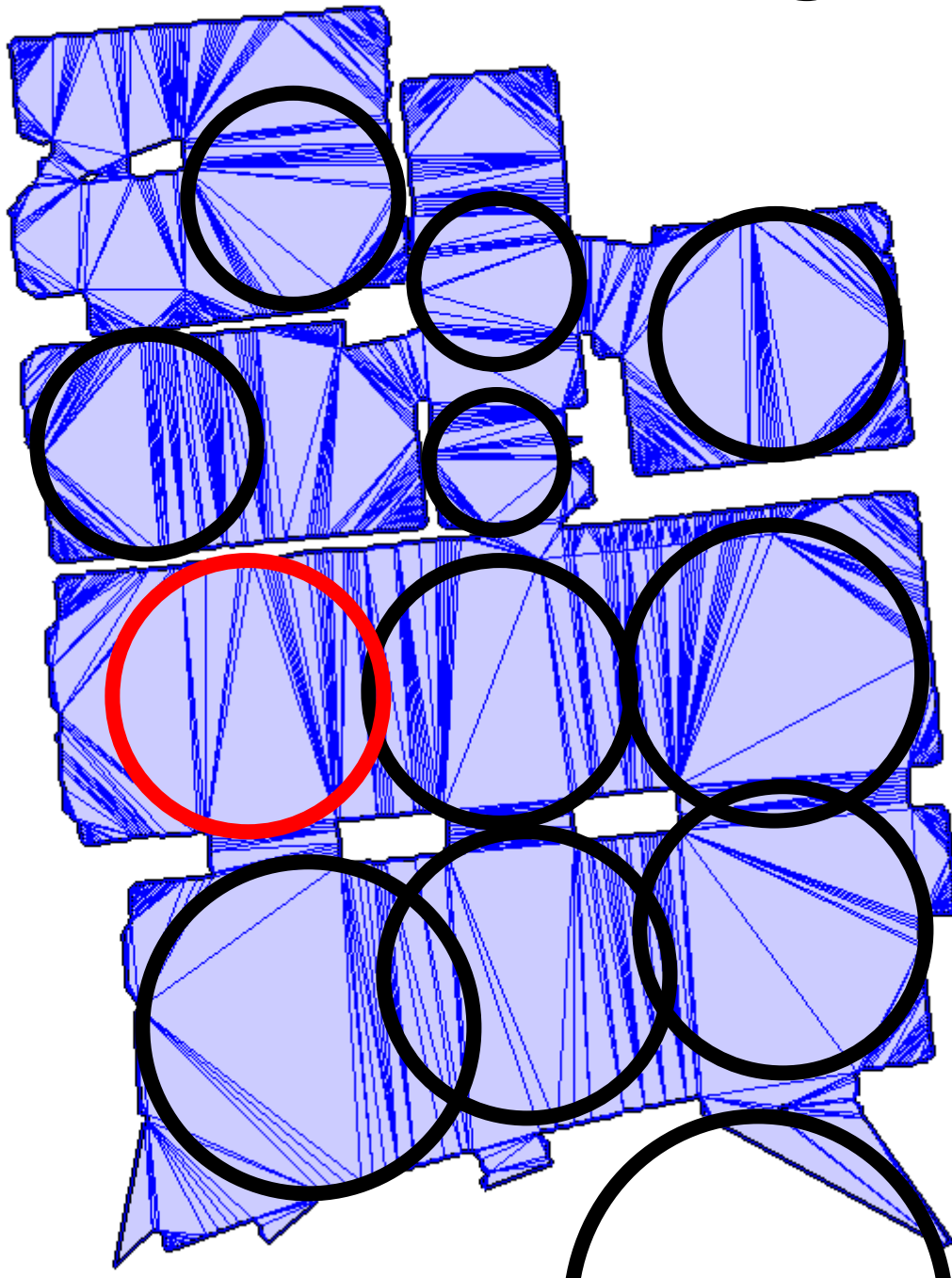
- Find **local maxima** of circumradii
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# Room Partitioning



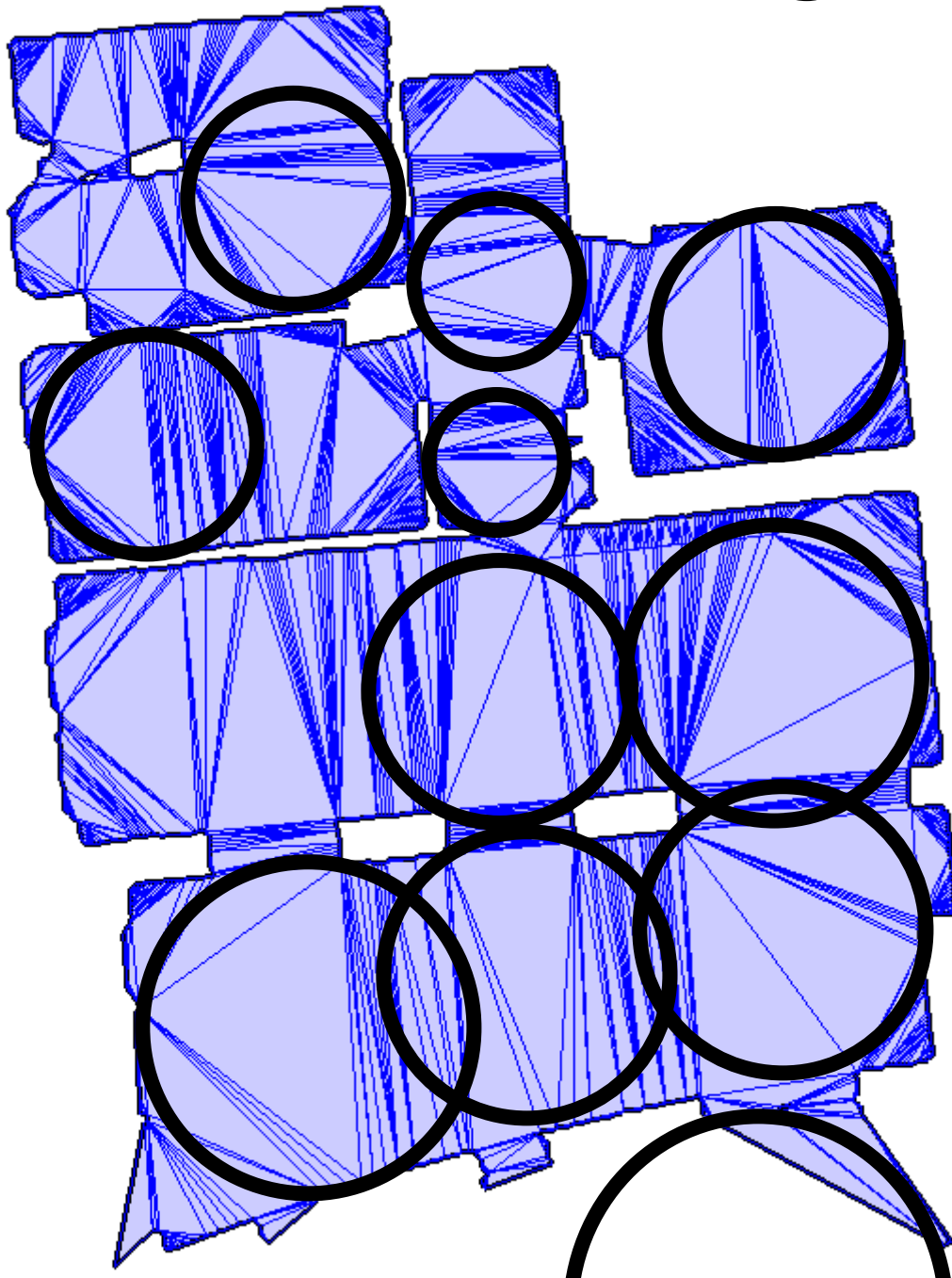
- Find **local maxima** of circumradii
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# Room Partitioning



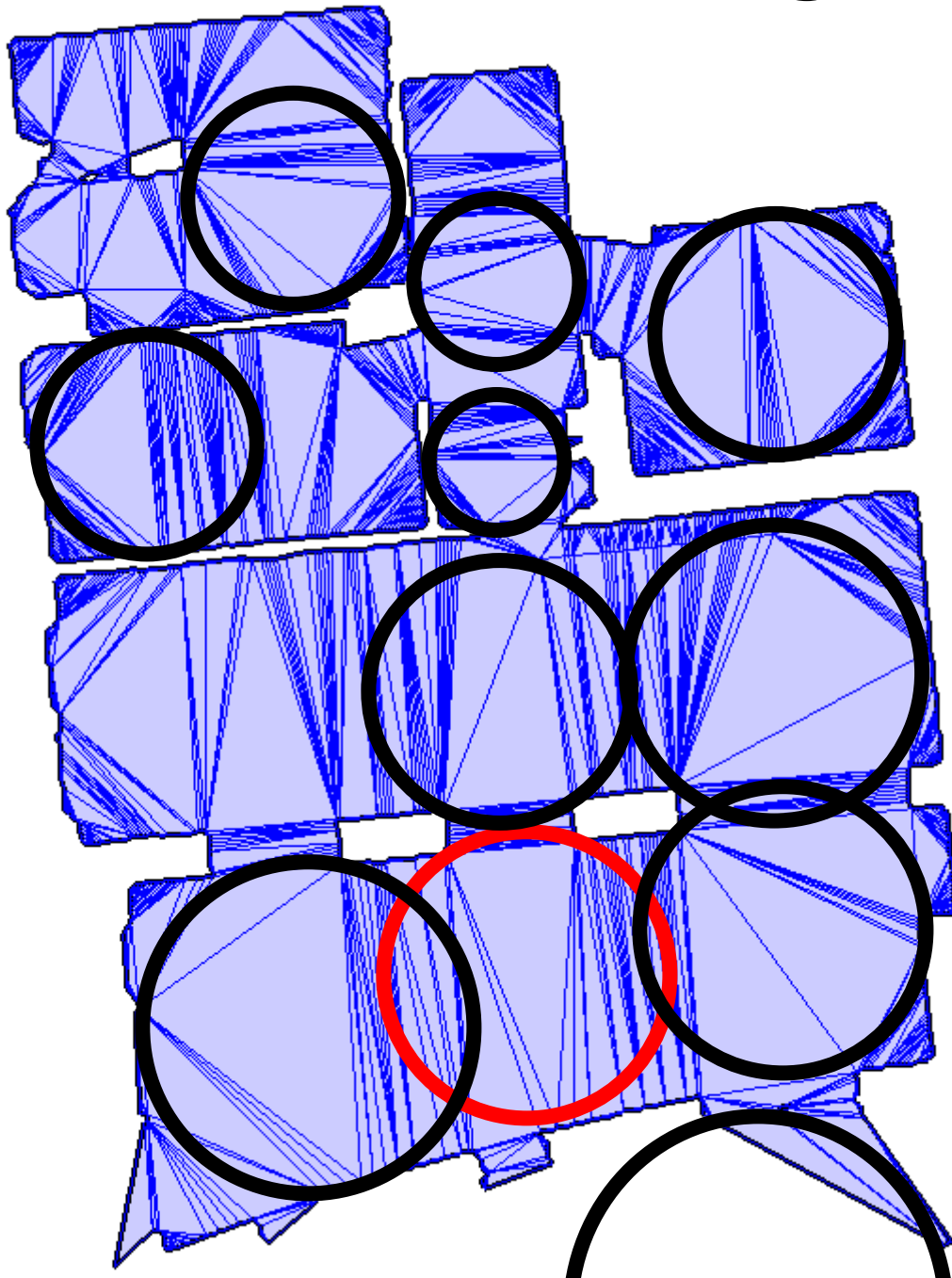
- Find **local maxima** of circumradii
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# Room Partitioning



- Find **local maxima** of circumradii
- The circumcircles who are larger than all other **intersecting** circumcircles

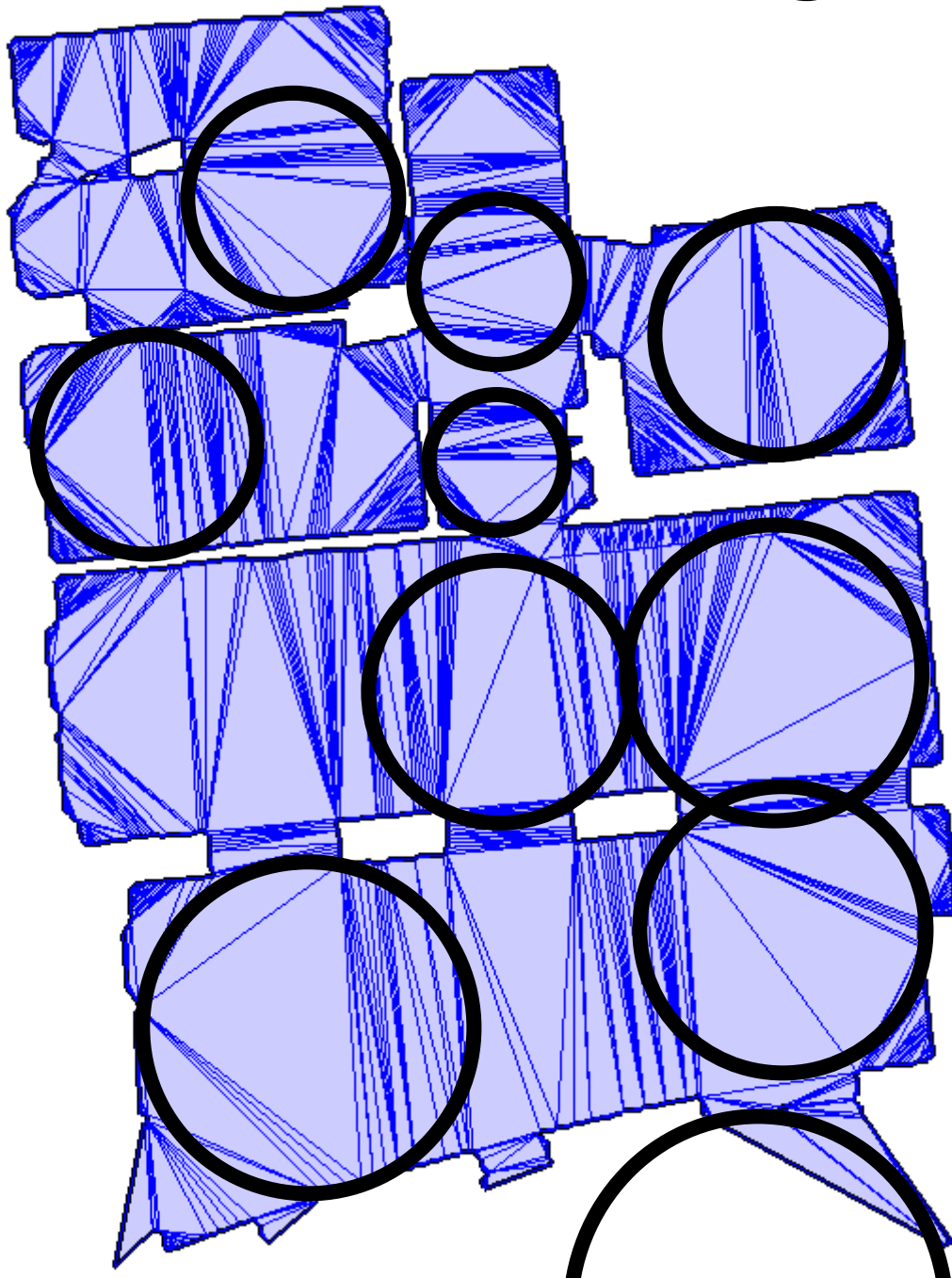
# Room Partitioning



- Find **local maxima** of circumradii
- The circumcircles who are larger than all other **intersecting** circumcircles

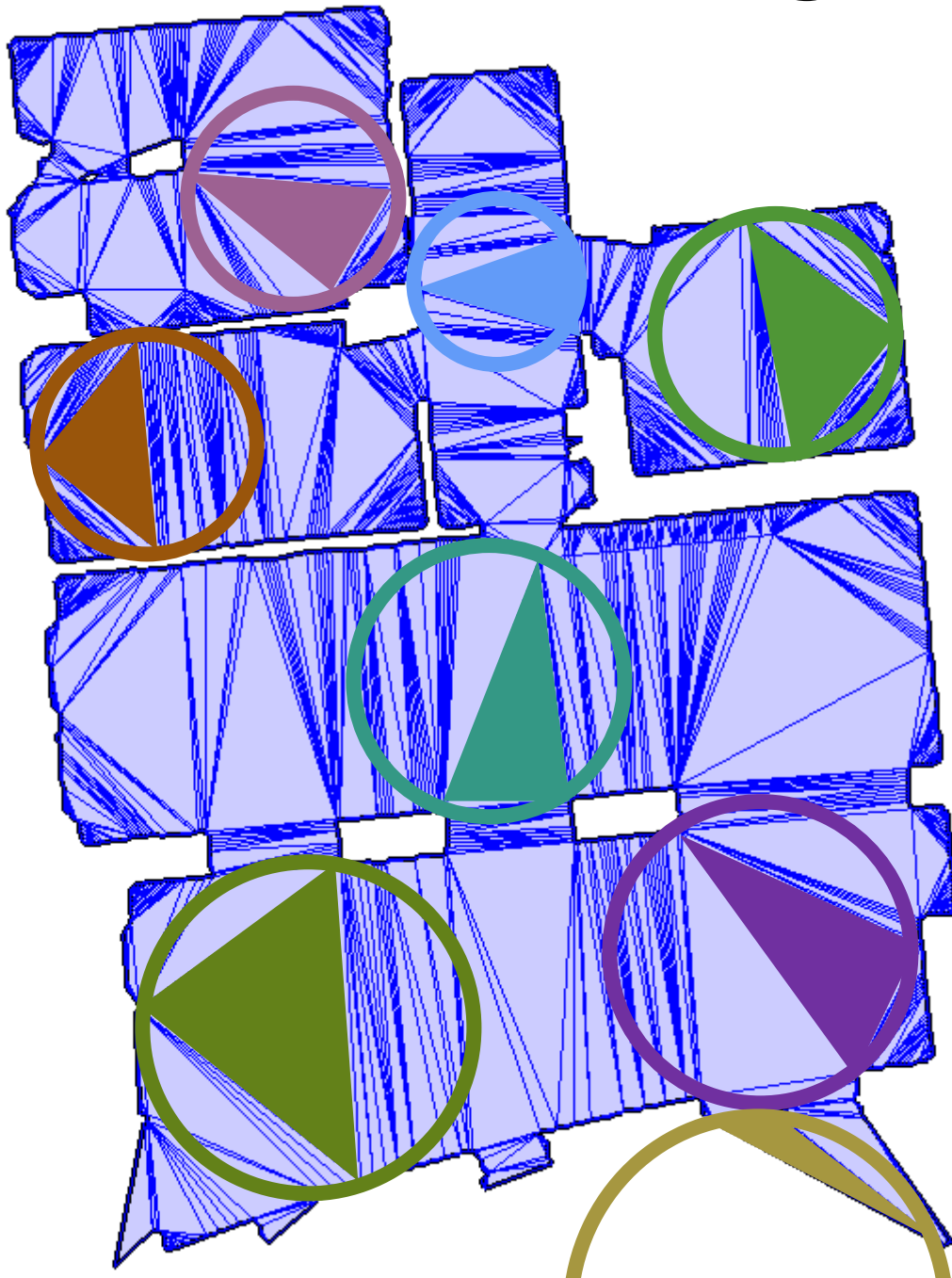


# Room Partitioning



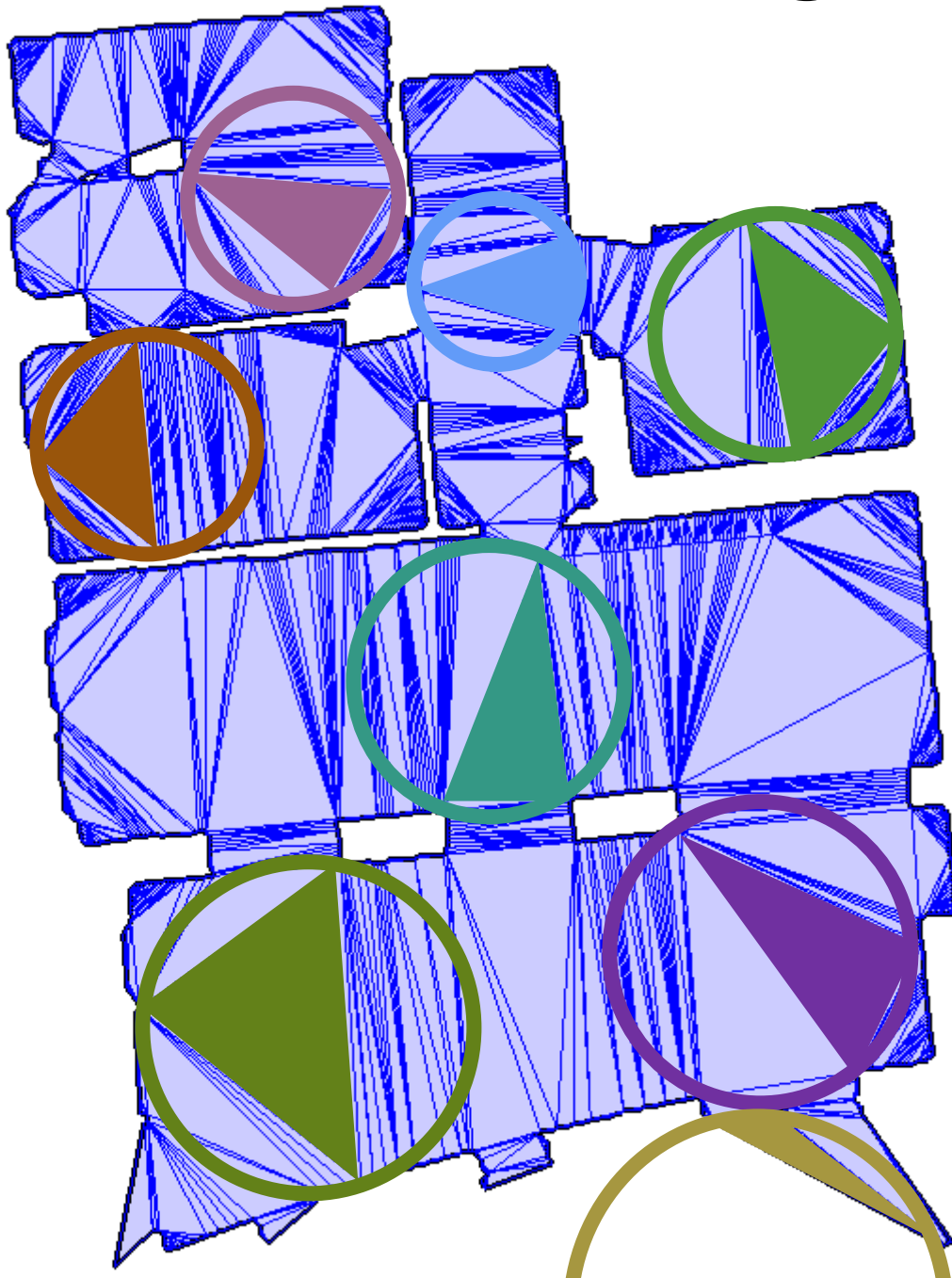
- Find **local maxima** of circumradii
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# Room Partitioning



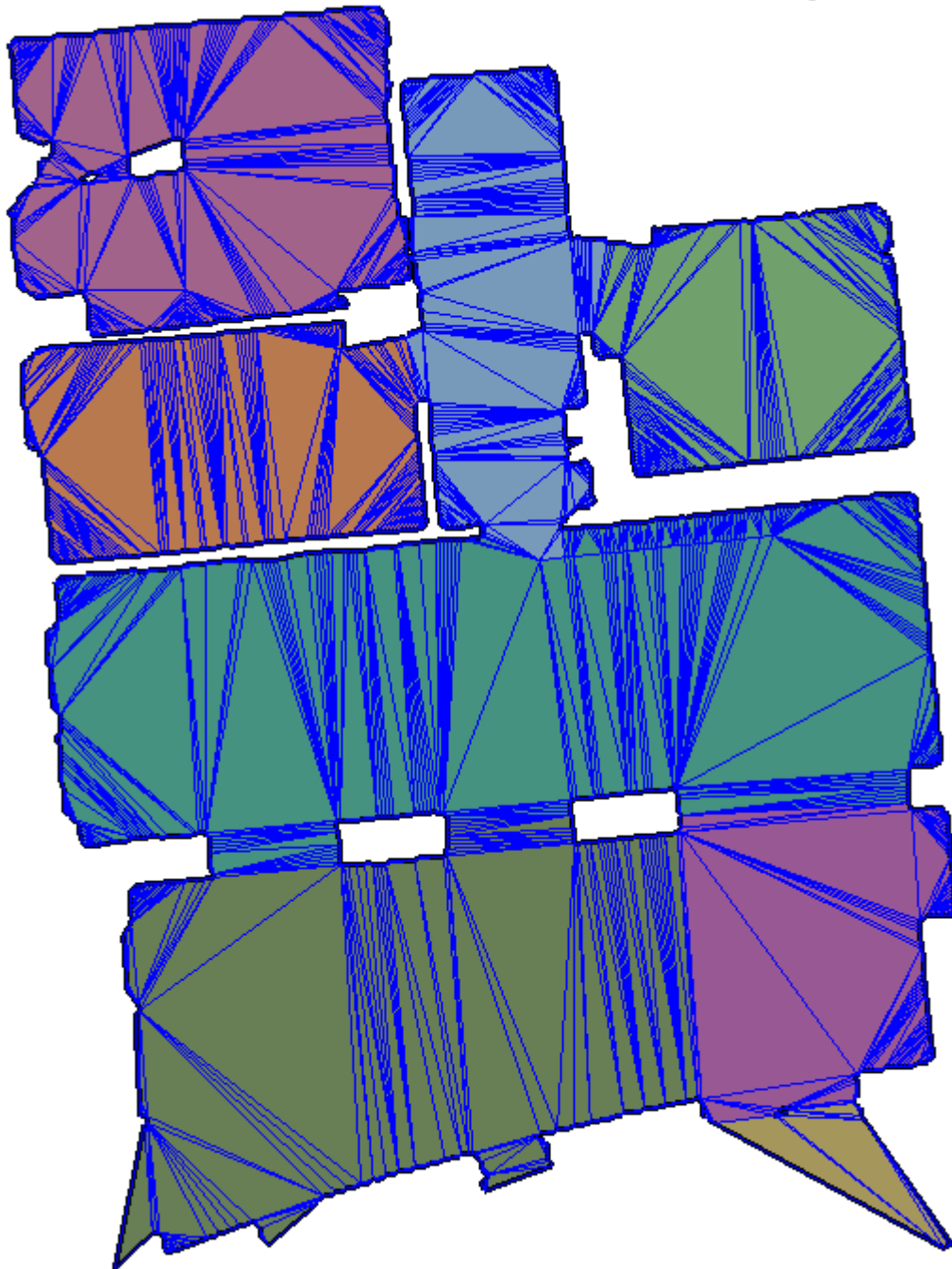
- Final set of local maxima

# Room Partitioning



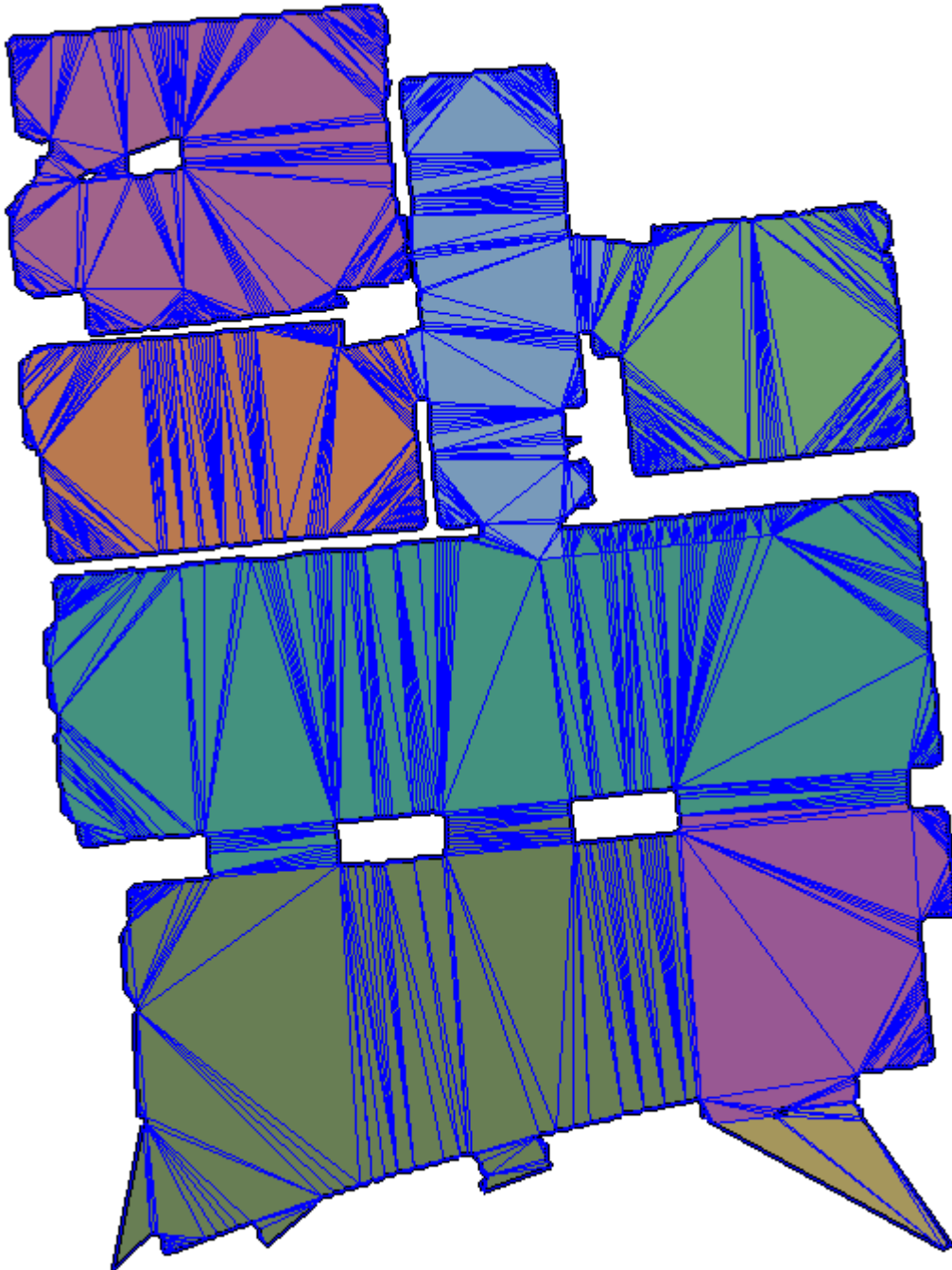
- Final set of local maxima
- **Graph Partition** remaining triangles

# Room Partitioning

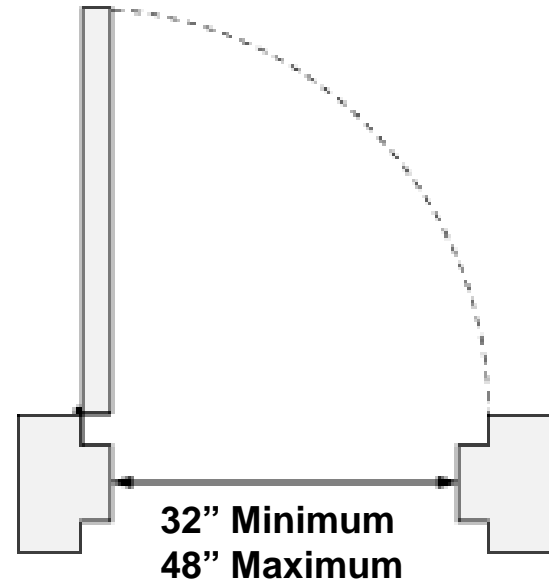


- Final set of local maxima
- **Graph Partition** remaining triangles

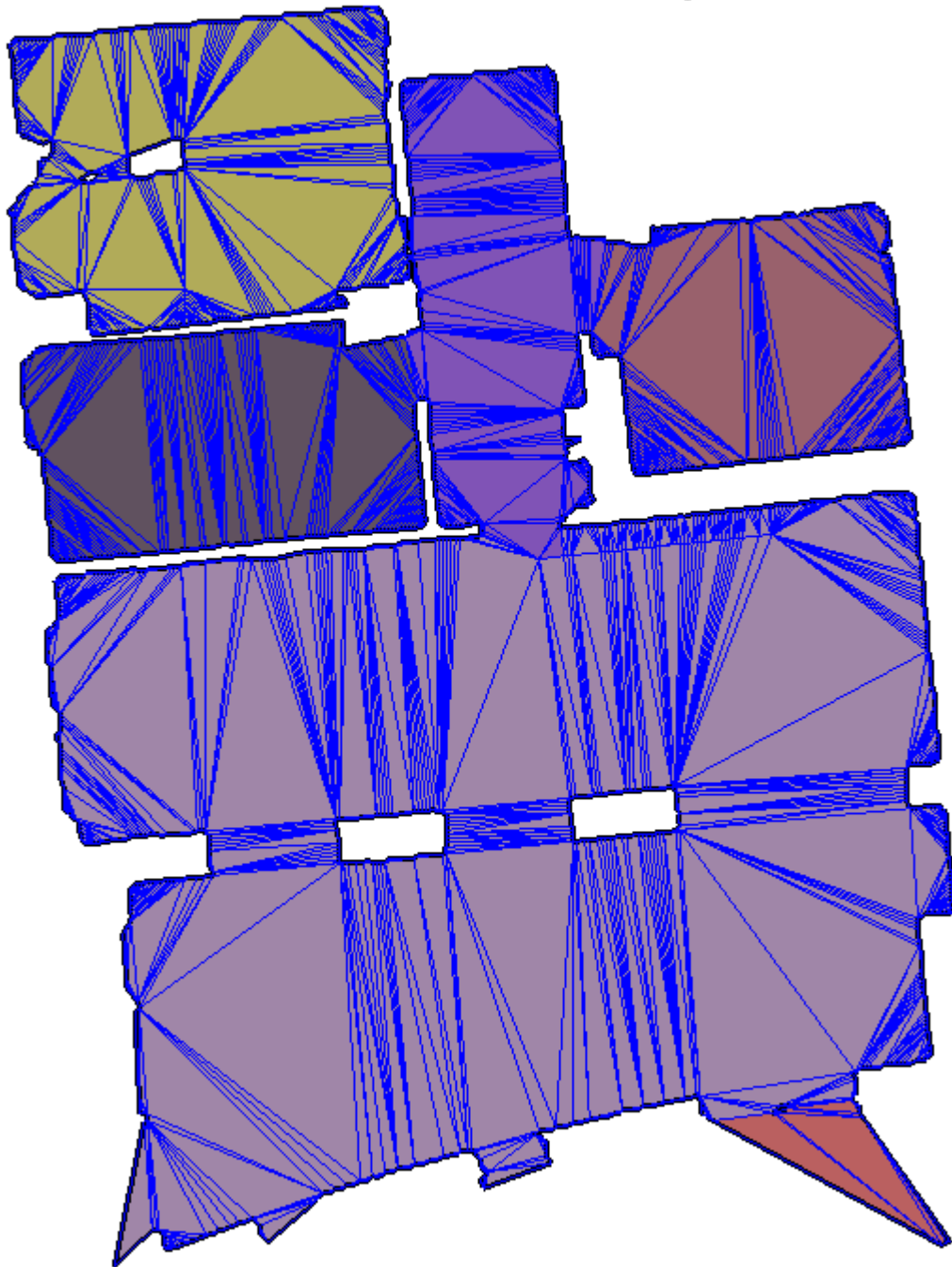
# Post Processing: Room Merging



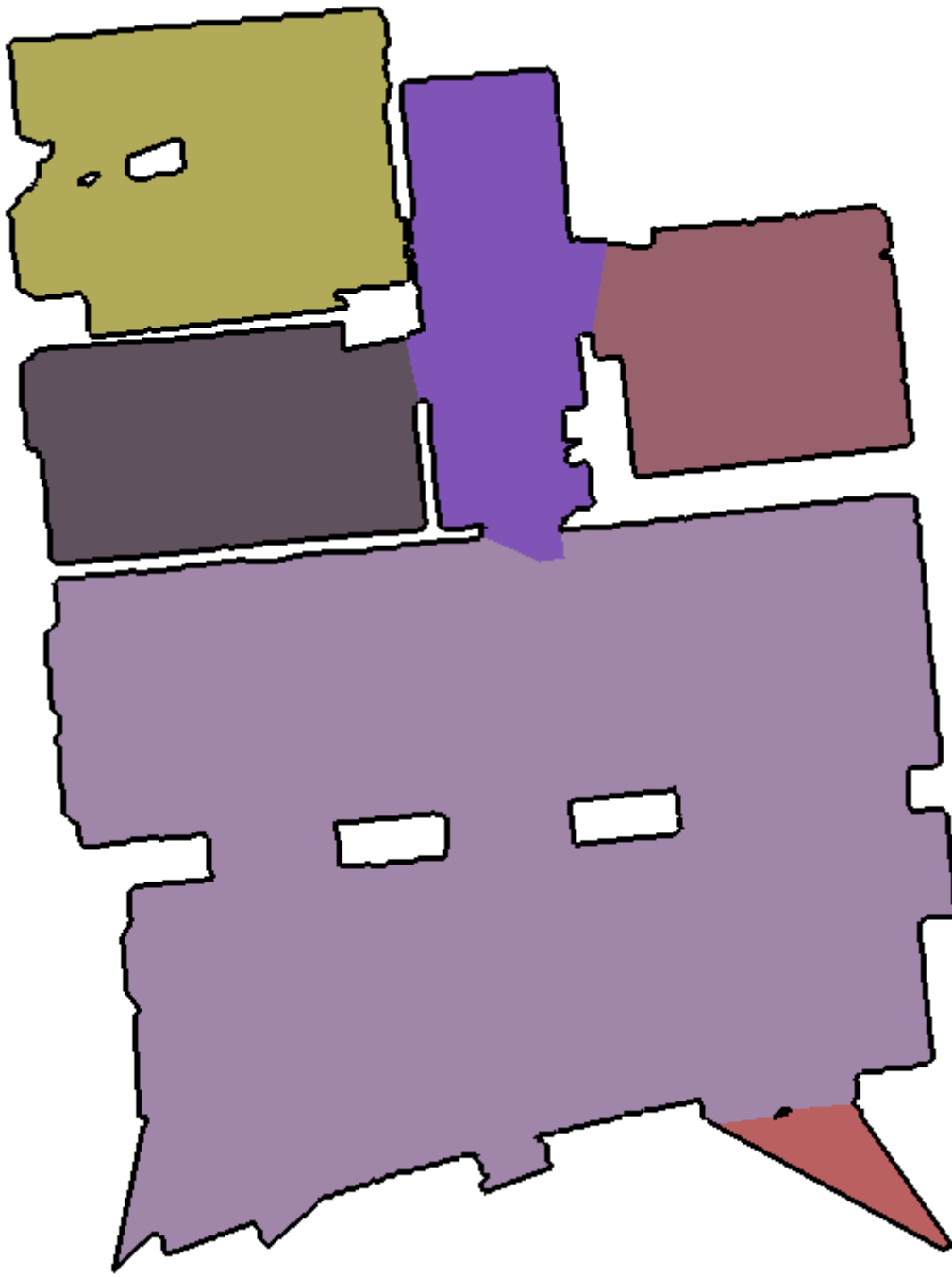
- Provides **overlabeling**
- Use **building standards** to **refine labels**



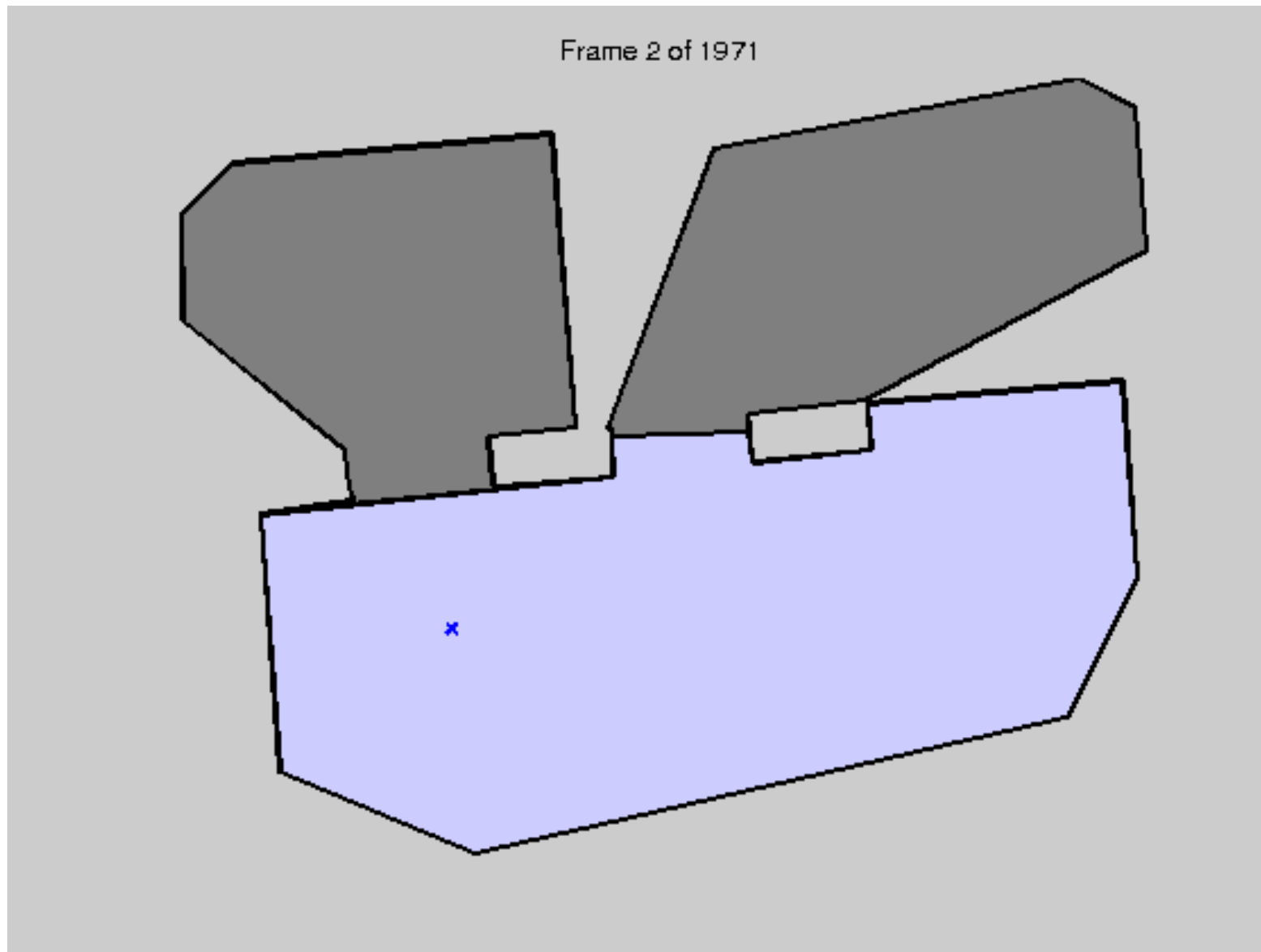
# Post Processing: Room Merging



# Post Processing: Room Trimming

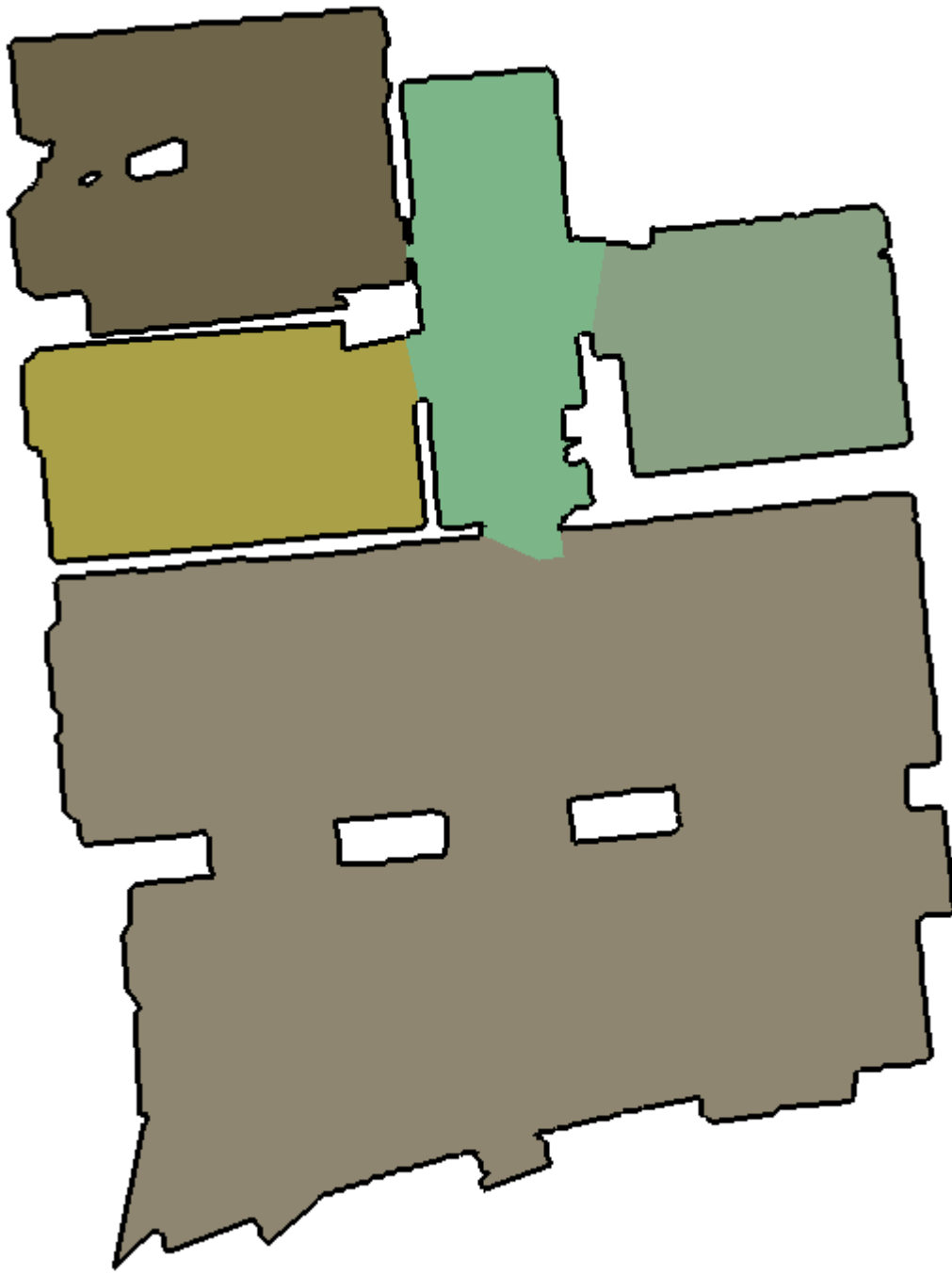


# Post Processing: Room Trimming



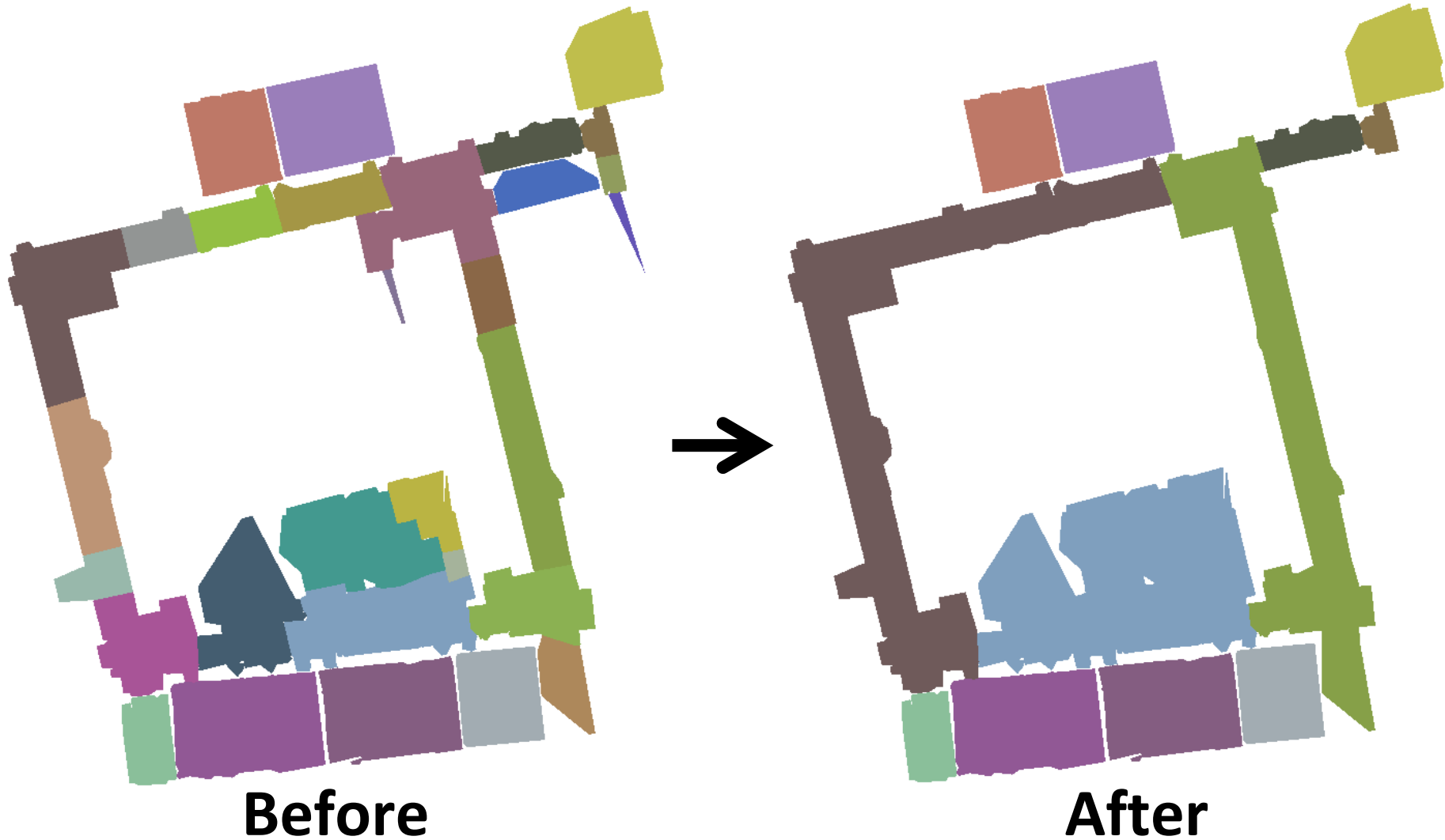


# Final Partitioning

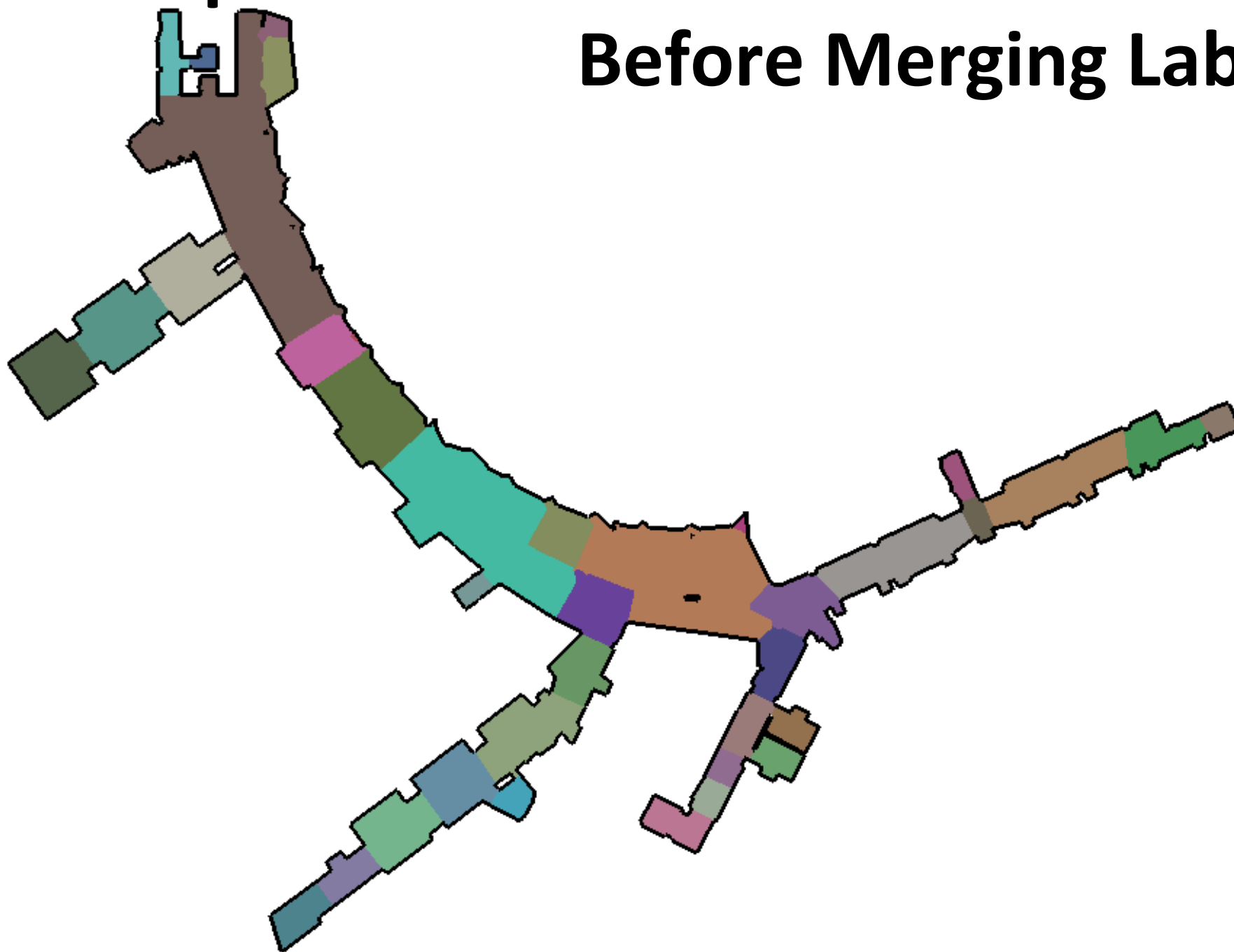


# Generating Floor Plans

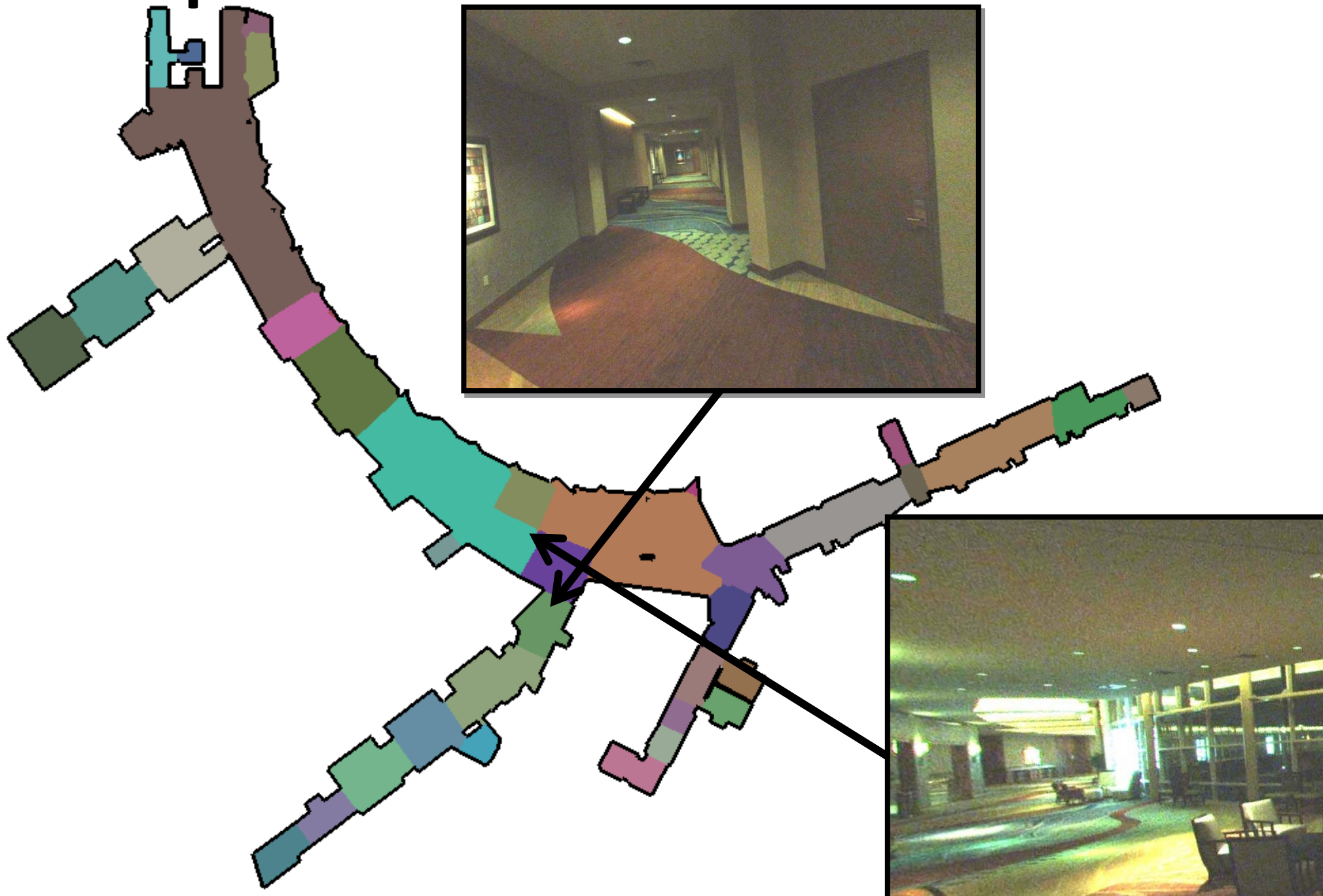
- Improving models with trimming



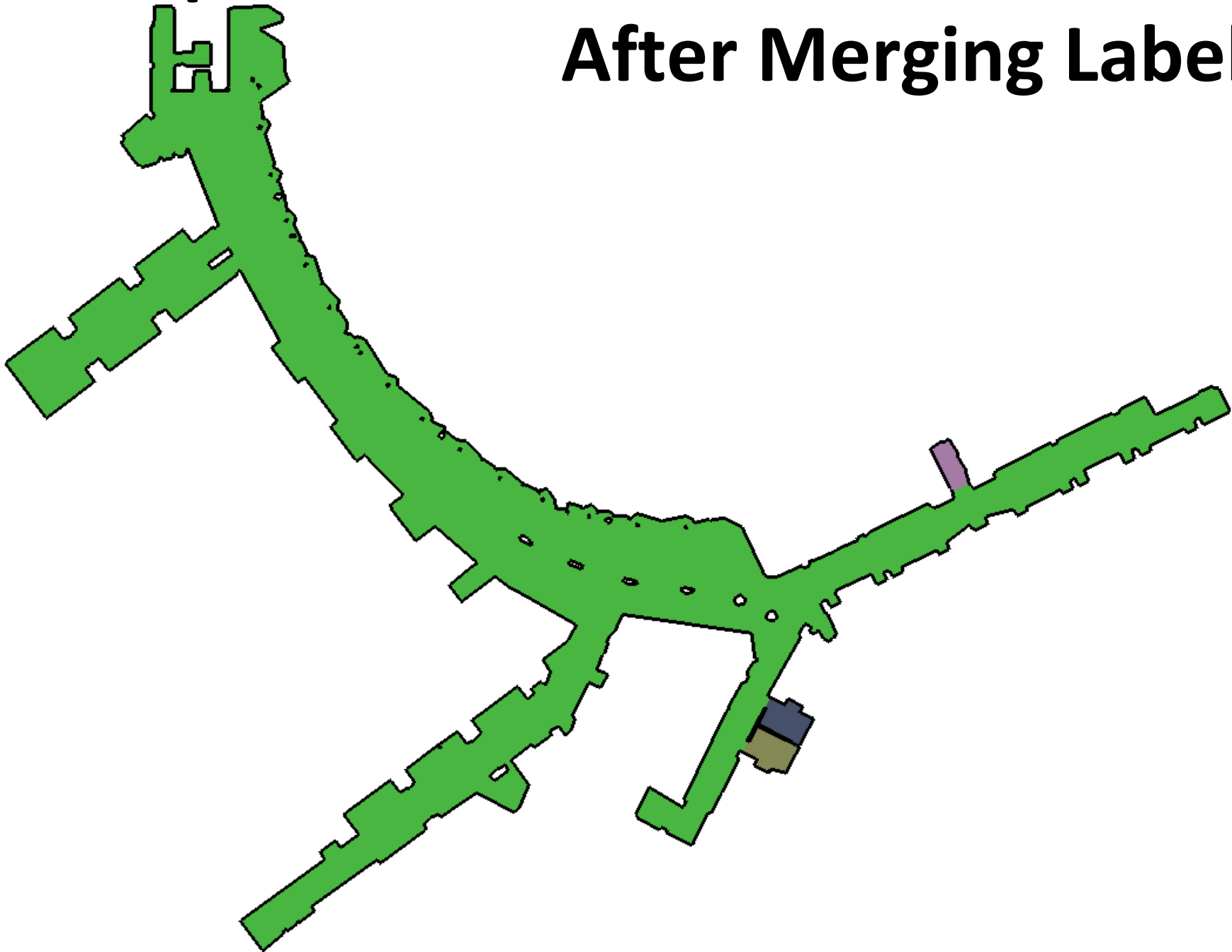
# Example Labeled Floor Plans: Before Merging Labels



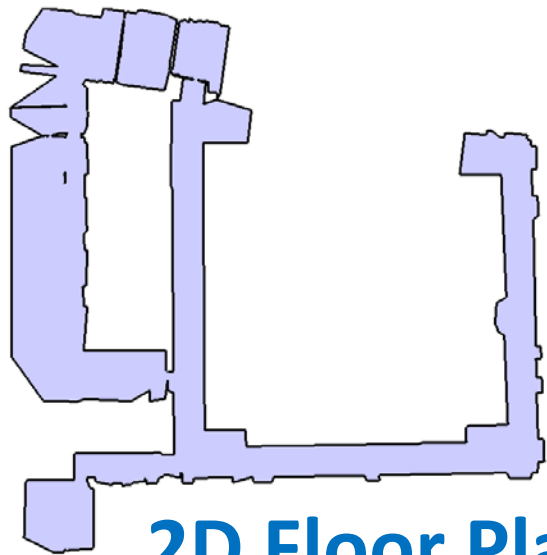
# Example Labeled Floor Plans



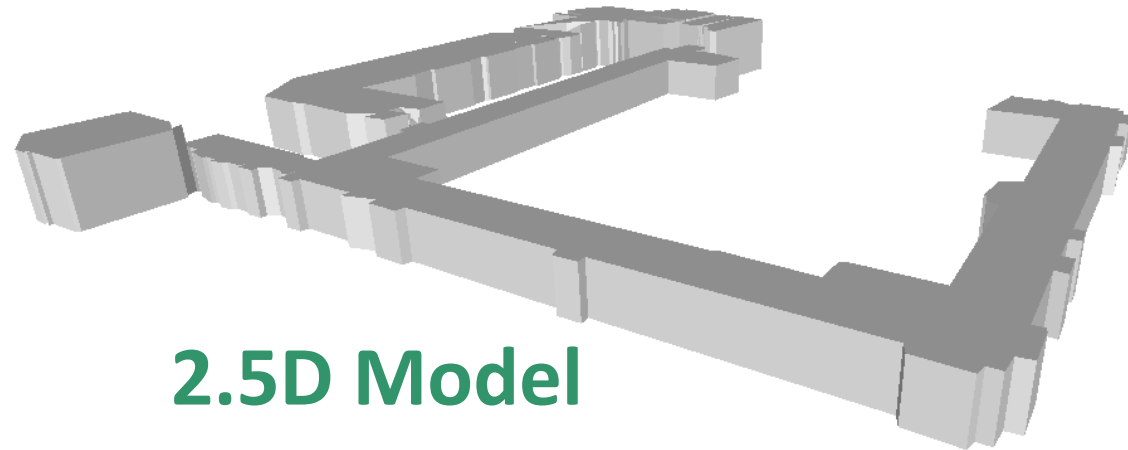
# Example Labeled Floor Plans: After Merging Labels



# Add Height Information



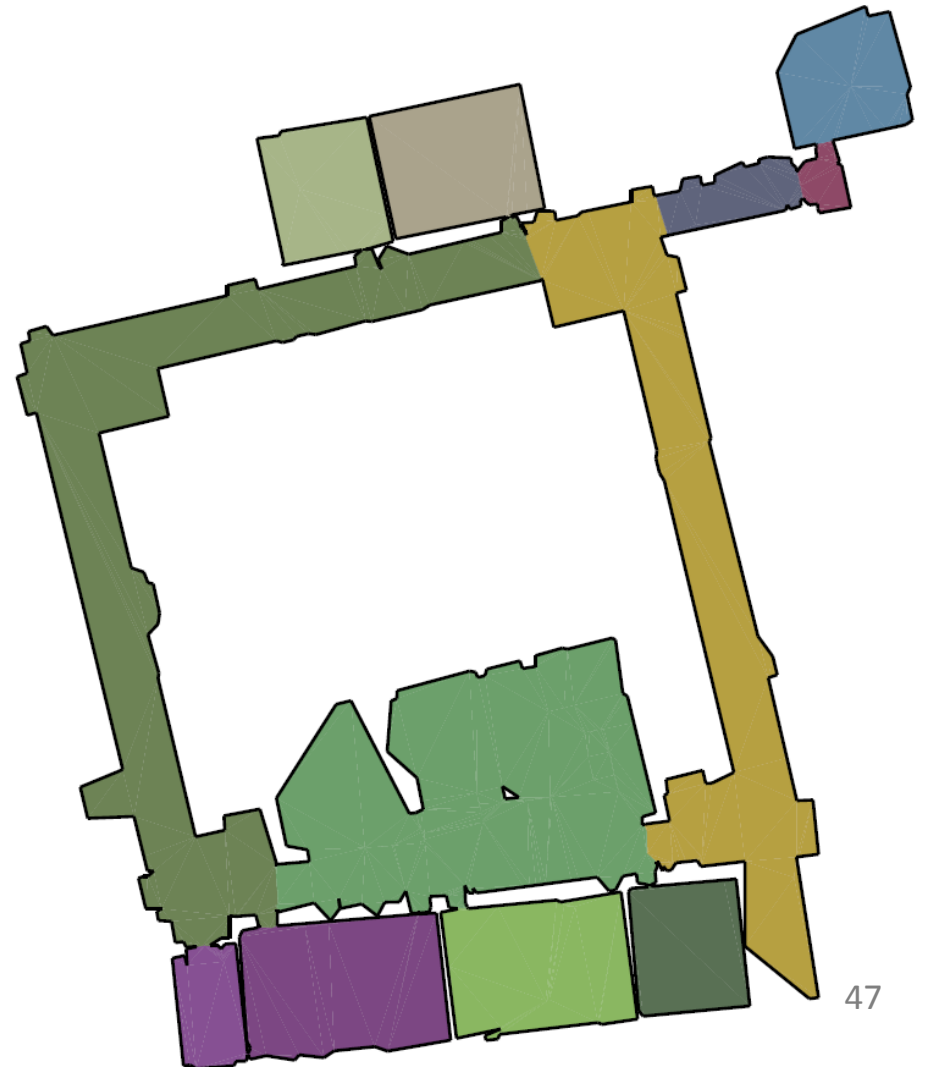
**2D Floor Plan**



**2.5D Model**

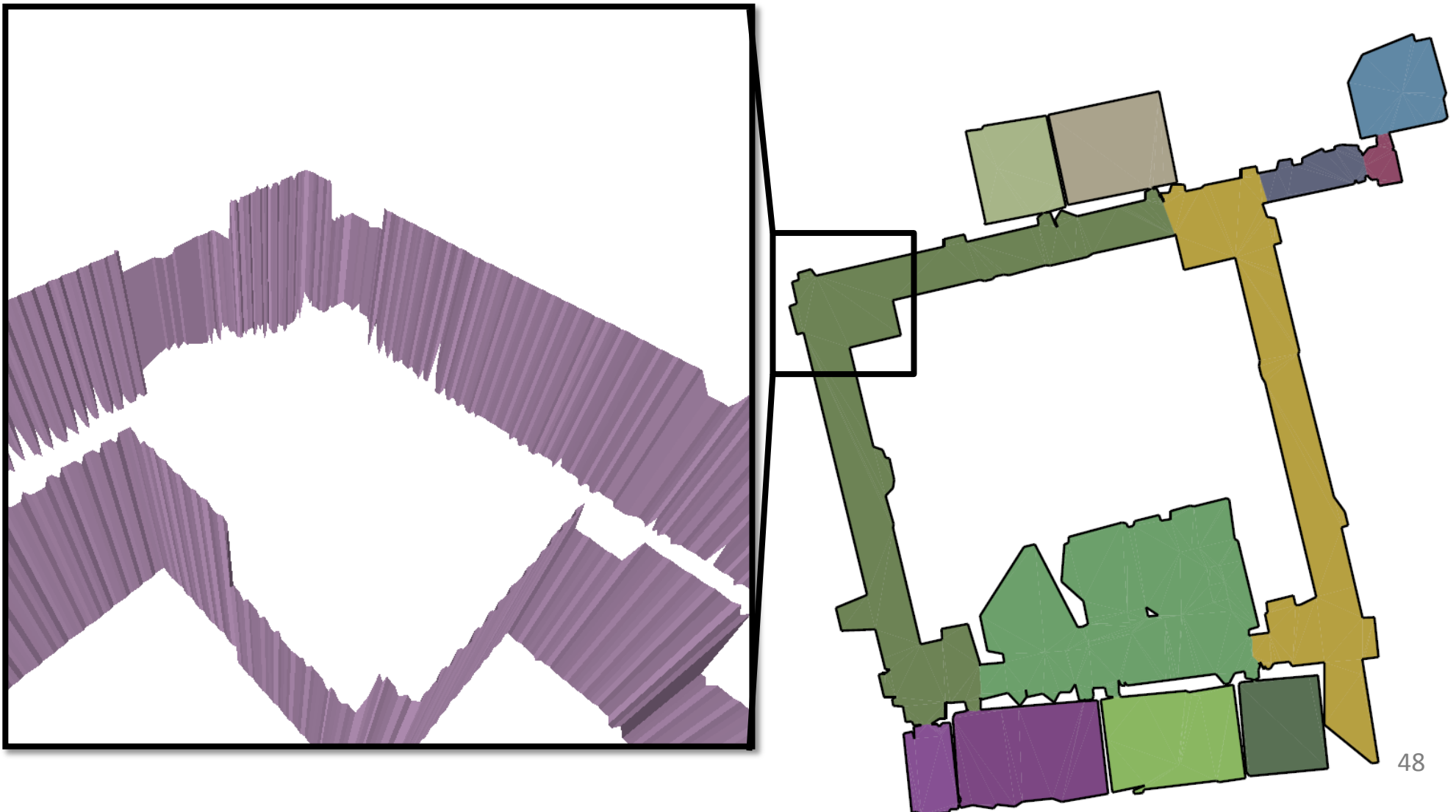
# Generating 3D Models from Floor Plans

- Each wall sample has height information



# Generating 3D Models from Floor Plans

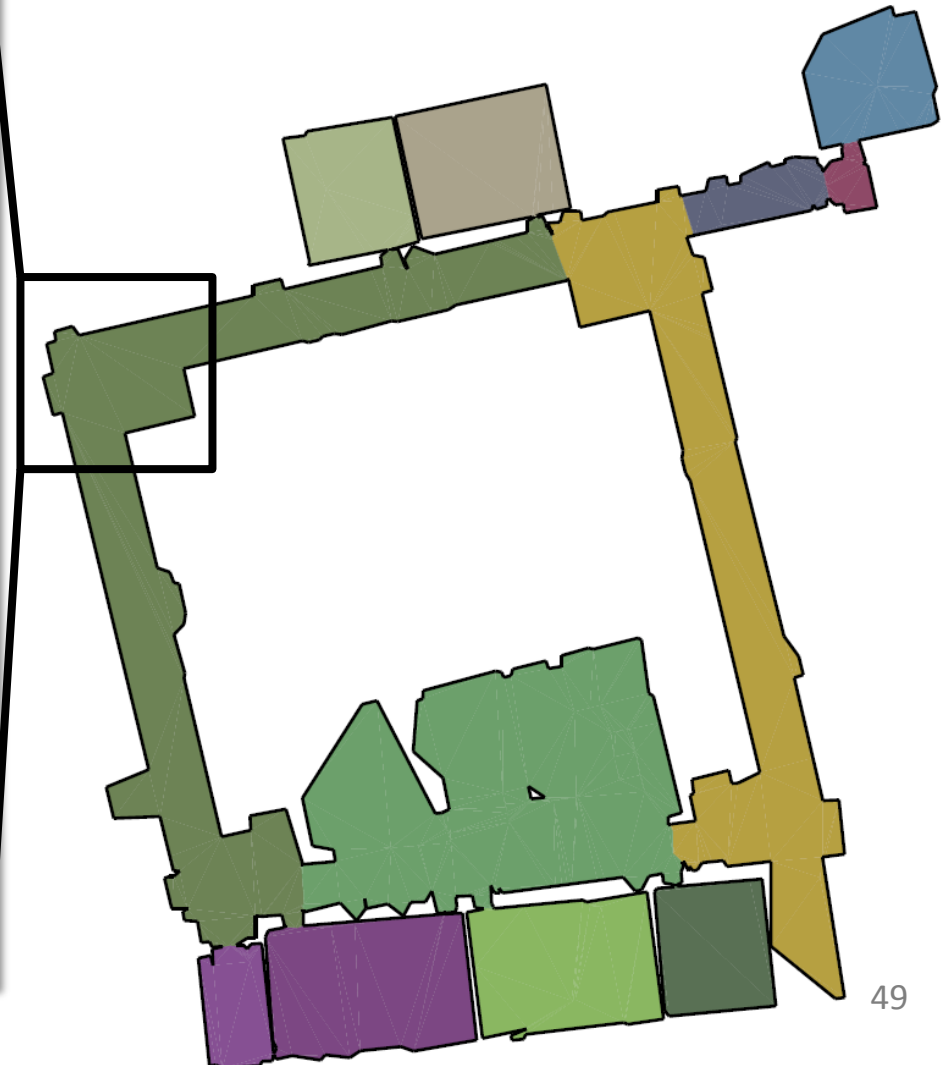
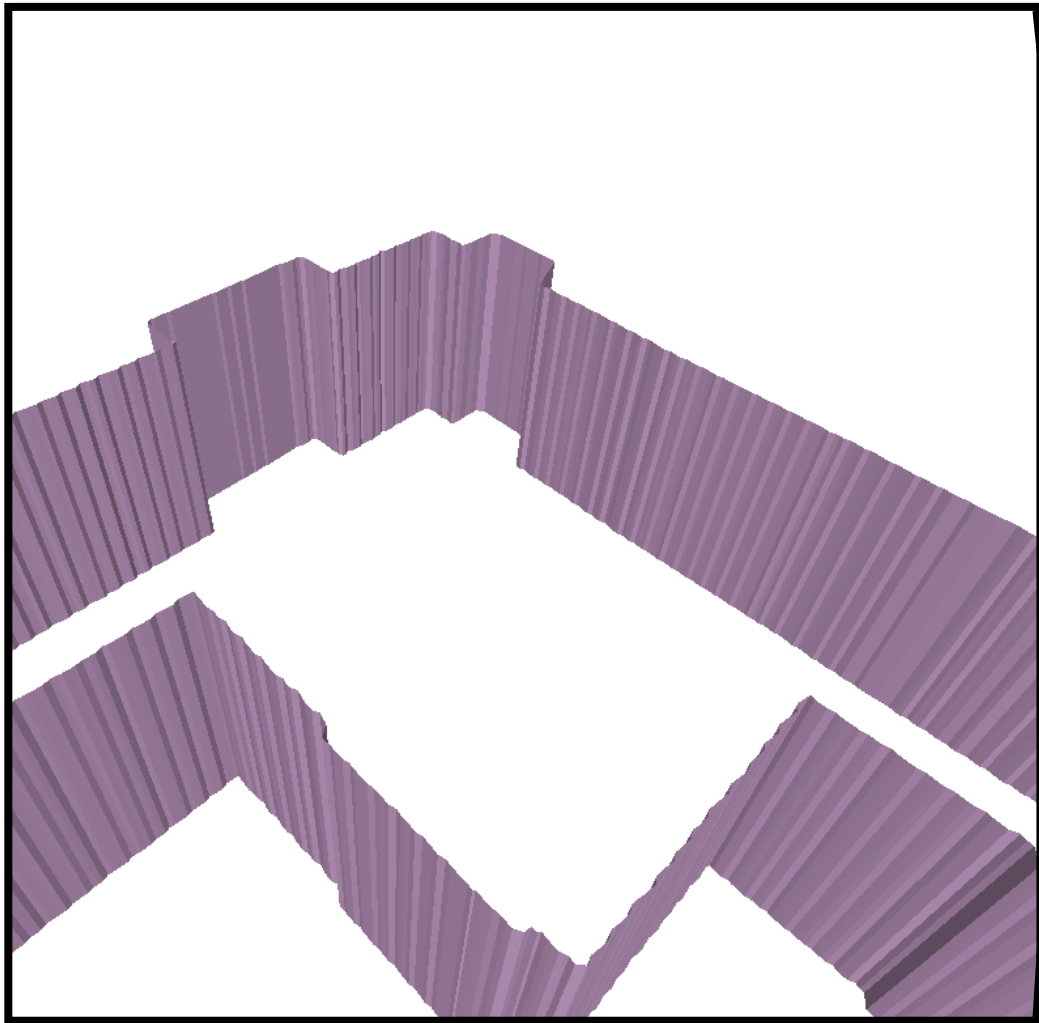
- Each wall sample height estimated individually





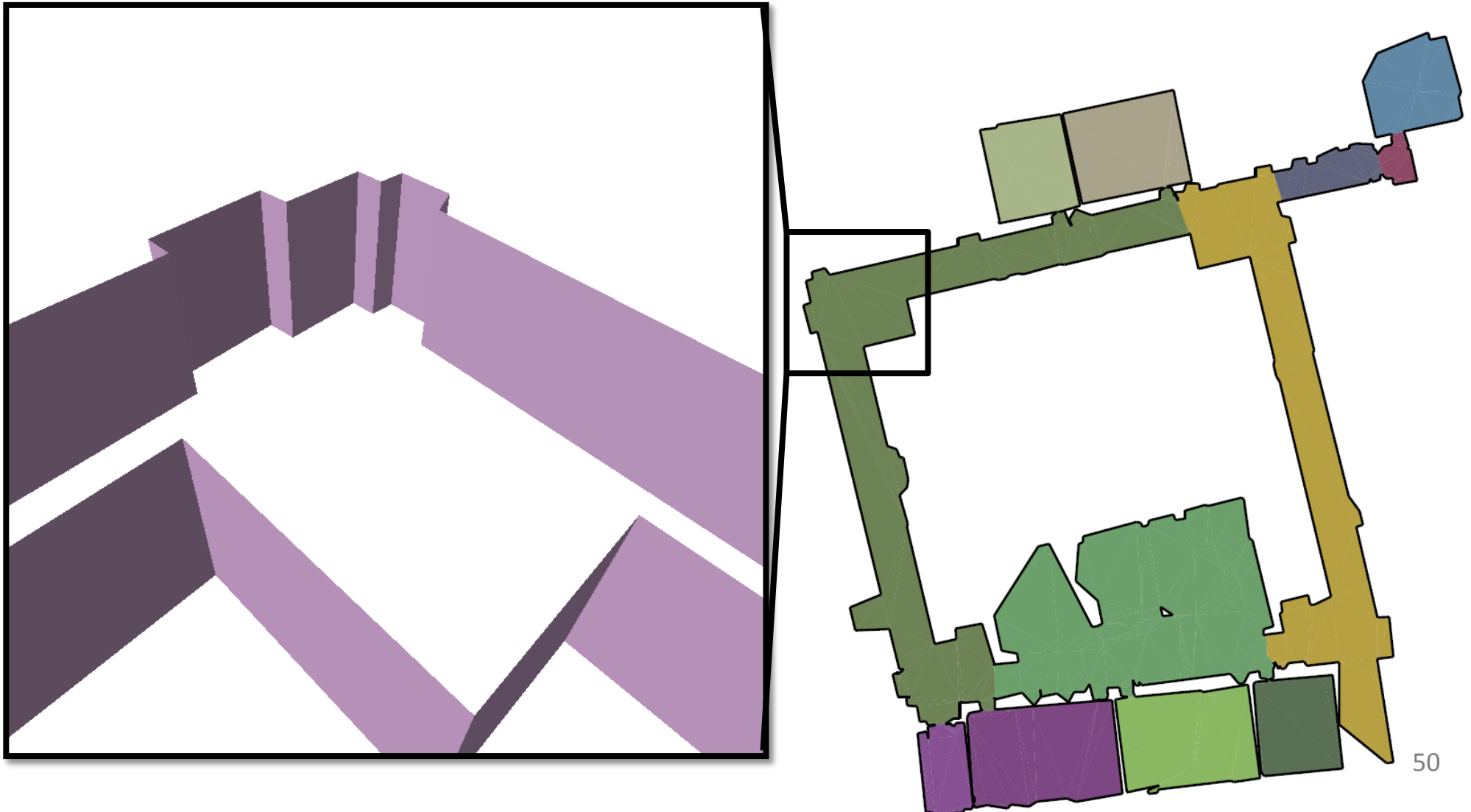
# Generating 3D Models from Floor Plans

- Median floor/ceiling height by room



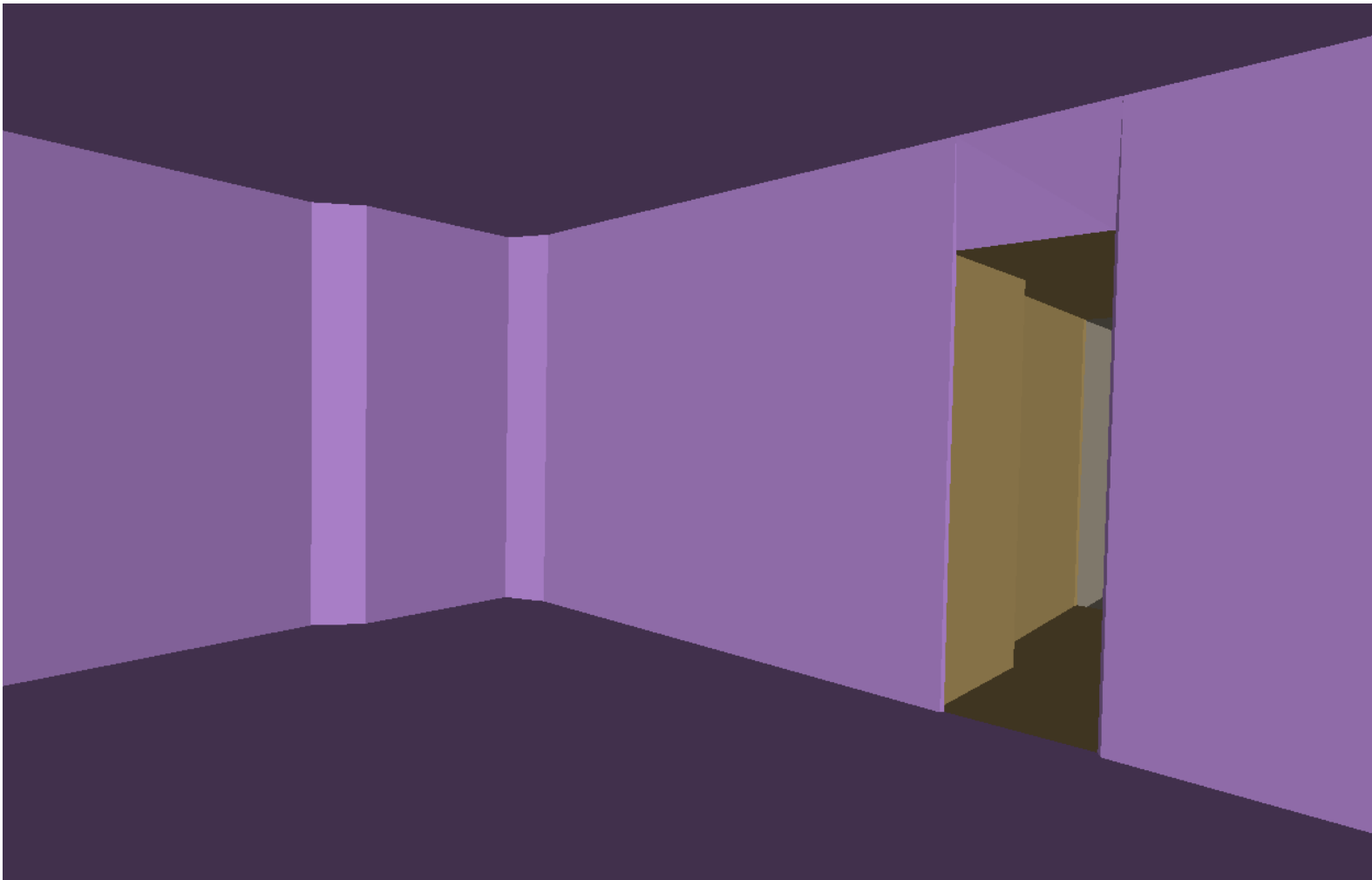
# Generating 3D Models from Floor Plans

- Wall Simplification using QEM



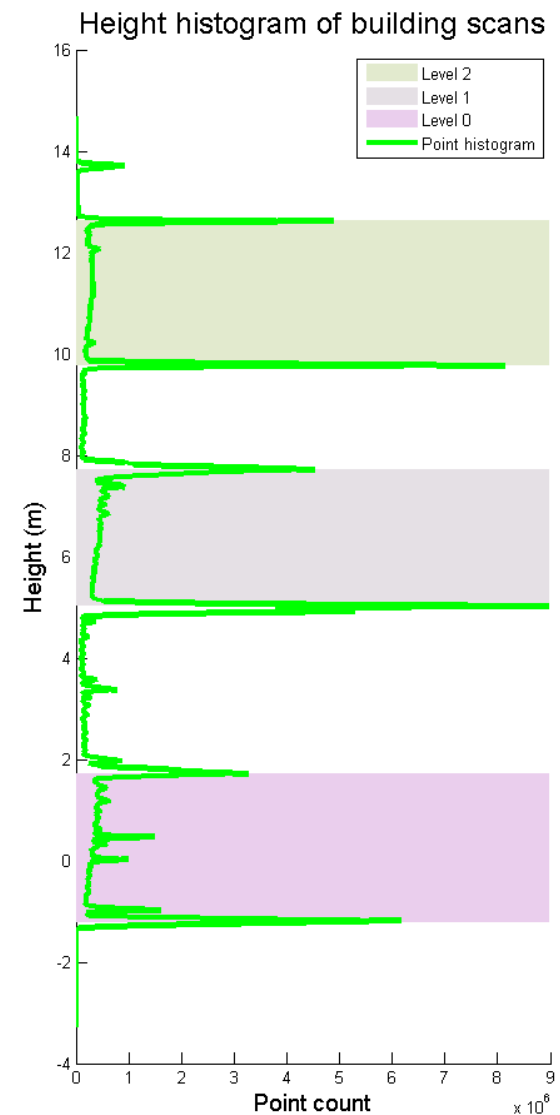
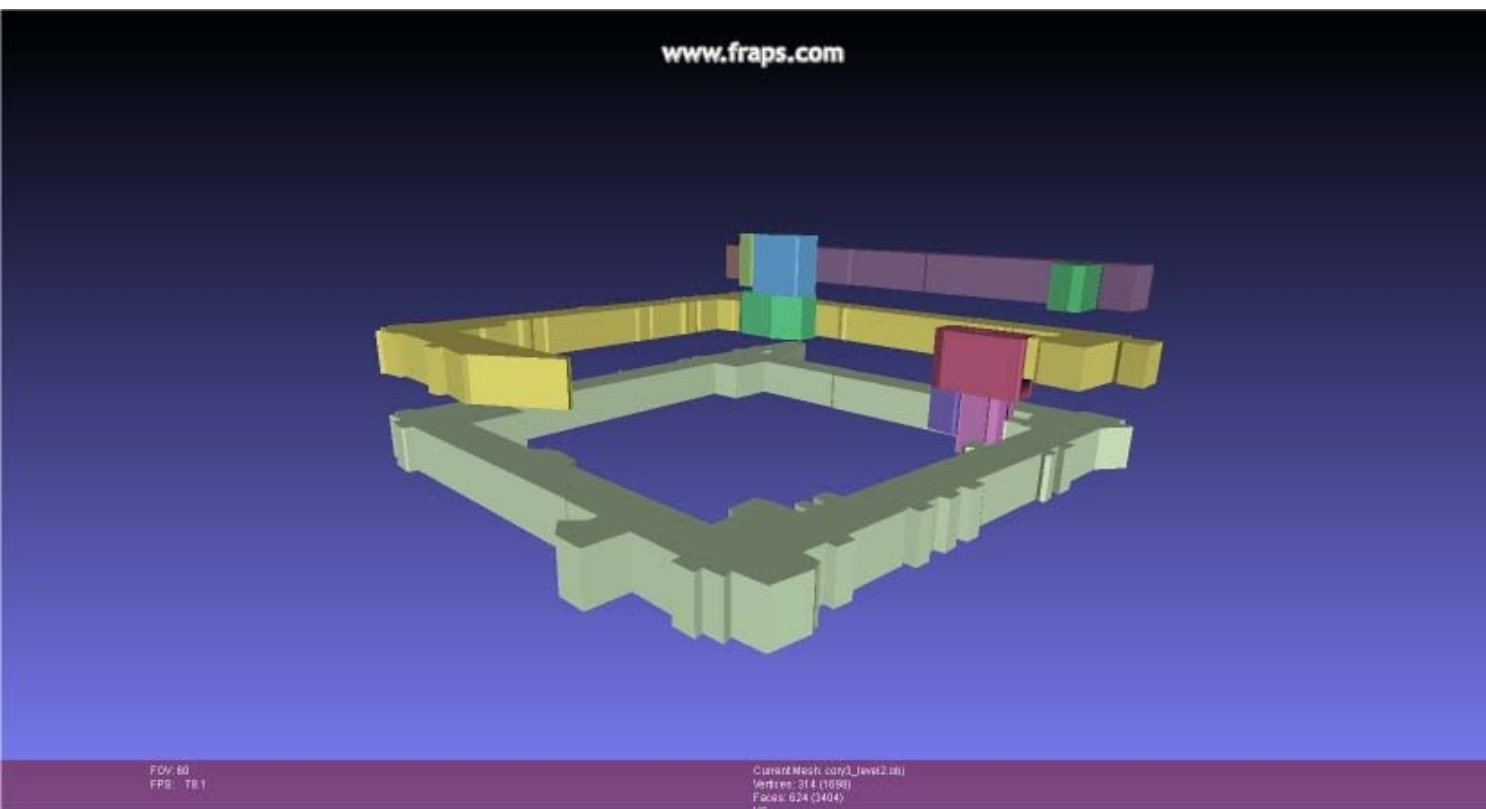
# Generating Models

- Extruding to 3D



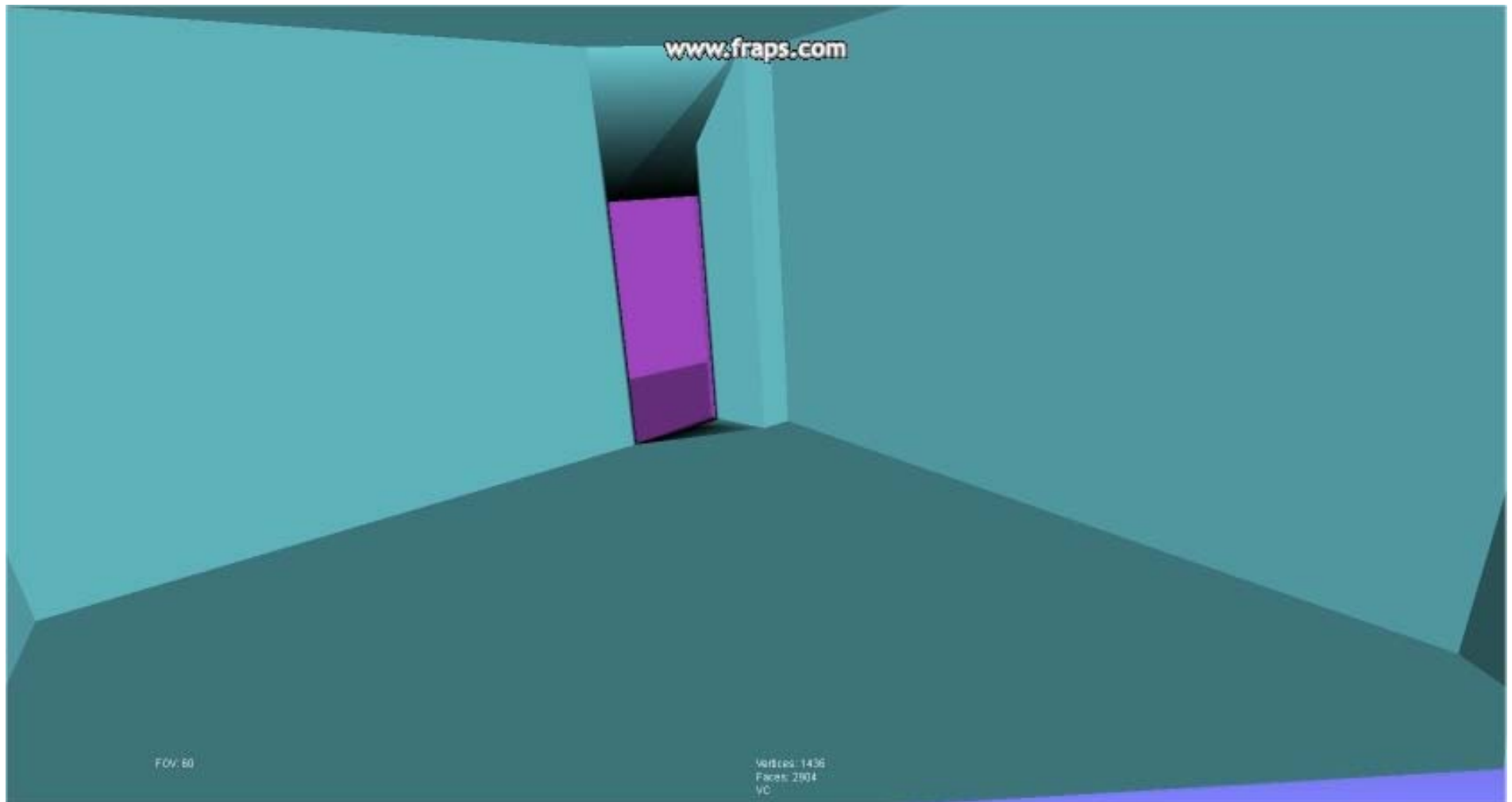
# Multi-story models

- Generate each floor separately



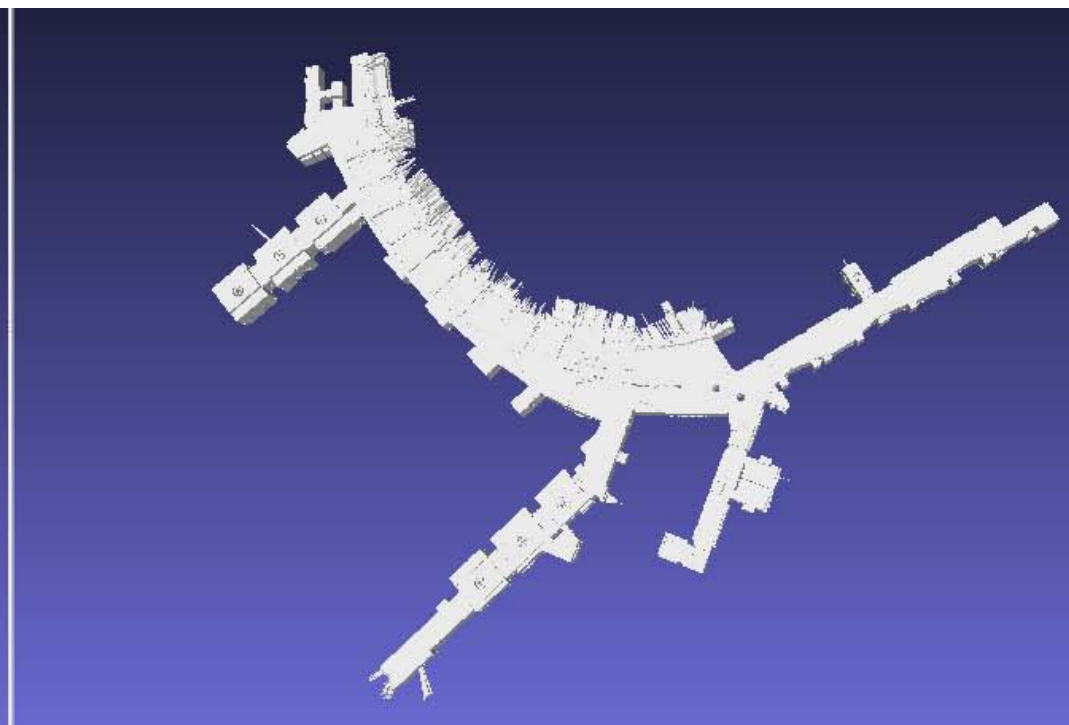
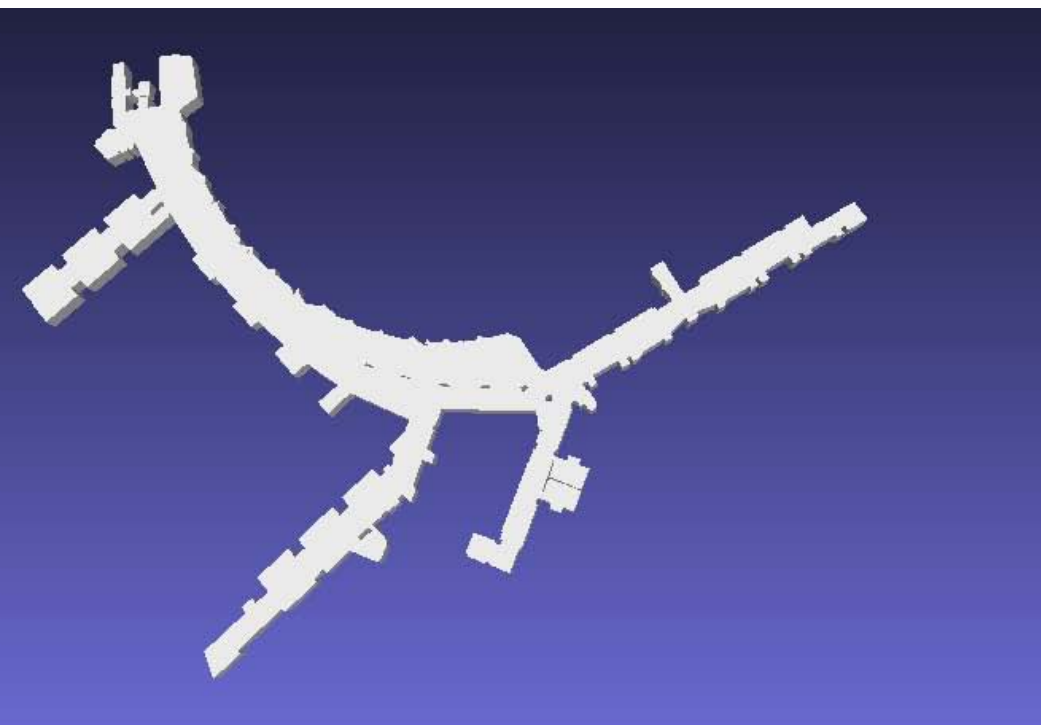
# Results

## ■ 3D Models



# Results

- Comparison to other modeling methods

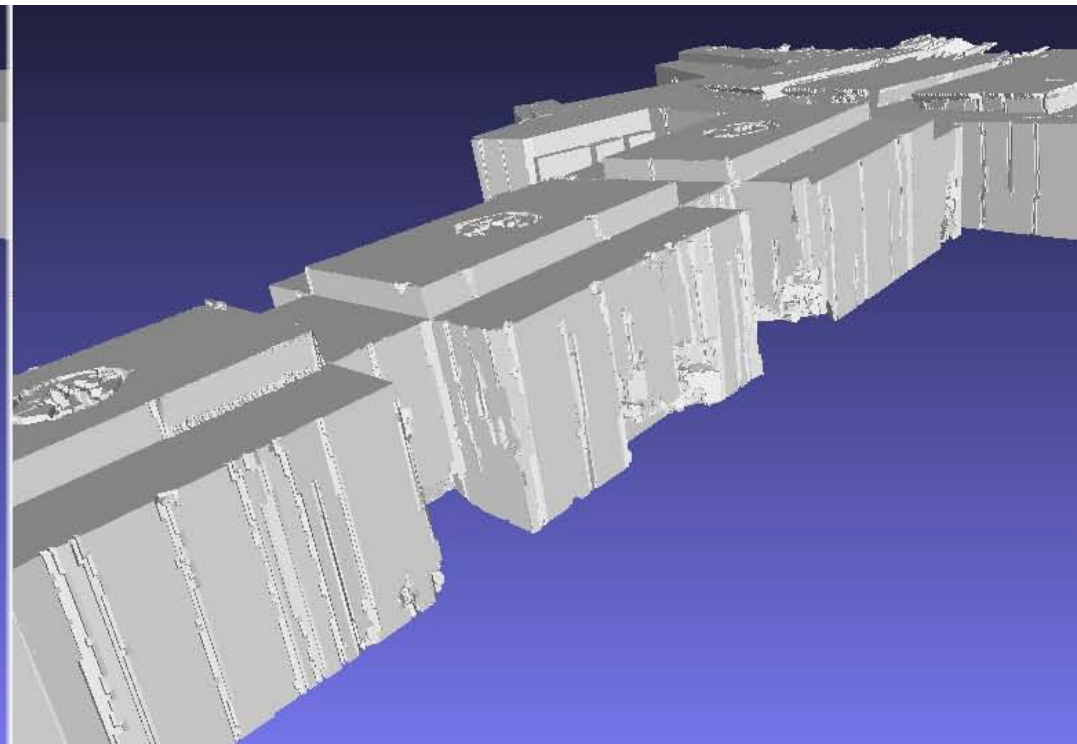
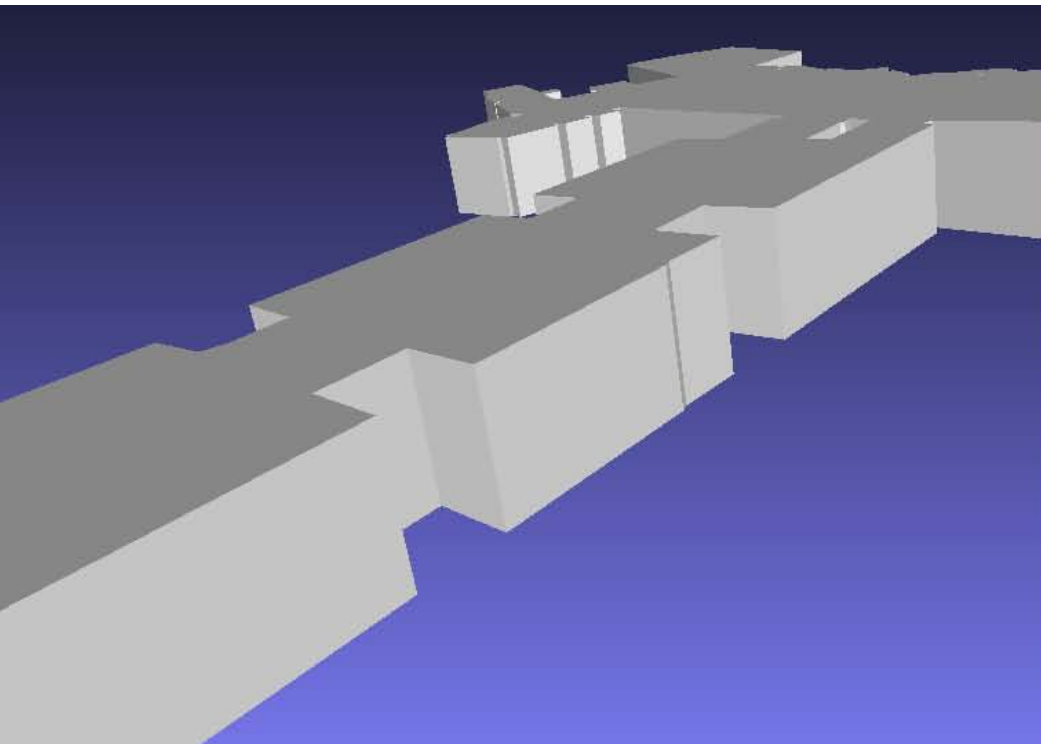


Proposed Modeling Technique  
2,943 Triangles  
88 KB on Disk (Wavefront OBJ format)  
10 seconds to process

Reference Model  
4,147,345 Triangles  
82 MB on Disk (Wavefront OBJ format)  
5 hours to process

# Results

- Comparison to other modeling methods

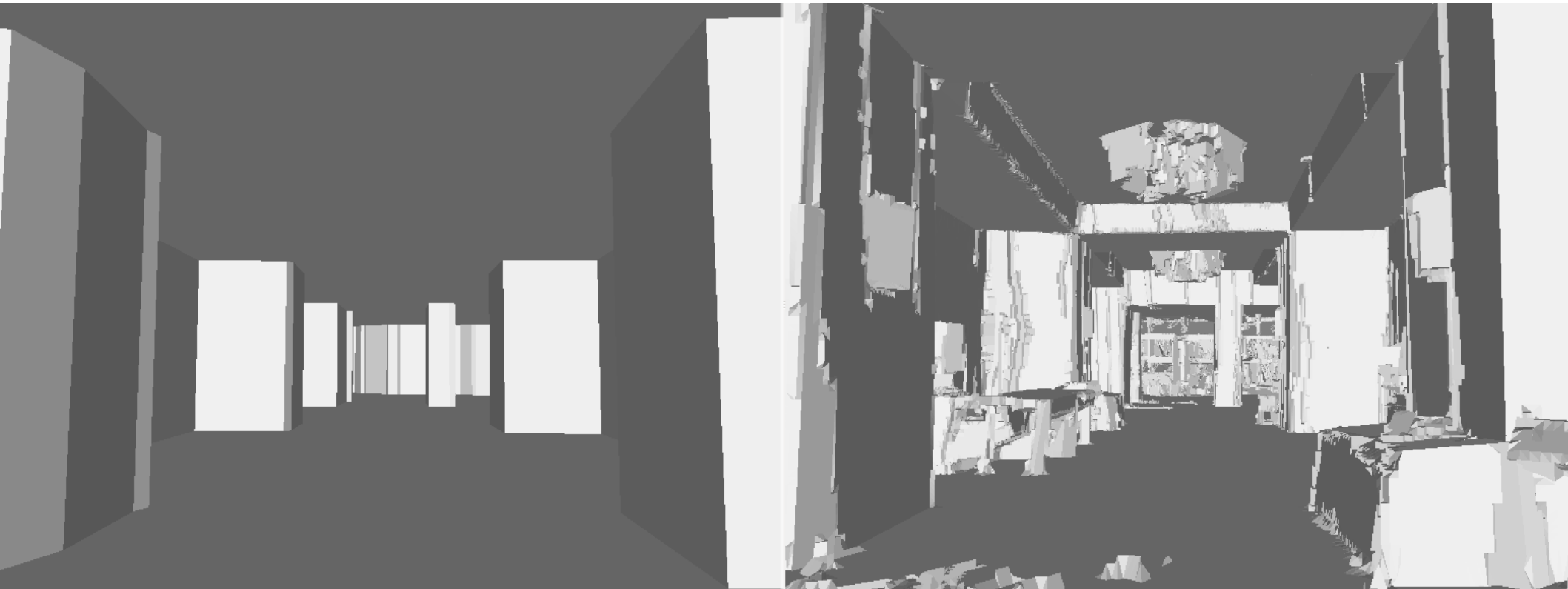


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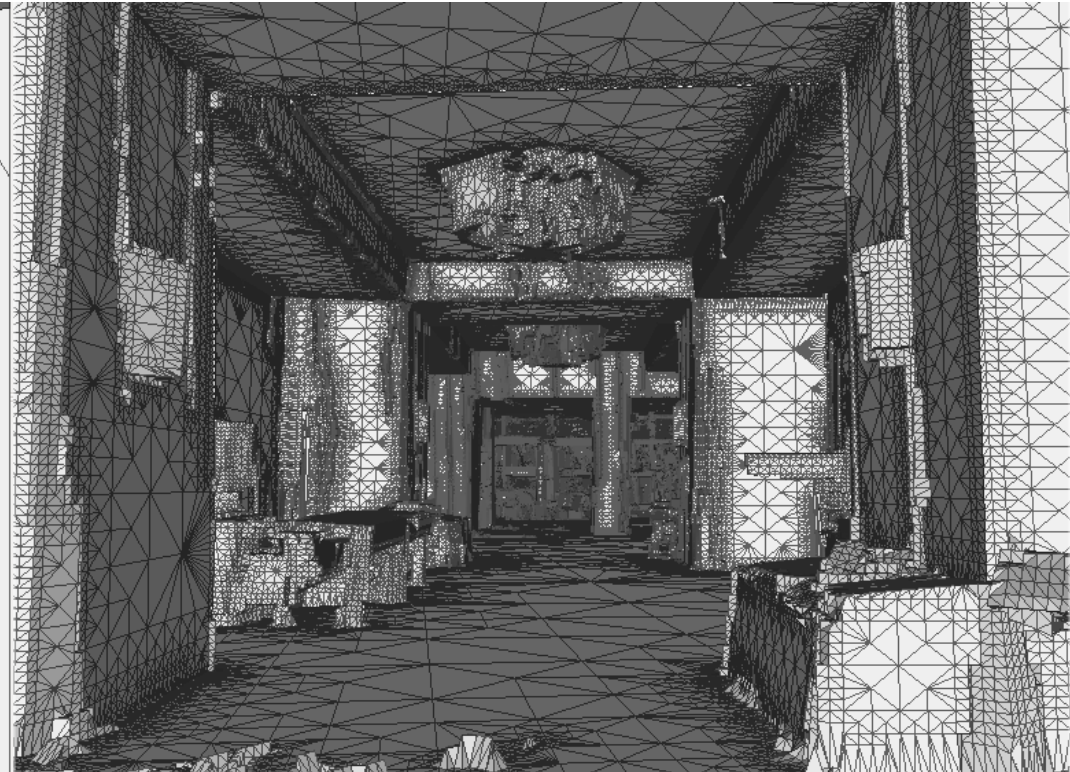
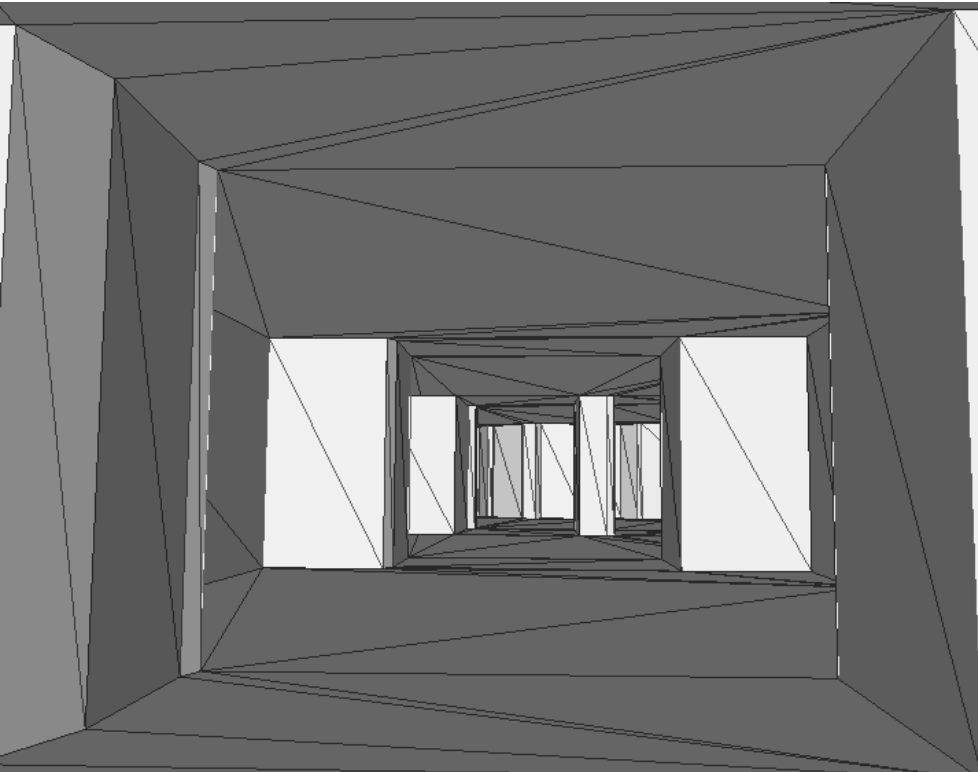
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# Results

- Simple Models with Texture



# Results

- Simple Models with Texture from Imagery

Cheng 2013

[www.fraps.com](http://www.fraps.com)



# Limitations

- Assumes walls are dominant surfaces



# Limitations

- Assumes walls are dominant surfaces



# Thank You