Watertight As-Built Architectural Floor Plans Generated from Laser Range Data

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Home Owners?
Home Owners?

Made any renovations?
Home Owners?

Made any renovations?
Have latest blueprints?
Goal

Millions of 3D points

2D Floor plan
Point Clouds of Building Interiors

Methods for Collection:

- Static
- Wheeled
- Ambulatory
Point Clouds of Building Interiors
Floor Plans

- Actual Building Floor Plan
Floor Plans

- Desired Output
  - Watertight
  - Simplicial Complex
How has this been tried before?

- Top-down 2D histogram of input points
- Hough Transform to find lines in histogram

Not Watertight
Not Watertight

- Floating (or double) walls
Not Watertight

- Floating walls
- Output lines are unordered
Not Watertight

- Floating walls
- Output lines are unordered
- Requires complete scan of building
Our Approach - Outline

- Too many points!
  - 3D point-cloud → 2D wall samples
Our Approach - Outline

- Too many points!
  - 3D point-cloud $\rightarrow$ 2D wall samples

- Connect wall samples
Our Approach - Outline

- Too many points!
  - 3D point-cloud $\rightarrow$ 2D wall samples

- Connect wall samples

Naïve connections not watertight
Our Approach - Outline

- Too many points!
  - 3D point-cloud → 2D wall samples

- Define interior area
Our Approach - Outline

- Too many points!
  - 3D point-cloud → 2D wall samples

- Define **interior** area

- Export boundary
Our Approach - Outline

- Too many points!
  - 3D point-cloud ➔ 2D wall samples

- Define **interior** area

- Export boundary

- Fit circles, lines
Algorithm

- Given full point-cloud
Algorithm: Find Each Story

- Separate stories in point-cloud

Point-cloud from ambulatory system
Algorithm

- Reduce 3D point-cloud to 2D wall samples
3D points
2D projection
Algorithm: Find 2D Wall Samples

- Filter grid cells
Algorithm: Find 2D Wall Samples

- Filter grid cells, keep if:
  - Has 50 points or more
  - Uniform coverage from floor to ceiling
  - Points distributed along a line
Algorithm: Find 2D Wall Samples

- Get wall sample from cell
Algorithm: Find 2D Wall Samples

- Get wall sample from cell

Neighbor points of a grid cell
Algorithm: Find 2D Wall Samples

- Get wall sample from cell

Neighbor points of a grid cell

Median position is 2D wall sample
18 Million points

Point-cloud from static scanners
3,568 wall samples
Algorithm

- Delineate interior area with *Eigencrust*

Guarantees *watertightness*
Algorithm: Eigencrust

- Delaunay Triangulation
Algorithm: Eigencrust

- Weighted graph connects triangles

- Positive edges:

\[ w_{u,v} = e^{4 - 4 \cos \phi} \]
Algorithm: Eigencrust

- Weighted graph connects triangles

- Negative edges: \( w_{u,v} = -e^{4+4\cos\phi + 2\sin\theta_1 + 2\sin\theta_2} \)
Output of *Eigencrust*
Exported Boundaries

2D Wall Samples  Labeled Triangles  Exported Boundary
Fit Lines and Circles to Boundary

Before

After
Results

Static Scan 18 Million Points

2D Wall Samples

Delaunay Triangulation

Eigencrust Labels

Boundary Edges

Fit Primitives
Results

- Three stories extracted (1st floor)
Results

- Actual building plan

Ambulatory Mobile System
17.3 million points
Results

- Three stories extracted (2nd floor)

Wall samples

Output floor plan

Ambulatory Mobile System
17.3 million points
Results

- Actual building plan

Ambulatory Mobile System
17.3 million points
Results

- Three stories extracted (3rd floor)

Wall samples

Ambulatory Mobile System
17.3 million points

Output floor plan
Results

- Actual building plan

Ambulatory Mobile System
17.3 million points
Results
Summary

3D point cloud

Labeled triangles

2D wall samples

Watertight boundary
Thank You