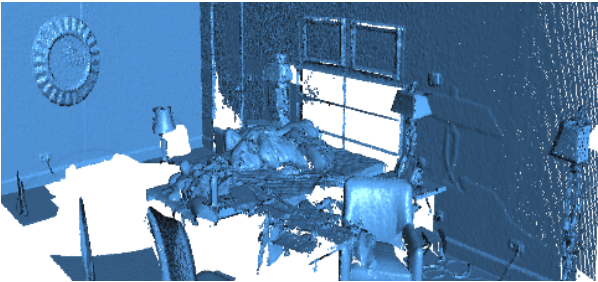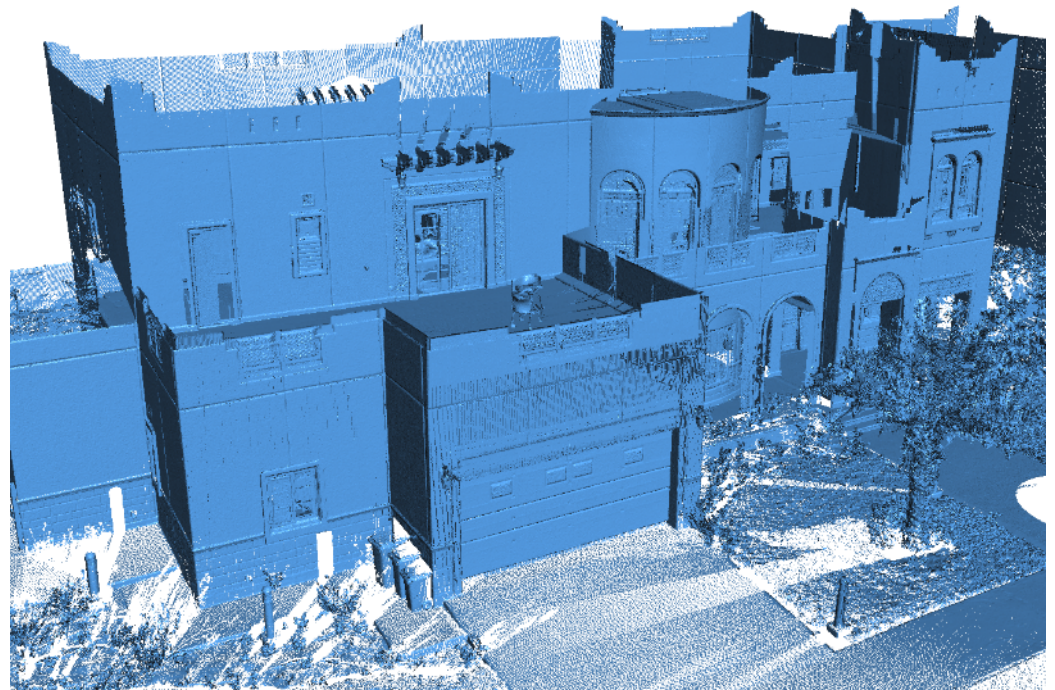# Point Cloud Registration & Reconstruction

Liangliang Nan

Registration

- ## **Scanning large buildings**
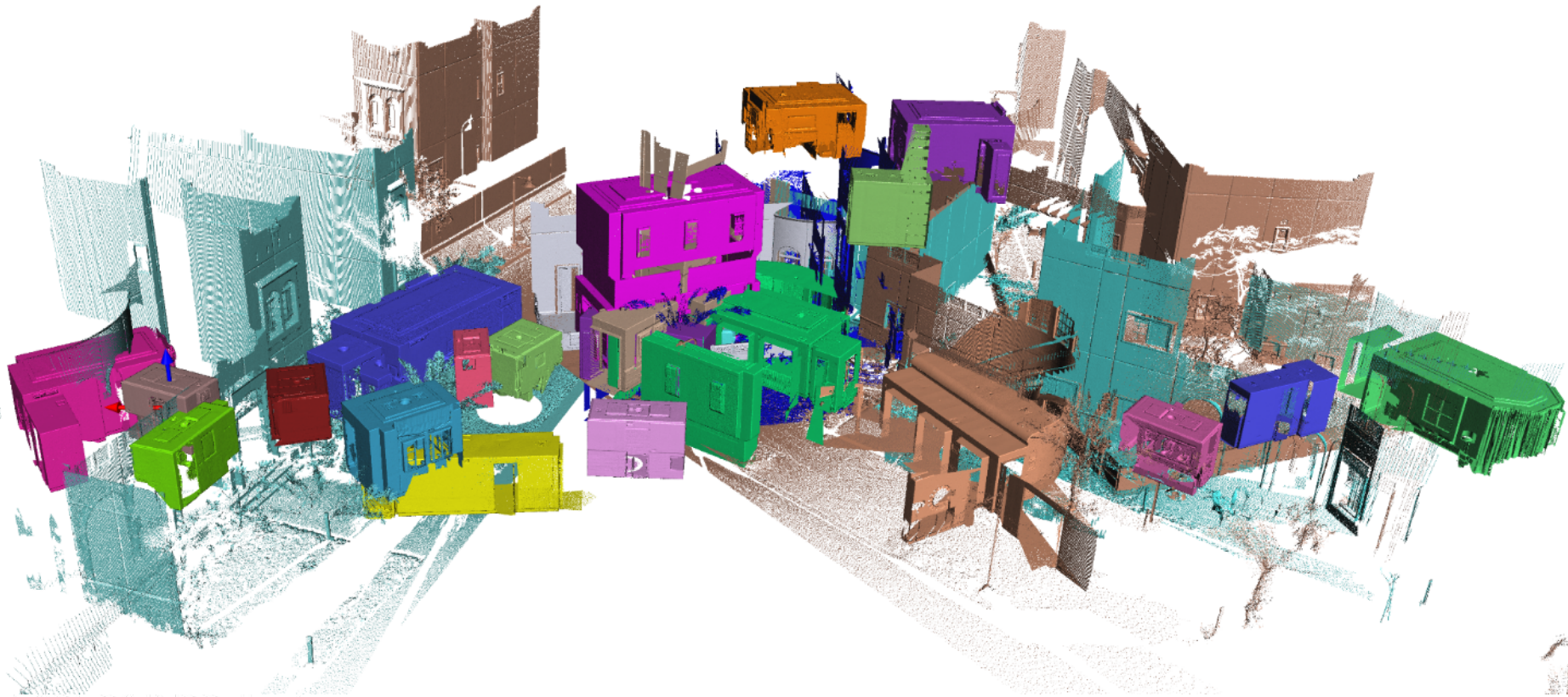 - Scans capturing interiors and exteriors
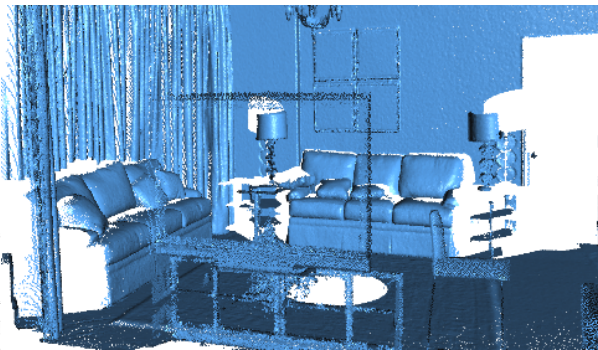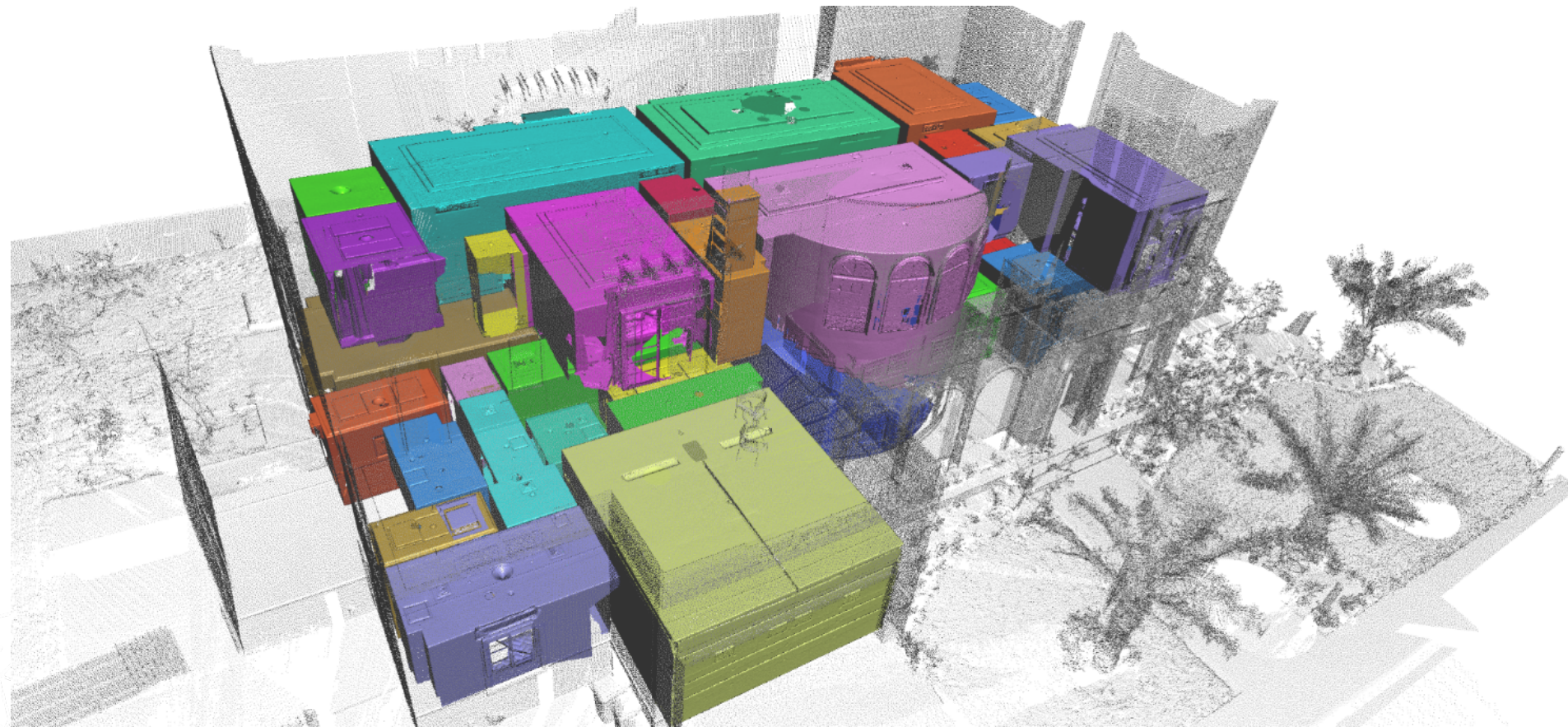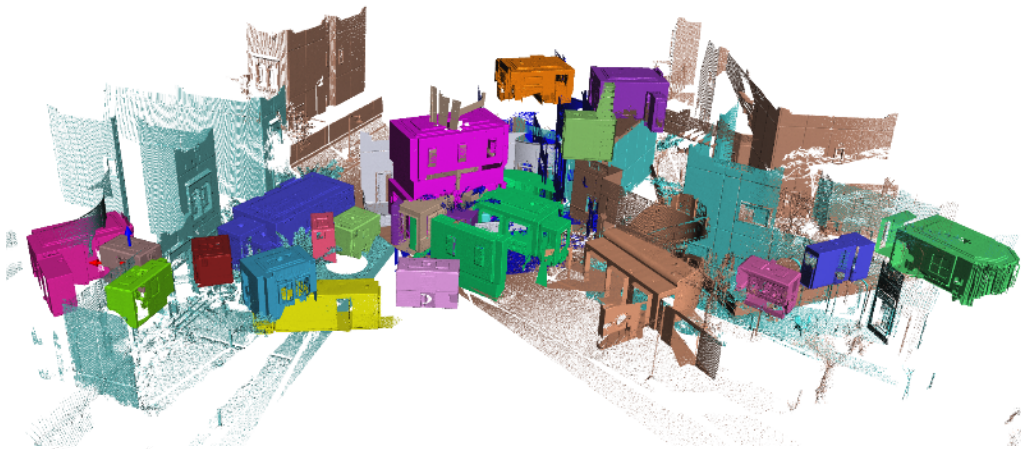

Interior

Exterior

Registration

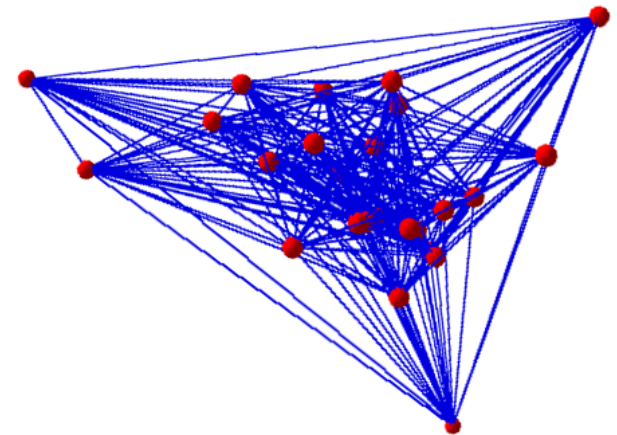37 scans (exterior + 29 rooms)

Registration

Registration Is Challenging

- ## **Challenges**
  - A global matching problem
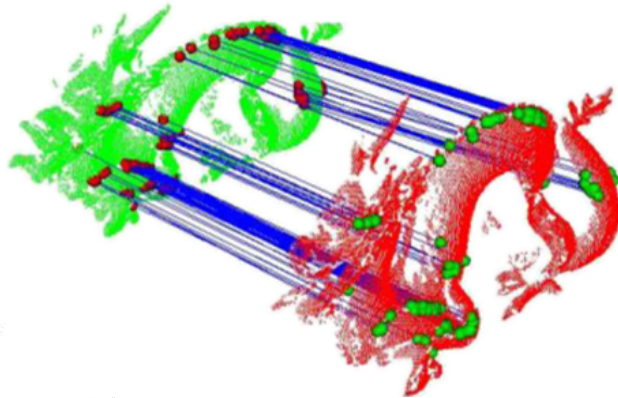   - Unknown positions and orientations

Input scans

Potential matchings

Registration Is Challenging

- ## Challenges

  - A global matching problem

  - Fewer features can be extracted

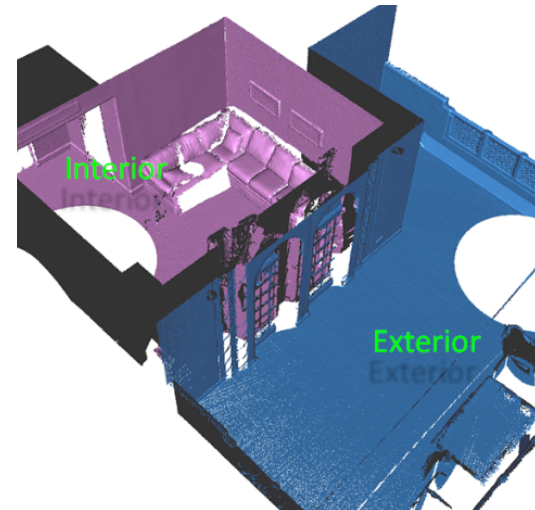   - Piecewise planar regions

Corresponding feature points

[Lu *et al.* 2015]

Buildings

Registration Is Challenging

- **Challenges**
  - A global matching problem
  - Fewer features can be extracted
  - Overlaps cannot be guaranteed
    - Isolated rooms
    - Interior to exterior registration
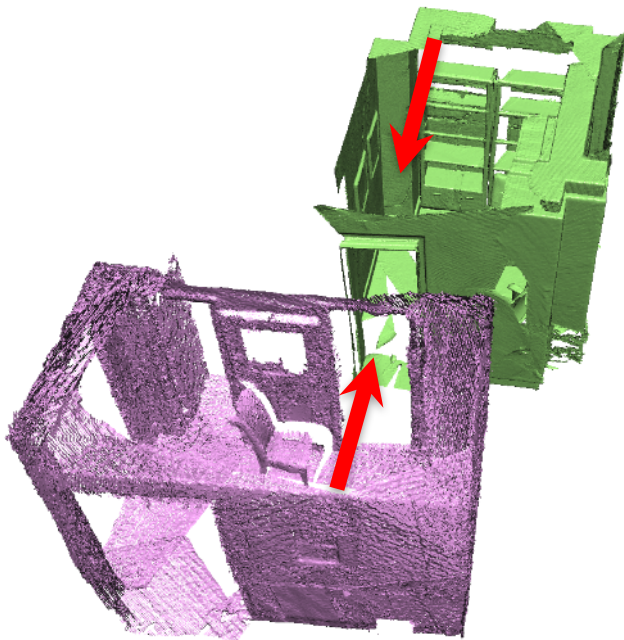   - Multiple users/scanners

Registration Is Challenging

- **Challenges**
  - A global matching problem
  - Fewer features can be extracted
  - Overlaps cannot be guaranteed
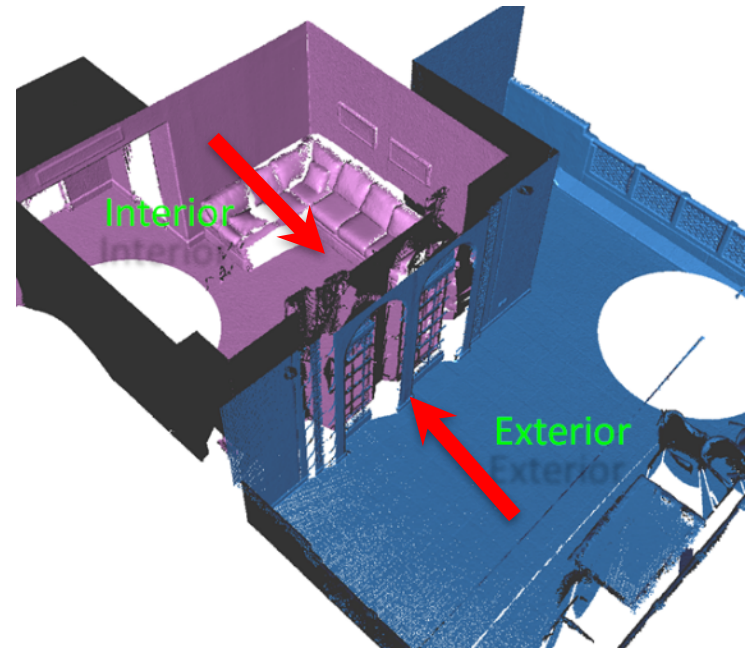 - Overlaps may not work

The Idea

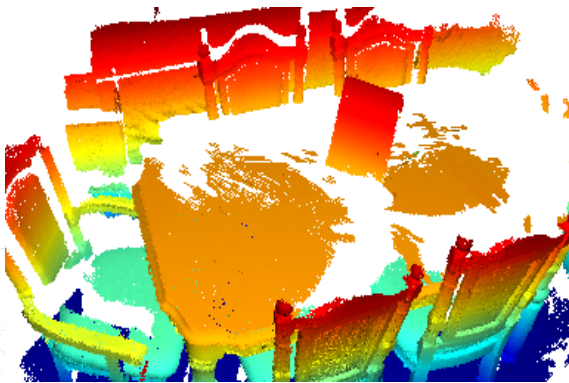- **Observation: portals (i.e., doors, windows)**
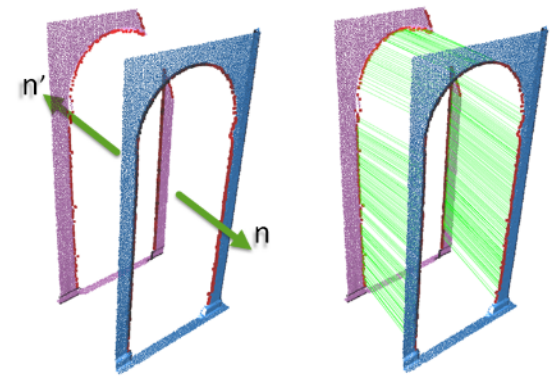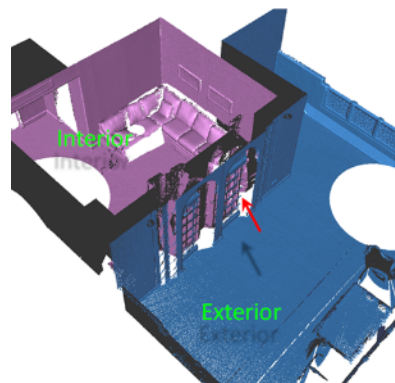 - Natural connectors

Isolated rooms

Building interior and exterior

The Idea

- **Observation: portals (i.e., doors, windows)**
  - Natural connectors
  - Promising information for registration
    - Residing in walls: shape clearly captured
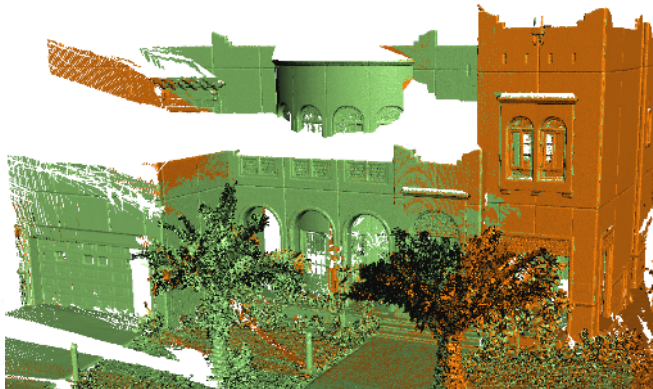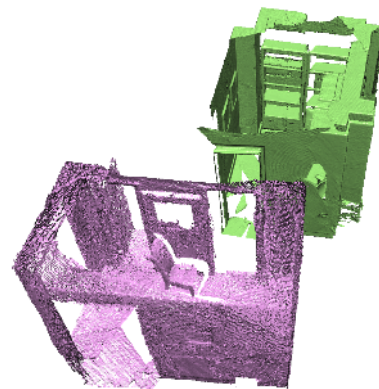   - Easy detection, easy matching

Indoor objects

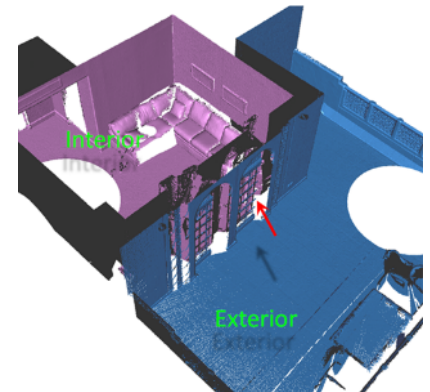Portal and portal matching

The Idea

- **Observation: portals (i.e., doors, windows)**
- **Global registration framework**
  - Overlaps + portals
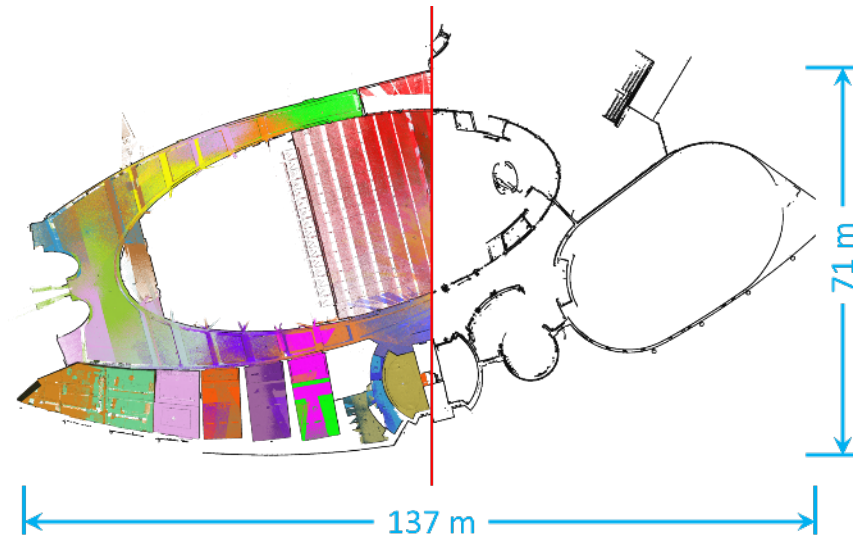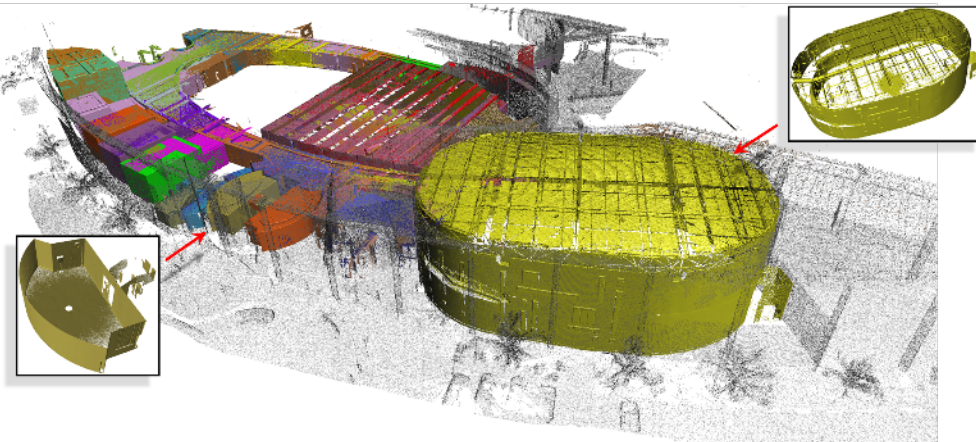 - Combinatorial optimization
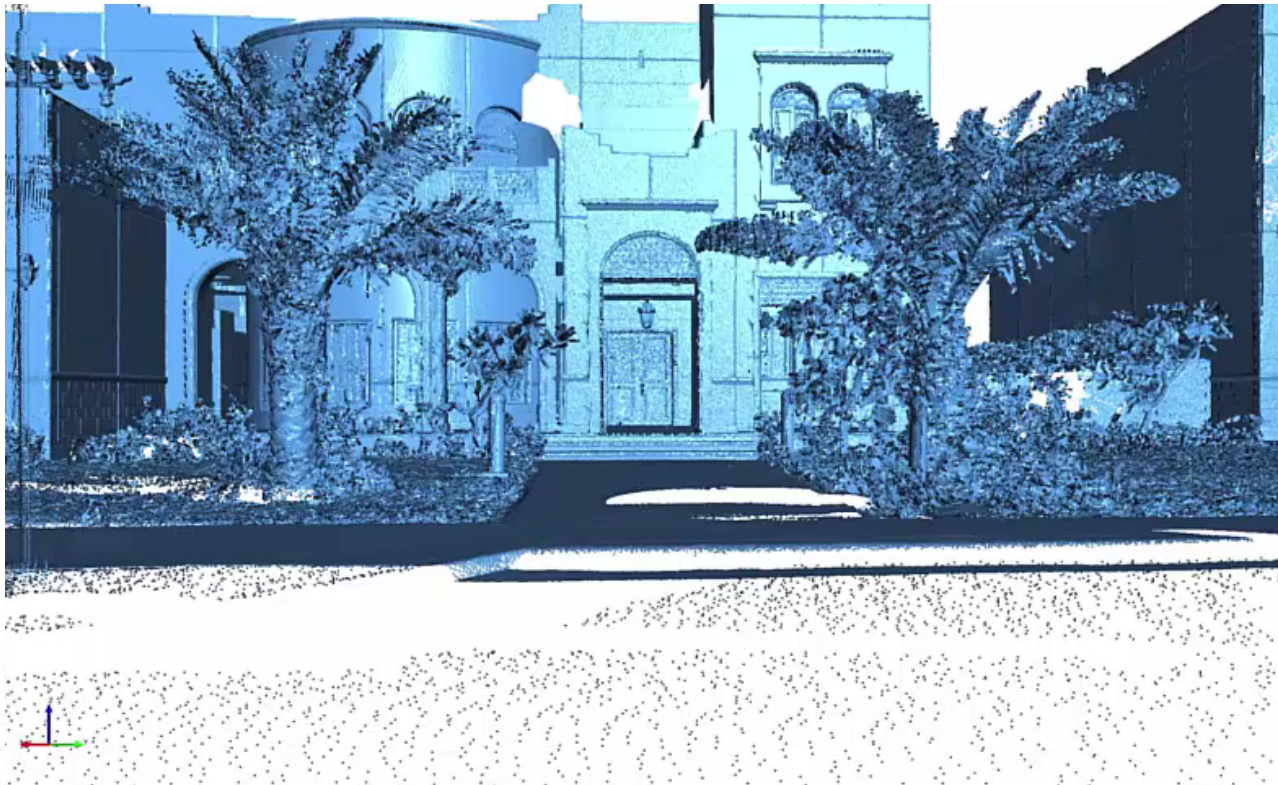

Overlaps

Portals

11

Results

- **A large sports center**
  - 11 rooms, 67 scans
  - Rooms along curved hallways
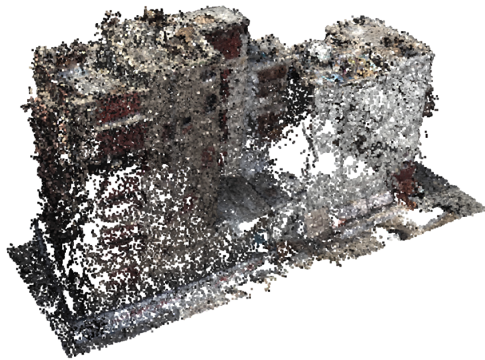
Results

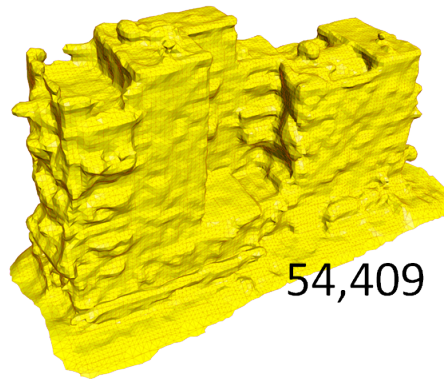- ## **A two-floor residential building**
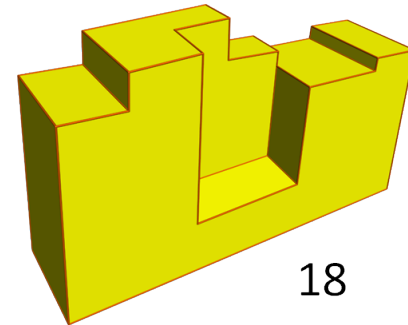 - 29 rooms, 37 scans

Reconstruction

- **Which is better?**

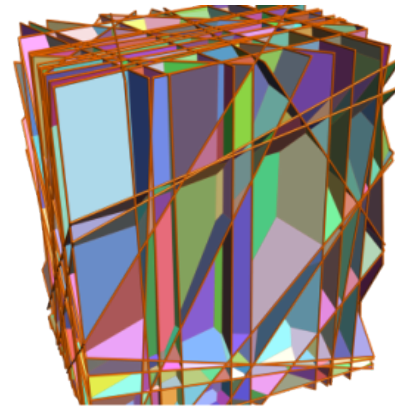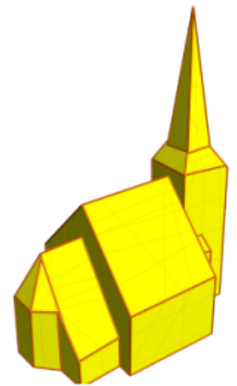| Point Cloud	Poisson reconstruction	Expected result
	54,409	18

The Idea

Input

Planar segments
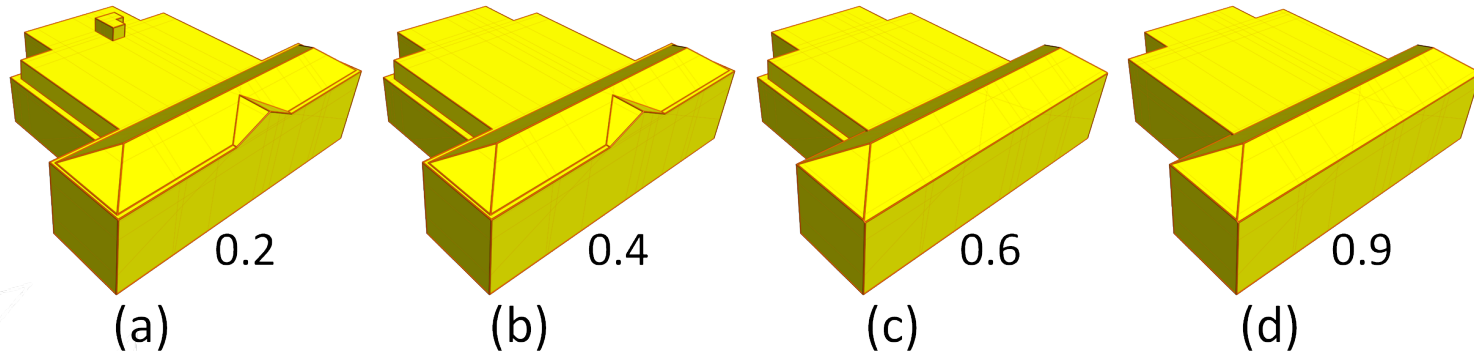
Candidate faces

Result

Method

- **Our formulation**

Data fitting

$$\min_{\mathbf{X}} \quad \lambda_f \cdot \underline{E_f} + \lambda_m \cdot E_m + \lambda_c \cdot E_{\text{connectivity}}$$
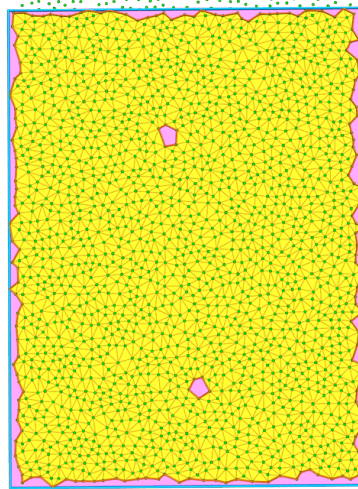
16

Method

- **Our formulation**

Model complexity

$$\min_{\mathbf{X}} \quad \lambda_f \cdot E_f + \lambda_m \cdot \underline{E_m} + \lambda_c \cdot E_c$$

0.2   0.4   0.6   0.9

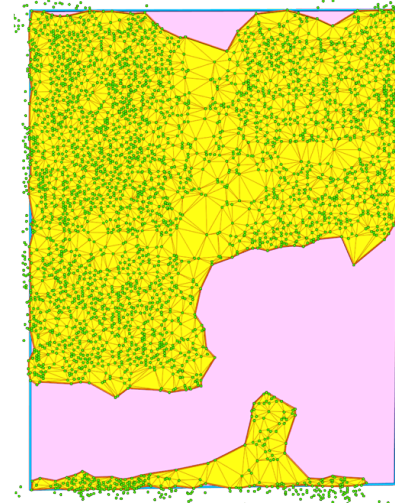(a)   (b)   (c)   (d)

Method

- **Our formulation**

Point coverage

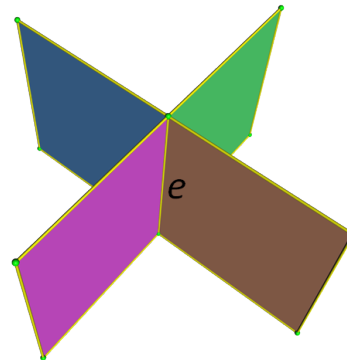$$\min_{\mathbf{X}} \quad \lambda_f \cdot E_f + \lambda_m \cdot E_m + \lambda_c \cdot \underline{E_c}$$
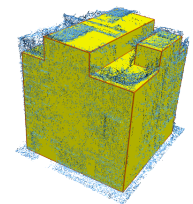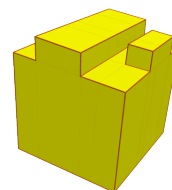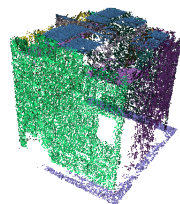
0.93   0.65

Method

- ## Our formulation
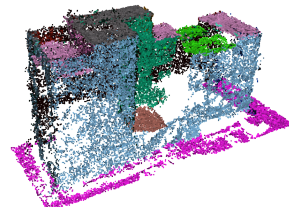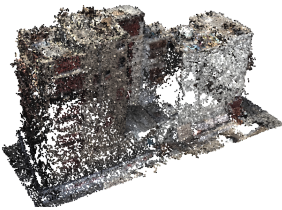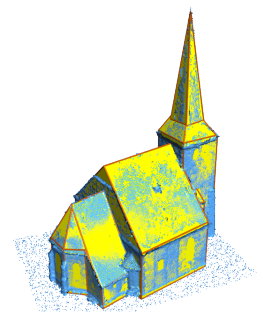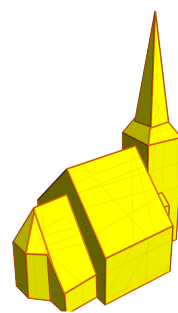
$$\min_{\mathbf{X}} \quad \lambda_f \cdot E_f + \lambda_m \cdot E_m + \lambda_c \cdot E_c$$

$$\text{s.t.} \quad \begin{cases} \sum_{j \in \mathcal{N}(e_i)} x_j = 2 \quad \text{or} \quad 0, \quad 1 \leq i \leq |E| \\ x_i \in \{0, 1\}, \qquad\qquad 1 \leq i \leq N \end{cases}$$
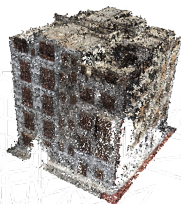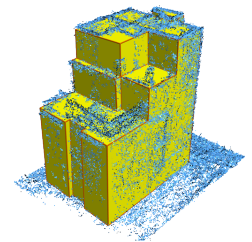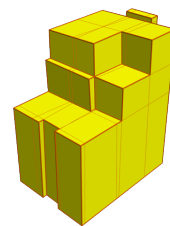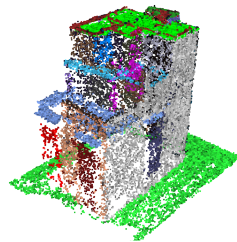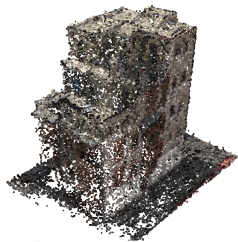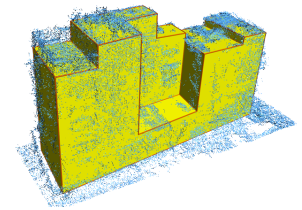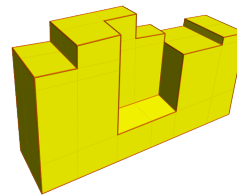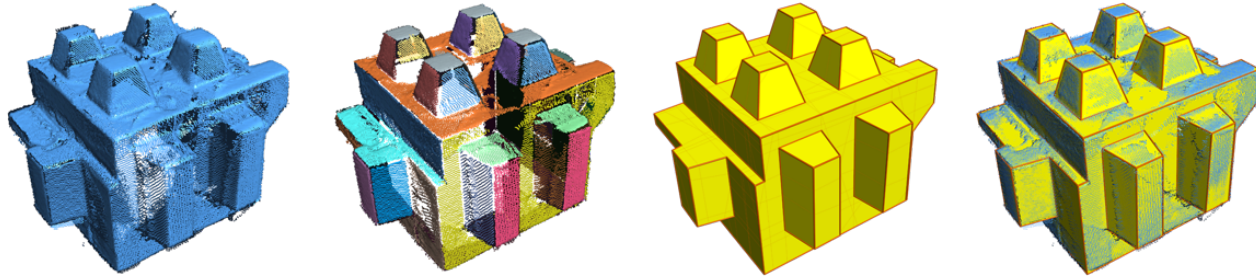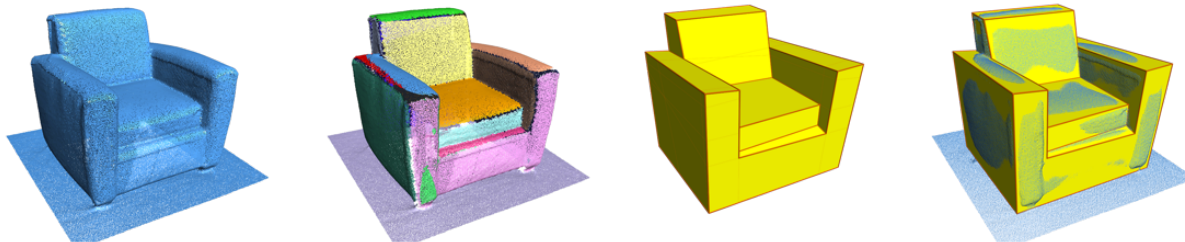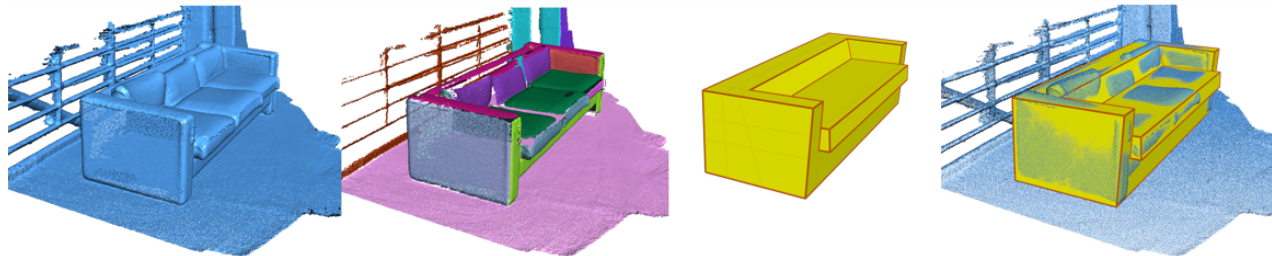
Results

Results

Packing foam box

Chair

Sofa

Code & data available:
https://3d.bk.tudelft.nl/liangliang/publications/2017/polyfit/polyfit.html
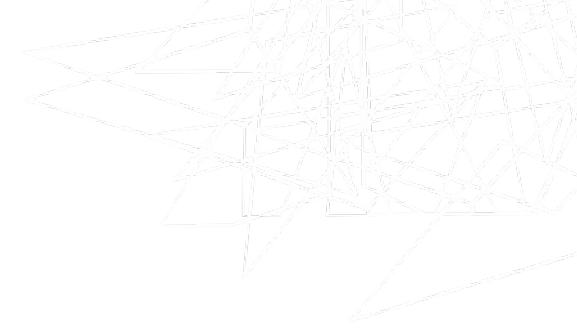
Conclusion

- **Registration**

  - Semantic information is useful

    - Portals are good features

- **Reconstruction**

  - Cast as labeling problem

  - Manifold and water-tight constraints

  - LOD control

Thank you !