STRUCTURED INDOOR MODELING

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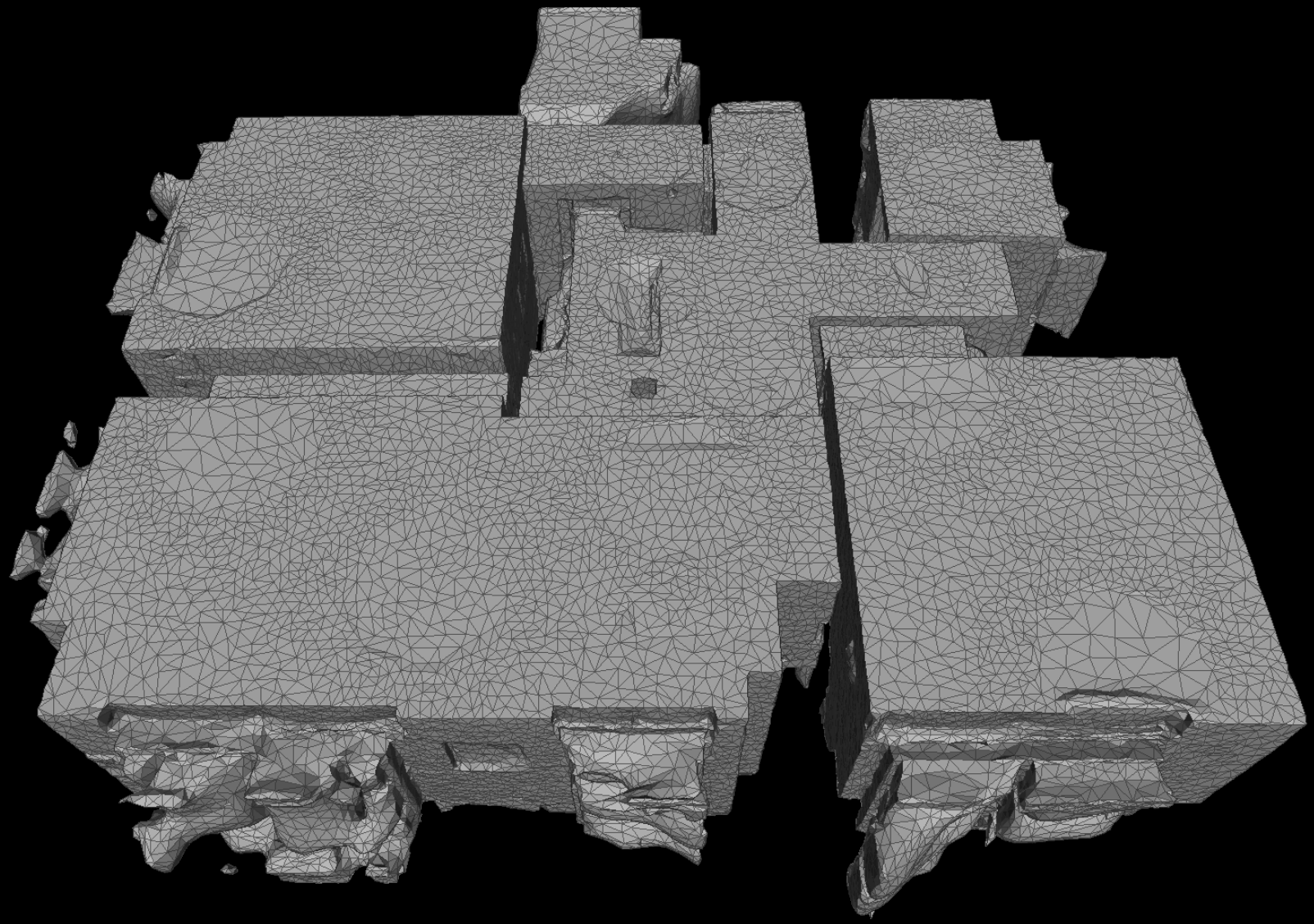
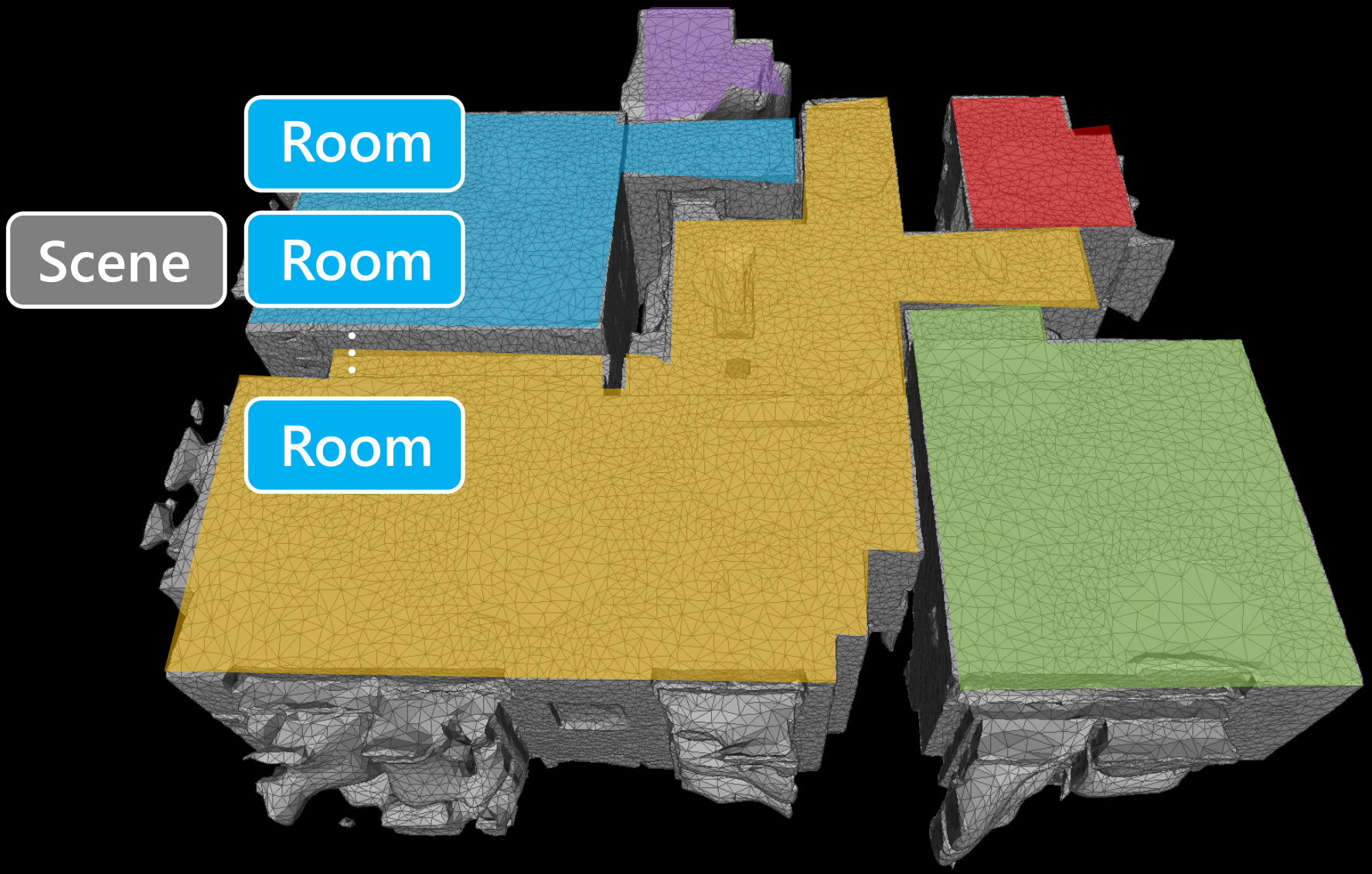
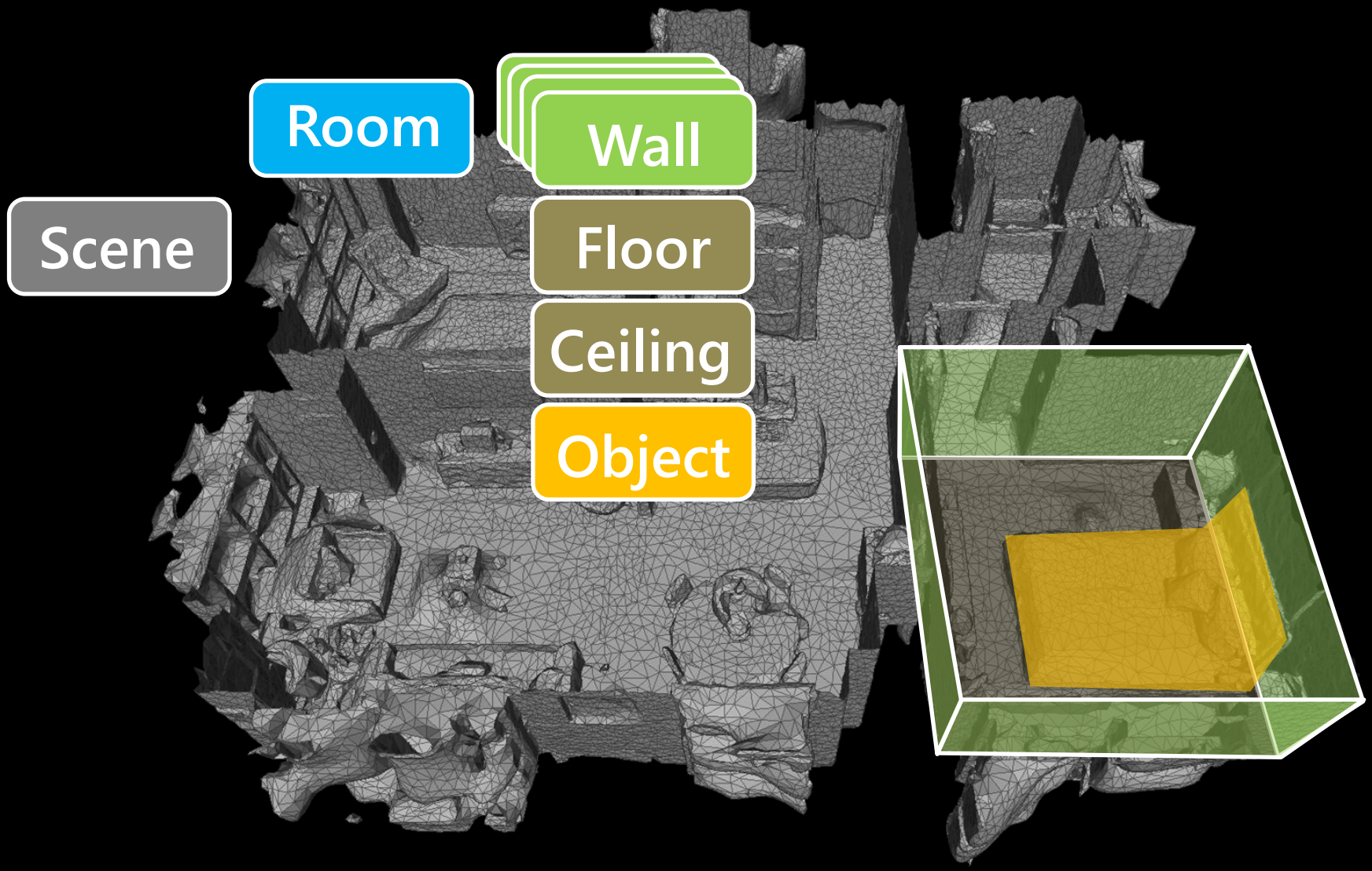
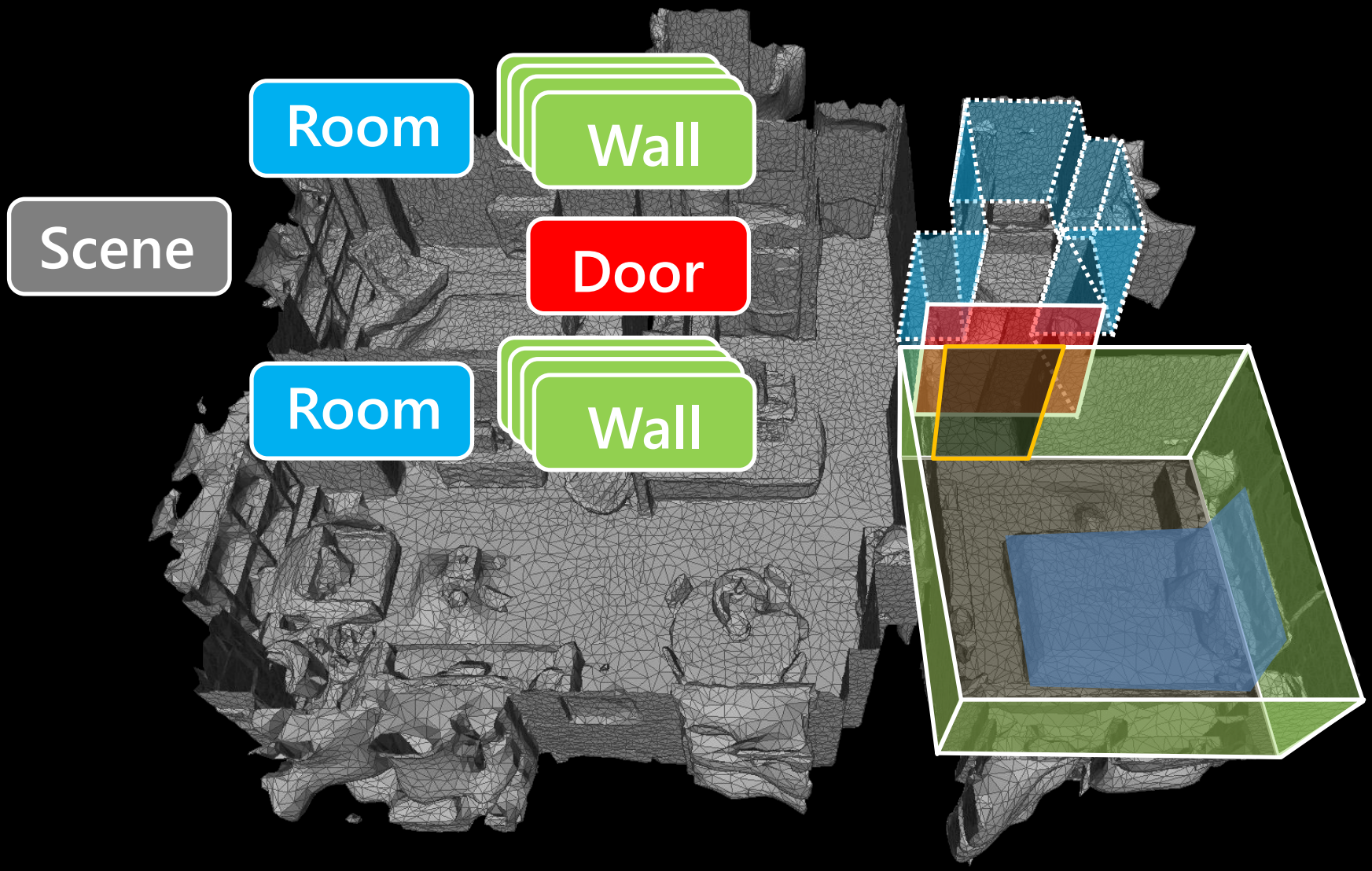
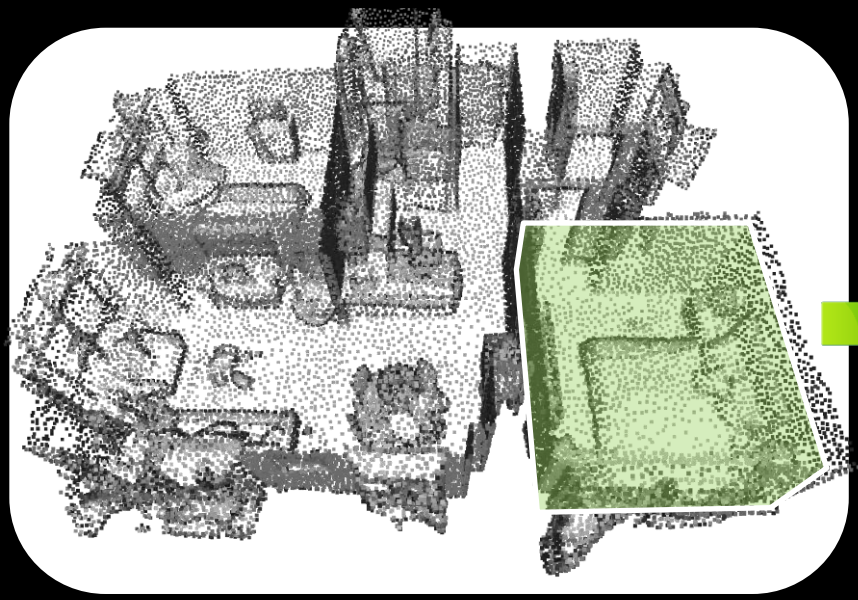
Indoor scenes are structured

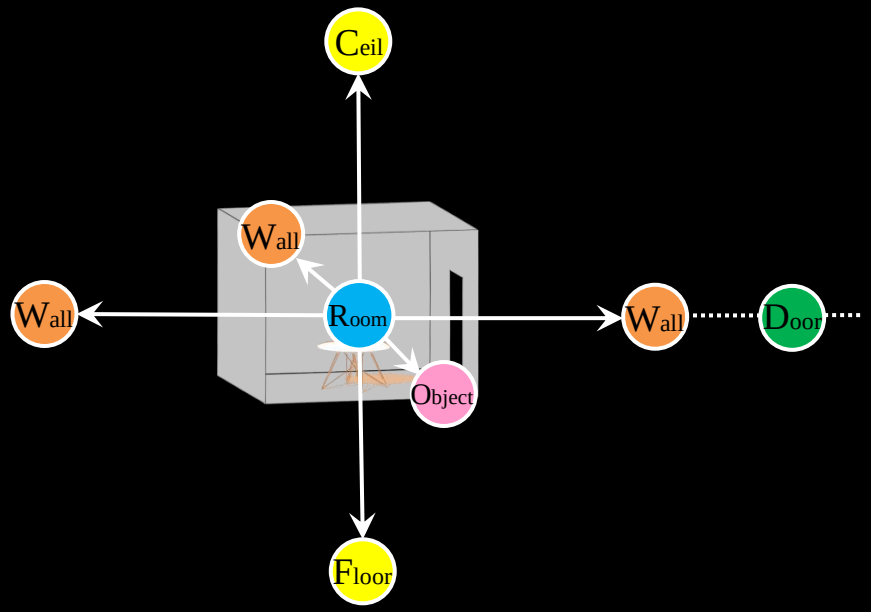



Scene
Room
Room
Room


Scene
Room
Wall
Floor
Ceiling
Object


Scene
Room
Wall
Door
Room
Wall





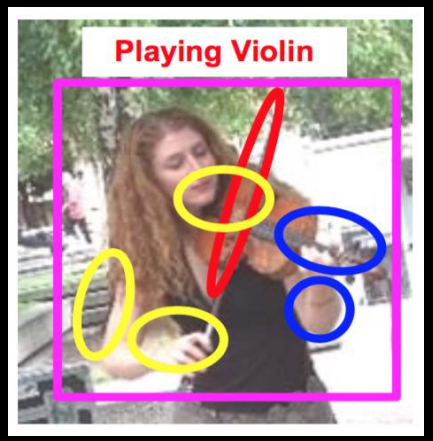
Point cloud

Dense geometry

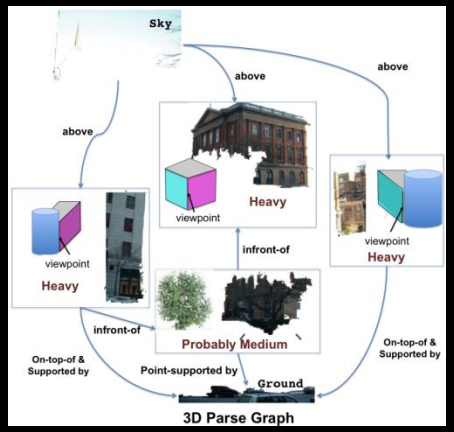
Structure graph

associated with its structure

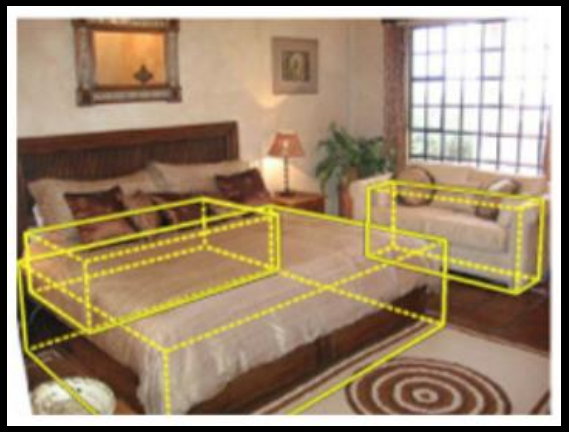
Structured representation in computer vision



[Yao and Fei-Fei, 2010]



[Gupta, Efros and Hebert, 2010]

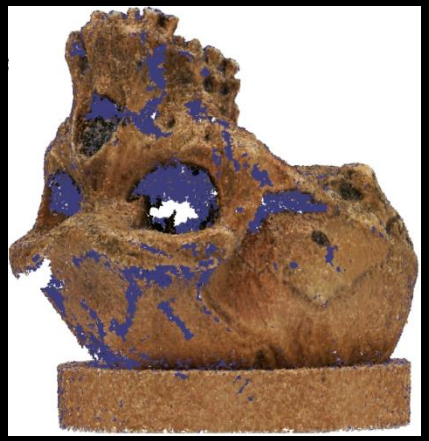


[Hedau, Hoiem and Forsyth, 2012]

Dense reconstruction methods

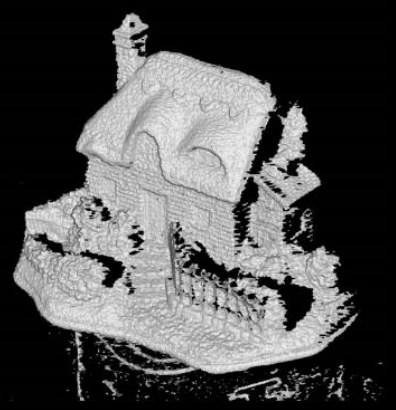
Polygons

[Hiep et al.]



Point cloud

[Furukawa et al.]

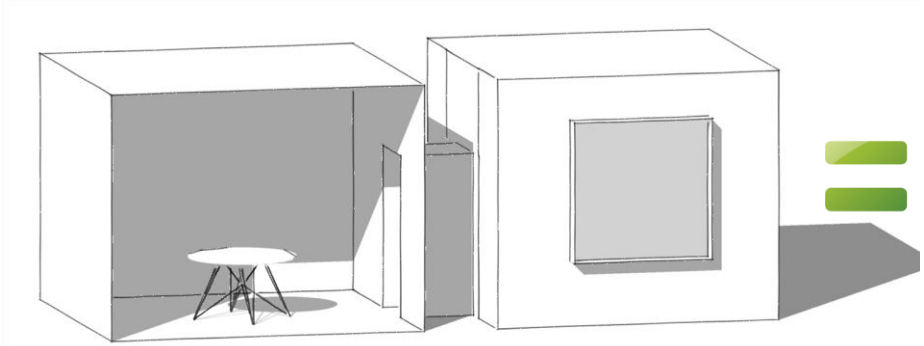


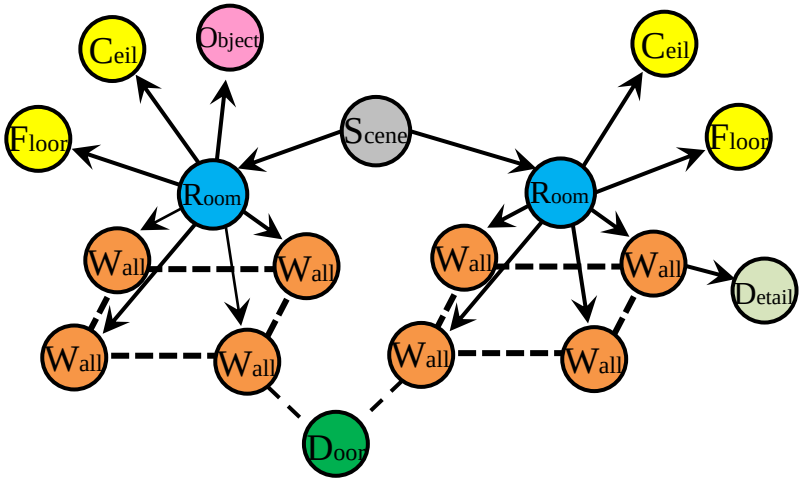
Depthmap

[Campbell et al.]

Structure graph

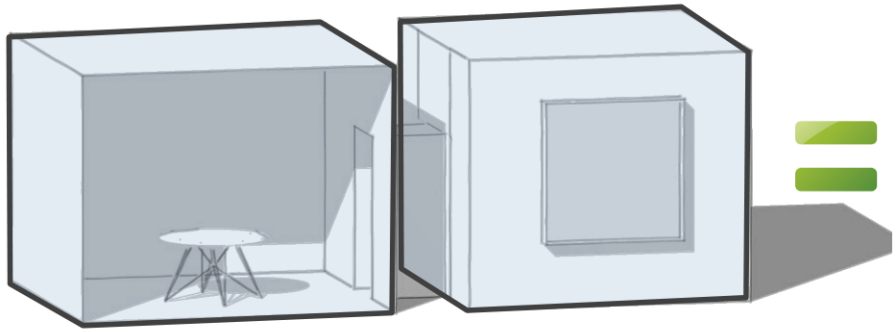
A new 3D representation

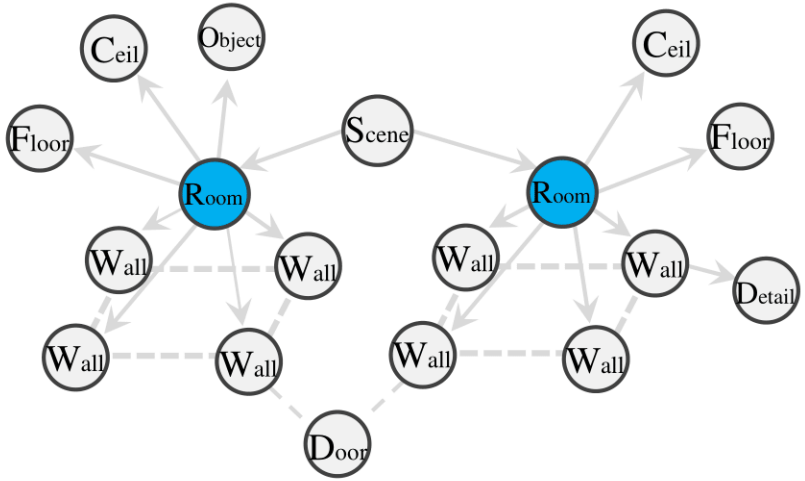




Structure graph

A new 3D representation





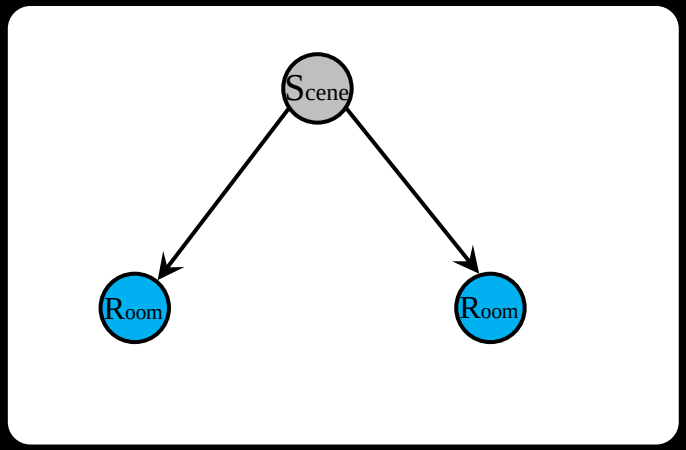
Node: Structural element

- Contains geometry

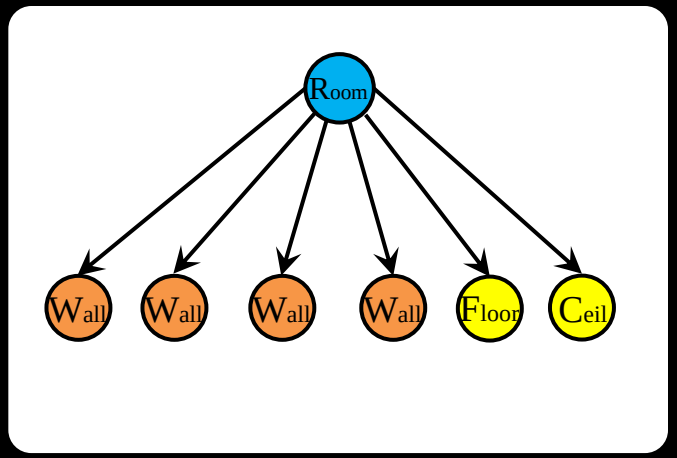
Structure graph

A new 3D representation

Edge: "Consist of"



Scene consists of rooms

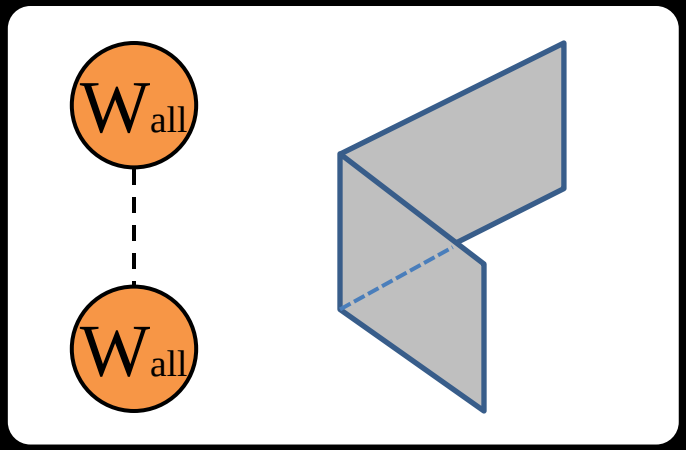


Room consists of walls, floor and ceiling

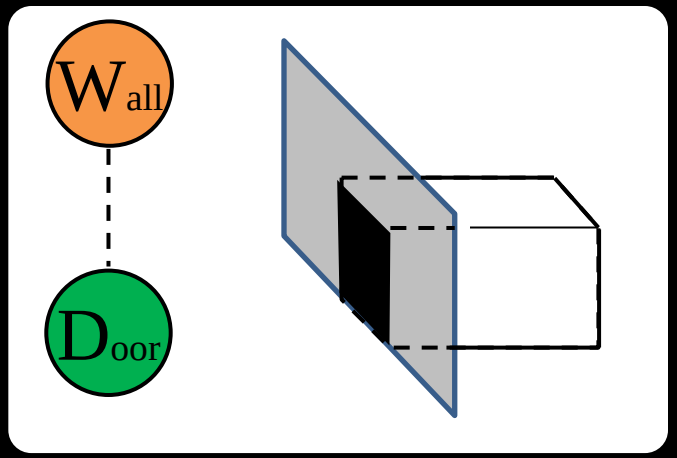
Structure graph

A new 3D representation

Edge: "Connected"



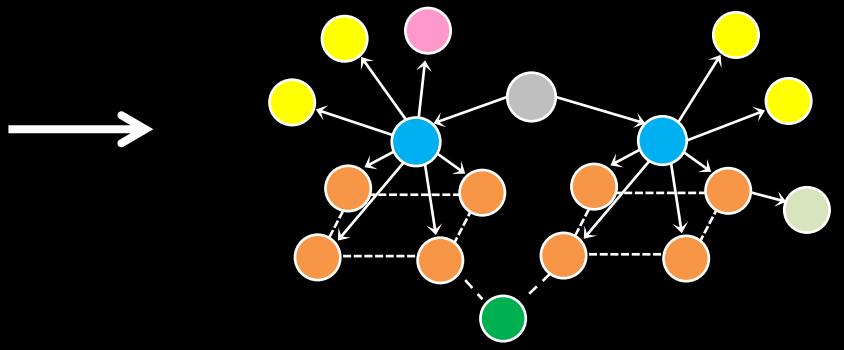
Walls are connected sharing a room corner



Wall and door are connected

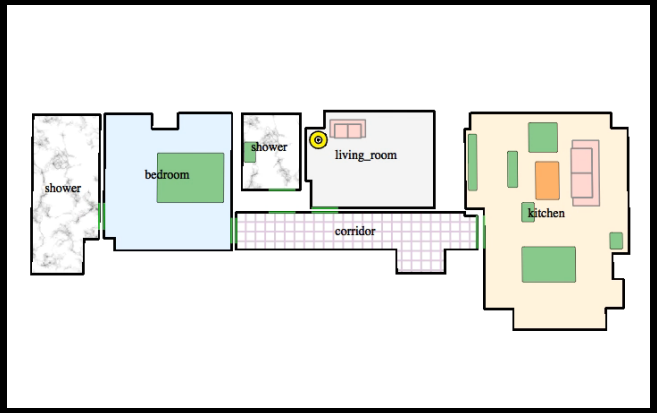
Structured Indoor Modeling

A point-cloud
(from panorama RGB-D images)



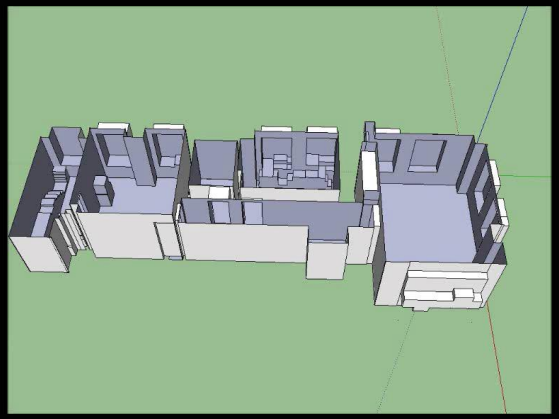
Structure graph

Applications



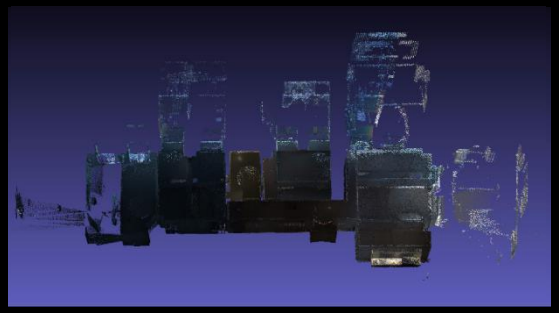
Floor-plan generation

Indoor viewer

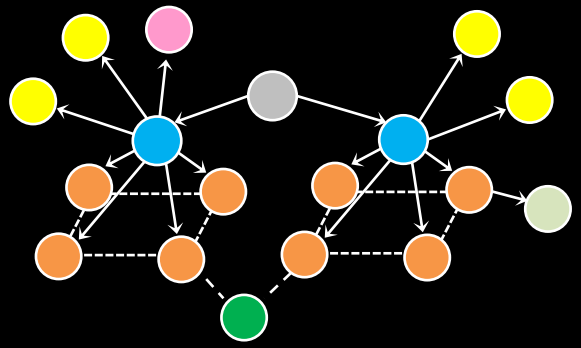


Inverse CAD

Structured Indoor Modeling

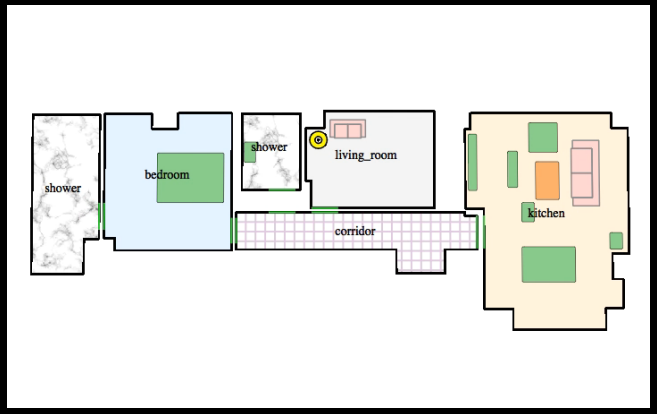


A point-cloud
(from panorama RGB-D images)



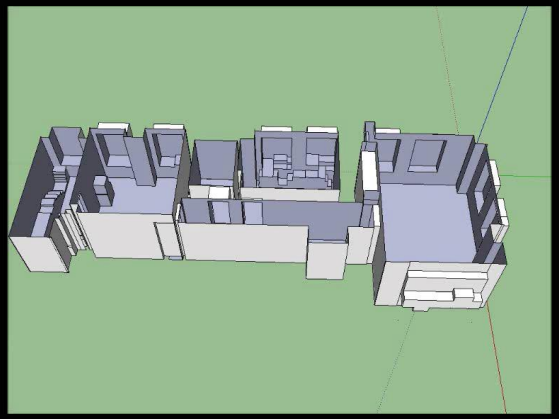
Structure graph

Applications



Floor-plan generation

Indoor viewer



Inverse CAD

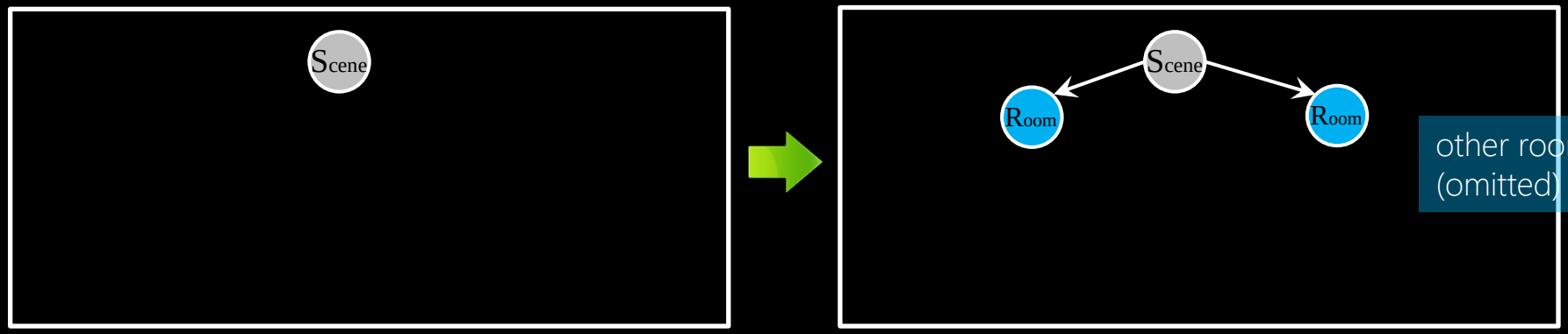
How to recover structure graph?

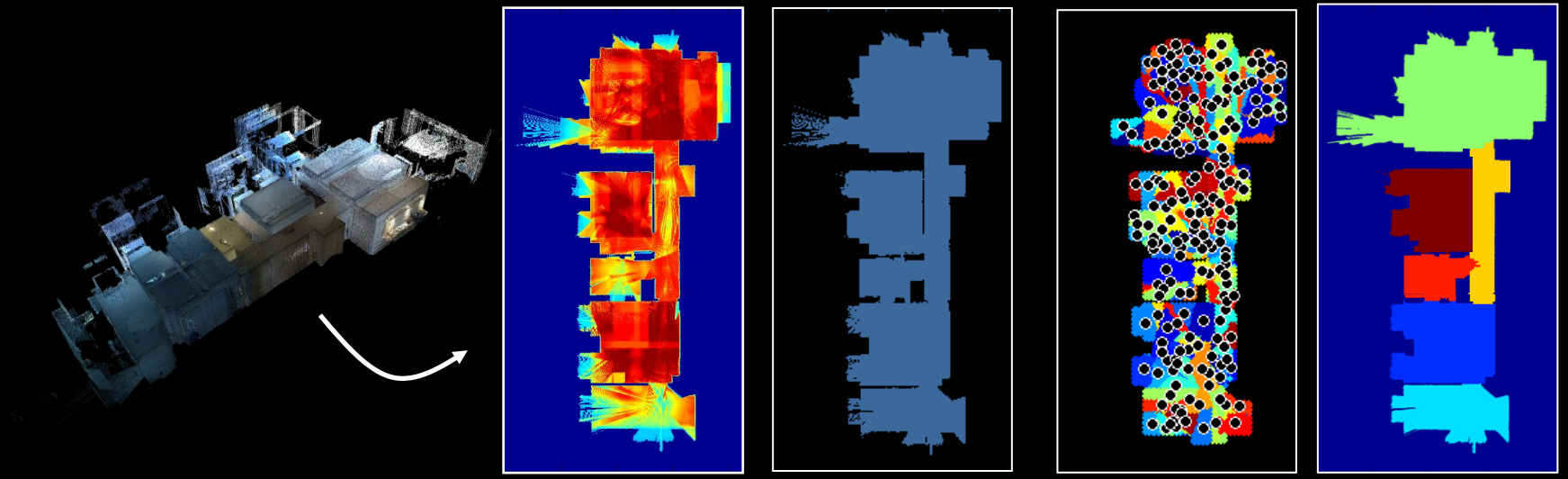
II

Sequential grammar rule applications

(Assumption: Manhattan-world and single-story building)

Room segmentation rule

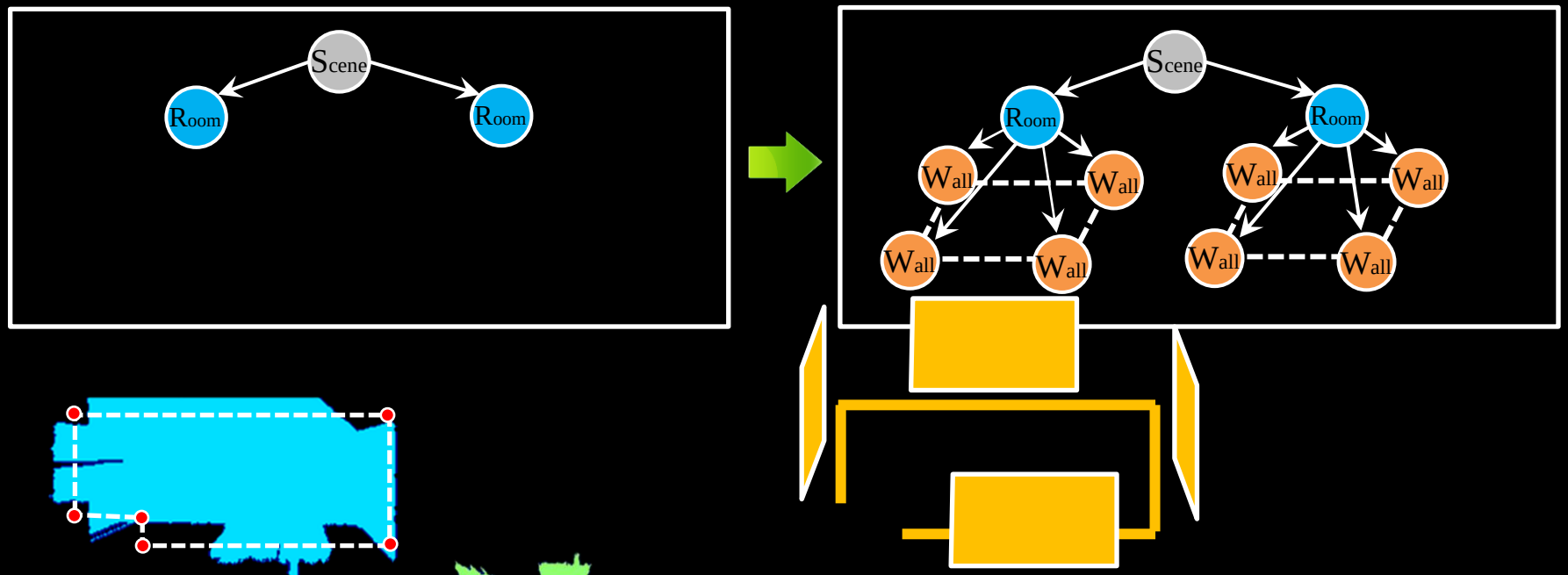


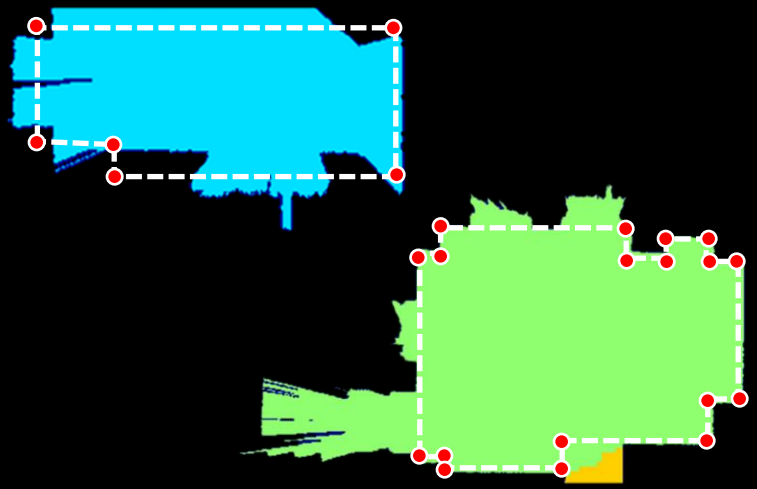


2D free-space evidence
and binary mask (input)

k-medoids clustering
based on visibility feature

Room reconstruction rule



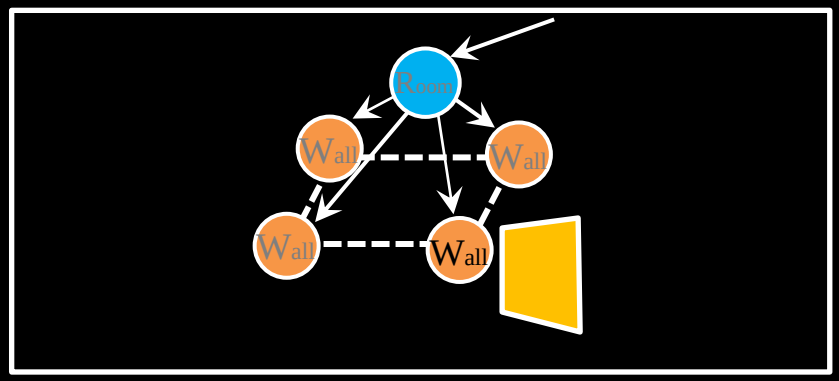


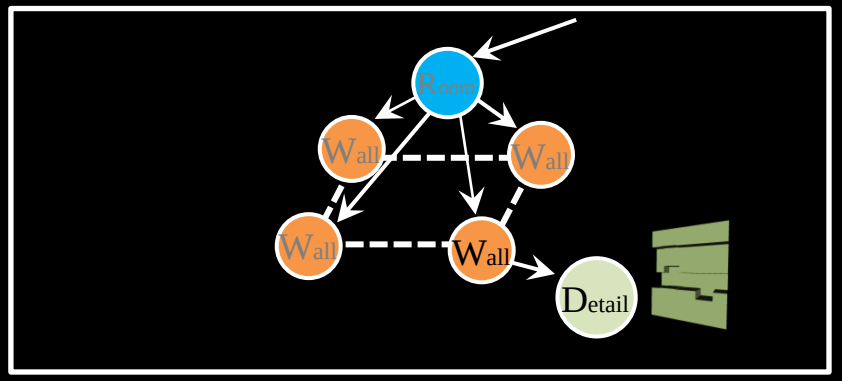
Room segment

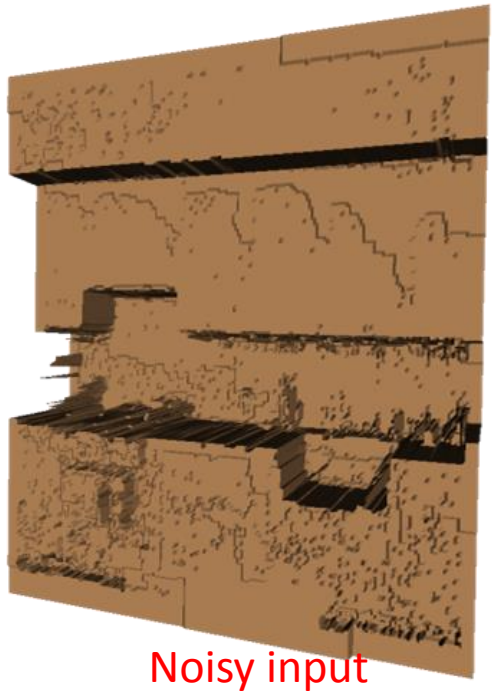
Reconstructed piece-wise planar 3D model [1]

[1] R. Cabral and Y. Furukawa. Piecewise planar and compact floorplan reconstruction from images. Proc. CVPR, 2014.

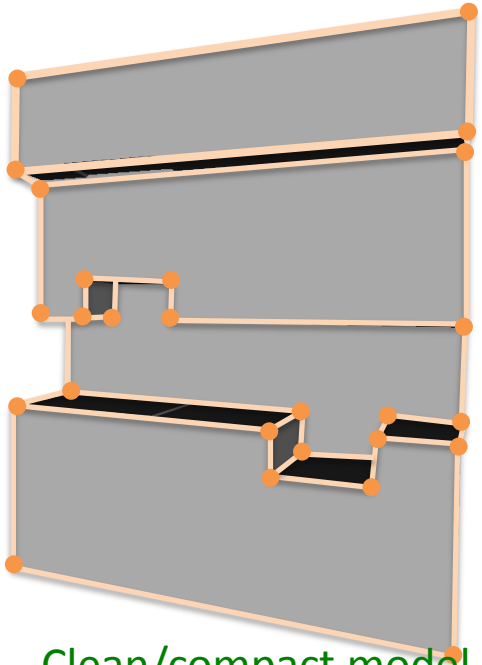
Detail reconstruction rule





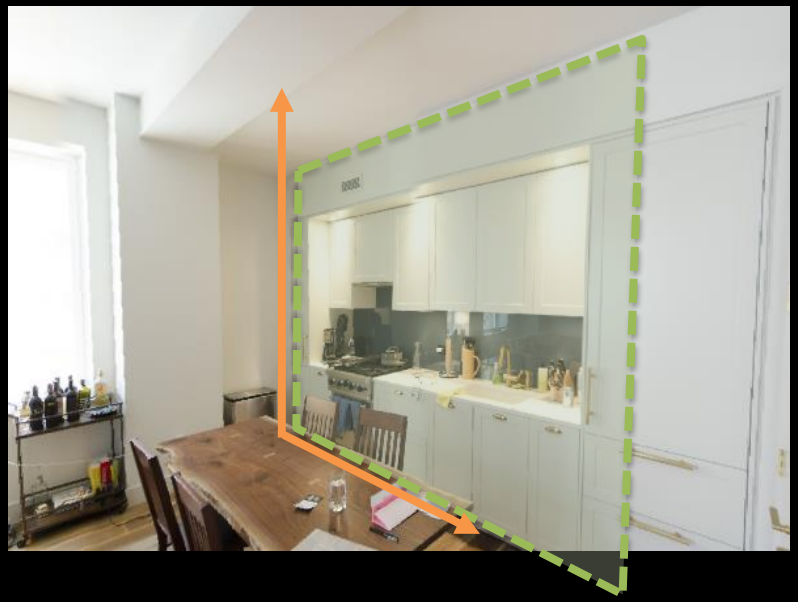


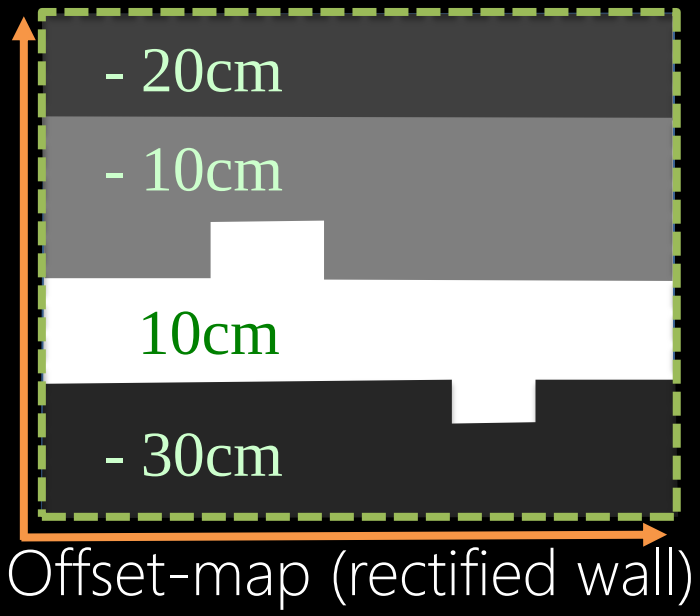
Noisy input
(due to objects, sensor errors)



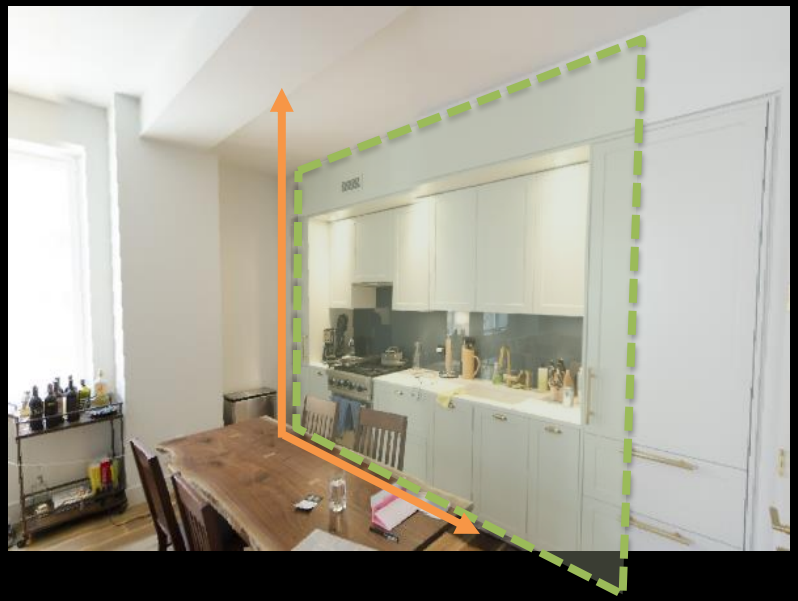
Clean/compact model
(CAD quality)

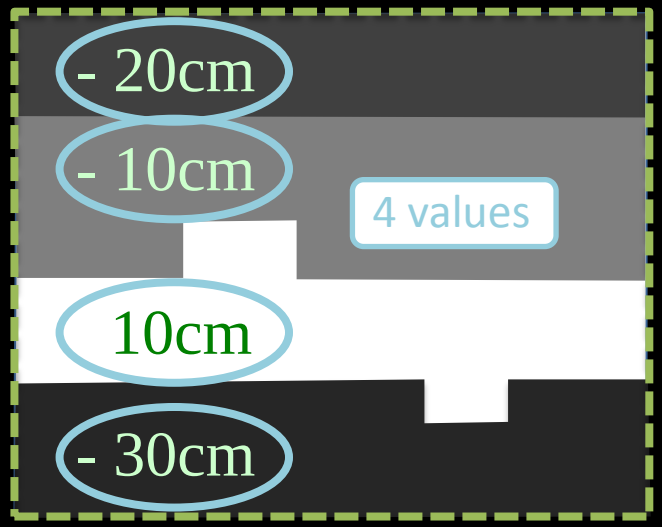
Detail reconstruction rule



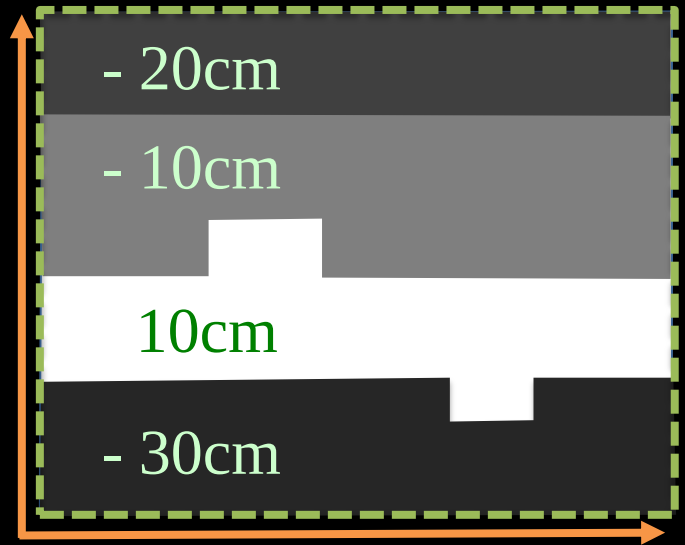


Detail reconstruction rule



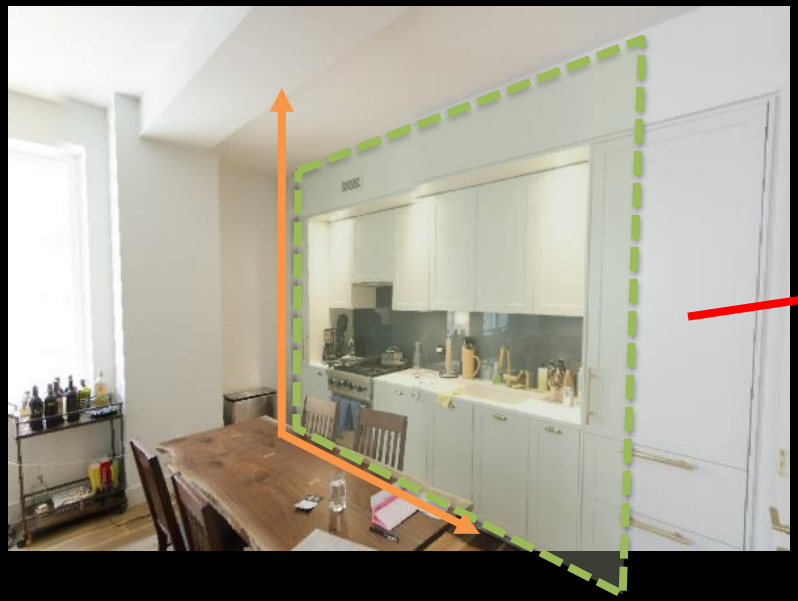


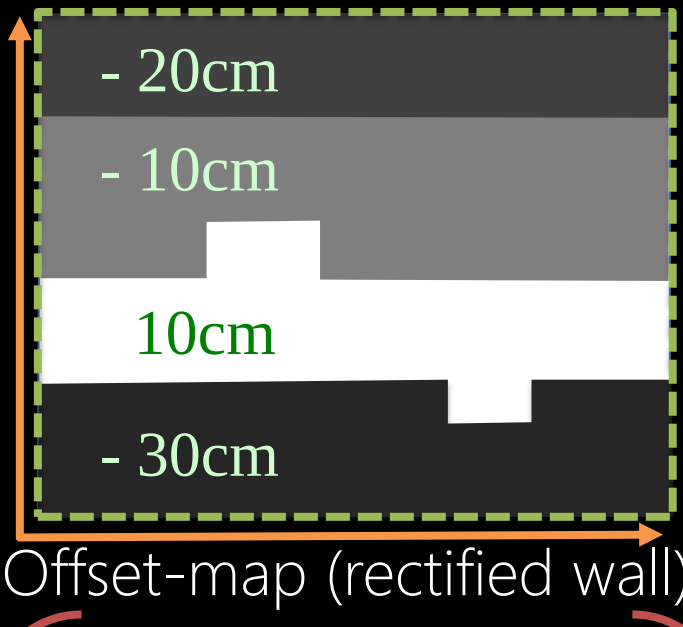
Low entropy



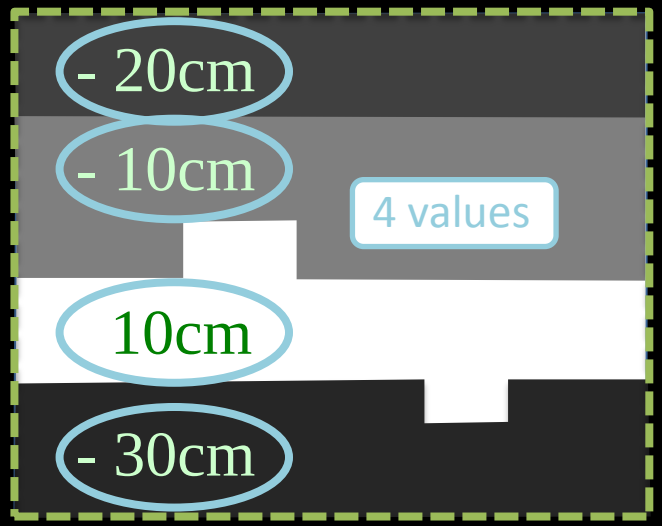
Offset-map (rectified wall)

Detail reconstruction rule

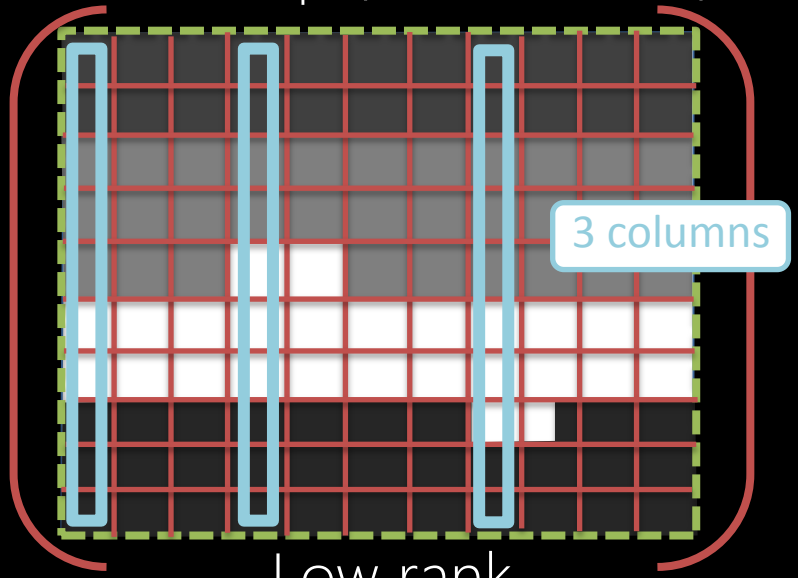




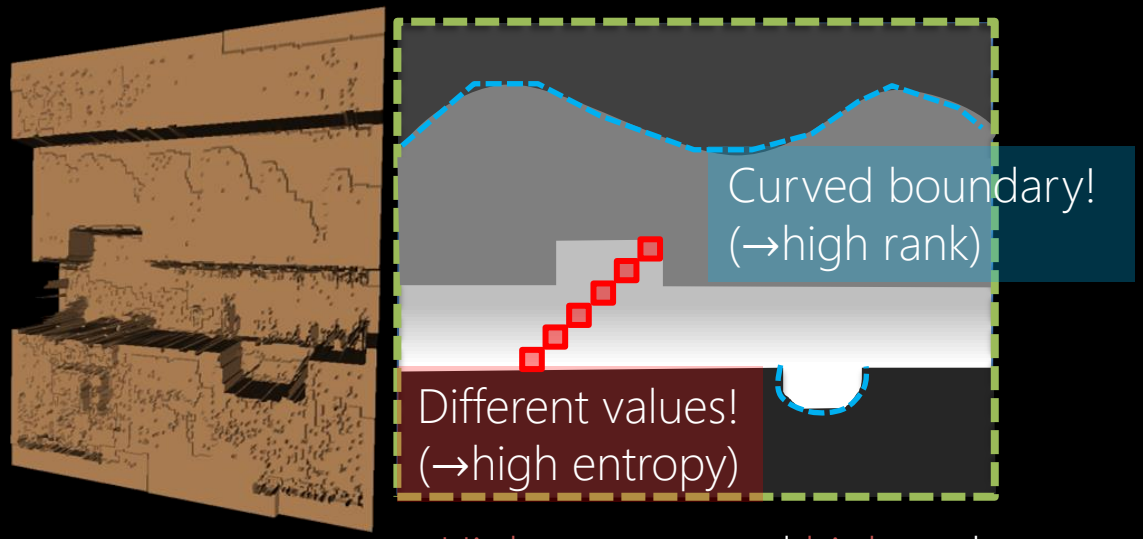
Offset-map (rectified wall)



Low entropy



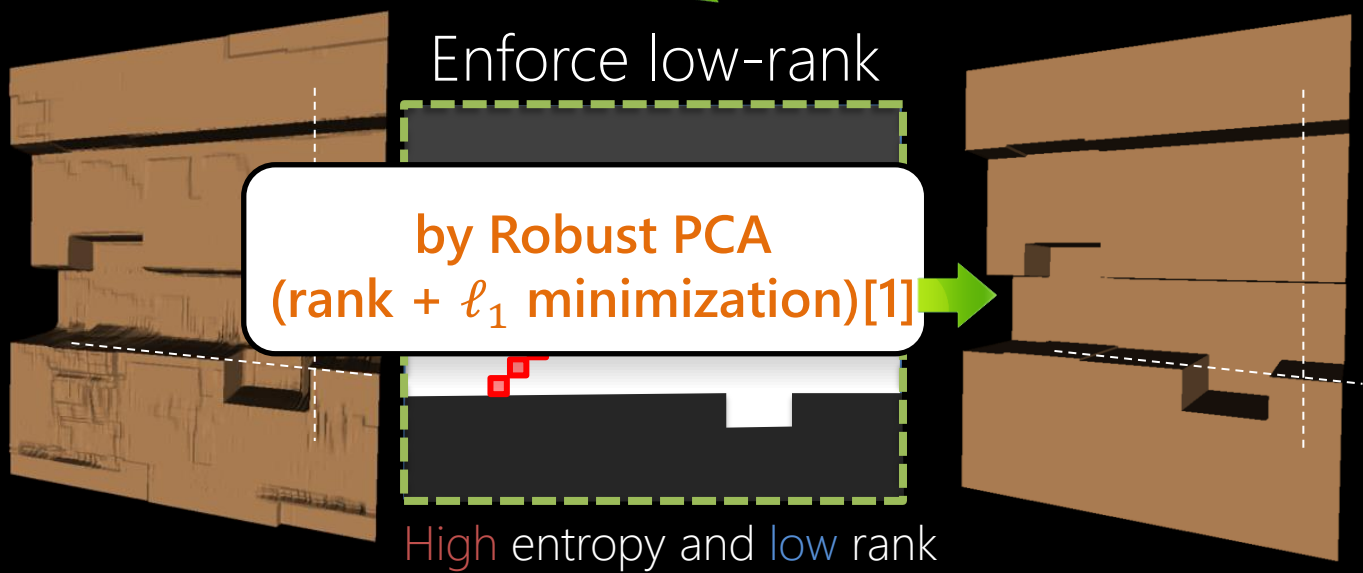
Low rank



High entropy and high rank

Enforce low-rank

by Robust PCA
(rank + ℓ_1 minimization)[1]



High entropy and low rank

Enforce low-entropy

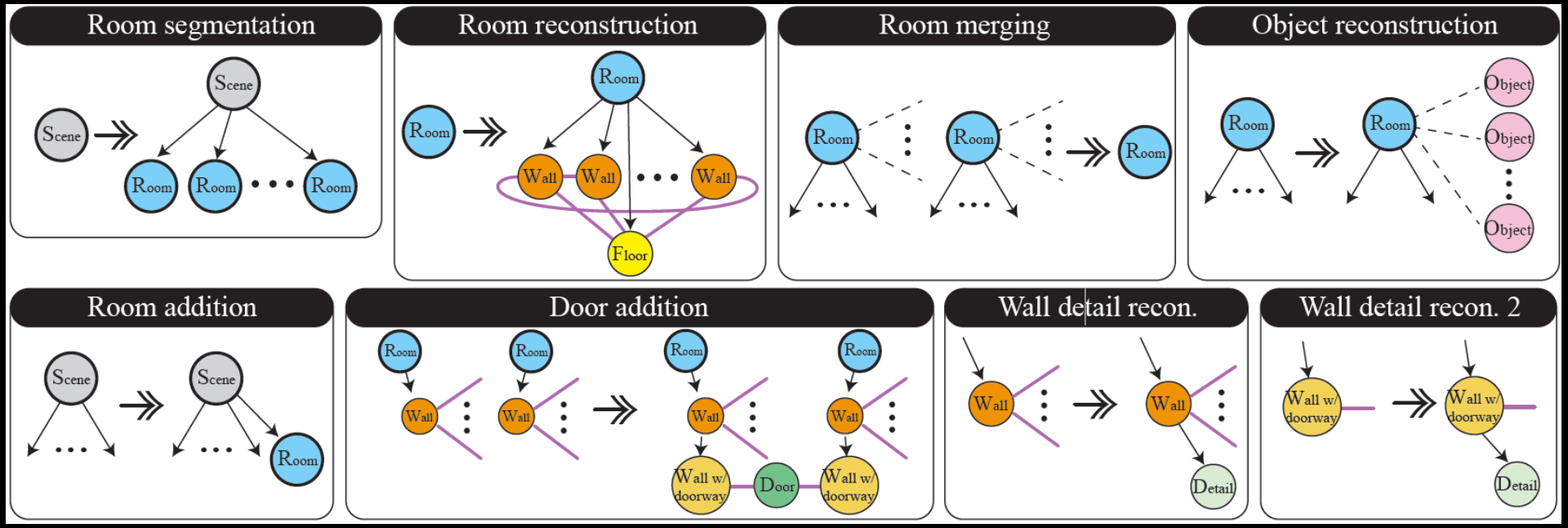
by Potts model &
label-cost MRF [2]

Low entropy and low rank

[1] E. J. Candes et al. Robust principle component analysis? Journal of the ACM, 58(3), 2011.

[2] A. Delong et al. Fast approximate energy minimization with label costs. International Journal of Computer Vision, 96(1), 2012.

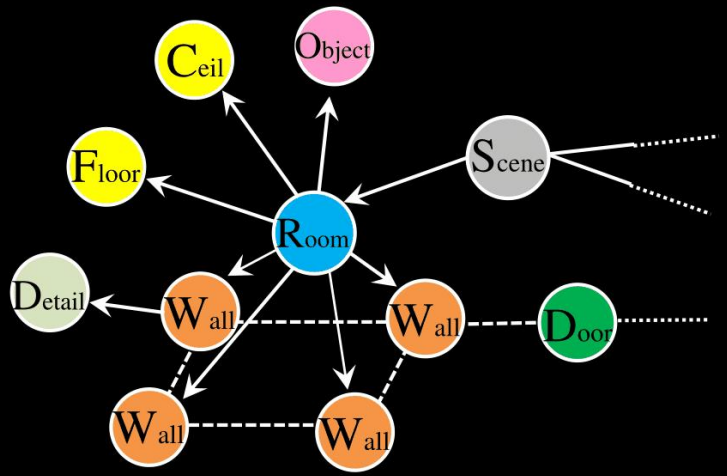
Structure grammar for indoor scenes
(Manhattan-world + single story)

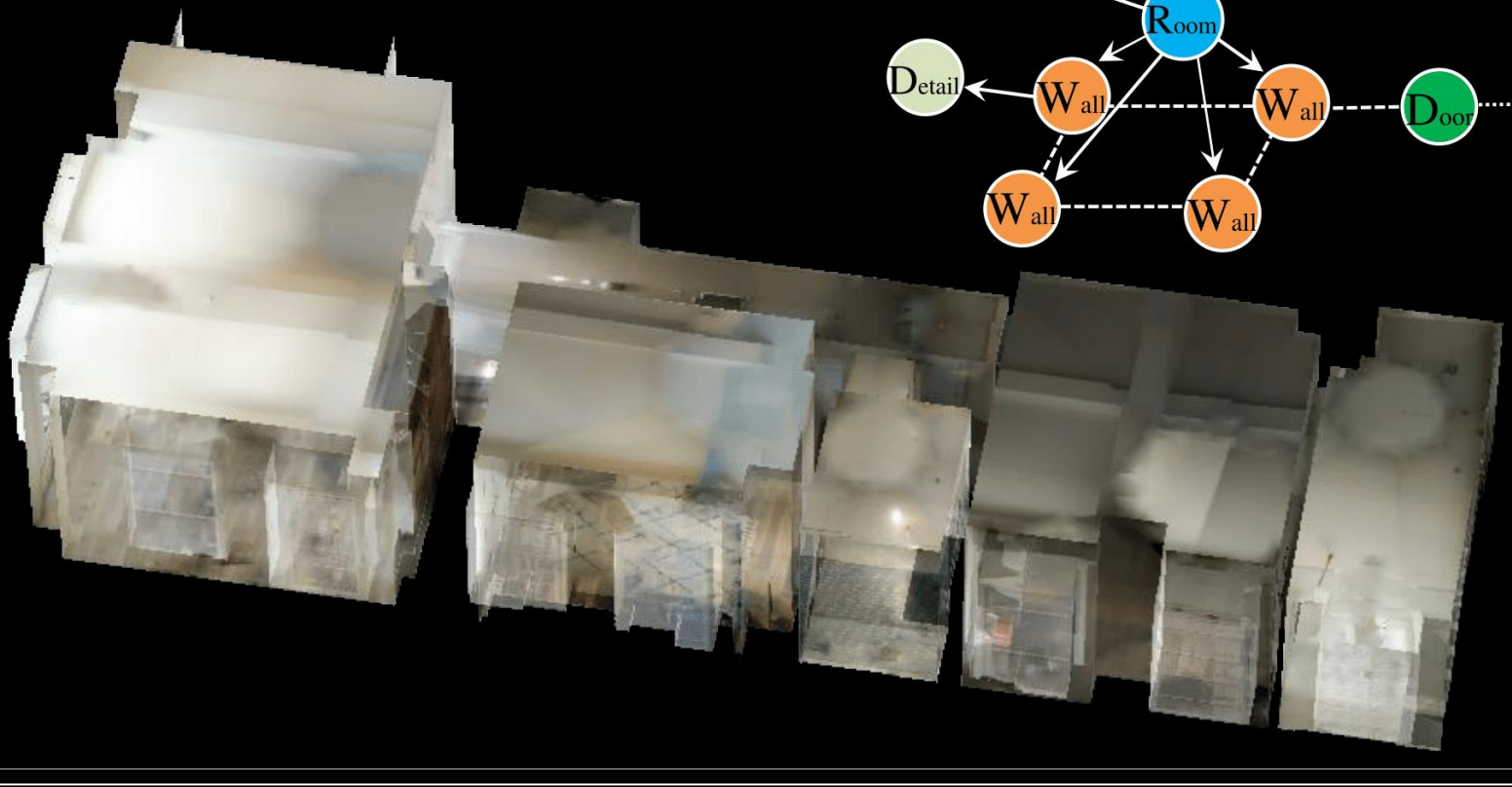


Flexible model compilation

guarantees manifoldness in architectural elements

Everything

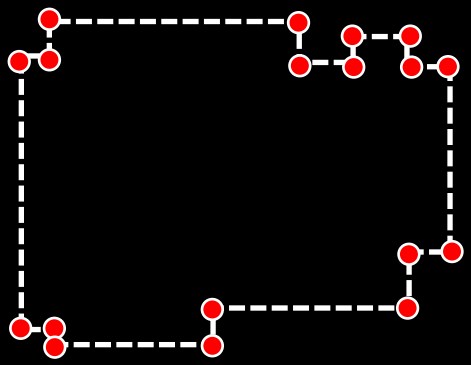




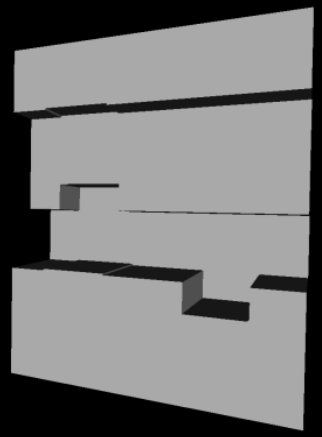
Structured reconstruction changes

- geometric representation
- reconstruction algorithm

based on an element type



1D polygon
for a room
via DP



2D offset-map
for details
via MRF+RPCA

3D point cloud
for an objects
via 3D segmentation

Experimental results

4M - 10M input points

1.6K-3.6K output polygons (excluding objects)

- **934 sec – 3198 sec** for graph reconstruction
- **0.5 sec – 2.0 sec** for model compilation

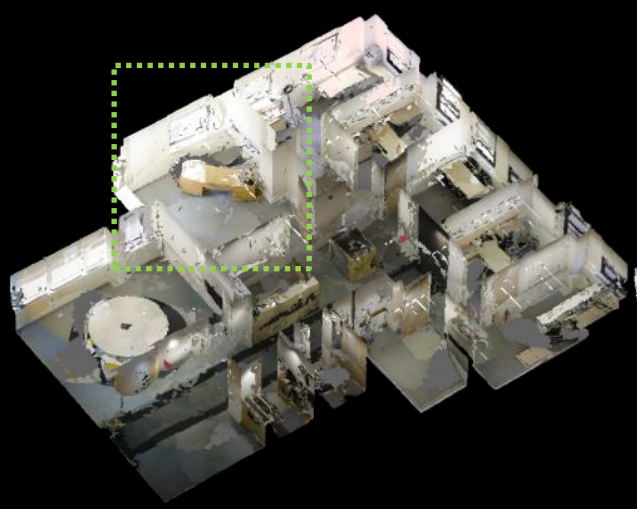
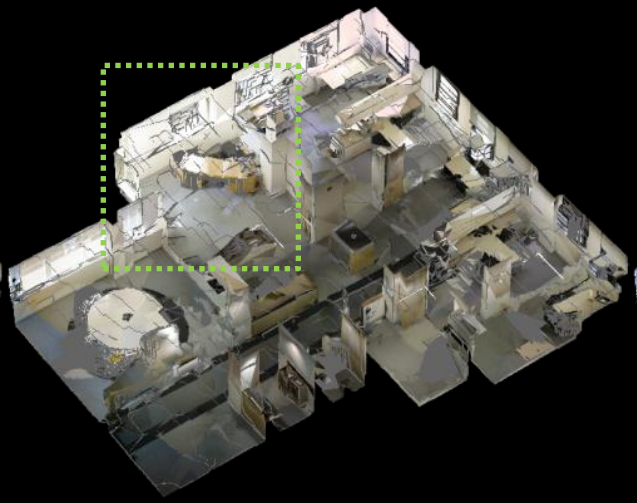
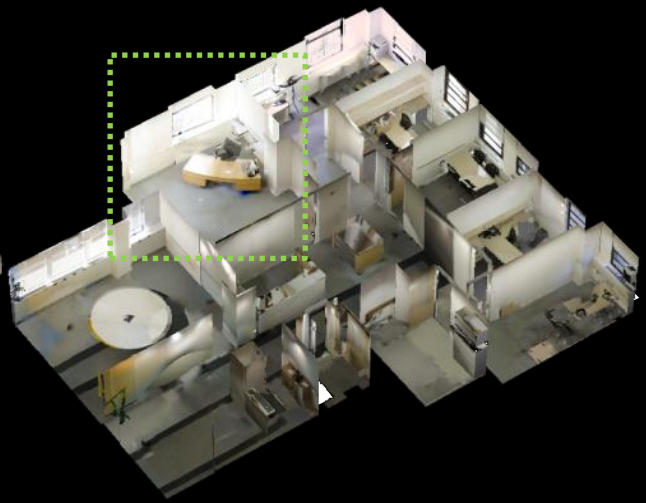
Indoor navigation

Structured Indoor Modeling, Satoshi Ikehata, Hang Yan, Yasutaka Furukawa. Washington University in St. Louis

Inverse CAD on SketchUp

Our model has only 1750 faces from 5,000,000 input points

Comparison with other methods



Poisson [Kazhadan2013]

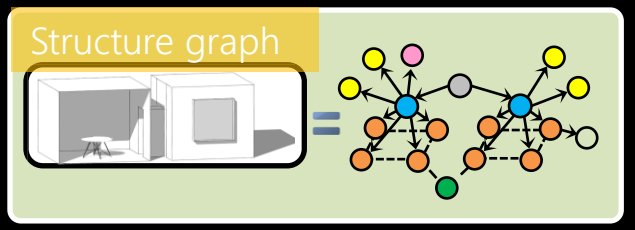
Vgcut [Furukawa2009]

Structured modeling (Ours)

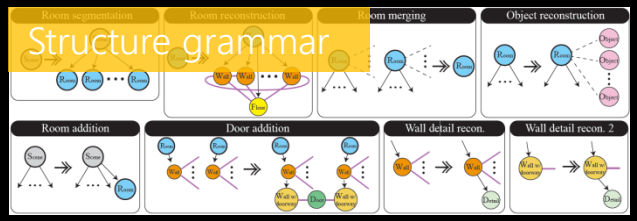
Summary and future work

Contributions

Structure graph



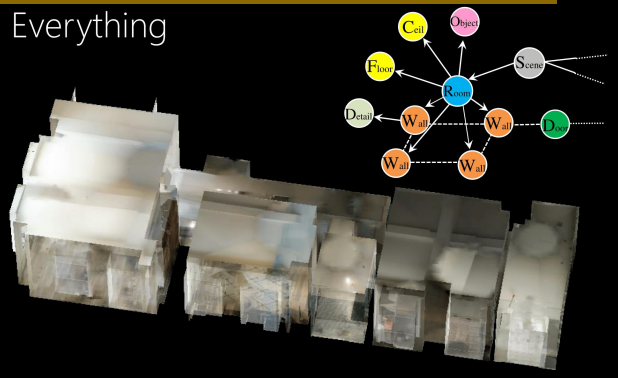
Structure grammar



Framework contribution

CAD quality indoor 3-D models

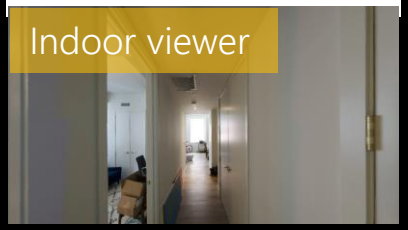
Everything



Technical contribution

Floorplan generation

Indoor viewer



System contribution

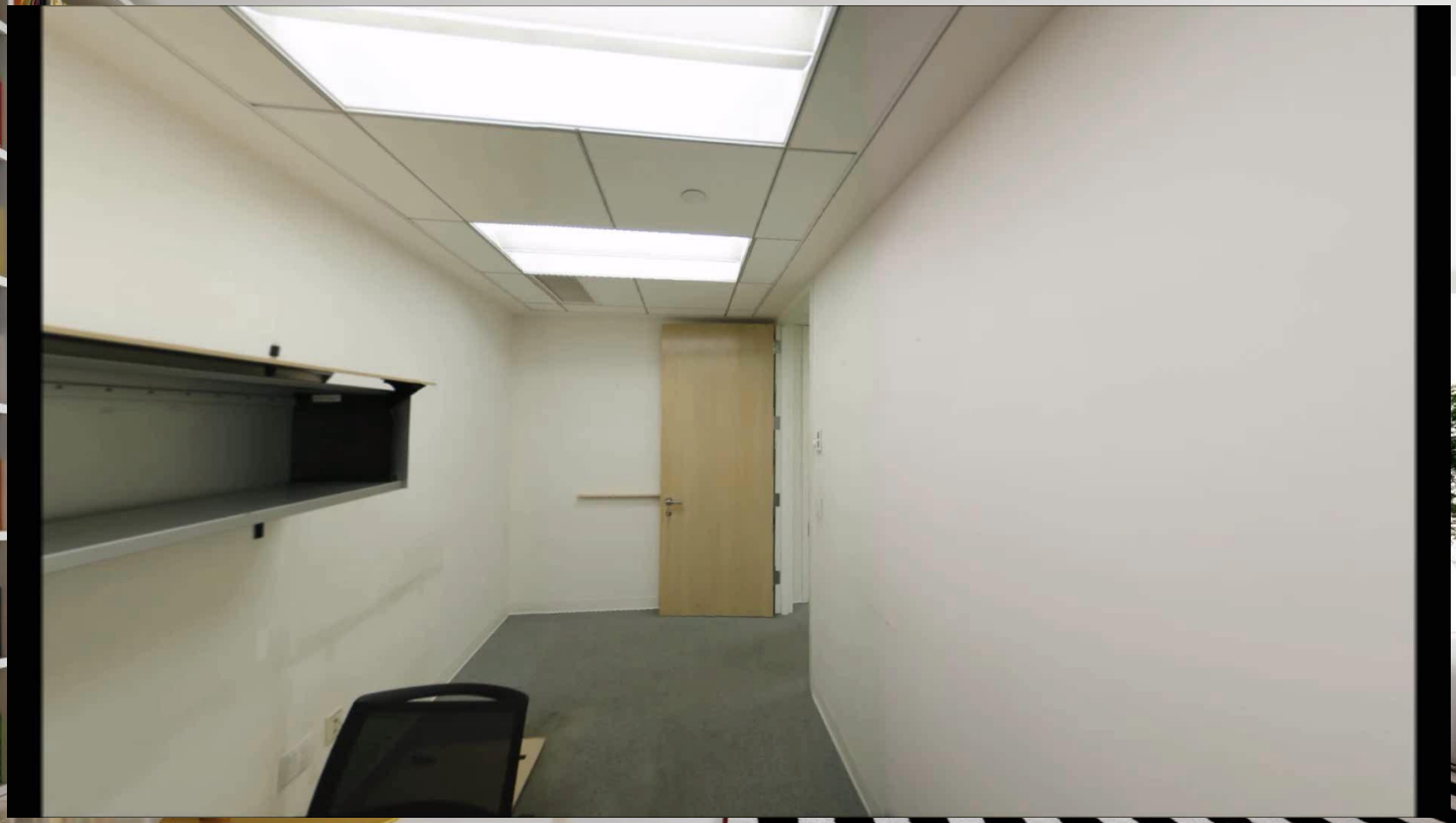
Future work

Structure grammar for multi-story, non-Manhattan building

Extension to the general 3-D object

Thank you very much!

Dataset and source codes will be released



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