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Indexing 3D Scenes Using the Interaction Bisector Surface

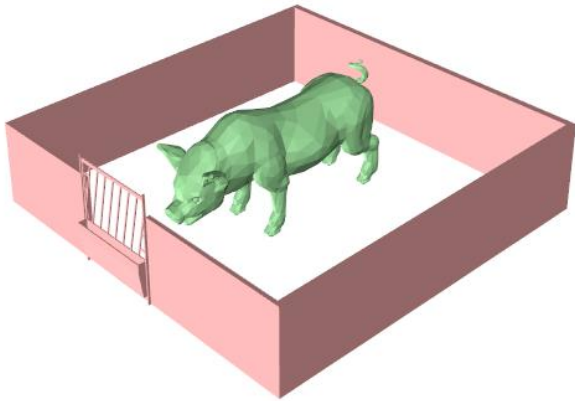
Xi Zhao

He Wang

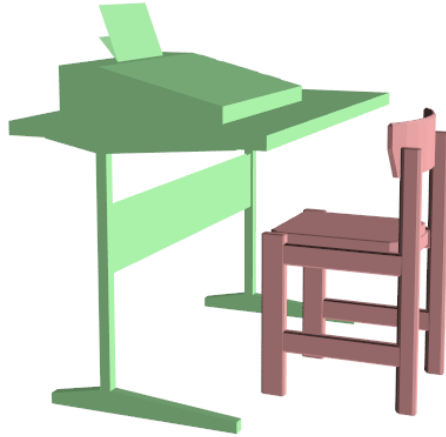
Taku Komura

University of Edinburgh

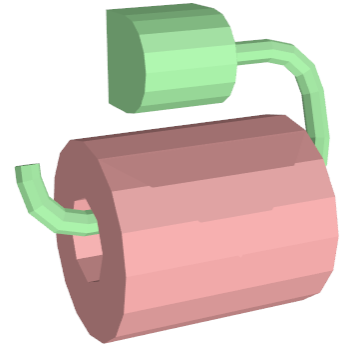
How do we describe the spatial relationships between these pairs of objects?



“surround”



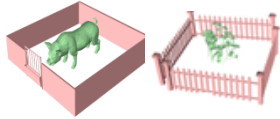
“tucked under”



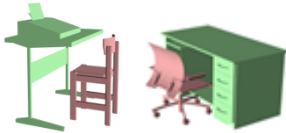
“hook on”

How can we quantify these spatial relationships?

“surround”



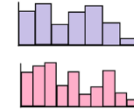
“tuck under”



“hook on”



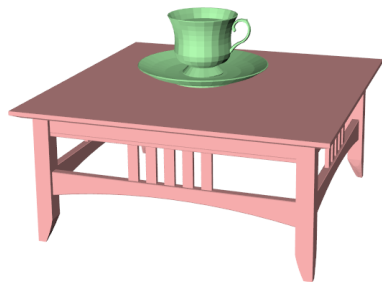
	P	PDI	PDD	PDDb	DIS
S	78.33%	84.07%	85.90%	82.77%	41.25%
C	80.00%	96.00%	92.00%	100.00%	44.00%
S+C	76.47%	81.37%	83.33%	84.31%	38.73%



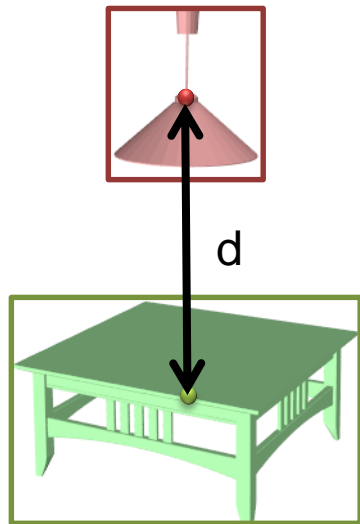
0.00	0.12
0.00	0.12
0.00	-0.12
0.00	-0.12



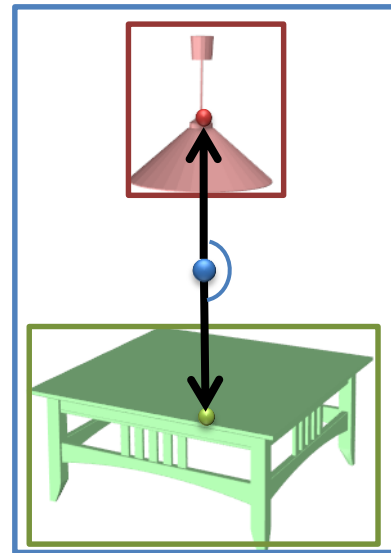
Previous Representations of Spatial Relationships



1. Contact
[Fisher et al. 2011]



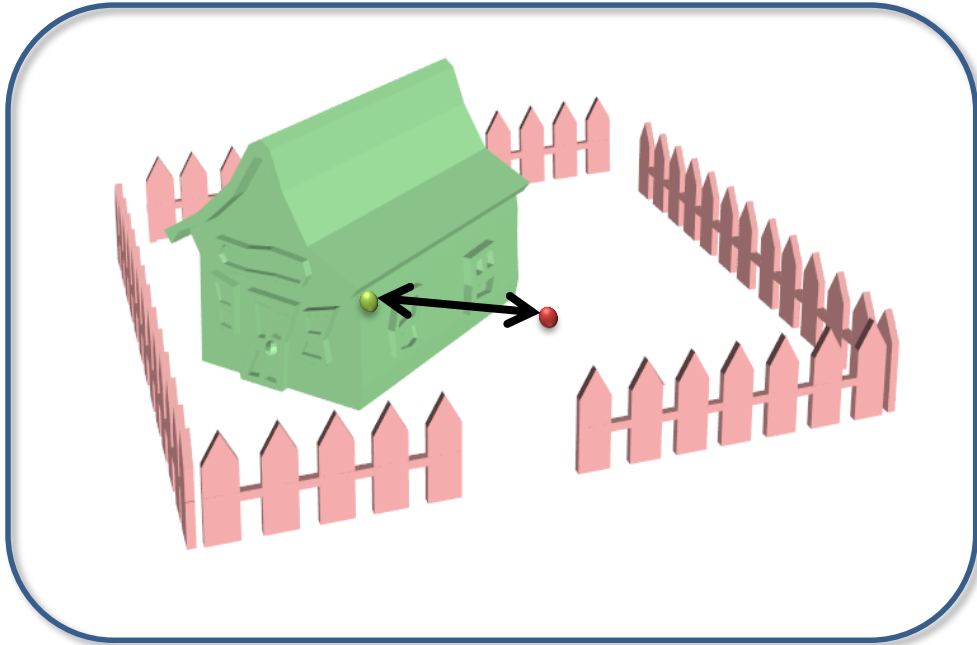
2. Distance
[Fisher et al. 2010]



3. Relative direction
[Fisher et al. 2010]

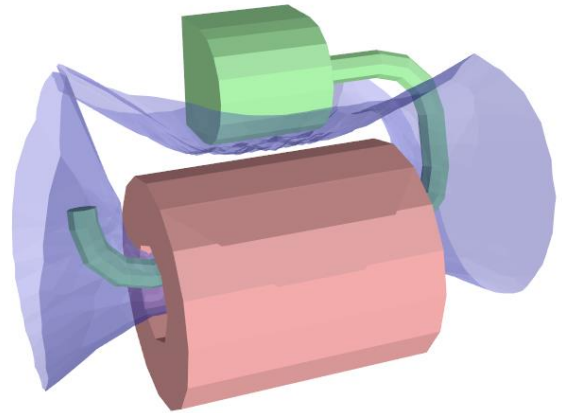
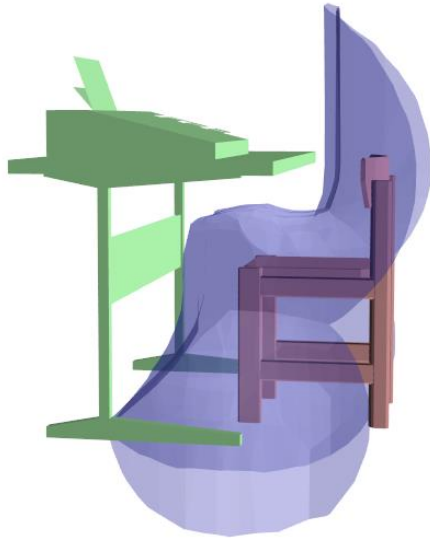
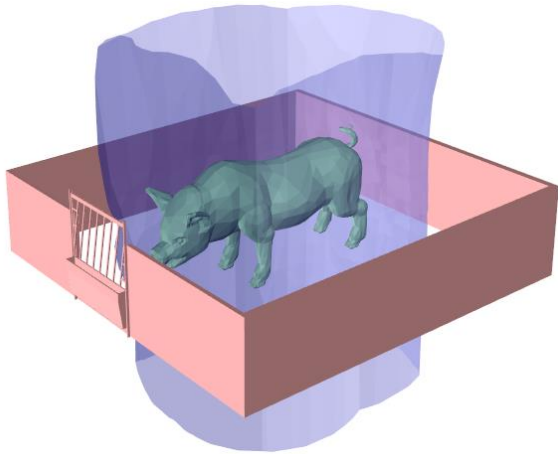
Limitation of Previous Presentations

Distances between object centres for these two scenes are quite similar:



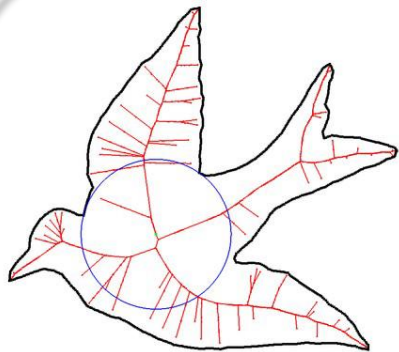
Objective

- Quantify spatial relationships by **Interaction Bisector Surface (IBS)**

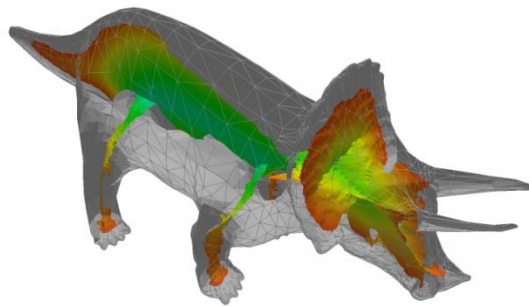


Medial Axis and IBS

Medial Axis

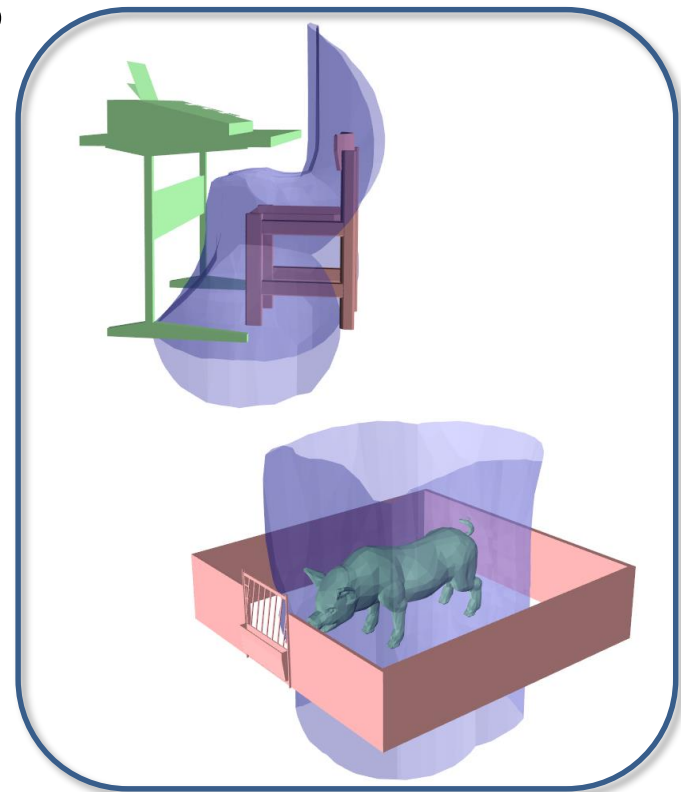


2D Medial Axis
[Shapiro. 2011]



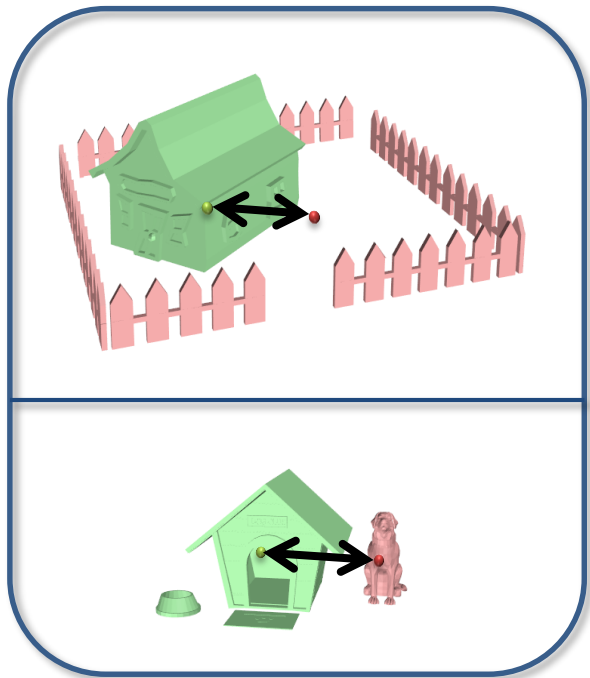
3D Medial Axis
[Sud et al. 2004]

IBS

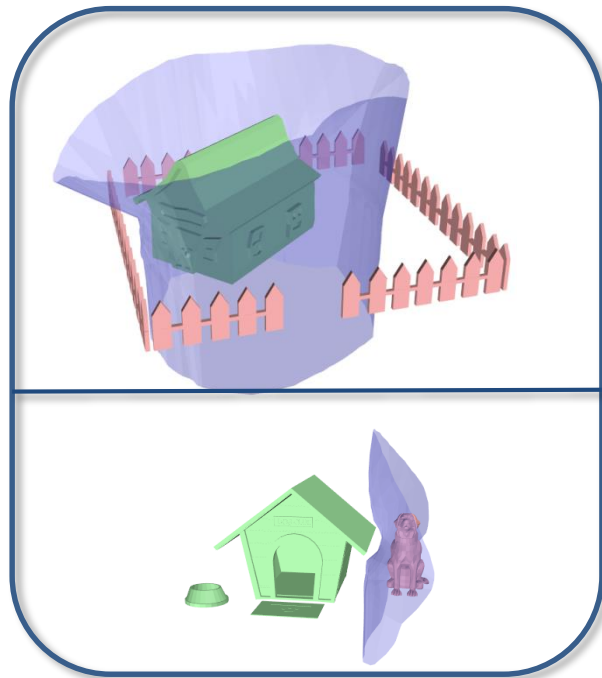


Previous Representation vs IBS

Distance between object centres:

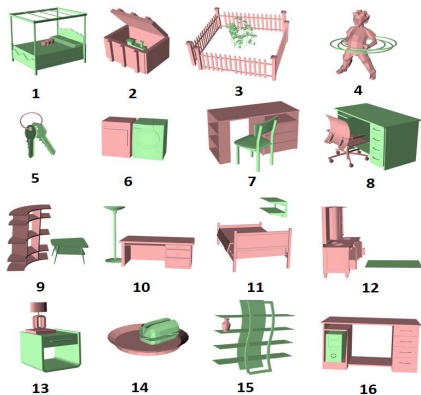


Interaction Bisector Surface (IBS):

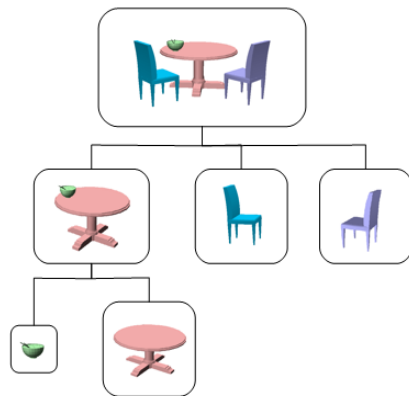


Objective

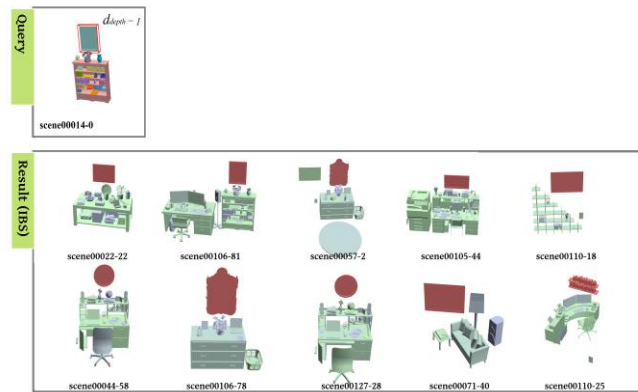
- Apply our new representation IBS to 3D scenes analysis



Scene classification



Scene structure construction



Retrieval

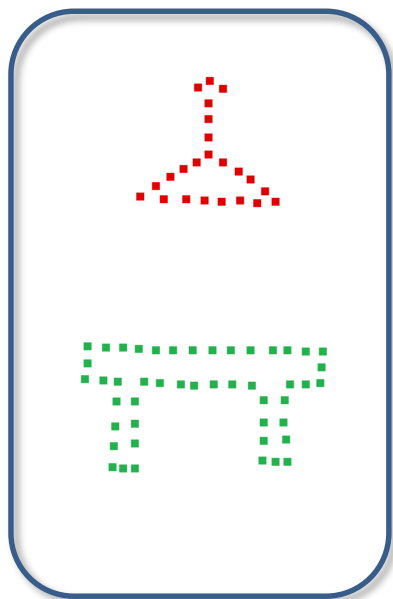
Overview

- **Basics of IBS**
 - **Computation**
 - **Features**
- Applications
 - Scene classification
 - Scene structure analysis
 - Spatial relationship based retrieval

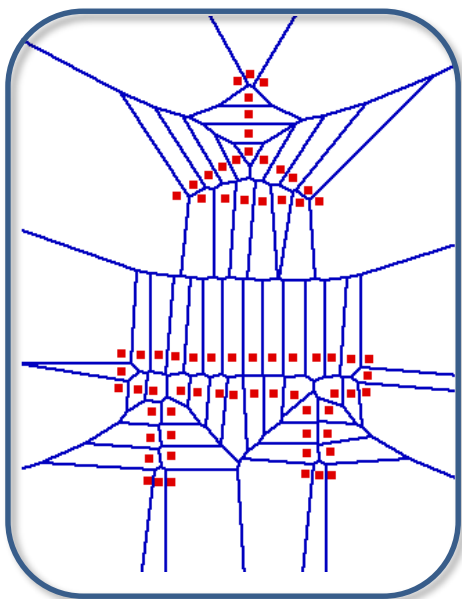


Computation of IBS

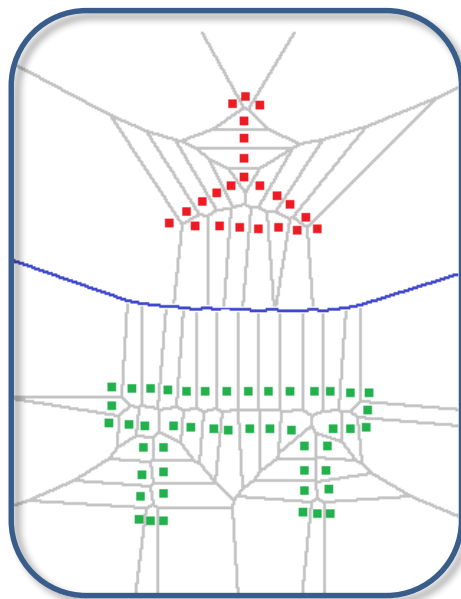
Input



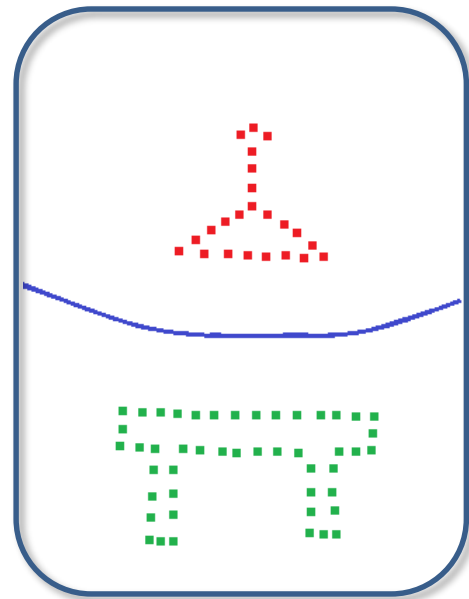
Voronoi Diagram



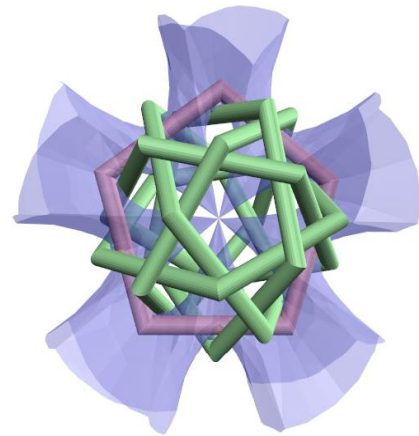
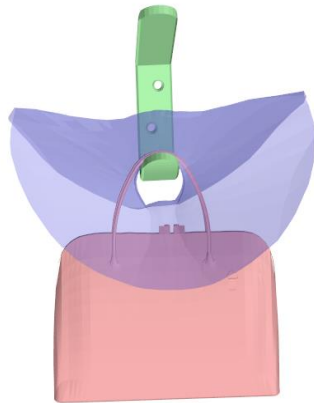
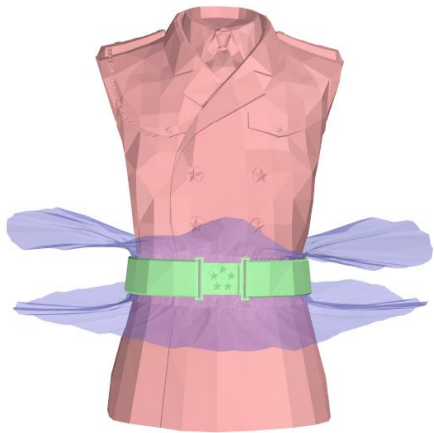
Select Voronoi edges
between two parts



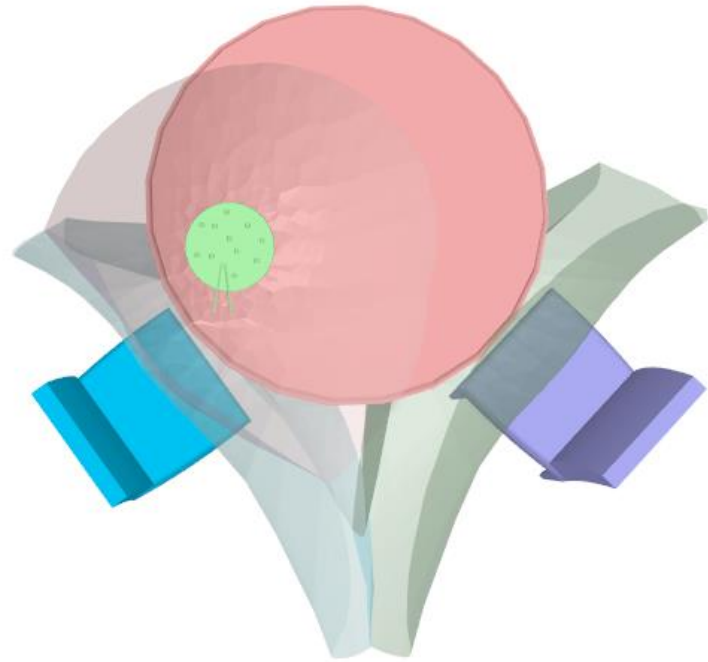
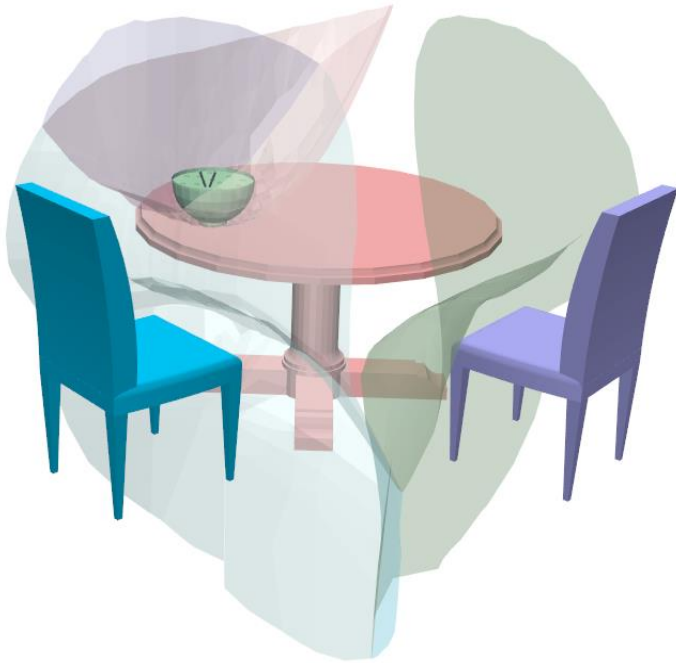
Resulting IBS



IBS Between Two Objects



IBS Between Multiple Objects



IBS Features

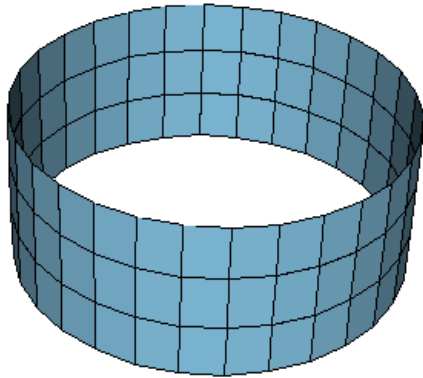
Features of IBS which are useful for scene analysis:

- Topological features (Betti numbers)
- Geometric features (distance, direction, PFH)

Topological Features: Betti Numbers

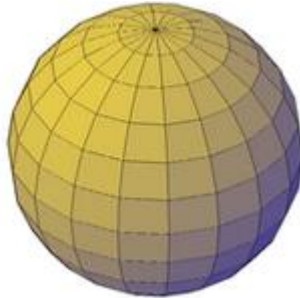
b_1 : number of loops

b_2 : number of closed surfaces



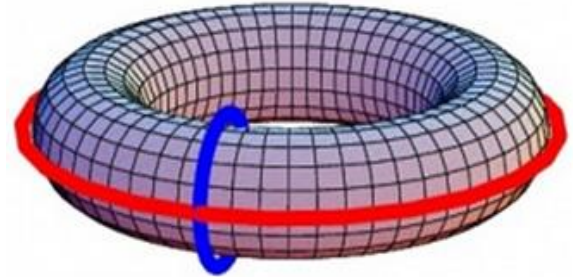
$$b_1 = 1$$

$$b_2 = 0$$



$$b_1 = 0$$

$$b_2 = 1$$



$$b_1 = 2$$

$$b_2 = 1$$

Topological Features



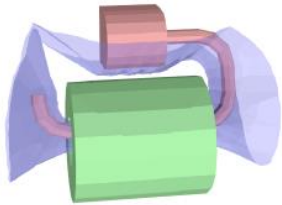
$$b_1 = 0$$
$$b_2 = 0$$



$$b_1 = 0$$
$$b_2 = 1$$



$$b_1 = 1$$
$$b_2 = 0$$



$$b_1 = 2$$
$$b_2 = 0$$

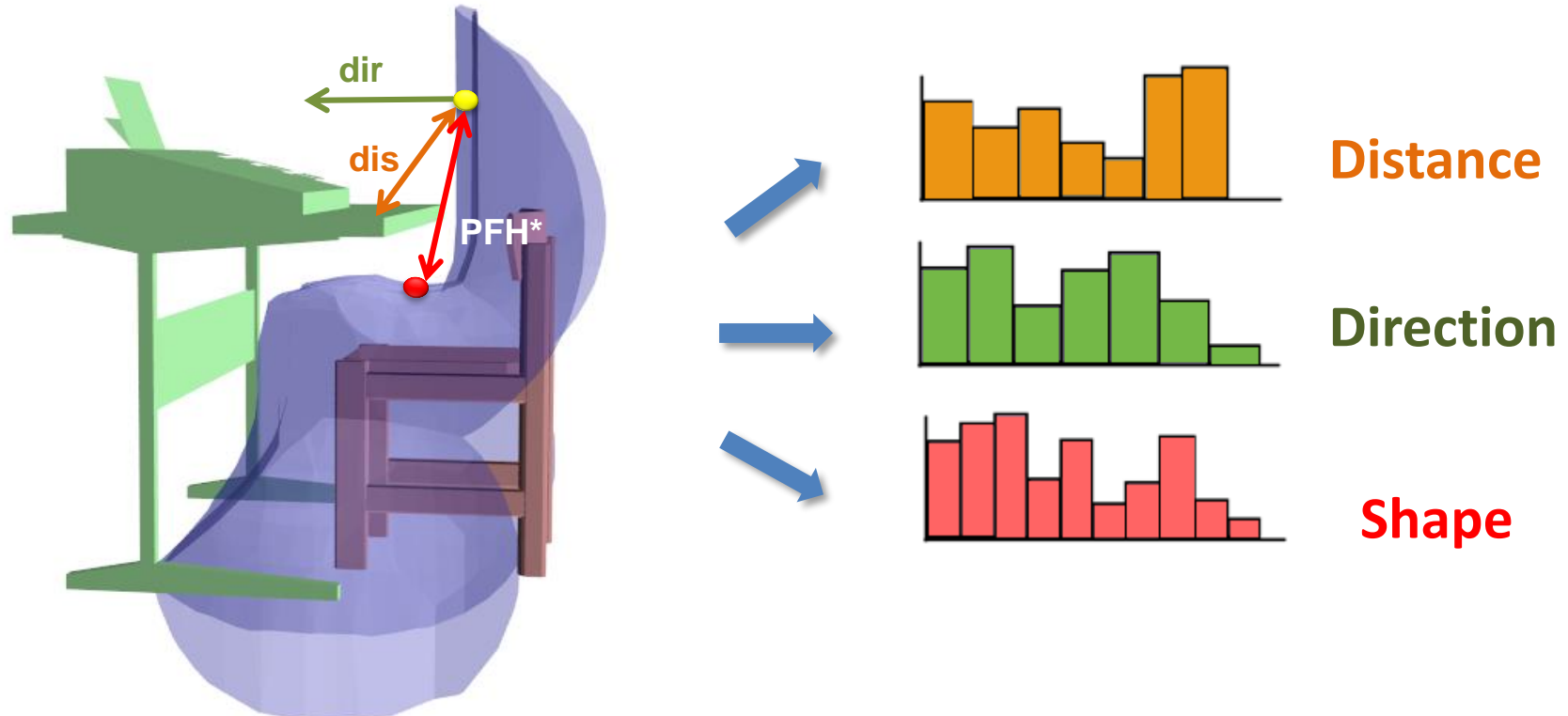


$$b_1 = 3$$
$$b_2 = 0$$



$$b_1 = 4$$
$$b_2 = 0$$

Geometric Features



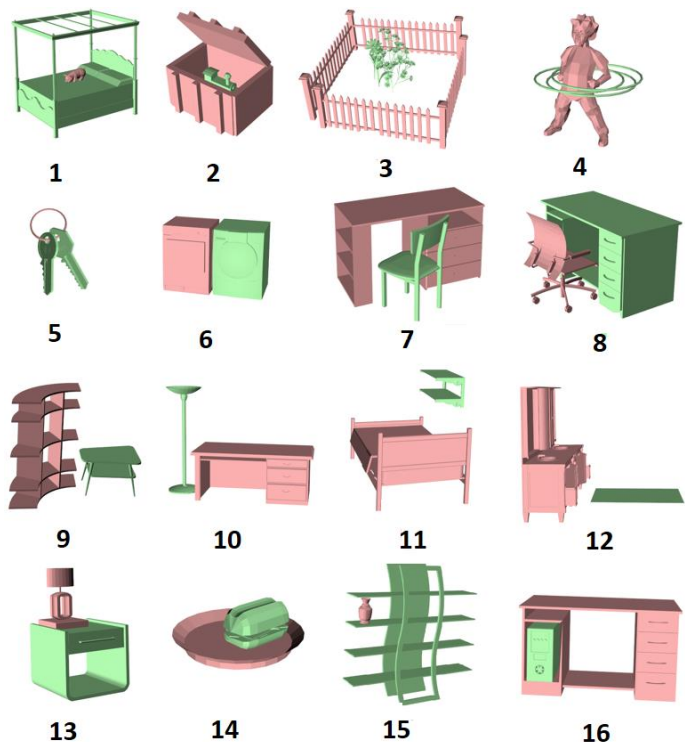
*PFH: Point Feature Histogram [Rusu et al. 2008]

Overview

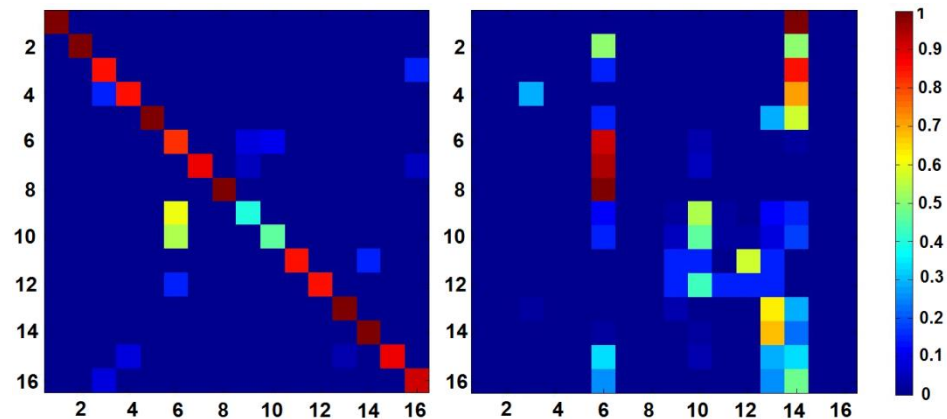
- Basics of IBS
 - Computation
 - Features
- **Applications**
 - **Scene classification**
 - **Scene structure analysis**
 - **Spatial relationship based retrieval**

Classification

Database



Resulting confusion matrix











Our method

Previous method

Building Scene Structure

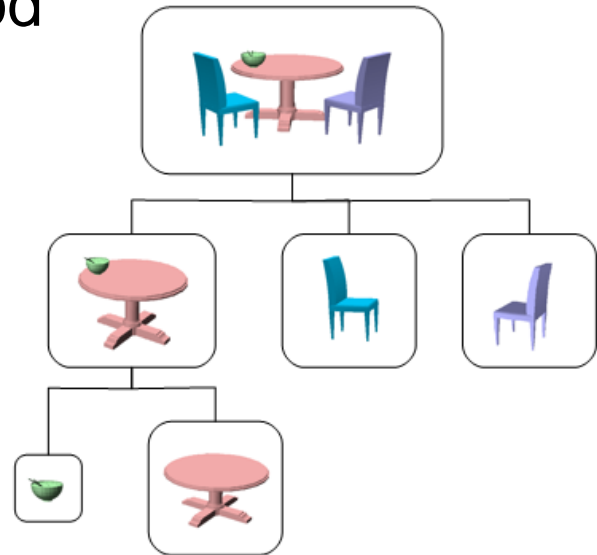
Compute
closeness matrix
based on IBS



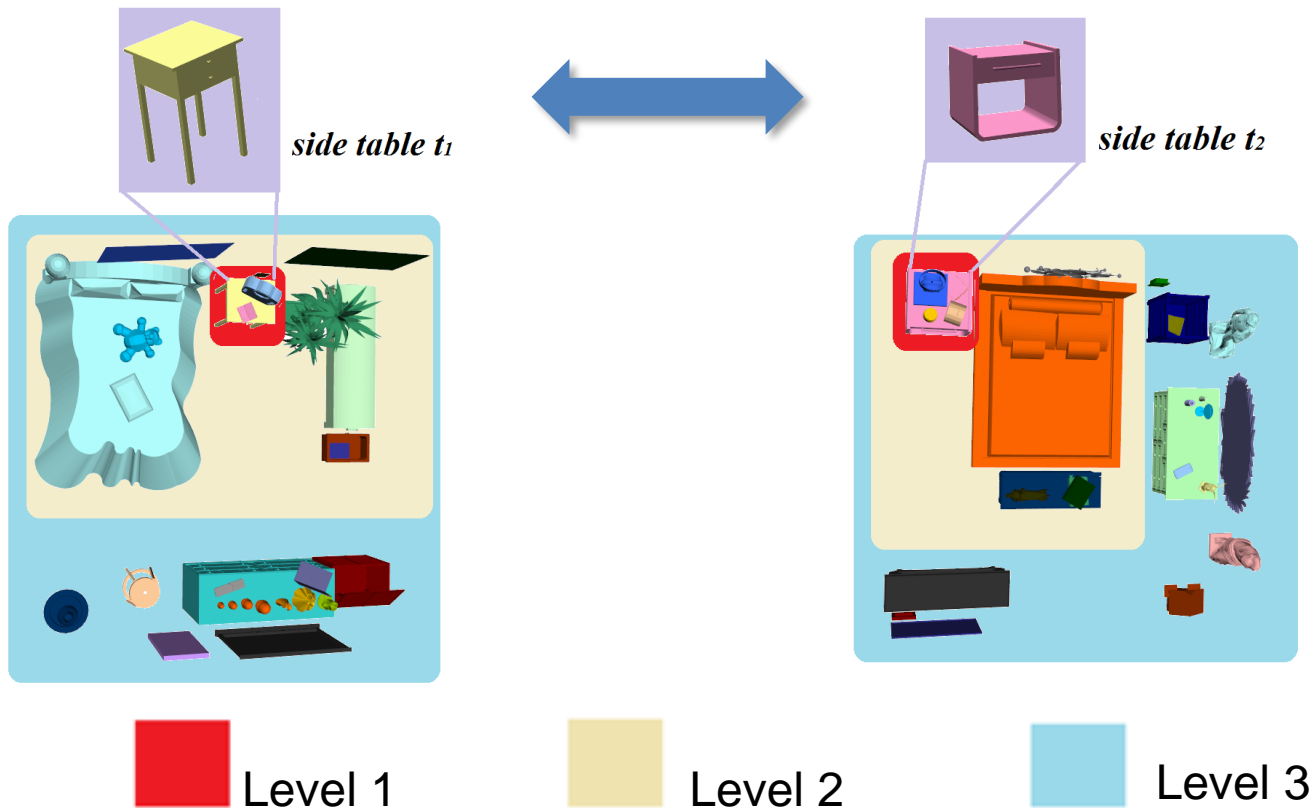
				
	--	0.77	0.02	0
	0.77	--	0.61	0.61
	0.02	0.61	--	0
	0	0.61	0	--



Build scene
structure by HAC
method



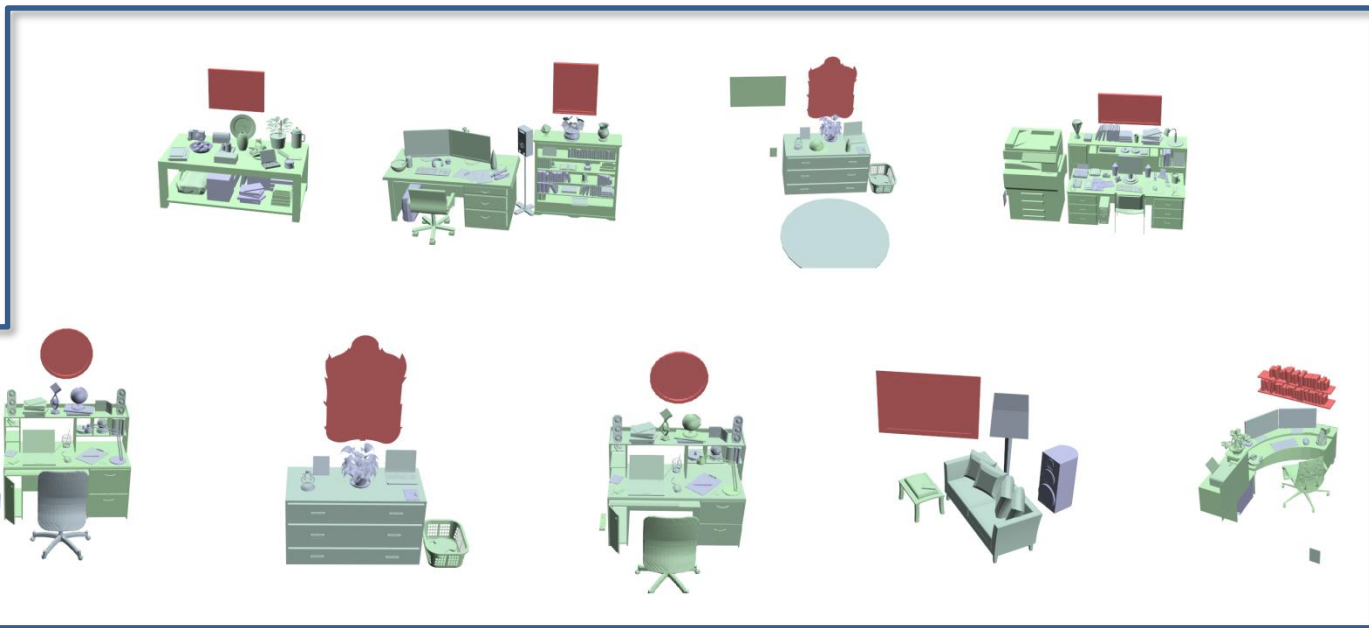
Retrieval of Object in the Scene



Retrieval of Object in the Scene

Query:

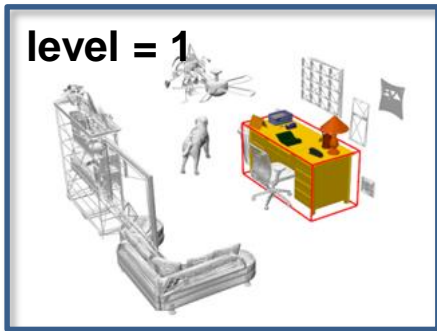
Results:



Retrieval of Object in the Scene

Query:

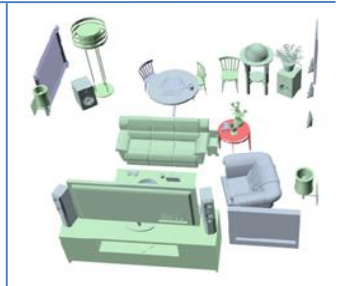
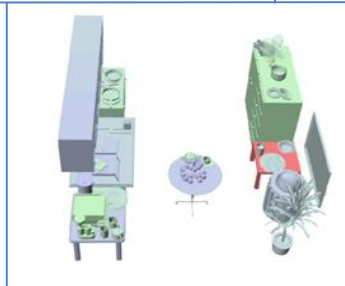
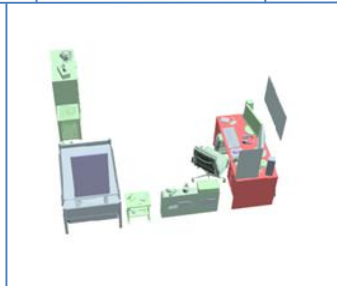
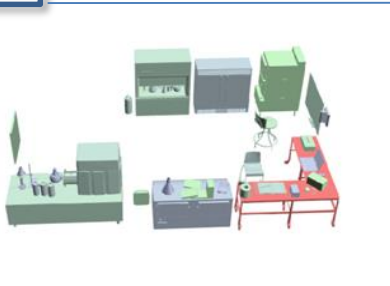
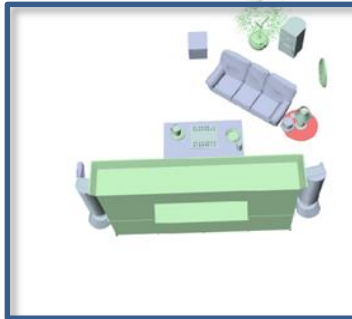
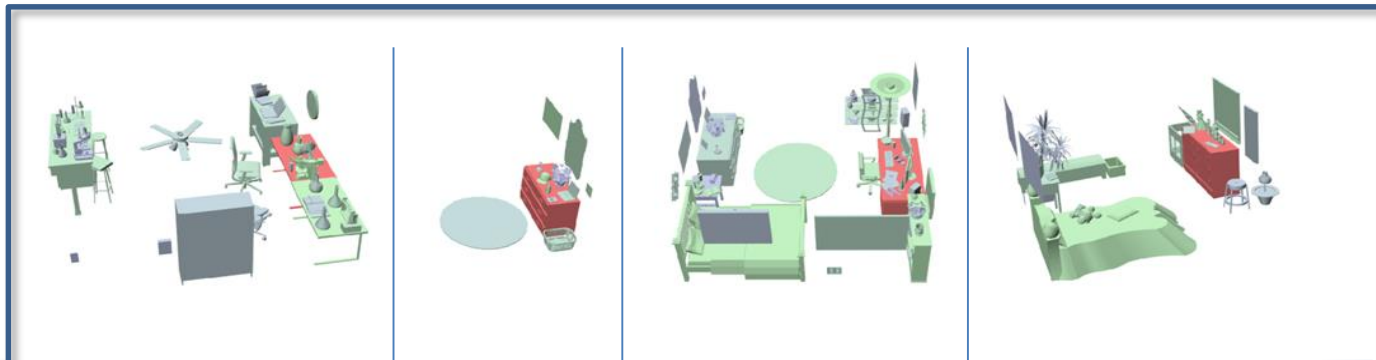
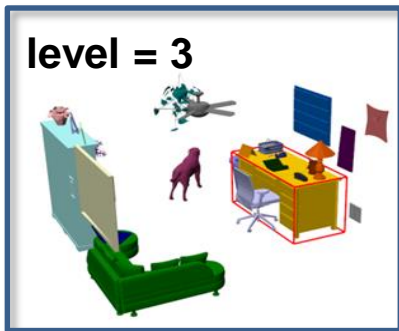
Results:



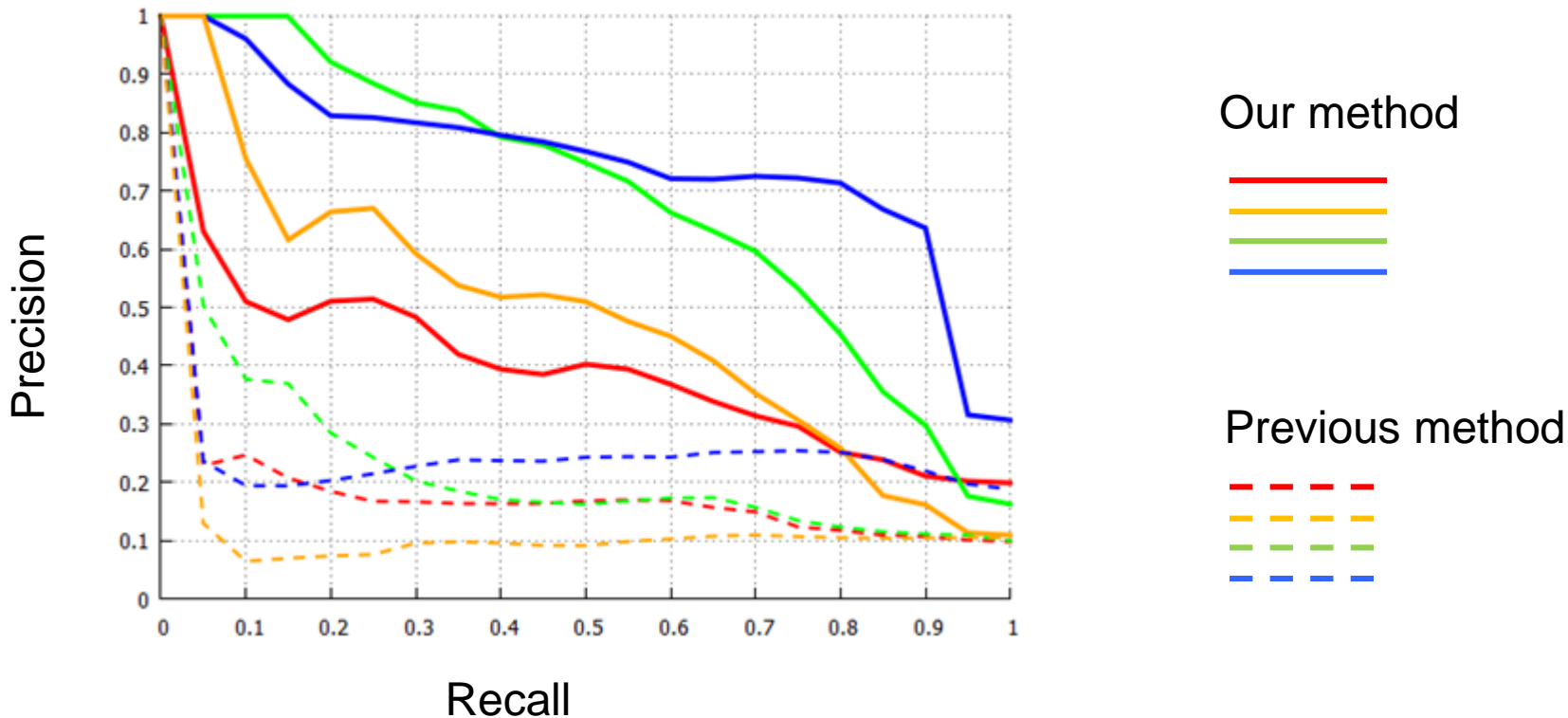
Retrieval of Object in the Scene

Query:

Results:

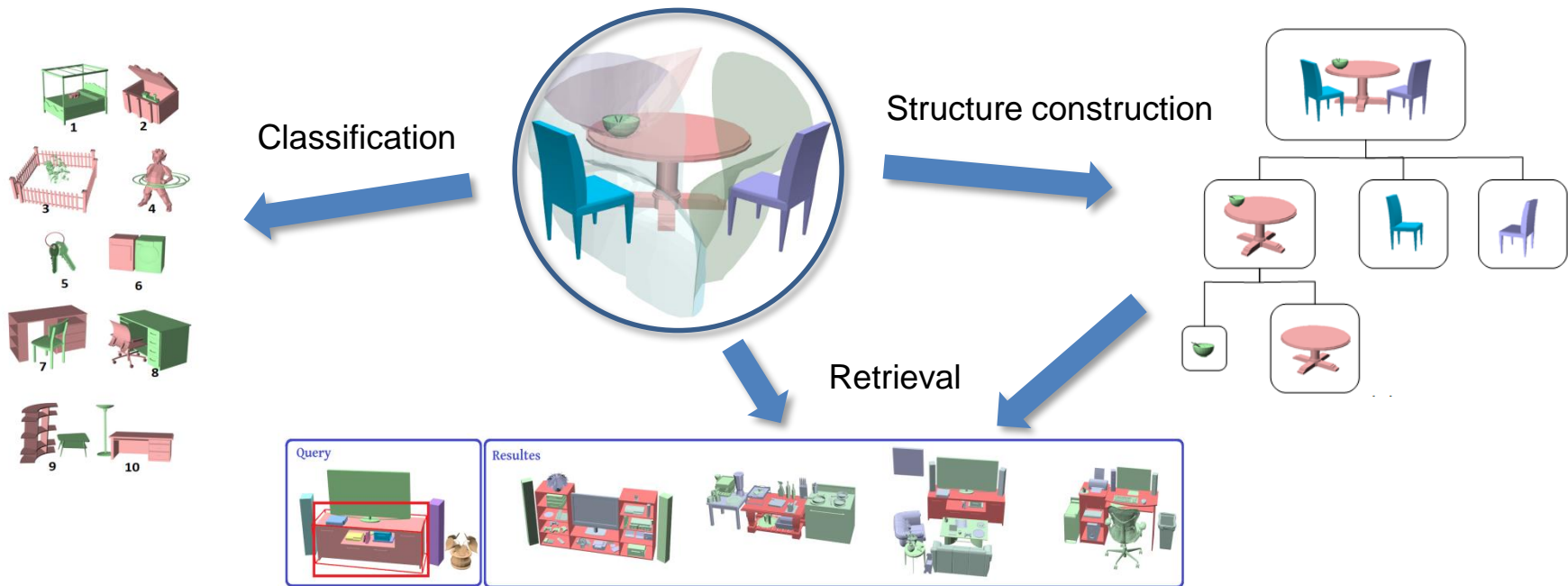


Evaluation of Retrieval Results



Conclusion

- IBS is a rich representation of spatial relationships between objects in 3d scenes



Limitations and Future Work

- Limitations
 - The computational cost is higher
 - Only focus on spatial relationship
- Future work
 - Extra features (labels, object geometry)
 - Whole scene retrieval
 - Character-object interaction

Acknowledgement



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Shin Yoshizawa



Attendees of user study



China Scholarship Council



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