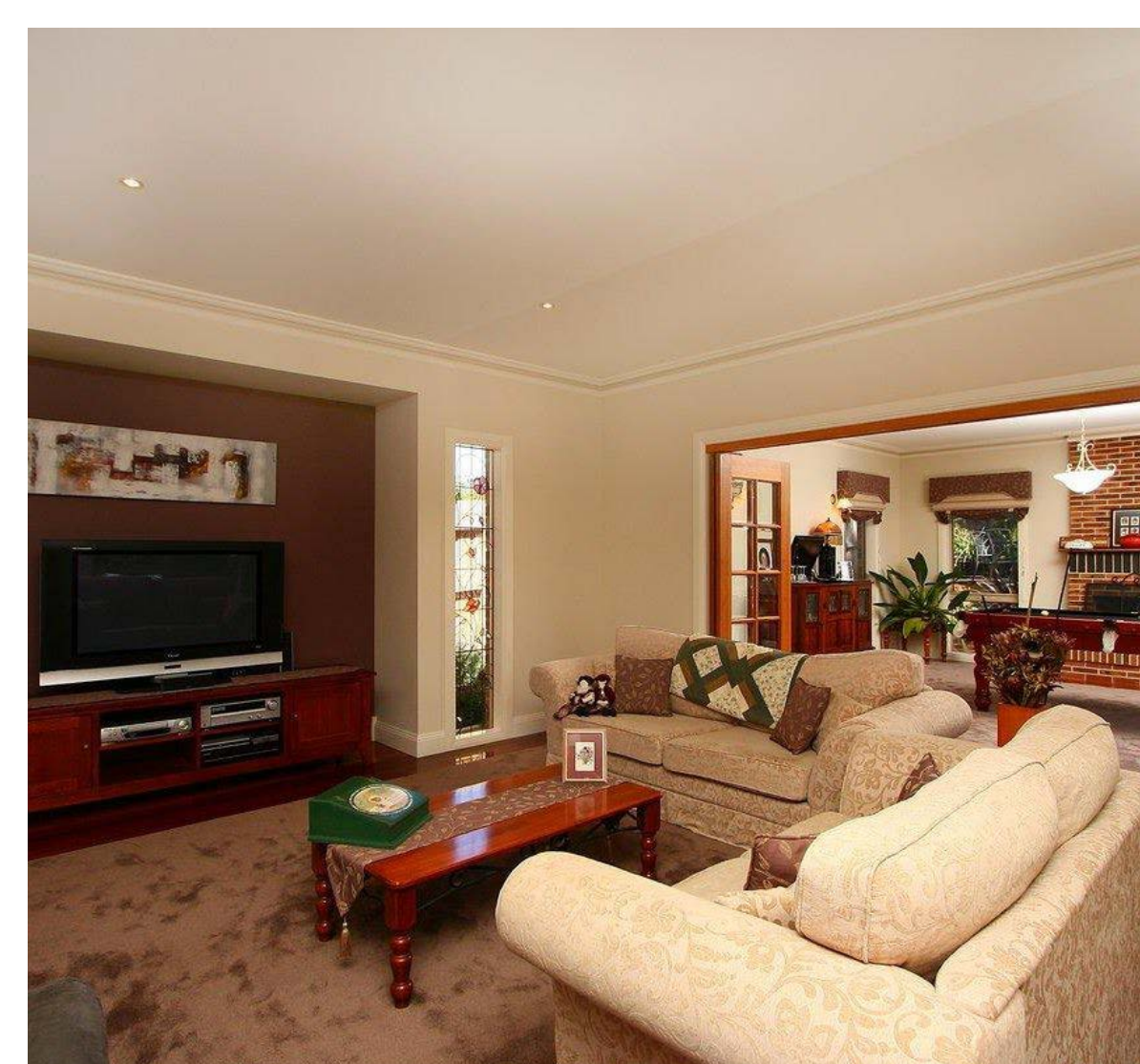


Motivation

Existing scene datasets contain only a limited set of views of a place, and they lack representations of complete 3D spaces. We introduce SUN3D, a large-scale RGB-D video database with camera poses and object labels, capturing the full 3D extent of big spaces.



2D View-based SUN database



3D Place-centric SUN3D database



UW Berkeley



NYU

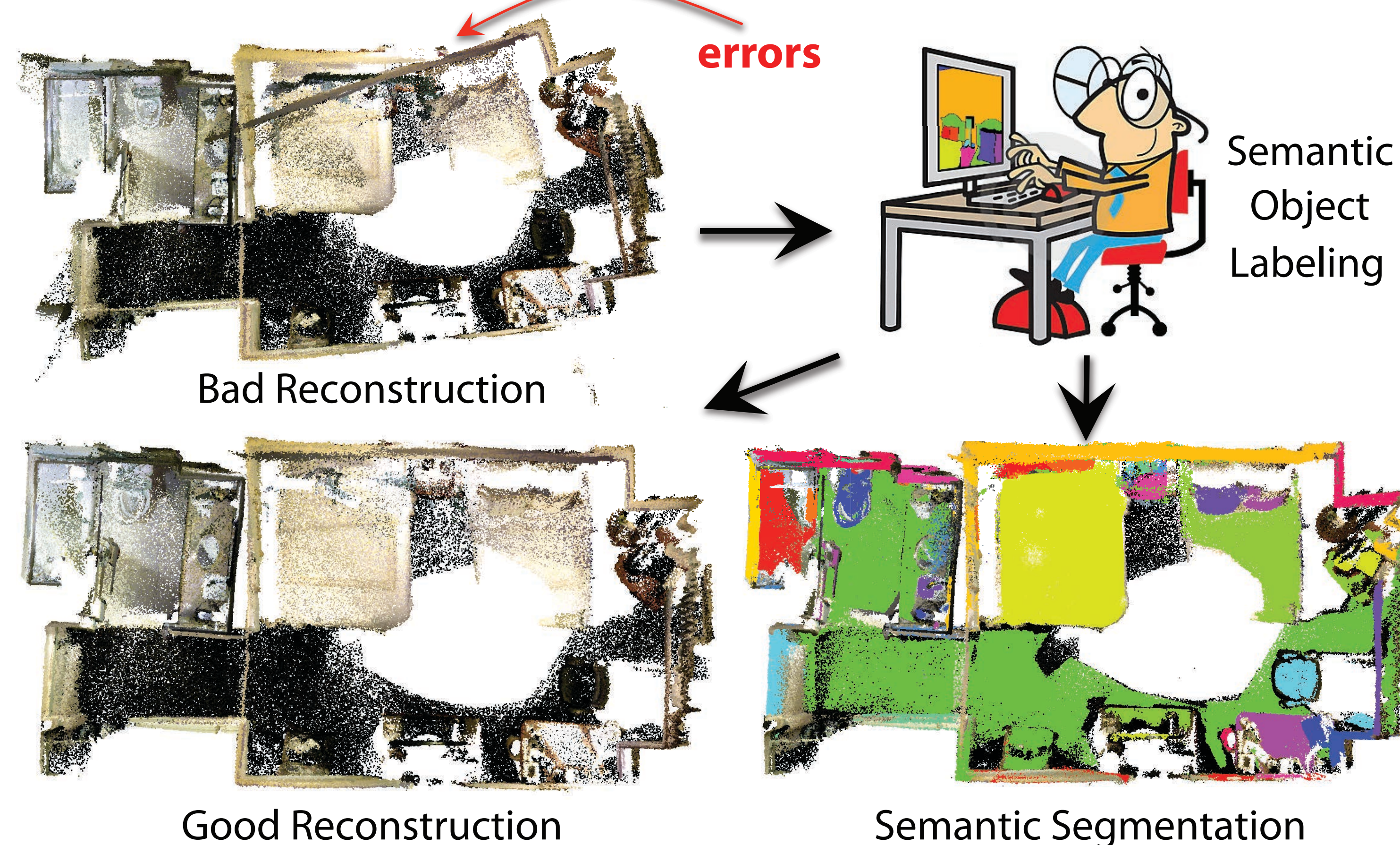


SUN3D

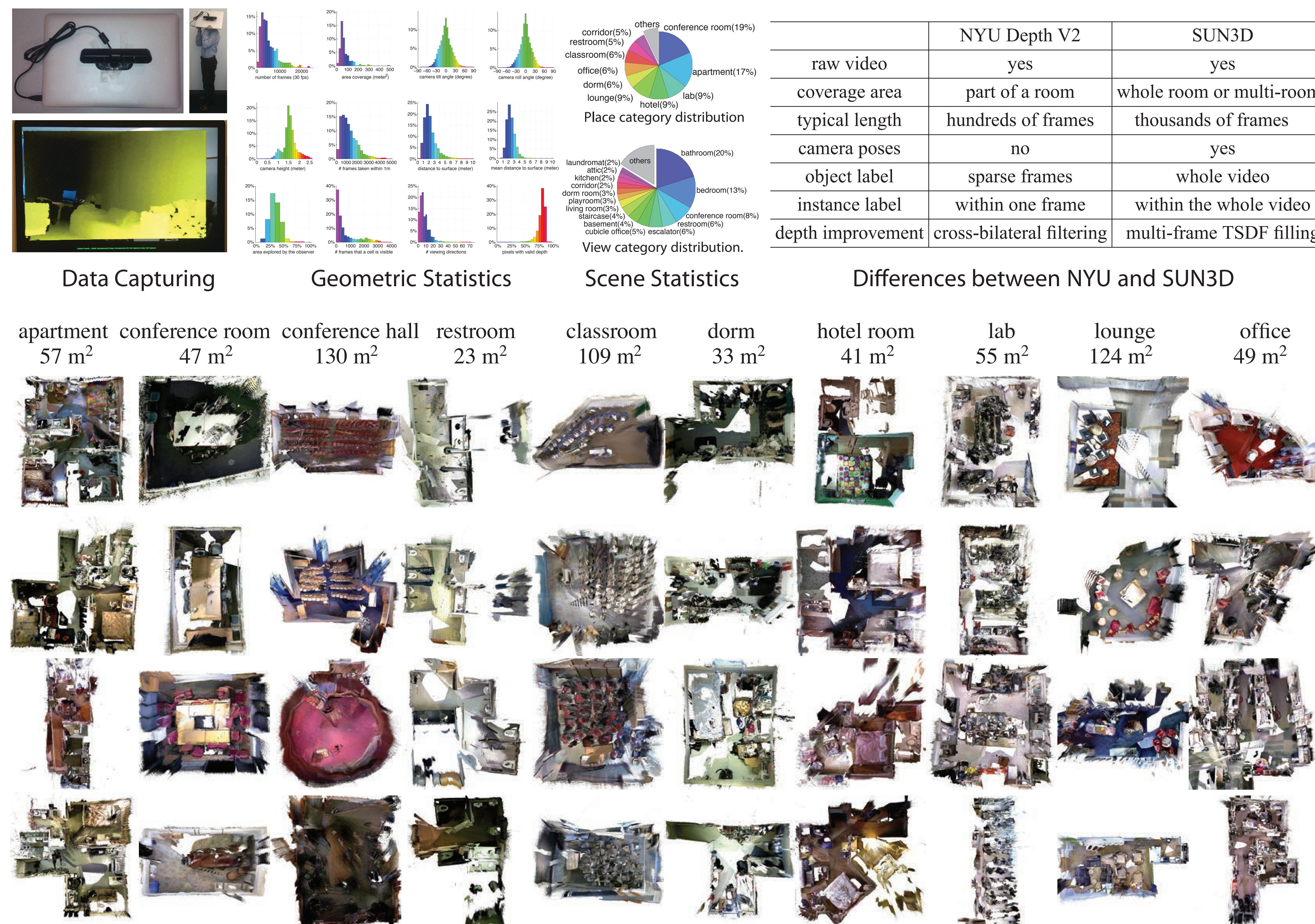
The tasks that go into creating such a dataset are difficult in isolation:

- Labeling videos is painstaking
 - SfM is unreliable for large spaces.
- But if we combine them together, we make the dataset construction task easier.

We use 3D to make object annotation easier, and we use object labels to correct large camera pose errors.

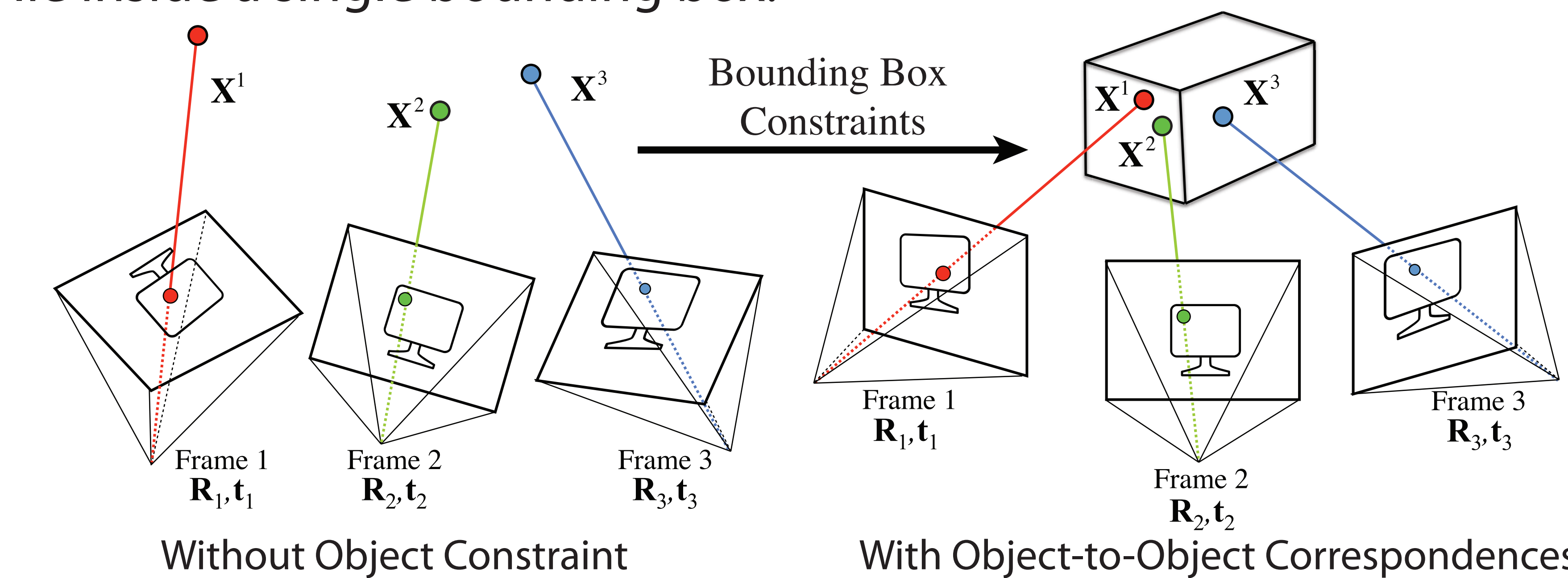


SUN3D: A Place-centric 3D Database



Generalized Bundle Adjustment

Idea: Turn object annotations into bounding box constraints to fix loop closure errors. Constrain the points for each object instance to lie inside a single bounding box.



$$\min \sum_c \sum_{p \in V(c)} (\|\tilde{x}_p^c - K[R_c|t_c] X_p\|^2 + \lambda_0 \|\tilde{x}_p^c - [R_c|t_c] X_p\|^2) + \lambda_1 \sum_o \sum_c \sum_{p \in L(o,c)} \Psi([R_o|t_o][R_c|t_c]^{-1} \tilde{x}_p^c, s_o)^2$$

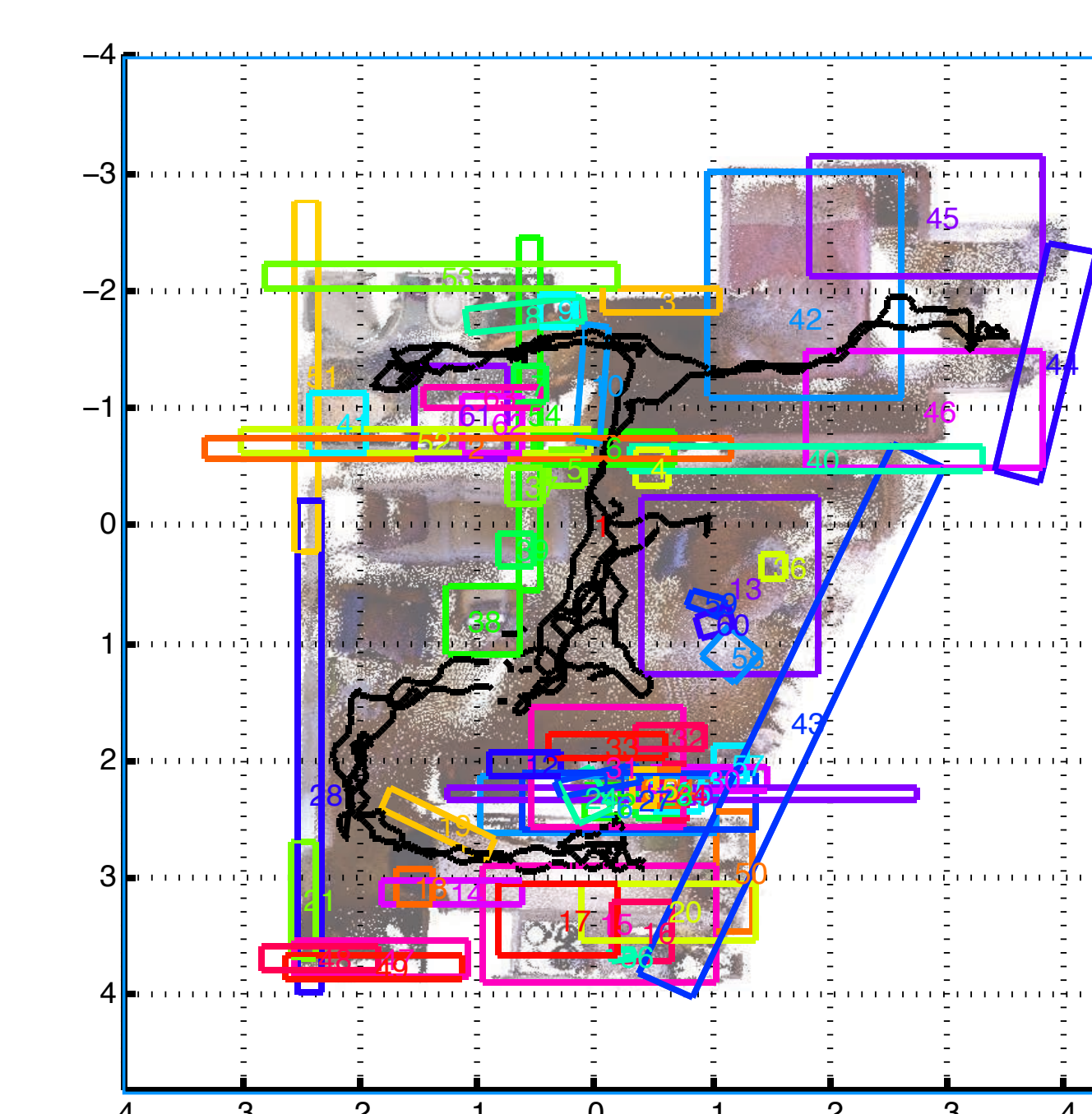
RGB-D bundle adjustment

where $\Psi(X, s) = \left\| \max\left(0, X - \frac{s}{2}, -X - \frac{s}{2}\right) \right\|$



Segmented Point Cloud Merged from Different Views

Bounding box costs



Visualization of the Constraints

“Data-driven” Brute-force SfM

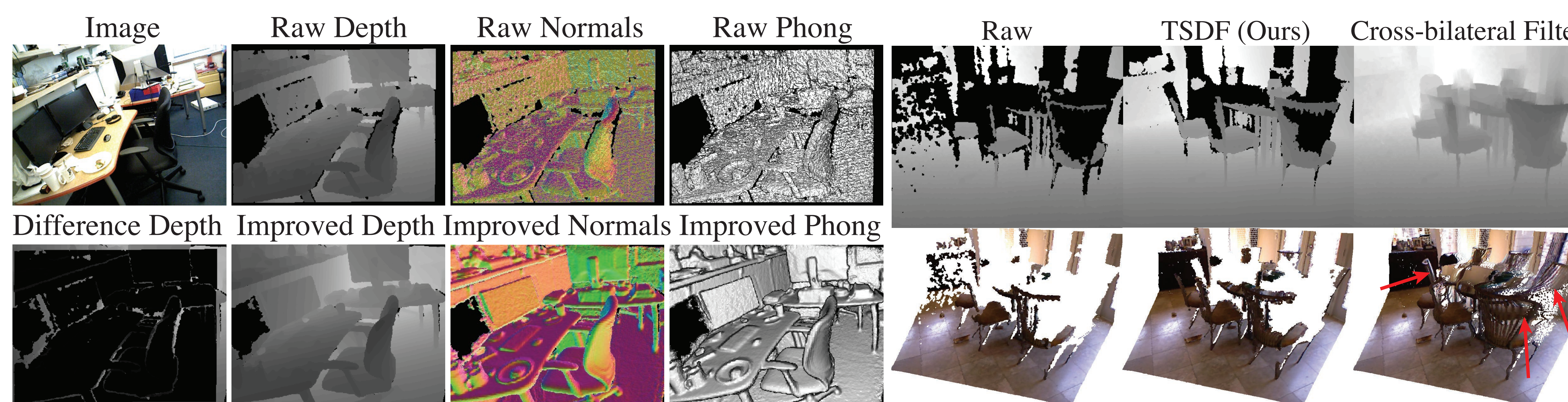
- Use conservative loop closing (high precision and low recall)
- Capture video in many passes so that similar views appear frequently, and loop closing succeeds.



Frame 1448

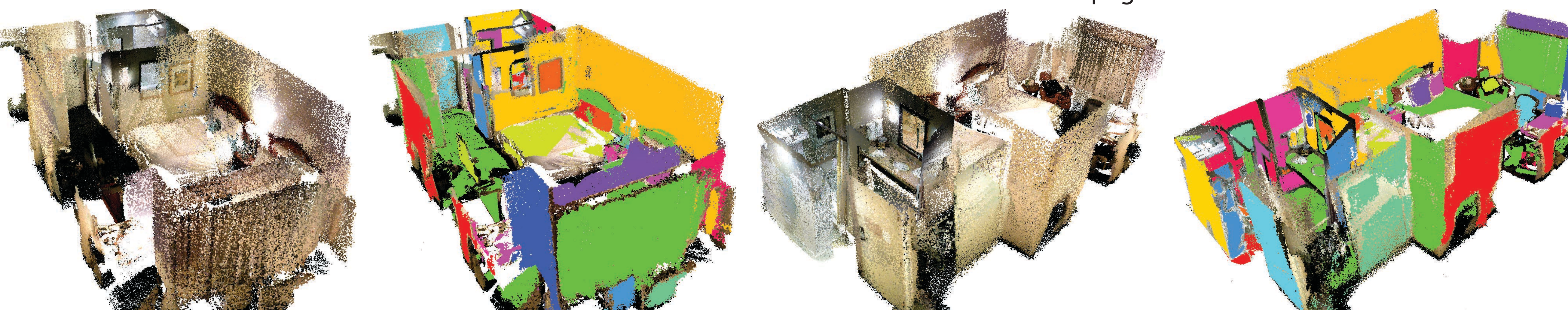
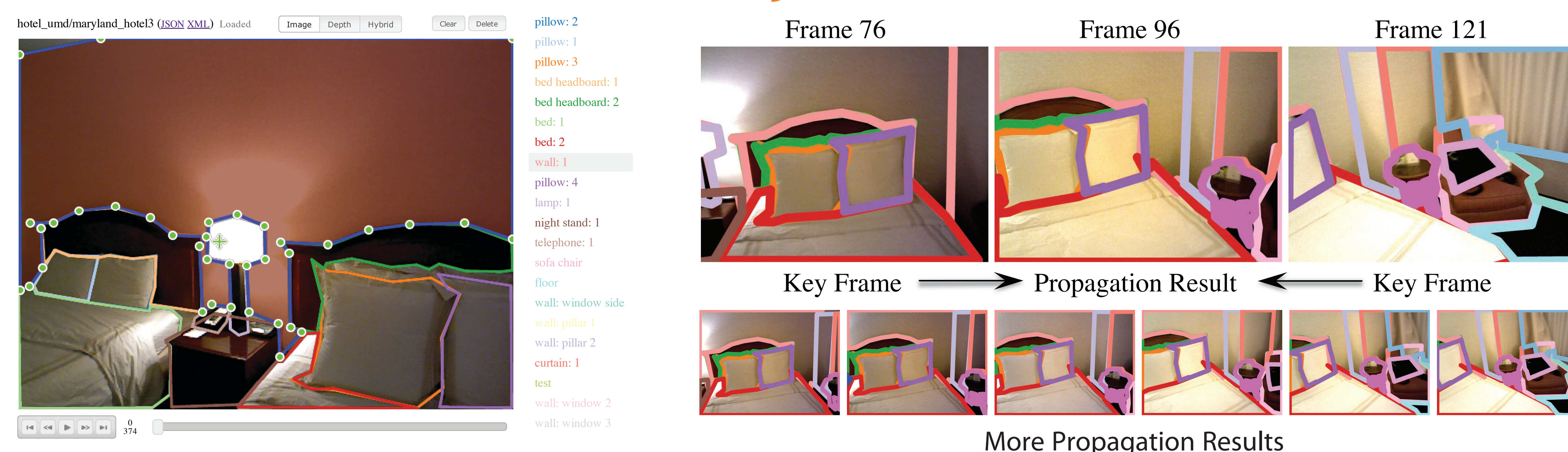
Frame 1188

BOW td-idf scores



TSDF-based Depth Map Improvement

Multi-view Object Annotation



Corrected Reconstruction and Object Annotations (Colored Based on Semantic Categories)

Data & Source Code Available

<http://sun3d.cs.princeton.edu>

SUN3D Data:

- RGB-D Video for Big Spaces
- Camera Poses
- Refined Depth Maps
- Object Labels (in progress)
- Point Cloud

Source Code:

- Automatic RGB-D SfM
- Generalized Bundle Adjustment
- TSDF Depth Improvement
- Online Annotation Tool
- IO functions to read SUN3D

References

- [1] SUN Database: Large-scale Scene Recognition from Abbey to Zoo. J. Xiao, J. Hays, K. A. Ehinger, A. Oliva, and A. Torralba. CVPR2010.
- [2] Indoor Segmentation and Support Inference from RGBD Images. N. Silberman, P. Kohli, D. Hoiem and R. Fergus. ECCV2012.
- [3] Shape Anchors for Data-driven Multi-view Reconstruction. A. Owens, J. Xiao, A. Torralba and W. T. Freeman. ICCV2013.
- [4] Recognizing Scene Viewpoint using Panoramic Place Representation. J. Xiao, K. A. Ehinger, A. Oliva and A. Torralba. CVPR2012.