Rectified Point Flow:
Generic Point Cloud Pose Estimation

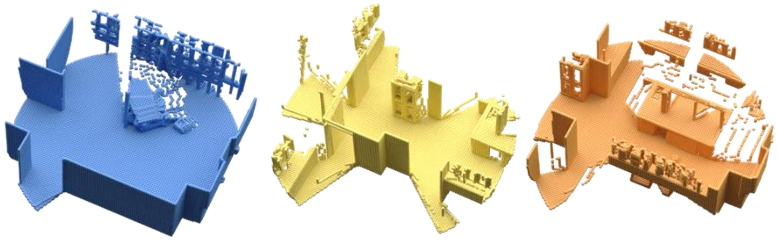
NeurIPS 2025 (Spotlight)

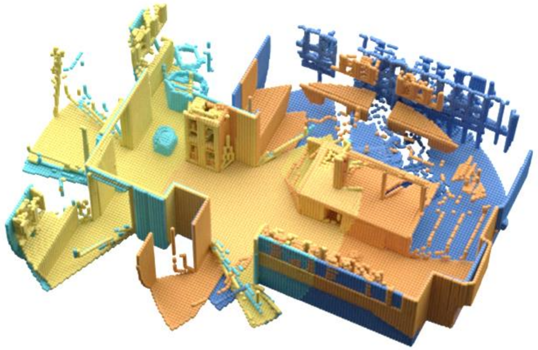
Tao Sun*, Liyuan Zhu*, Shengyu Huang,
Shuran Song, Iro Armeni

Why Pose Estimation?

Many 3D vision tasks can be reduced to part-level pose estimation.

Point Cloud Registration	Fragments Reassembly	Robotic Assembly



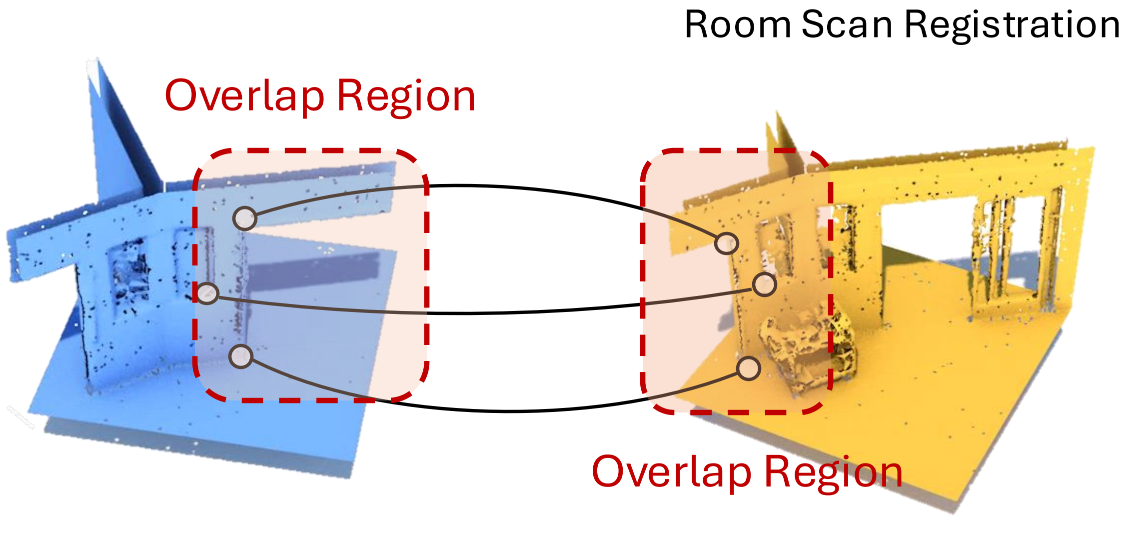


Figures from GARF

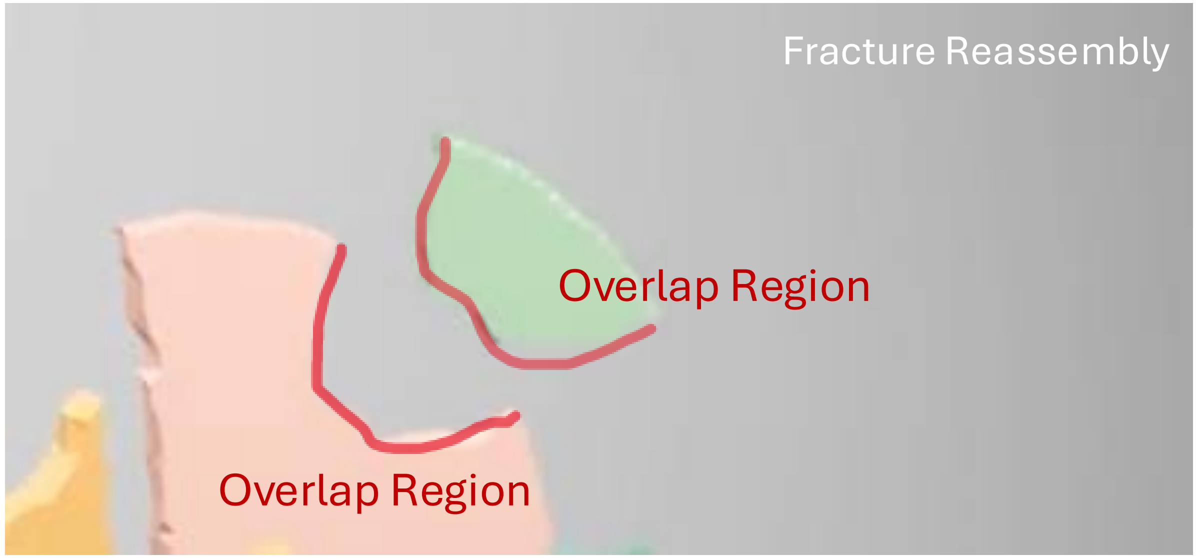
Why Pose Estimation Can Be Hard?

1. Most registration methods rely on correspondence pairs.

Enough Overlap	Not Enough Overlap



Overlap Ratio > 10%

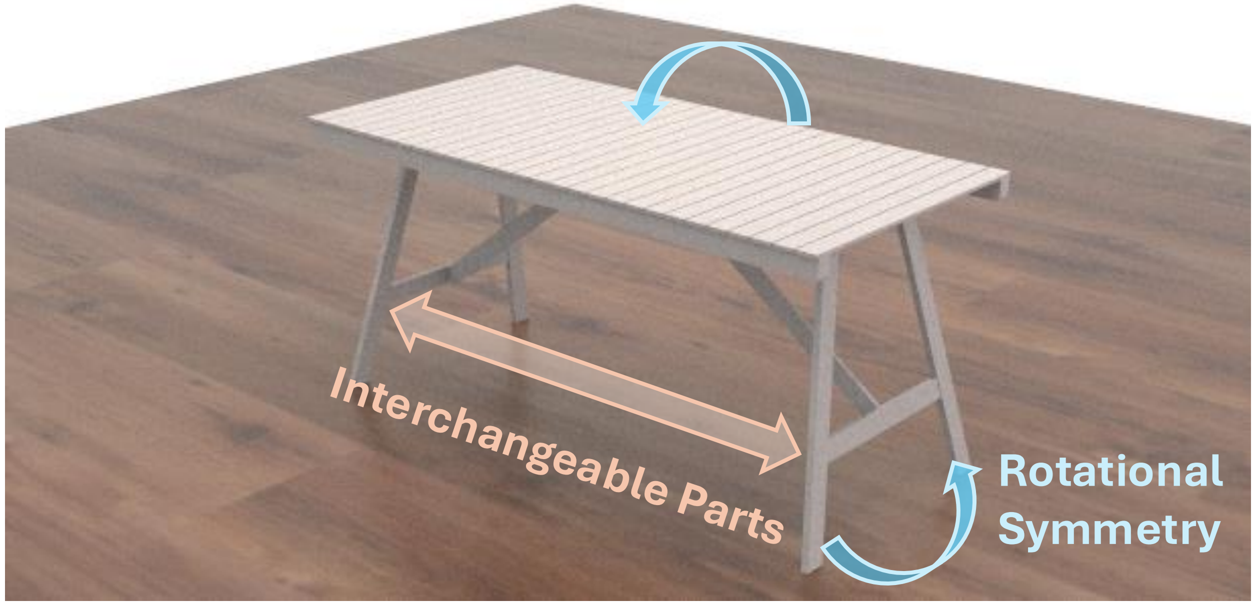


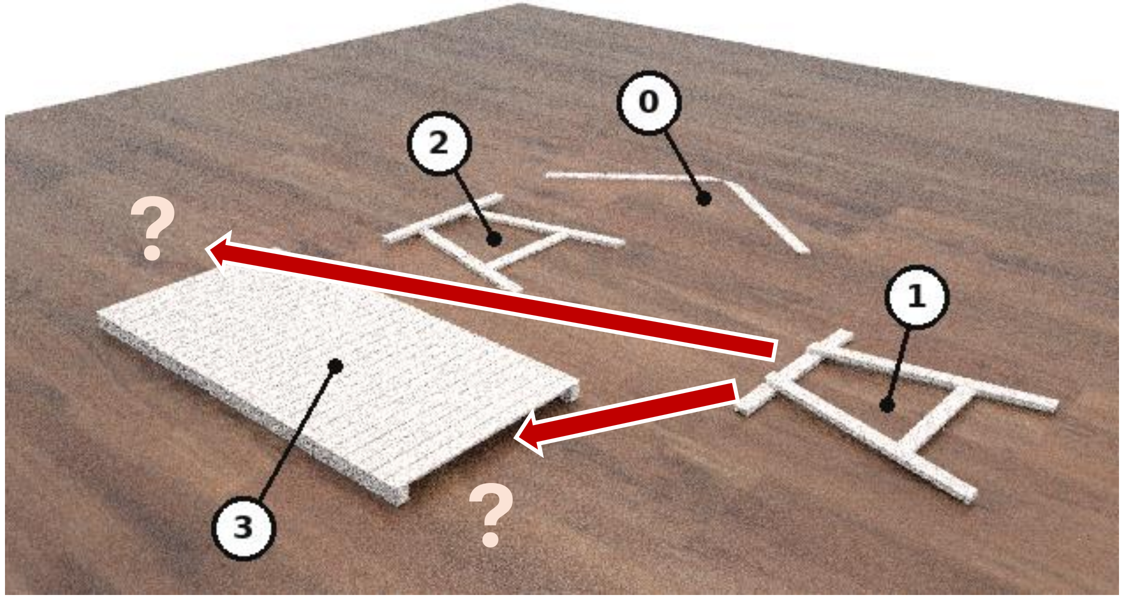
Overlap Ratio < 1%

We need a formulation **does not rely on** point or feature correspondences.

Why Pose Estimation Can Be Hard?

2. Part-level symmetry further complicates the issue.



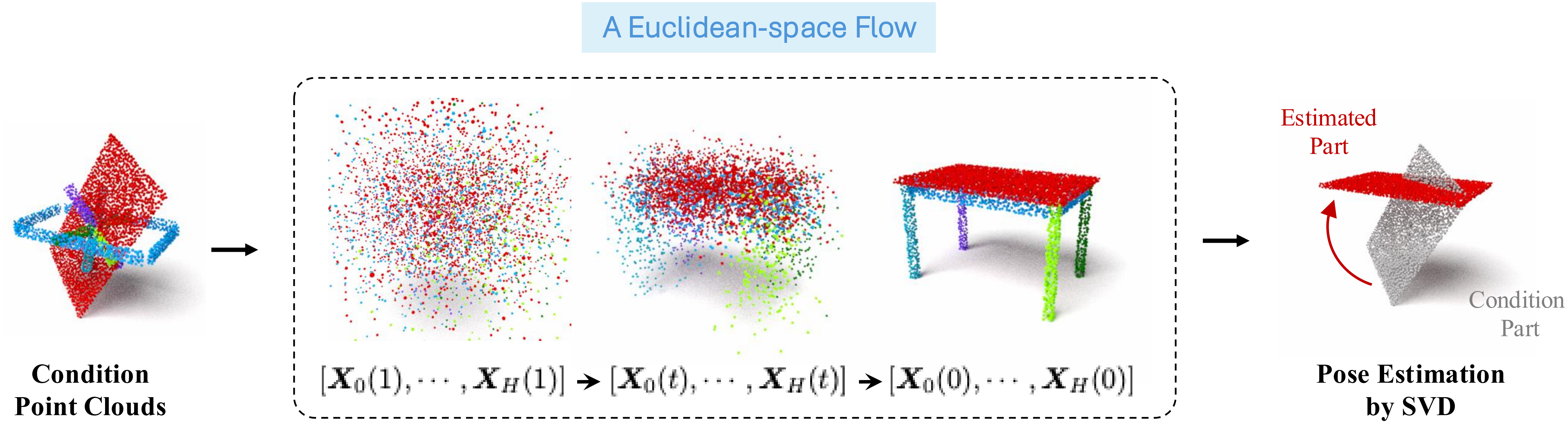


Multiple Plausible Configurations Exists

Pose estimation is fundamentally a **generative problem**.

Our Solution: Pose from Shape

First shape, then pose.

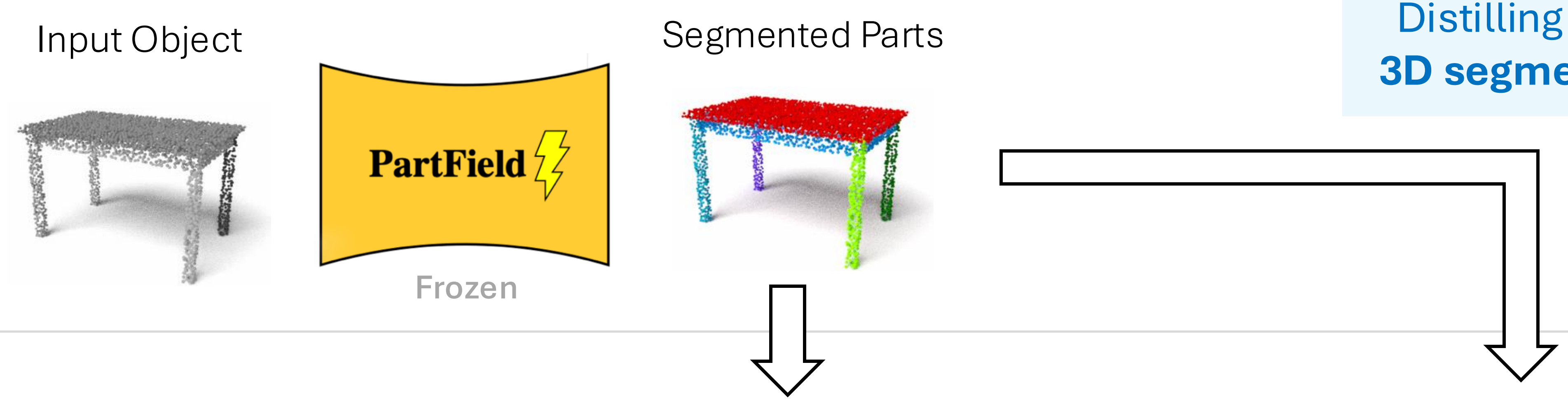


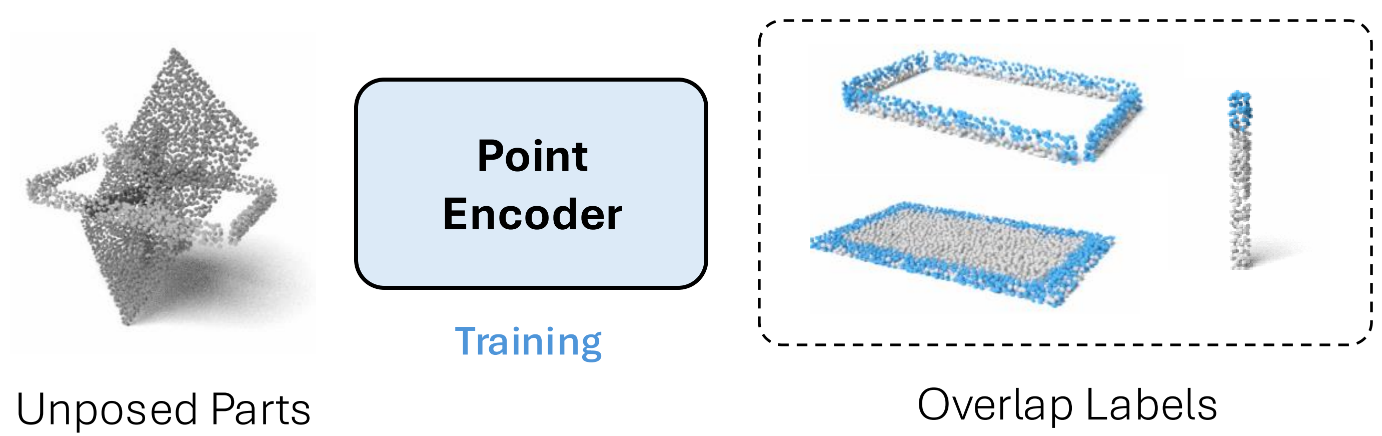
Shape is independent of **correspondence** and encodes all the **symmetry** information.

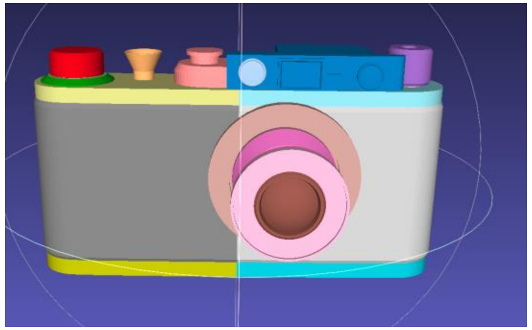
Overlap-aware Pretraining

Large-scale pretraining with additionally Objaverse data via PartField [1] distillation

Distilling knowledge from
3D segmentation models.





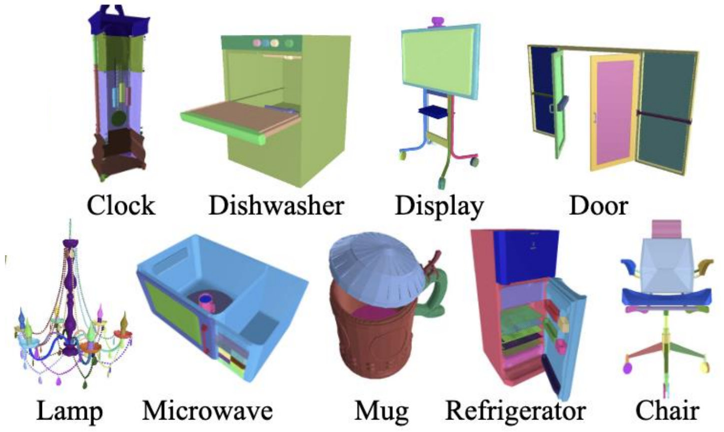


[1] PartField: Learning 3D Feature Fields for Part Segmentation and Beyond [ICCV 2025]

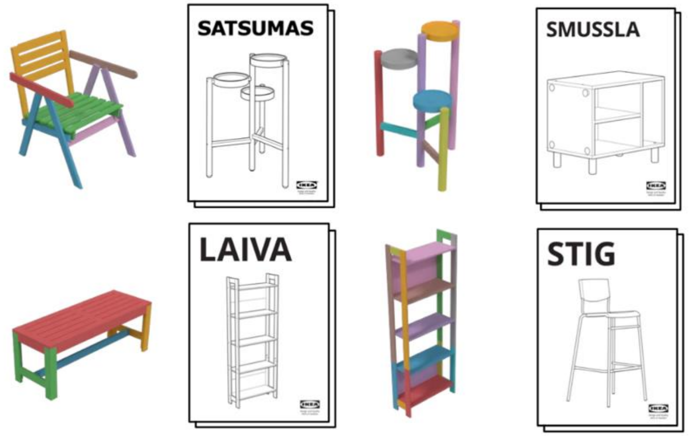
Scalable to Diverse Tasks and Datasets

Task: Assembly Registration

PartNet



IKEA-Manual

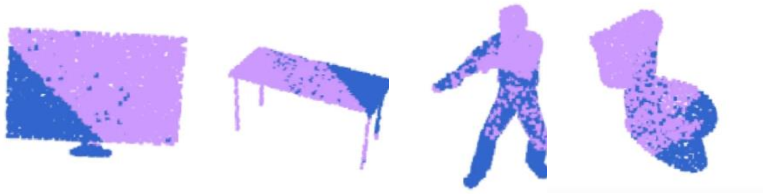


BreakingBad

TwoByTwo

TUD-L

ModelNet-40



Scalable to Diverse Part Definition

Task: Assembly Registration

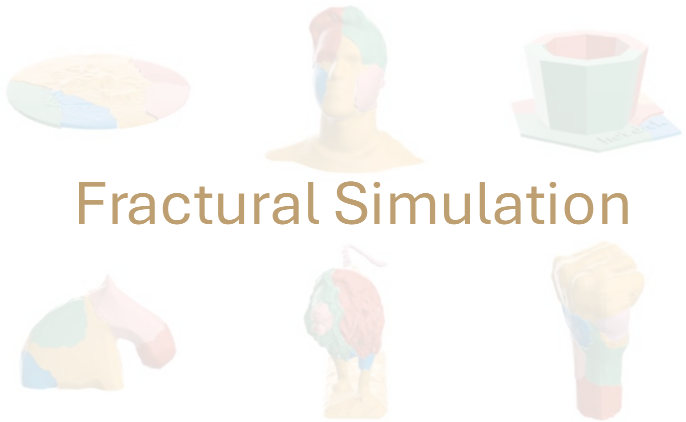
PartNet

Semantics and Function

IKEA-Manual

Reusability and Packing Efficiency

BreakingBad



Fractural Simulation

TwoByTwo

Insertable Parts

TUD-L

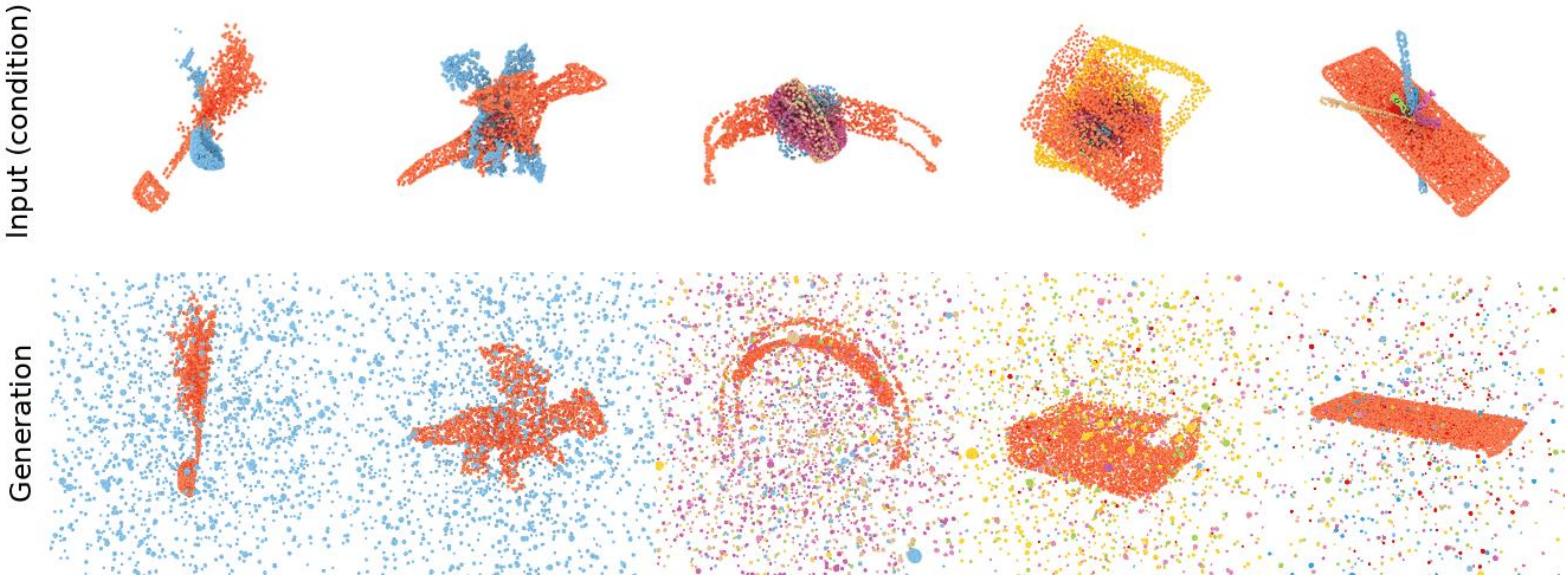
Real RGBD Scan

ModelNet-40

Random Plane Cropping

Flow Trajectories

Assembly prediction given unposed parts

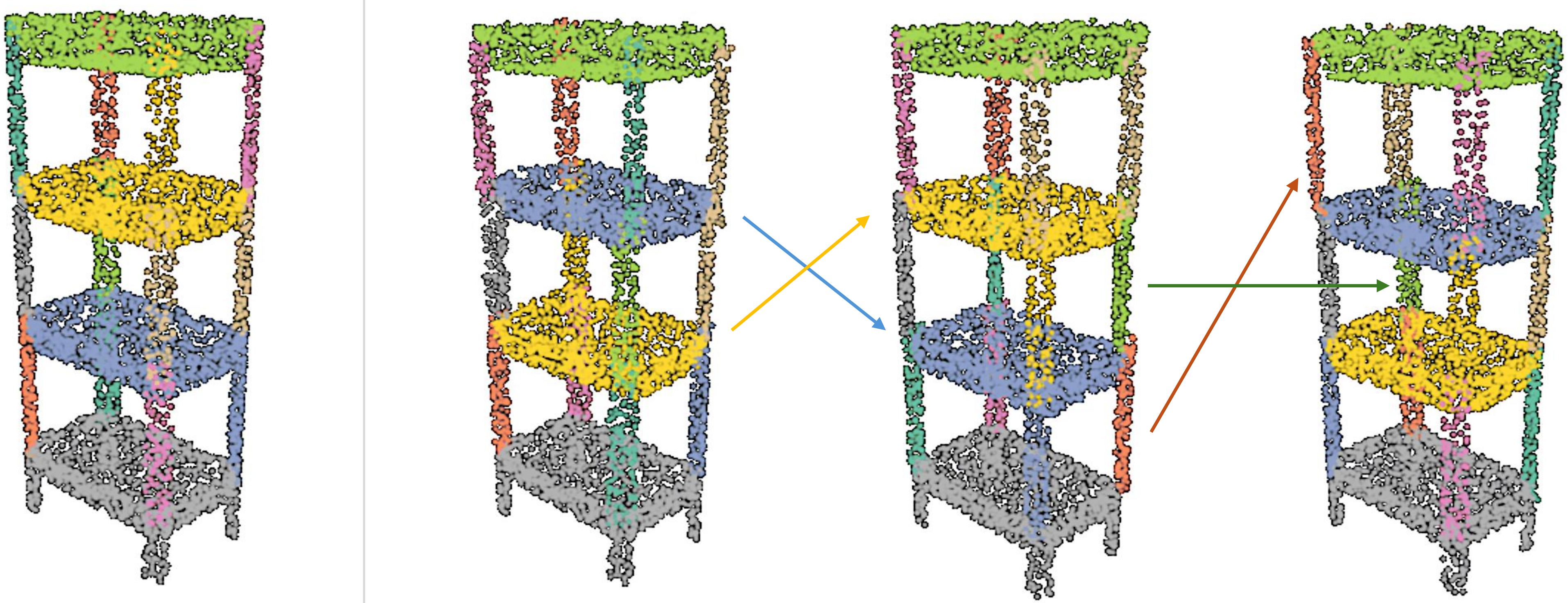


Flow Trajectories

Assembly prediction given unposed parts

Learning Part Symmetry by Construction

Without any symmetry labels



Ground Truth

Generated Result 1

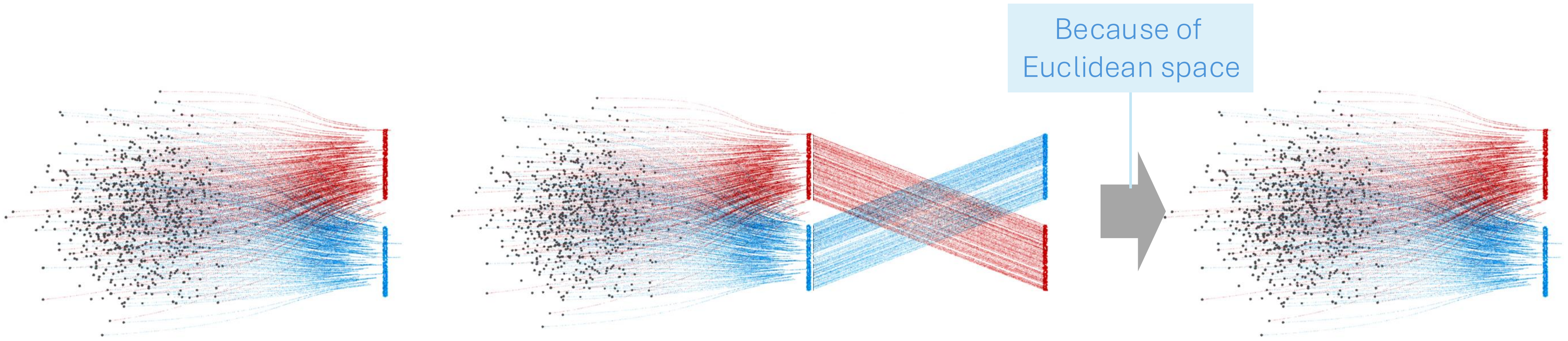
Generated Result 2

Generated Result 3

Model swaps 2 middle baskets and 12 vertical bars.

Learning Part Symmetry by Construction

For part interchangeability and arbitrary part segmentation



$[\boldsymbol{Z}_1, \boldsymbol{Z}_2] \longrightarrow [\boldsymbol{X}_1, \boldsymbol{X}_2]$

Gaussians — Parts

$[\boldsymbol{Z}_1, \boldsymbol{Z}_2] \longrightarrow [\boldsymbol{X}_2, \boldsymbol{X}_1]$

Gaussians — Swapped Parts

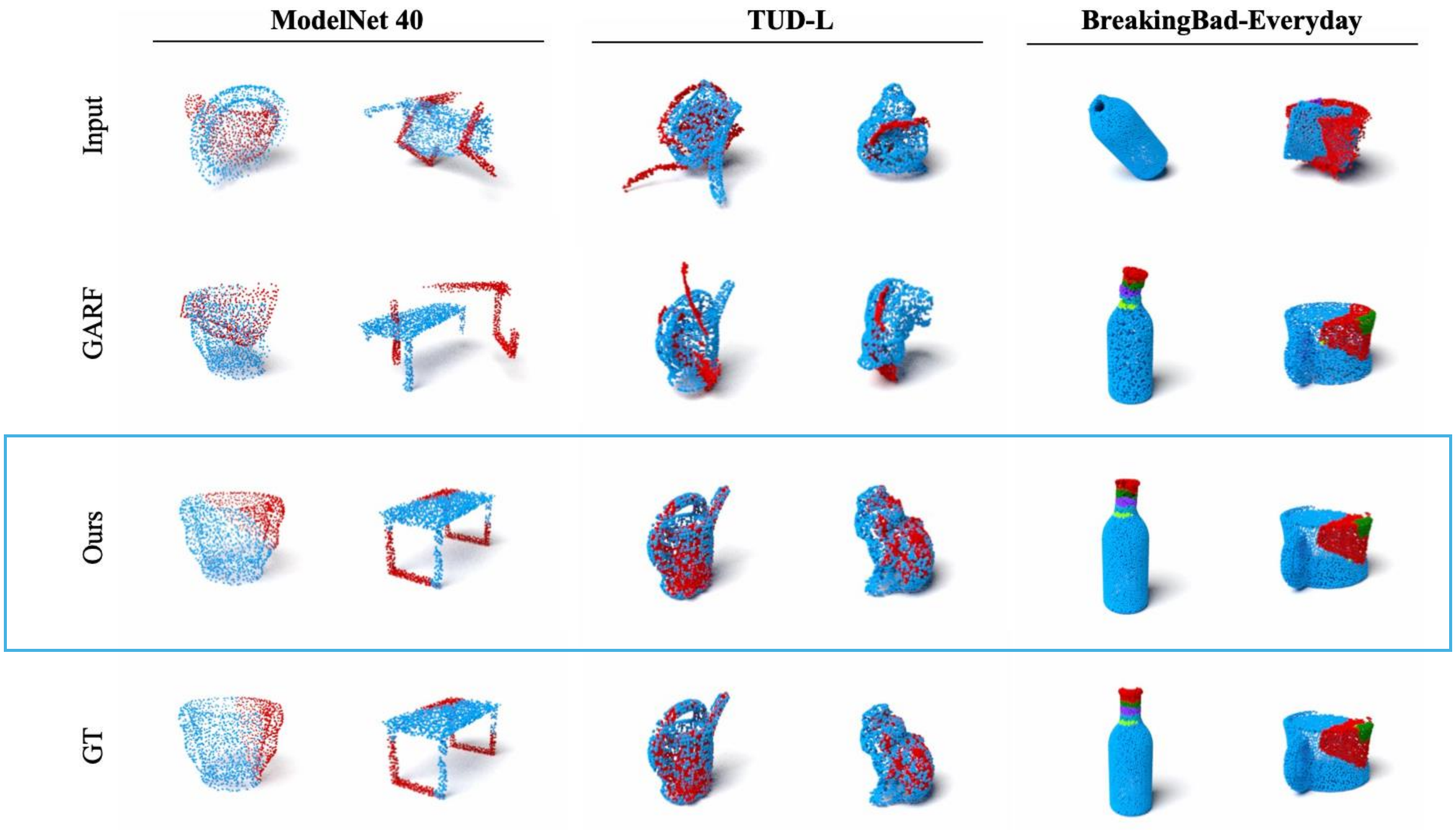
$[\boldsymbol{Z}_2, \boldsymbol{Z}_1] \longrightarrow [\boldsymbol{X}_1, \boldsymbol{X}_2]$

Swapped Gaussians — Parts

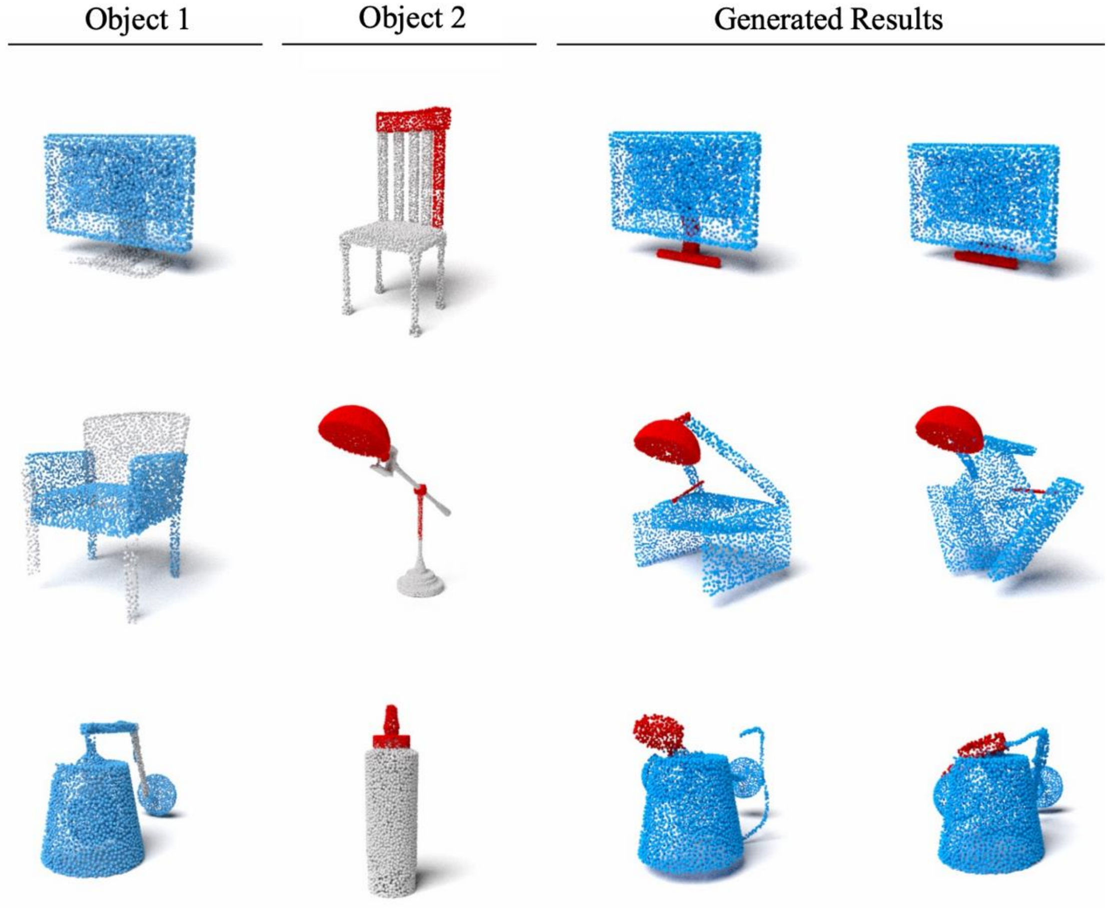
Asymptotic equivalent!

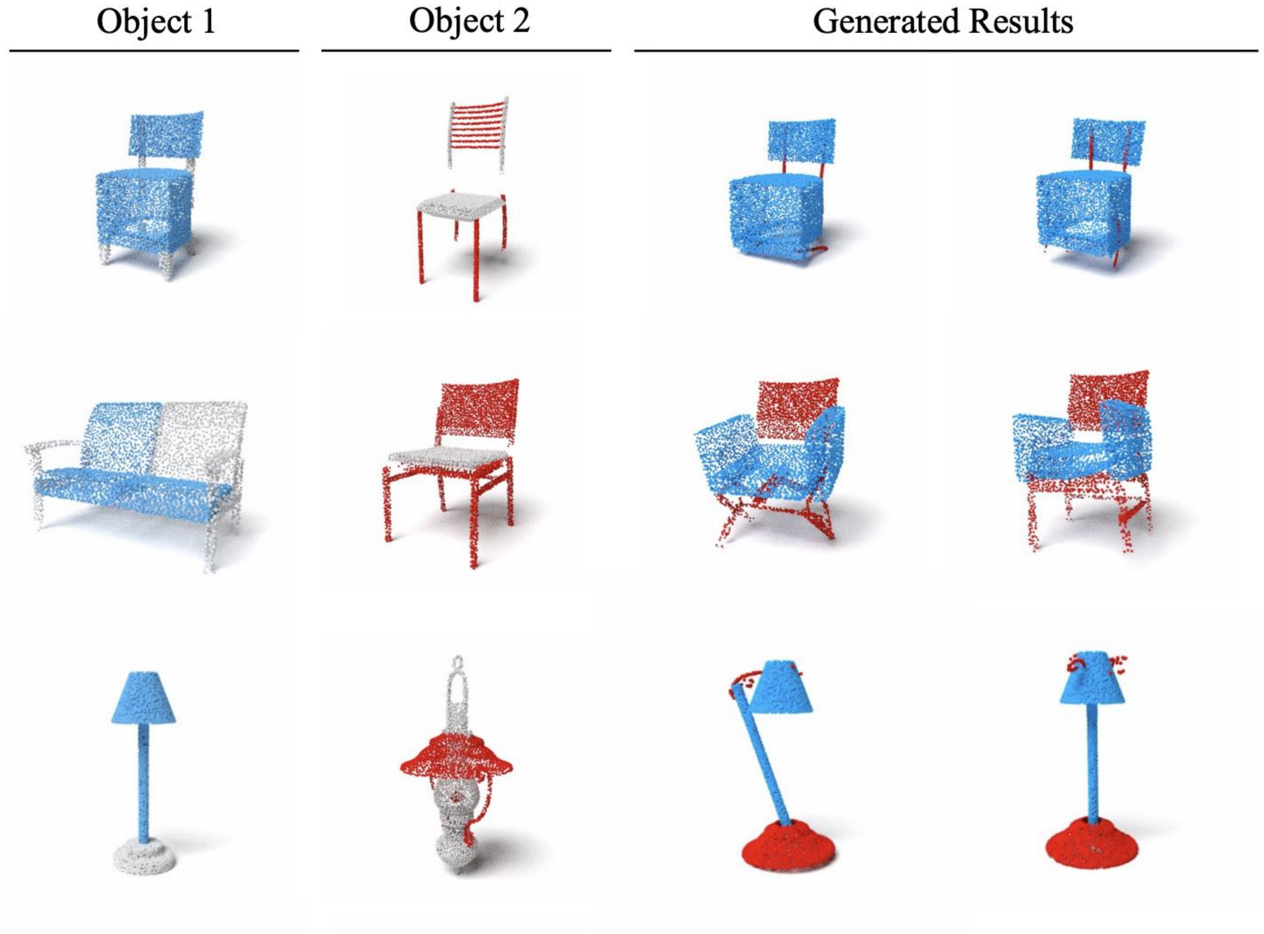
Experiments: Shape Assembly

Experiments: Pairwise Registration and Reassembly

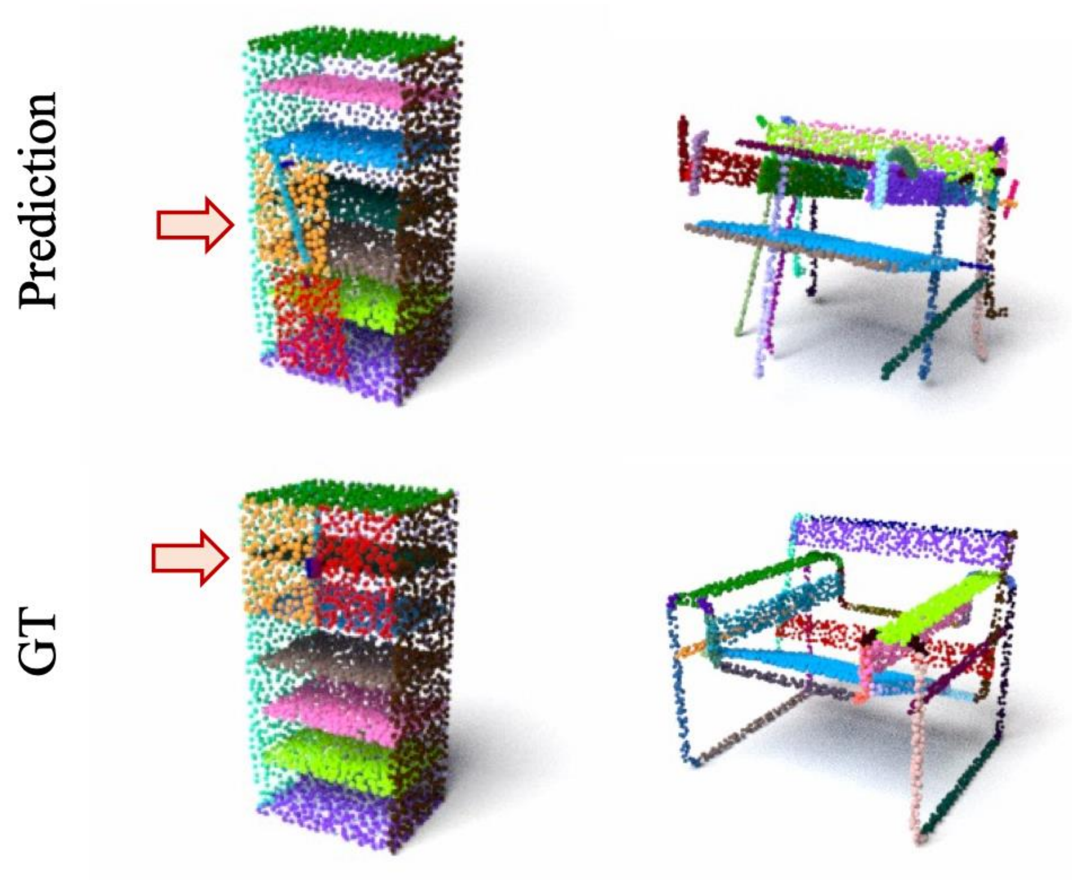


Generating Novel Objects





Failure Cases



Geometrically plausible, but functionally incorrect.

Objects with high geometric complexity.

Rectified Point Flow:
Generic Point Cloud Pose Estimation

Tao Sun [1,*]   Liyuan Zhu [1,*]   Shengyu Huang [2]   Shuran Song [1]   Iro Armeni [1]

[1]Stanford University   [2]NVIDIA Research   ([*]equal contribution)

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Paper   Code   Model   Dataset

Learning a continuous Euclidean-space point flow that
assembles unposed parts and recovers **poses from assembled shapes.**

Homepage: rectified-pointflow.github.io/

Homepage

GitHub

Thu 4 Dec
4:30 - 7:30 PM

Poster Session