SuperDec: 3D Scene Decomposition with Superquadric Primitives

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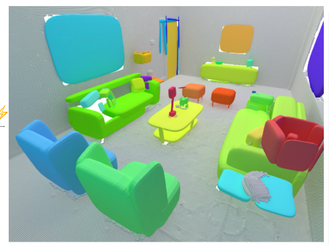
Introduction

Input: Point Cloud

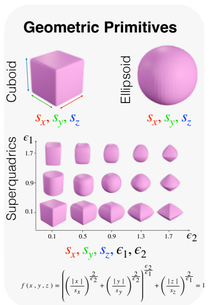
1.000.000 points

430ms



Output: Superquadrics

300 geometric primitives



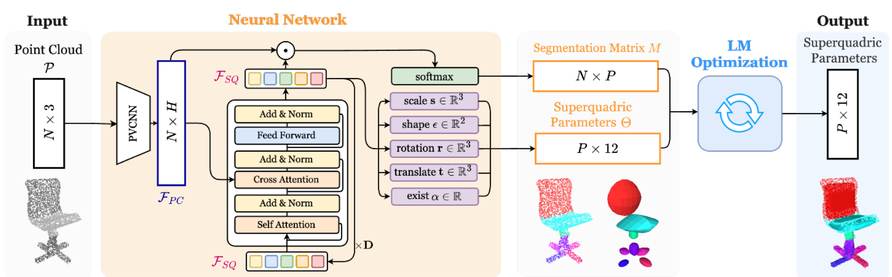
Motivation

1. Existing representations for 3D scenes focus on *photorealism*
2. We focus on a *compact*, *modular*, and *explicit* representation

Task

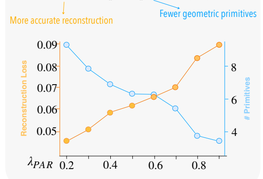
Given a point cloud of a 3D scene, we decompose it in a compact set of superquadrics.

Method



Unsupervised training

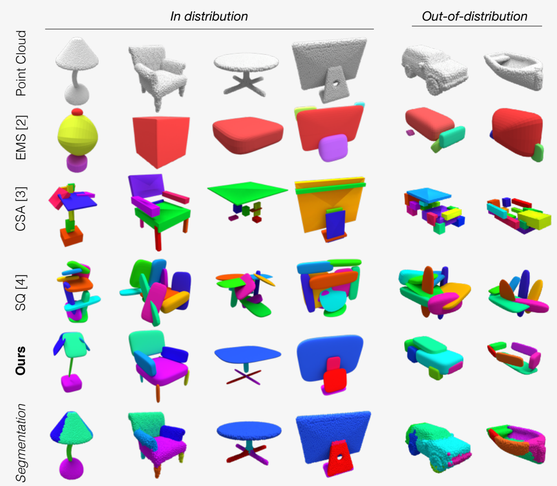
$$\mathcal{L} = \mathcal{L}_{rec} + \lambda_{par}\mathcal{L}_{par} + \lambda_{exist}\mathcal{L}_{exist}$$



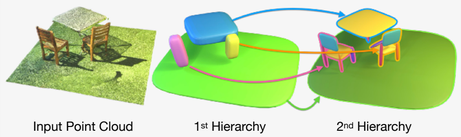
Extension to Full Scenes

Results

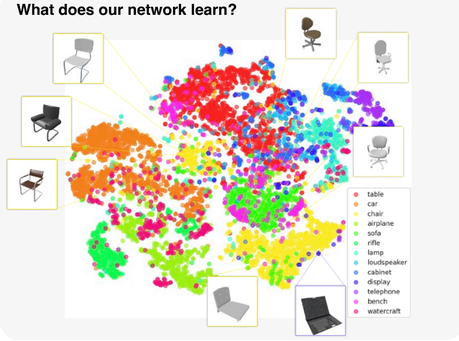
Qualitative Results on Objects from ShapeNet



Unsupervised decomposition



What does our network learn?



Qualitative Results on Scenes from Replica and ScanNet++

Application 1: Robotics

Path planning from start to target

Grasping poses [5]

Application 2: Controlled Image Generation

Original *Editing* *Addition* *Deletion*

Quantitative Results

			ShapeNet		Replica		ScanNet++	
Method	**Primitive Type**	**Seg.**	**L2**	**#Prim.**	**L2**	**#Prim.**	**L2**	**#Prim.**
EMS [2]	Superquadrics	✗	1.34	**5.68**	2.12	**3.61**	2.11	**4.25**
CSA [3]	Cuboids	✓	0.53	9.21	0.70	9.63	0.41	11.64
SQ [4]	Superquadrics	✗	0.28	10	5.91	10	4.26	10
SuperDec (ours)	Superquadrics	✓	**0.05**	5.8	**0.19**	6.58	**0.11**	5.18

References

[1] Schult et al., *Mask3D: Mask Transformer for 3D Semantic Instance Segmentation*, ICRA 2023.

[2] Liu et al., *Robust and Accurate Superquadric Recovery: A Probabilistic Approach*, CVPR 2022.

[3] Paschalidou et al., *Superquadrics revisited: Learning 3d shape parsing beyond cuboids*, CVPR 2019.

[4] Yang et al., *Unsupervised learning for cuboid shape abstraction via joint segmentation from point clouds*, TOG 2021.

[5] Vezzani et al., *A grasping approach based on superquadric models*, ICRA 2017.