



复杂几何结构和精细几何细节 的递归深度生成模型

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2022年05月26日

Short Bio

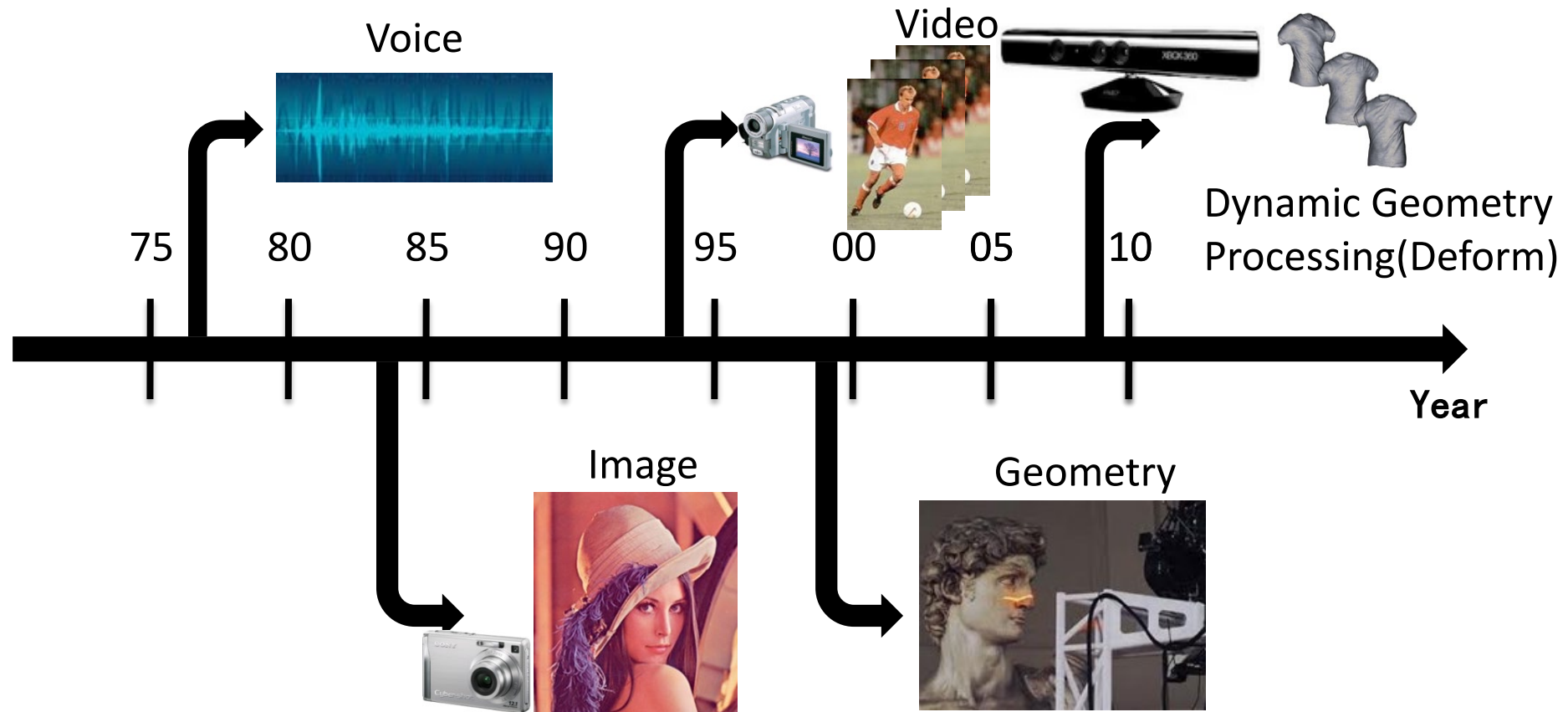
- Jie Yang 杨洁
- Final year CS Ph.D. at ICT, CAS
- Advisor: Prof. Lin Gao, Prof. Shihong Xia
- <http://people.geometrylearning.com/~jieyang/>
- yangjie01@ict.ac.cn



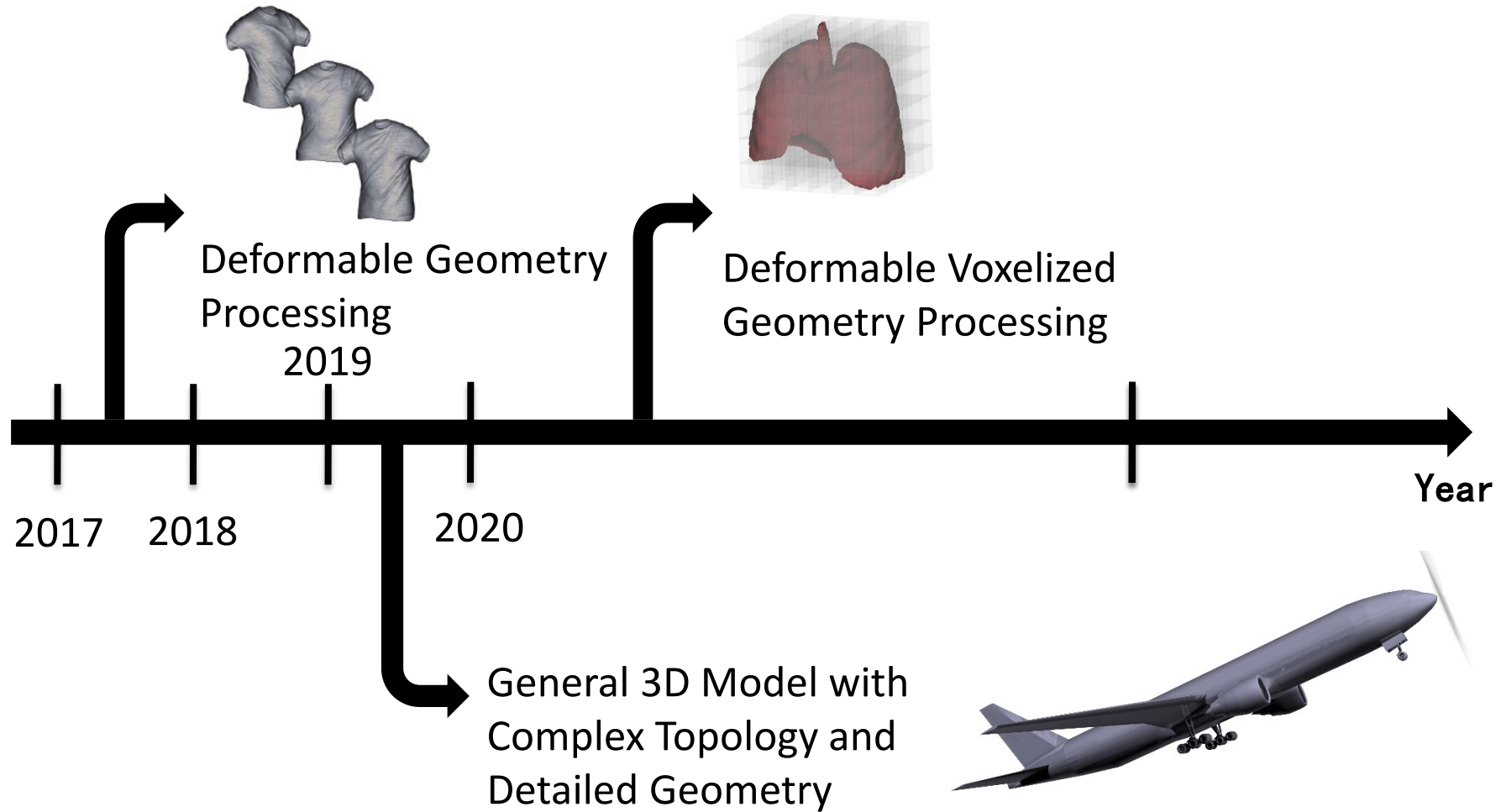
■ Research Area

- ◆ Geometry processing, Computer graphics, and Deep learning

Background



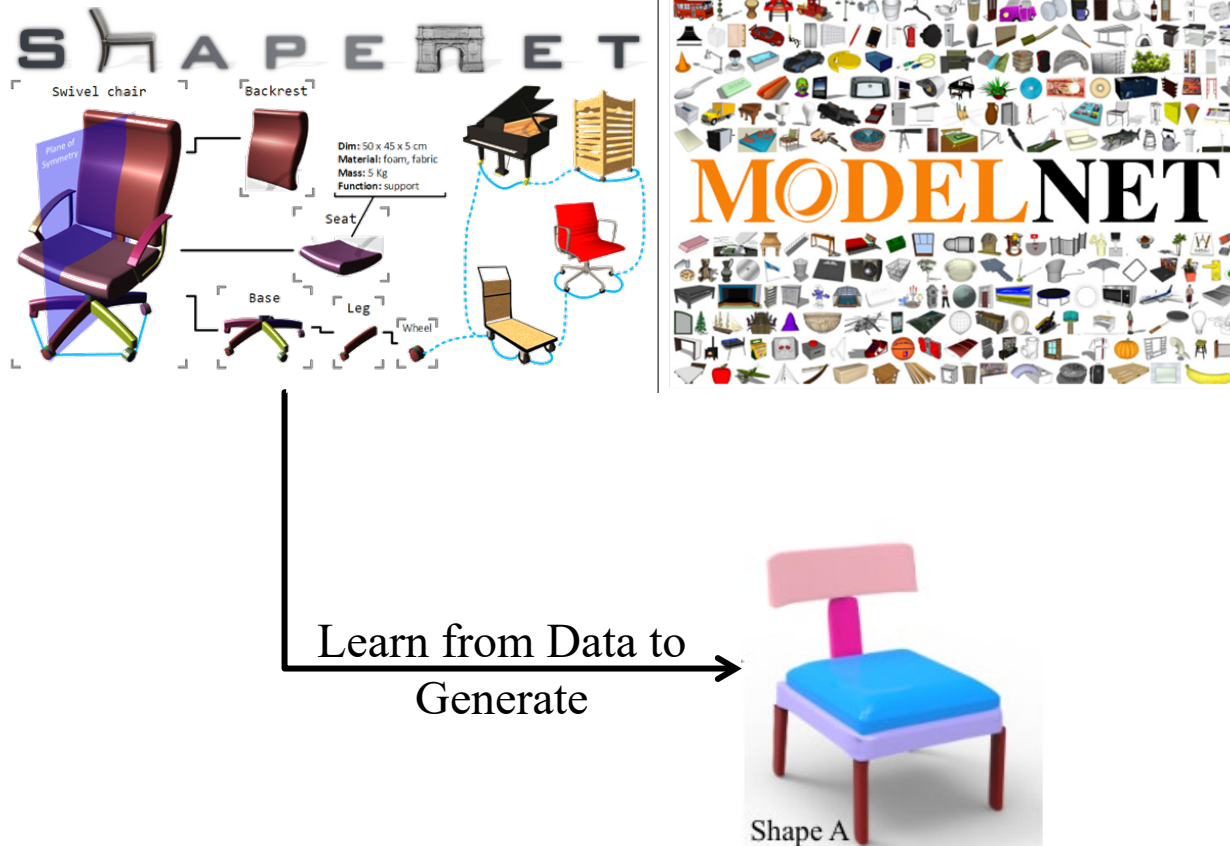
Background



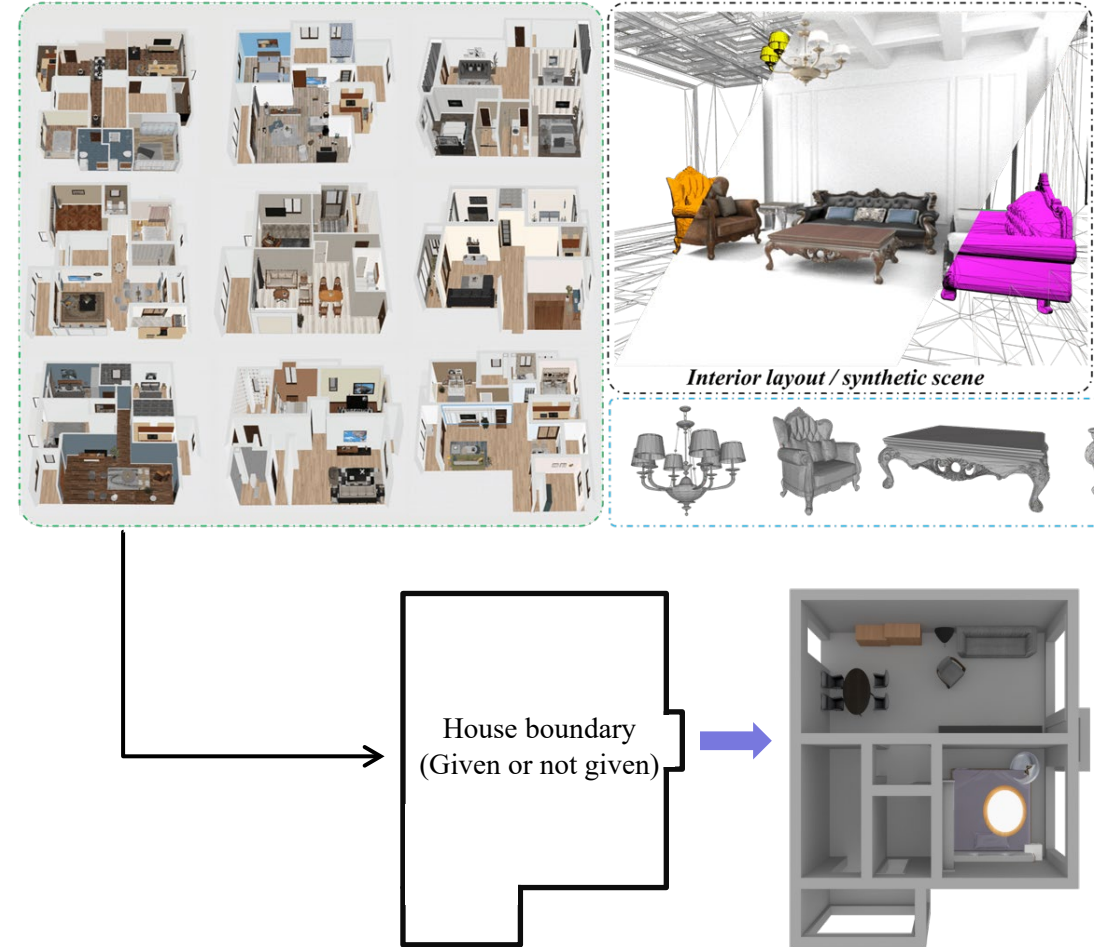
Motivations



3D Object Dataset



3D Indoor Scene Dataset



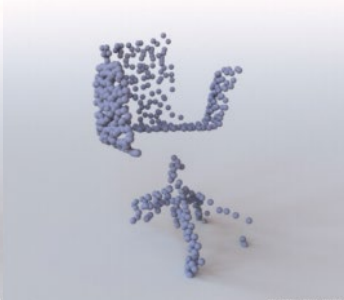
Challenges



复杂几何拓扑

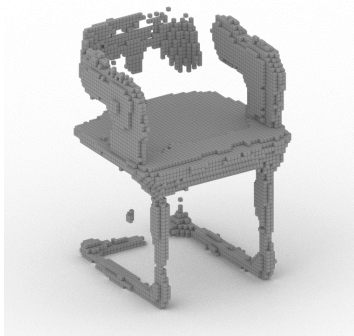


噪声



缺失

精细几何细节



建模质量差



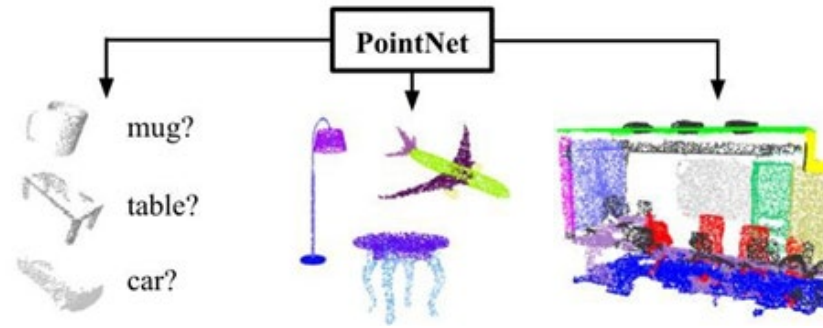
布局 and 结构
复杂多样

空间分布
稀疏不规则

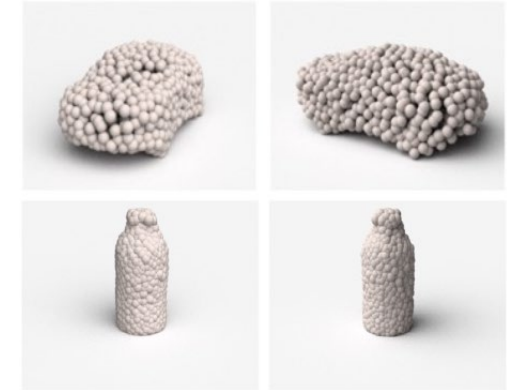
Related Works

■ Point clouds

- ◆ Coarse Geometry
- ◆ Irregular structure



[Qi et al. 2017]



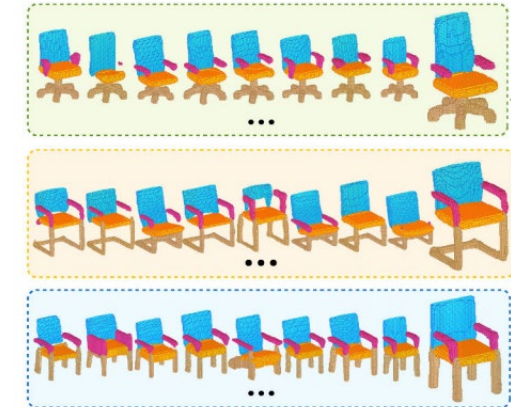
[Fan et al 2017]

■ Voxel grids

- ◆ Regular structure
- ◆ Lack of the detail
- ◆ Huge memory and calculation costs



[Girdharetal.2016]



[Wang et al 2018]

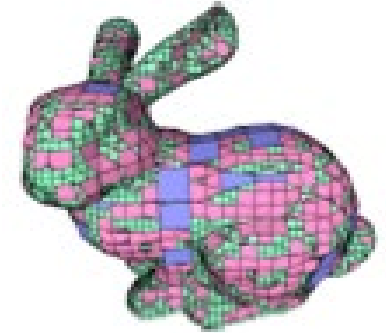
Related Works

■ Patches & Multi Charts

- ◆ Not smooth or connected
- ◆ Unstructured



[Groueix et al 2018]



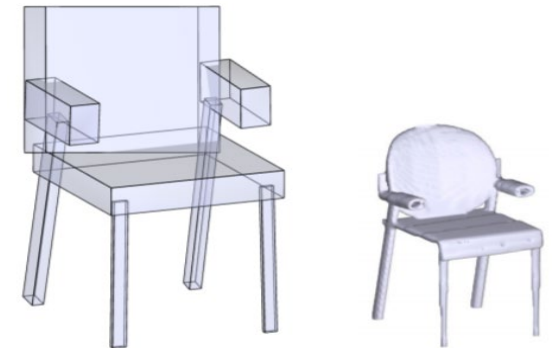
[Wang et al 2018]

■ Boxes with structures

- ◆ Loss geometry details
- ◆ Not physical reliable



[Nash and Williams 2017]



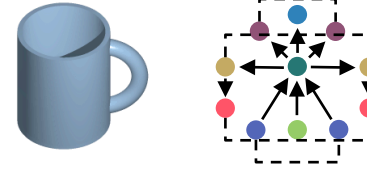
[Li et al 2017]

Related Works

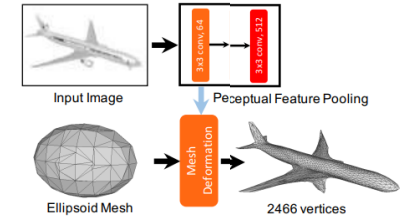
■ Meshes

- ◆ Detailed Geometry
- ◆ Limited Topology

Geometry Structure



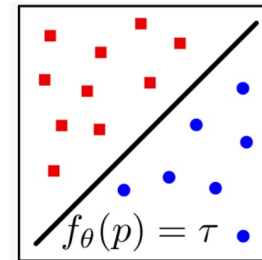
[Gao et al. 2019]



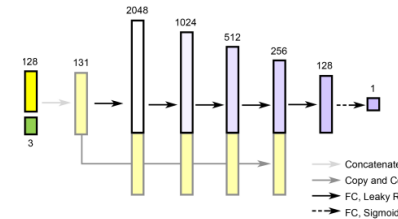
[Wang et al. 2018]

■ Implicit Field

- ◆ Implicit representation
- ◆ Topology Free
- ◆ Extra way to extract explicit mesh



OccNet
Mescheder et al.

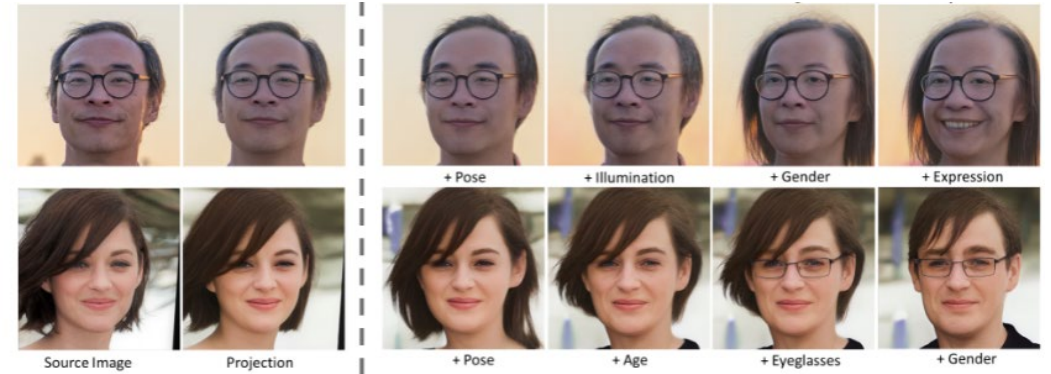


IM-Net
Chen et al.

Related works

■ 2D Image Controllable Generation

- ◆ Expression, Age, Gender
- ◆ Supervised and Unsupervised



[Abdal et al. 2021 (TOG)]

■ 3D Shape Generation

- ◆ Not Controllable
- ◆ Human or Faces
- ◆ Can't Handle general shape



DSG-Net: Learning Disentangled Structure and Geometry for 3D Shape Generation

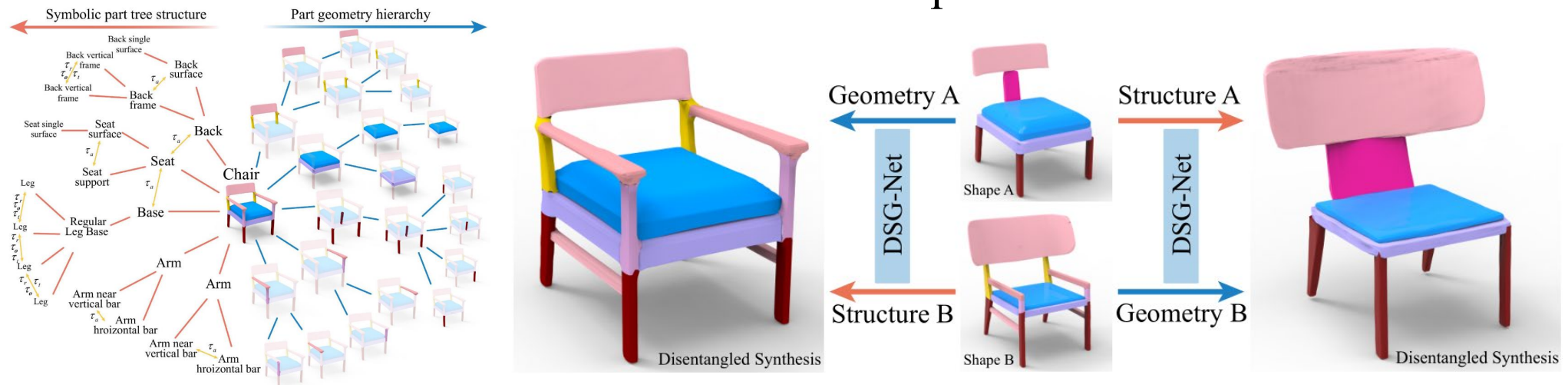
Jie Yang^{1,2*} Kaichun Mo^{3*} Yu-Kun Lai⁴ Leonidas J. Guibas³ Lin Gao^{1,2†}

¹ Institute of Computing Technology, Chinese Academy of Sciences

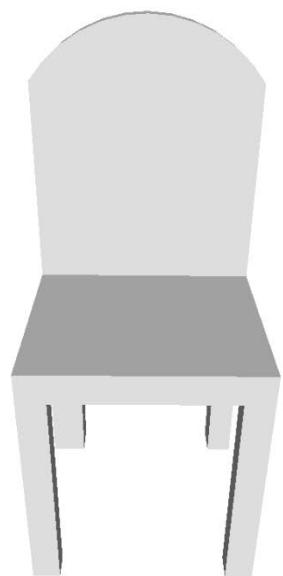
² University of Chinese Academy of Sciences

³ Stanford University ⁴ Cardiff University

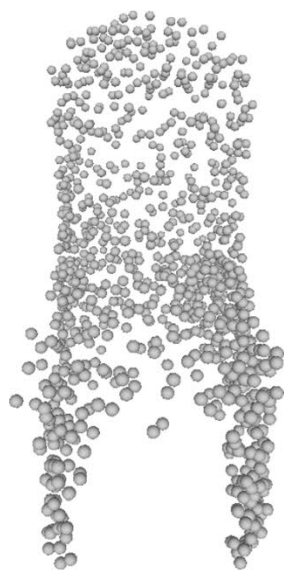
ACM Transactions on Graphics



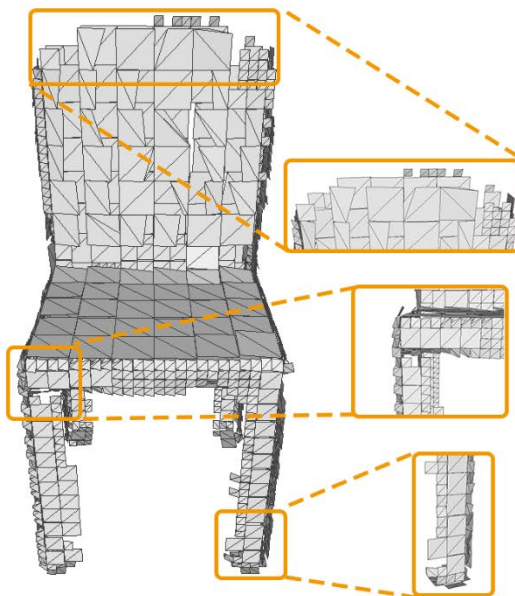
Motivation & Insight



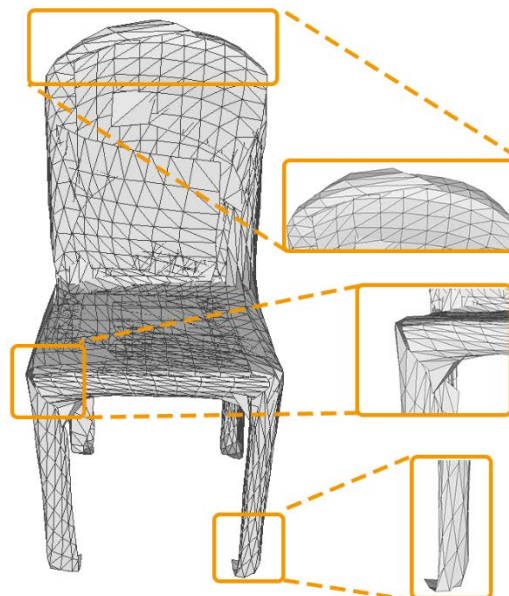
(a) Input shape



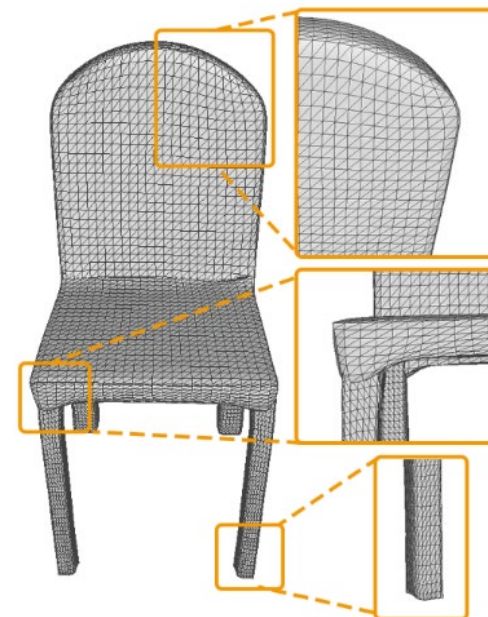
(b) PSG



(c) Adaptive O-CNN



(d) AtlasNet



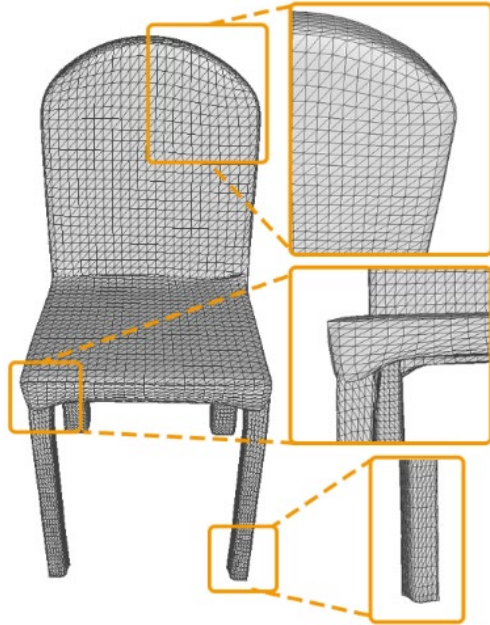
(e) SDM-Net

目前已有的深度几何表示方法， (b) 斯坦福大学的点云的方法(CVPR 2017)， (c) 微软的自适应八叉树 (SIGGRAPH 2018) (d) 斯坦福的片段表示方法 (CVPR 2018) (e) 结构化的变形表示方法

Motivation & Insight

Geometry Details

Using deformation to approximate geometry details

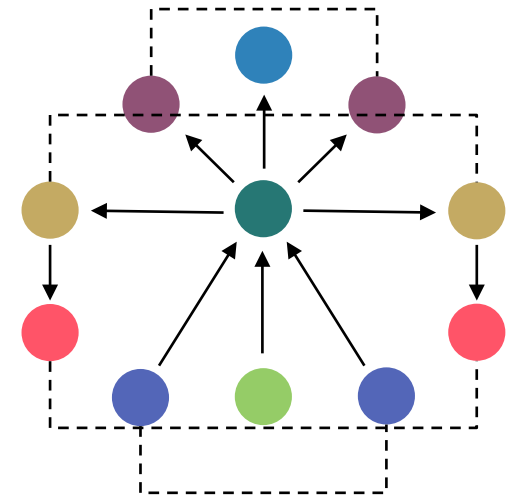


Gao et al. SDM-NET
SIGGRAPH ASIA 2019



Structure

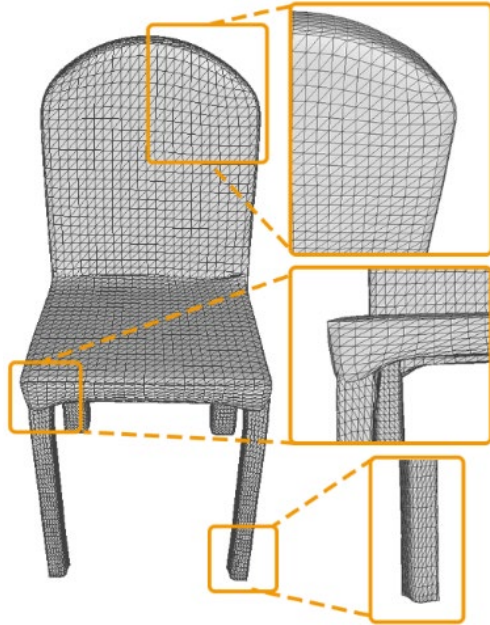
Using directed graph to encode the support structure



Motivation & Insight

Geometry Details

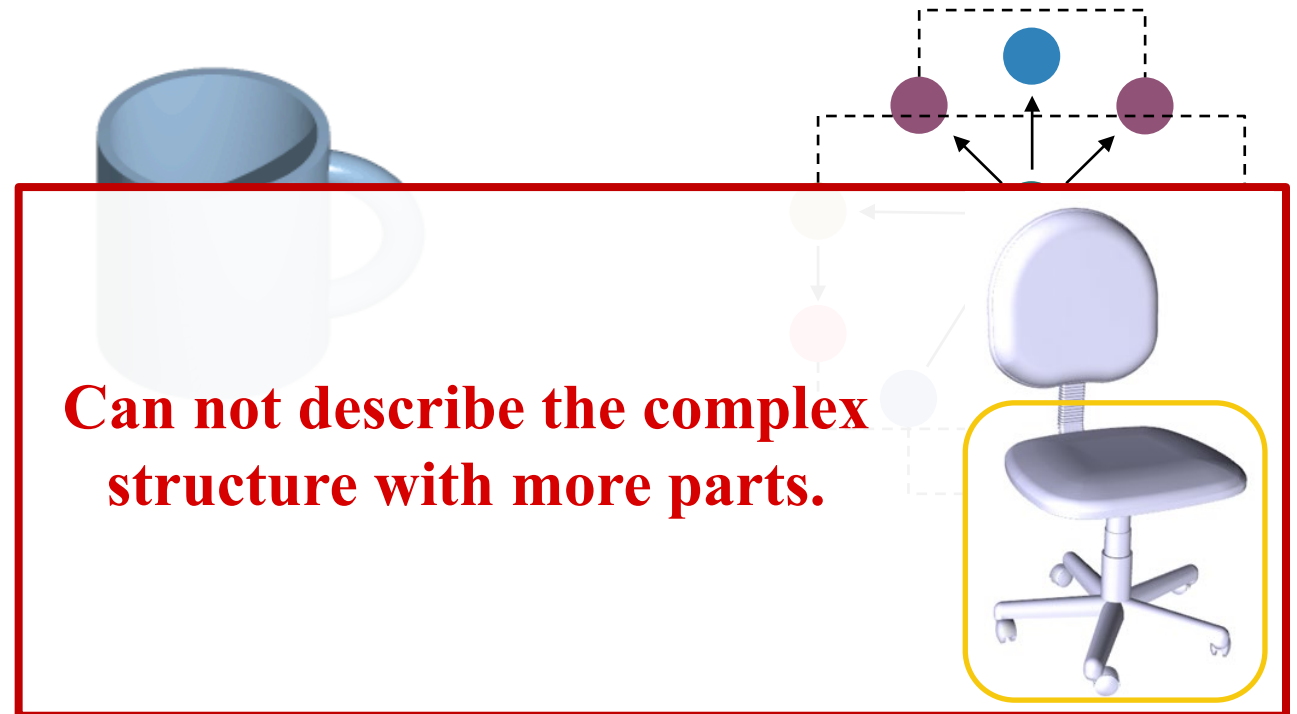
Using deformation to approximate geometry details



Gao et al. SDM-NET
SIGGRAPH ASIA 2019

Structure

Using directed graph to encode the support structure



Motivation & Insight



Disentangled Control



Same Pose
Different Shape

Same Shape
Different Pose

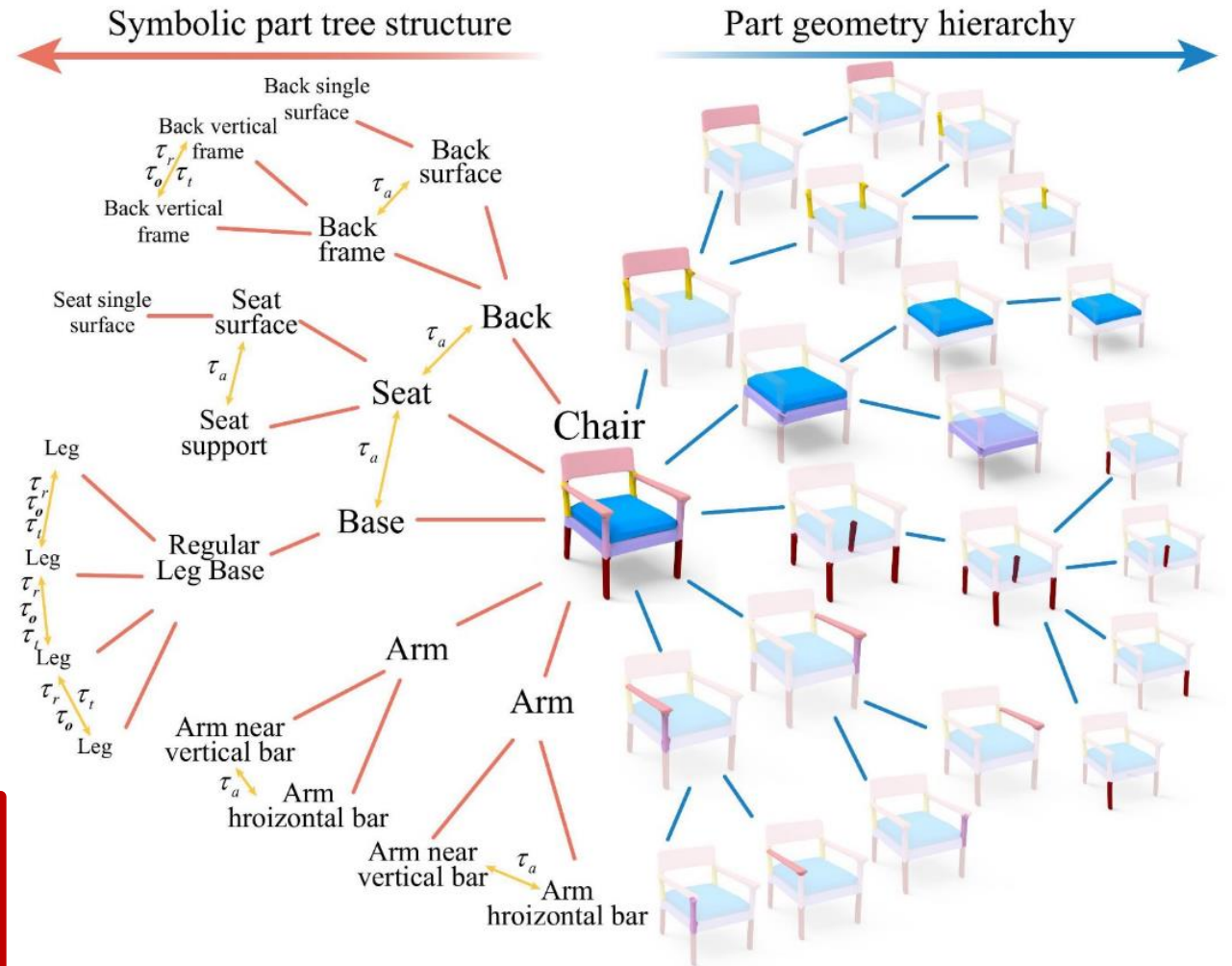
**Can not
Handle General Shape.**



Aumentado-Armstrong et al.
ICCV 2019

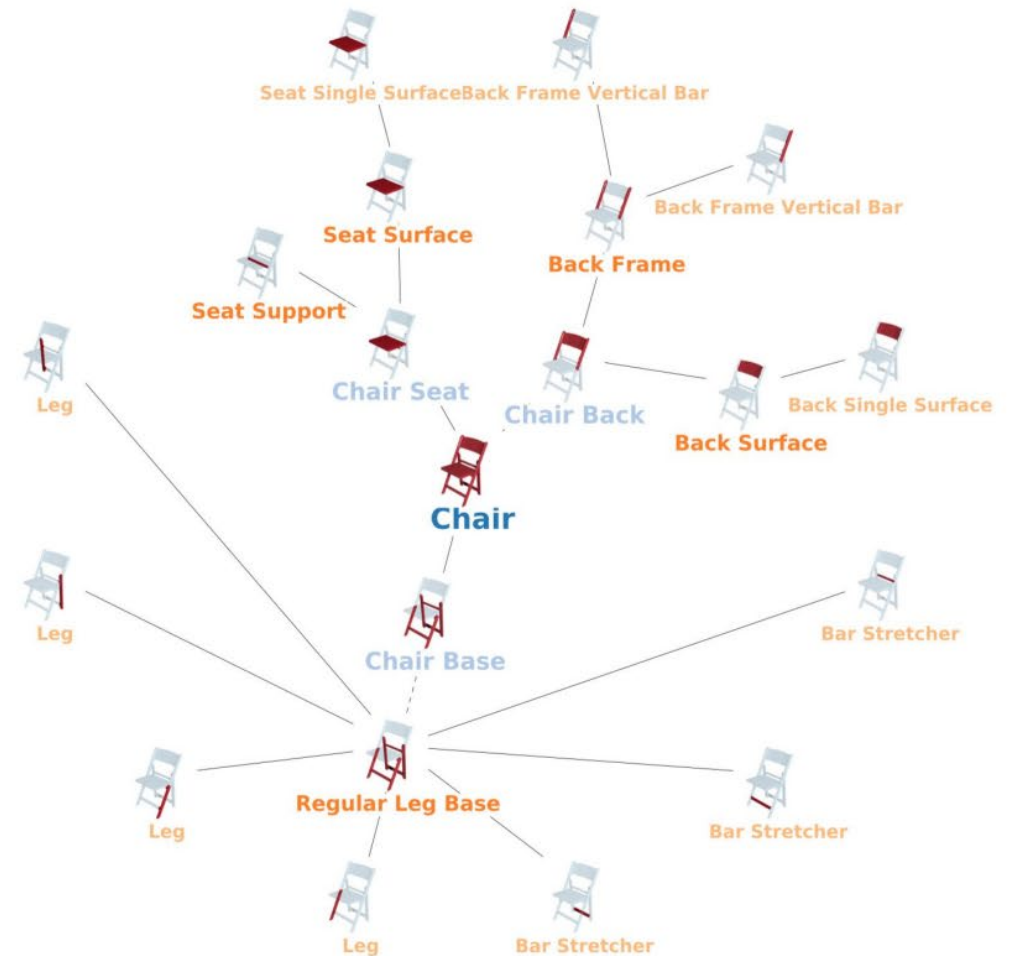
Methodology -- Representation

Disentangled but Highly Synergistic Representation of Shape Geometry and Structure Hierarchies



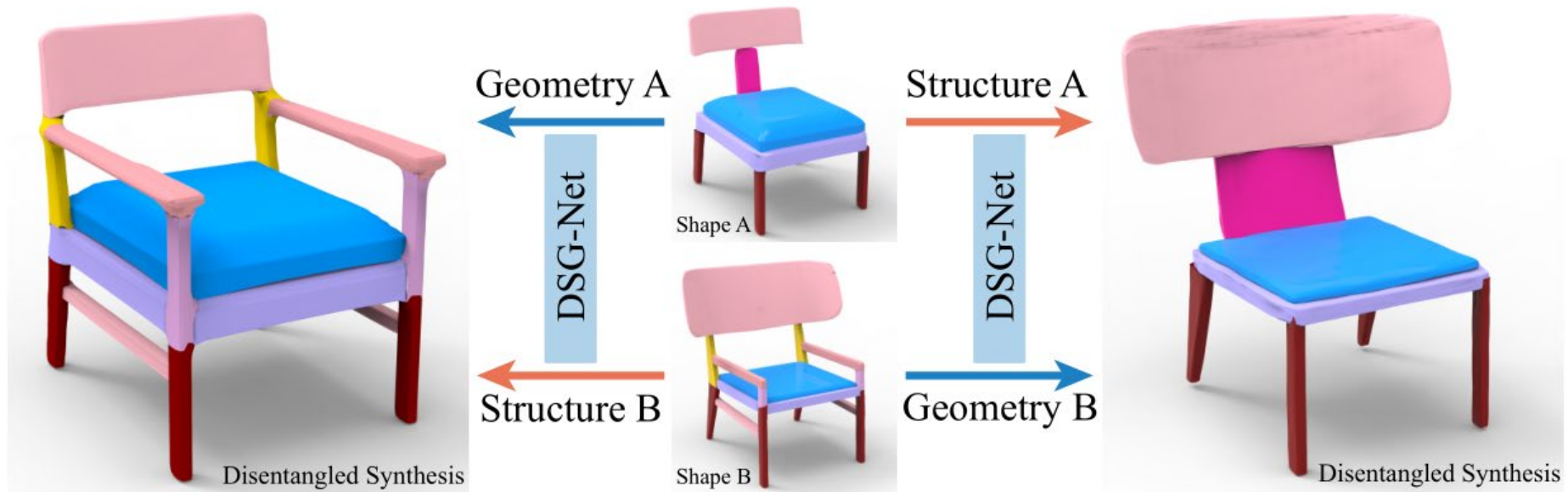
Complex Relations among parts
Fine Geometric Details on parts

Methodology -- Representation



Methodology – Dsg-Net

Disentangled Shape Synthesis



Use the **geometry** from A;
Use the **structure** from B;

Use the **structure** from A;
Use the **geometry** from B;

Fine Geometry Details & Complex Structure.

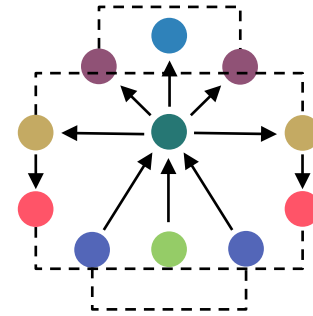
Methodology -- Geometric Details

Inspired by **SDM-Net** [Gao et al. 2019]
Using deformation to approximate geometry details

Geometry Details



Complex Structure



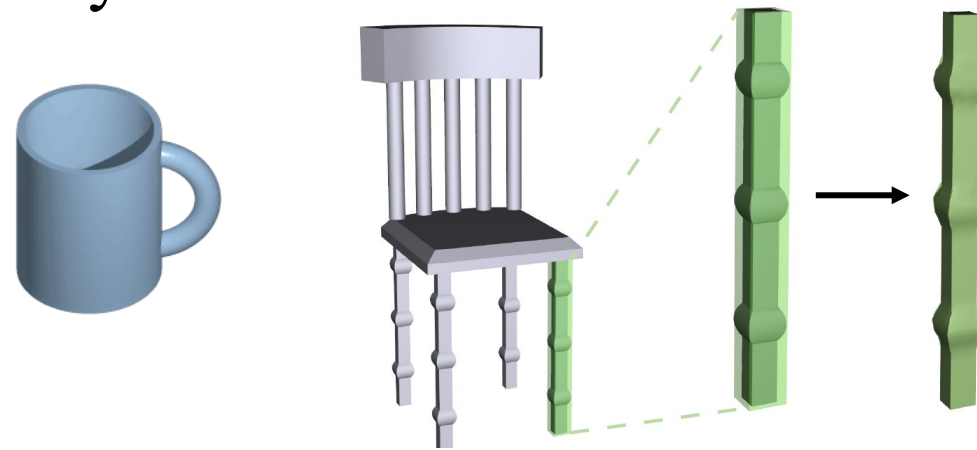
Using deformation to approximate
geometry details

Using directed graph to
encode the support structure

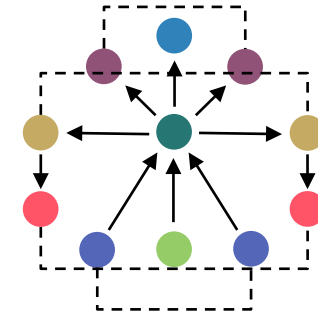
Methodology -- Geometric Details

Inspired by **SDM-Net** [Gao et al. 2019]
Using deformation to approximate geometry details

Geometry Details



Complex Structure

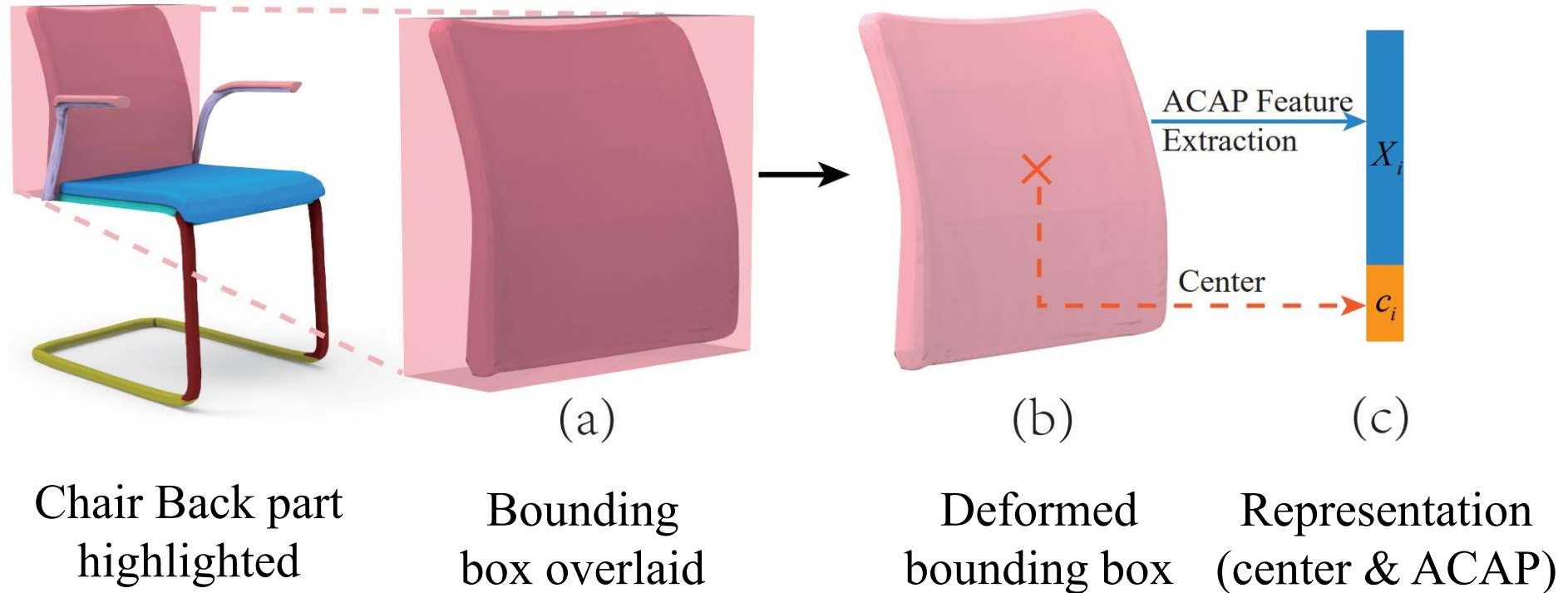


Using deformation to approximate
geometry details

Using directed graph to
encode the support structure

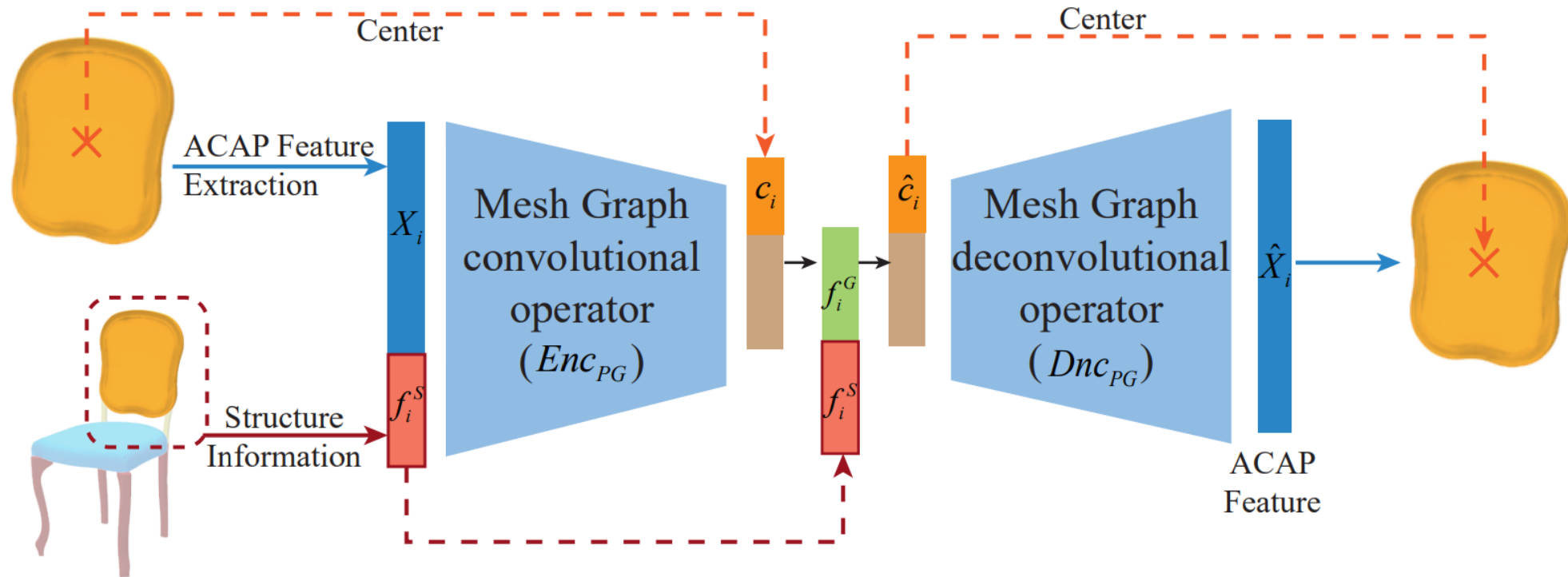
Methodology -- Geometric Details

Inspired by **SDM-Net [Gao et al. 2019]**
 Using deformation to approximate geometry details



Methodology -- Geometric Details

Conditional Part Geometry Variational Autoencoder (PG-VAE)

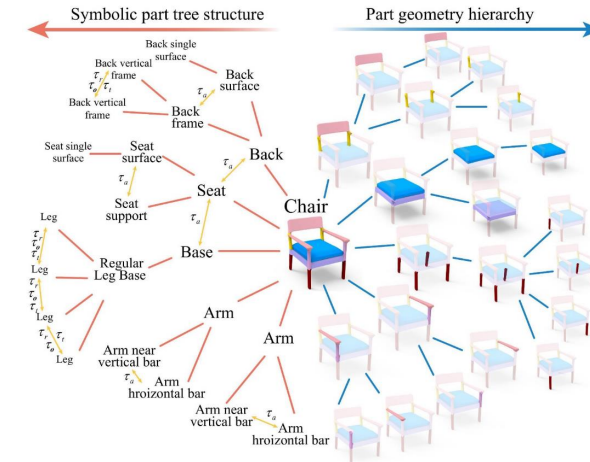
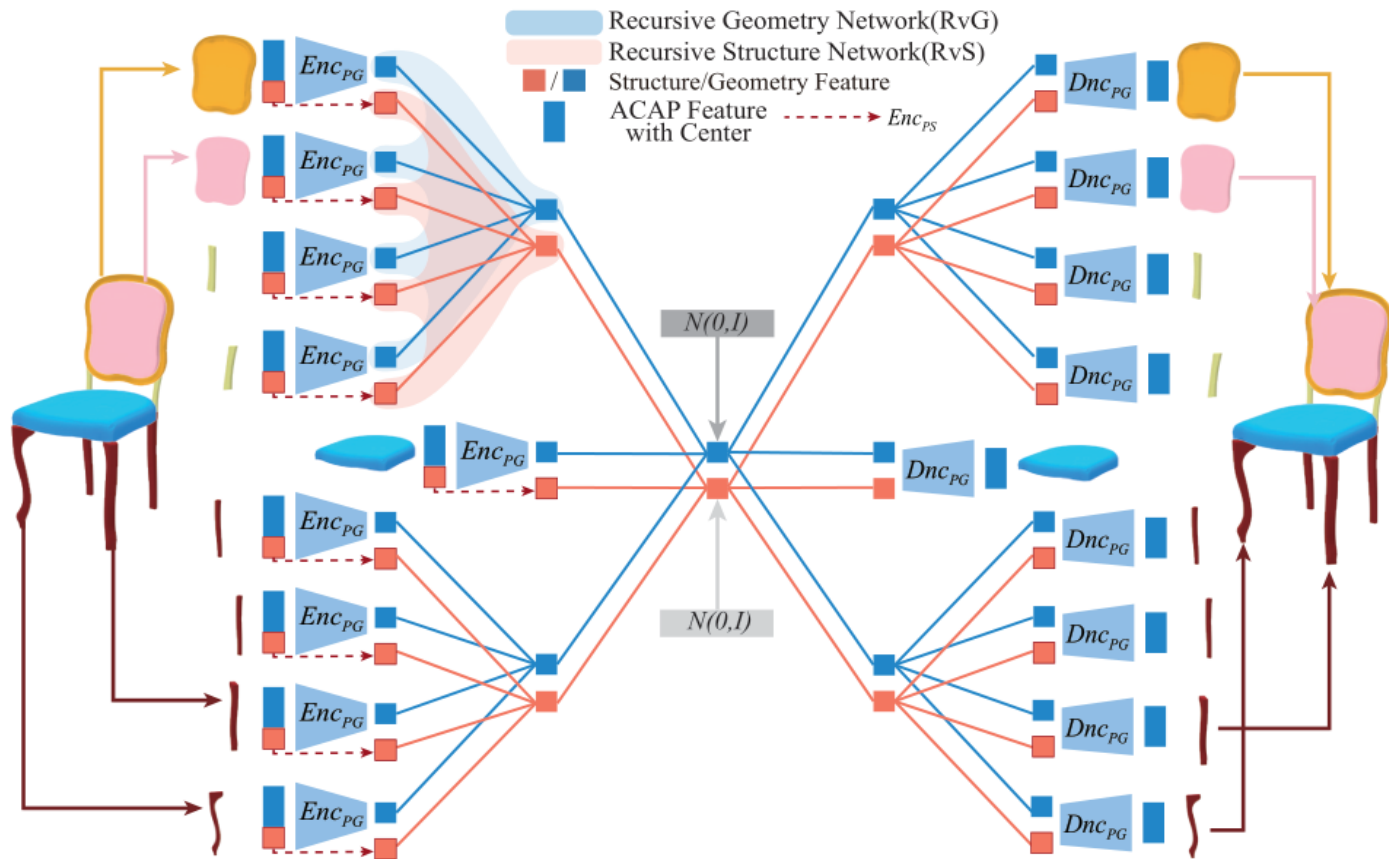


Graph Convolution on Mesh with ACAP [Tan et al. 2018]

$$\text{Loss function of PG-VAE: } \mathcal{L}_{\text{cond-PartVAE}} = \lambda_1 \mathcal{L}_{\text{cond-PartVAE}}^{\text{recon}} + \mathcal{L}_{\text{cond-PartVAE}}^{\text{KL}}$$

Methodology -- Complex Structure

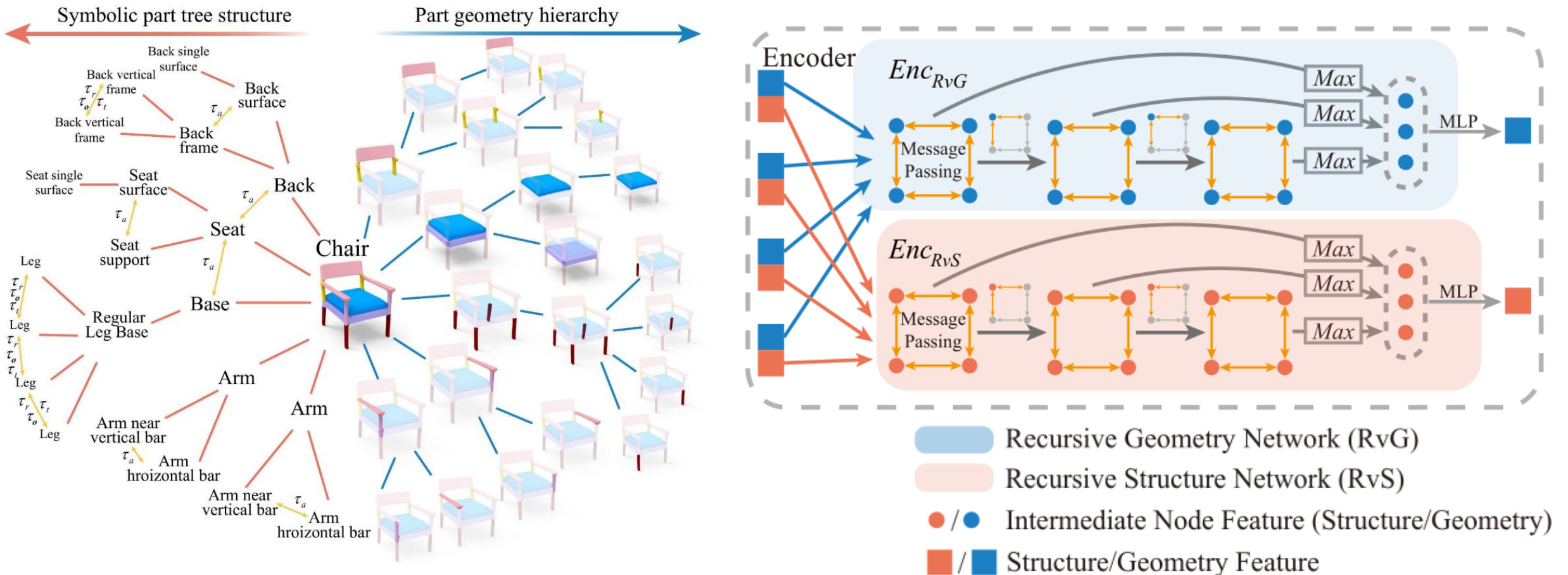
Coupled Hierarchical Graph Network Architecture for Geometry and Structure



Communication between **Geometry** and **Structure**
 Ensure their compatibility:
 the **structure** is used to guide
 the **geometry** and vice versa.

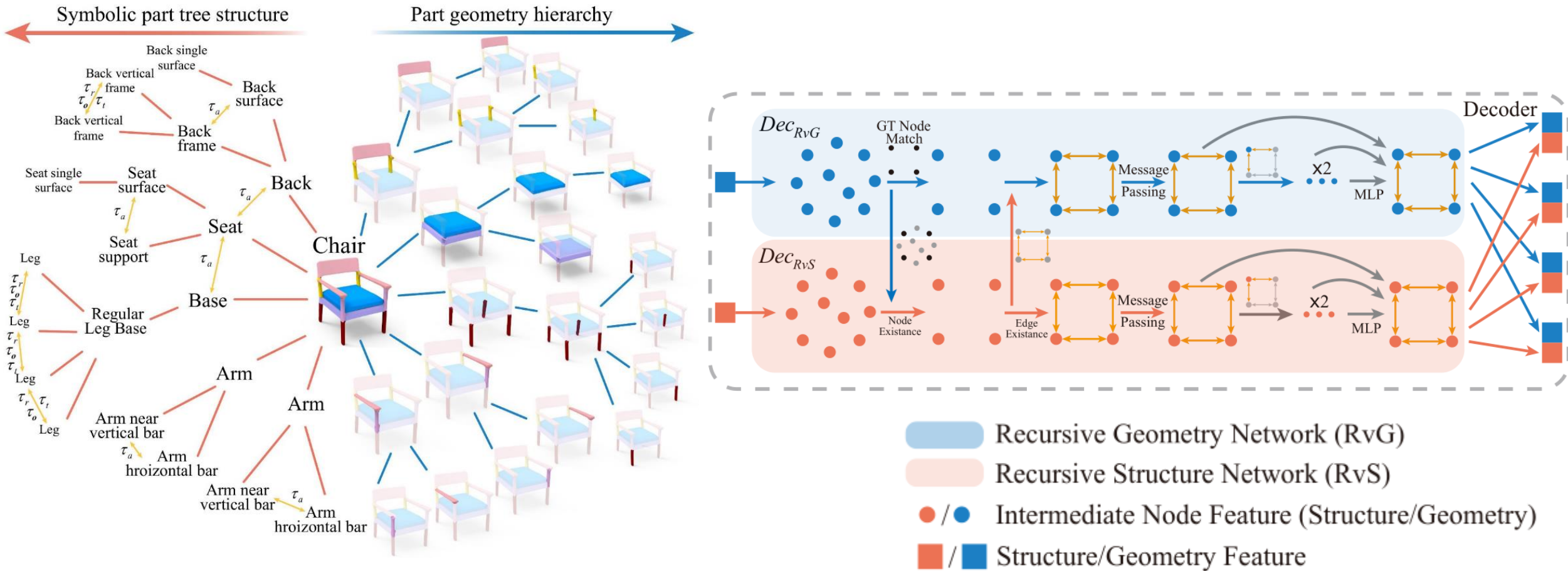
Methodology – Encode process

Communication between Geometry and Structure



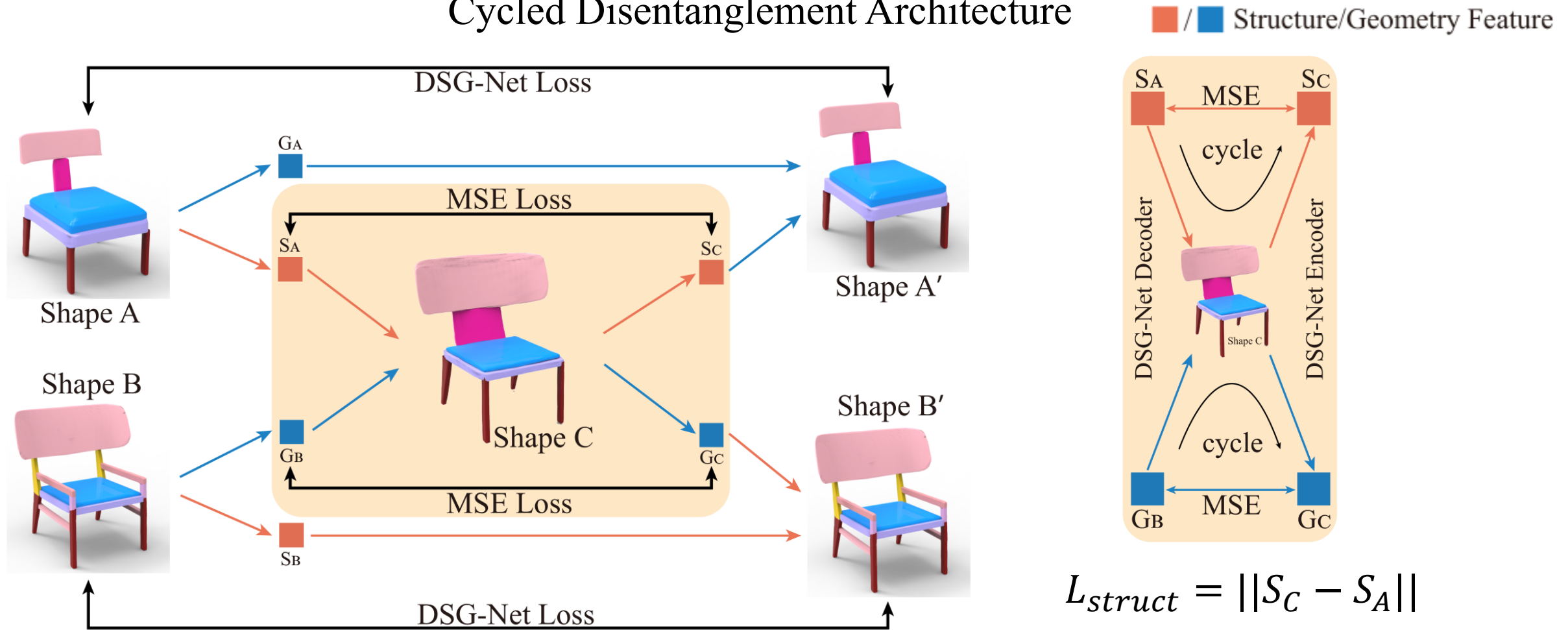
Methodology – Decode process

Communication between Geometry and Structure



Methodology – Cycled Disentanglement

Cycled Disentanglement Architecture



$$L_{struct} = ||S_C - S_A||$$

$$L_{geo} = ||G_C - S_B||$$

Results -- Comparison



输入模型

隐式场方法

二叉空间分割方法

结构化变形方法

结构化的点云方法

我们的方法

Results -- Disentangled Generation & Interpolation

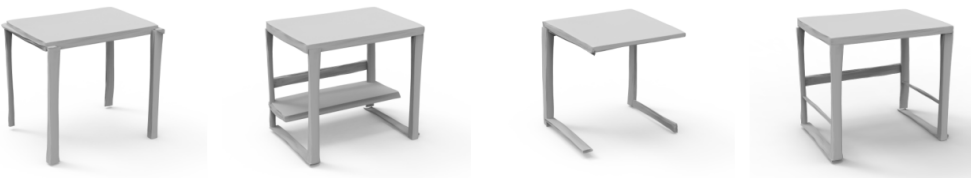
Disentangled Shape Generation



Same **Geometric** Details



Same **Structure** Relations



Same **Geometric** Details



Same **Structure** Relations

(a) Given Shape

(b) Random generation

Results -- Disentangled Generation & Interpolation

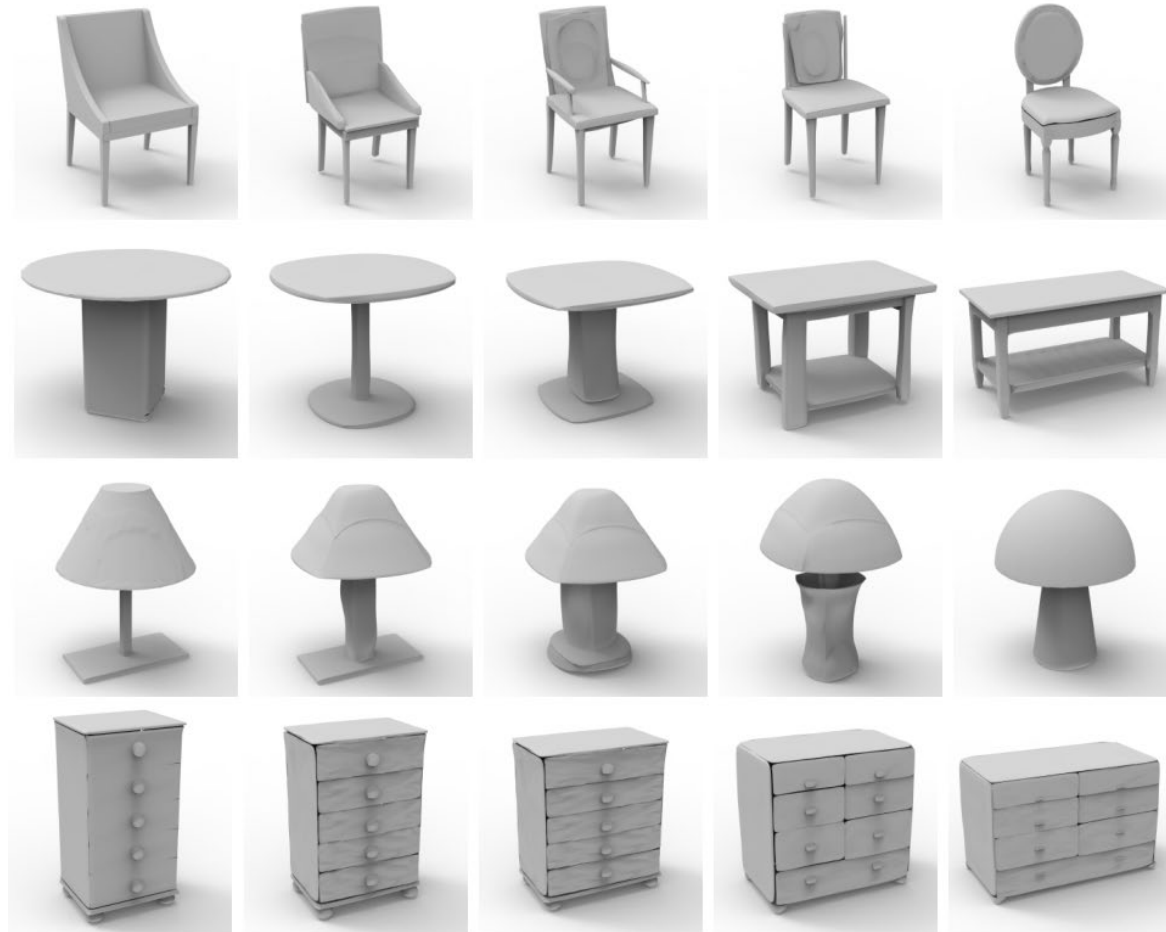
Disentangled Shape Interpolation



First Row: Same **Geometric** Details with (b), Interpolate **Structure**

Second Row: Same **Structure** Relations with (b), Interpolate **Geometric**

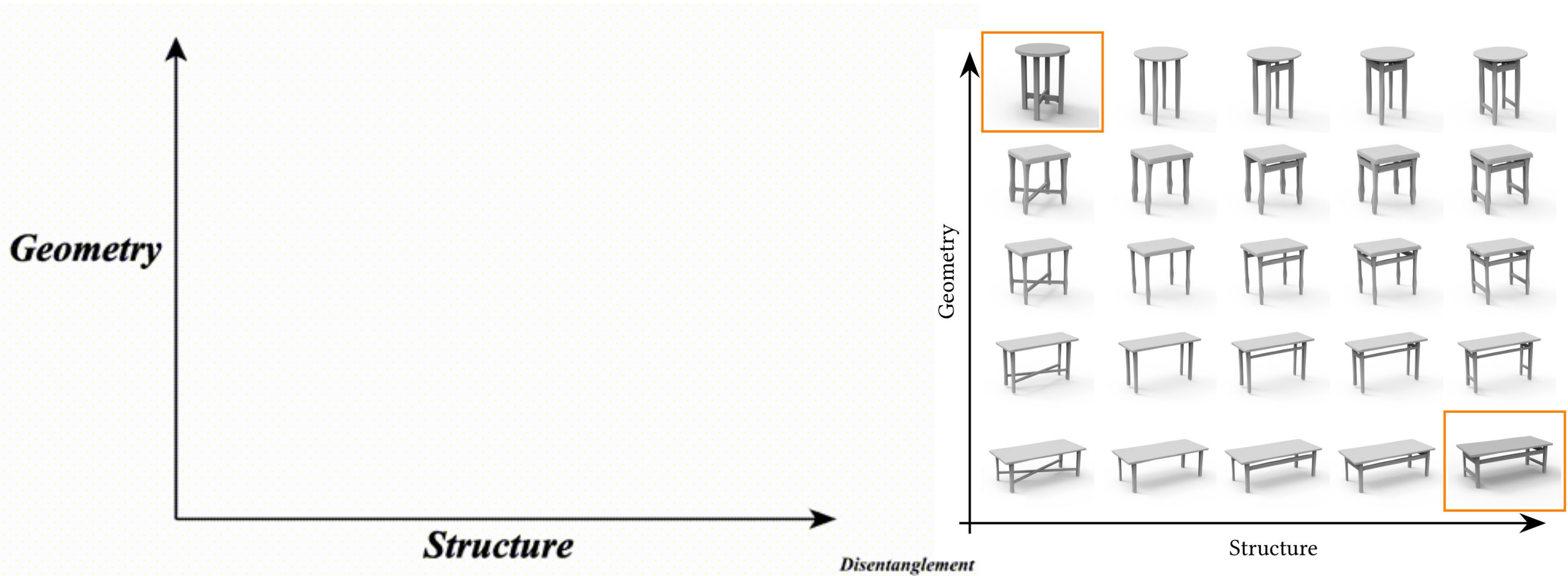
Results -- Disentangled Generation & Interpolation



Source

Target

Results -- Disentangled Generation & Interpolation



SceneHGN: Hierarchical Graph Networks for 3D InDoor Scene Generation with Fine-Grained Geometry

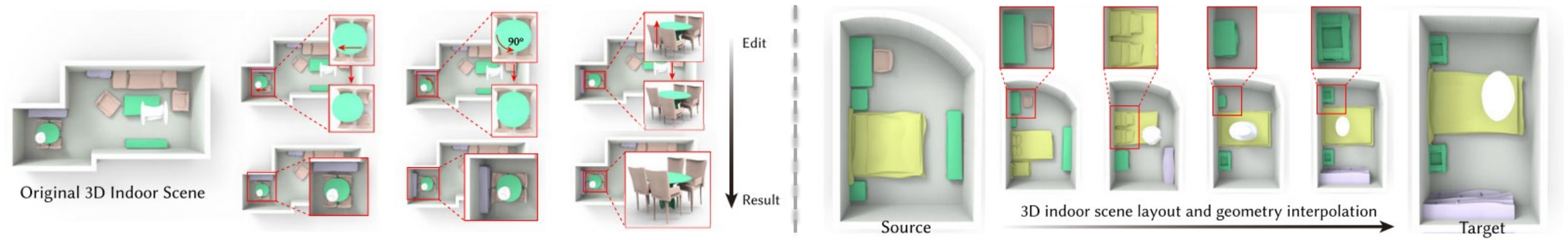
Jie Yang, Jia-Mu Sun, Kaichun Mo, Yu-Kun Lai, Leonidas Guibas and Lin Gao

¹ Institute of Computing Technology, Chinese Academy of Sciences

² University of Chinese Academy of Sciences

³ Stanford University ⁴ Cardiff University

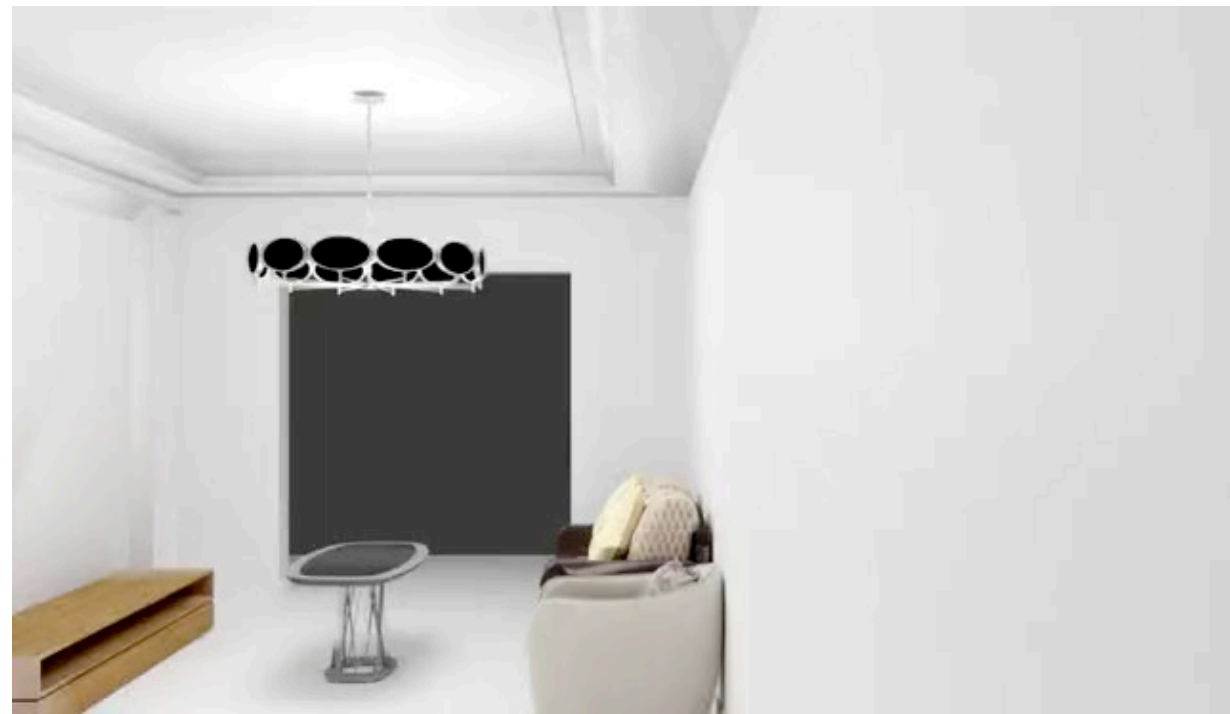
IEEE TPAMI with Minor Revision



Challenges



布局和结构
复杂多样



空间分布
稀疏不规则

Related Work



Recursive Structure

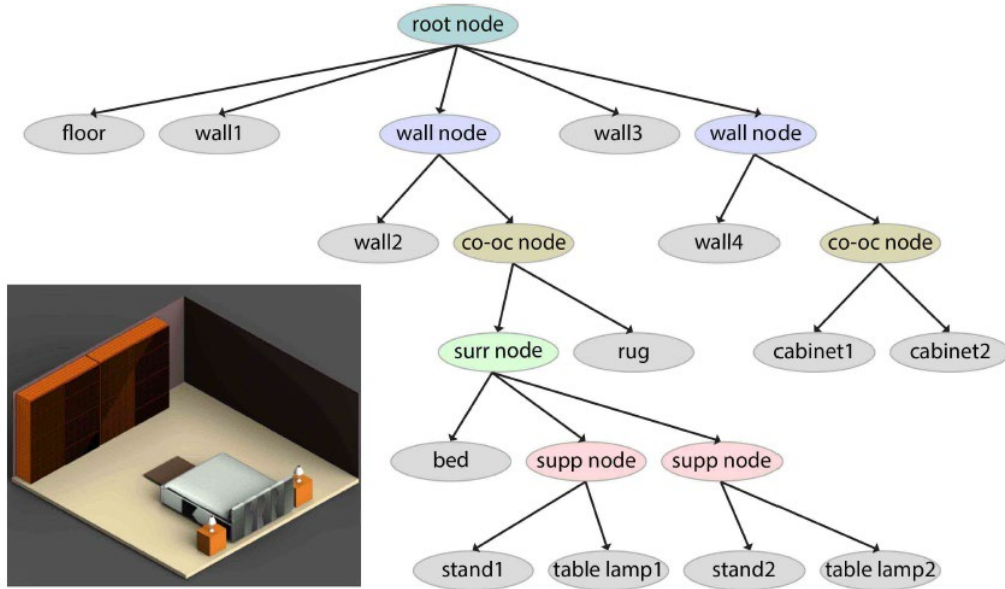
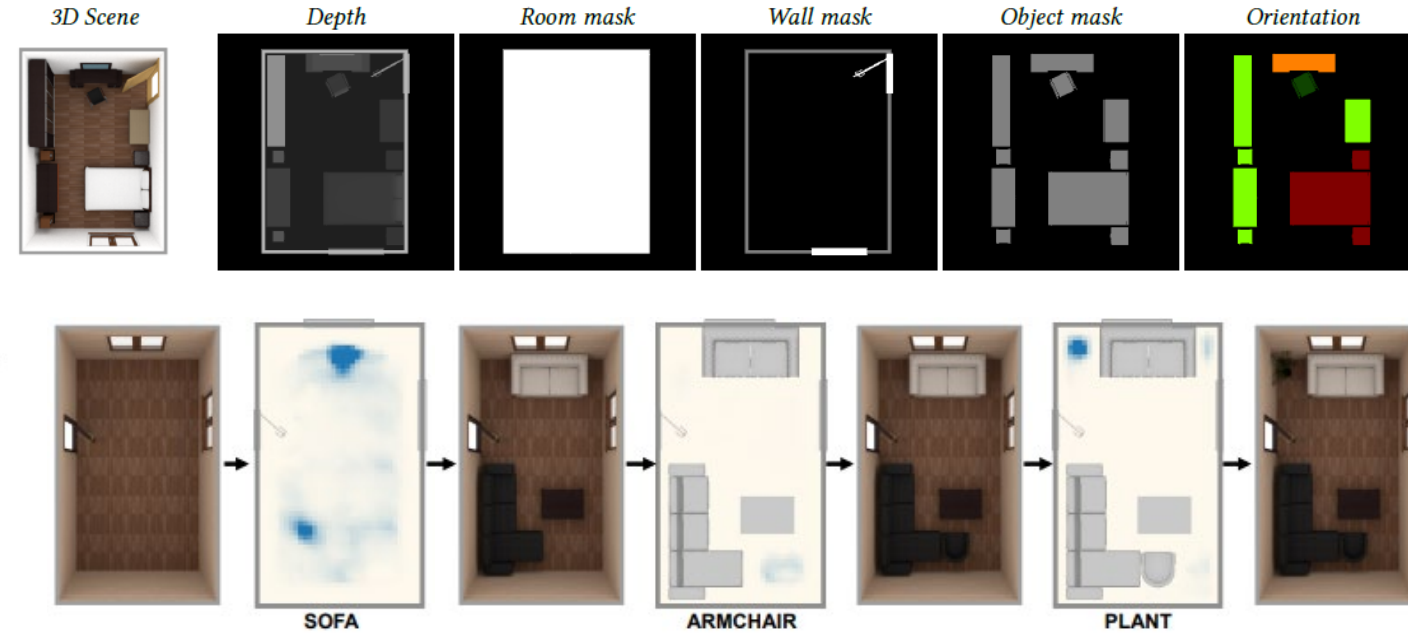


Image Based



GRAINS: Generative Recursive Autoencoders for INdoor Scenes **Deep priors:** Deep Convolutional Priors for Indoor Scene Synthesis

RvNN + VAE = Generative Deep Model

Input: hierarchical scene structure

Output: free generation

Limitation:

1) Room containing four walls, 2) Retrieved Object

Input: top-down multi-channel image of the room

Output: Place objects in sequence until stop

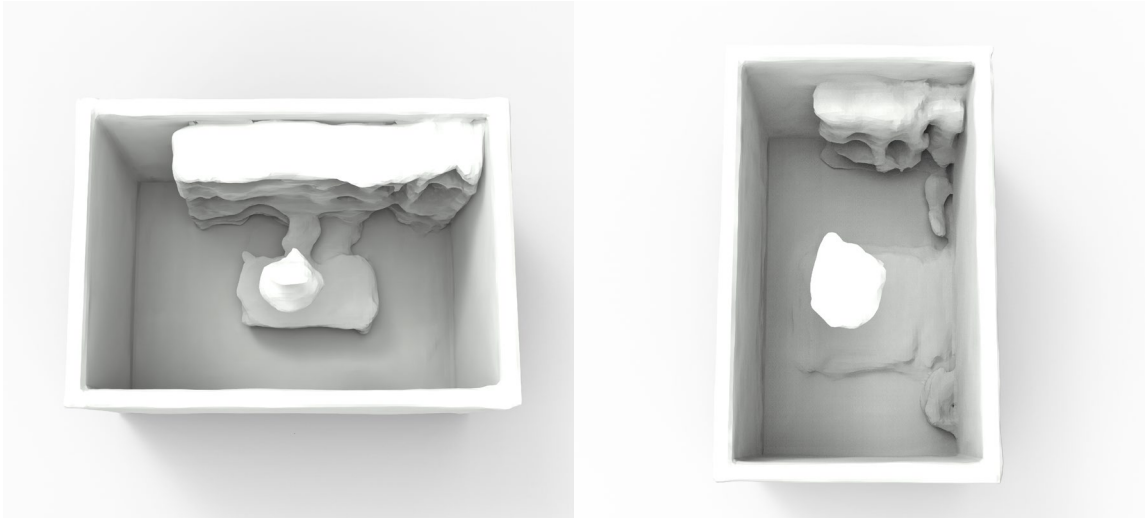
Limitation:

1) Not capture geometric details, 2) Retrieved Object

Related Work



Implicit-Based Methods



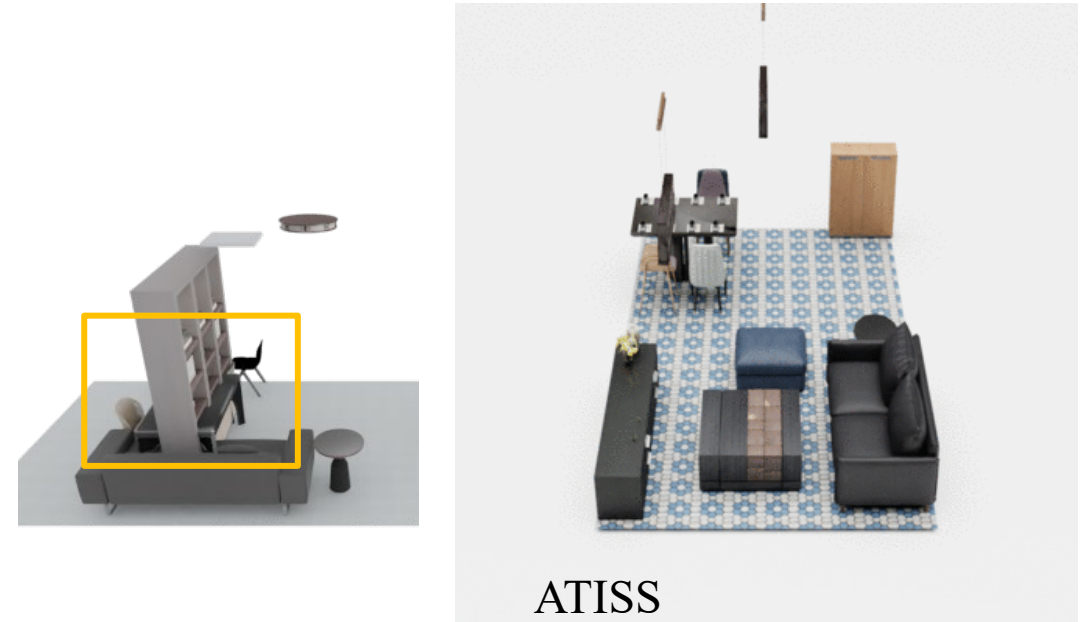
Occupancy Networks

Learning 3D Reconstruction in Function Space
[CVPR 2020]

Limitation:

Not capture the detailed geometry and complex structure

Transformer-Based Methods



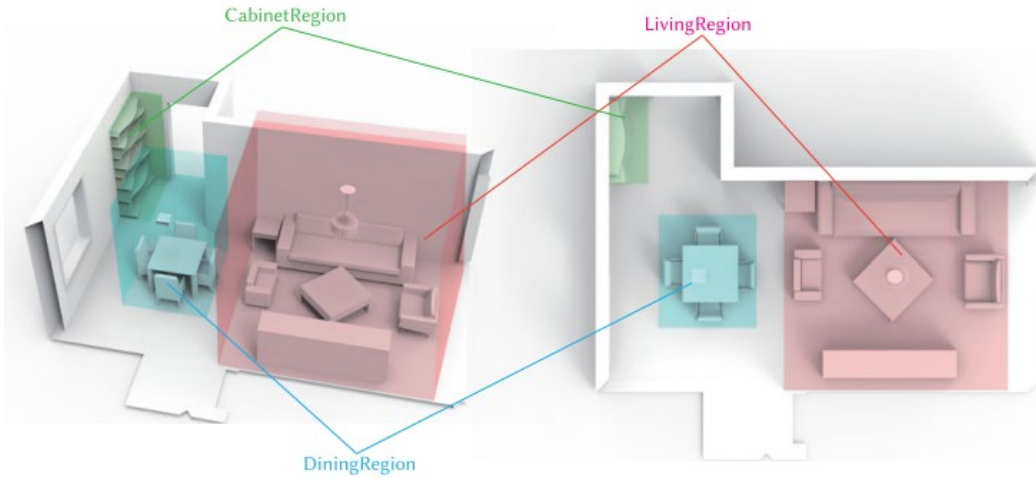
ATISS

Autoregressive Transformers for Indoor Scene Synthesis
[NeurIPS 2021]

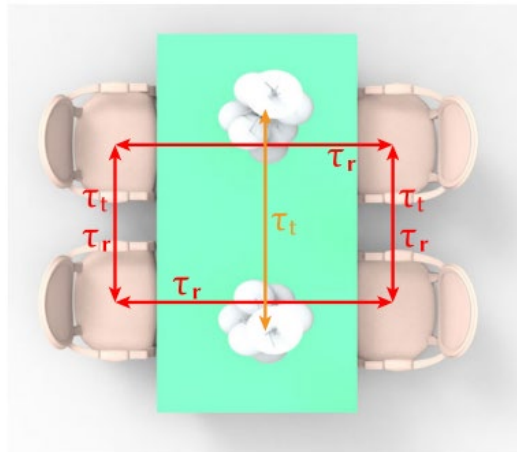
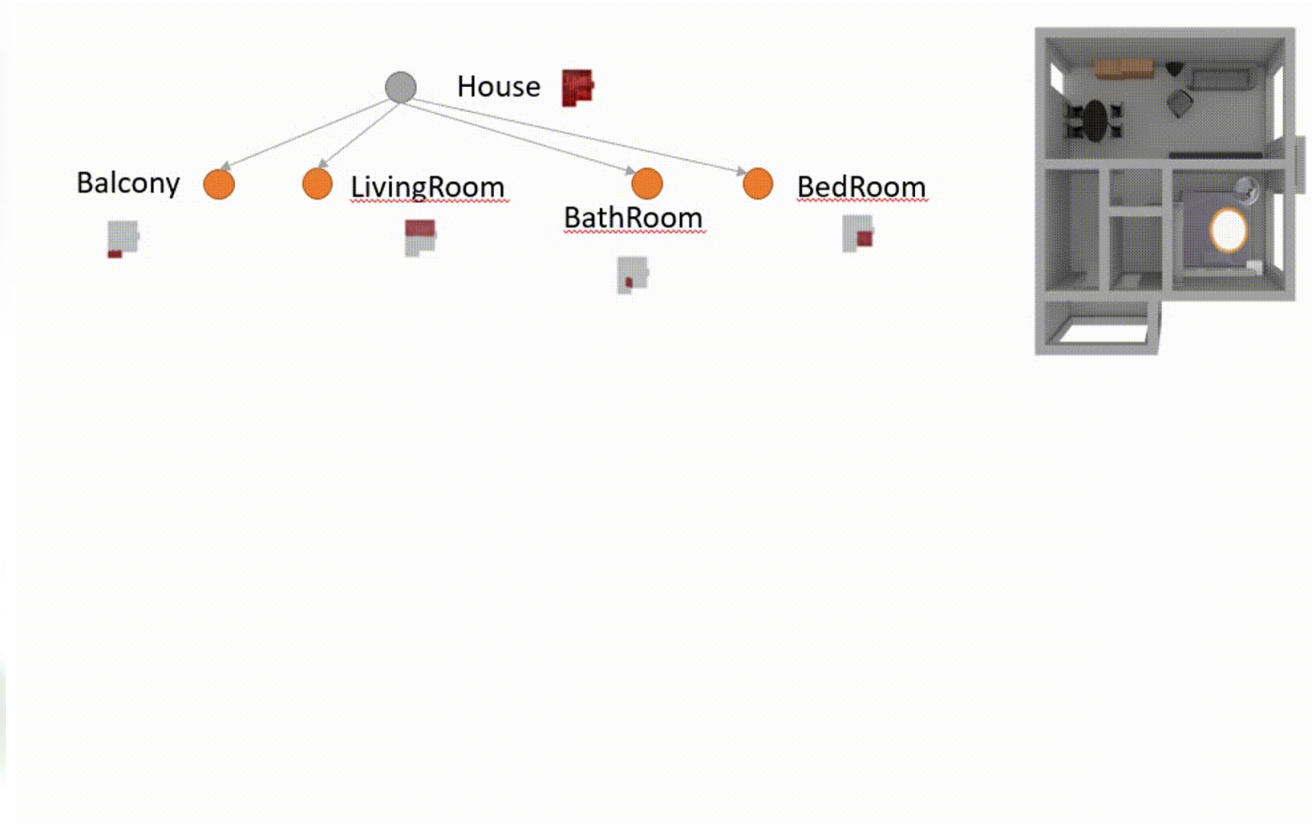
Limitation:

1) Not consistency, 2) Collided, 3) Retrieved Object

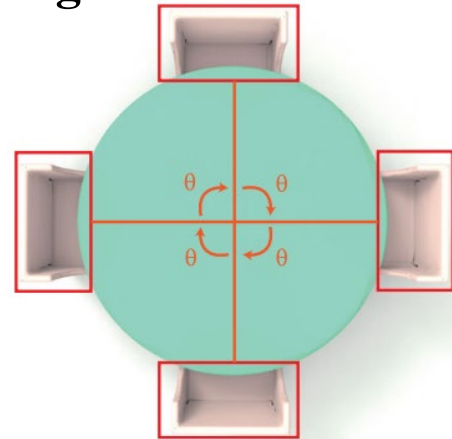
SceneHGN - Hierarchical Graph Network



Functional Region



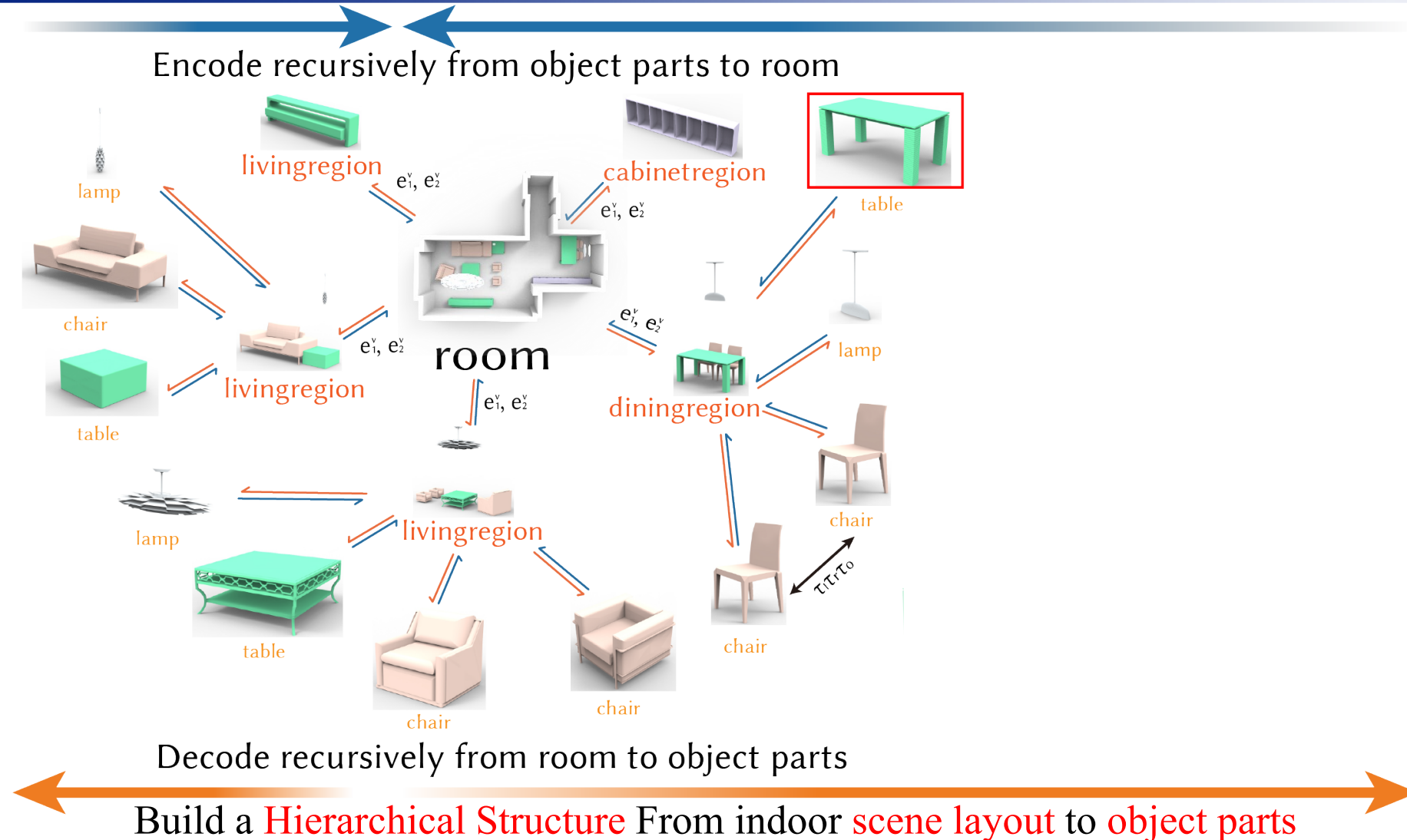
Binary-edge



Hyper-edge

3D Indoor Scene Hierarchical Representation

SceneHGN - Hierarchical Graph Network



SceneHGN – scene comparison & interpolation

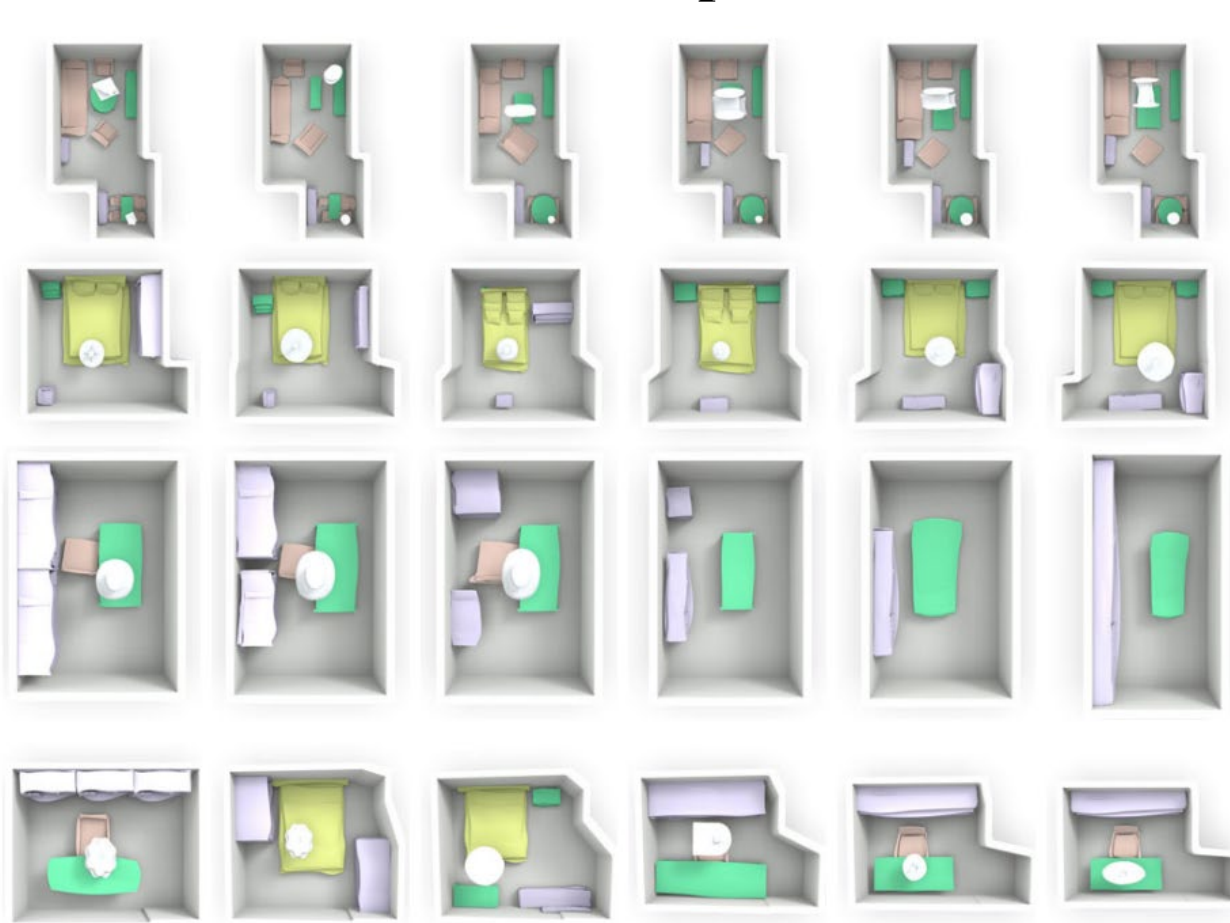


Comparison of Scene Generation



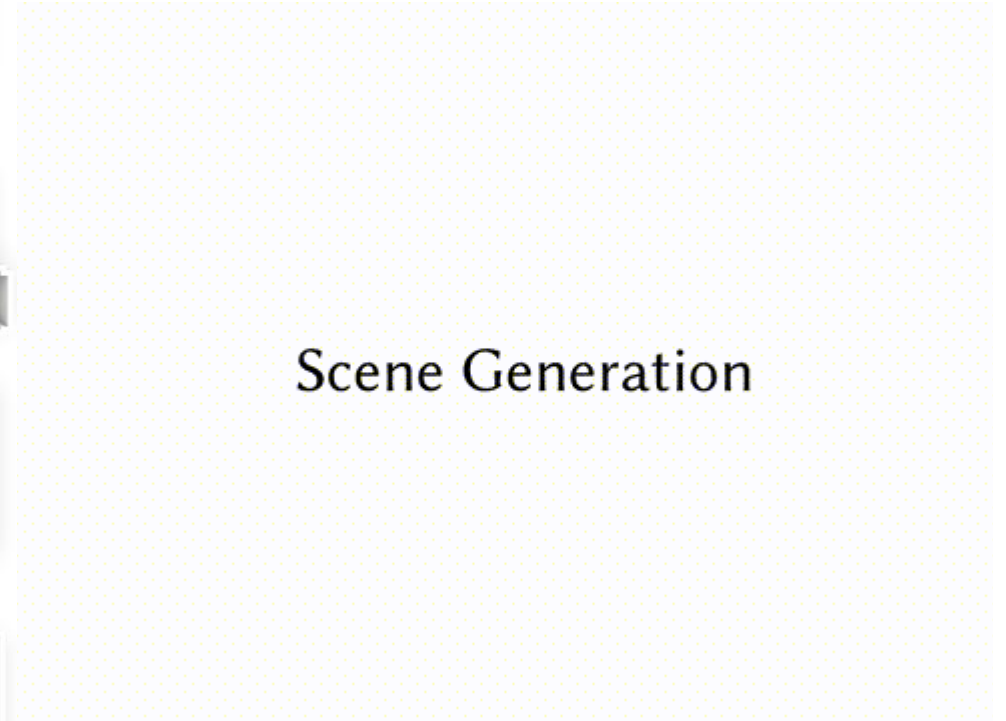
(a) Input (b) GRAINS (c) Deep Priors (d) Ours

Scene Interpolation



(a) source (b) target

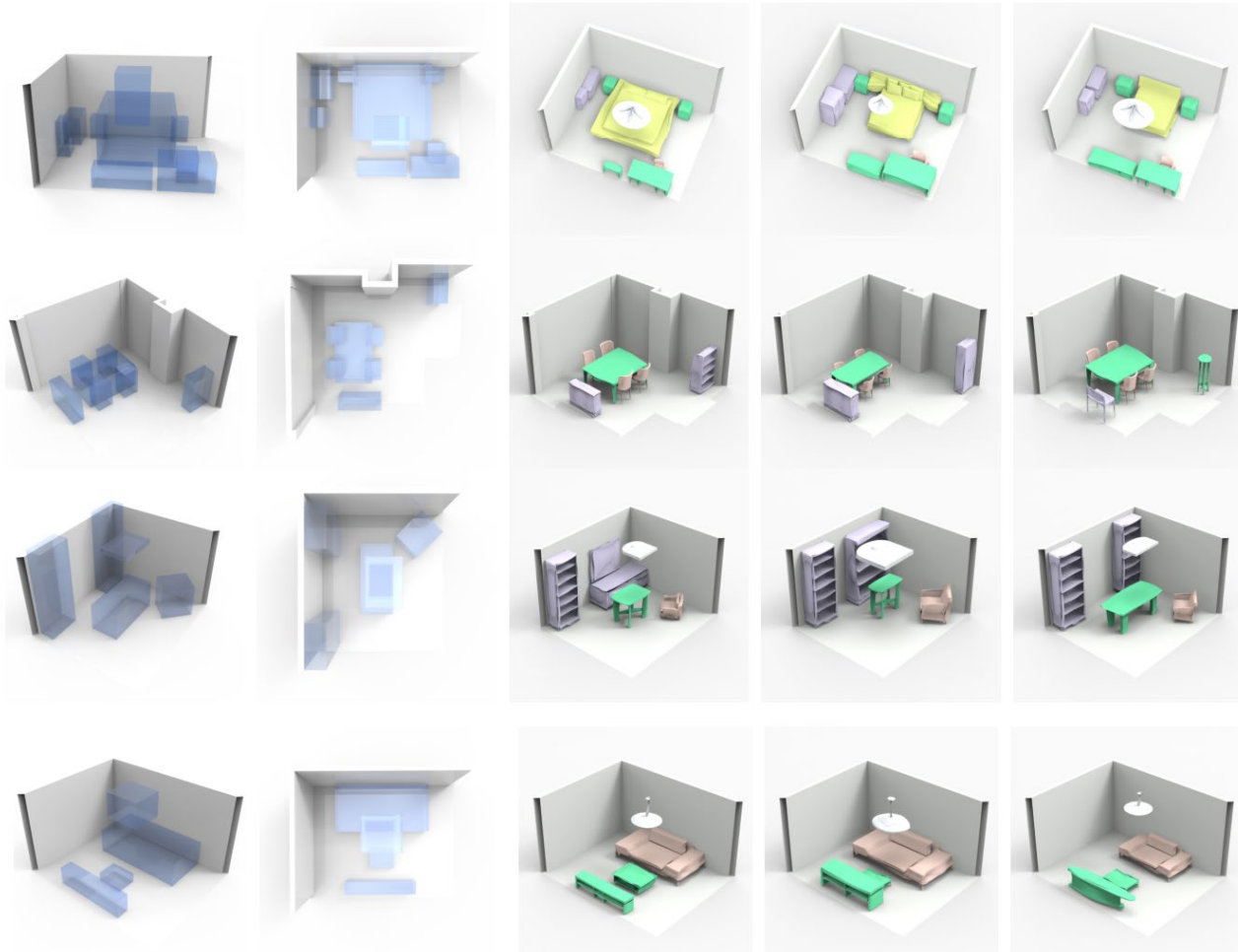
SceneHGN – scene generation



Scene Generation

Scene Generation

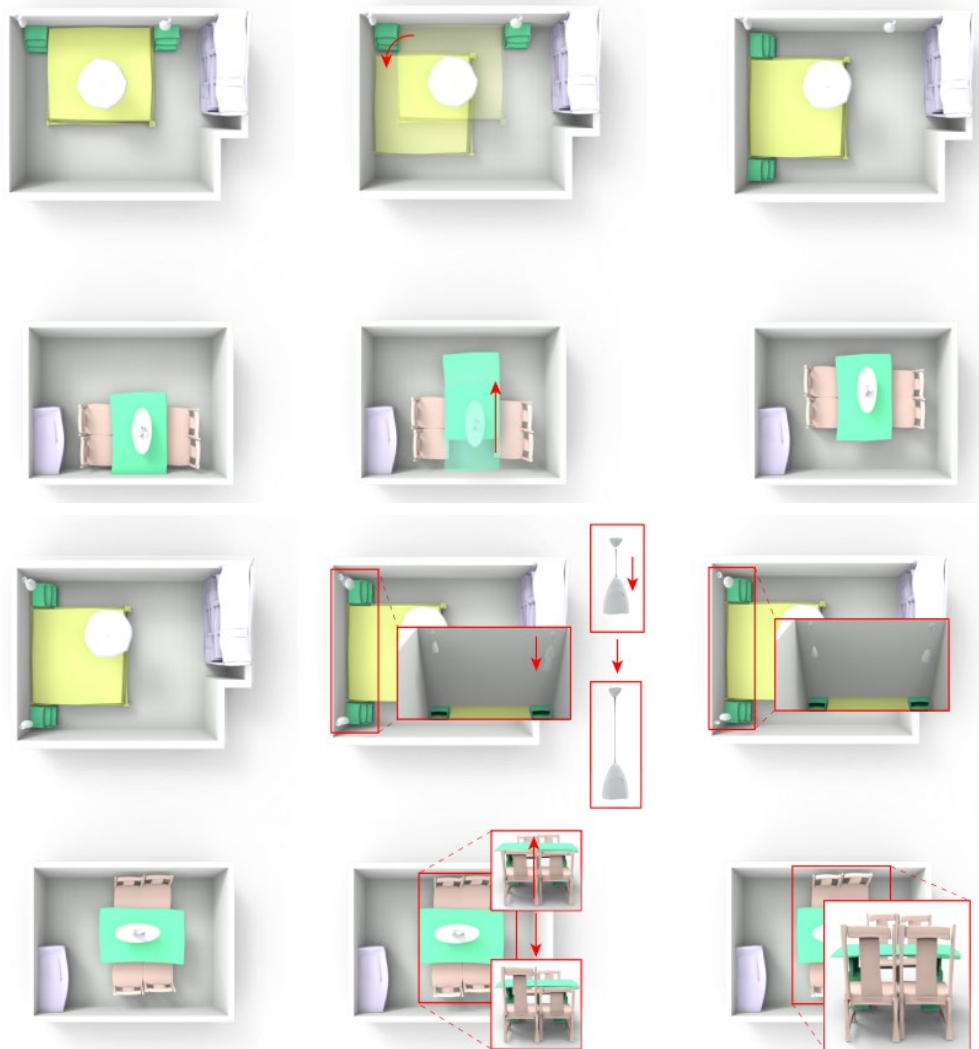
SceneHGN – indoor scene generation



Scene Generation
from 3D Box Layout

3D scene generation from 3D box layout

SceneHGN – scene editing



Scene Editing

Scene Editing



谢谢
请大家批评指正