CAADRIA
The Association for Computer-Aided Architectural Design Research in Asia

GenScan: A Generative Method for Populating Parametric 3D Scan Datasets

(CAADRIA '21 Presentation)

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FOR ENHANCED REALITY

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Motivation

3D Deep Learning

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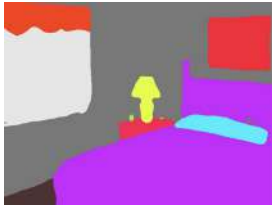
3D Deep Learning Tasks

Scene Completion

[1]

Semantic Segmentation

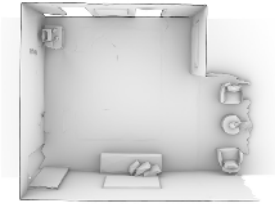


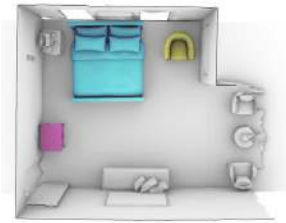
[2]

Mesh Reconstruction

[3]

Scene Synthesis





[4]

[1] Dai, Angela, et al. ".Scancomplete: Large-scale scene completion and semantic segmentation for 3d scans." In Proceedings of the IEEE CVPR, 2018.
[2] Zhang, Hang et al."Context encoding for semantic segmentation." In Proceedings of the IEEE CVPR, 2018.
[3] Gkioxari, Georgia, Jitendra Malik, and Justin Johnson. "Mesh R-CNN."In Proceedings of the IEEE CVPR, 2019.
[4] Keshavarzi, Mohammad et al. ""SceneGen: Generative Contextual Scene Augmentation using Scene Graph Priors." arXiv preprint arXiv:2009.12395. 2020..

Learning Data

Learning Data

2D Learning Data

3D Learning Data?

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Learning Data

Synthetic Data (SUNCG) [1]

Scanned Data (MatterPort3D) [2]

[1] Song, Shuran et al. "Semantic scene completion from a single depth image." In Proceedings of the IEEE CVPR, 2017.
[2] Chang, Angel, et al. "Matterport3d: Learning from rgb-d data in indoor environments." In 3DV, IEEE, 2017.

Learning Data

Synthetic Data (SUNCG) [1]

+45,600 Houses

Scanned Data (MatterPort3D) [2]

90 Houses

[1] Song, Shuran et al. "Semantic scene completion from a single depth image." In Proceedings of the IEEE CVPR, 2017.
[2] Chang, Angel, et al. "Matterport3d: Learning from rgb-d data in indoor environments." In 3DV, IEEE, 2017.

GenScan

A Generative Method for Populating Parametric 3D Scan Datasets

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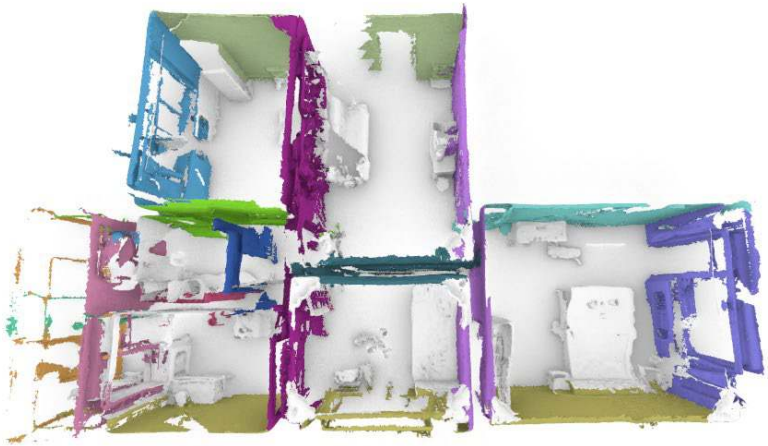
Input 3D Scan

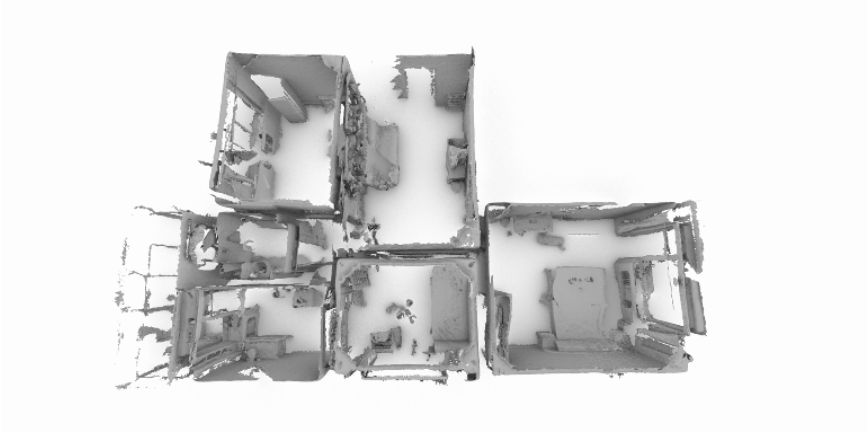


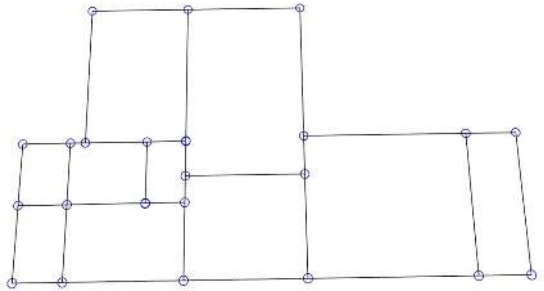
Wall Parametrization

Model Generation

Method

Floorplan Extraction





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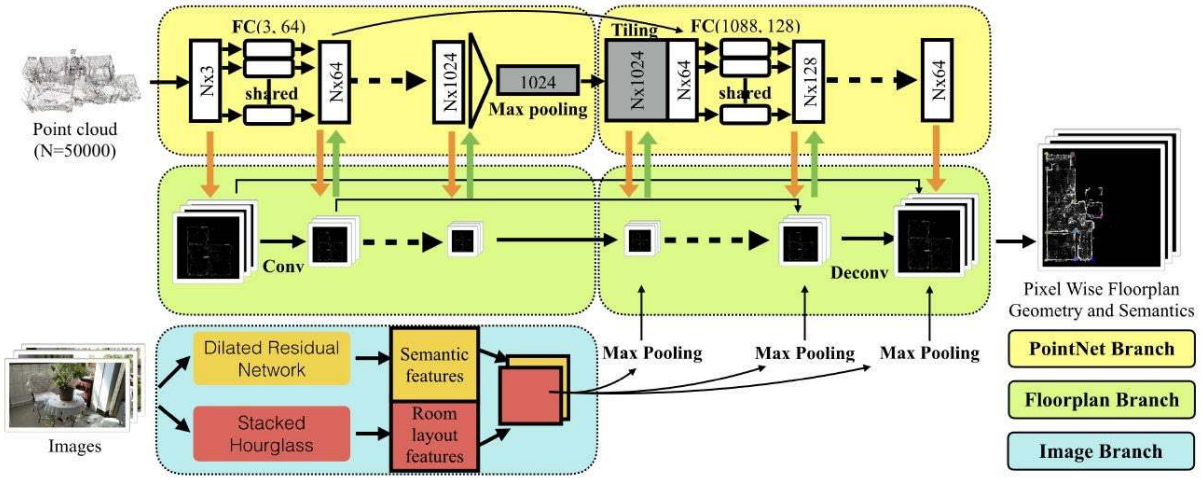
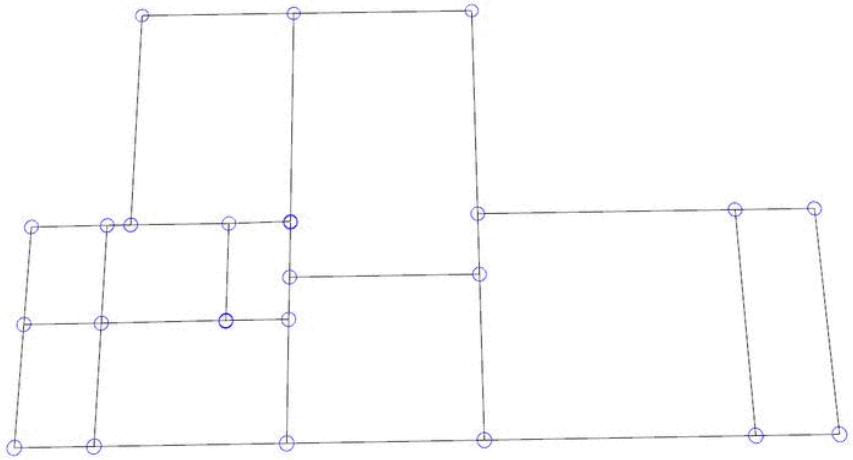
FloorNet [1]



Adapted From [1]

[1] Liu, Chen et al.. "Floornet: A unified framework for floorplan reconstruction from 3d scans." In Proceedings of the IEEE ECCV, 2018.

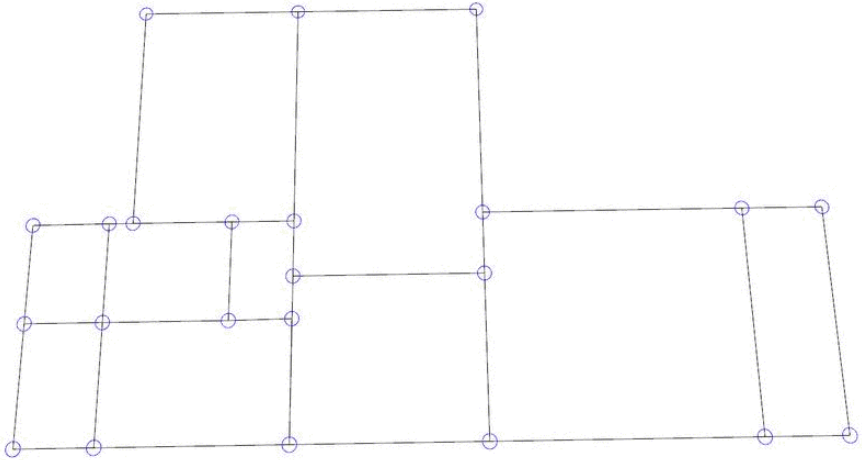
Parametrization



While line list is smaller than the square of line list count
    Foreach line:
    Construct direction vector
    If vector is equal to neighbouring line vector:
    Merge two lines, delete old lines
    Store containing nodes and old nodes in new line

Non- parametric floor plan

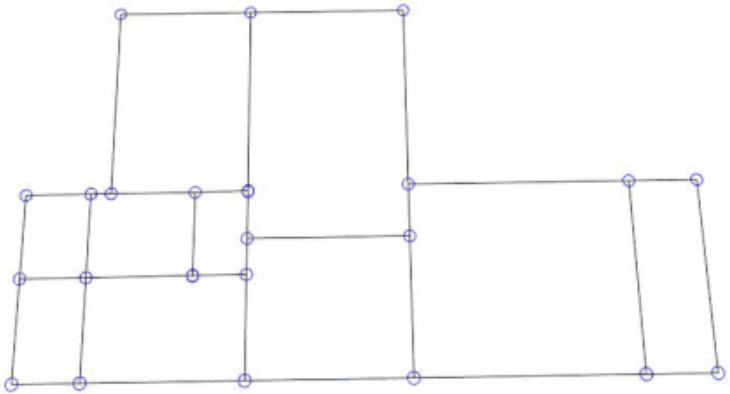
Parametrization



While line list is smaller than the square of line list count
- Foreach line:
- Construct direction vector
- If vector is equal to neighbouring line vector:
- Merge two lines, delete old lines
- Store containing nodes and old nodes in new line

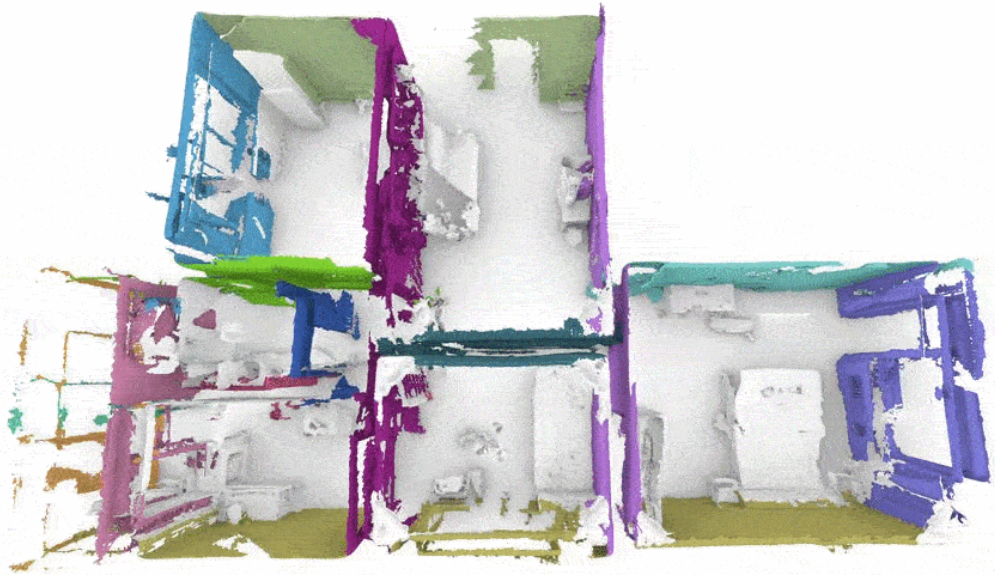
Parametric Floor plan

Containment Extraction



Foreach contained mesh:
Compare old length and new length
Compute scale factor
Find center of assigned line
Apply scale factor to x, y coordinates

Transform



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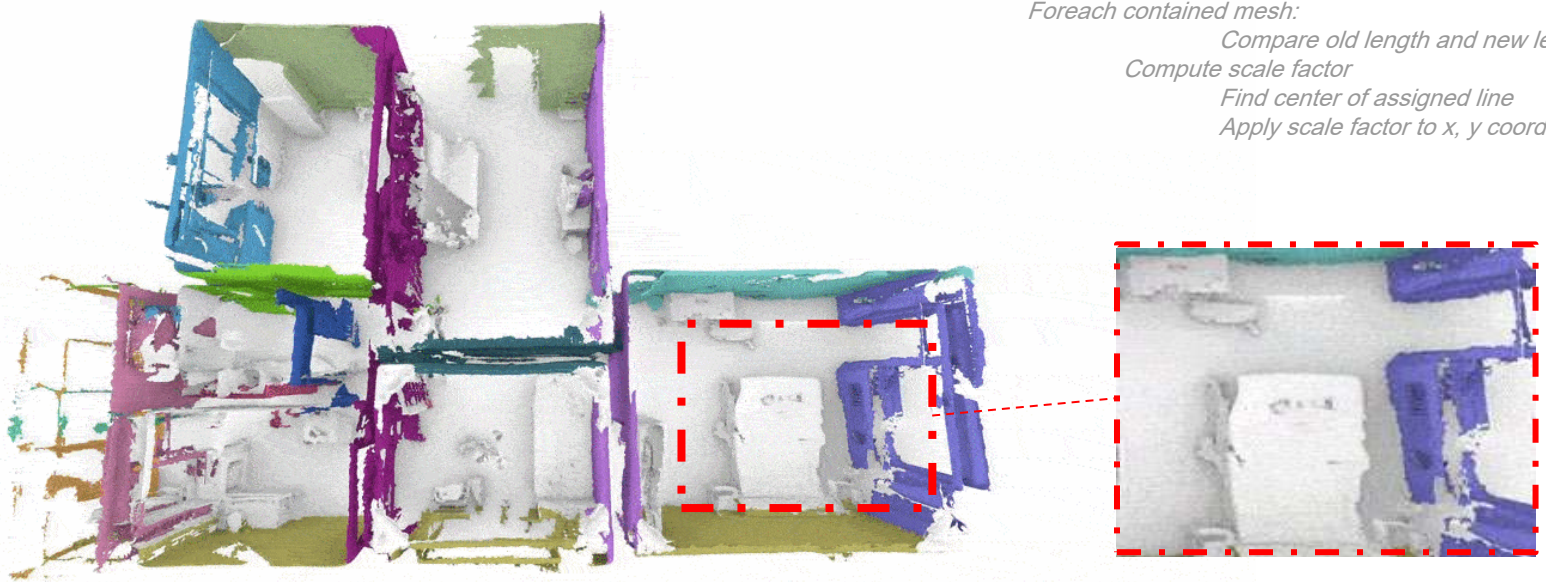

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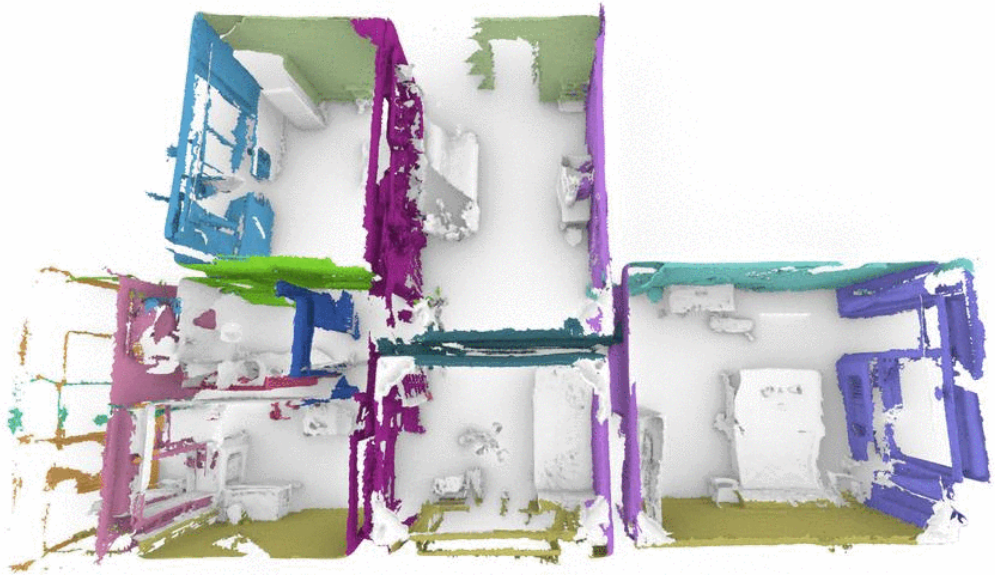
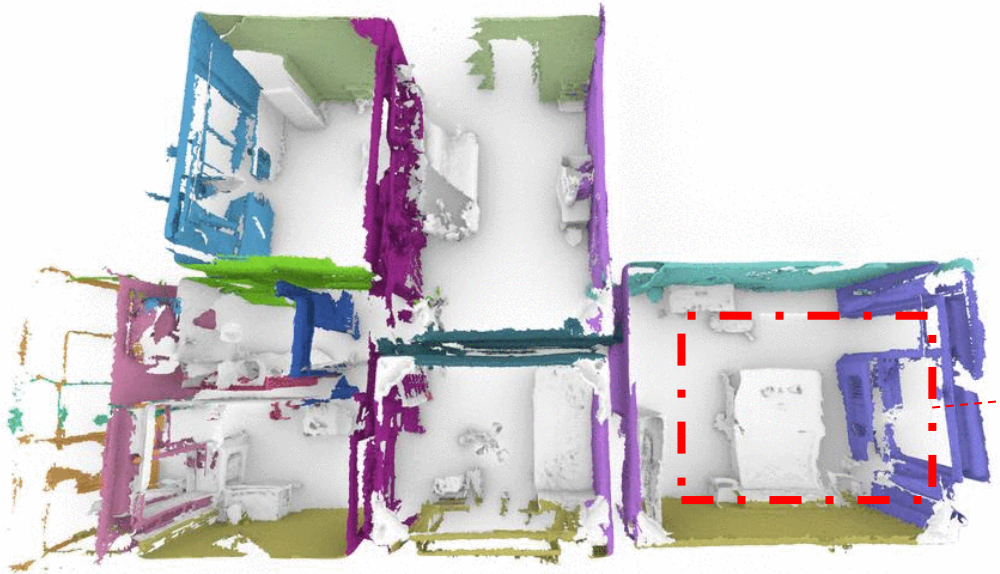


Foreach unassigned mesh:
- *Construct bounding box*
- *Find closest line to center of bounding box*
- *Follow transformation vector of line*
- *Exclude scale transformation of line*

Transform



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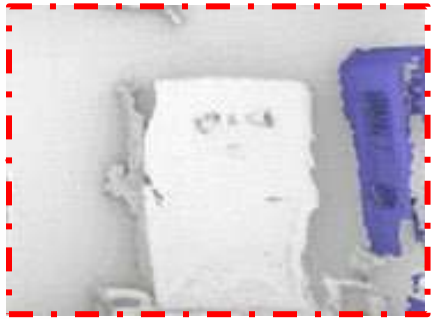
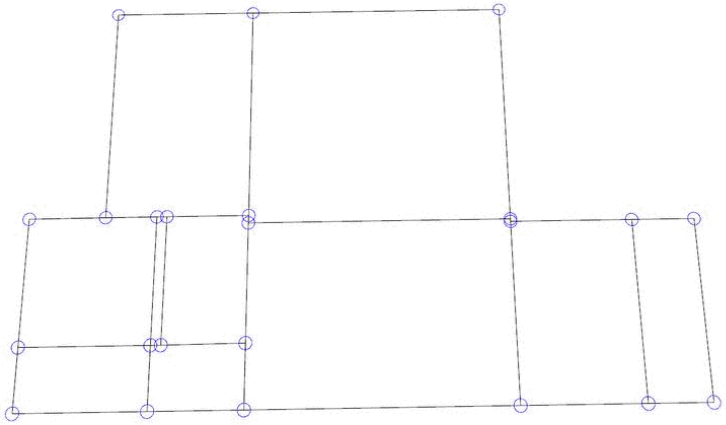
Exclude scale transformation of line



Generation



Foreach parametric line:
- *Find perpendicular vector*
- *Amplify vector by random value*
- *Assign transform vector to contained node*
- *Update all nodes*
- *Reconstruct all lines*

Random Generation

Generation

Foreach parametric line:
- *Find perpendicular vector*
- *Amplify vector by random value*
- *Assign transform vector to contained node*
- *Update all nodes*
- *Reconstruct all lines*

Update contained mesh

Random Generation

Datasets

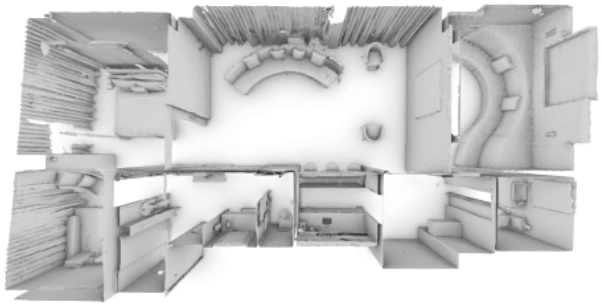
MatterPort3D

Scanned by MatterPort camera
90 Scans
Mesh with textures

FloorNet

Scanned by Google Tango
71 Scans
Mesh with textures

Generation



Input

Output

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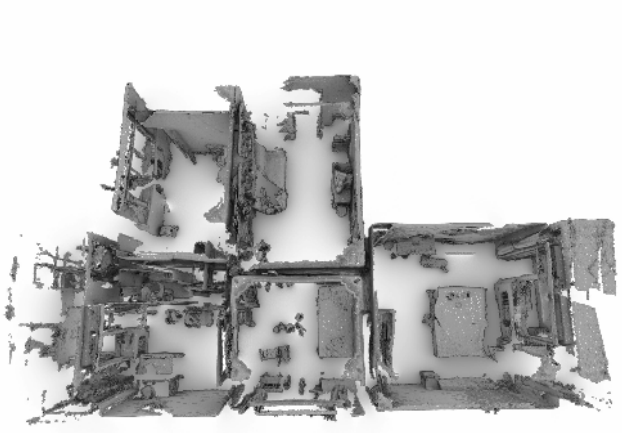
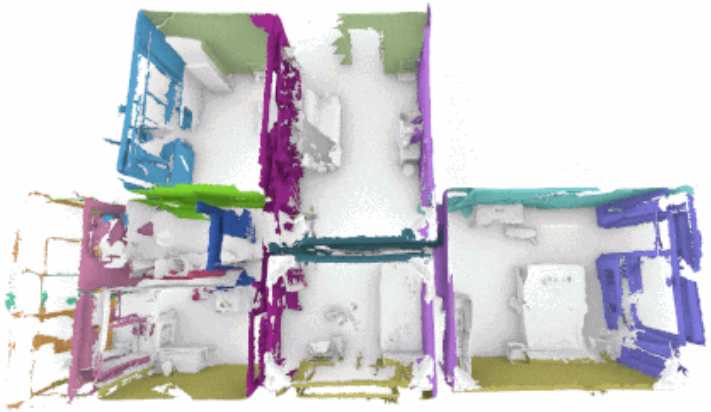
Generation



Input



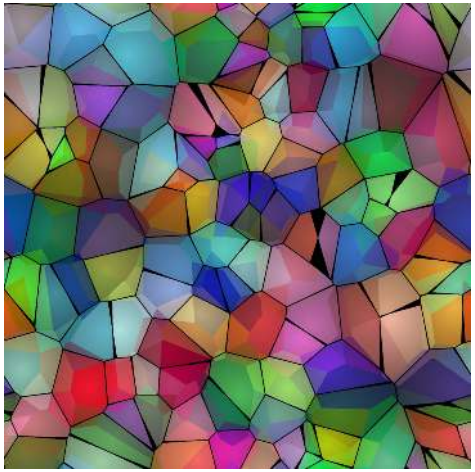
Output

Texture Synthesis

Style Transfer

Original Texture Map

+

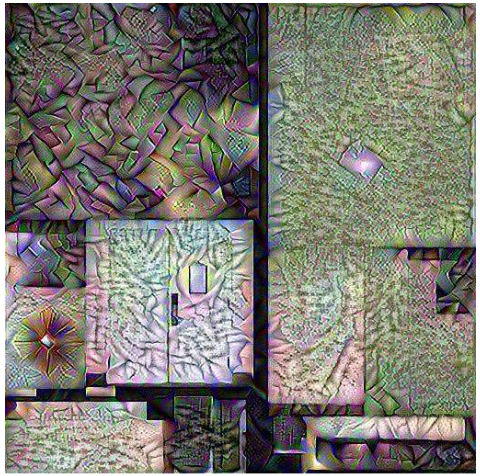


Texture Map

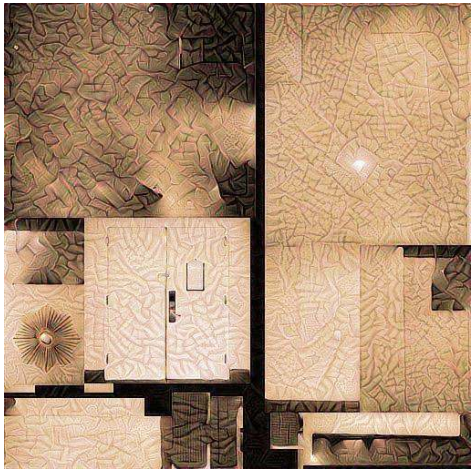
Style Transfer

Texture Synthesis

Image Adjustments



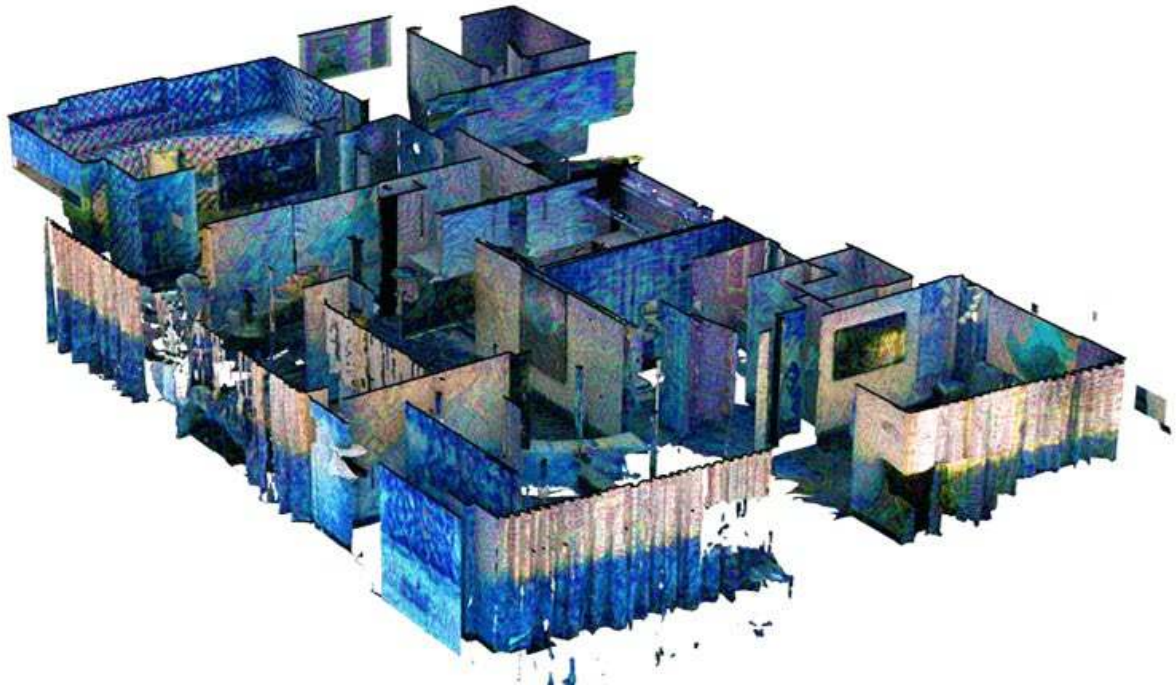
ITERATIONS: 50



Original Texture Map → Style Transfer → Tint + Saturation

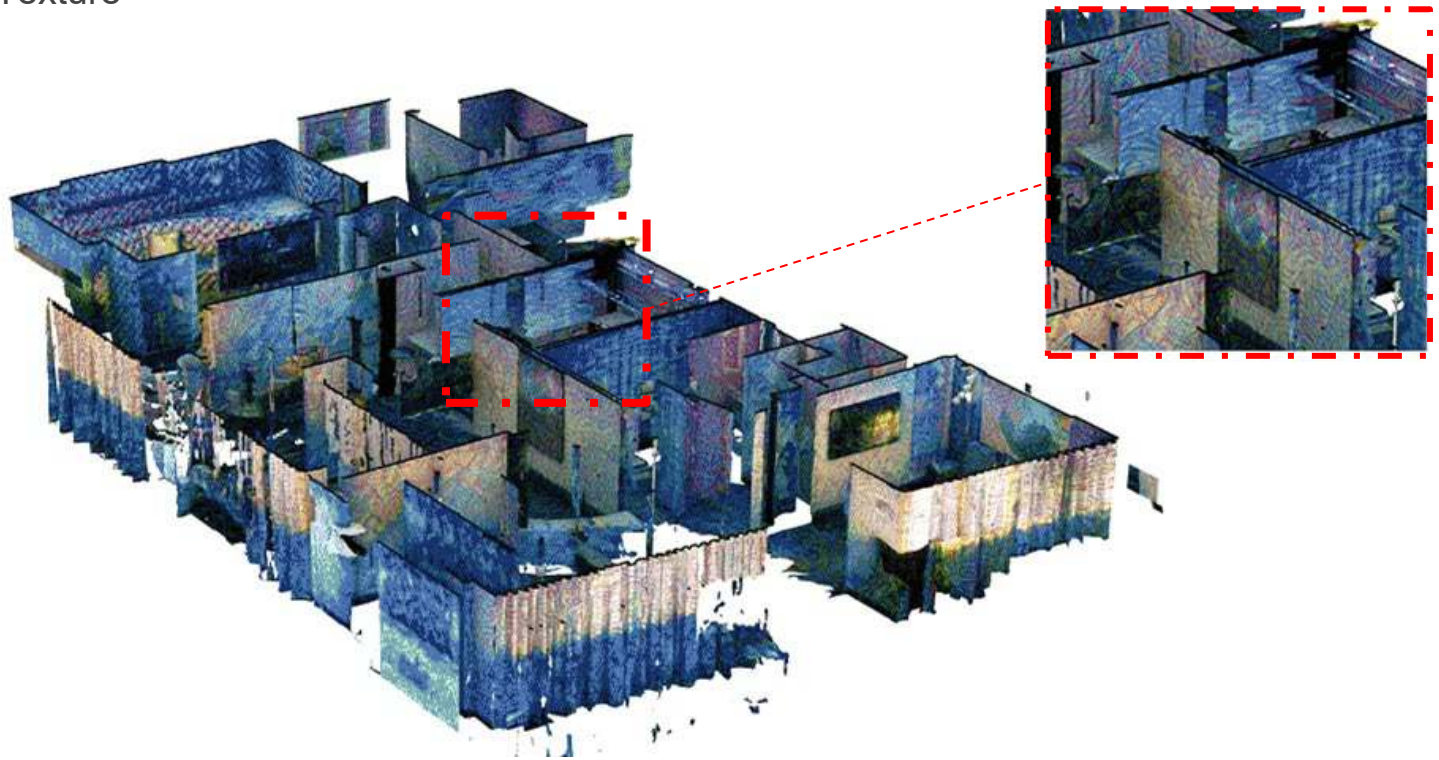
Final Generation

Geometry + Texture



Final Generation

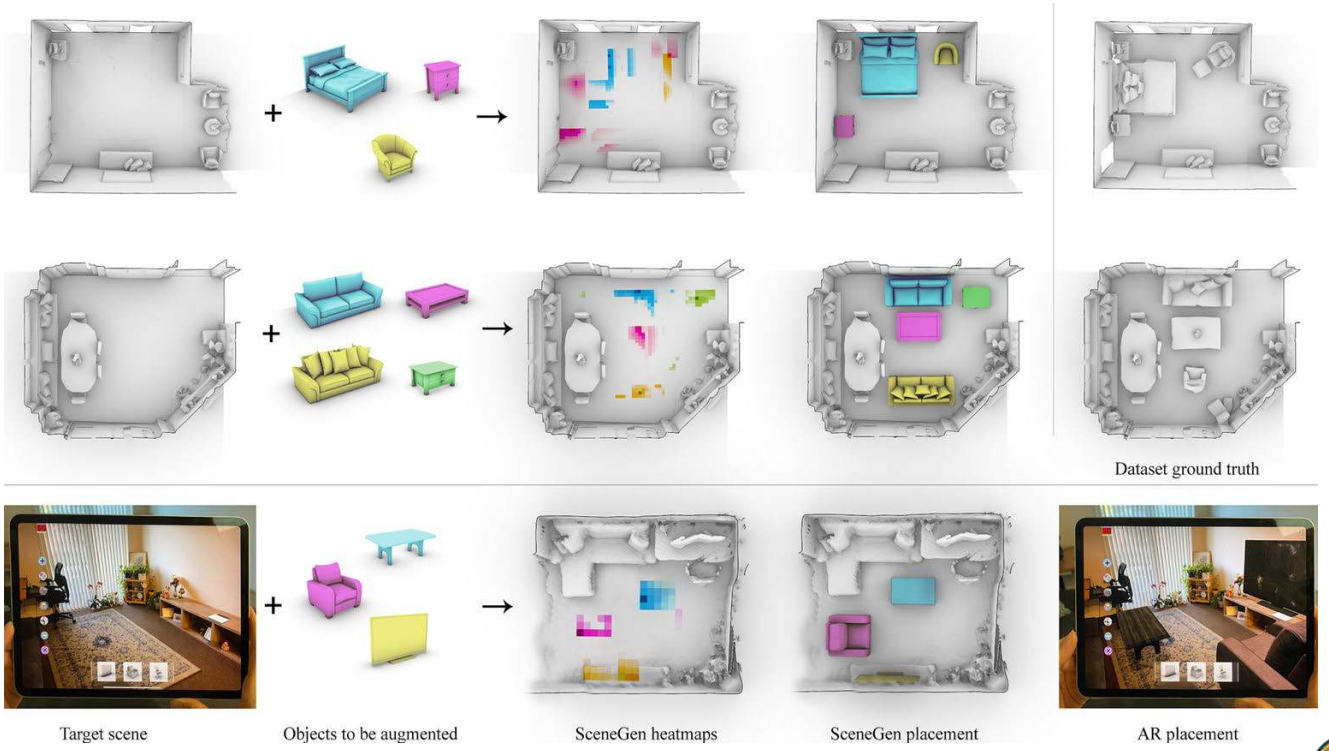
Geometry + Texture



Example Application

Scene Augmentation

Contextual placement via SceneGen [1]



[1] Keshavarzi, Mohammad et al. ""SceneGen: Generative Contextual Scene Augmentation using Scene Graph Priors." arXiv preprint arXiv:2009.12395. 2020.

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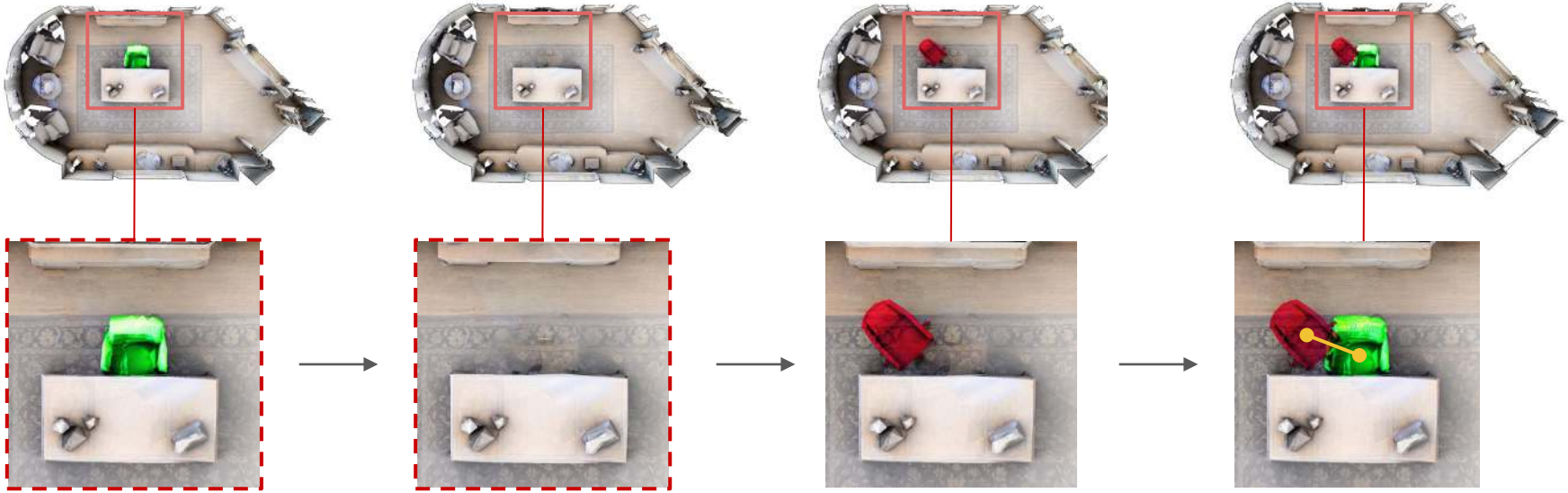
Scene Augmentation

SceneGen [1] Experiments



Ground Truth

Target Scene
(Removed Object)

Augmented Scene

Distance Error

[1] Keshavarzi, Mohammad et al. ""SceneGen: Generative Contextual Scene Augmentation using Scene Graph Priors." arXiv preprint arXiv:2009.12395. 2020.

Scene Augmentation

SceneGen [1] Experiments

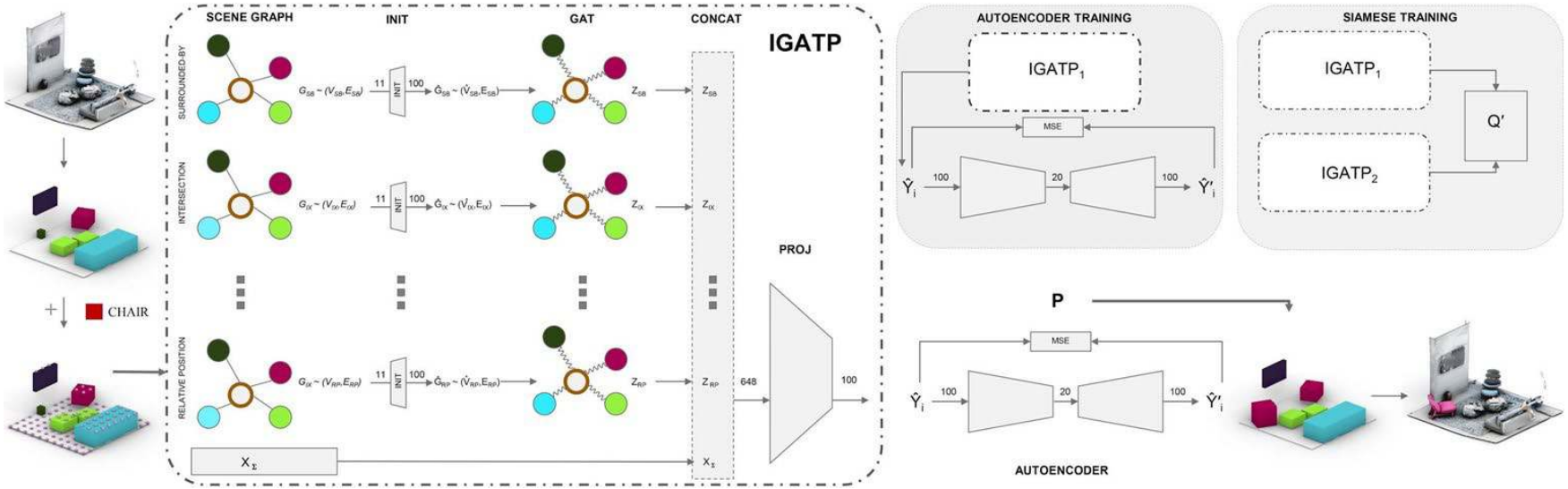
System	Bed		Chair		Decor		Picture		Sofa		Storage		Table		TV		Overall	
	T1	T5	T1	T5	T1	T5	T1	T5	T1	T5	T1	T5	T1	T5	T1	T5	T1	T5
SceneGen (Ours) [1]	**1.58**	**0.87**	**2.26**	**1.35**	**2.27**	**1.45**	**2.71**	**1.71**	**2.80**	**1.99**	**2.15**	**1.47**	**2.56**	**1.58**	**2.49**	**1.52**	**2.40**	**1.54**
SceneGraphNet [2]	1.91	1.56	3.01	2.49	2.37	1.95	3.14	2.70	3.36	2.94	3.80	3.31	3.57	3.12	3.97	3.40	3.25	2.80

Average distance error between ground truth and top -1 (T1) and top-5 (T5) predicted positions for scene augmentation task via di fferent models

[1] Keshavarzi, Mohammad et al. ""SceneGen: Generative Contextual Scene Augmentation using Scene Graph Priors." arXiv preprint arXiv:2009.12395. 2020.
[2] Zhou, Yang, et al. "Scenegraphnet: Neural message passing for 3d indoor scene augmentation." In Proceedings of the IEEE/CVF ICCV. 2019.

Scene Augmentation

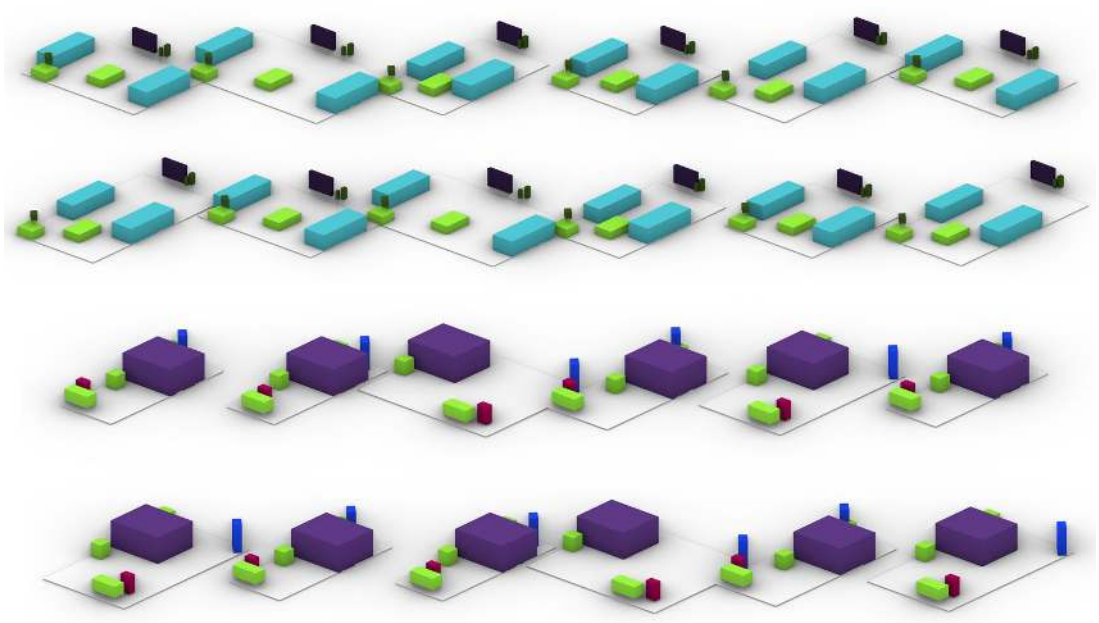
Contextual placement via GASANet



+ GenScan

Scene Augmentation

Experiments with GenScan



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Scene Augmentation

Experiments with GenScan

Training Datasets

MatterPort3D (Regular)	M3D + GenScan	MGS + Area Check	MGSAC + Object Removal
MREG	MGS	MGSAC	MGSAC4

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Scene Augmentation

Experiments with GASANet + GenScan

Furniture	T1	T5	*Furniture*	T1	T5
Bed	**MGSAC**	**MGSAC**	*Chair*	**MGS**	**MGS**
Decor	**MGSAC**	**MGSAC**	*Picture*	MREG	**MGSAC4**
Sofa	**MGSAC**	**MGSAC**	*Storage*	**MGSAC4**	**MGSAC4**
Table	MREG	**MGSAC**	*TV*	**MGS**	**MGSAC4**

Smallest average distance error between ground truth and top-1 (T1) and top-5 (T5) predicted positions for scene augmentation task.

Conclusions

- We develop a generative tool for populating parametric 3D scan models.
- The system takes a 3D scan as an input and outputs alternative layouts and texture maps.
- The generated data can be used as a data augmentation method for 3D deep learning tasks.
- The process is fully automatic, and can also be manually controlled by a user-in-the-loop.
- Experiment show our method can improve results of indoor scene synthesis via deep learning.

Thank you

References

- Dai, Angela, Daniel Ritchie, Martin Bokeloh, Scott Reed, Jürgen Sturm, and Matthias Nießner. "Scancomplete: Large-scale scene completion and semantic segmentation for 3d scans." In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, pp. 4578-4587. 2018.
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- Song, Shuran, Fisher Yu, Andy Zeng, Angel X. Chang, Manolis Savva, and Thomas Funkhouser. "Semantic scene completion from a single depth image." In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, pp. 1746-1754. 2017.
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- Keshavarzi, Mohammad, Clayton Hutson, Chin-Yi Cheng, Mehdi Nourbakhsh, Michael Bergin, and Mohammad Rahmani Asl. "SketchOpt: Sketch-based Parametric Model Retrieval for Generative Design." arXiv preprint arXiv:2009.00261 (2020).
- Keshavarzi, Mohammad, and Mohammad Rahmani-Asl. "GenFloor: Interactive Generative Space Layout System via Encoded Tree Graphs." arXiv preprint arXiv:2102.10320 (2021).