GIFS: Neural Implicit Function for General Shape Representation

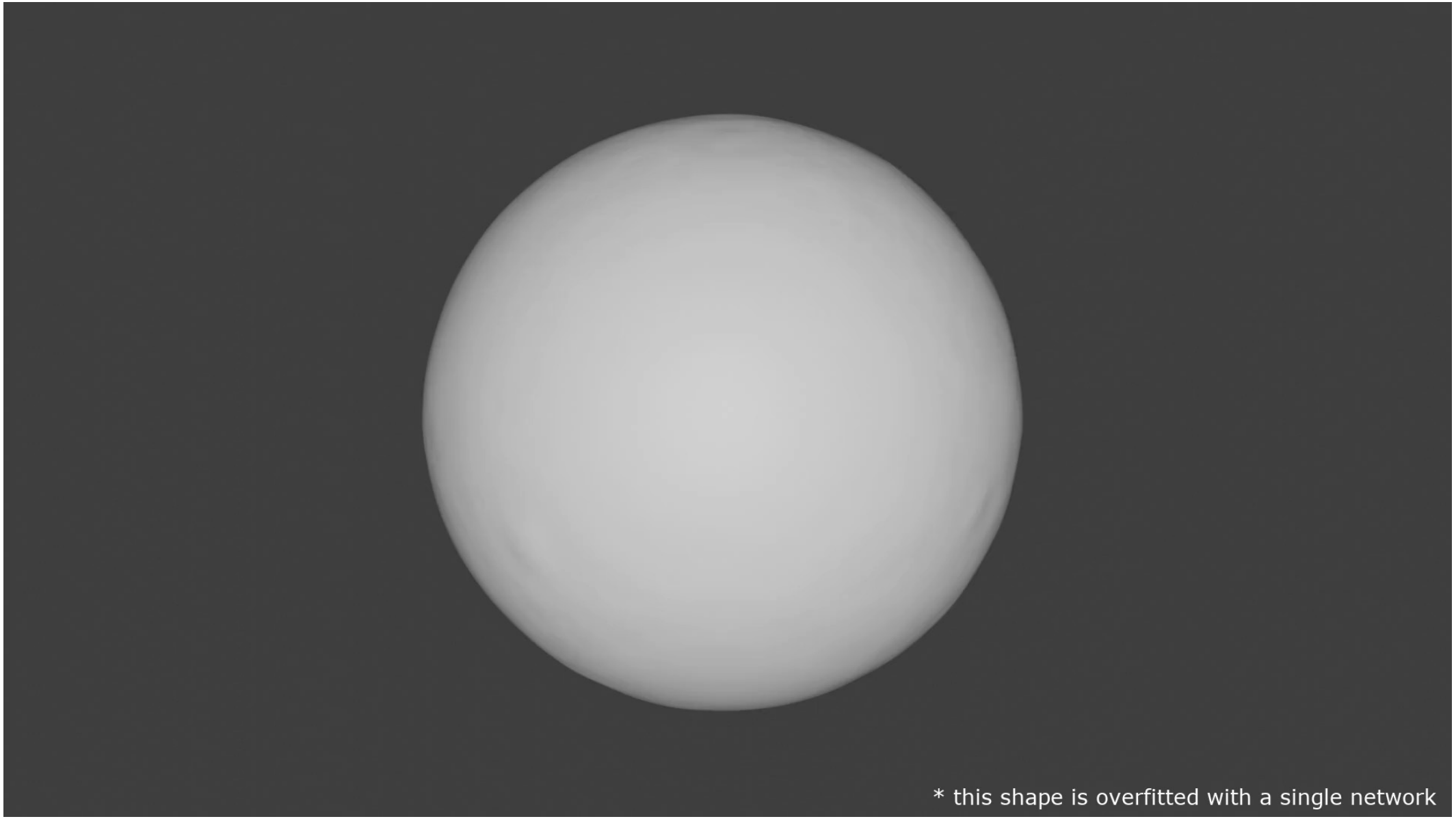
CVPR 2022

Jianglong Ye[1], Yuntao Chen[2], Naiyan Wang[2], Xiaolong Wang[1]

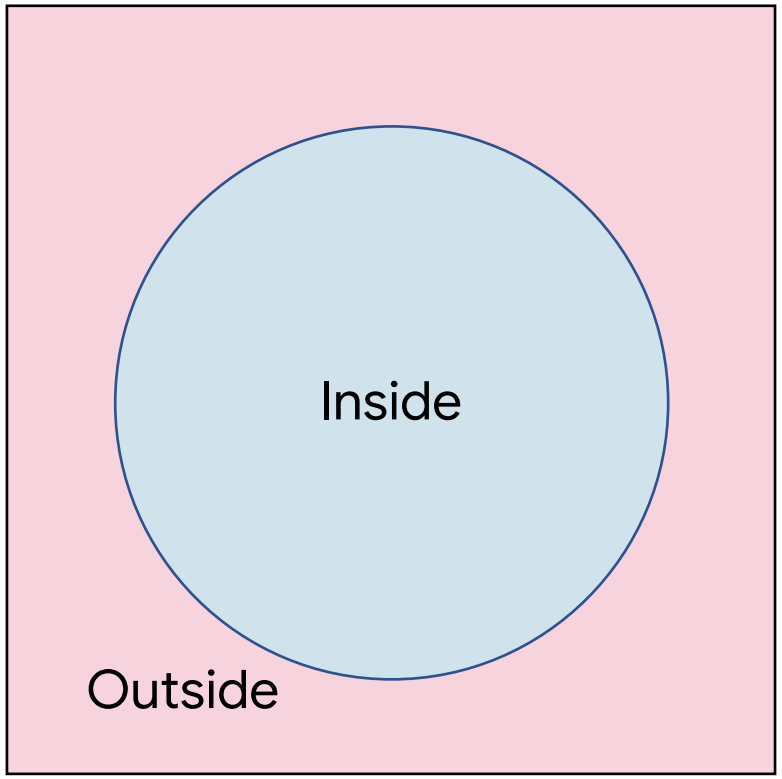
[1]UC San Diego, [2]TuSimple

UC San Diego tusimple

GIFS allows the reconstruction of **general** object shapes including watertight, non-watertight, and multi-layer shapes.



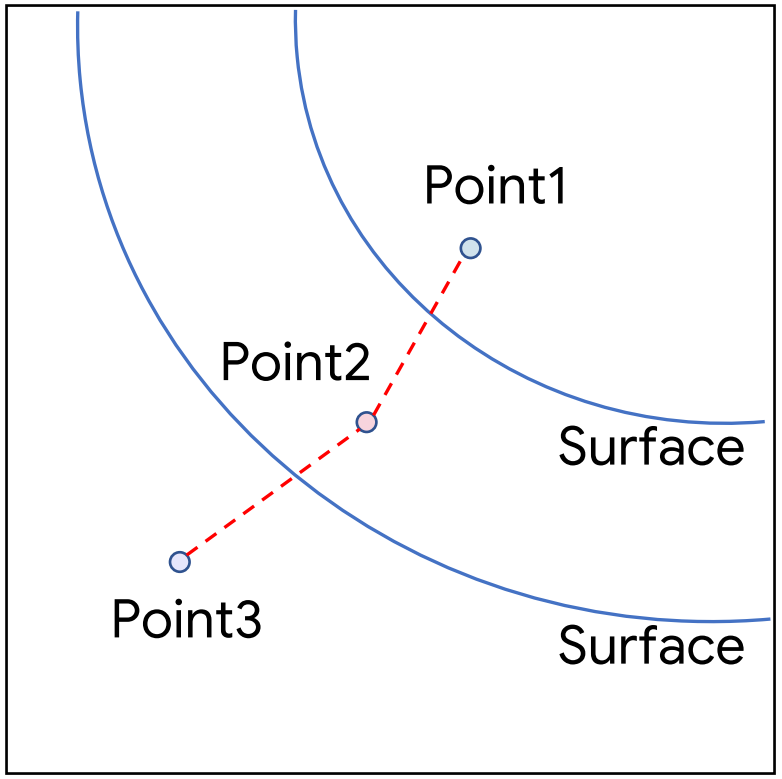
Our Idea



- Previous works[1,2] divide the space into inside and outside
- They can not represent **multi-layer** and **non-watertight** shapes

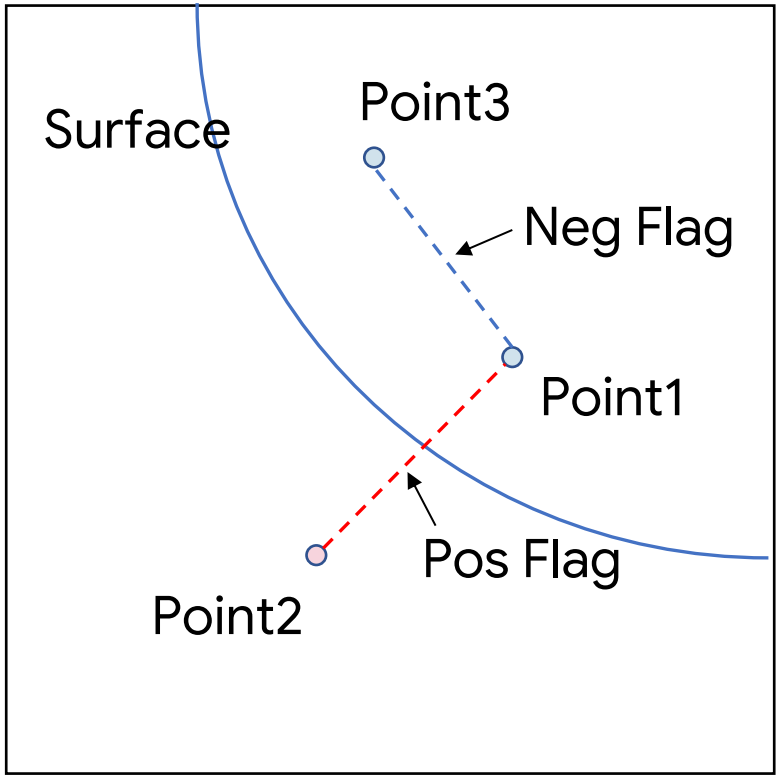
1. Park, Jeong Joon, et al. "Deepsdf: Learning continuous signed distance functions for shape representation." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2019.
2. Mescheder, Lars, et al. "Occupancy networks: Learning 3d reconstruction in function space." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2019.

Our Idea



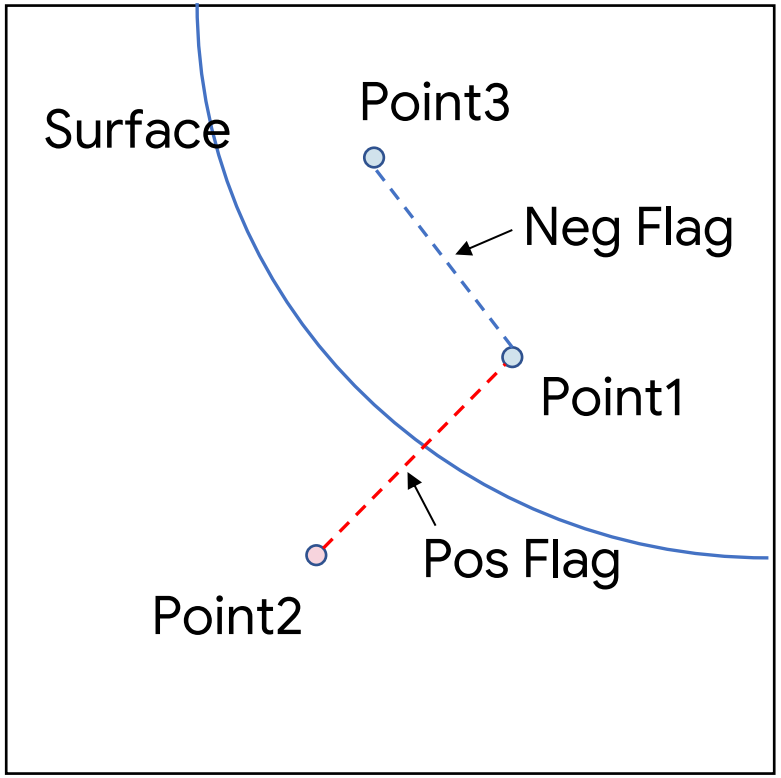
- Instead of modeling the relationship between point and surface
- we model the relationship between different points to represent **general** shapes

Proposed Representation



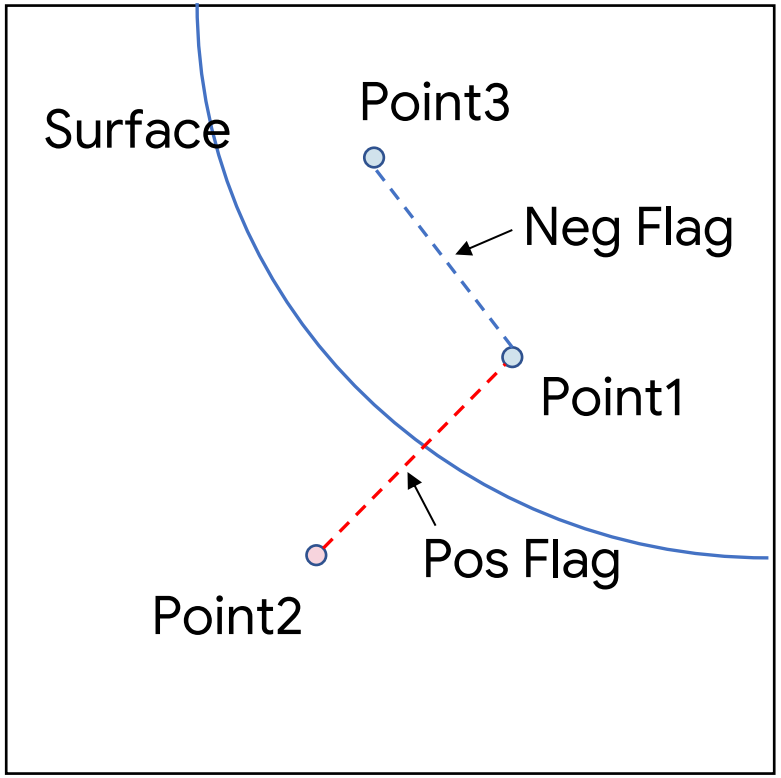
We use a **binary flag** to indicate whether two points are separated by any surface

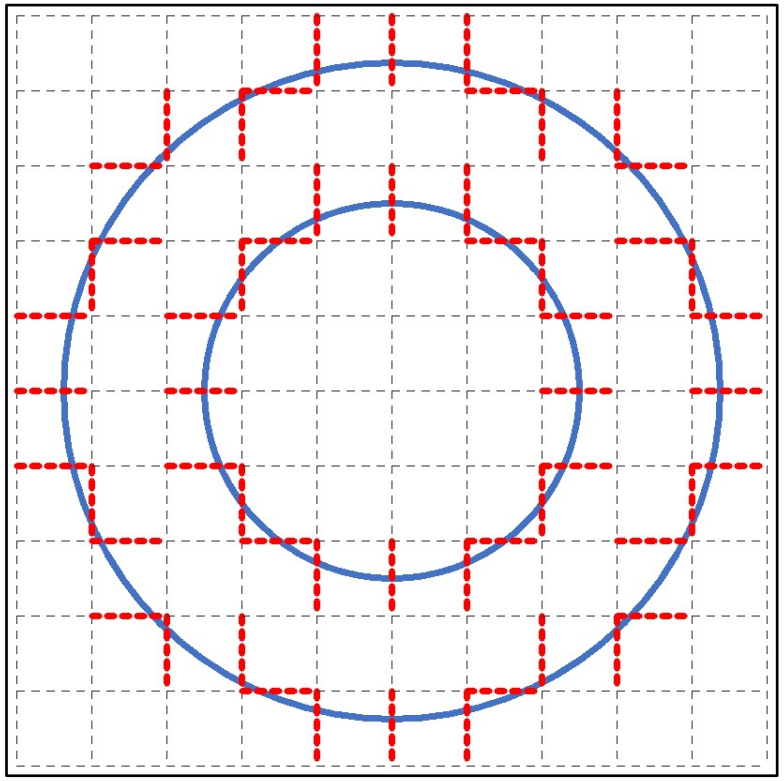
Proposed Representation



- Point1 and Point3 are not separated by any surface, thereby have the negative flag
- Point1 and Point2 have the positive flag

Proposed Representation

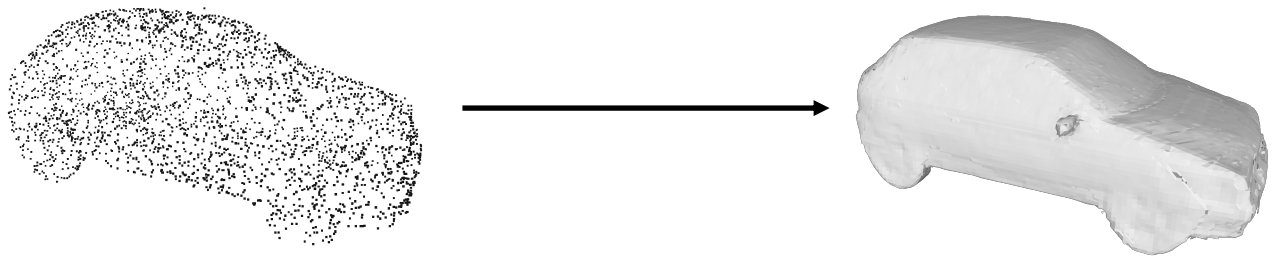




Here, we show how a multi-layer shape is represented, the positive flags are red bolded

Let’s look at some reconstruction results

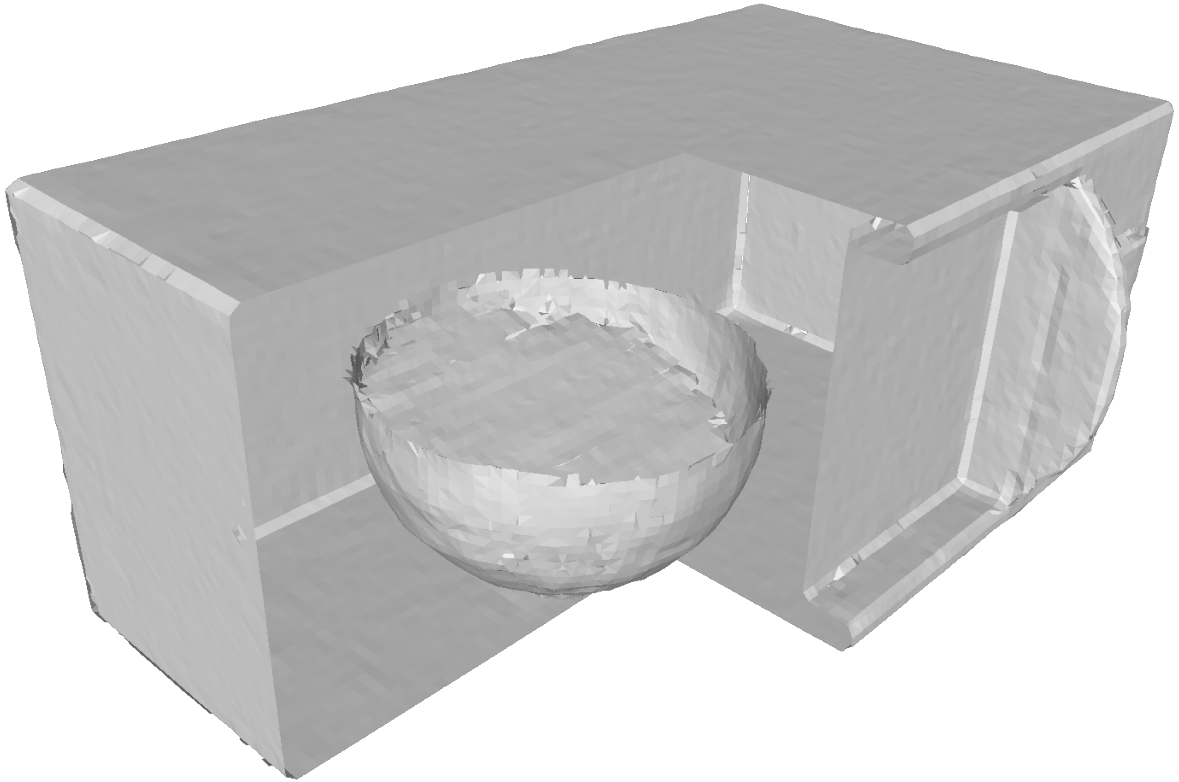
*We evaluate our representation on the task shape reconstruction from sparse **point cloud**.*



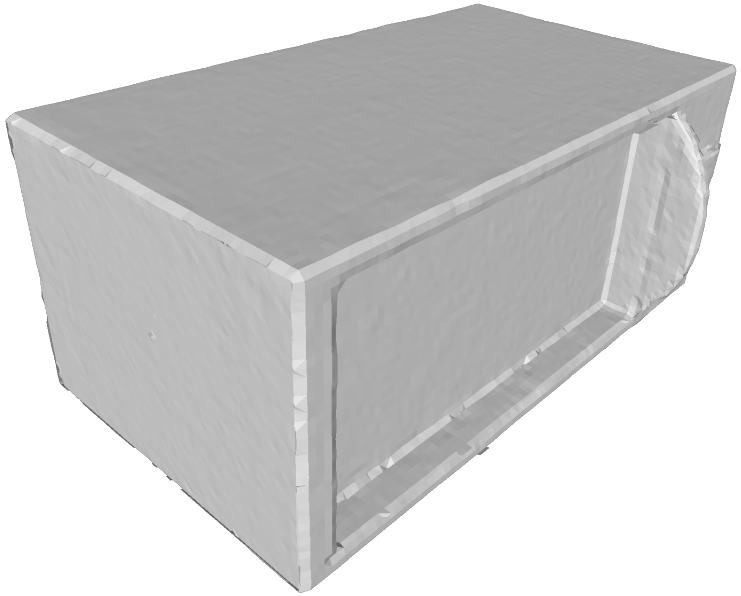
Input

Output

Reconstruction Results



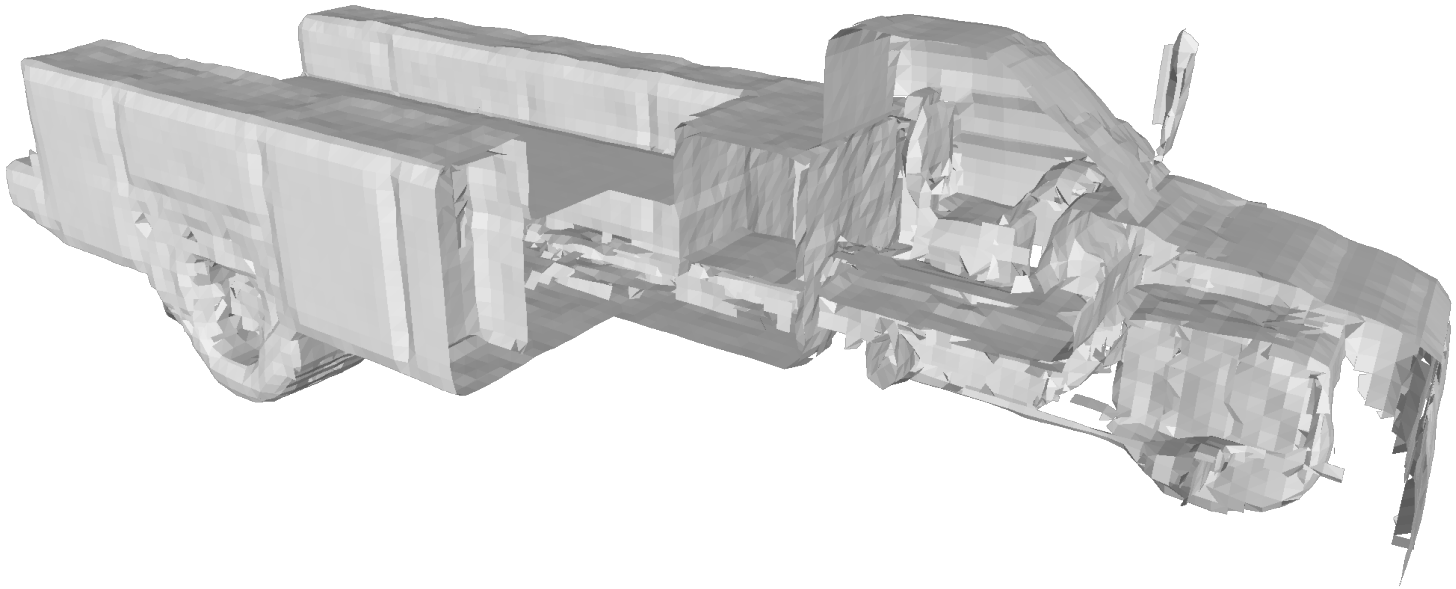
Cut view



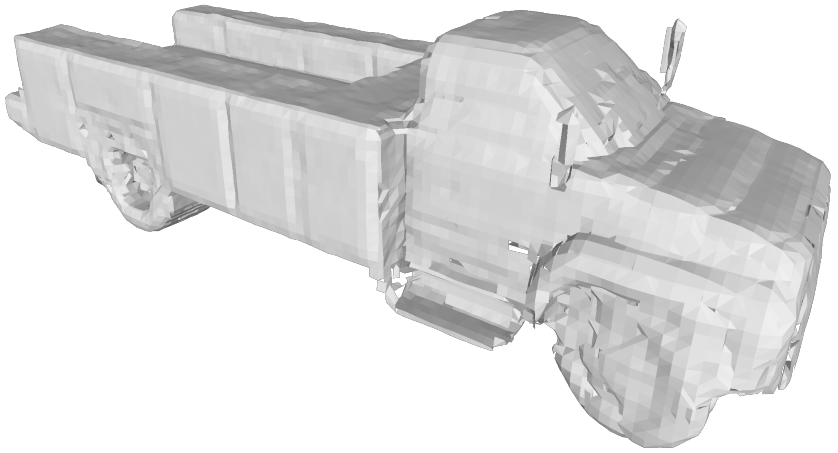
Outside view

Our method can represent microwave with a bowl inside

Reconstruction Results



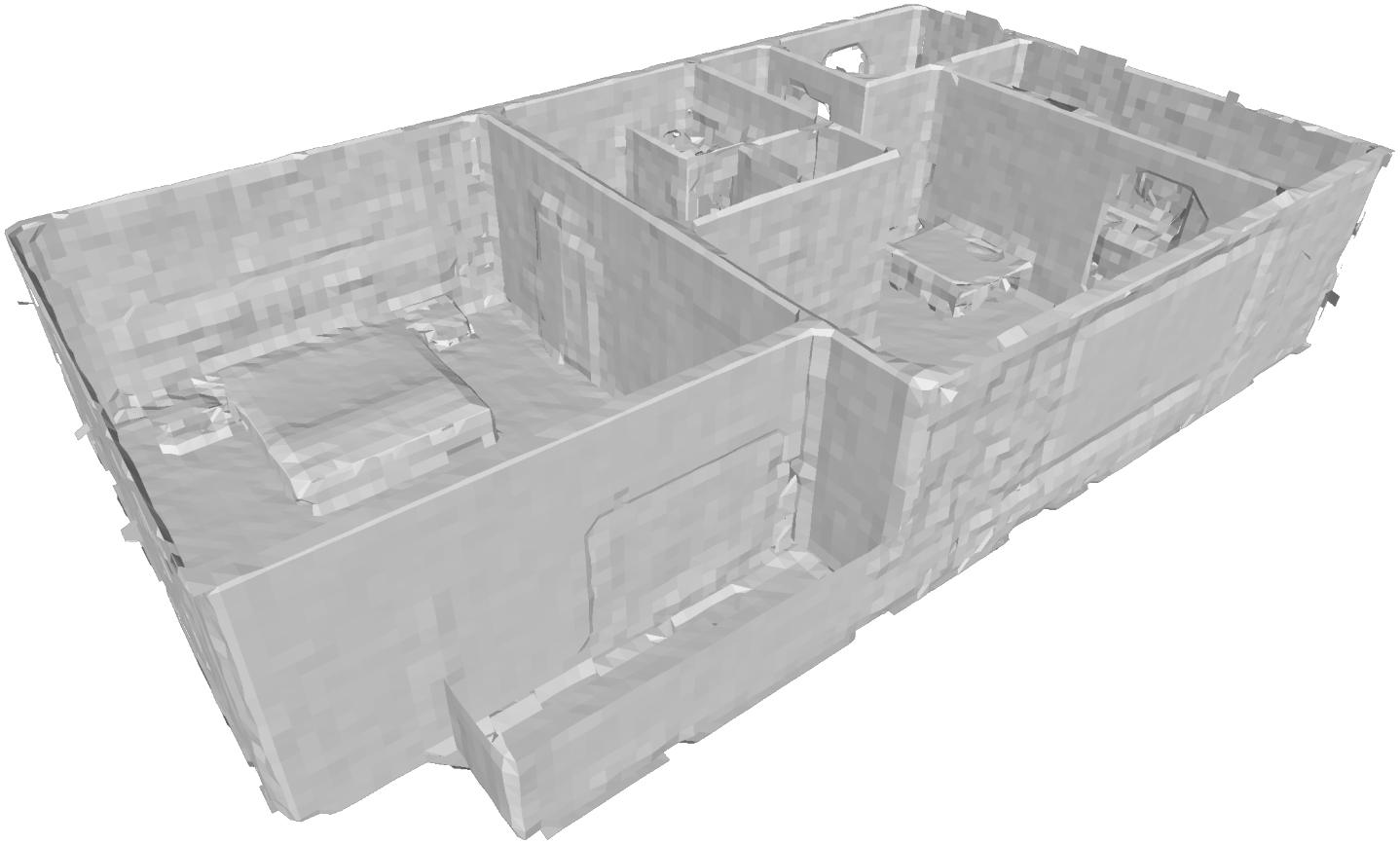
Cut view



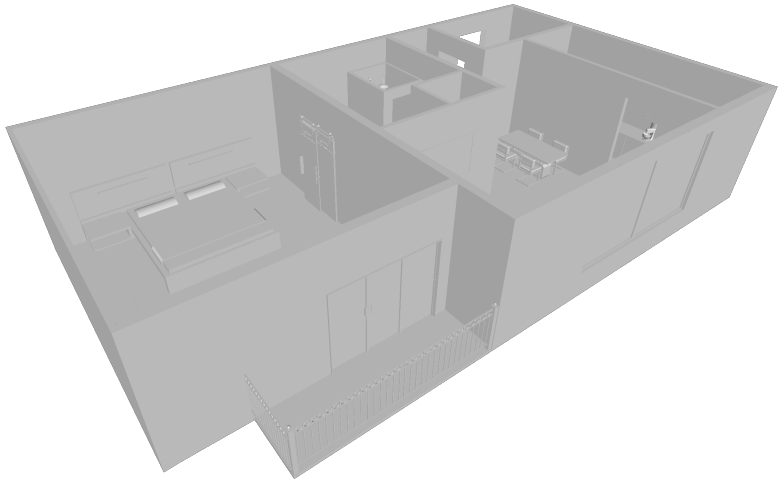
Outside view

truck with some inner structures

Reconstruction Results

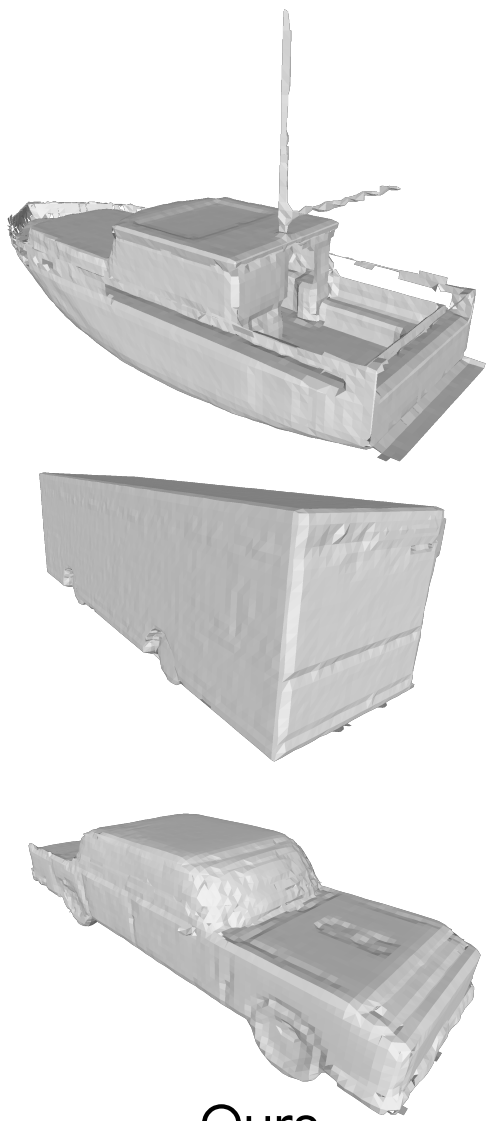


Ours

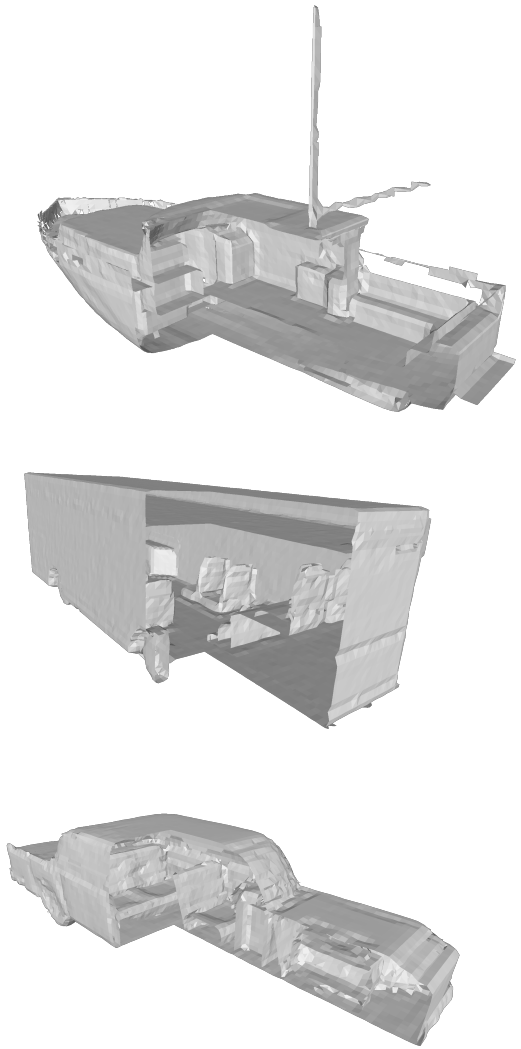


GT

house with multiple furniture inside

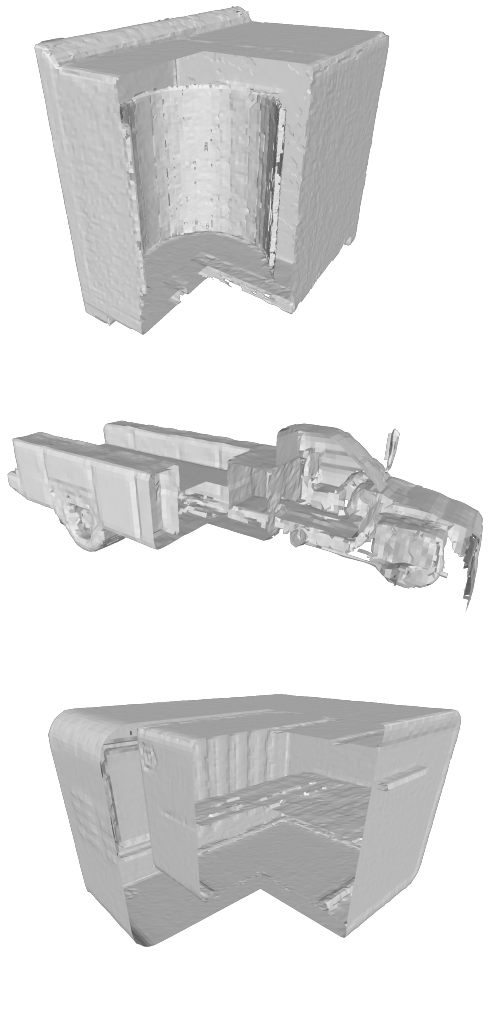


Ours



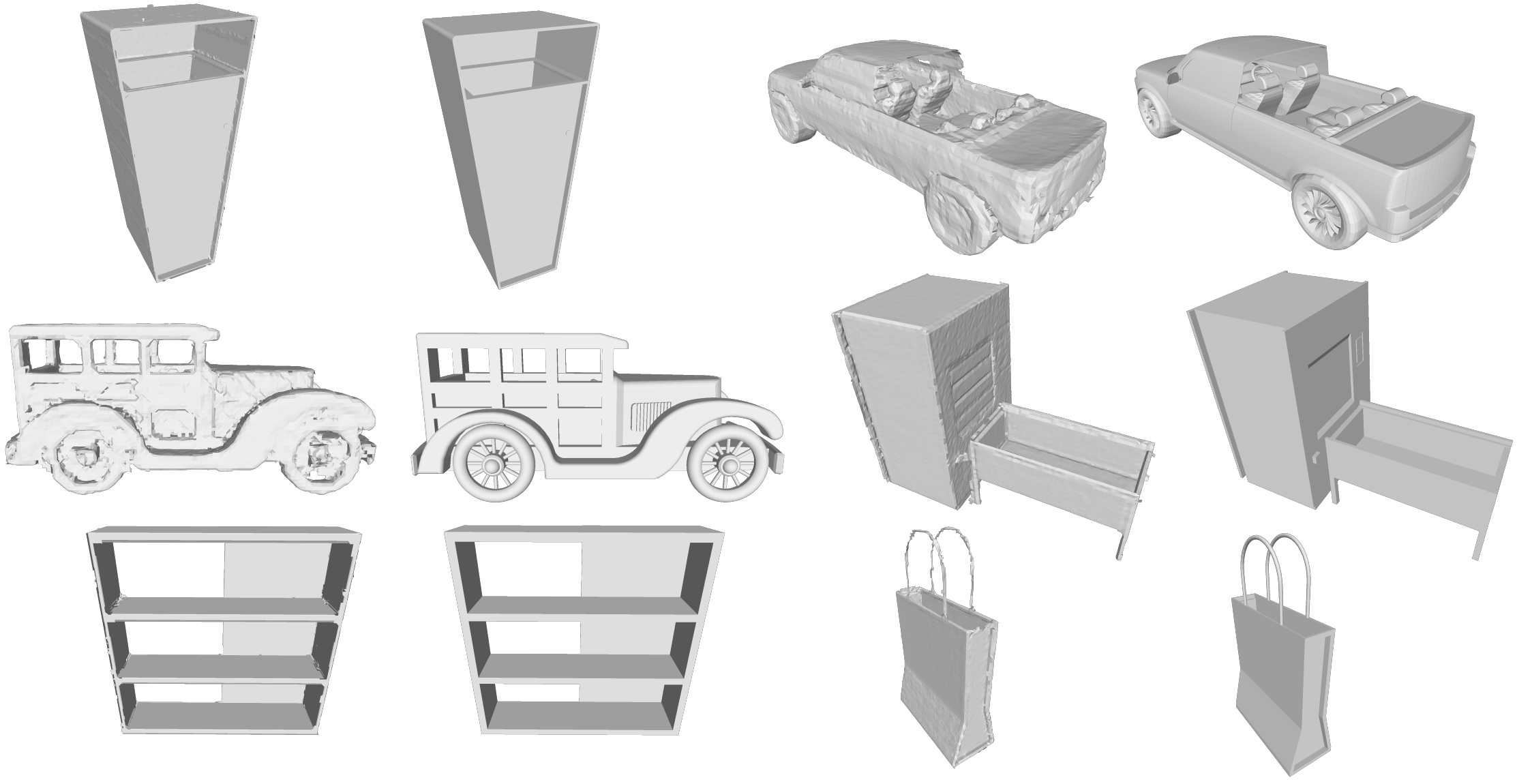
Ours (Cut)

Ours



Ours (Cut)

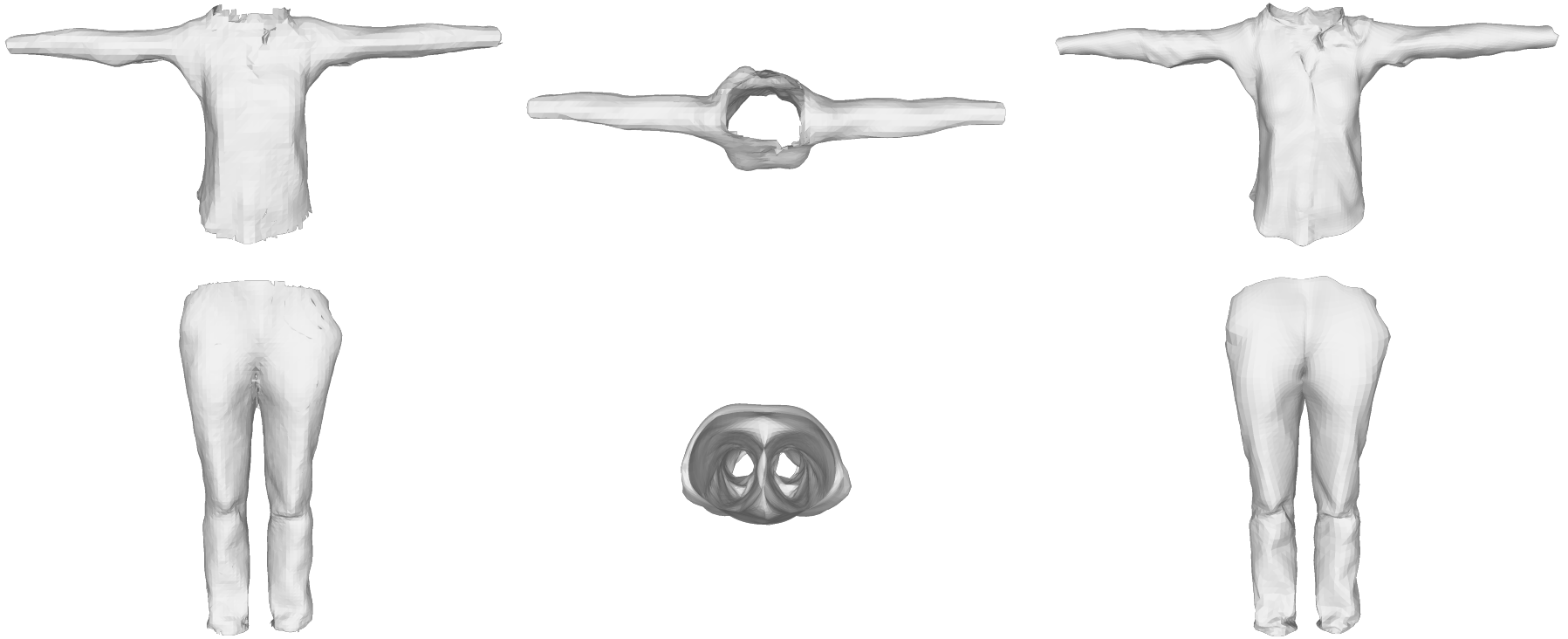
many other multi-layer shapes.....



Ours GT Ours GT

many other non-watertight shapes.....

Reconstruction Results

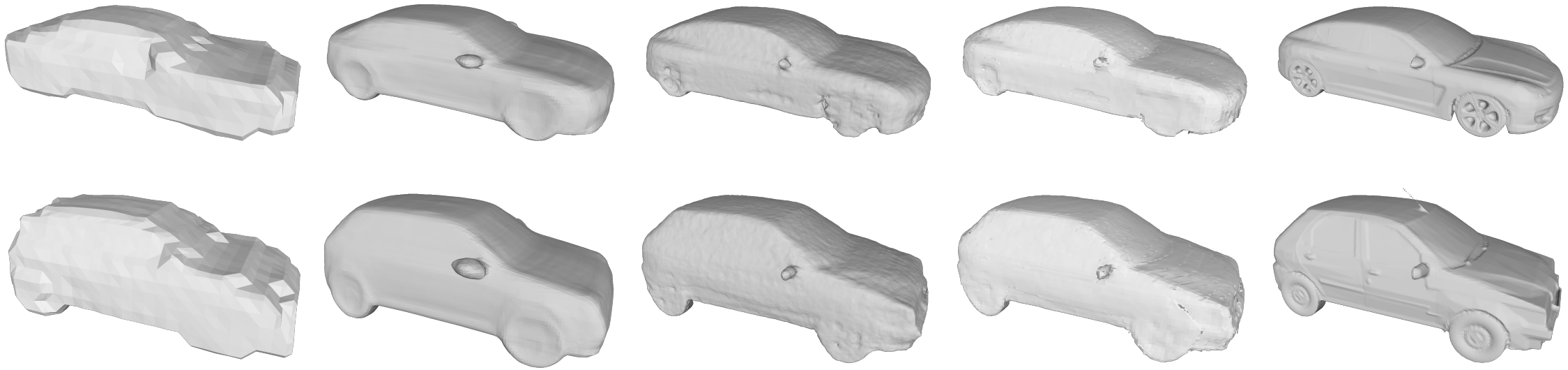


Ours | Ours (Top view) | GT

and non-watertight garments.

Compared to previous works

Comparison

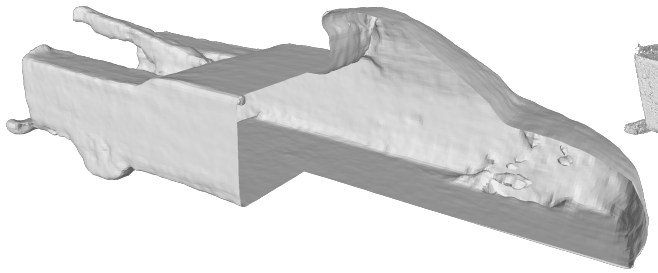


DMC[1] OccNet[2] IF-Net[3] Ours GT

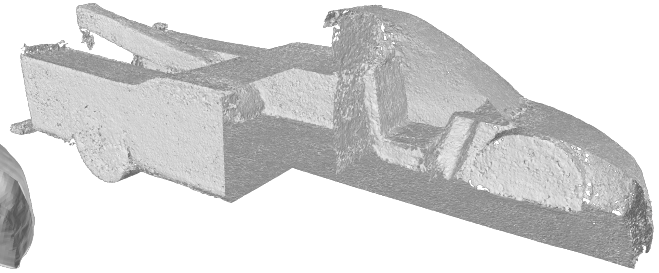
Our method achieves the **SOTA** performance on watertight shapes

1. Liao, Yiyi, Simon Donne, and Andreas Geiger. "Deep marching cubes: Learning explicit surface representations." Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. 2018.
2. Mescheder, Lars, et al. "Occupancy networks: Learning 3d reconstruction in function space." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2019.
3. Chibane, Julian, Thiemo Alldieck, and Gerard Pons-Moll. "Implicit functions in feature space for 3d shape reconstruction and completion." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2020.

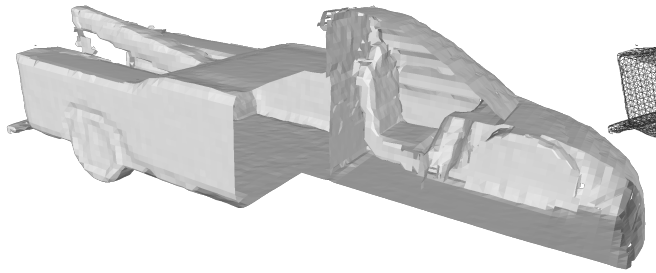
Comparison



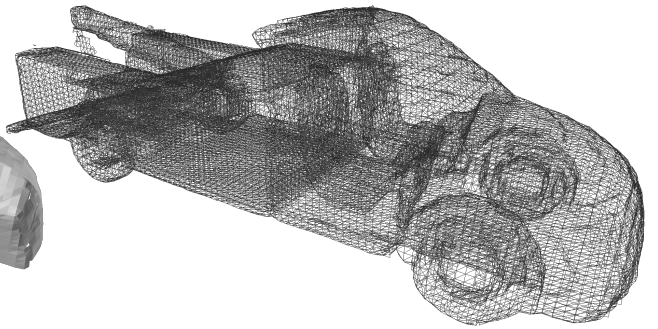
IF-Net[1] (Cut)



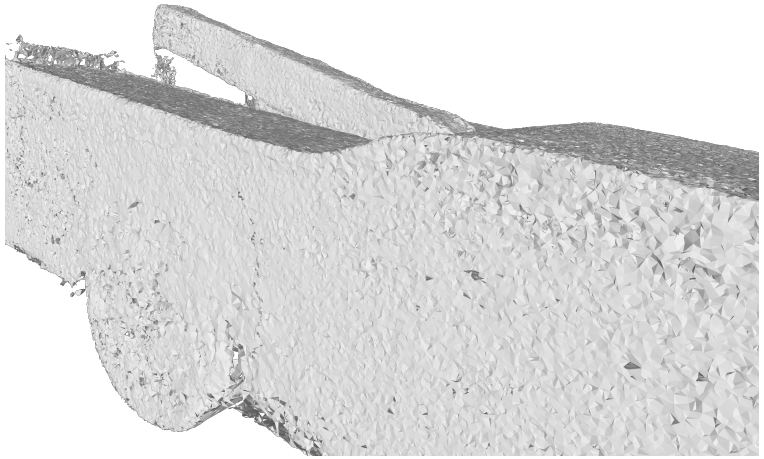
NDF[2] (Cut)



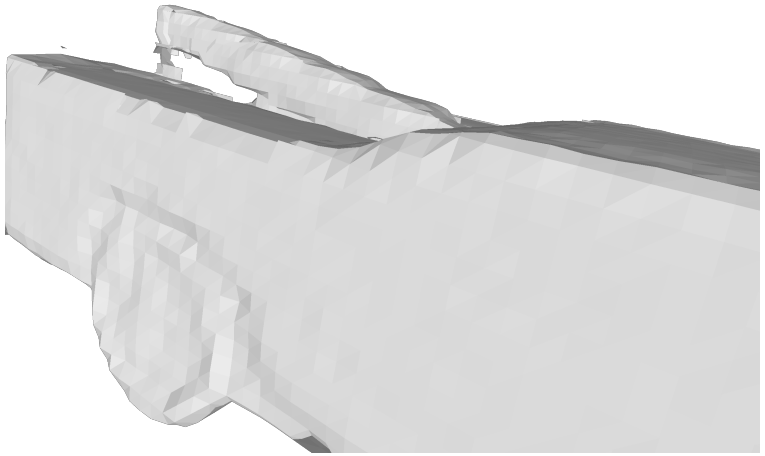
Ours (Cut)



Ours (Wireframe)



NDF (Crop)



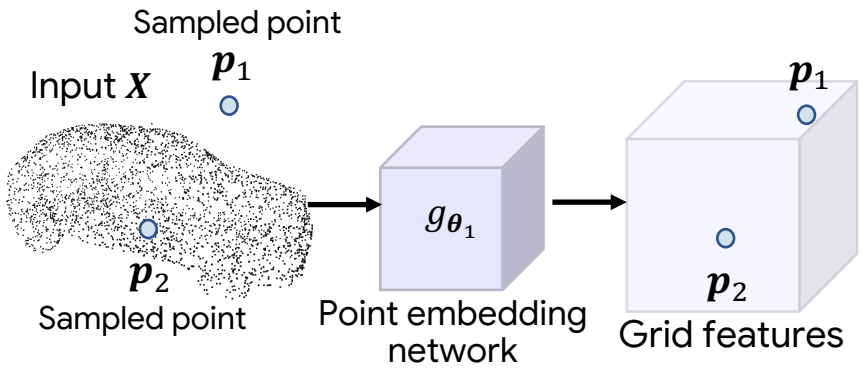
Ours (Crop)

and better visual effect on **general** shapes

1. Chibane, Julian, Thiemo Alldieck, and Gerard Pons-Moll. "Implicit functions in feature space for 3d shape reconstruction and completion." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2020.
2. Chibane, Julian, and Gerard Pons-Moll. "Neural unsigned distance fields for implicit function learning." Advances in Neural Information Processing Systems 33 (2020): 21638-21652.

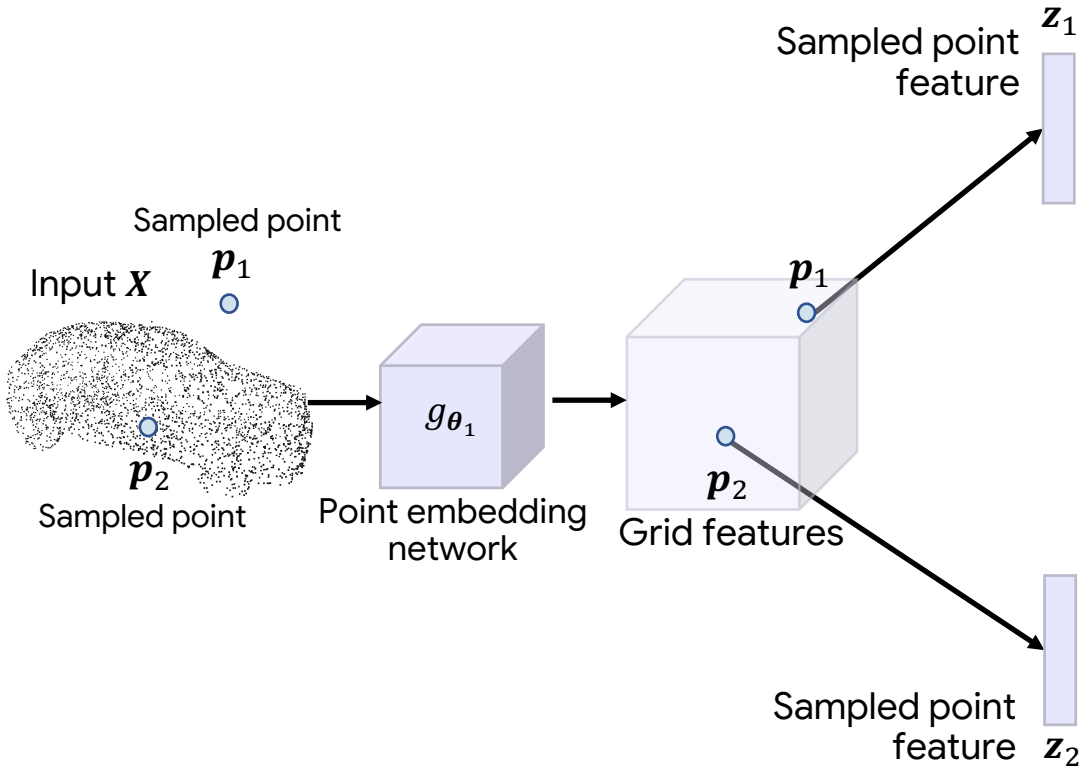
Here is our architecture

Architecture



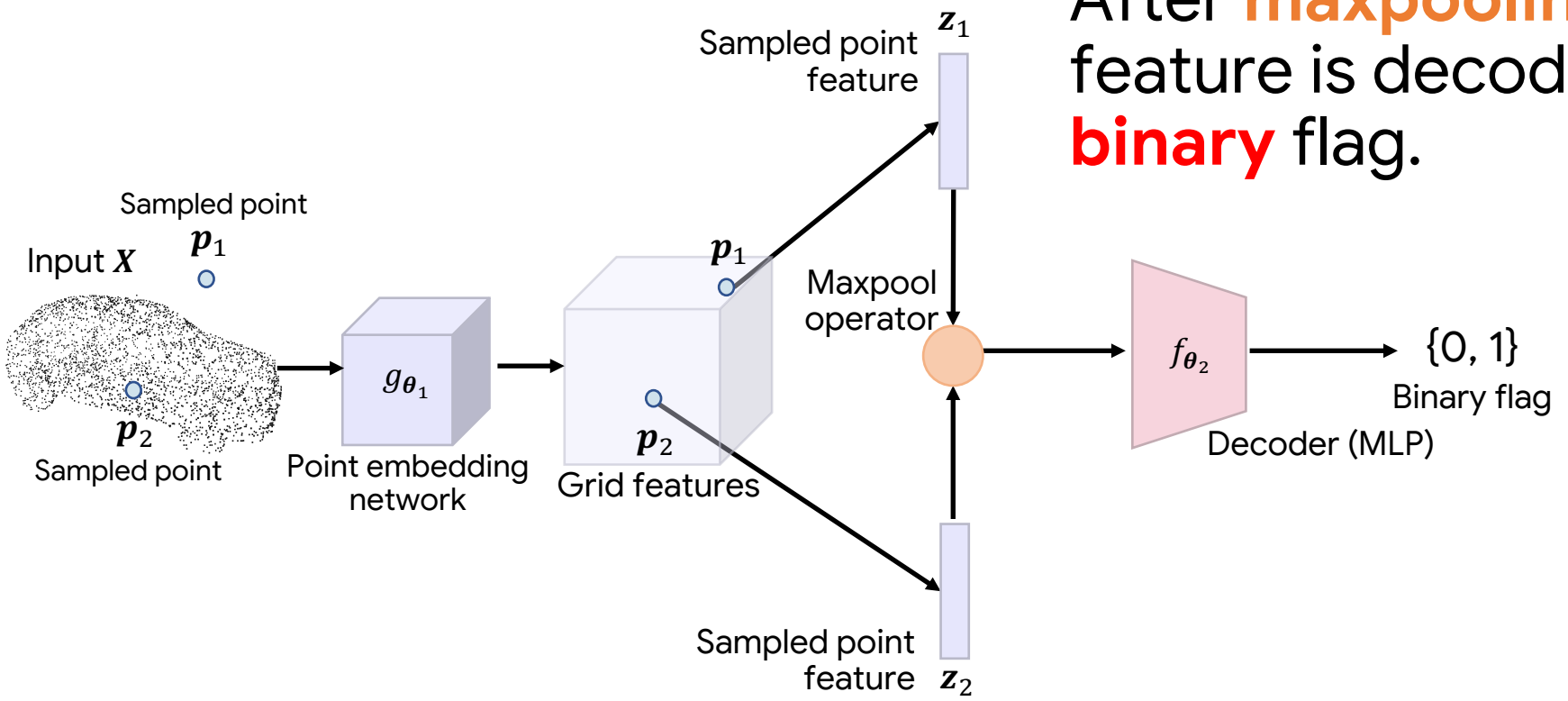
First, the input point cloud is encoded to a grid of **features** .

Architecture



Given two 3D points, corresponding **features** are extracted from the grid.

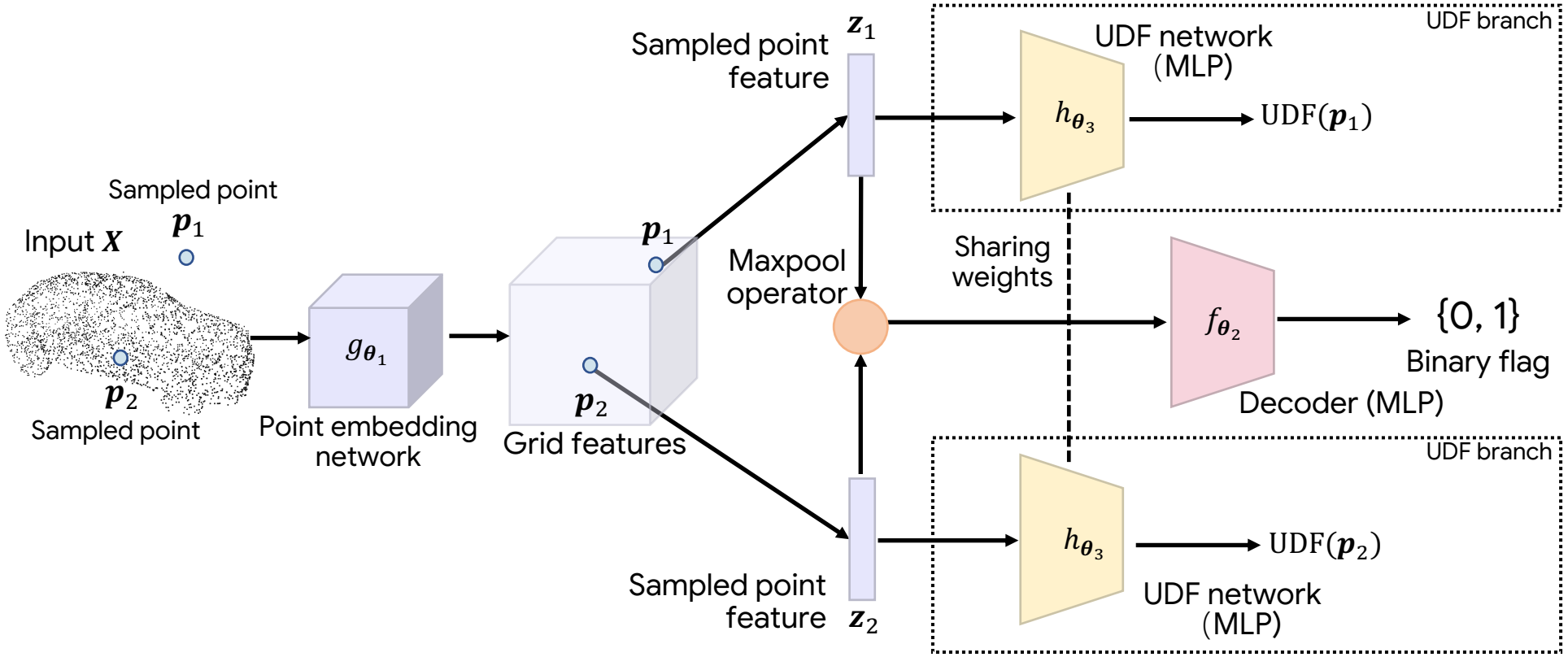
Architecture



After **maxpooling**, the fused feature is decoded to the **binary** flag.

Architecture

Two extra **UDF branch** can be used to enhance the point embedding



Thanks