ECCV'20 ONLINE
23-28 AUGUST 2020

GRNet: Gridding Residual Network for Dense Point Cloud Completion

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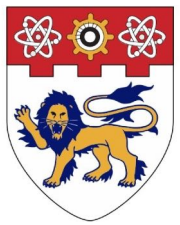
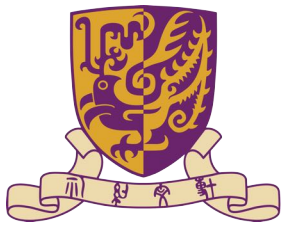
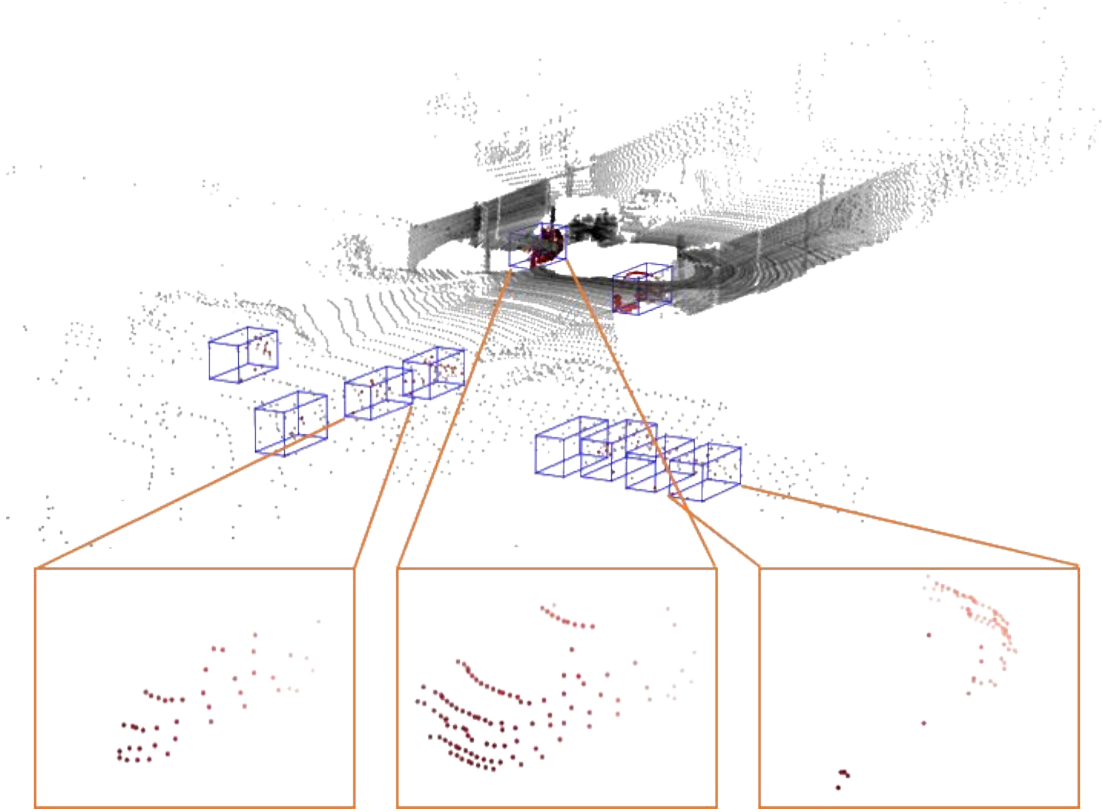
Jiageng Mao, Shengping Zhang, Wenxiu Sun



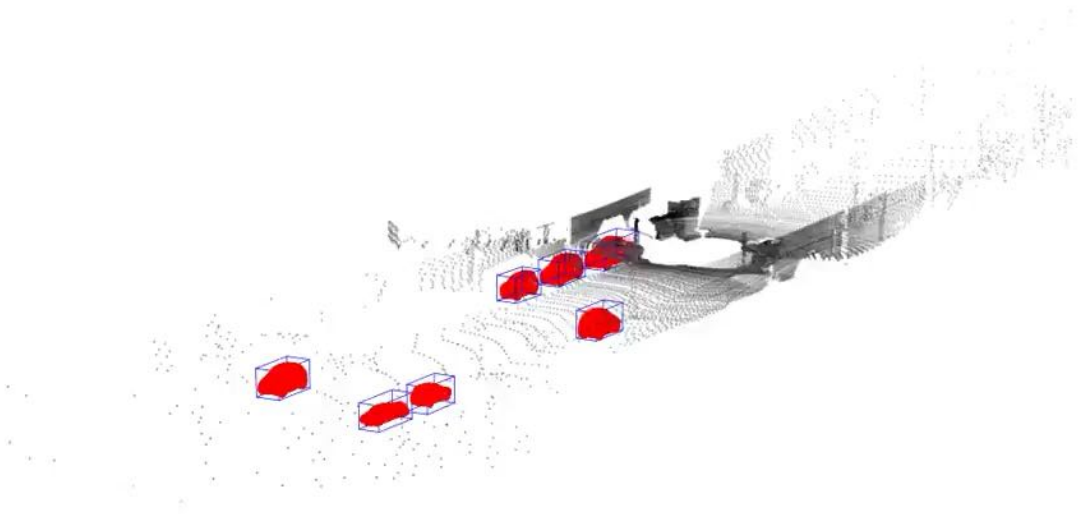


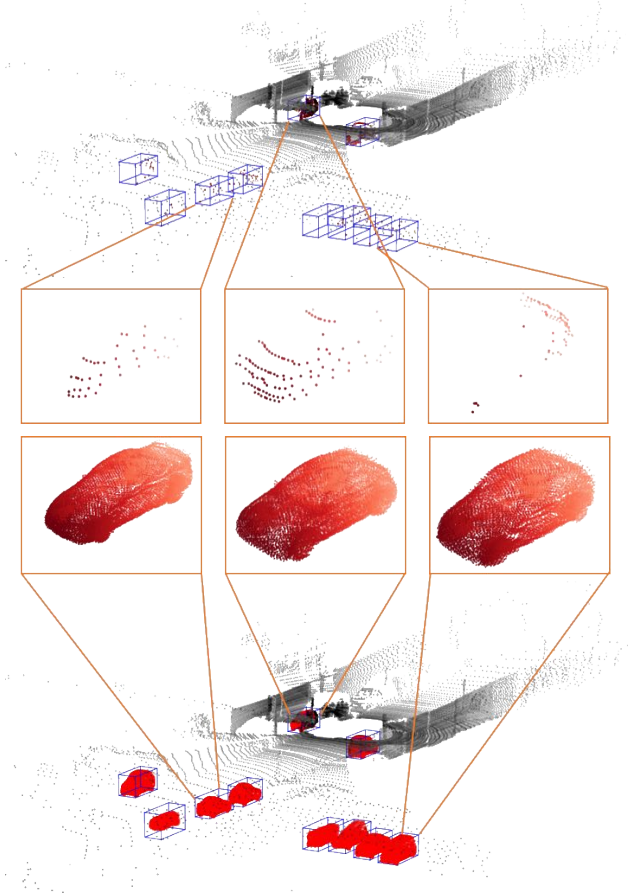
What is Point Cloud Completion?



Source: PCN: Point Completion Network

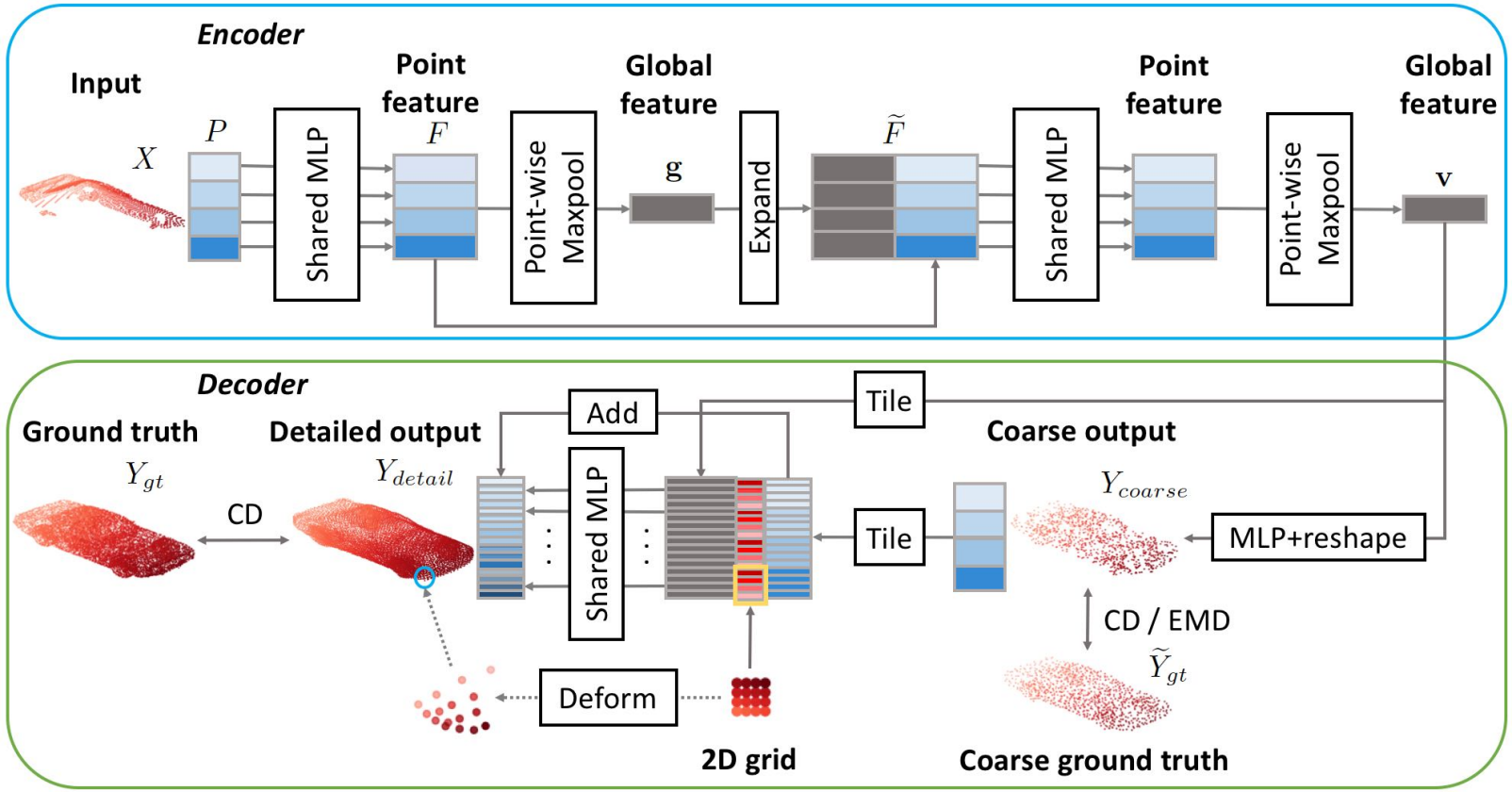
What is Point Cloud Completion?





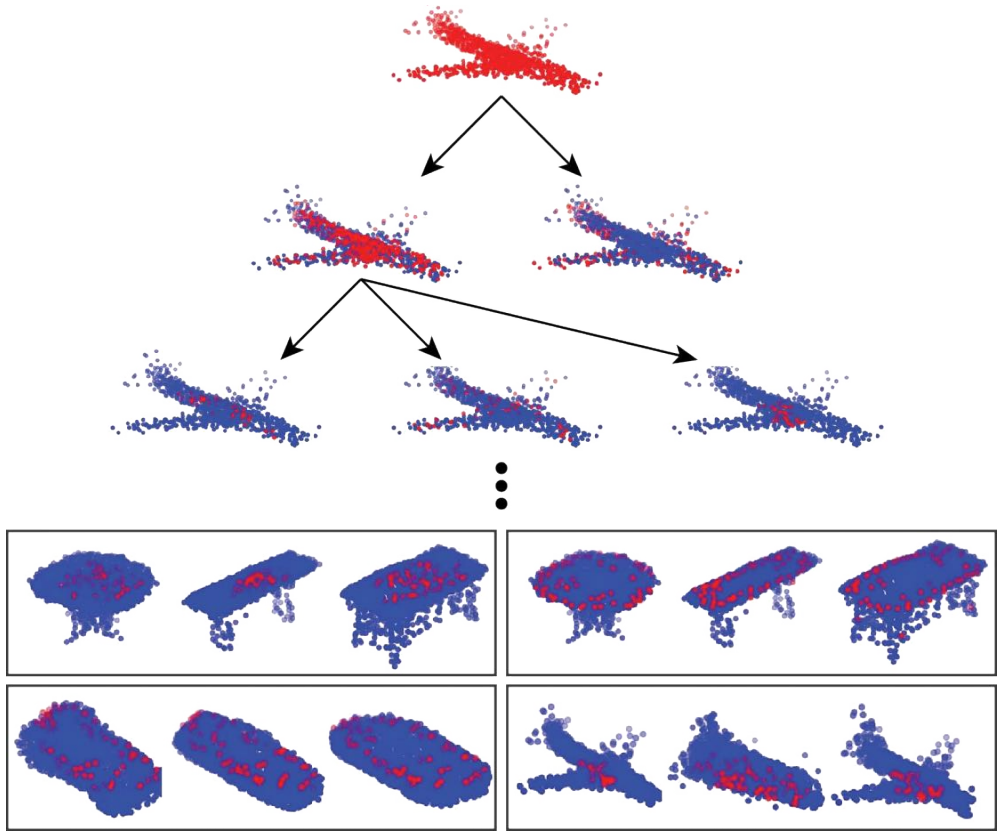
Source: PCN: Point Completion Network

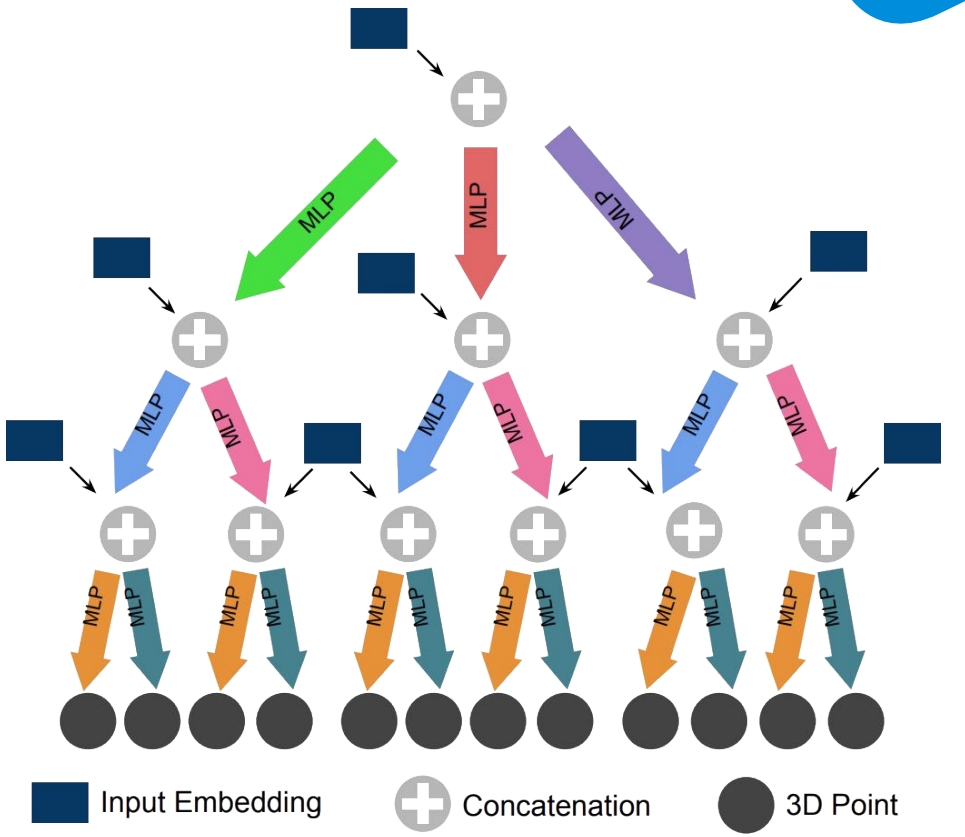
State-of-the-arts



Yuan *et al.* PCN: Point Completion Network. 3DV 2018.

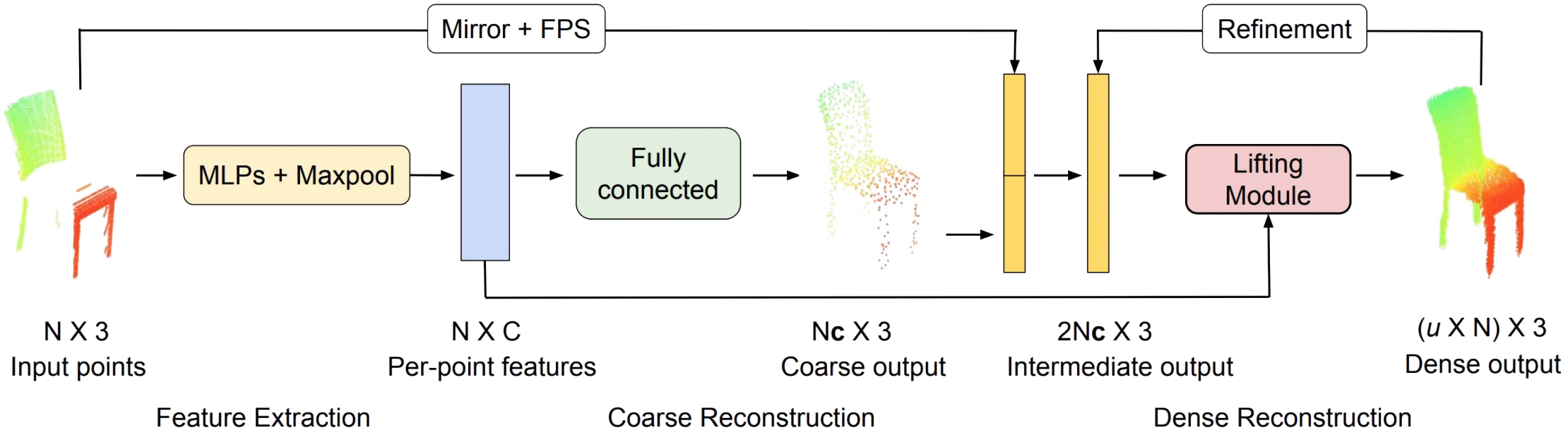
State-of-the-arts





Tchapmi *et al.* TopNet: Structural Point Cloud Decoder. CVPR 2019.

State-of-the-arts



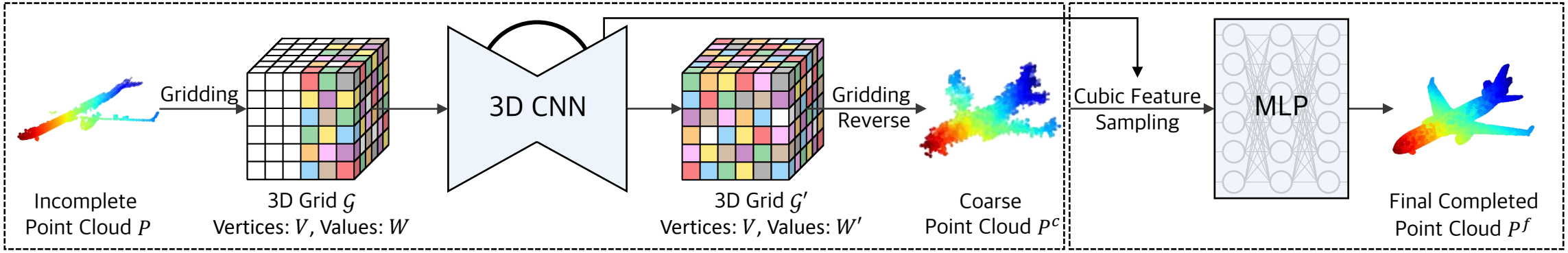
Wang *et al.* Cascaded Refinement Network for Point Cloud Completion. CVPR 2020.

Drawbacks of MLP-based Methods

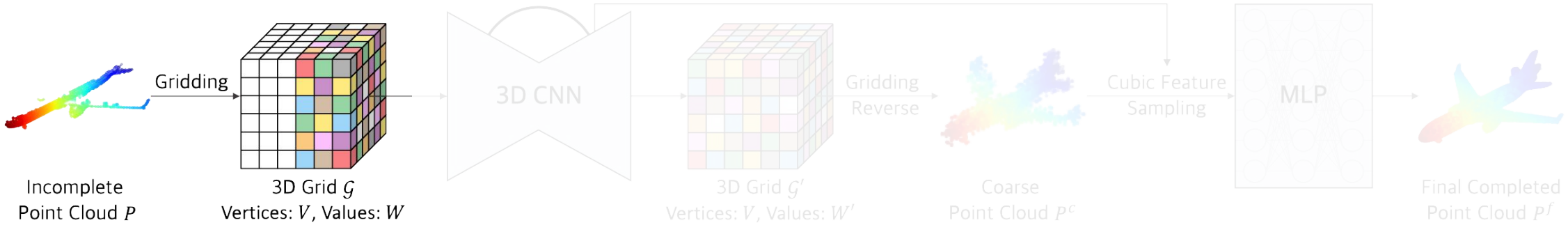
MLP-based methods ingore two important things:

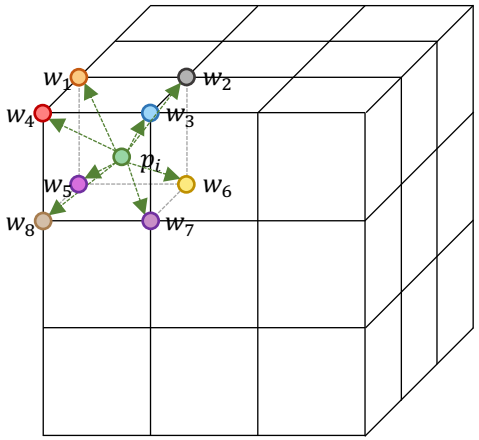
- Geometric Structure
- Context of Neighboring Points

The Proposed Method: GRNet



Gridding



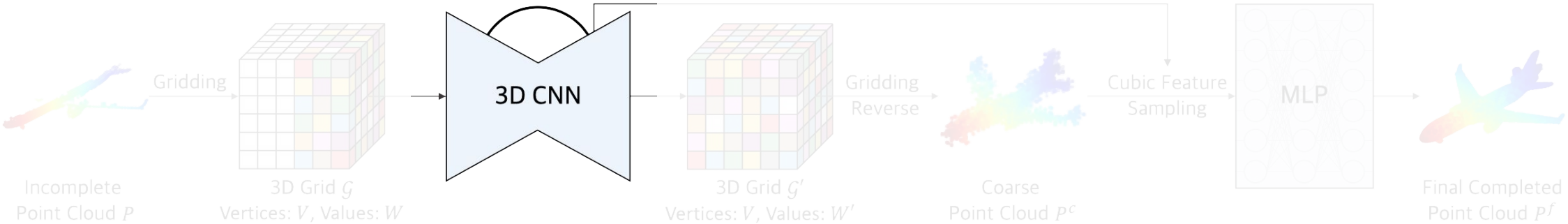


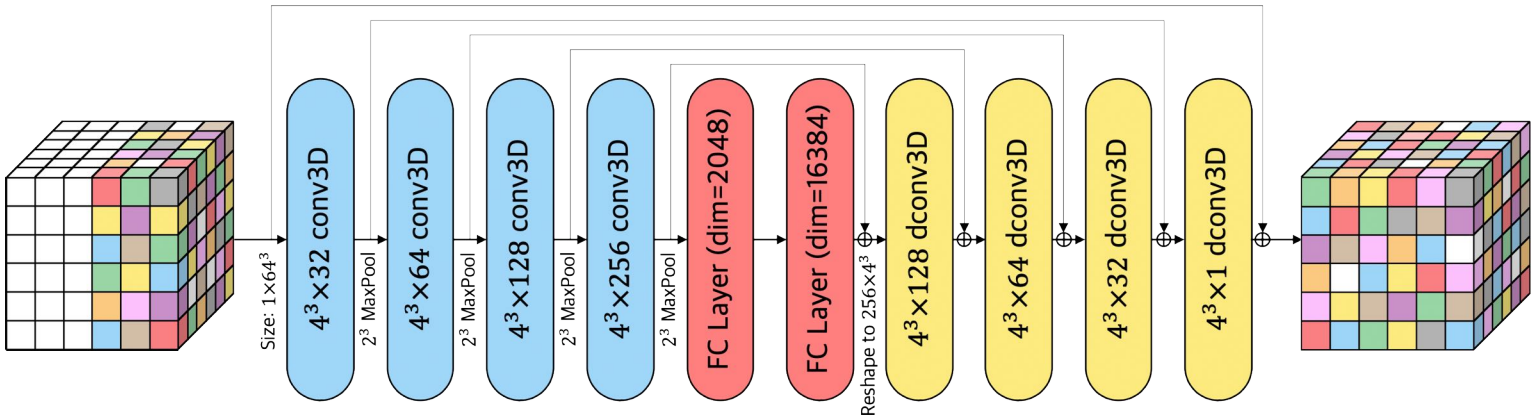
The value of the vertex w_i can be computed as

$$w_i = (1 - |x_i - x|)(1 - |y_i - y|)(1 - |z_i - z|)$$

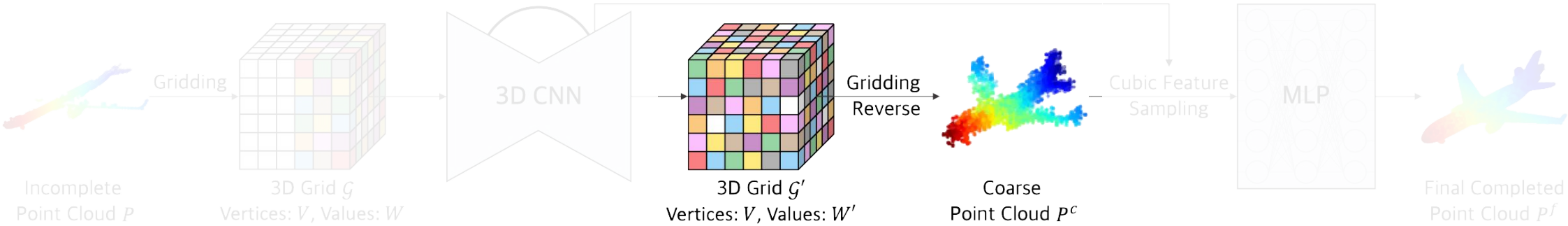
where (x_i, y_i, z_i) and (x, y, z) are the coordinates of w_i and p_i, respectively.

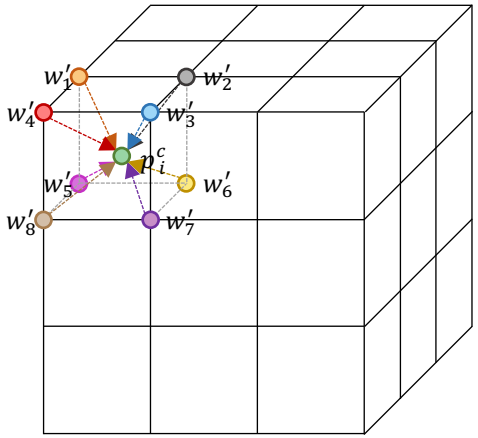
3D-CNN


Gridding
3D CNN
Gridding Reverse
Cubic Feature Sampling
MLP
Incomplete Point Cloud P
3D Grid $\mathcal{G}$ Vertices: V, Values: W
3D Grid $\mathcal{G}'$ Vertices: V, Values: W'
Coarse Point Cloud P^c
Final Completed Point Cloud P^f


Size: 1×64³
4³×32 conv3D
2³ MaxPool
4³×64 conv3D
2³ MaxPool
4³×128 conv3D
2³ MaxPool
4³×256 conv3D
2³ MaxPool
FC Layer (dim=2048)
FC Layer (dim=16384)
Reshape to 256×4³
4³×128 dconv3D
4³×64 dconv3D
4³×32 dconv3D
4³×1 dconv3D

Gridding Reverse



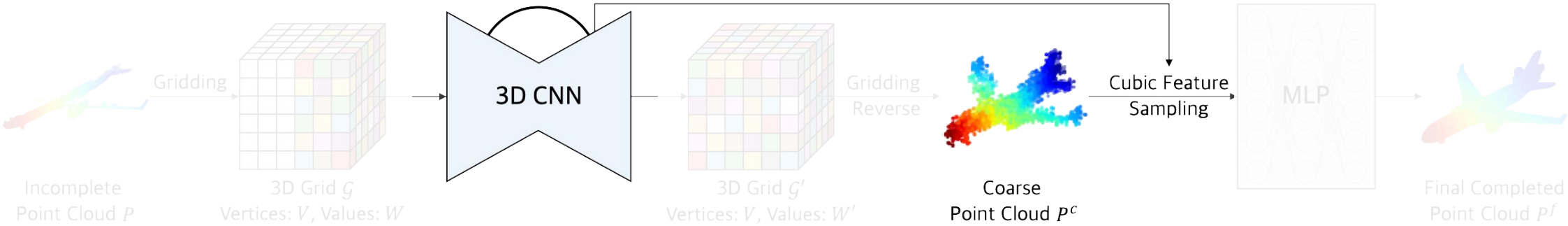


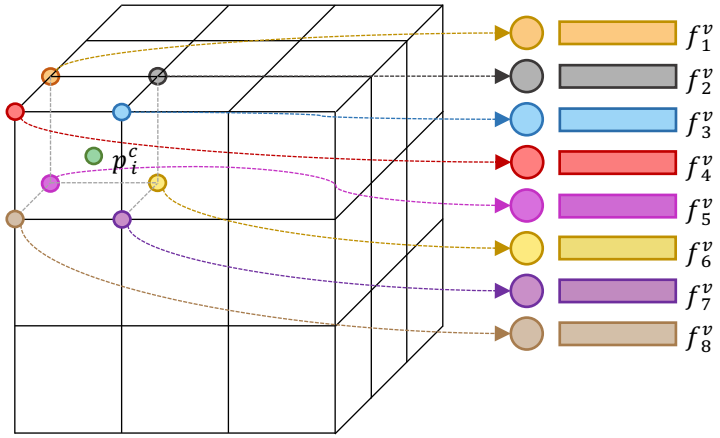
The coordinate of the generated point $\boldsymbol{p_i^c}$ can be computed as

$$\boldsymbol{p_i^c} = \frac{\sum_i w_i' \boldsymbol{v_i}}{\sum_i w_i'}$$

where the $\boldsymbol{v_i}$ and w_i' be the coordinate and value of the vertex i $(i = 1, \ldots, 8)$.

Cubic Feature Sampling

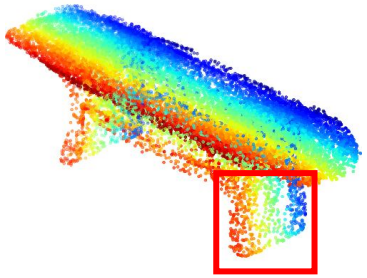




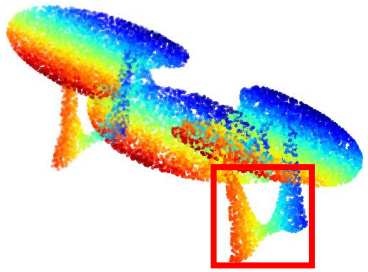
Therefore, the features f_i^c for point p_i^c can be computed as:

$$f_i^c = [f_1^v, f_2^v, \dots, f_8^v]$$

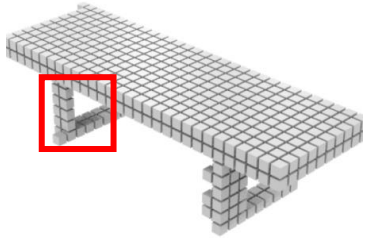
Gridding Loss



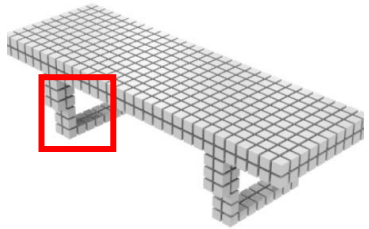
Reconstruction



Ground Truth



Reconstruction

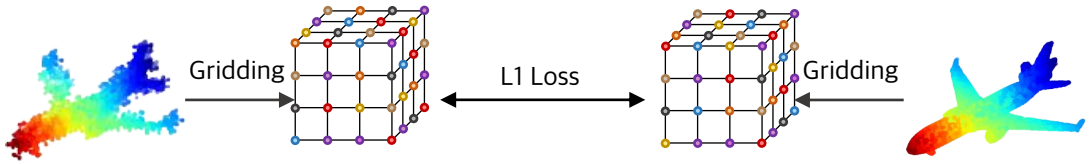


Ground Truth

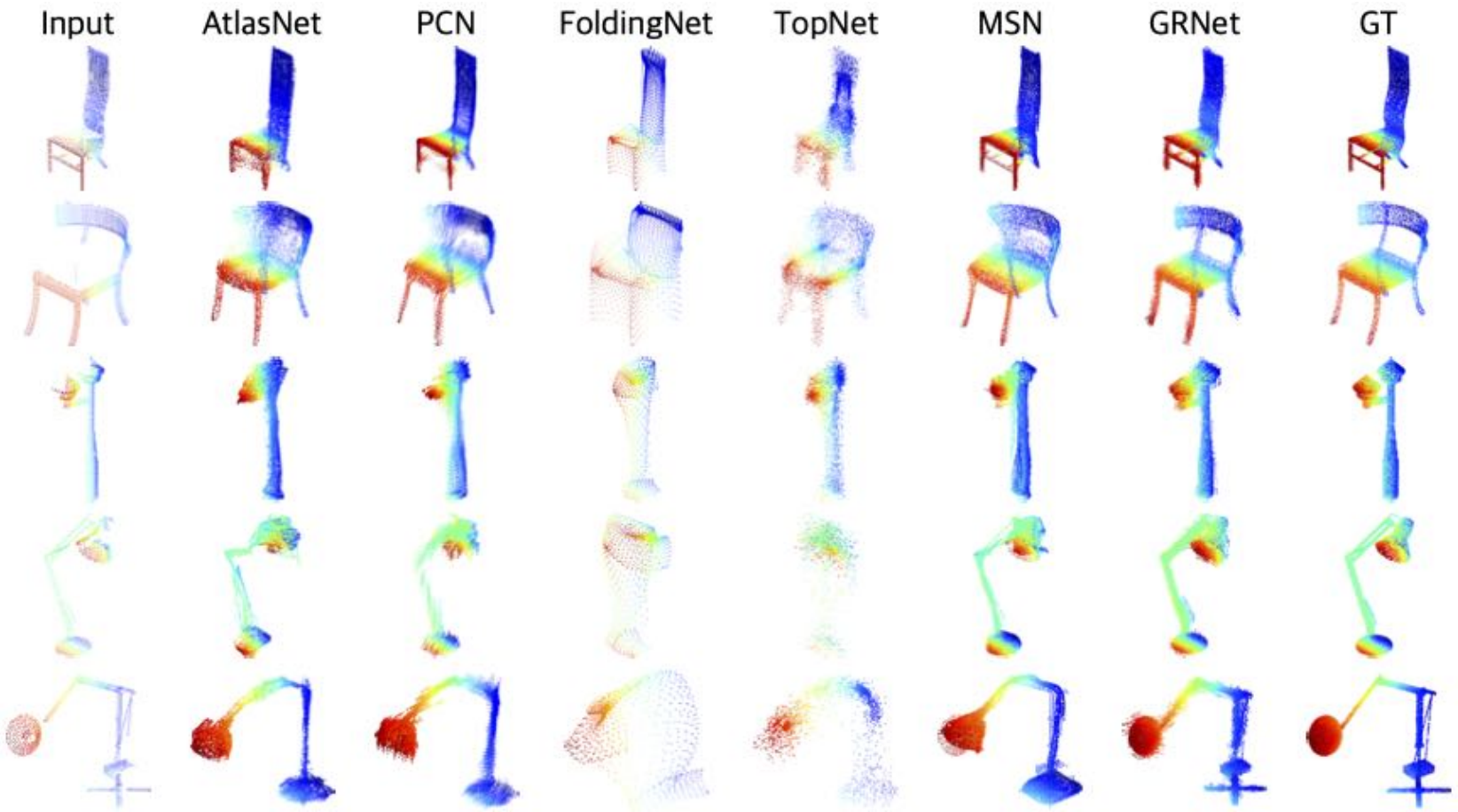
Chamfer Distance

$$\ell = \frac{1}{|P|}\sum_{p\in P}\min_{q\in Q}|p-q| + \frac{1}{|Q|}\sum_{q\in Q}\min_{p\in P}|p-q|$$

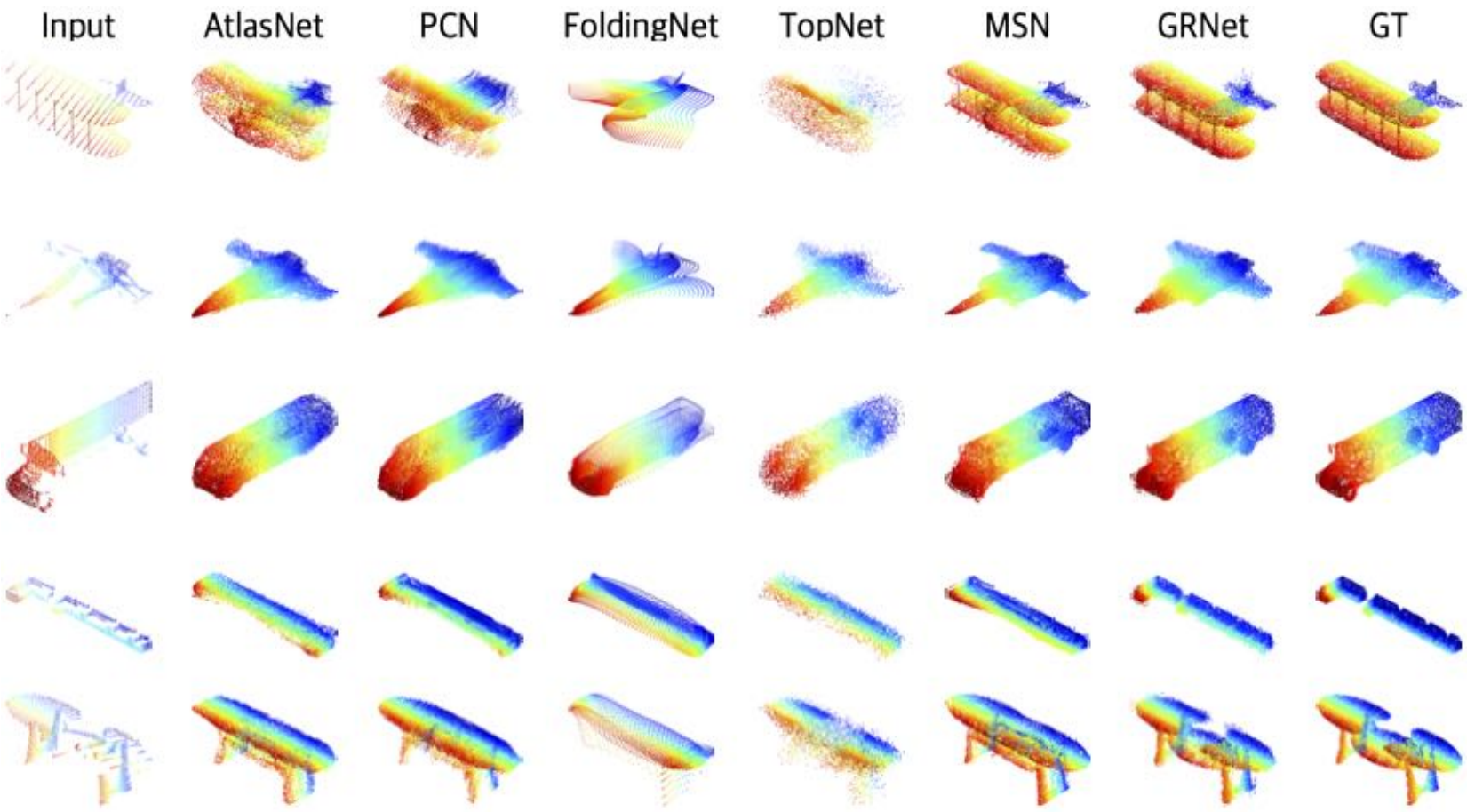
Gridding Loss



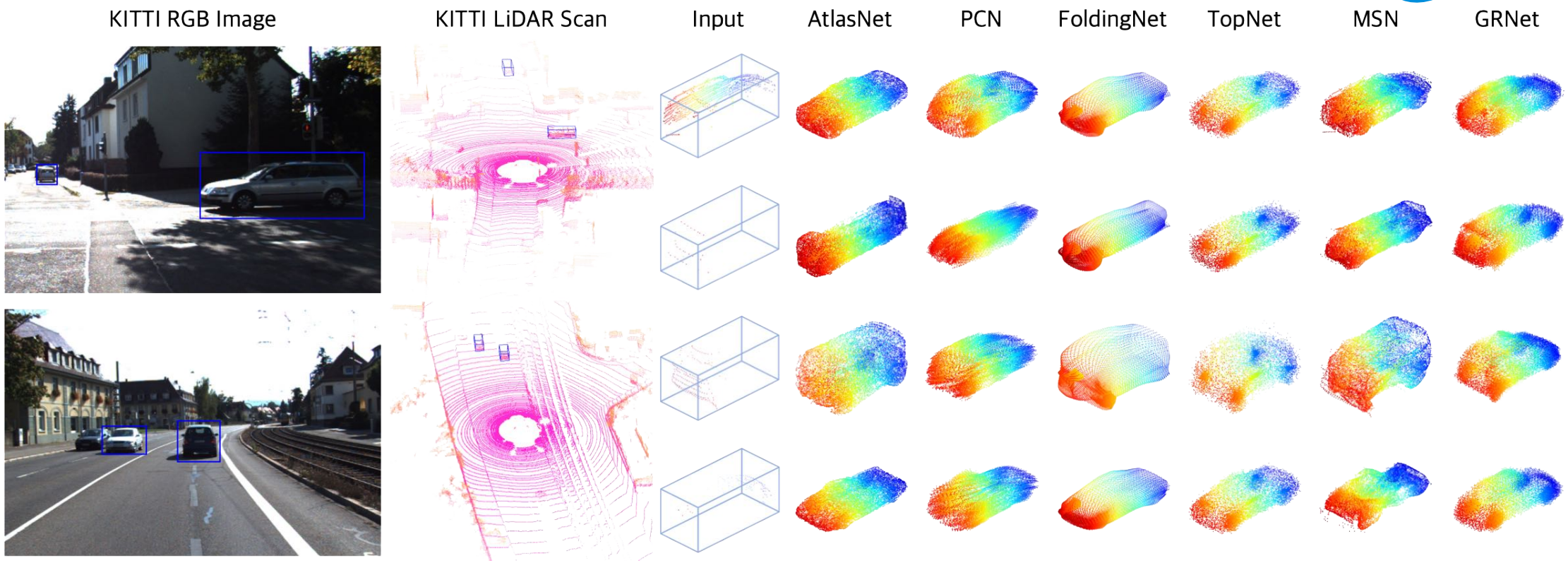
Qualitative Results on ShapeNet



Qualitative Results on ShapeNet



Qualitative Results on KITTI



Quantitative Results on ShapeNet

Chamfer Distance (L2)

Methods	Airplane	Cabinet	Car	Chair	Lamp	Sofa	Table	Watercraft	Mean
AtlasNet	1.753	5.101	3.237	5.226	6.342	5.990	4.359	4.177	4.523
PCN	**1.400**	4.450	**2.445**	4.838	6.238	5.129	3.569	4.062	4.016
FoldingNet	3.151	7.943	4.676	9.225	9.324	8.895	6.691	7.325	7.142
TopNet	2.152	5.623	3.513	6.346	7.502	6.949	4.784	4.359	5.154
MSN	1.543	7.249	4.711	4.539	6.479	5.894	3.797	3.853	4.758
GRNet	1.531	**3.620**	2.752	**2.945**	**2.649**	**3.613**	**2.552**	**2.122**	**2.723**

Quantitative Results on ShapeNet

F-Score@1%

Methods	Airplane	Cabinet	Car	Chair	Lamp	Sofa	Table	Watercraft	Mean
AtlasNet	0.845	0.552	0.630	0.552	0.565	0.500	0.660	0.624	0.616
PCN	0.881	**0.651**	**0.725**	0.625	0.638	0.581	0.765	0.697	0.695
FoldingNet	0.642	0.237	0.382	0.236	0.219	0.197	0.361	0.299	0.322
TopNet	0.771	0.404	0.544	0.413	0.408	0.350	0.572	0.560	0.503
MSN	**0.885**	0.644	0.665	0.657	0.699	0.604	**0.782**	0.708	0.705
GRNet	0.843	0.618	0.682	**0.673**	**0.761**	**0.605**	0.751	**0.750**	**0.708**

Leaderboard on Completion 3D

Chamfer Distance (L2)

Method	CD(10^{-4})	Airplane	Cabinet	Car	Chair	Lamp	Sofa	Table	Watercraft
GRNet	10.64	6.13	16.90	8.27	12.23	10.22	14.93	10.08	5.86
Haozhe Xie, Hongxun Yao, Shangchen Zhou, Jiageng Mao, Shengping Zhang, Wenxiu Sun: GRNet: Gridding Residual Network for Dense Point Cloud Completion. ECCV 2020									
TopNet	14.25	7.32	18.77	12.88	19.82	14.60	16.29	14.89	8.82
Lyne P. Tchapmi, Vineet Kosaraju, S. Hamid Rezatofighi1, Ian Reid, Silvio Savarese: TopNet: Structural Point Cloud Decoder. CVPR19									
PointNetFCAE(Topnet-baseline)	16.88	10.30	19.06	11.82	24.68	20.30	20.09	17.57	10.50
N/A: TopNet-Baseline. N/A									
AtlasNet(Topnet-baseline)	17.77	10.36	23.40	13.40	24.16	20.24	20.82	17.52	11.62
N/A: TopNet-Baseline. N/A									
PCN(Topnet-baseline)	18.22	9.79	22.70	12.43	25.14	22.72	20.26	20.27	11.73
N/A: TopNet-Baseline. N/A									
Folding(Topnet-baseline)	19.07	12.83	23.01	14.88	25.69	21.79	21.31	20.71	11.51
N/A: TopNet-Baseline. N/A									

Reference: https://completion3d.stanford.edu/results

Thank you!

Project Page:

https://haozhexie.com/project/grnet/