Adaptive O-CNN: A Patch-based Deep Representation of 3D Shapes

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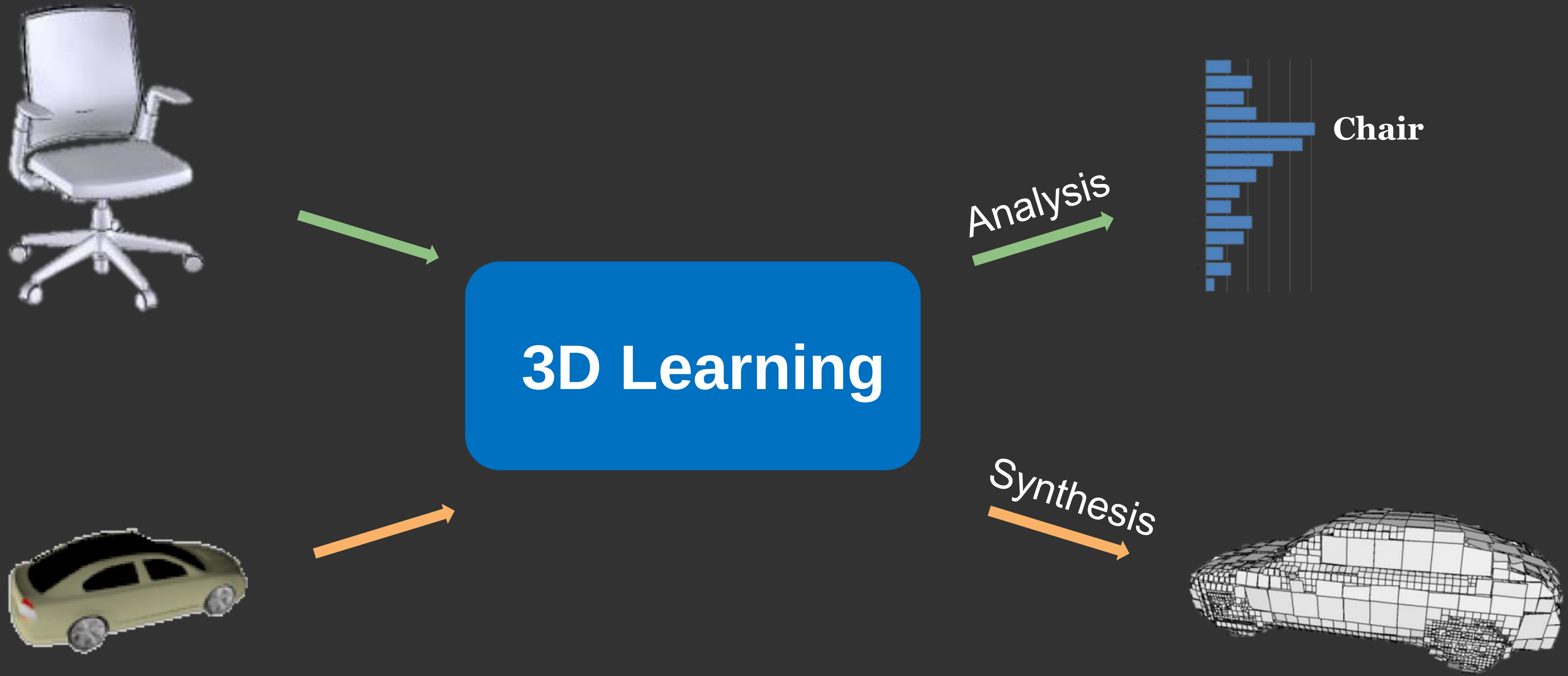
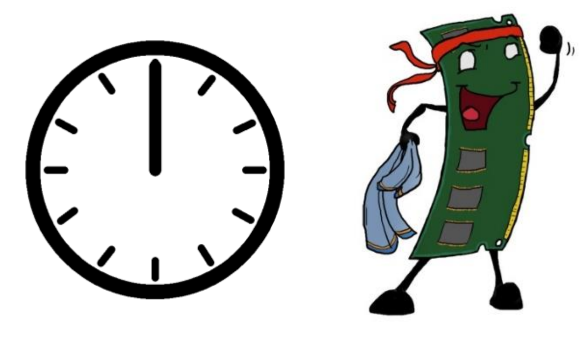
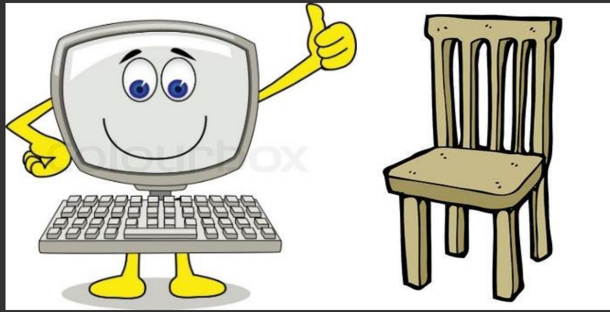
3D Learning for Shape Analysis and Synthesis



Our Goal

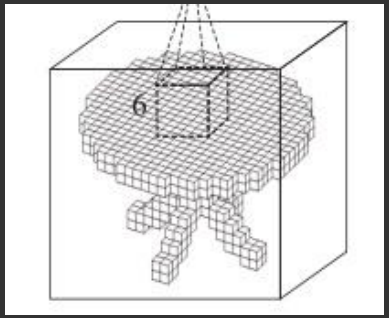
- A good 3D representation for shape learning
  - Compact: low memory and computational cost
  - Informative: good shape generation quality


Efficient

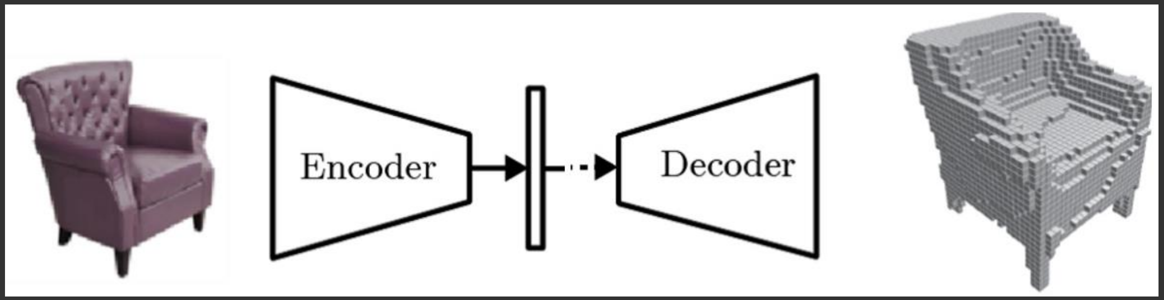

Shape quality

Full Voxel based Representation

- Related work: [Wu et al. 2015]; [Choy et al. 2016]; [Wu et al. 2016] ...
- ✓ Intuitive extension of images
- ✗ Low resolution



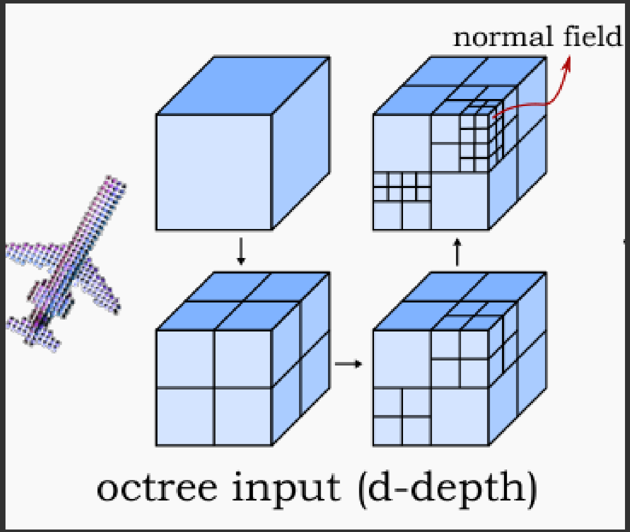
3D ShapeNet [Wu et al. 2015]



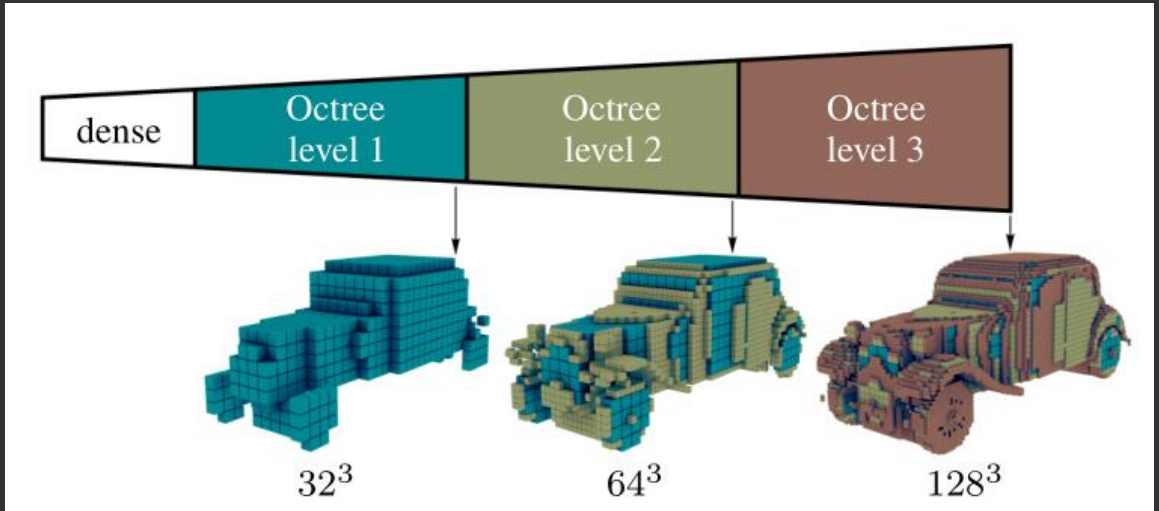
3D R^2N^2 [Choy et al. 2016]

Sparse Voxel based Representation

- Related work: [Wang et al. 2017]; [Tatarchenko et al. 2017]; [Riegler et al. 2017]...
- ✓ Support high resolution
- ✗ Low surface quality



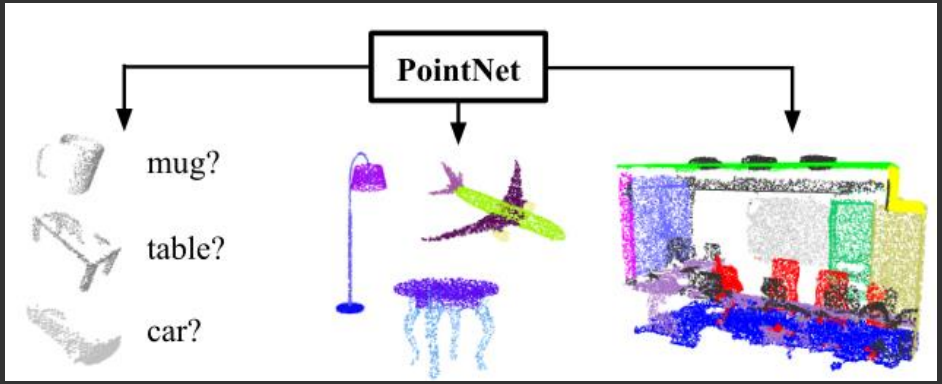
O-CNN [Wang et al. 2017]



OctGen [Tatarchenko et al. 2017]

Point based Representation

- Related work: [Qi et al. 2017]; [Su et al. 2017]; [Yin et al. 2018] ...
- ✔ Flexible to use, effective for point cloud input
- ✘ Generate scatter points, hard to extract surface

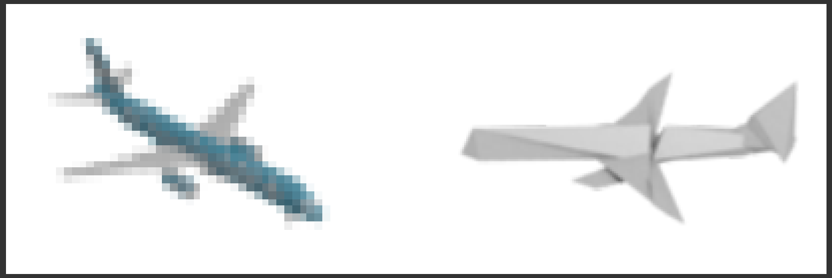


PointNet [Qi et al. 2017]

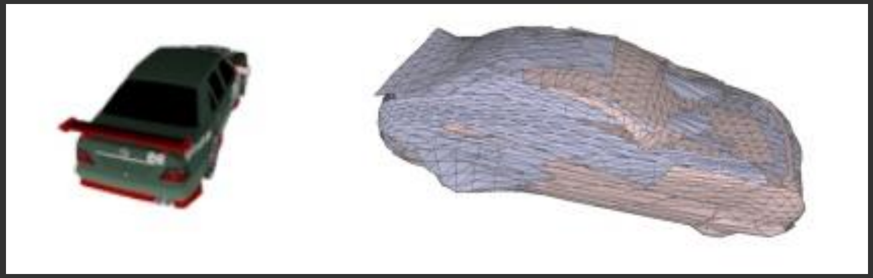
PSG [Su et al. 2017]

Mesh based Representation

- Related work: [Groueix et al. 2018]; [Kato et al. 2018]; [Sinha et al. 2017] ...
- ✓ Better visual quality compared with PSG [Su et al. 2017]
- ✗ Irregular and distorted mesh elements, restricted topology



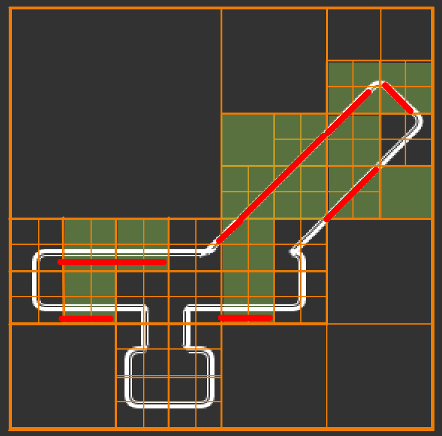
[Kato et al. 2018]



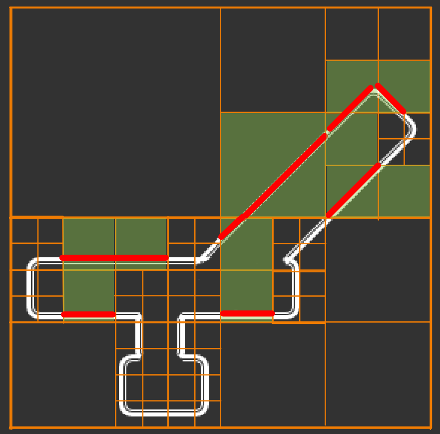
AtlasNet [Groueix et al. 2018]

Key Observation

- Subdivide the octree considering the geometry variation

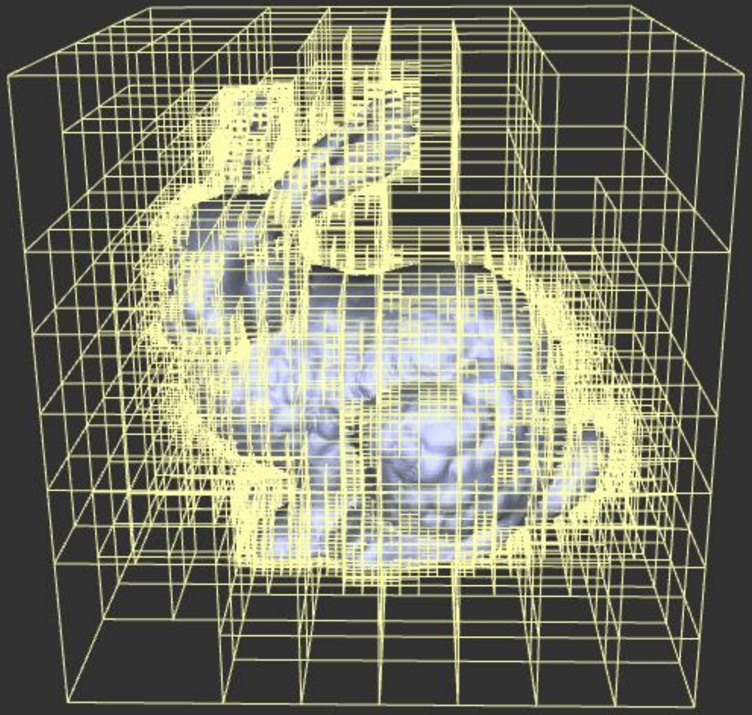


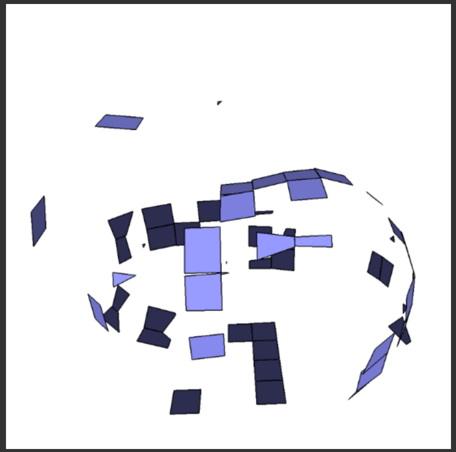
Octree:
subdivide if non-empty



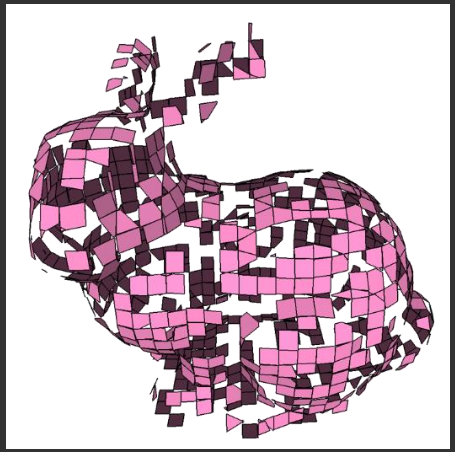
Adaptive octree:
subdivide if non-empty &&
plane fitting error < δ

Patch-Based Adaptive Octree

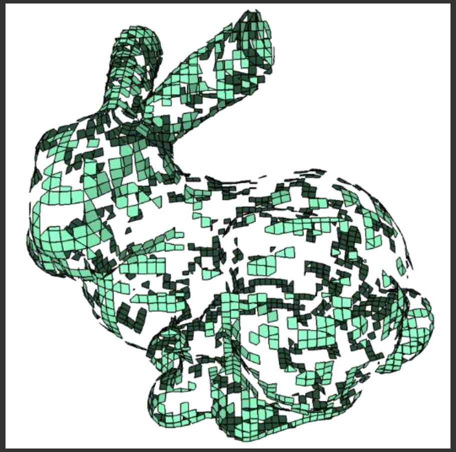




Planar patches at 4-level

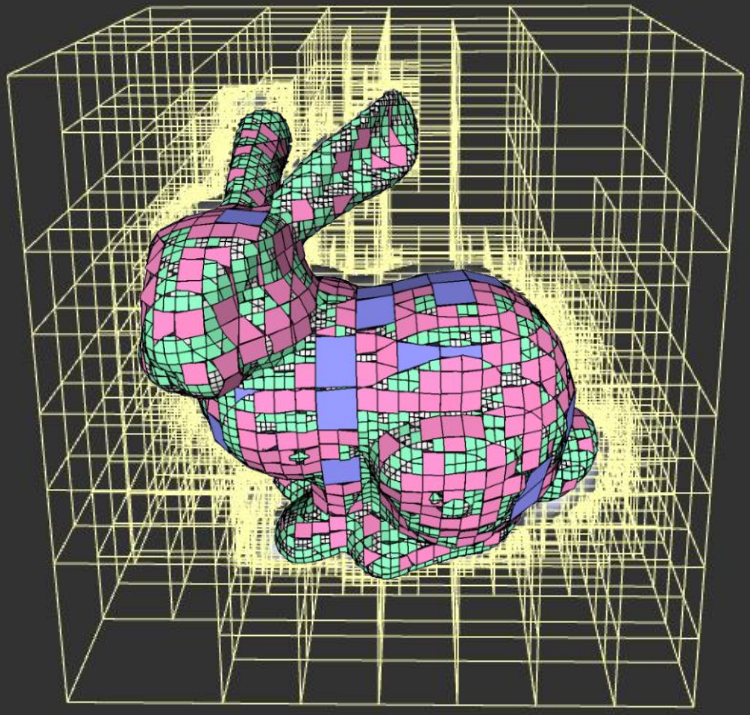


Planar patches at 5-level



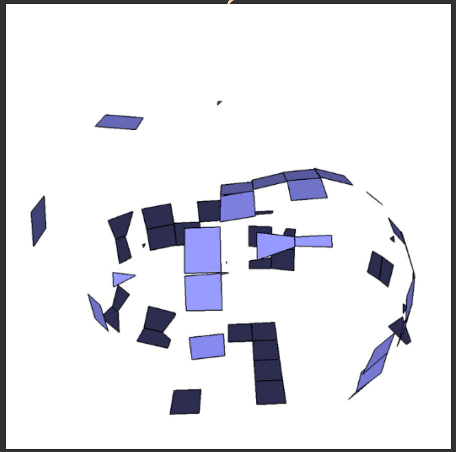
Planar patches at 6-level

Patch-Based Adaptive Octree

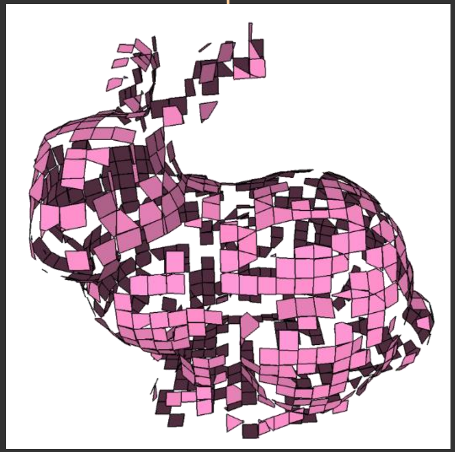


Planar patches

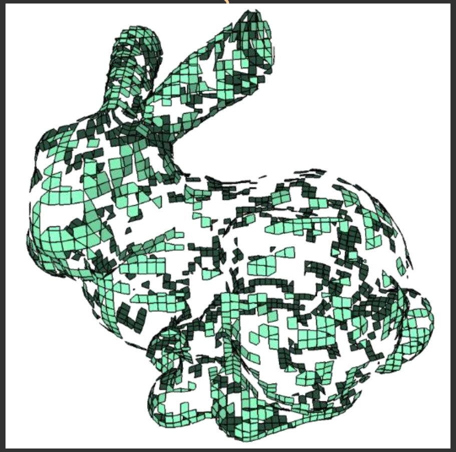
$$\boldsymbol{n} * (\boldsymbol{x} - \mathrm{c}) + d = 0$$



Planar patches
at 4-level



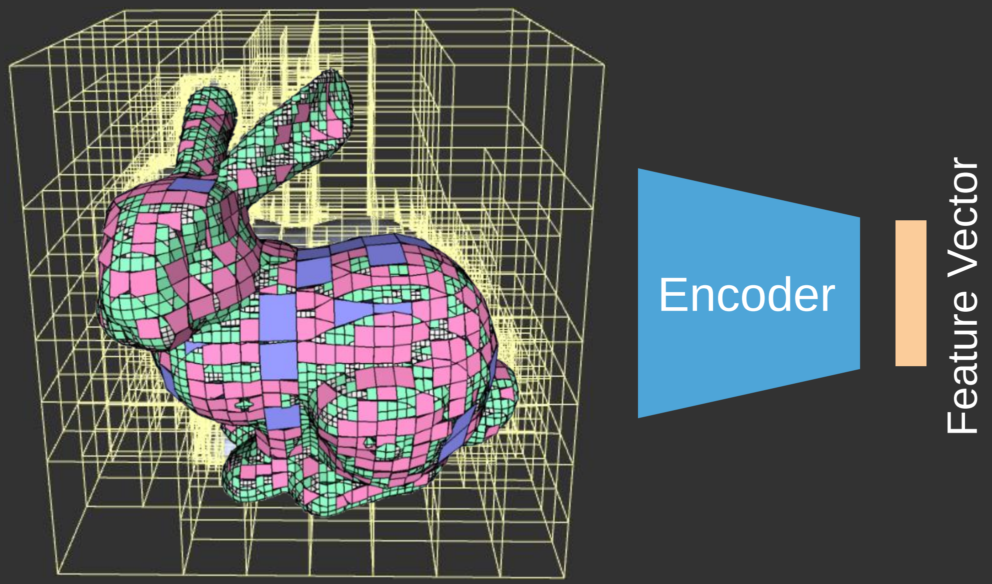
Planar patches
at 5-level



Planar patches
at 6-level

Technical Challenges: Adaptive O-CNN

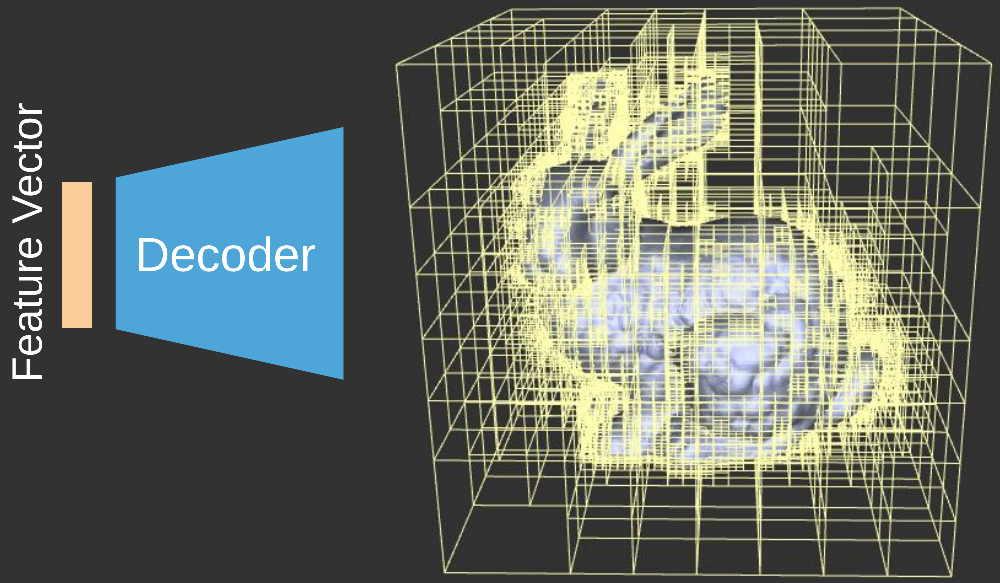
- Encoder network
  - How to deal with multi-resolution inputs



Adaptive Octree

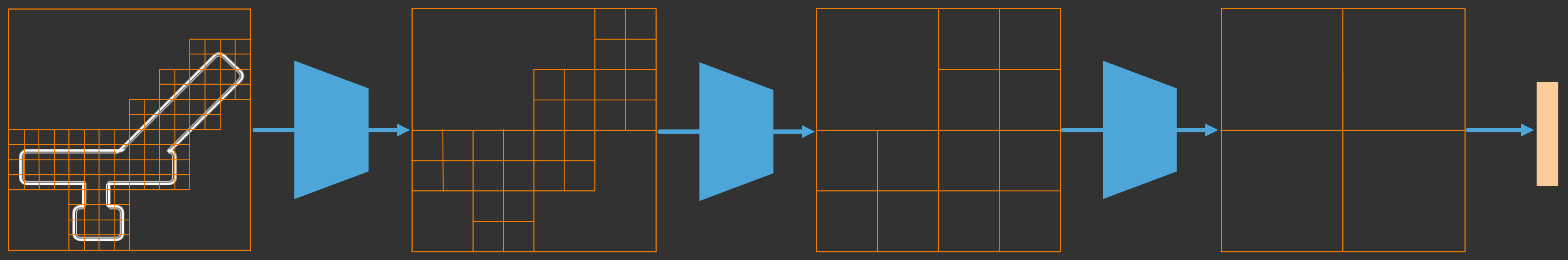
Technical Challenges: Adaptive O-CNN

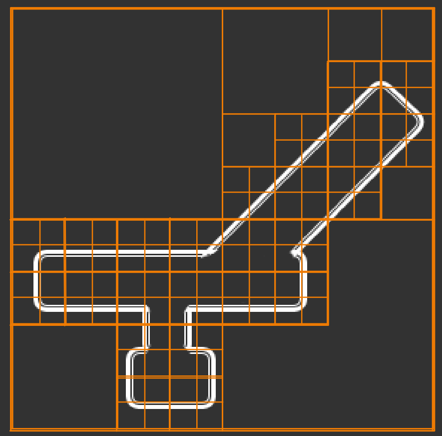
- Decoder network
  - How to generate the adaptive Octree



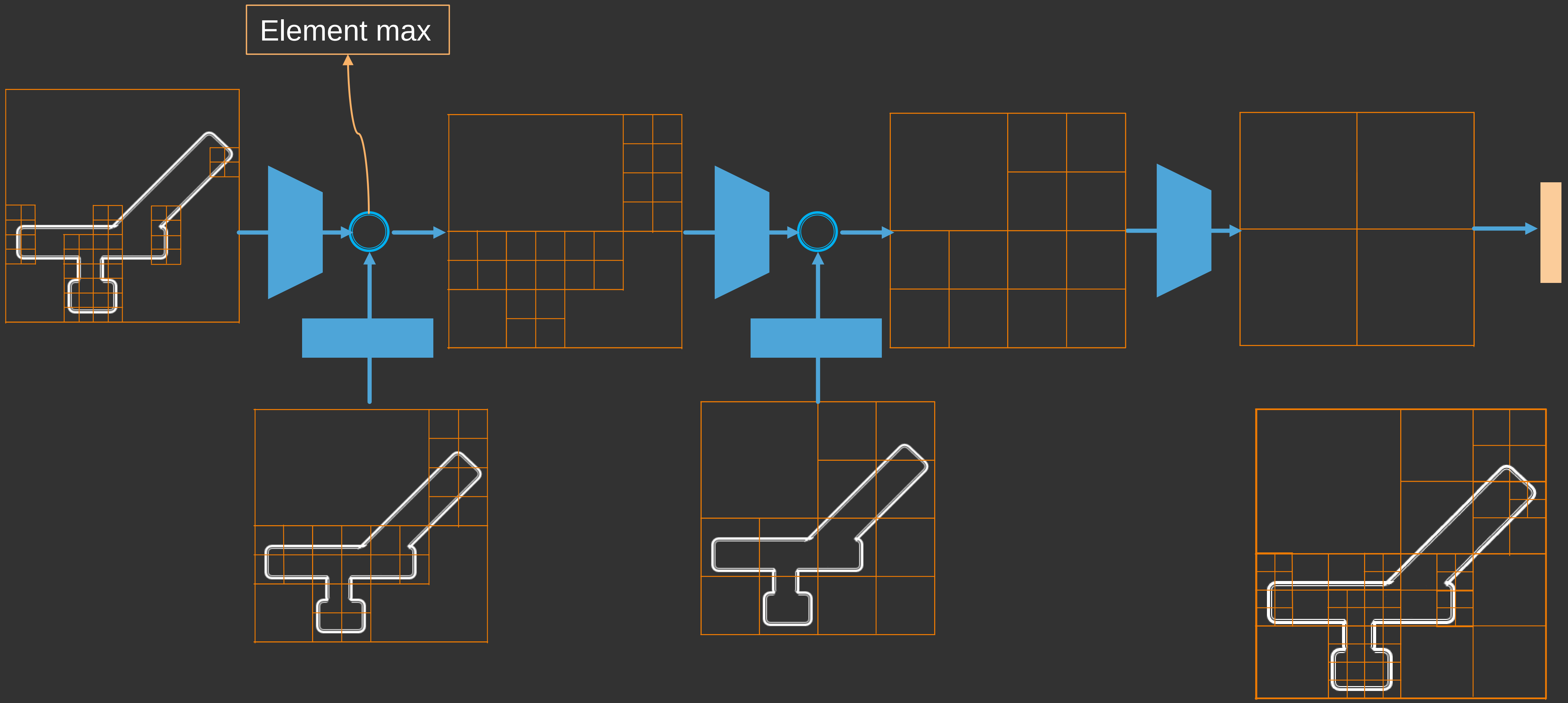
Adaptive O-CNN Encoder

- Reference: O-CNN encoder

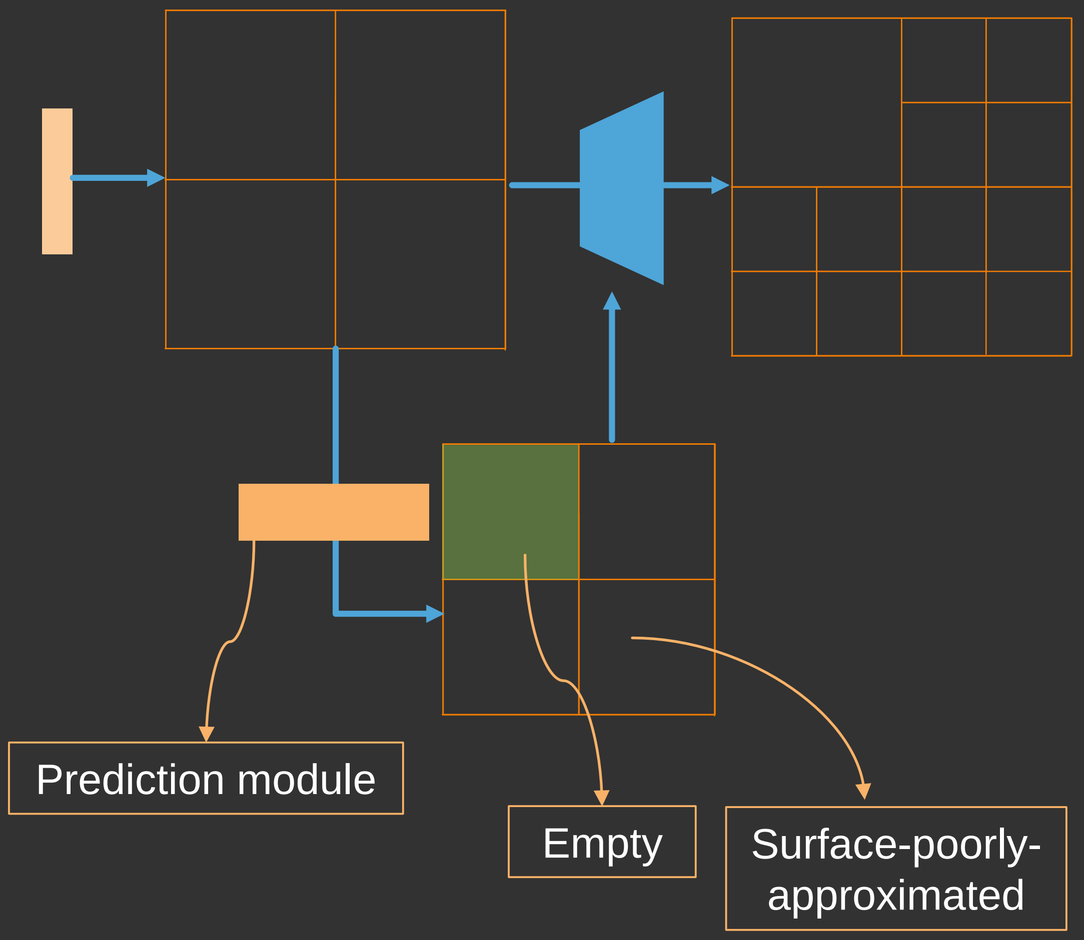




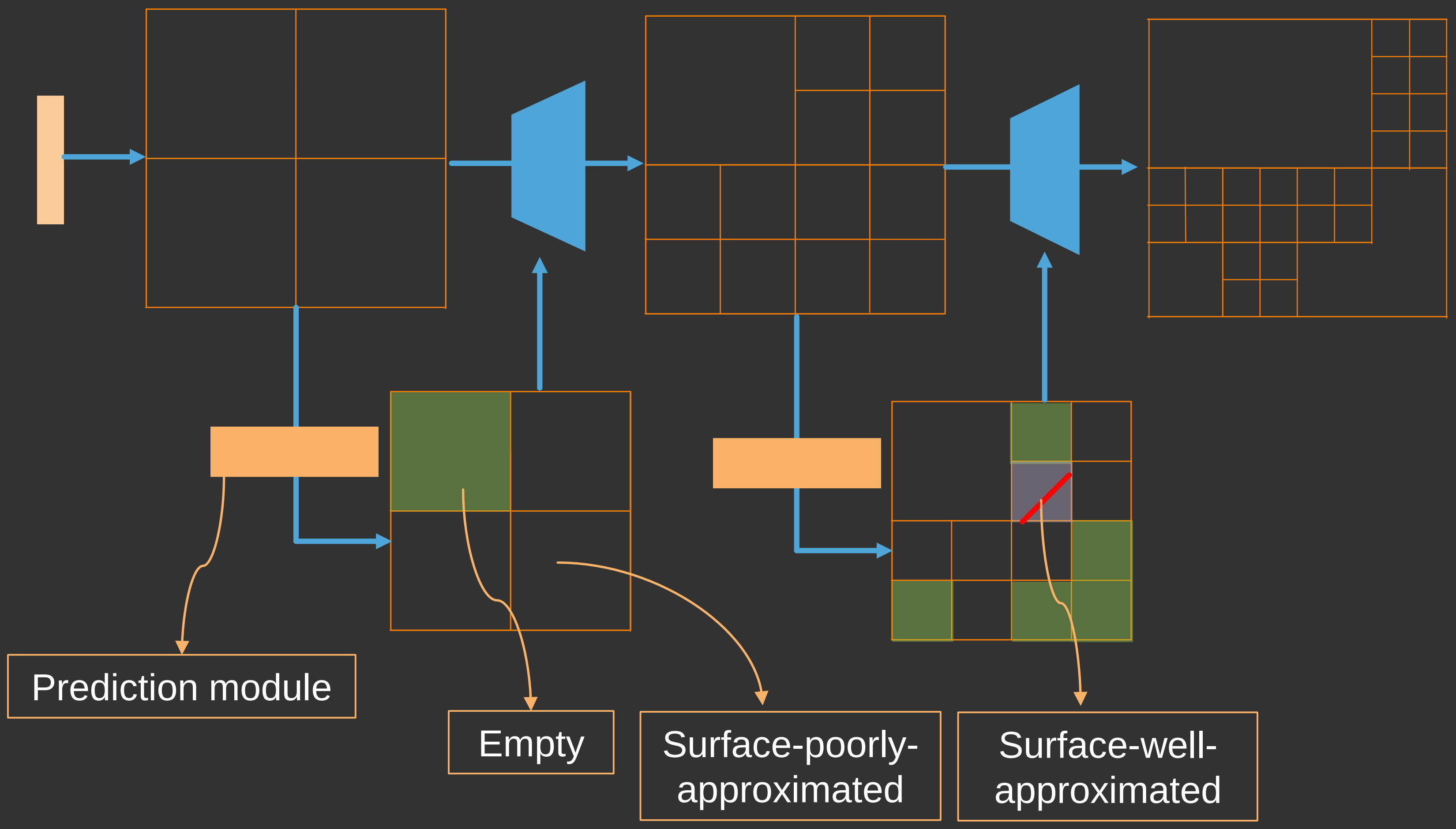
Adaptive O-CNN Encoder



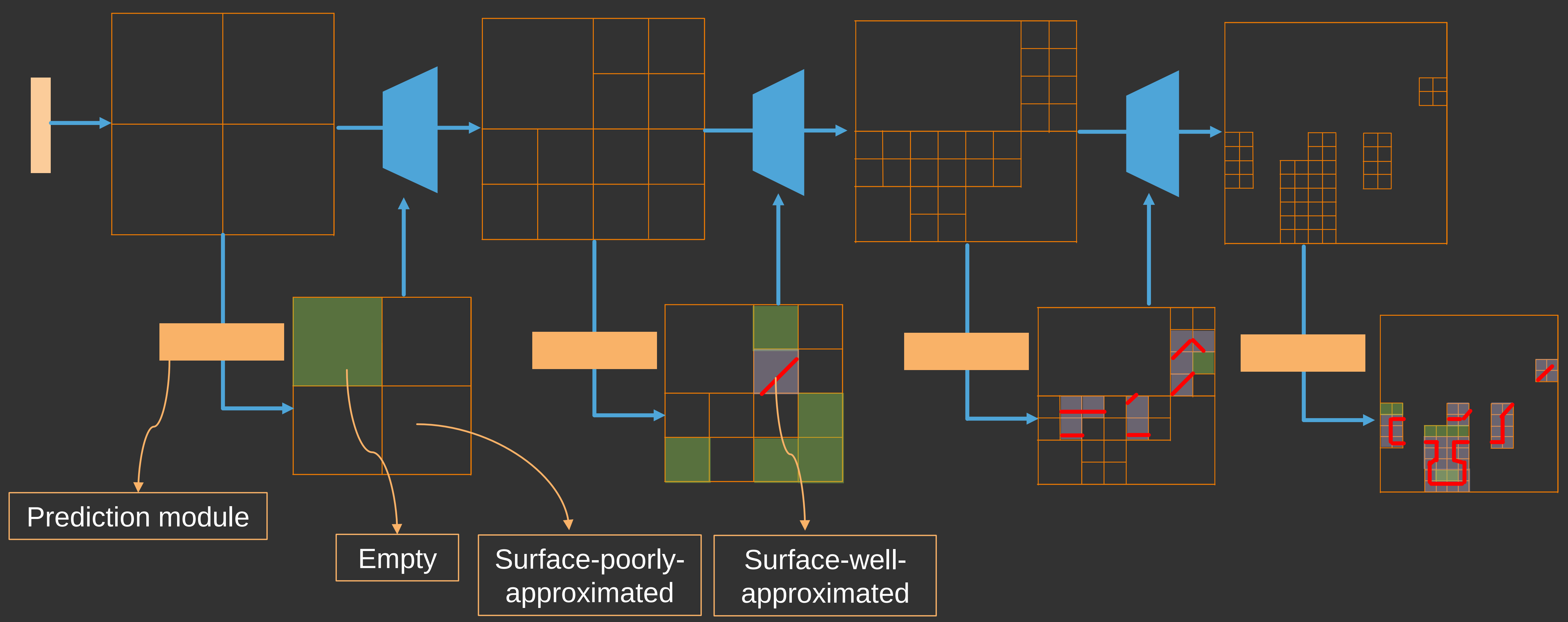
Adaptive O-CNN Decoder



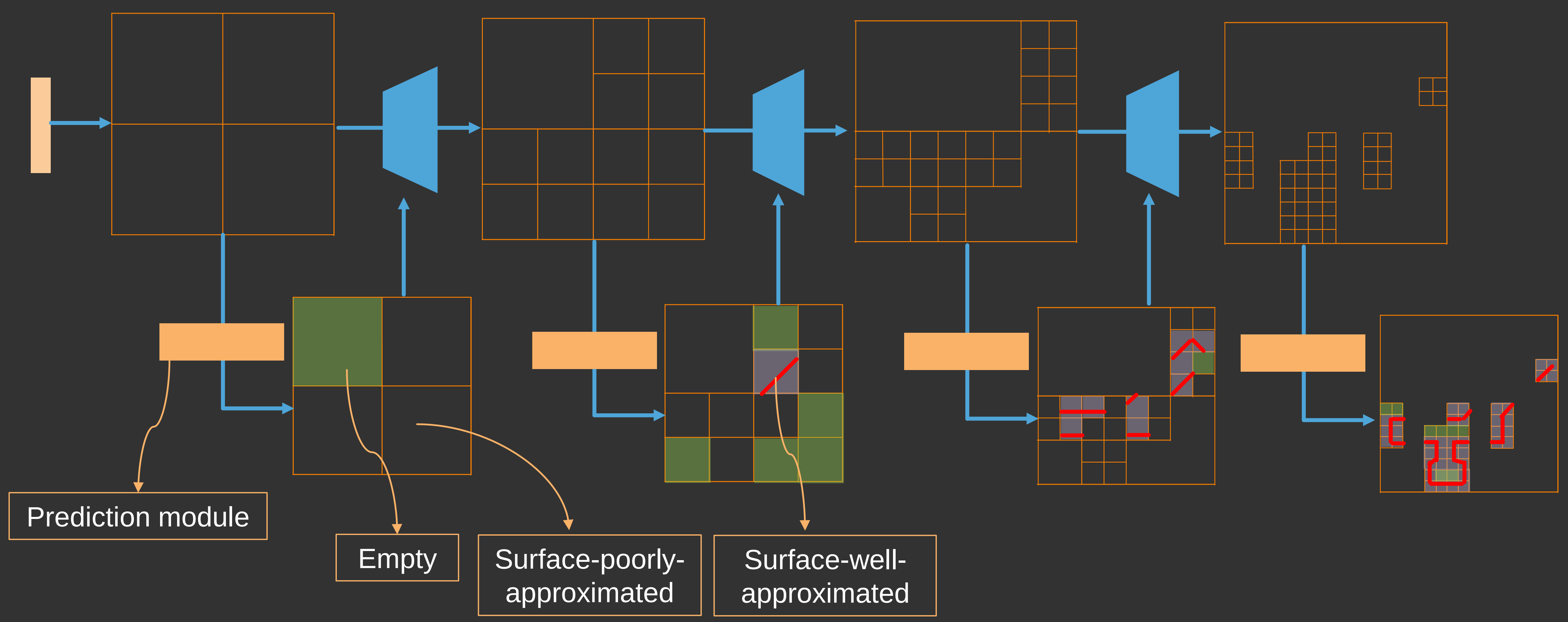
Adaptive O-CNN Decoder



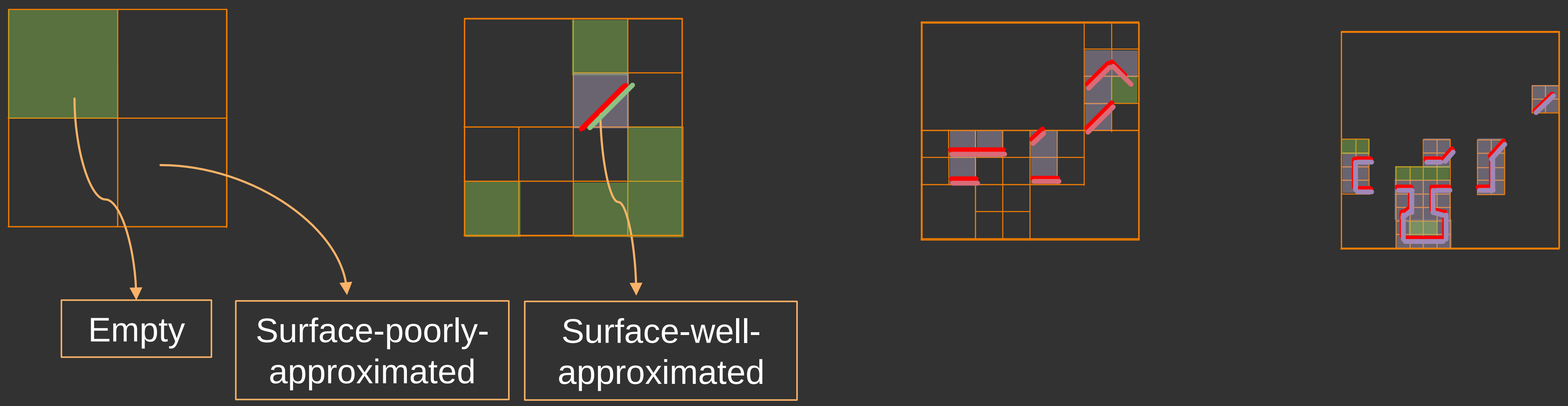
Adaptive O-CNN Decoder



Adaptive O-CNN Decoder

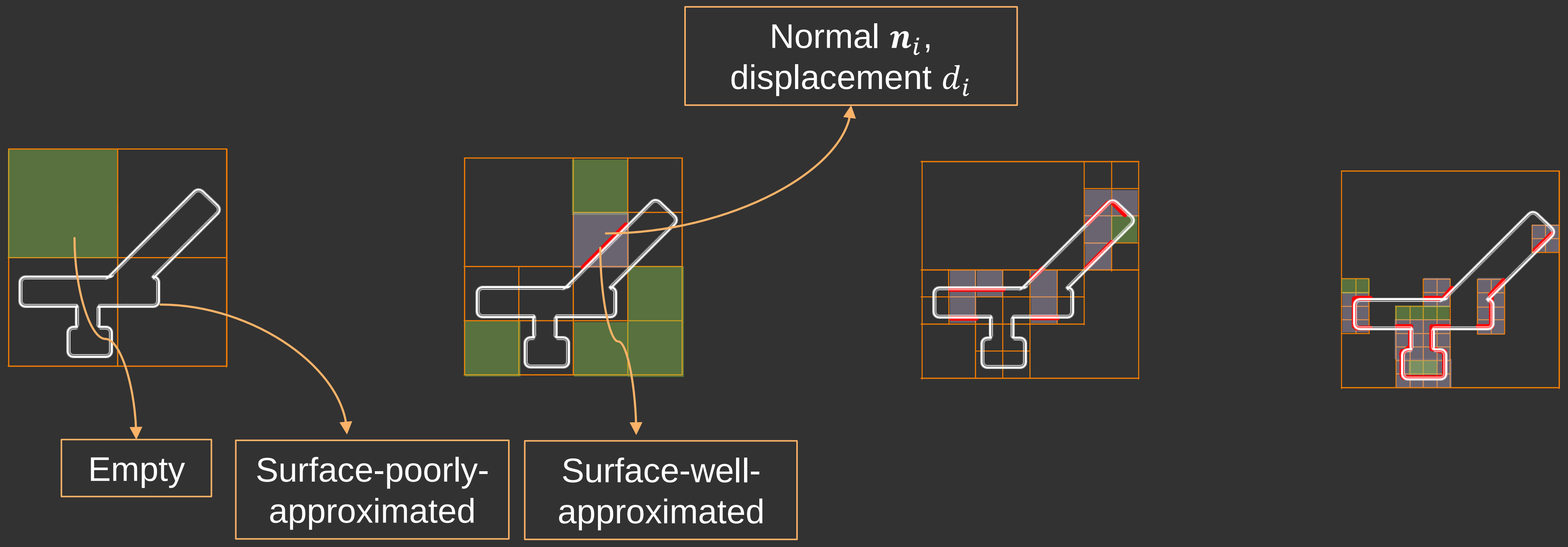


Adaptive O-CNN Decoder



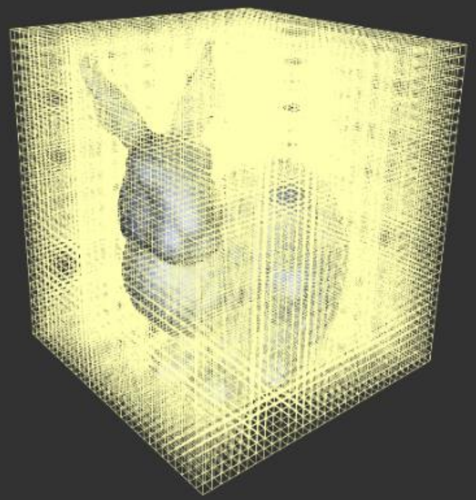
Adaptive O-CNN Decoder: Loss Function

- Octree node status: $L_{structure} = \sum_l H_l$
- Patch parameters: $L_{patch} = \sum_l \frac{1}{N_l} \sum_i \left\| n_i - n_i^g \right\|^2 + |d_i - d_i^g|$

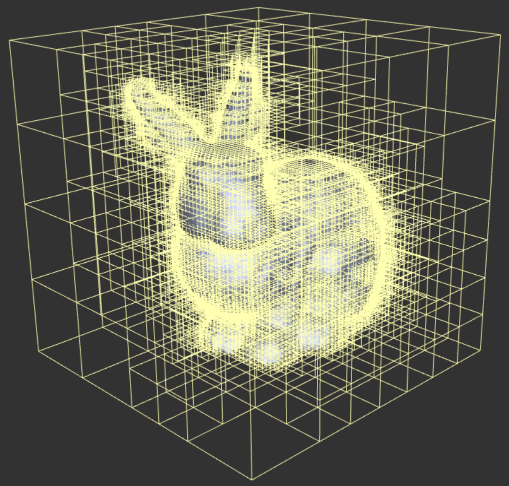


Efficiency of Adaptive O-CNN

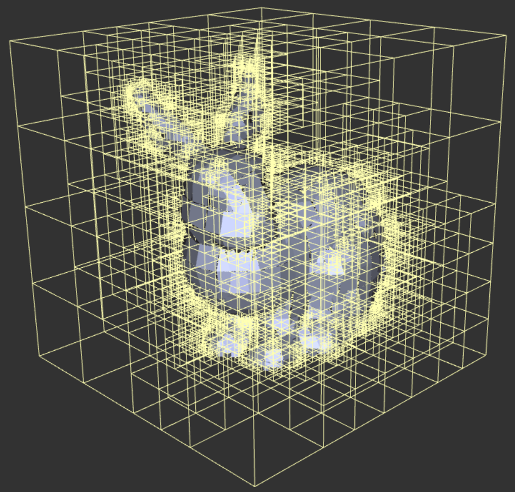
- Adaptive Octree: much less voxels compared with Octree
  - Titan X GPU; Batch size 32



Full Voxel
N^3

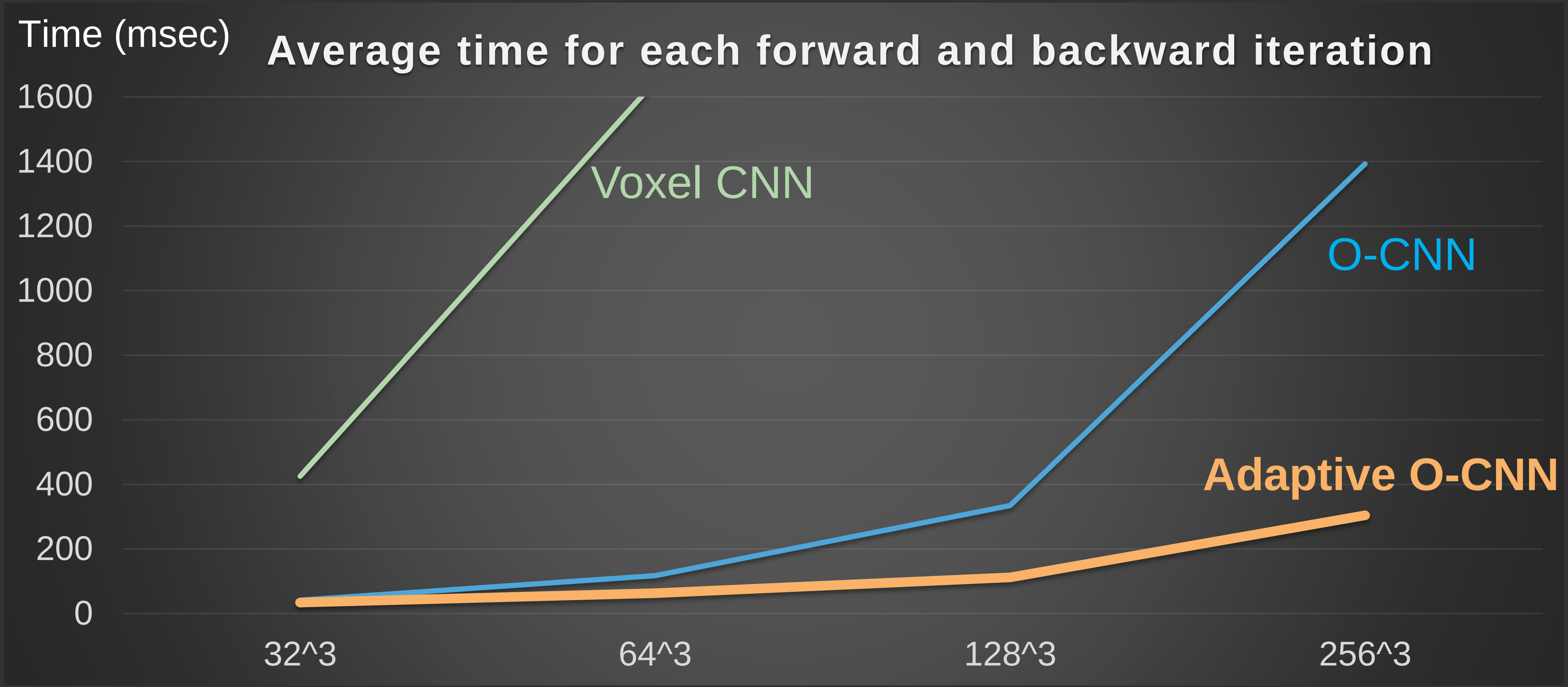


Octree
about $2.5 \times \mathrm{N}^2$

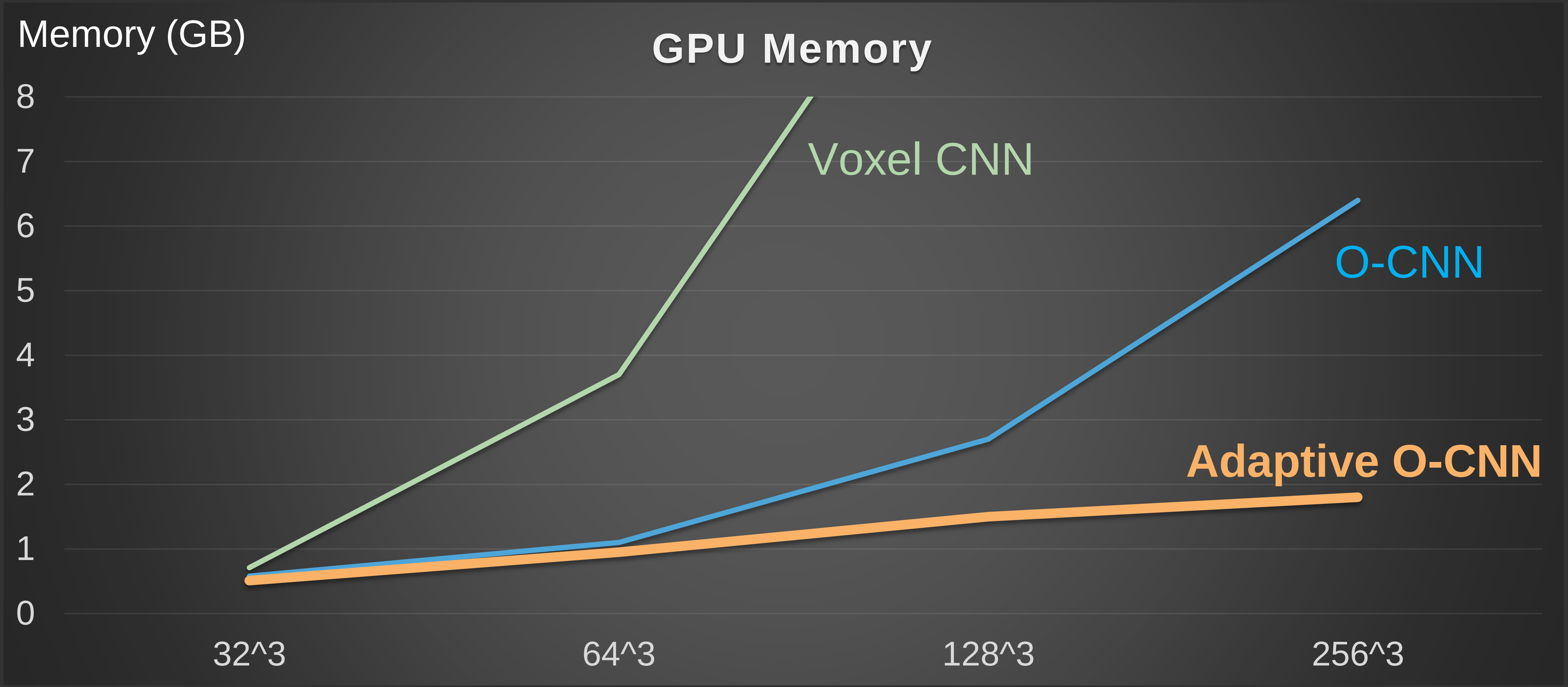


Adaptive Octree
about $0.8 \times \mathrm{N}^2$

Time Efficiency



Memory Efficiency



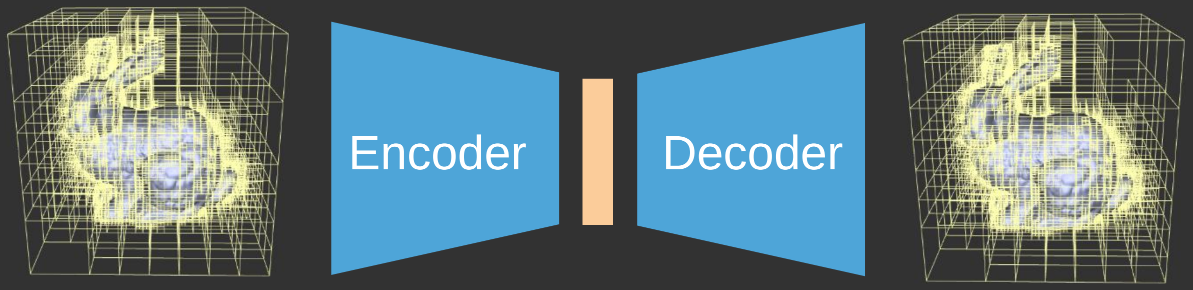
Results – Shape Classification

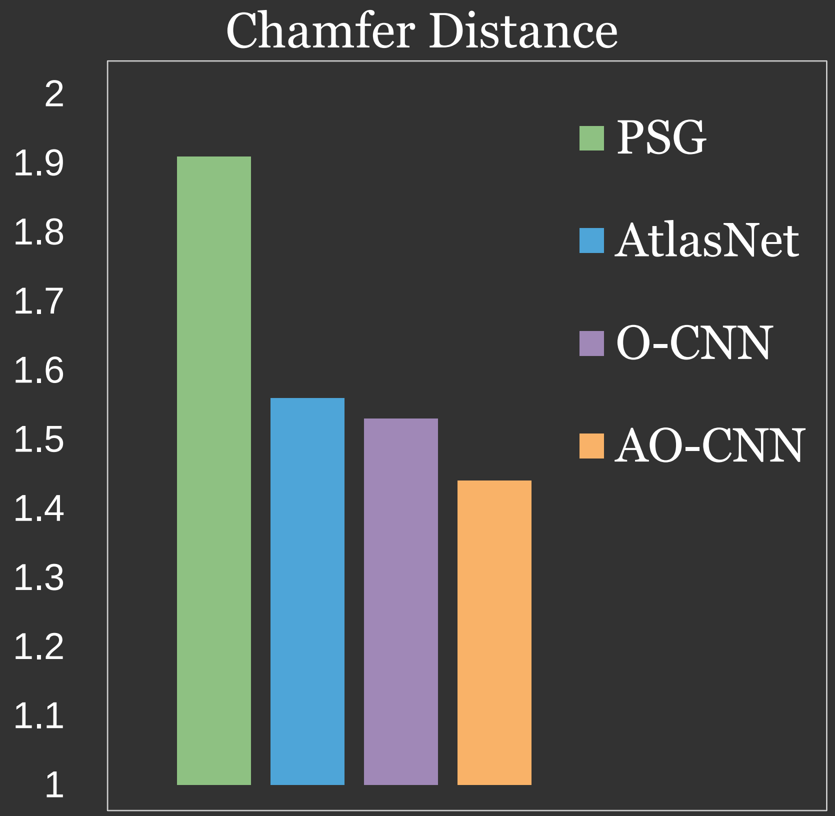
- Dataset: ModelNet40
- Comparable testing accuracy

Method	Accuracy	Method	Accuracy
PointNet [Qi et al. 2017]	89.2%	PointNet++ [Qi et al. 2017]	91.9%
VRN Ensemble [Brock et al. 2016]	95.5%	SubVolSup [Qi et al. 2016]	89.2%
OctNet [Riegler et al. 2017a]	86.5%	O-CNN [Wang et al. 2017]	90.6%
Kd-Network [Klokov and Lempitsky 2017]	91.8%	Adaptive O-CNN	90.5%

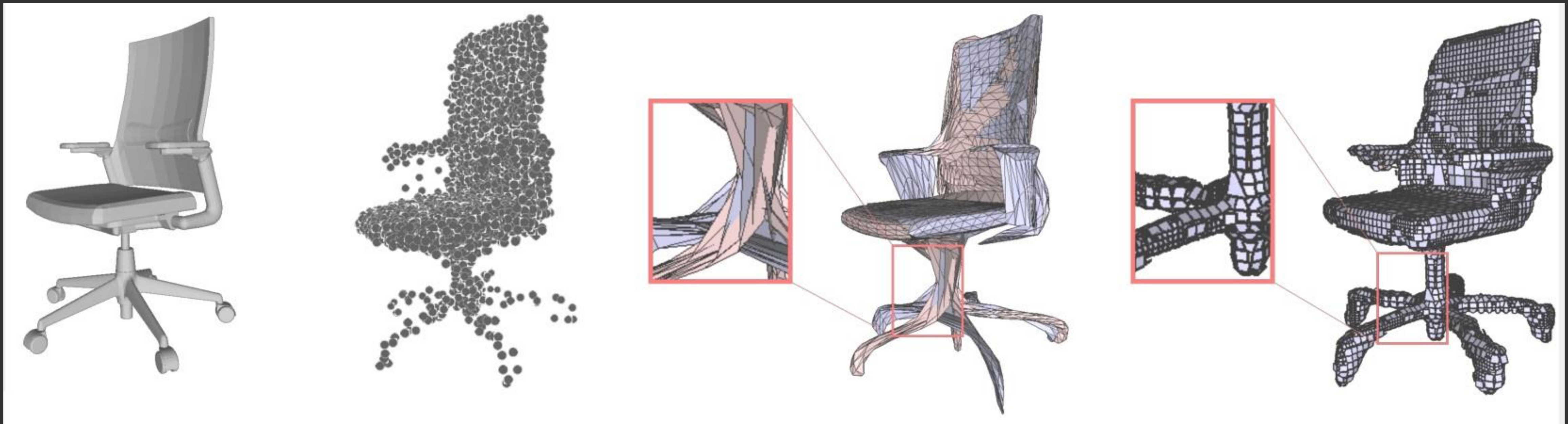
Results – 3D Autoencoder

- Dataset: ShapeNet55
  - 39,715 3D models from 13 categories
- Network



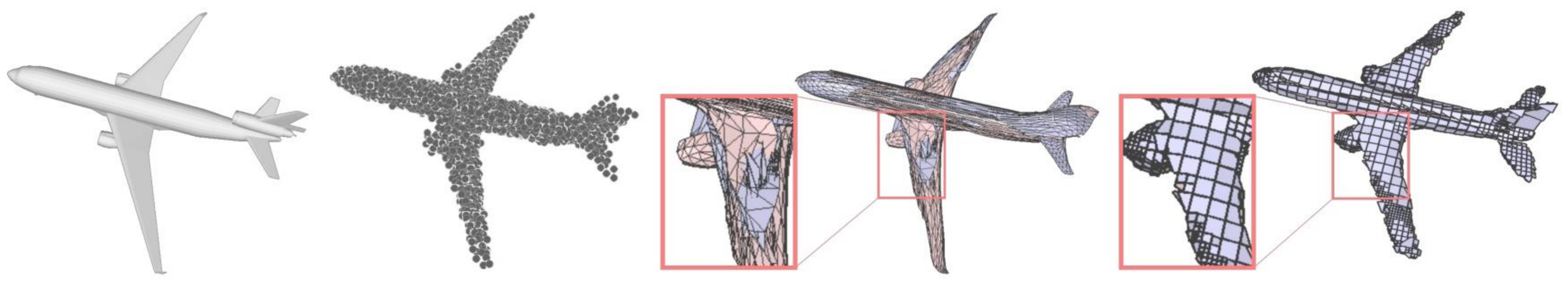


Visual Comparison



Ground-truth PSG [Su et al. 2017] AtlasNet [Groueix et al. 2018] Adaptive O-CNN

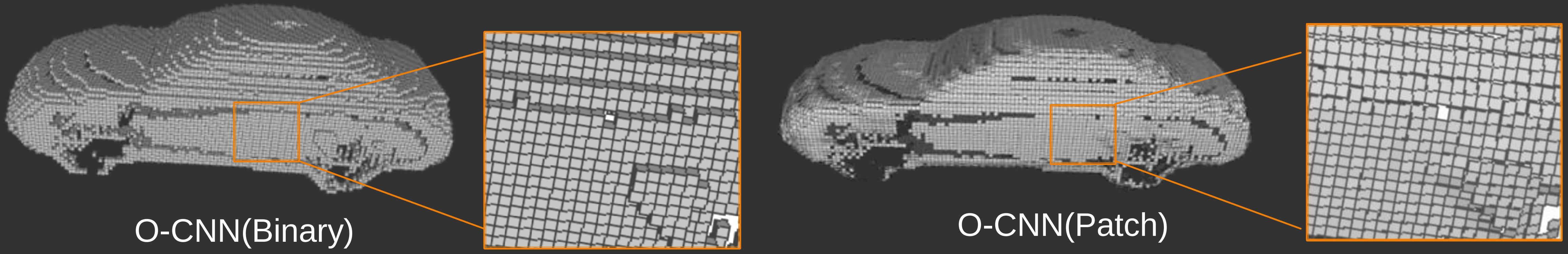
Visual Comparison



Ground-truth PSG [Su et al. 2017] AtlasNet [Groueix et al. 2018] Adaptive O-CNN

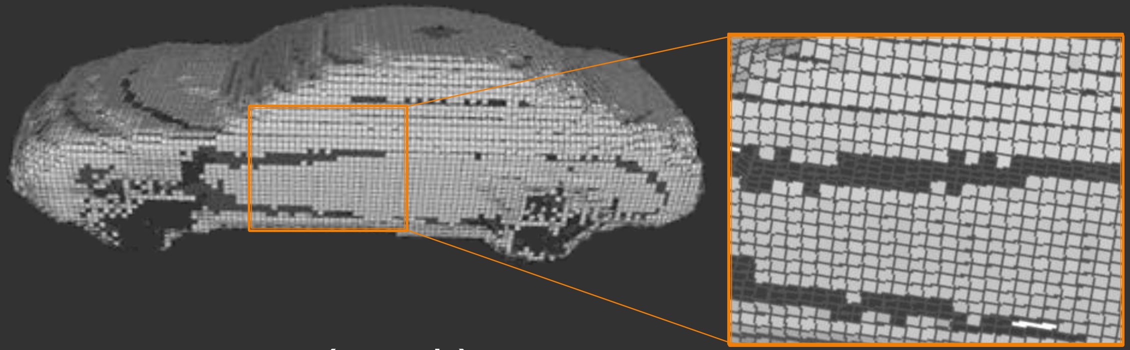
Ablation Study: Patch Primitive

- Patch primitive enables sub-voxel precision

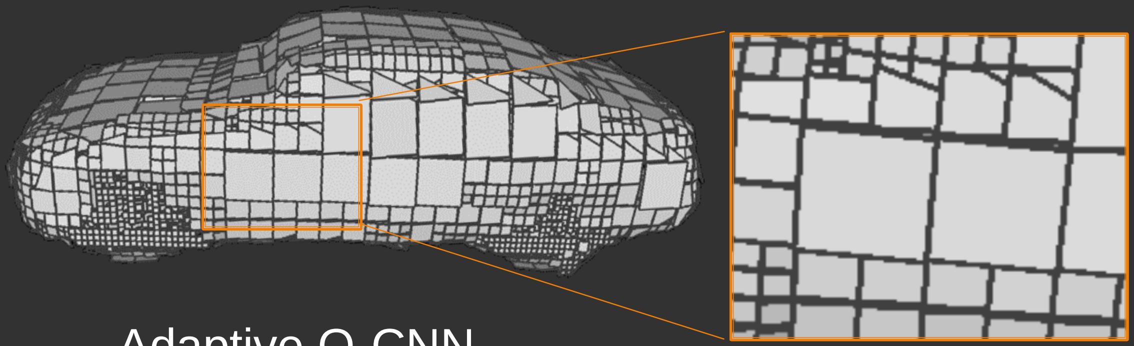


Ablation Study: Adaptive Patches

- Adaptive octree produces less holes on the output

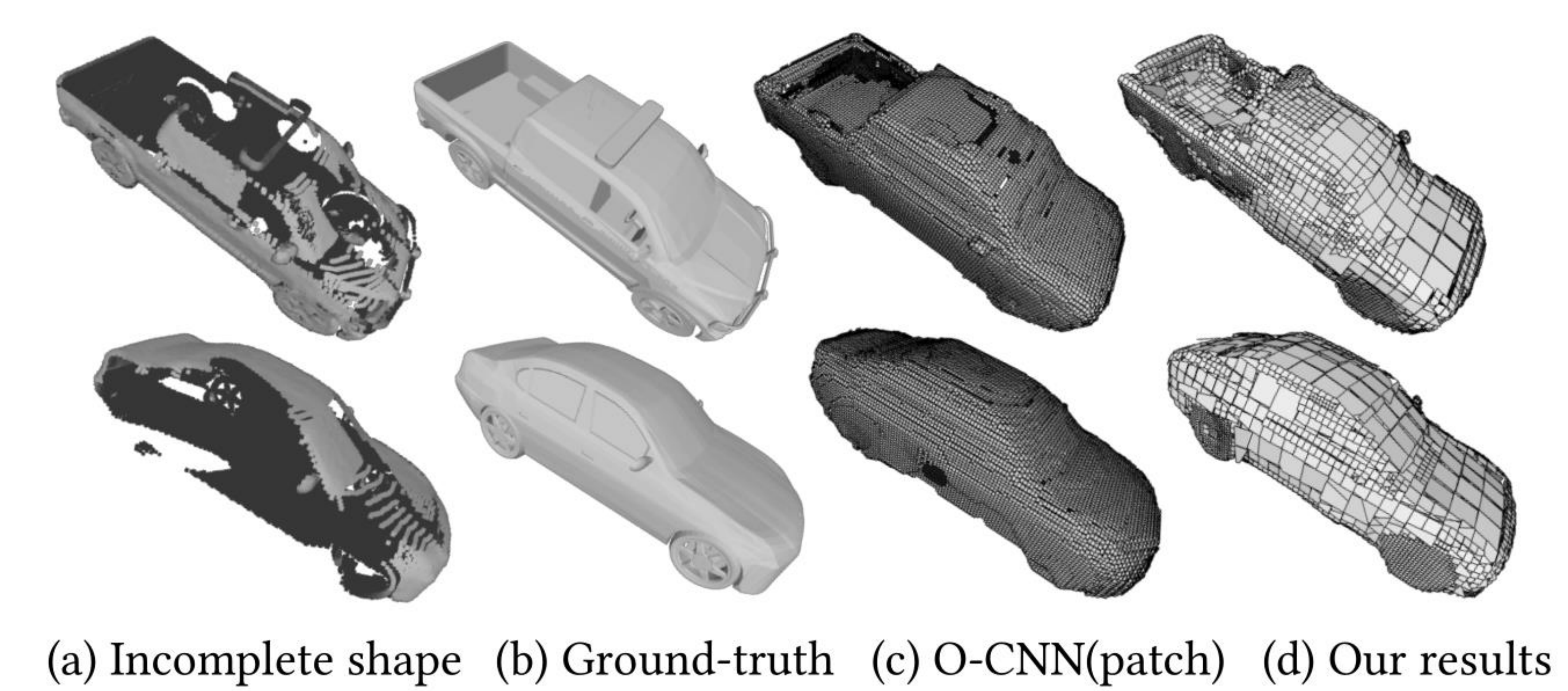


O-CNN(Patch)



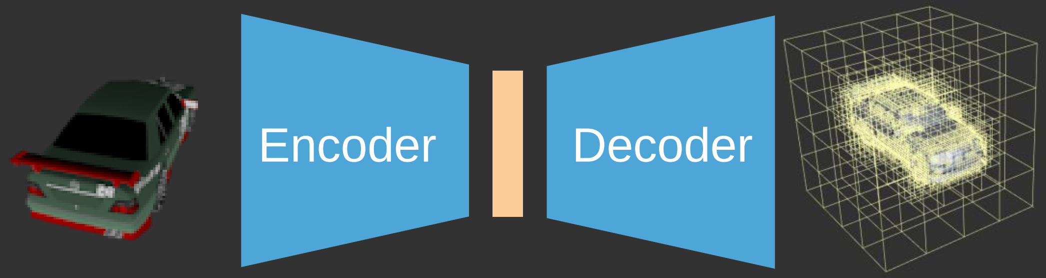
Adaptive O-CNN

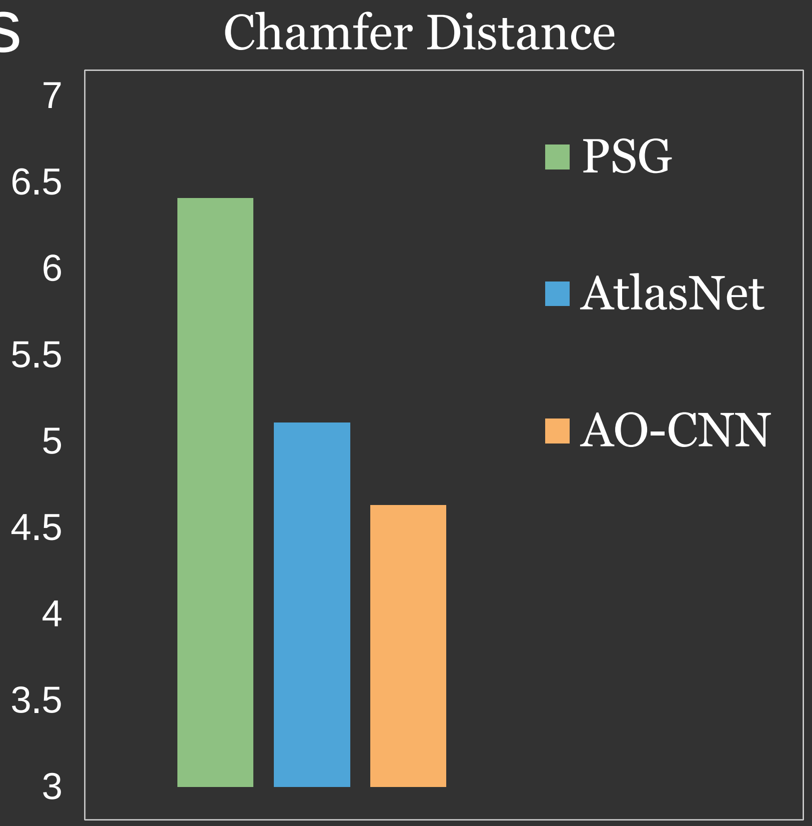
Results – Shape Completion



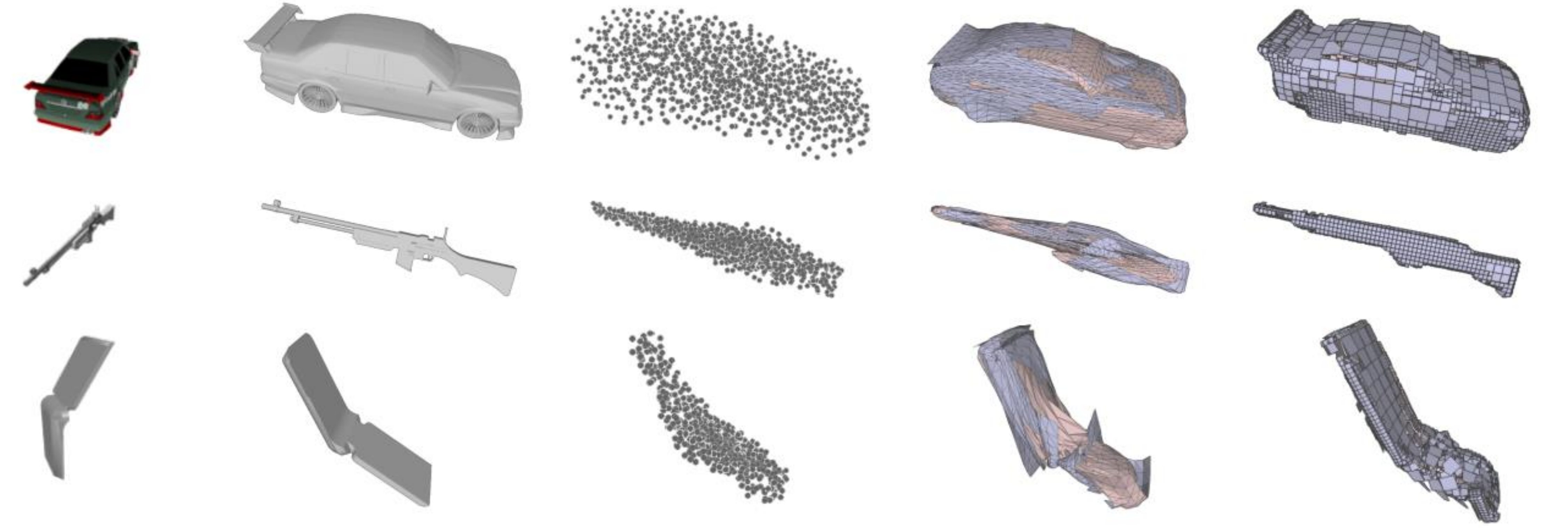
Results – Shape from a single image

- Dataset: ShapeNet55 and its renderings
  - 39,715 3D models from 13 categories
- Network



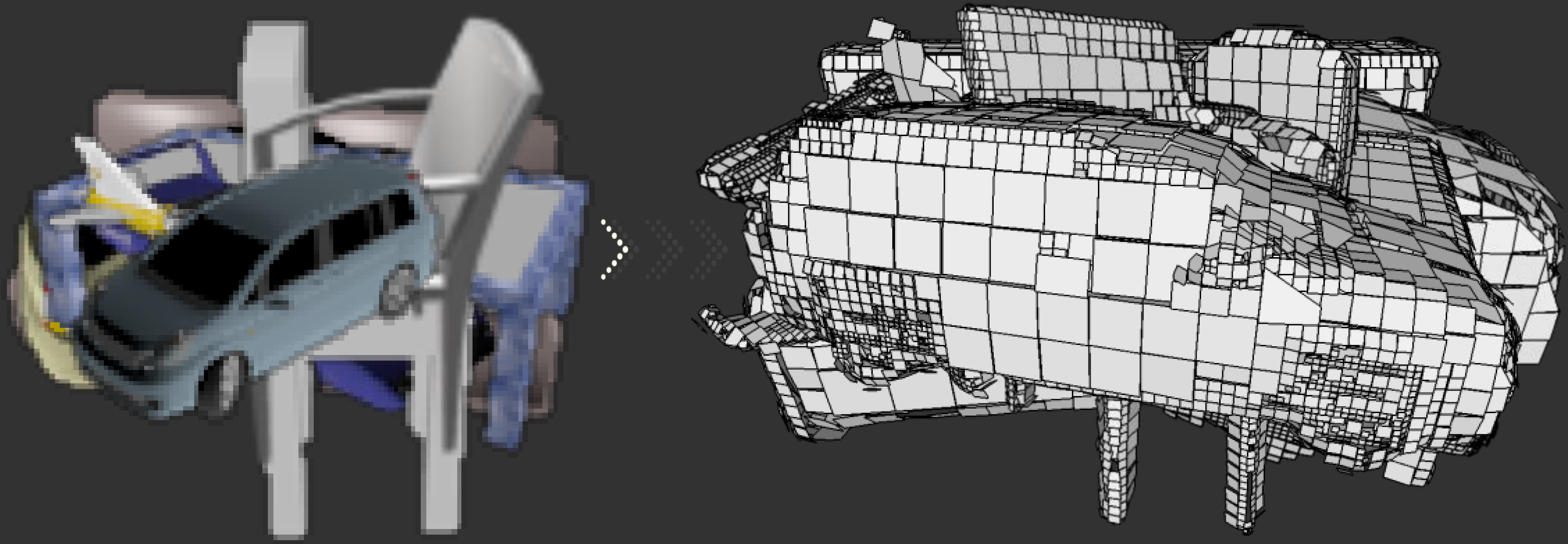


Visual Comparison



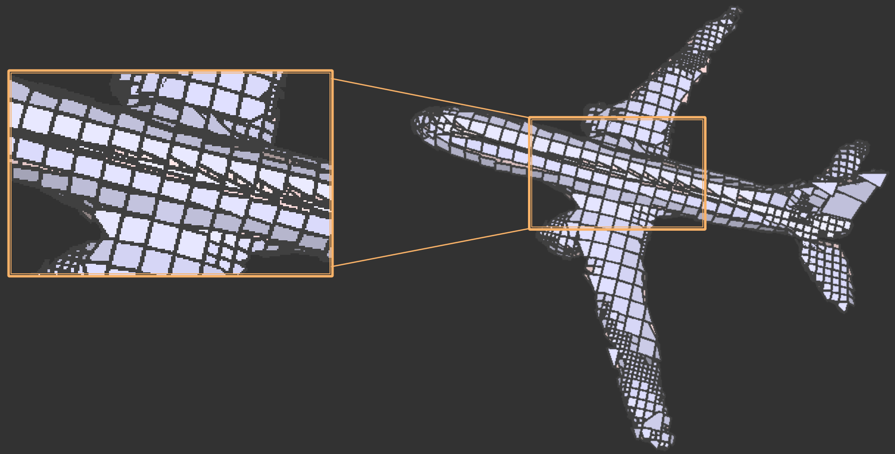
(a) Input image (b) Ground-truth (c) PSG (d) AtlasNet (e) Our results

More Results



Limitation and Future Work

- The output is not seamless mesh
  - Post-processing, mesh repair



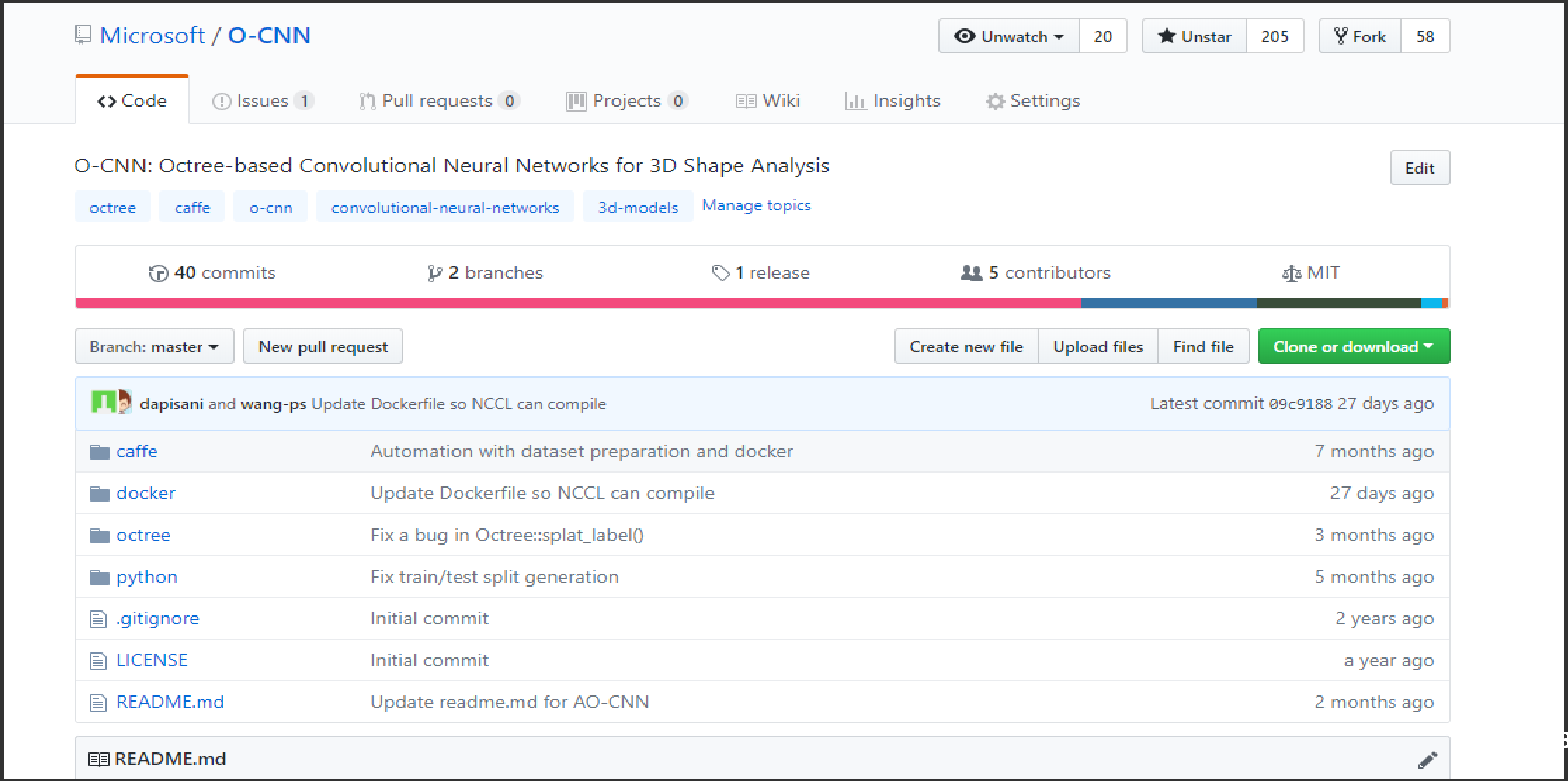
- Currently only planar patch is used
  - Extension: general primitive such as quadratic surface patches

Conclusion

- Adaptive O-CNN
  - Patch-Guided adaptive octree
  - High memory and computational efficiency
  - High shape generation quality

- Code and data online
  - https://github.com/Microsoft/O-CNN

Code Online



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Manage topics
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2 branches
1 release
5 contributors
MIT
Branch: master
New pull request
Create new file
Upload files
Find file
Clone or download
dapisani and wang-ps Update Dockerfile so NCCL can compile
Latest commit 09c9188 27 days ago
caffe
Automation with dataset preparation and docker
7 months ago
docker
Update Dockerfile so NCCL can compile
27 days ago
octree
Fix a bug in Octree::splat_label()
3 months ago
python
Fix train/test split generation
5 months ago
.gitignore
Initial commit
2 years ago
LICENSE
Initial commit
a year ago
README.md
Update readme.md for AO-CNN
2 months ago
README.md