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CVPR
VANCOUVER, CANADA

# NeuralEditor:
## Editing Neural Radiance Fields via Manipulating Point Clouds




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Paper Tag: WED-PM-009

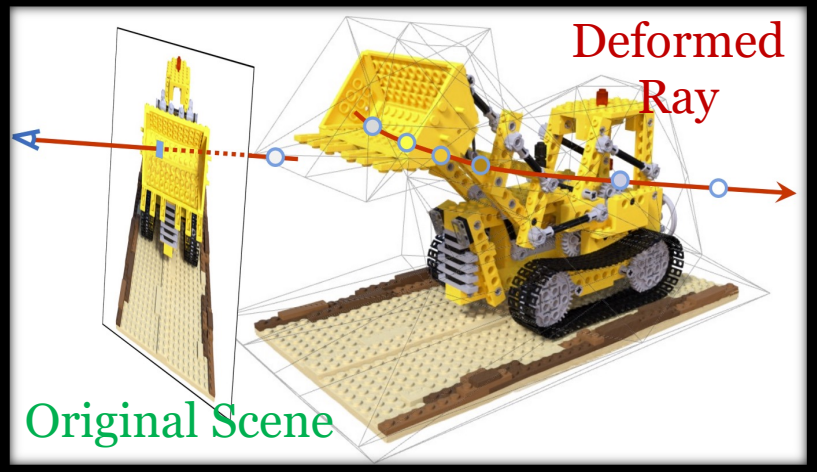
# Shape Editing of Scenes

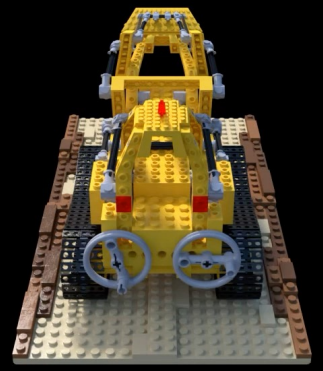
- Objective: render edited scene
  - ✓ Visually faithful
  - ✓ Consistent with ambient environment

Image from https://www.lego.com/zh-cn/product/optimus-prime-10302#blt670d3bb1af988230.

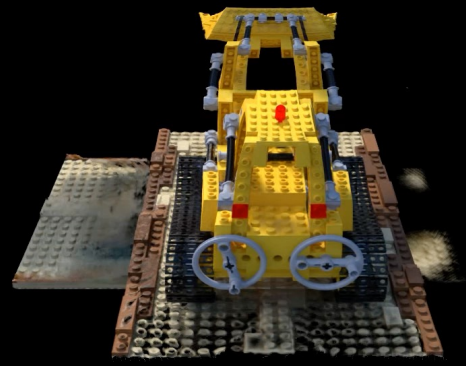
# Limitations of Previous Work

- Render edited scene by deforming viewing rays in original scene
  - Only support coarse-grained, mild, continuous deformations
  - Only designed for shape deformation
  - Not support fine-tuning



Ground Truth

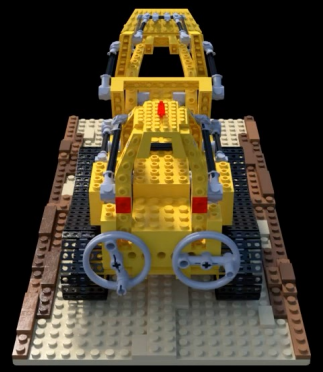


Baseline

Xu and Harada, ECCV'22. Yuan et al., CVPR'22. Peng et al., NeurIPS'22.

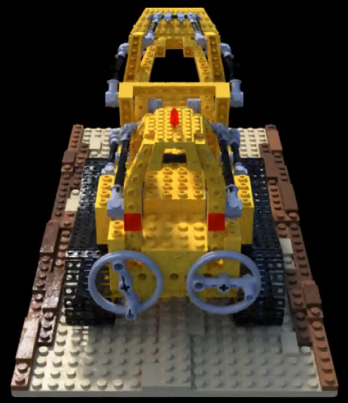
# Our Contribution

- Previous work renders edited scene by deforming viewing rays in original scene
- Our Contribution: NeuralEditor
  - A unified method for all shape editing tasks, including shape deformation and scene morphing
  - Support fine-tuning to further enhance the results



Ground Truth

Shape Deformation



Shape Deformation Fine-tuned

Scene Morphing

Xu and Harada, ECCV'22. Yuan et al., CVPR'22. Peng et al., NeurIPS'22.

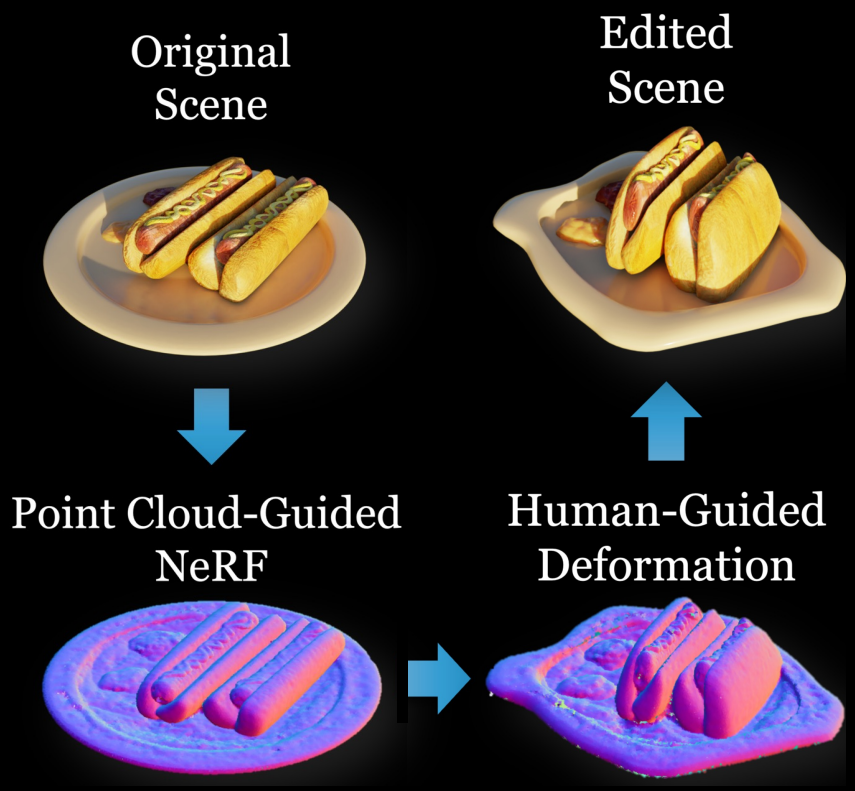
# Key Insight

- Implicit representation: NeRF
  - 👍 Good rendering results
  - 👎 Not support shape editing
- Explicit representation: point cloud
  - 👍 Natively allow shape editing

❖ NeRF rendering ≡ plotting point cloud

➢ Our solution: point cloud-guided NeRF

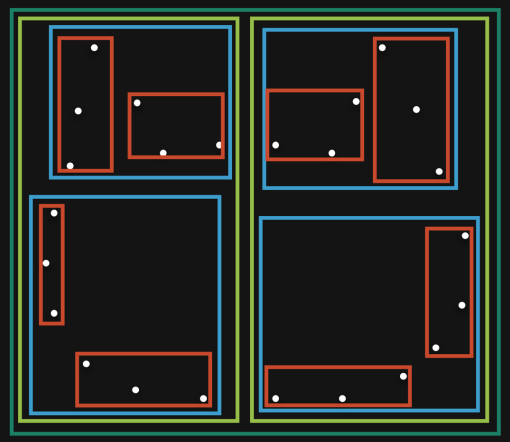
- An improved point cloud-guided NeRF based on PointNeRF
- Perform editing by manipulating its point cloud



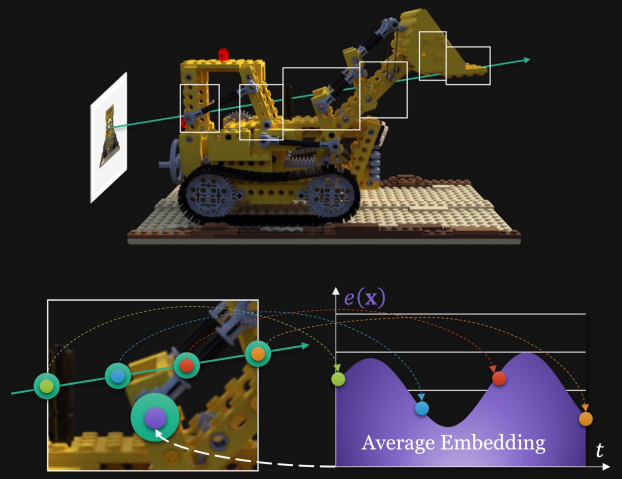

Mildenhall et al., ECCV'20. Xu et al., CVPR'21.

# Improved Point Cloud-Guided NeRF

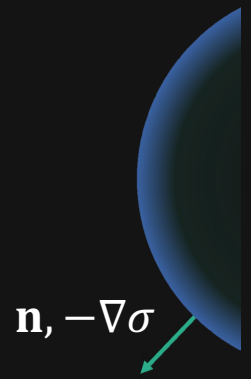
- An improved point cloud-guided NeRF based on PointNeRF



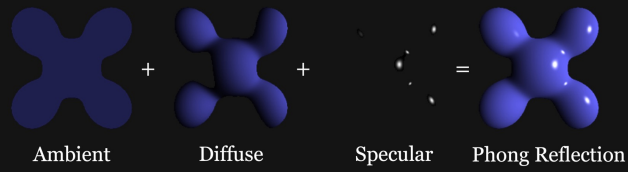
Point Cloud Organization




Rendering Scheme




Shape Optimization



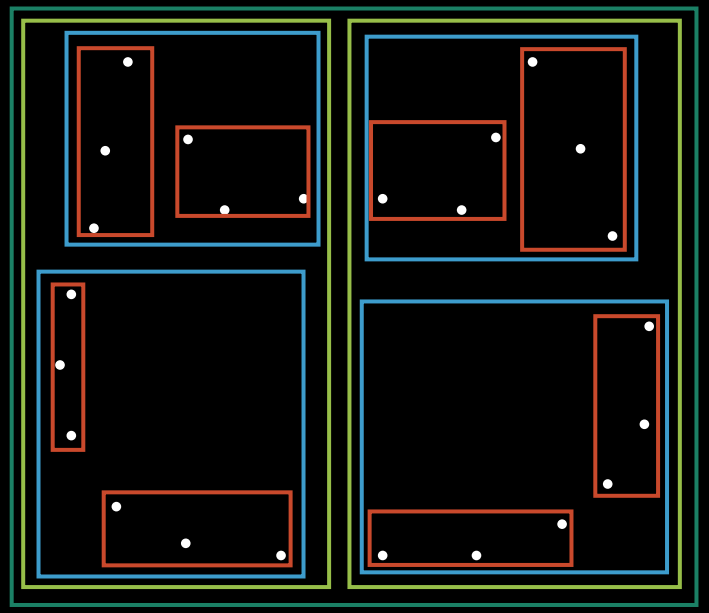

Color Modeling

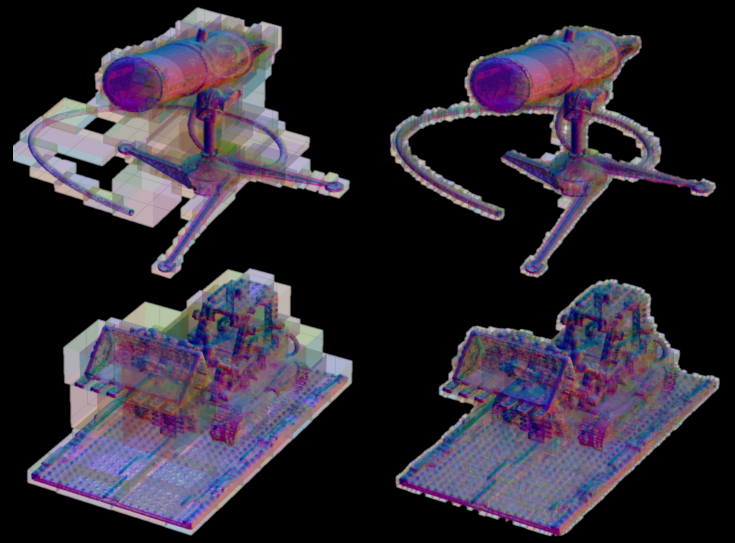
➢A unified method for general shape editing task

Xu et al., CVPR'21. Image from https://en.wikipedia.org/wiki/Phong_reflection_model.

# K-D Tree-Guided Voxels

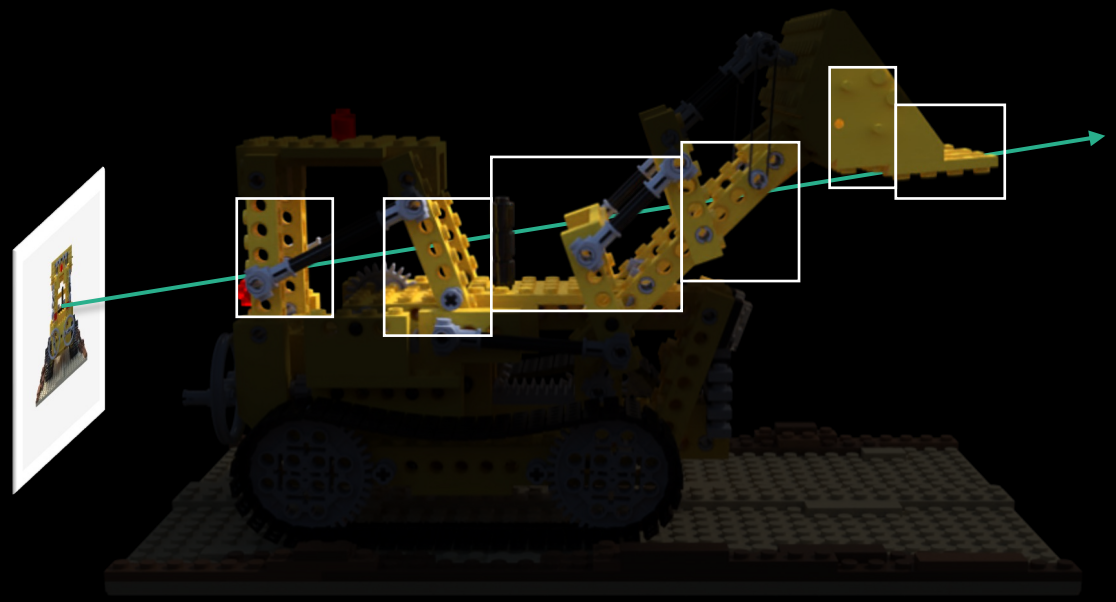
- K-D Tree produces multi-scale bounding boxes for point cloud
- Each layer represents a scale – natively, implicitly coarse-to-fine





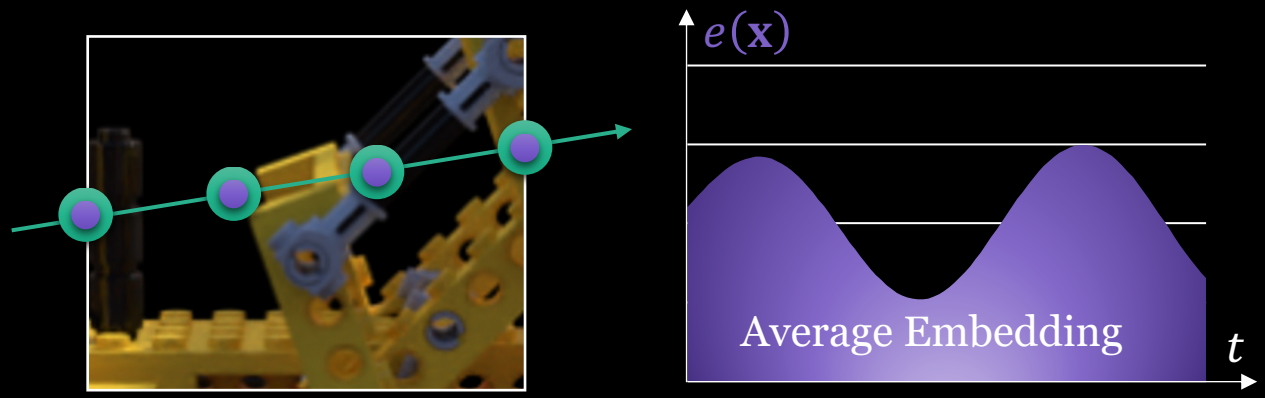
Coarse Fine

# Rendering Over Voxels



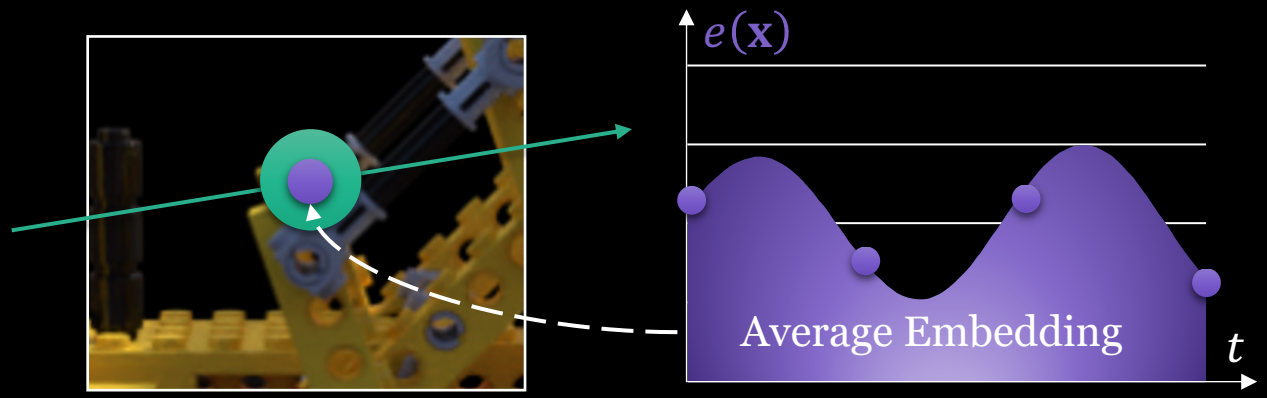
- K-D Tree produces multi-scale bounding boxes for point cloud
- Top-down recursion for coarse-to-fine rendering

# Rendering with Deterministic Integration




- K-D Tree guarantees the complexity (# of points) of each voxel
- A deterministic spline integration inspired by DIVeR
  - Uniformly sample points on the intersecting segment

# Rendering with Deterministic Integration



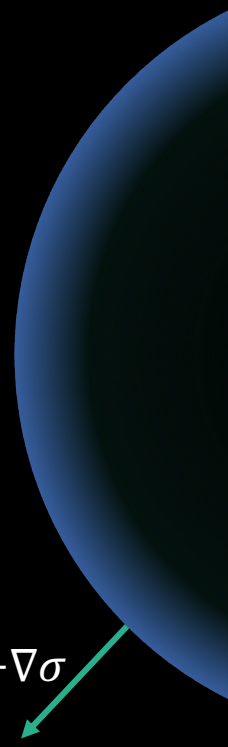

- K-D Tree guarantees the complexity (# of points) of each voxel
- A deterministic spline integration inspired by DIVeR
  - Uniformly sample points on the intersecting segment
  - Spline integration to calculate the average embedding over the segment

➢ Efficient and stable rendering scheme

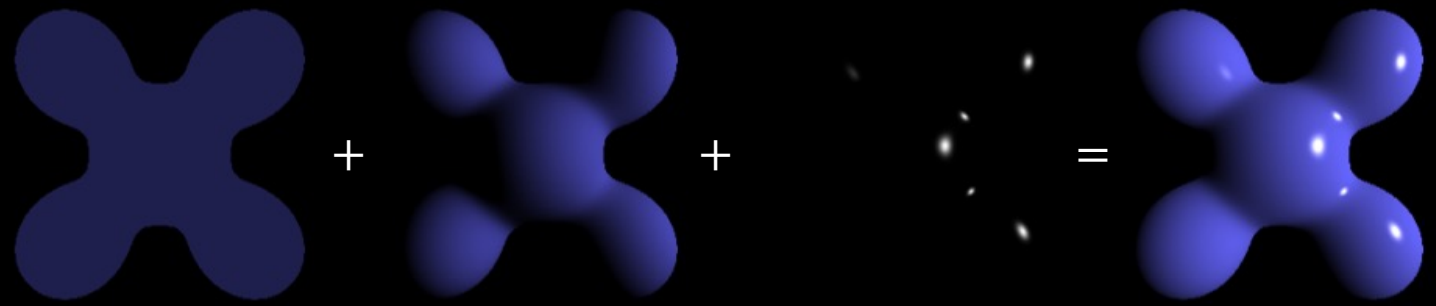
# Engaging Shape in Training with Norms

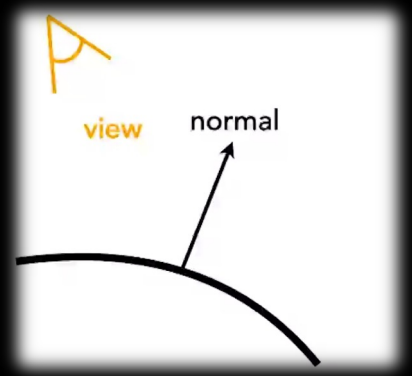
- Model surface normal vectors (norms) for better shape utilization
- Two ways to calculate norm
  - From Point Cloud: Estimate each point's norm from KNN
  - From NeRF: Norm is the gradient of volume density
- Regularize by enforcing both two calculations to be the same

➢ Precise shape obtained by point cloud optimization



# Phong-Reflection with Norms



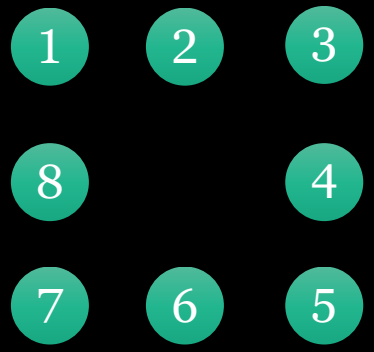

- Further utilize the norms for color modeling
- Phong reflection-based color modeling inspired by RefNeRF
  - Specular is a function of reflection of viewing direction by norm

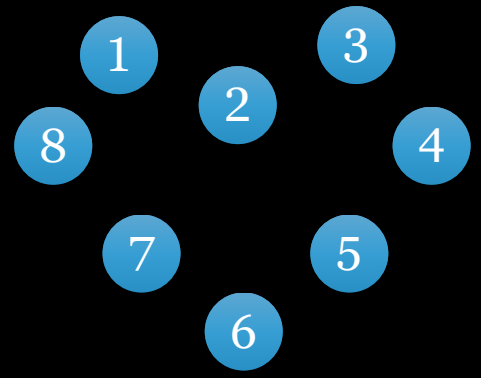
➢ Better color modeling and decomposition & norm utilization

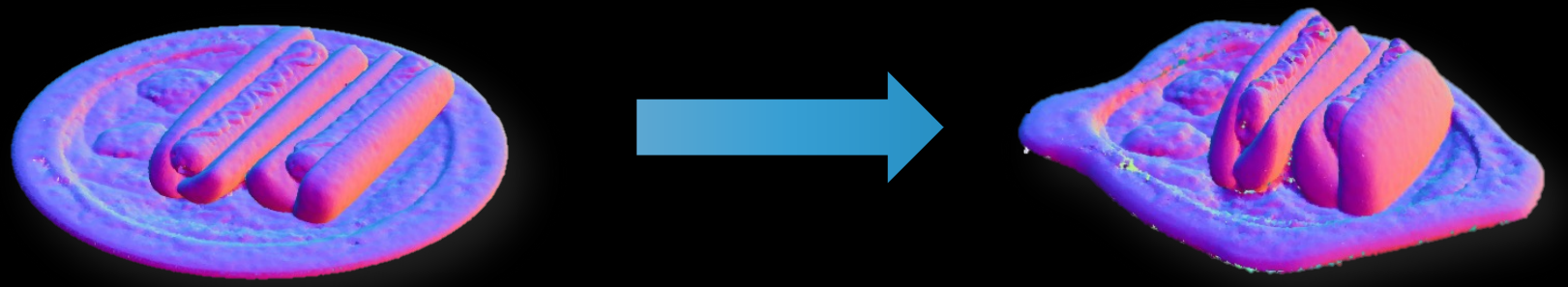
Verbin et al., CVPR'22.
Image from https://en.wikipedia.org/wiki/Phong_reflection_model. Video from https://dorverbin.github.io/refnerf/.

# Point-Guided Unified Editing

- Define unified shape-editing with indexed point cloud

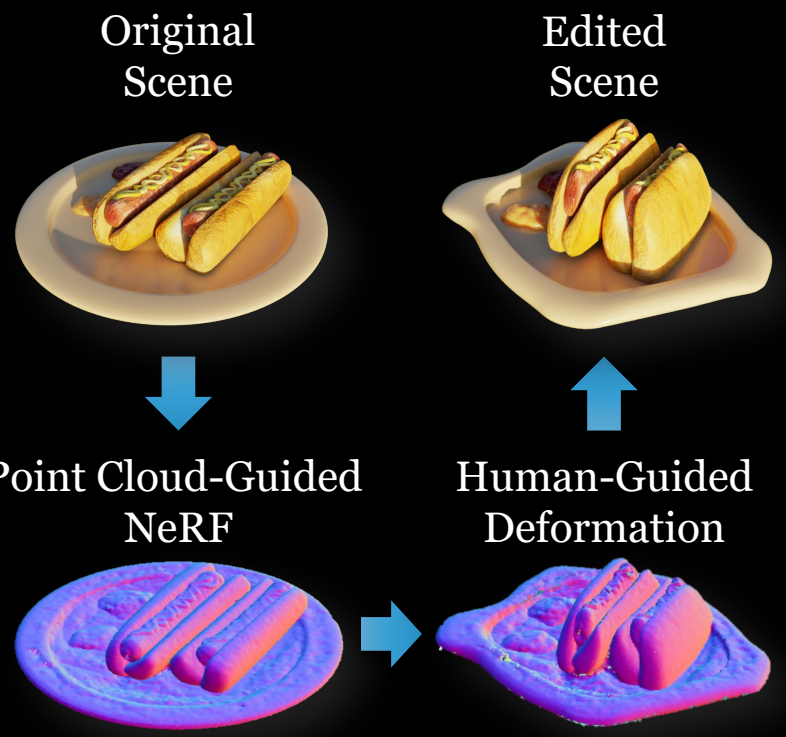


# Point-Guided Unified Editing

- Define unified shape-editing with indexed point cloud



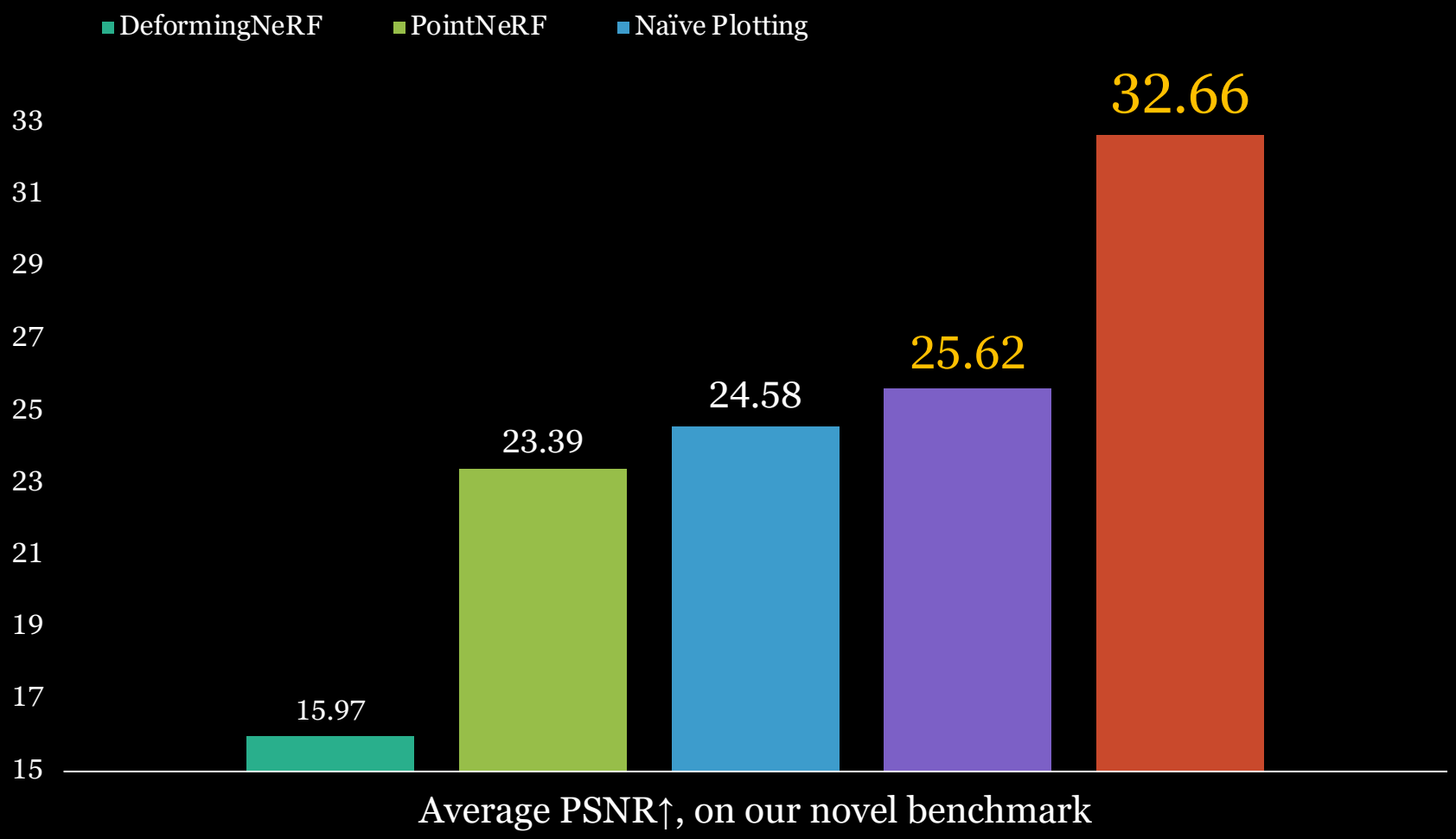

- A simple yet general formulation
  - No extra assumption of editing
  - Shape deformation, scene morphing, etc.
- Apply scene editing by replacing the point cloud of NeRF
- The edited model is still fully functional – supports fine-tuning

# NeuralEditor renders high-quality results, in both shape deformation and scene morphing tasks

Shape Deformation

Scene Morphing

# NeuralEditor significantly outperforms baselines in the shape deformation




Xu et al., ECCV'22. Xu et al., CVPR'21.

# NeuralEditor renders more realistic results than PointNeRF in shape deformation

NeuralEditor (Ours)

PointNeRF (Baseline)

Xu et al., CVPR'21.

# NeuralEditor supports scene morphing not supported by previous work and renders better than PointNeRF

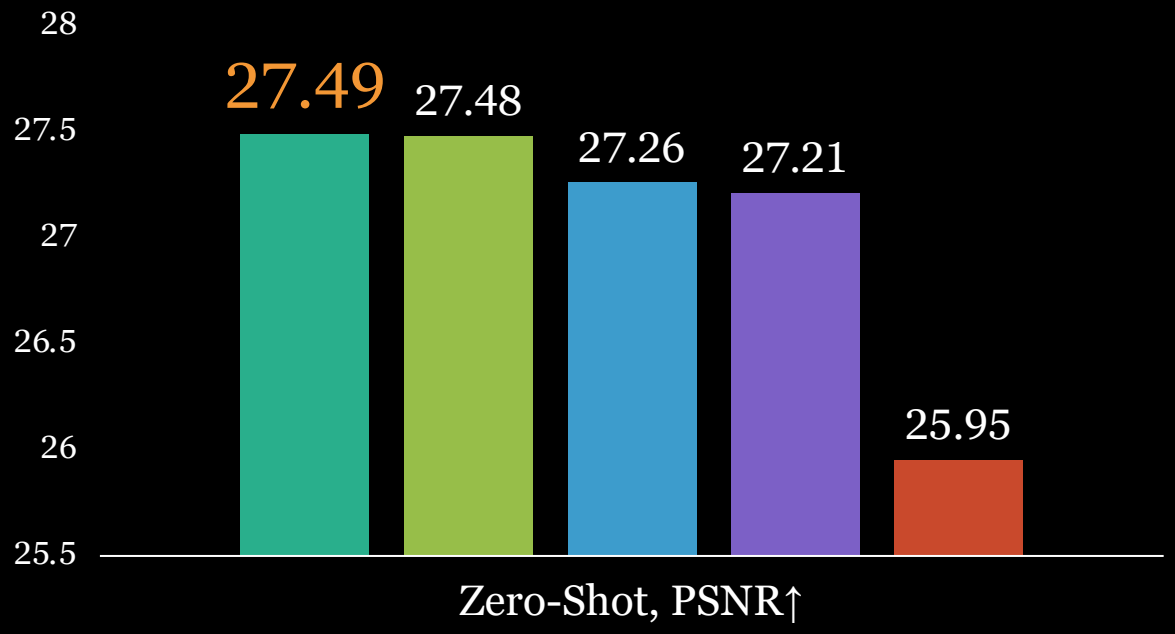
NeuralEditor
(Ours)

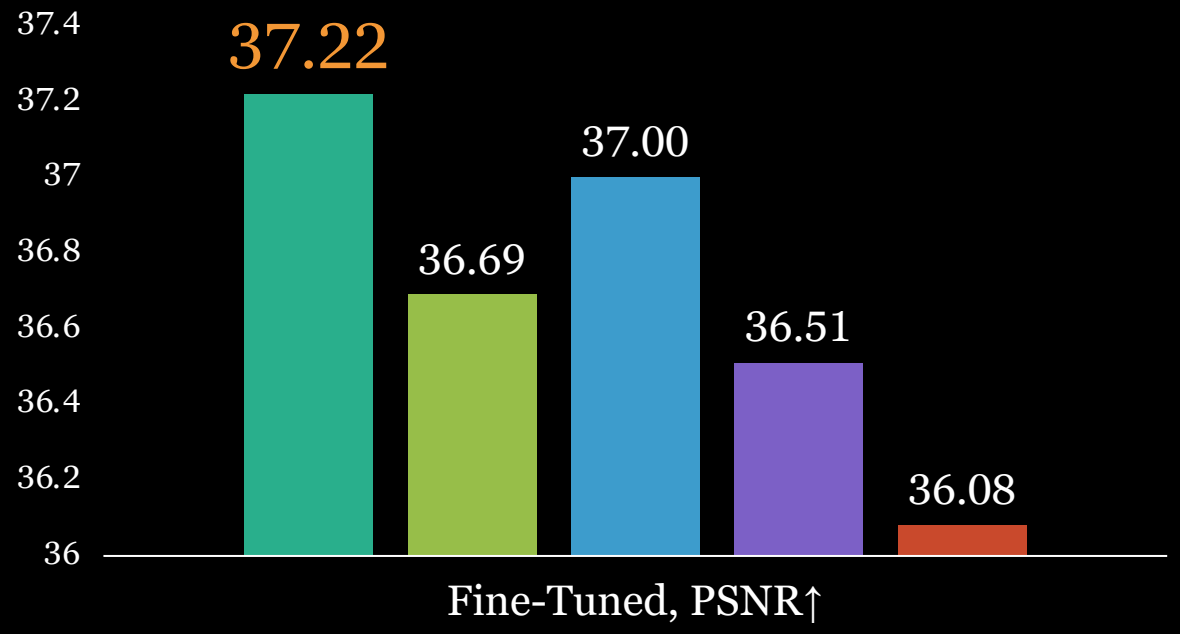
PointNeRF
(Baseline)

Xu and Harada, ECCV'22. Yuan et al., CVPR'22. Peng et al., NeurIPS'22. Xu et al., CVPR'21.

# Ablation study shows that all design choices benefit rendering results


■ Full NeuralEditor ■ w/o Integration ■ w/o Norms ■ w/o Phong reflection ■ PointNeRF




Xu et al., CVPR'21.

# Conclusion

- **NeuralEditor** enables general shape editing on NeRF in a unified way
- **NeuralEditor** renders high-quality and visually faithful results in both shape deformation and scene morphing tasks
- A novel benchmark for shape deformation

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# Thanks for Listening!

Paper Tag: `WED-PM-009`

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