SIGGRAPH ASIA 2023 SYDNEY

SimpleNeRF: Regularizing Sparse Input Neural Radiance Fields with Simpler Solutions

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Connecting STORIES

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Sparse Input NeRF

- NeRF [1] typically requires hundreds of images per scene.
- Produces severe distortions when trained with few images.
- Cause: Under-constrained volume rendering equations.

NeRF - Dense Input Views

NeRF - Sparse Input Views

[1] Mildenhall et al., "Representing Scenes as Neural Radiance Fields for View Synthesis", ECCV 2020.

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Related Work

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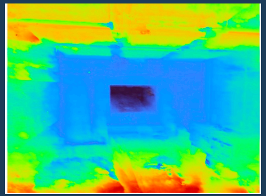
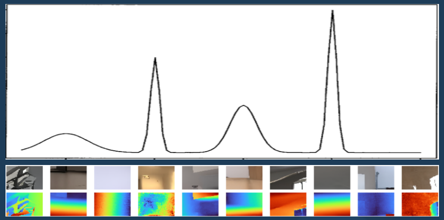
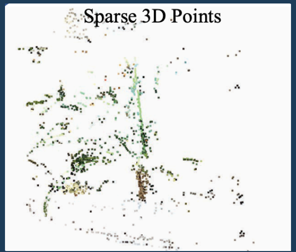
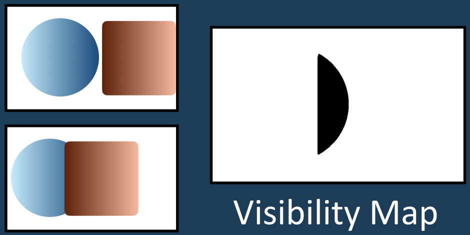
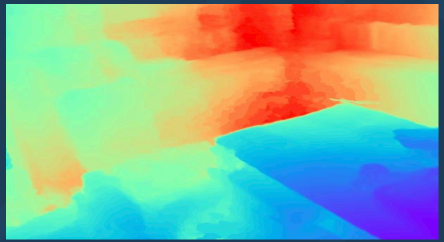
	Hand-crafted priors (Not strong enough)	Learned priors (Pre-training, generalization issues)
Scene agnostic priors	$\lVert \nabla$  $\rVert$ [CVPR '22] Smoothness of rendered depth	 [CVPR '23] Probability distribution of RGBD patches
Scene specific priors	 [CVPR '22];  [SIGGRAPH '23]	 [CVPR '23] Dense depth prior

Our solution: learn without pre-training scene-specific depth supervision.

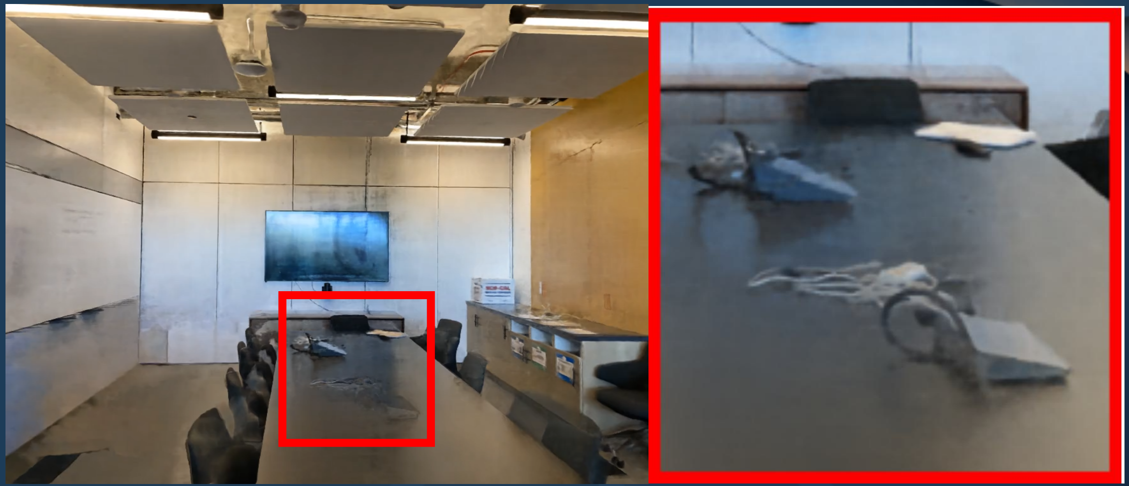
— train augmented/helper models along with the NeRF model.

Analyzing NeRF Limitations

Floater artifacts

NeRF learns undesired depth discontinuities due to high positional encoding.

Duplication artifacts (shape-radiance ambiguity)



NeRF changes colour to over-fit observations by exploiting its ability to learn view-dependent colour.

Common cause: High capability of NeRF in regions where it is not necessary.

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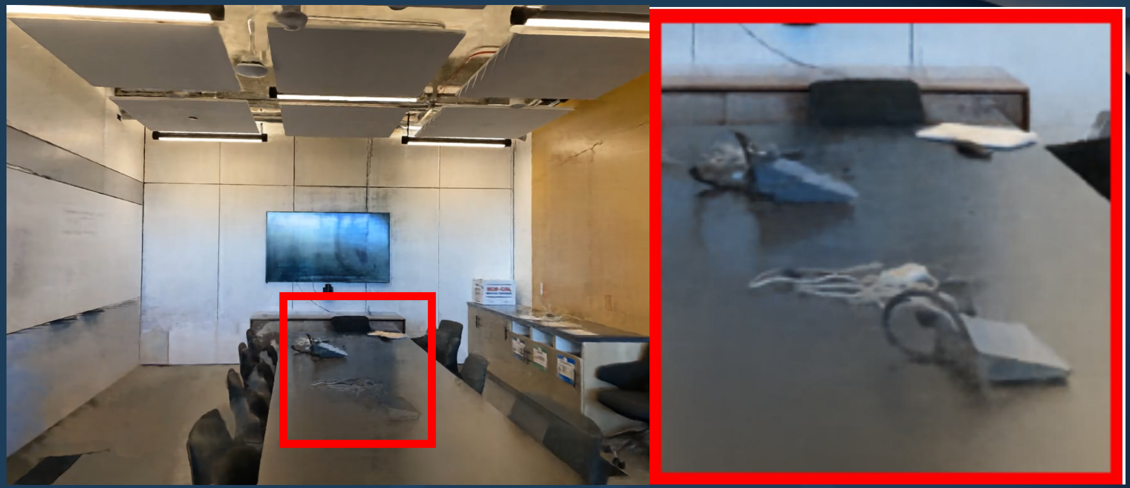

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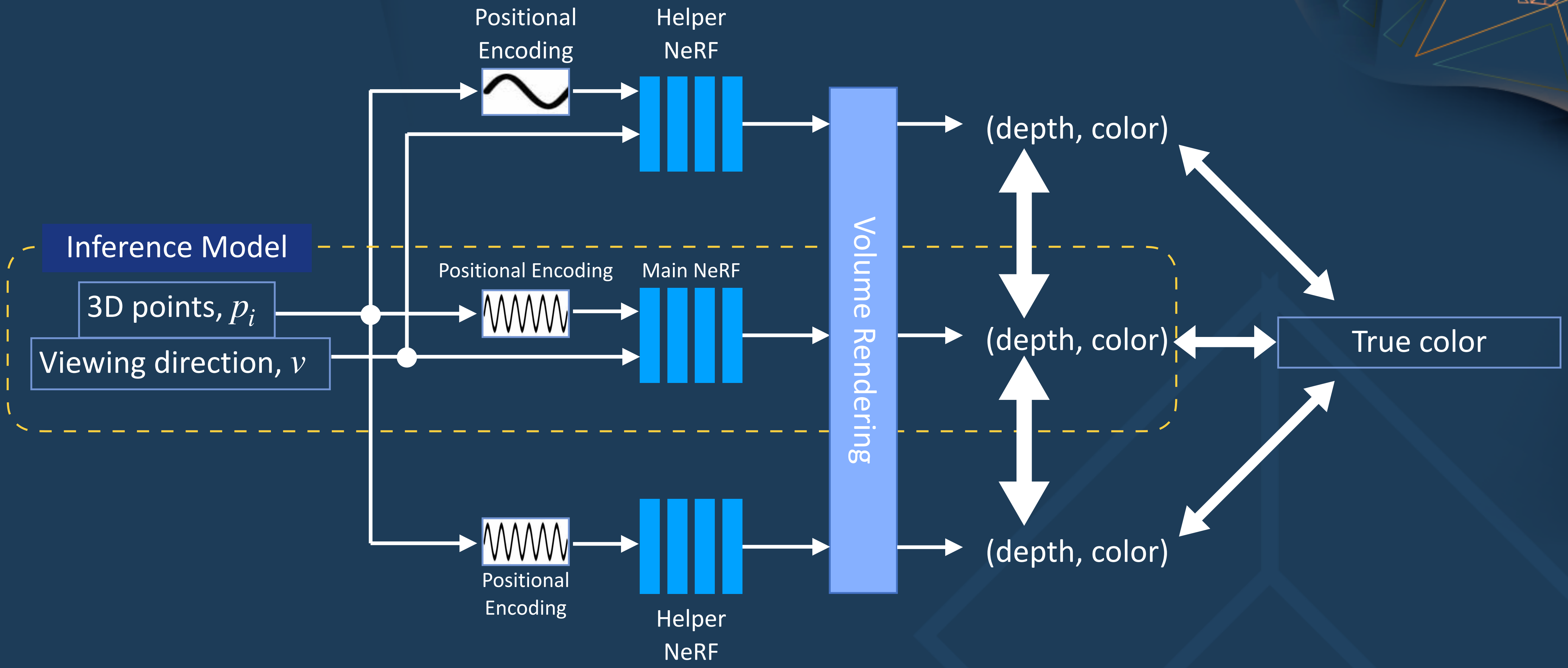
Regularizing with Simpler Solutions



We employ DS-NeRF [CVPR '22] as our baseline

Mitigating Floaters with Simpler Solutions

NeRF

Depth edges are sharp, but contains floaters

+

Helper NeRF (lower positional encoding)

Floaters reduced, but depth edges are not sharp

=

SimpleNeRF

Floaters reduced while retaining sharp depth edges

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Mitigating Shape-Radiance Ambiguity

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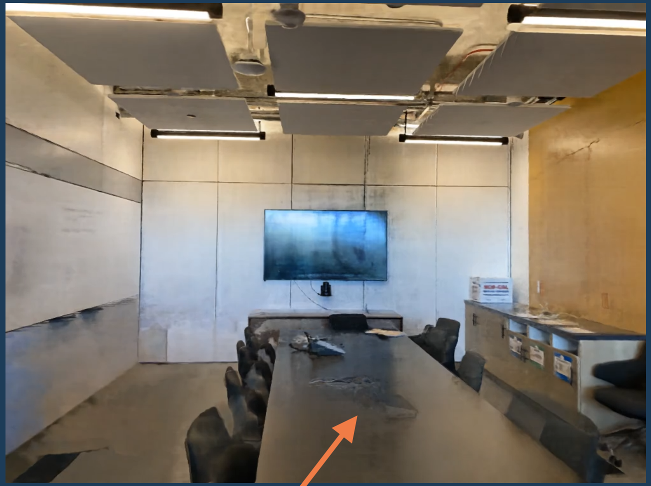

Observe the change in position of the object on the table

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Helper NeRF (View-independent color)

Does not support specularity

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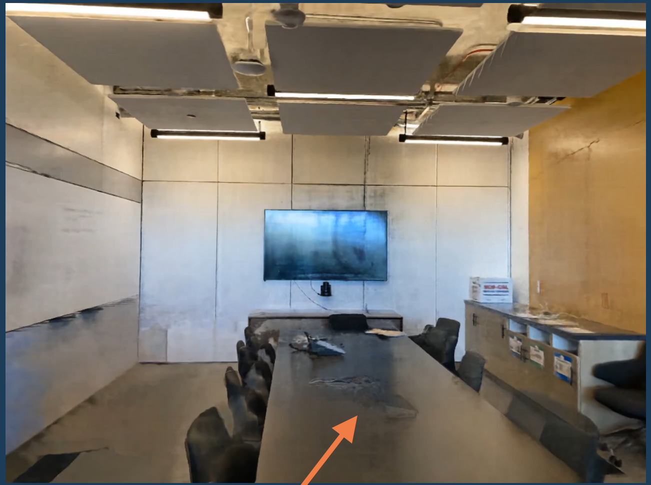
SimpleNeRF

Object does not change position while supporting specularity

Mitigating Shape-Radiance Ambiguity

NeRF



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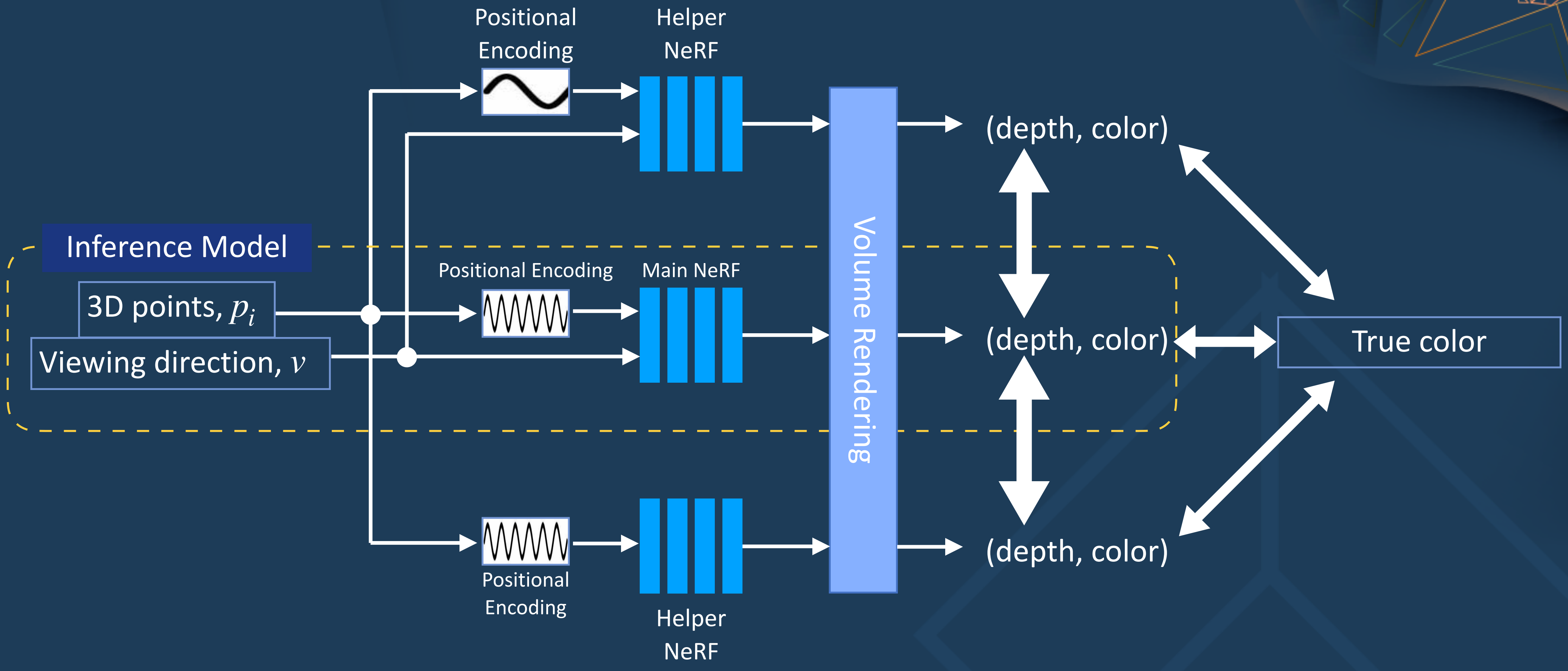

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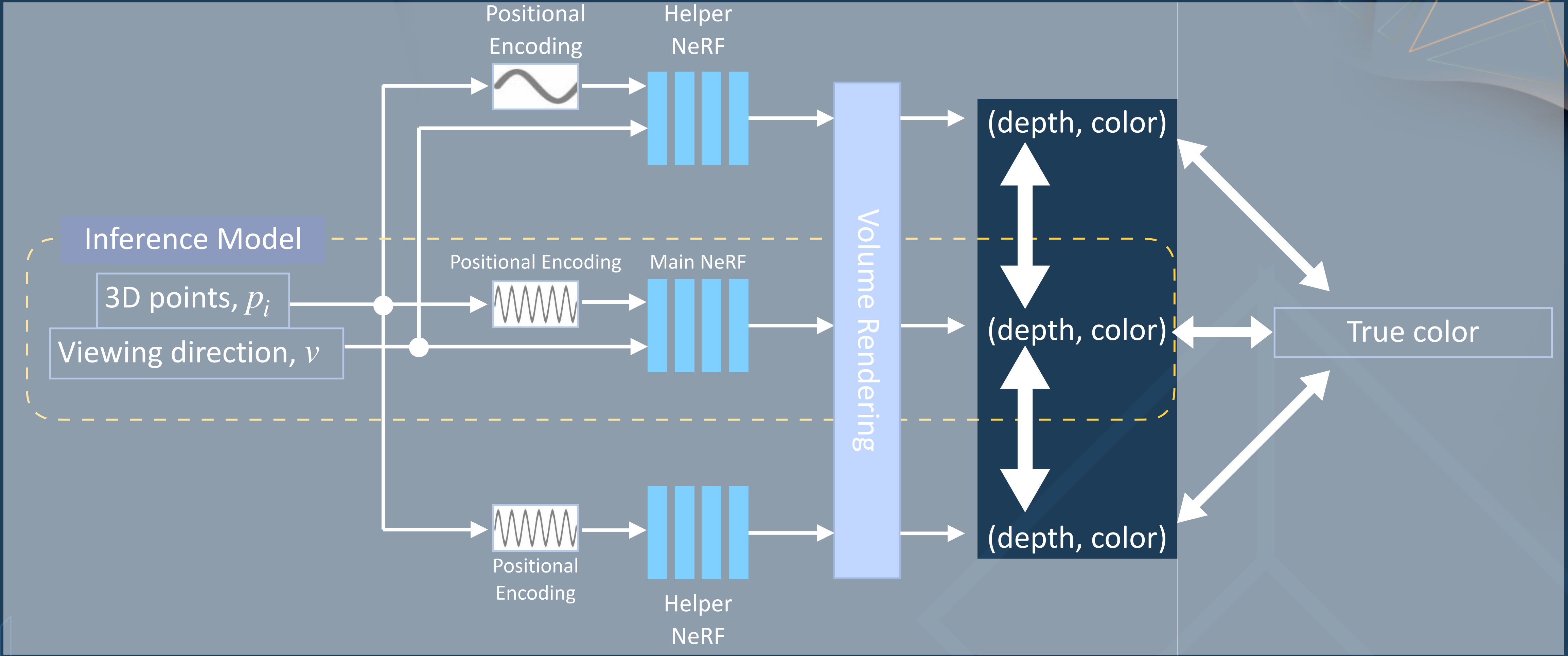

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Reliable Depth Supervision

Input view

Nearest input view

- Depth with higher similarity between reprojected patches → more reliable.
- Use the more reliable depth to supervise the other.

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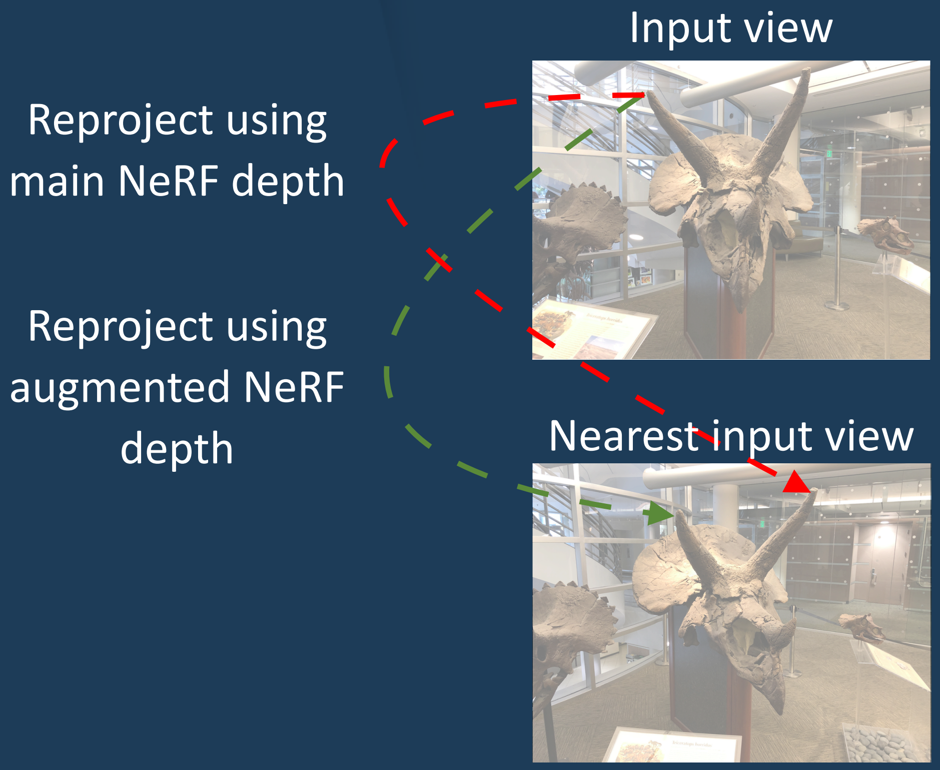

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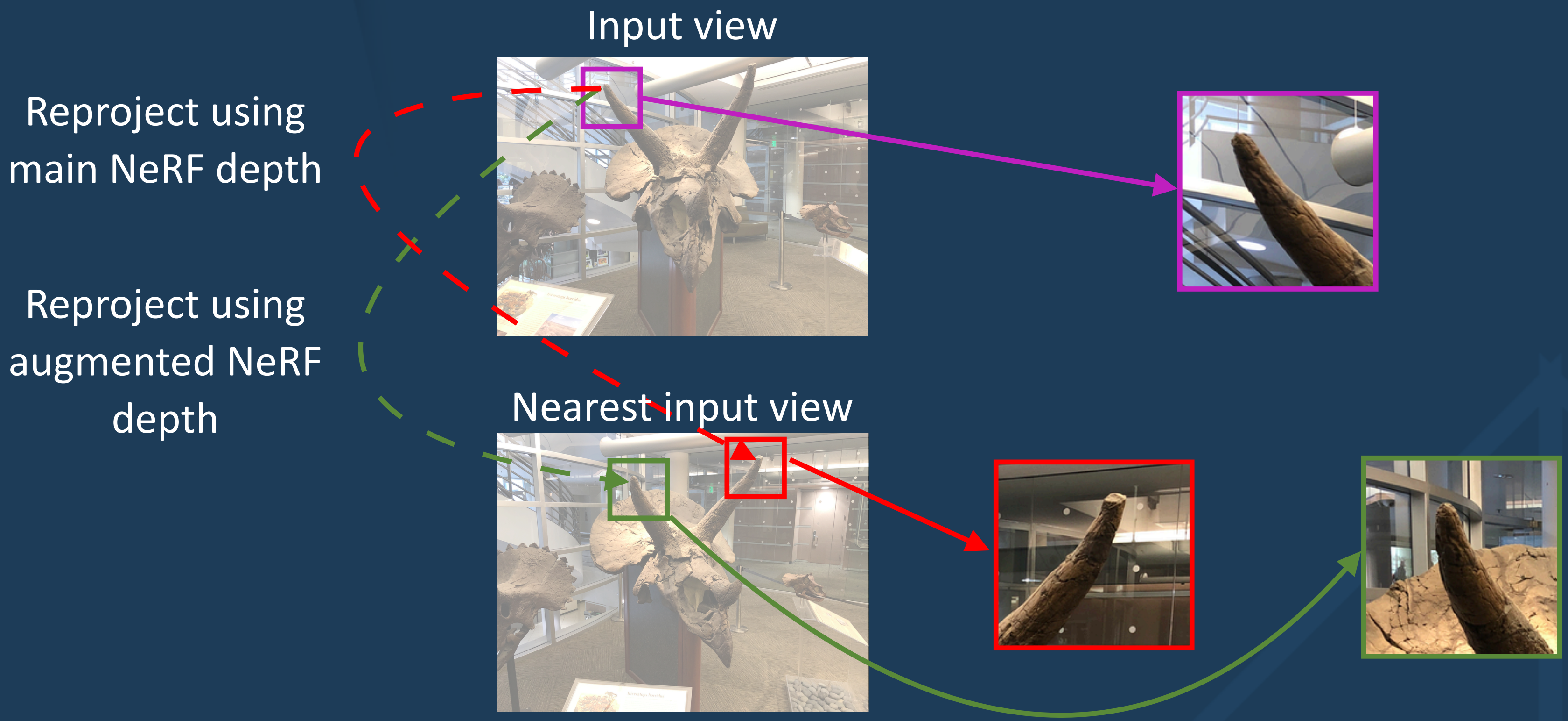

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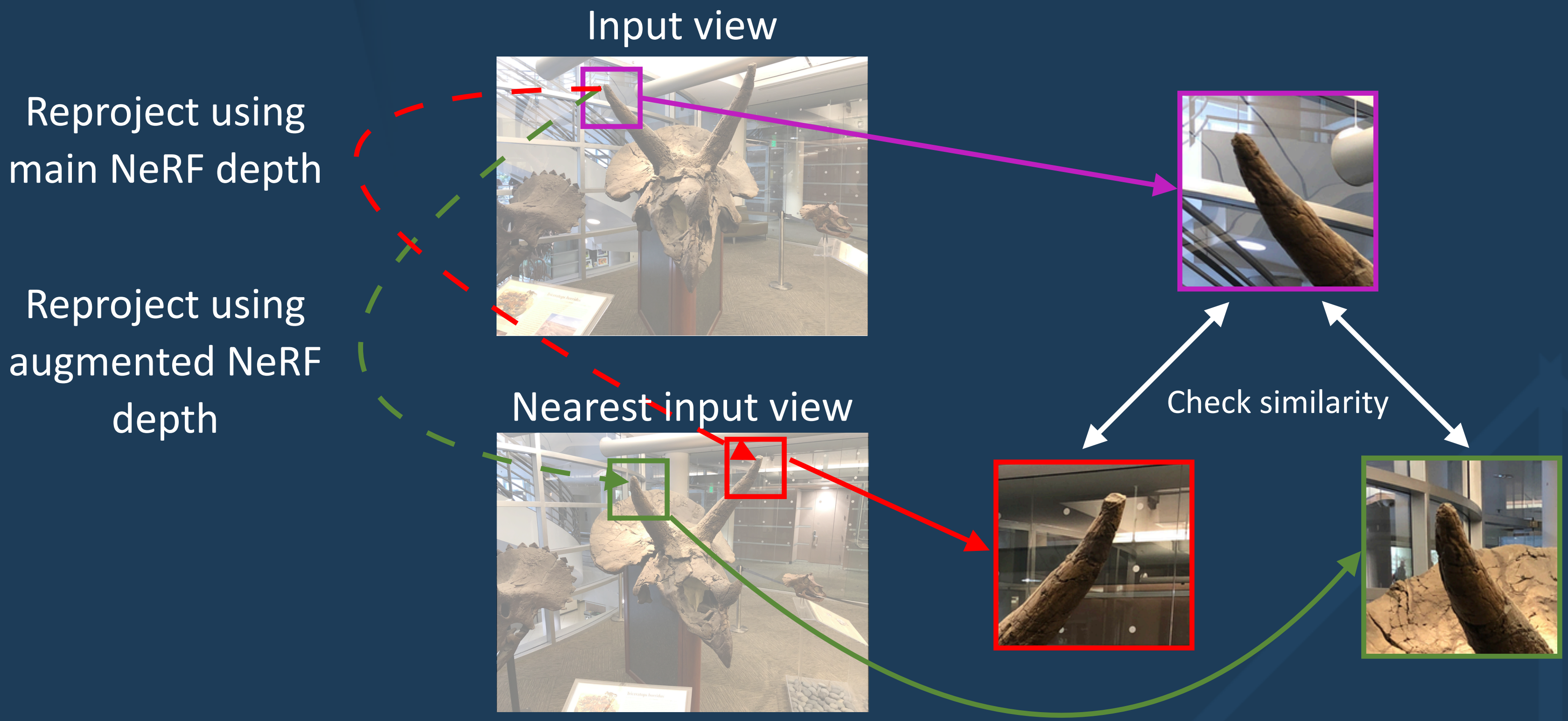

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Qualitative Results

Input views

NeRF - 3 input views

SimpleNeRF - 3 input views

NeRF - 54 input views

Qualitative Results

Input views



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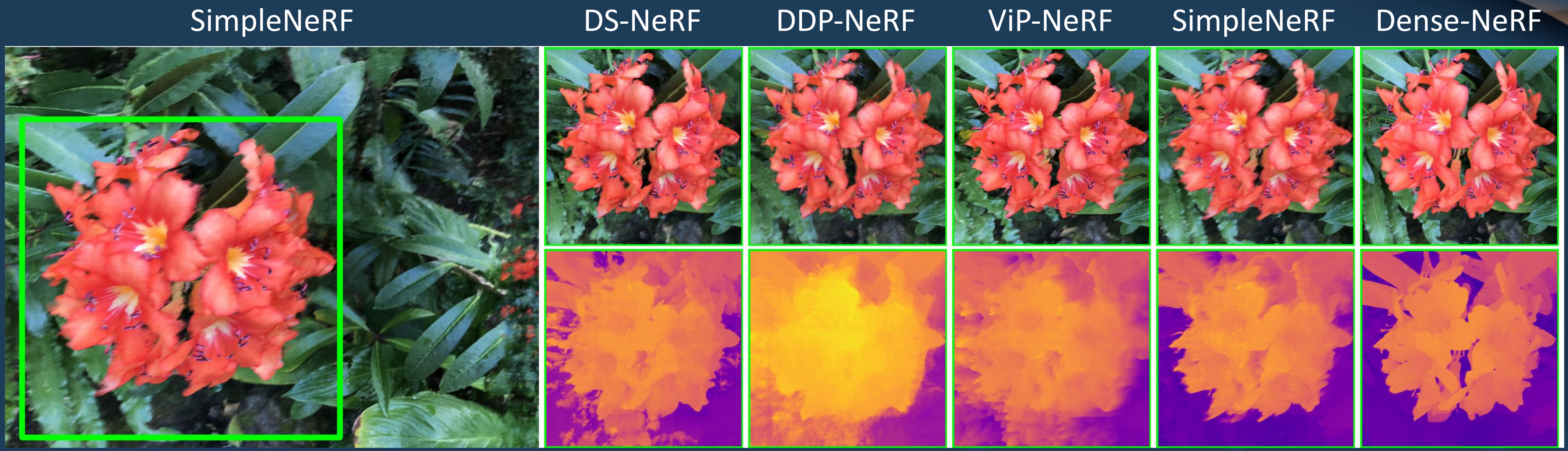
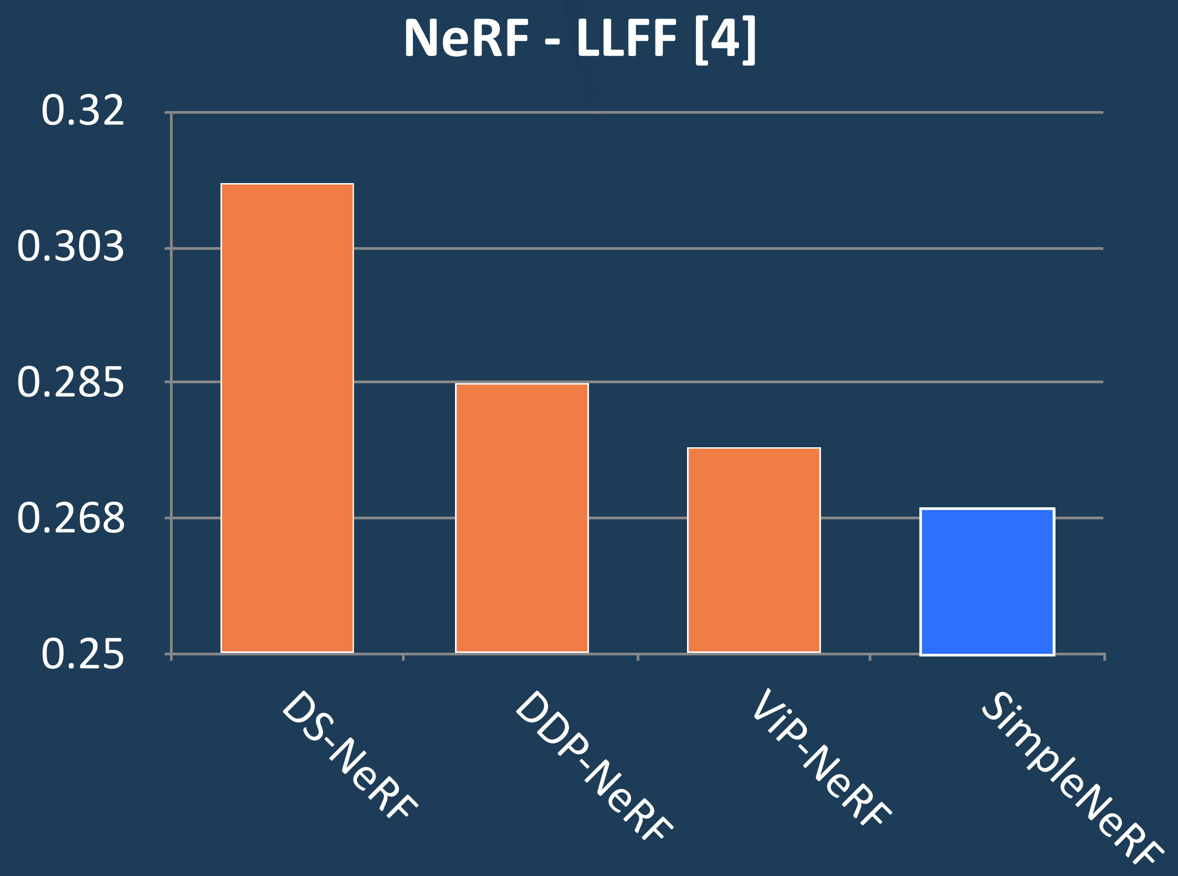
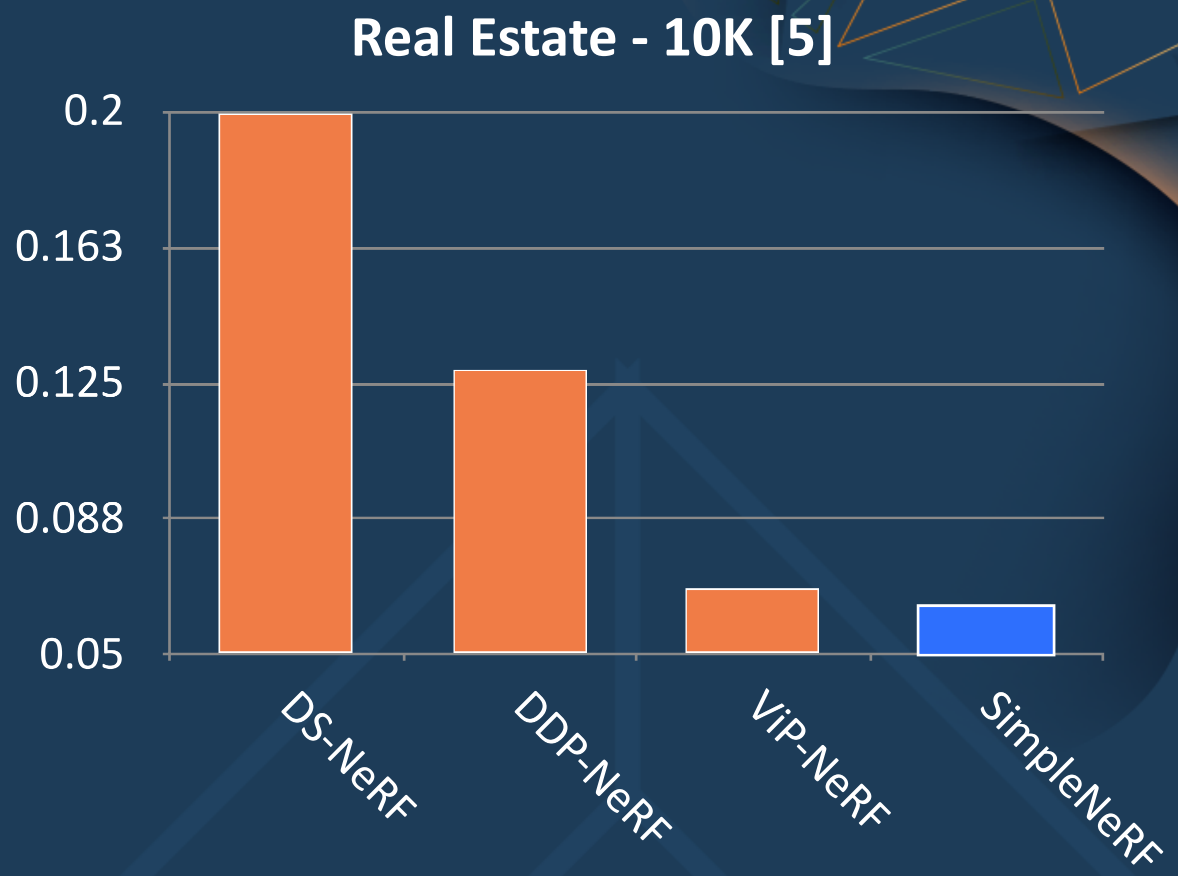
Qualitative Results - Depth Estimation



Significant improvement in estimating depth of the scene

Quantitative Results - LPIPS





Lower LPIPS score indicates better quality

[4] Mildenhall et al., "Local Light Field Fusion", SIGGRAPH 2019.
[5] Zhou et al., "Stereo Magnification: Learning View Synthesis using Multiplane Images", SIGGRAPH 2018.

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Conclusion

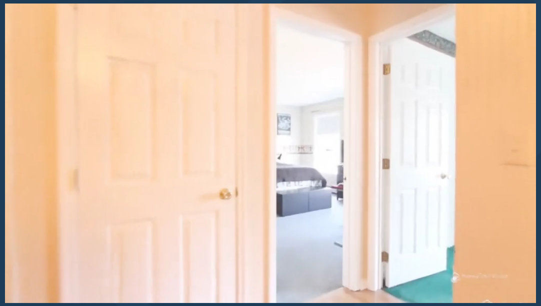
- Design of lower capability helper models biased towards simpler solutions.
  - Reducing positional encoding to mitigate floaters.
  - View-independent colour to reduce shape-radiance ambiguity.

- Framework extensible to any volumetric model.

For paper, code and more, visit

https://nagabhushansn95.github.io/publications/2023/SimpleNeRF.html

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