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COMPUTER GRAPHICS & INTERACTIVE TECHNIQUES

VIP-NERF: VISIBILITY PRIOR FOR SPARSE INPUT NEURAL RADIANCE FIELDS

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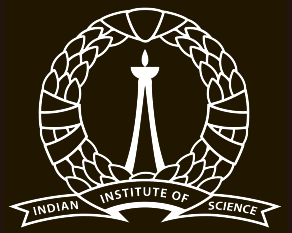

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SPARSE INPUT NERF

- 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.

RELATED WORK

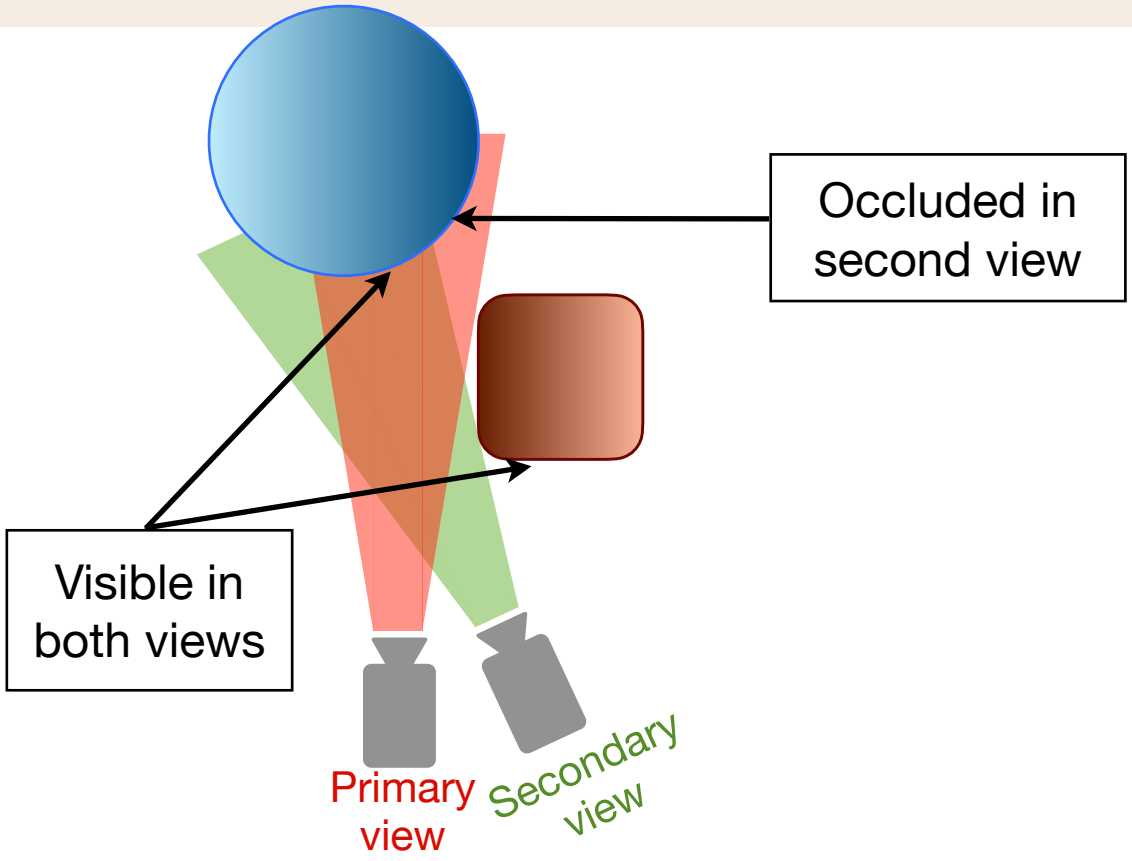
- DS-NeRF [2]:
  - Uses sparse depth obtained Structure from Motion (SfM) model as additional supervision.
  - Accurate but sparse supervision (only at keypoints).

- DDP-NeRF [3]:
  - Obtains dense depth by completing sparse depth using a pre-trained network.
  - Dense but may suffer from generalization issues while generating the prior.

- We need reliable and dense supervision.
  - We introduce visibility supervision.

[2] Deng et al., “Depth-Supervised NeRF: Fewer Views and Faster Training for Free”, CVPR 2022.
[3] Roessle et al., “Dense Depth Priors for Neural Radiance Fields From Sparse Input Views”, CVPR 2022.

VISIBILITY PRIOR

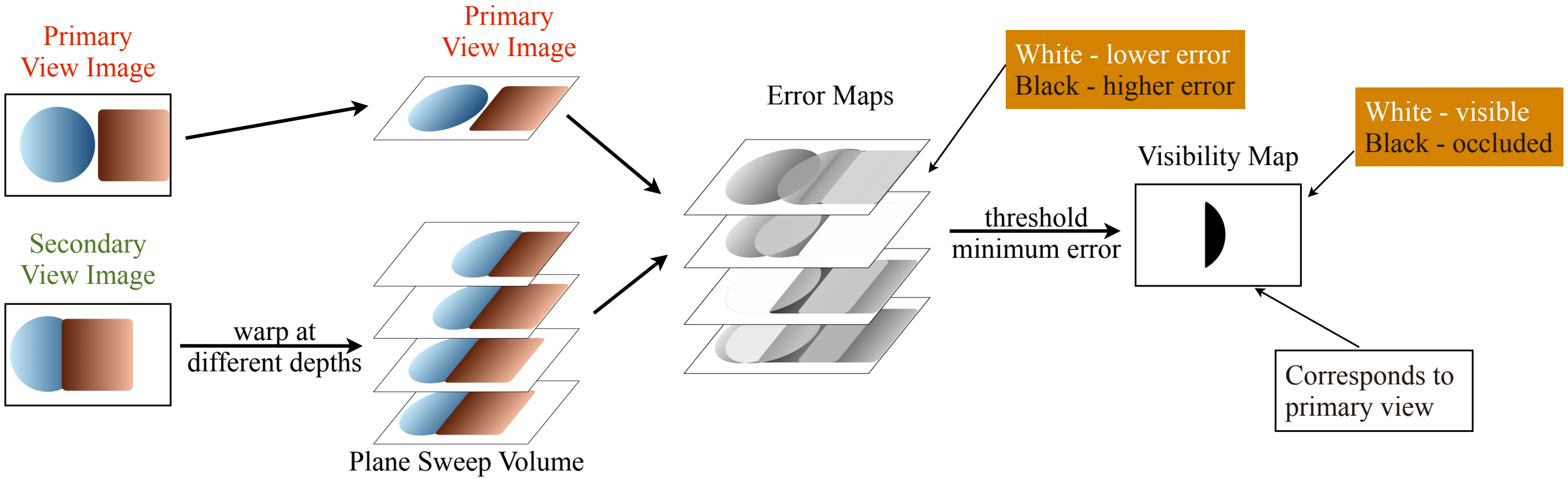


Why visibility supervision?

- Related to relative depth.
- Dense and Reliable.
- Easier to compute without pre-training.

- Visibility prior indicates if a pixel in primary view is visible in secondary view.
- We constrain the NeRF predicted visibility using this visibility prior.

VISIBILITY PRIOR ESTIMATION



- Visibility Prior computed using plane sweep volumes – no training involved.
- Highly specular regions may be marked as occluded – hence no loss imposed in such regions.

VISIBILITY PRIOR NERF (VIP-NERF)

- Supervise the visibility predicted by NeRF using the visibility prior $\tau' \in \{0,1\}$

$$\mathcal{L}_{vip} = \|\tau' - t'\|_1 \odot 1_{\{\tau'=1\}}$$

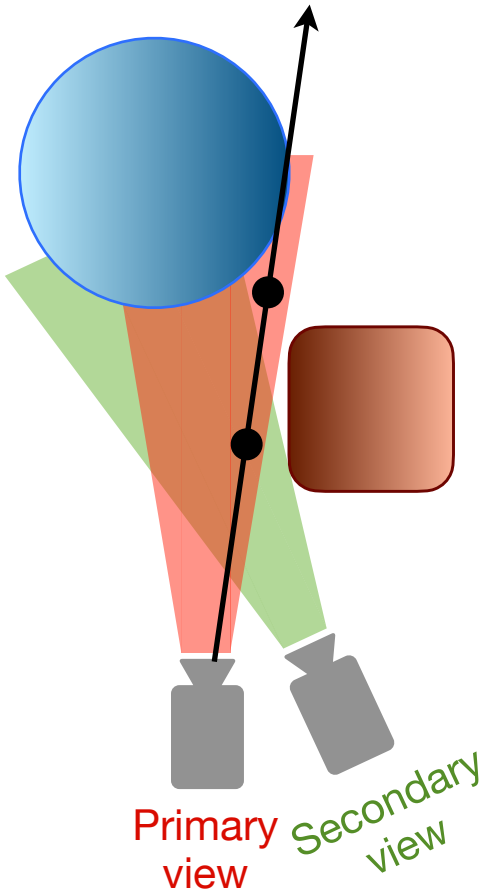
Prior reliable when $\tau' = 1$

- Estimate visibility of pixel in the secondary view:

$$t' = \sum_i w_i T_i'$$

$T_i' \leftarrow$ Visibility of 3D point in secondary view

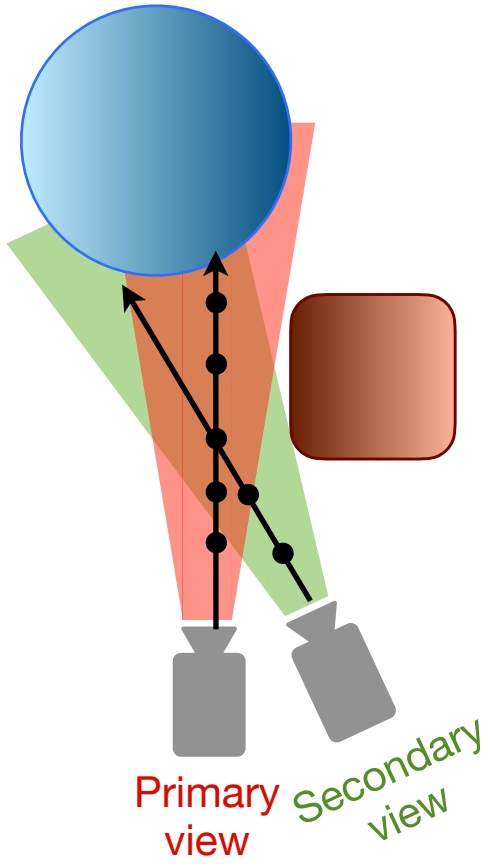
- Visibility Prior loss used in addition to the sparse depth loss [2]



[2] Deng et al., “Depth-Supervised NeRF: Fewer Views and Faster Training for Free”, CVPR 2022.

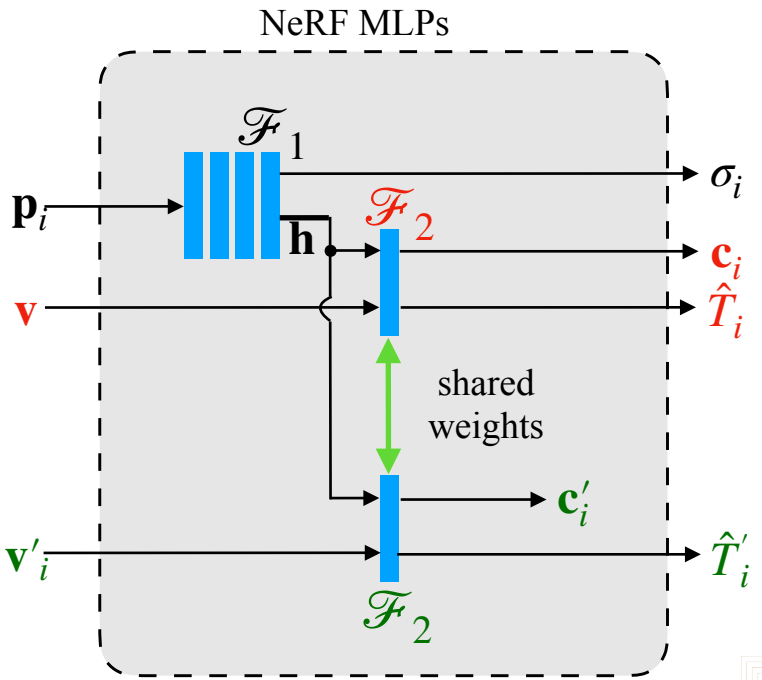
OBTAINING VISIBILITY OF 3D POINTS

Naive Approach



N^2 MLP queries per pixel instead of N.

Our Approach



NeRF learns view-dependent visibility

QUALITATIVE COMPARISONS

DS-NeRF

ViP-NeRF

Sparse supervision is probably insufficient in DS-NeRF; Visibility prior provides dense supervision.

[2] Deng et al., “Depth-Supervised NeRF: Fewer Views and Faster Training for Free”, CVPR 2022.

QUALITATIVE COMPARISONS

DDP-NeRF

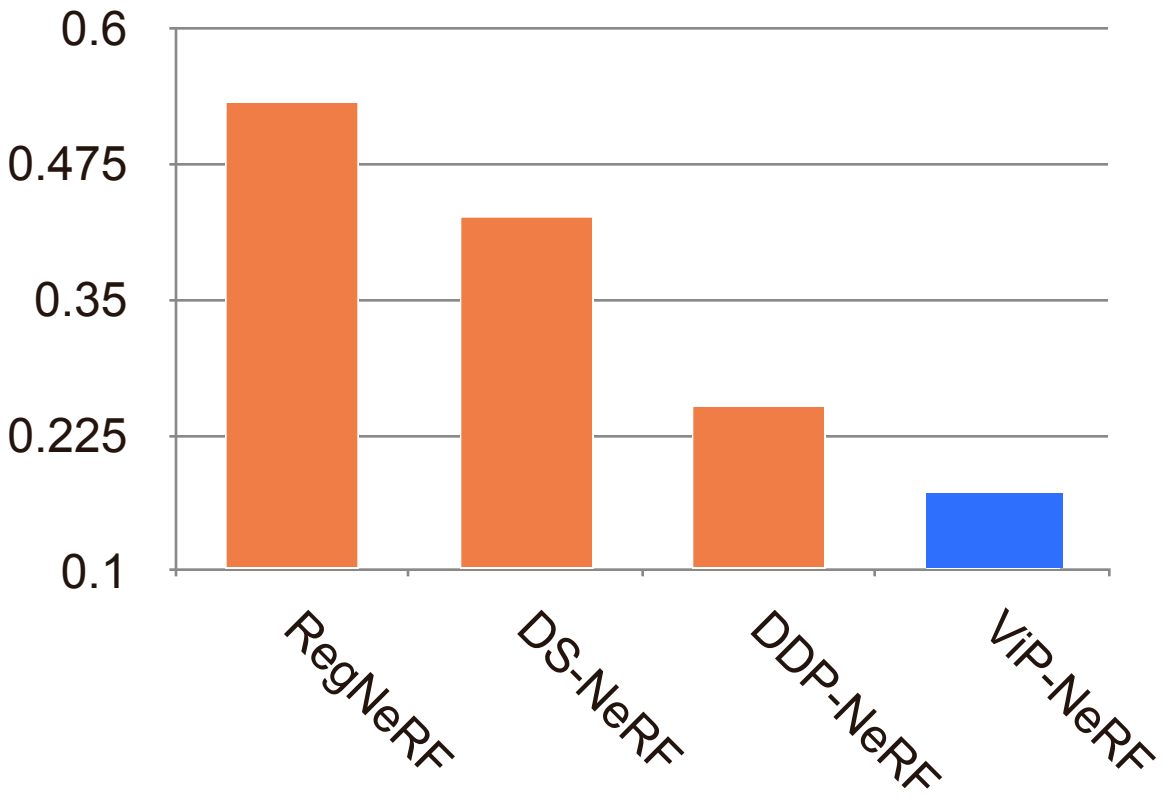
ViP-NeRF

Inaccurate dense depth supervision probably leads to blurred floaters in DDP-NeRF; Visibility prior is more reliable.

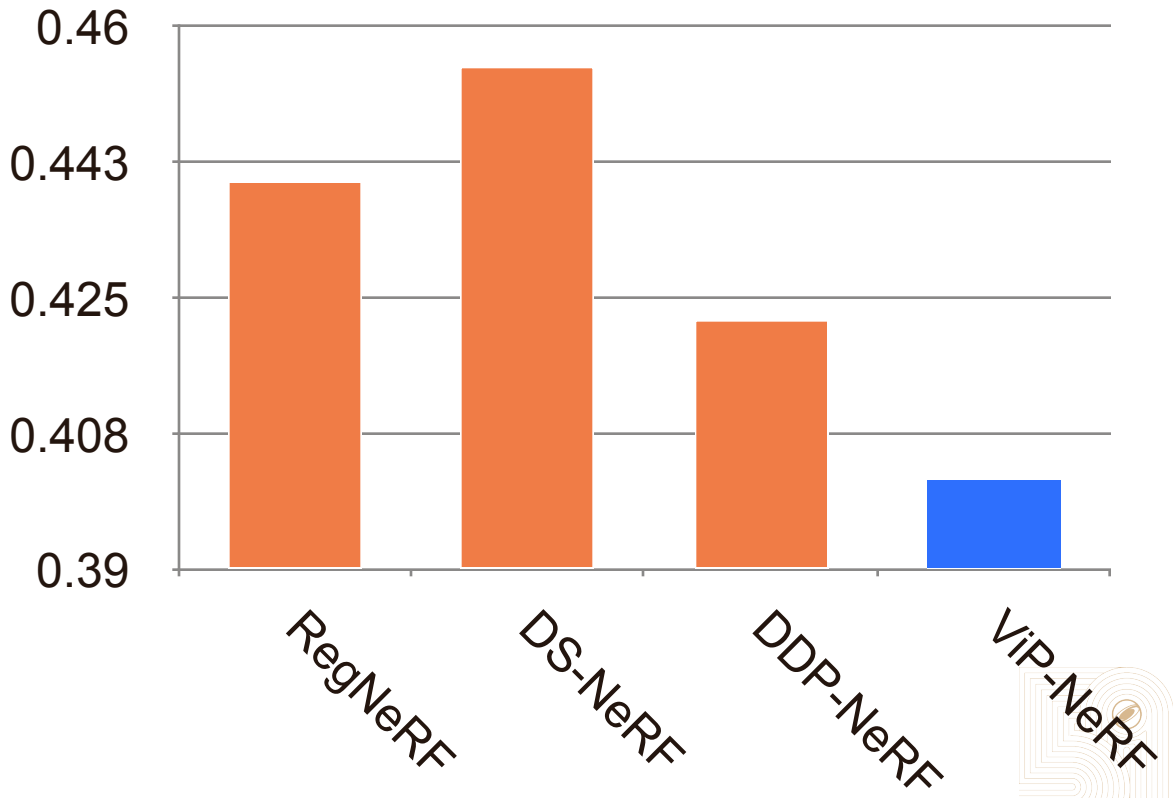
[3] Roessle et al., “Dense Depth Priors for Neural Radiance Fields From Sparse Input Views”, CVPR 2022.

QUANTITATIVE COMPARISONS - LPIPS - 2 INPUT VIEWS

Real Estate - 10K [4]



NeRF - LLFF [5]



Lower LPIPS score indicates better quality

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

CONCLUSION

Contributions

- Visibility prior to regularize few-shot NeRF.
  - Estimation without any pre-training.
  - Dense and Reliable.
- Faster training by making NeRF learn view-dependent visibility.
- **Plug and Play solution.**

For paper, code and more, visit

https://nagabhushansn95.github.io/publications/2023/ViP-NeRF.html

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