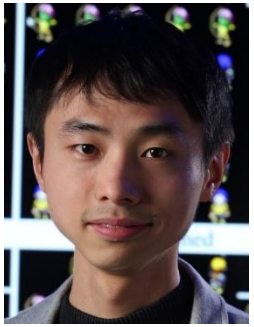
NEURAL INFORMATION PROCESSING SYSTEMS
NeurIPS 2021

Neural Relightable Participating Media Rendering



Quan Zheng[1,2] Gurprit Singh[1] Hans-Peter Seidel[1]

[1]Max Planck Institute for Informatics, Germany
[2]Institute of Software, Chinese Academy of Sciences, China

max planck institut informatik

ISCAS

Motivation

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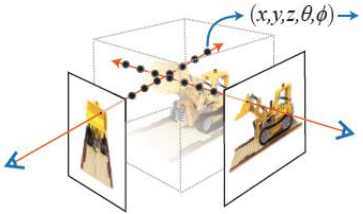
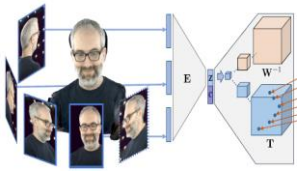
Neural radiance field



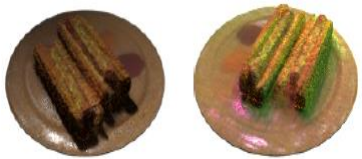
Mildenhall et al. 2020



Lombardi et al. 2019

Neural reflectance field

Bi et al. 2020



Srinivasan et al. 2021

Participating media

Problem overview

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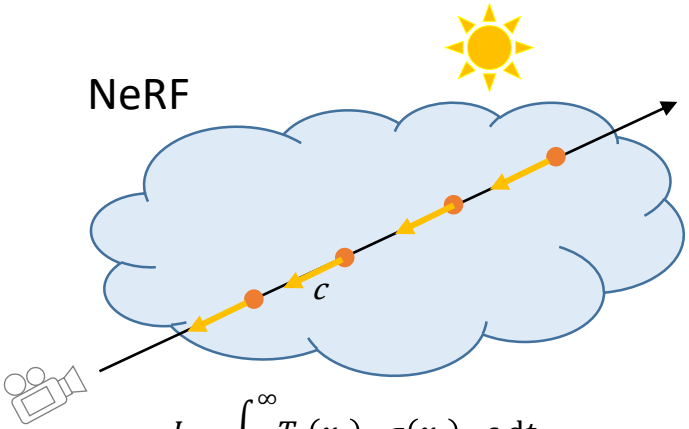
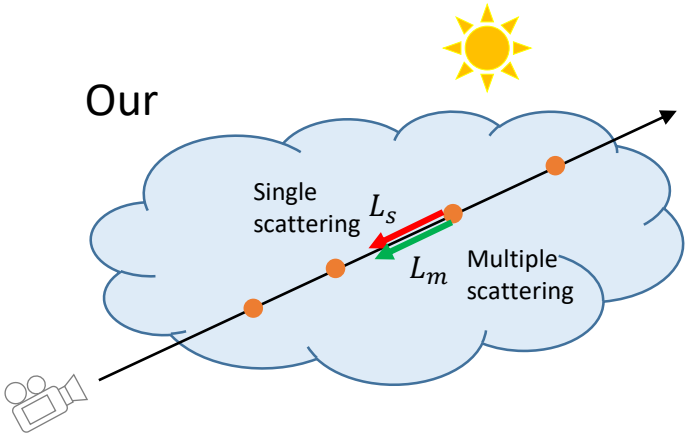
NeRF



$$L = \int_0^{\infty} T_r(x_t) \cdot \sigma(x_t) \cdot c \, \mathrm{d}t$$

Our



	NeRF	Our
Radiance	✓ Color c	✓ Single scattering L_s ✓ Multiple scattering L_m
Property	✓ Volume density σ	✓ Volume density σ ✓ Scattering albedo a ✓ Phase function parameter g

Single scattering

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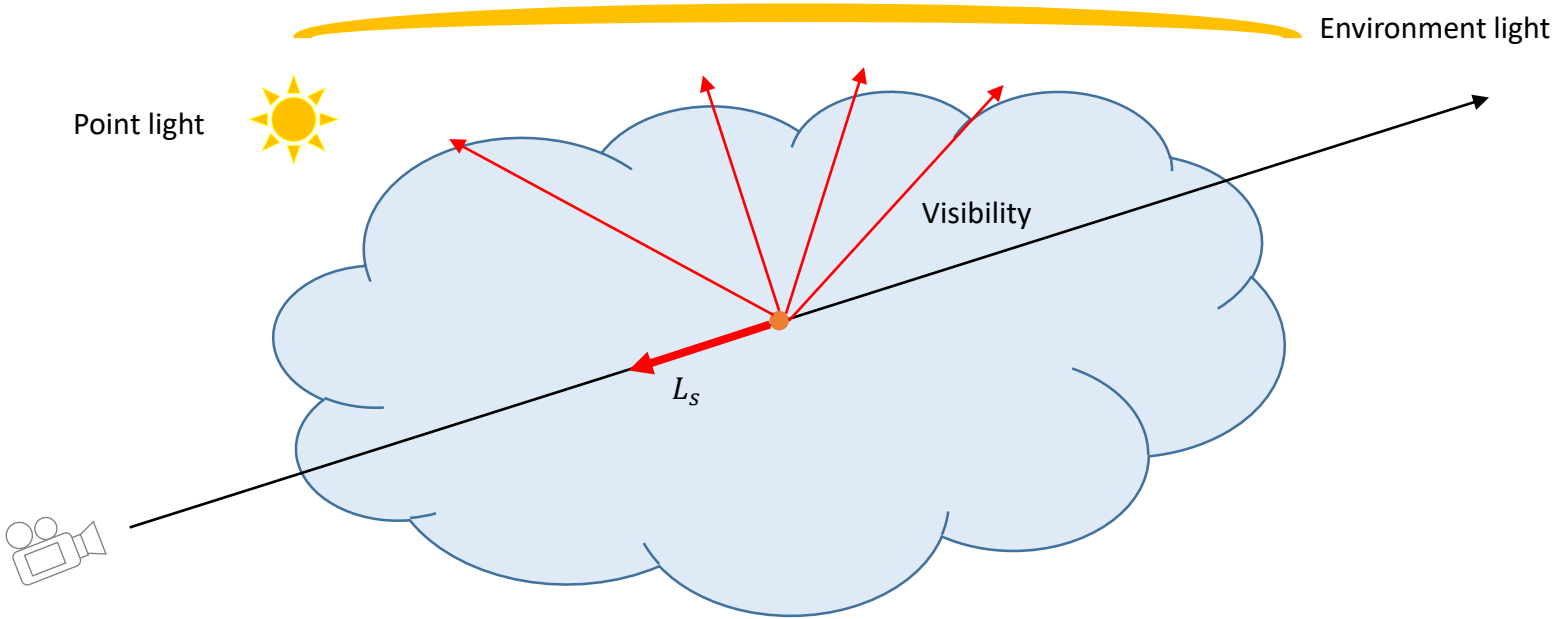
Direct lighting



Multiple scattering

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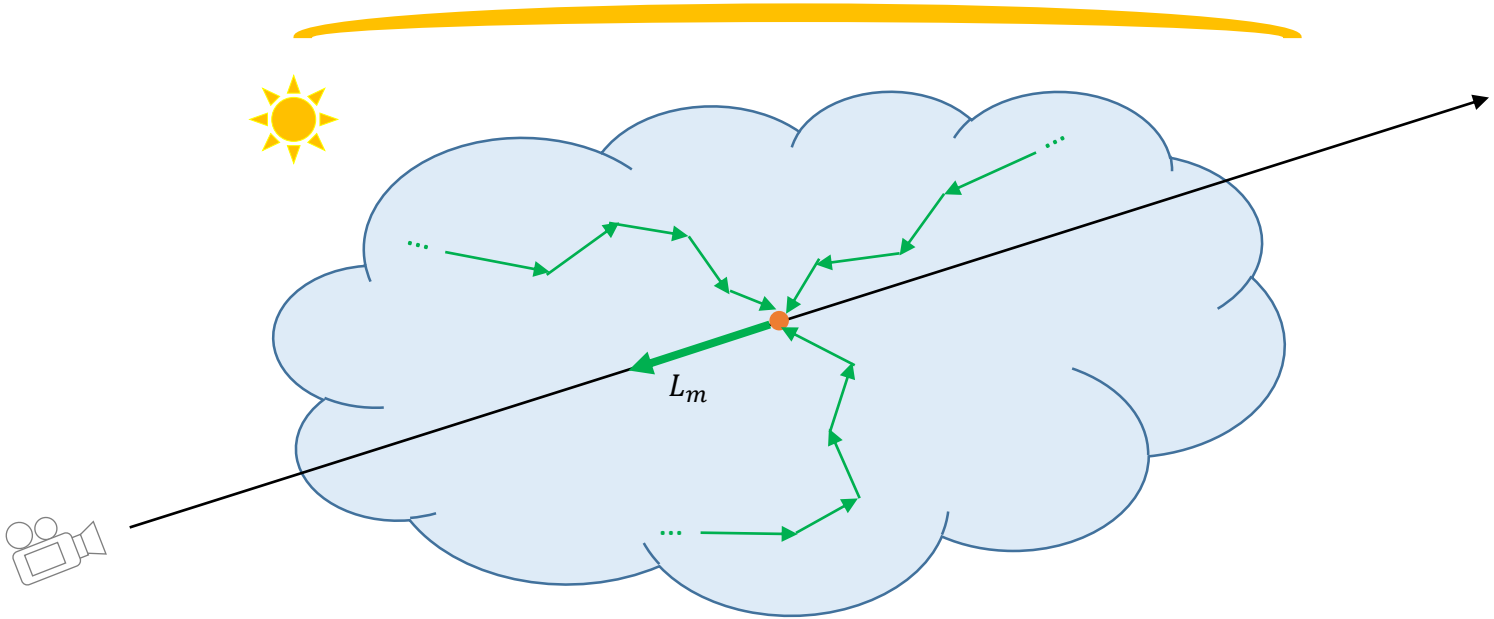
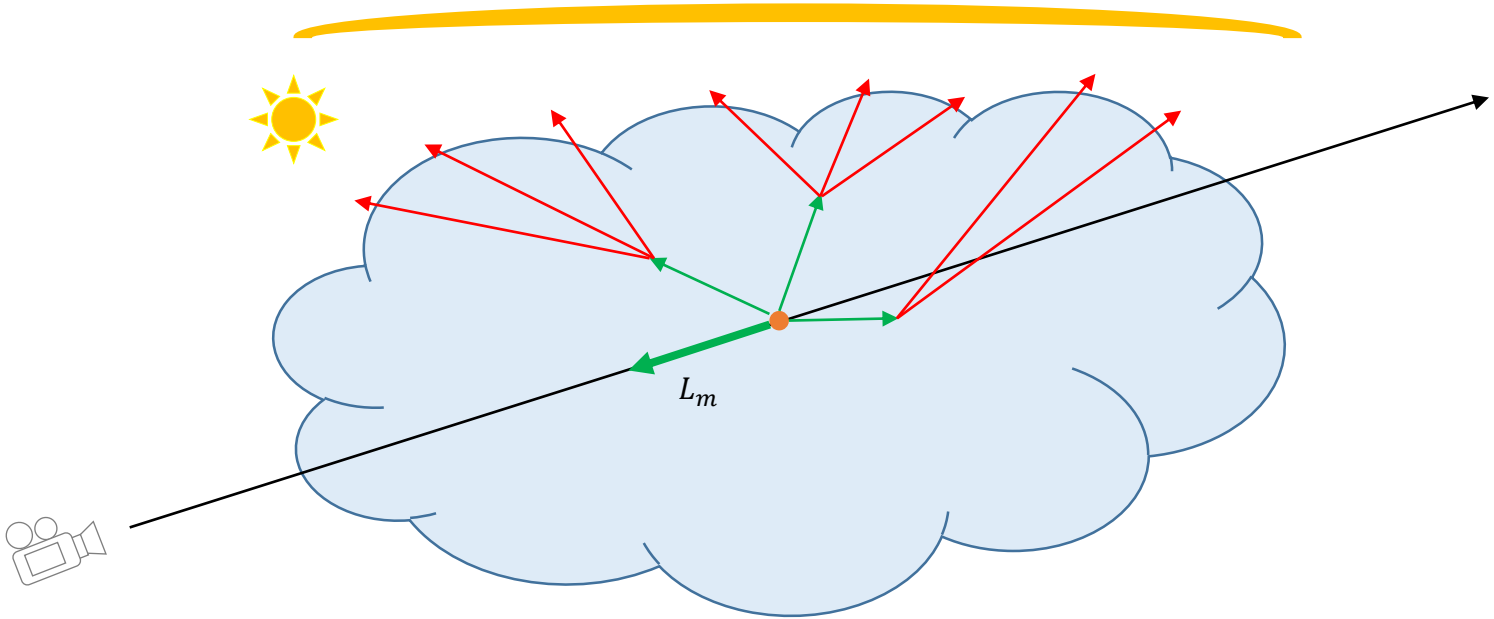
Indirect lighting



Simulate long paths are costly

Multiple scattering

NeRV's solution



Simulate one-bounce indirect lighting

Multiple scattering

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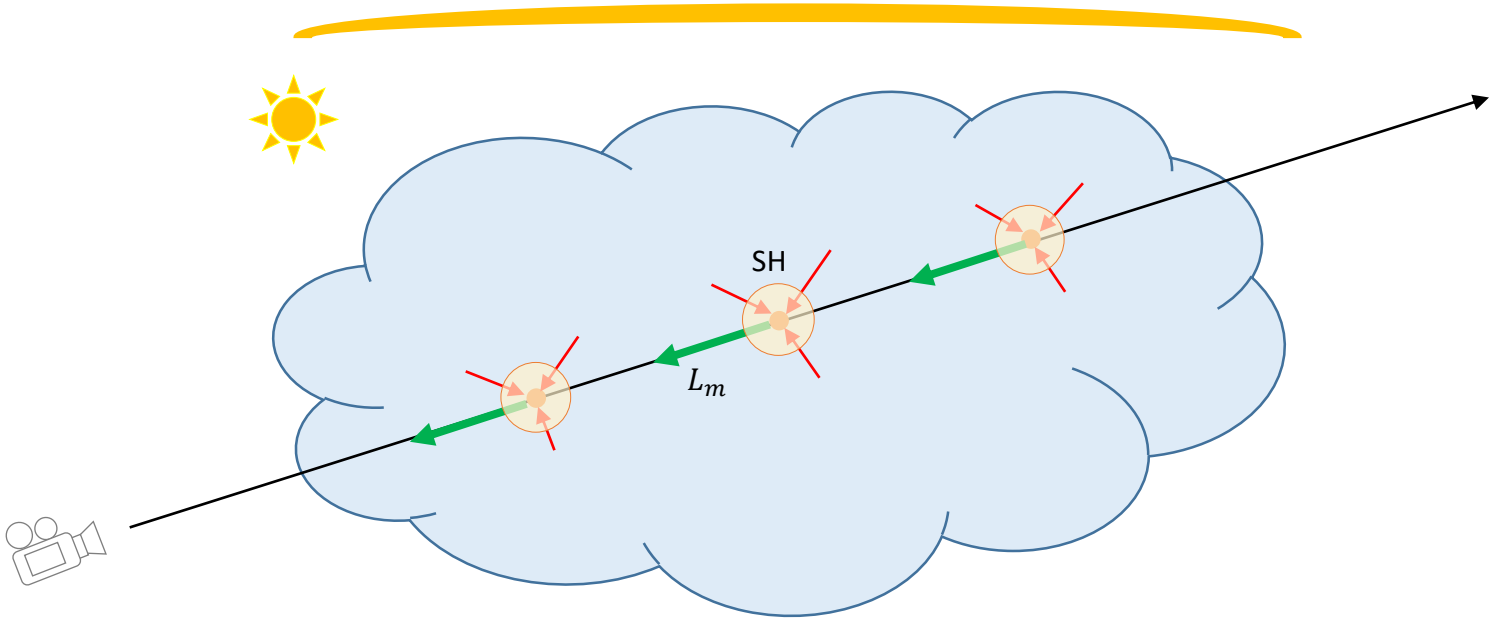
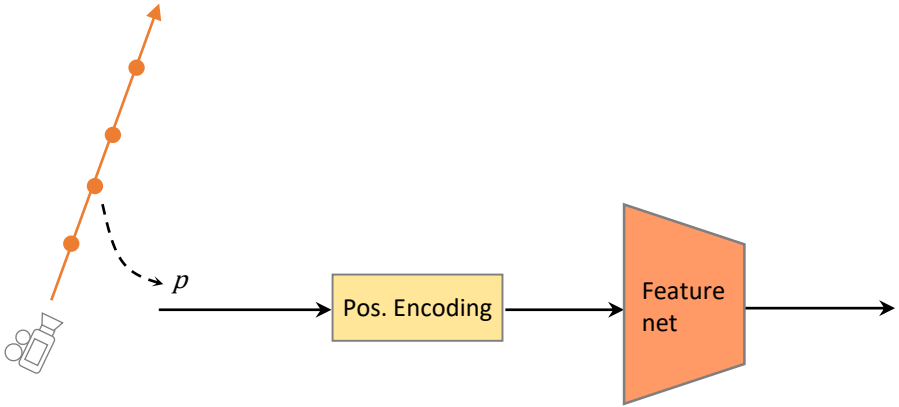
Our idea



Project incident radiance onto Spherical Harmonic (SH) Bases

Network architecture

We train neural networks to learn properties, visibility and SH coefficients



Network architecture

NEURAL INFORMATION PROCESSING SYSTEMS
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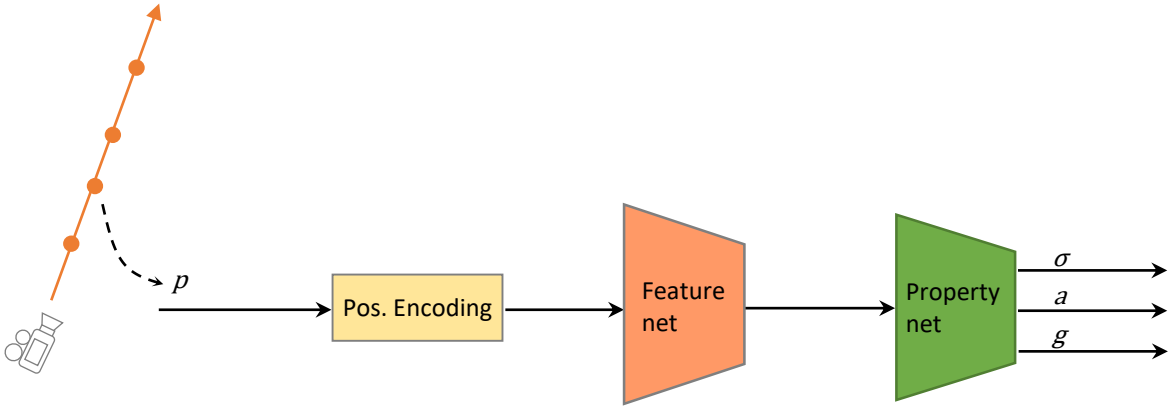
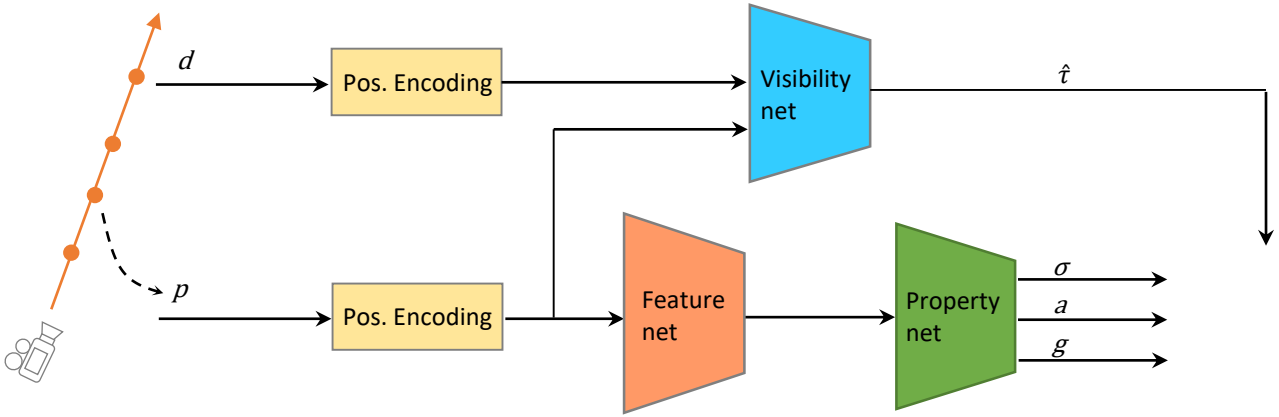
We train neural networks to learn properties, visibility and SH coefficients



Network architecture

We train neural networks to learn properties, visibility and SH coefficients



Network architecture

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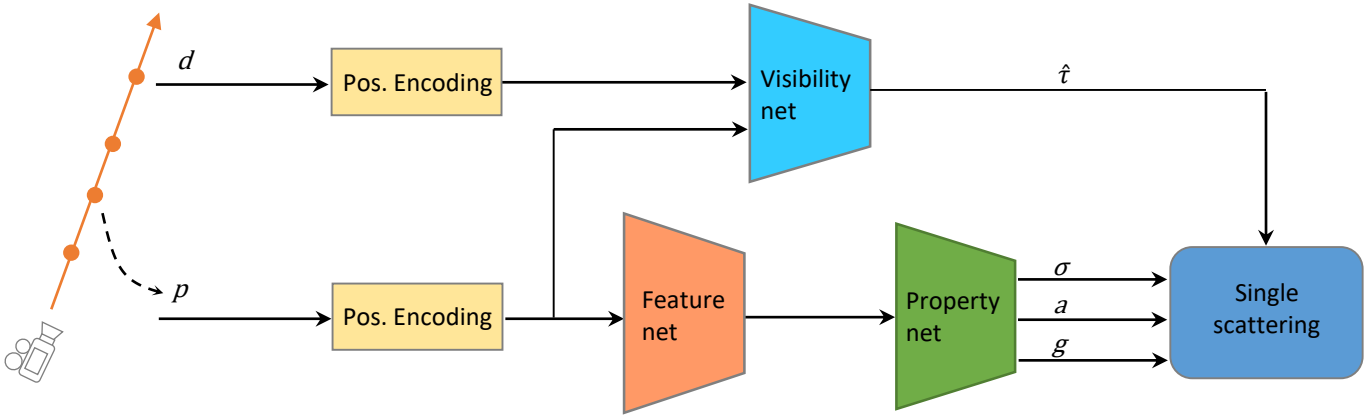
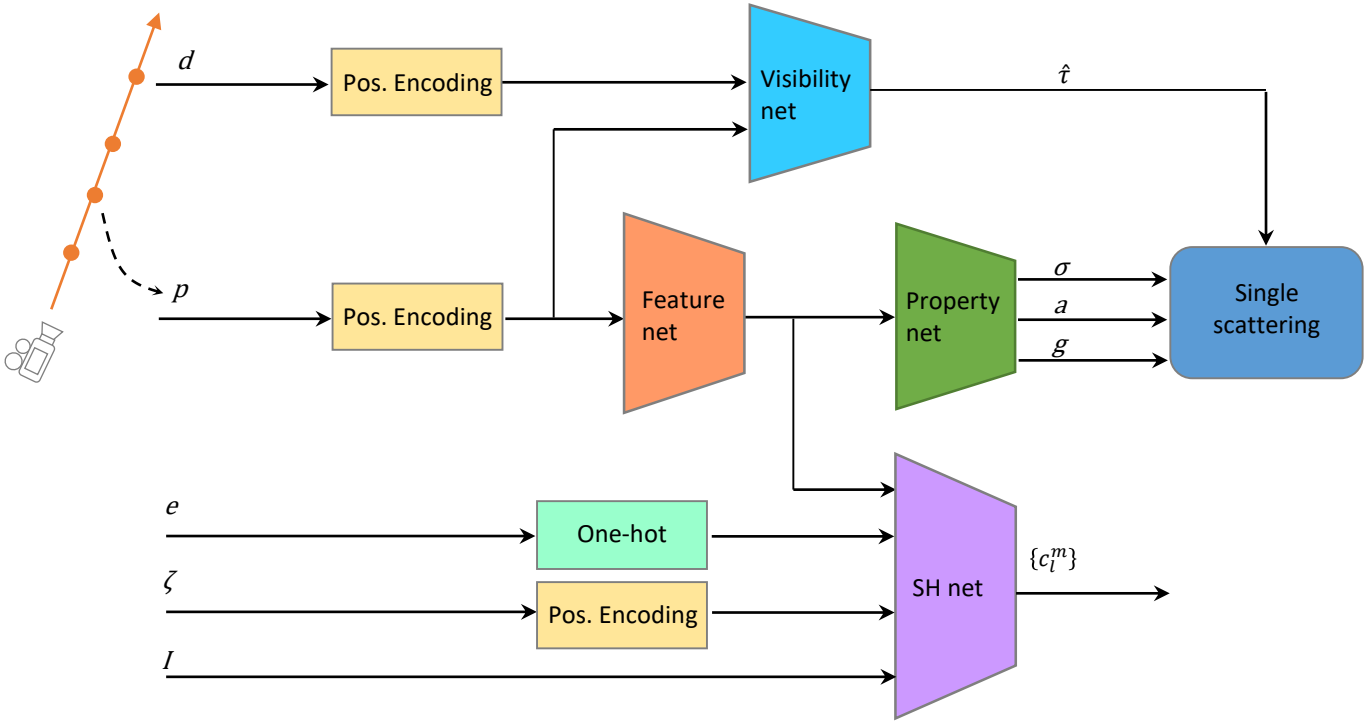
We train neural networks to learn properties, visibility and SH coefficients



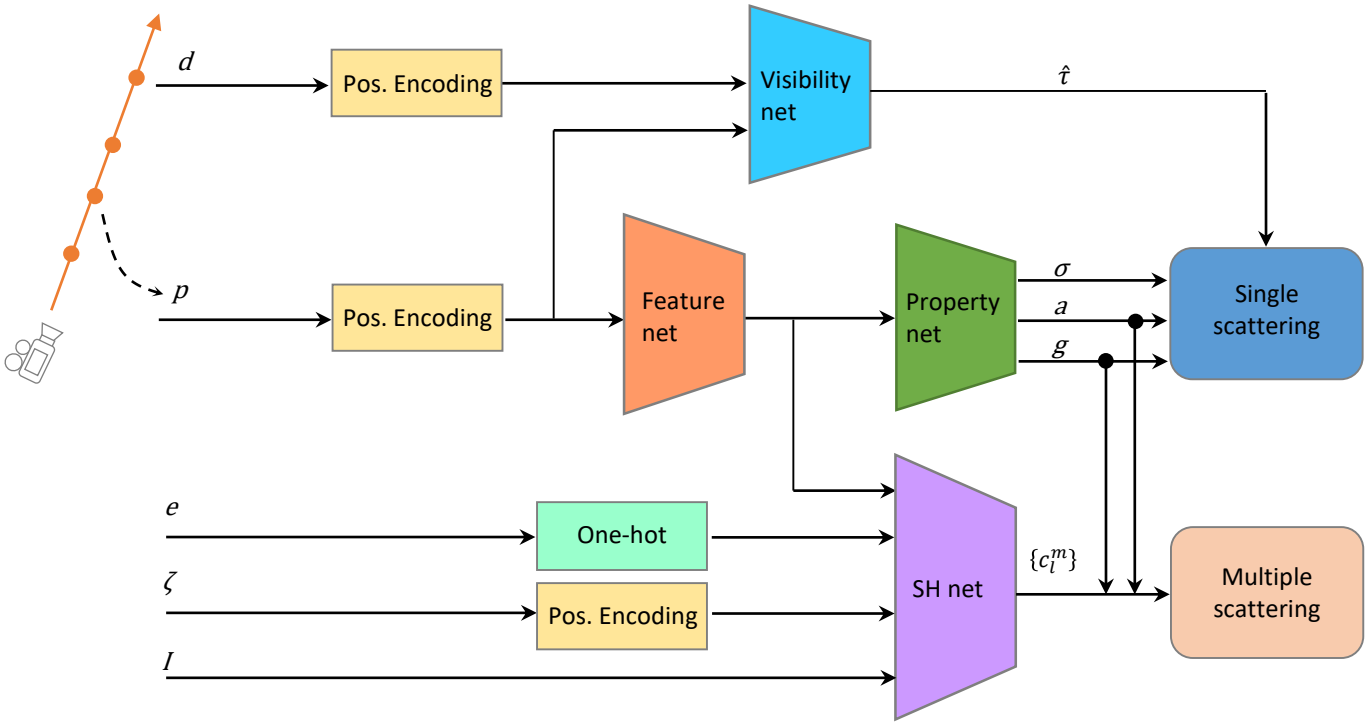
Network architecture

We train neural networks to learn properties, visibility and SH coefficients



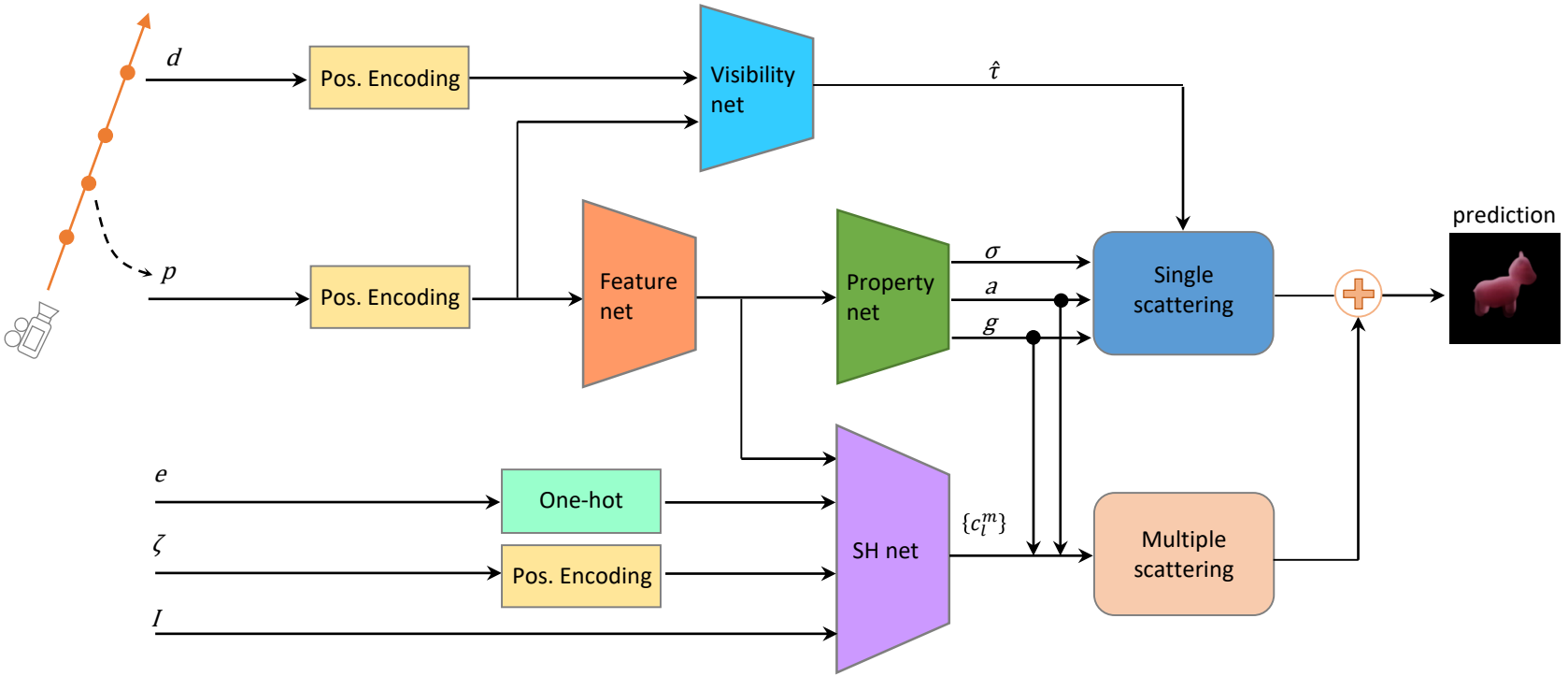
Network architecture

We train neural networks to learn properties, visibility and SH coefficients



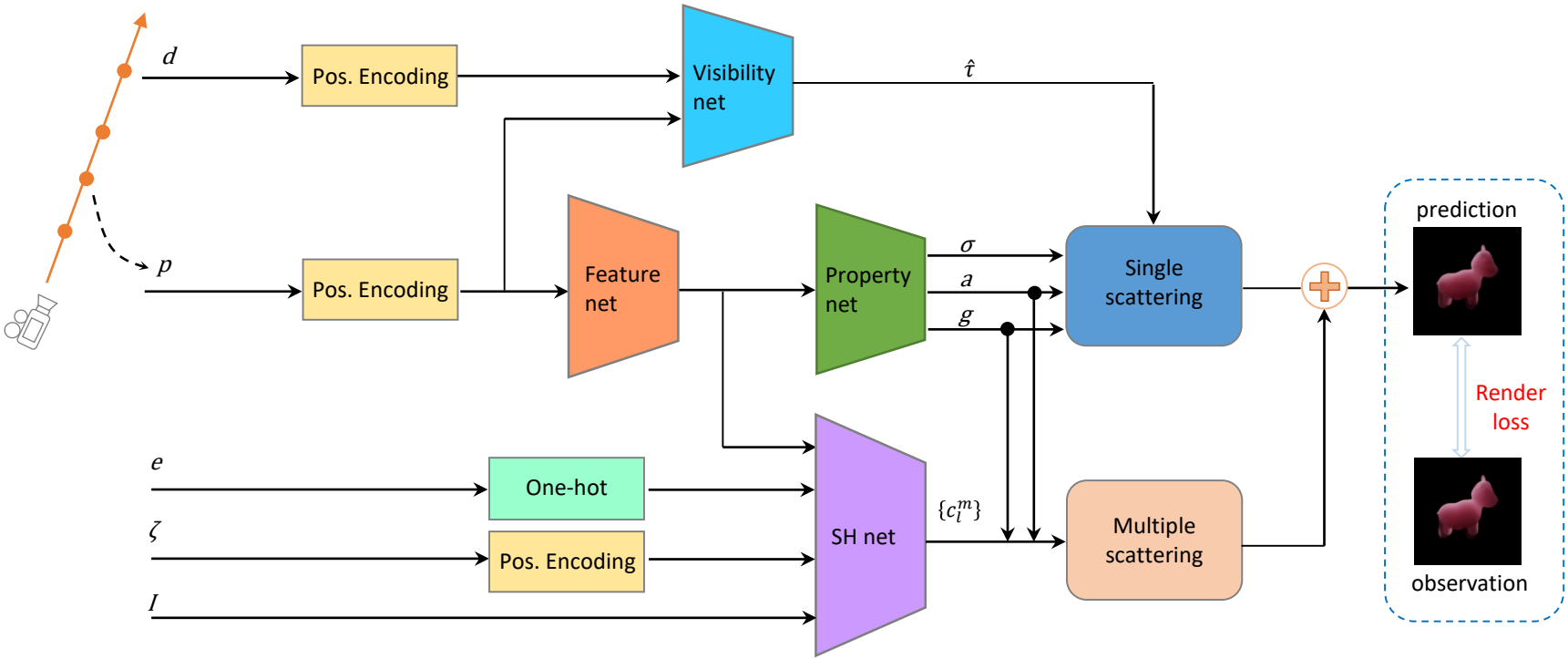
Network architecture

We train neural networks to learn properties, visibility and SH coefficients



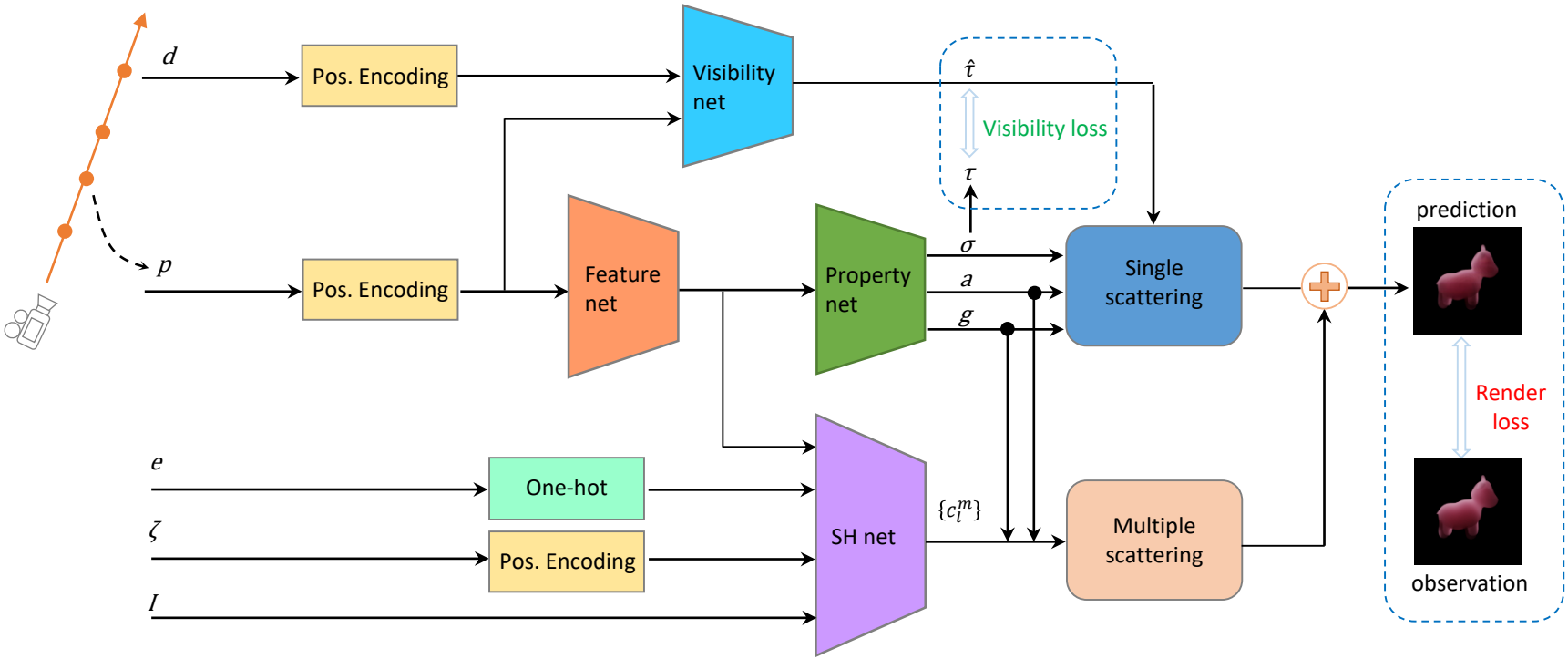
Network architecture

We train neural networks to learn properties, visibility and SH coefficients



Network architecture

We train neural networks to learn properties, visibility and SH coefficients



Experiments

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Our scenes


Cow


Cloud

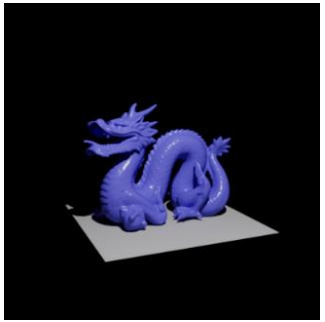

Bunny4-VaryG


Bunny4-VaryAlbedo


Buddha3


Bunny


Buddha


Dragon

Experiments

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Settings

- Training lighting condition
  - A point light
  - An environment light + A point light
- Test lighting condition
  - A novel point light
- Compared baselines
  - Neural reflectance field [Bi et al. 2020]
  - NeRV [Srinivasan et al. 2021]

Qualitative comparisons

NEURAL INFORMATION PROCESSING SYSTEMS
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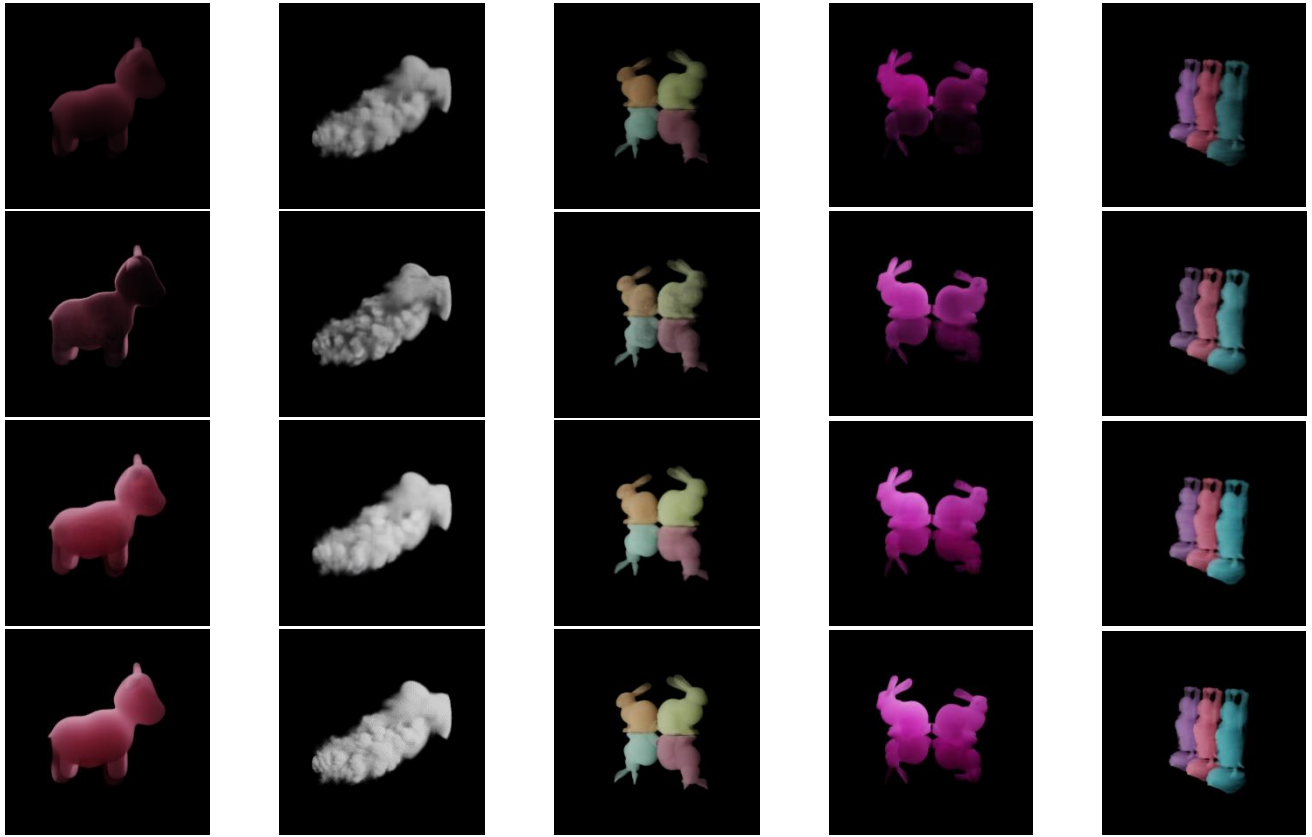
Train on “point”

Bi et al.

NeRV

Ours

Reference



Qualitative comparisons

NEURAL INFORMATION PROCESSING SYSTEMS
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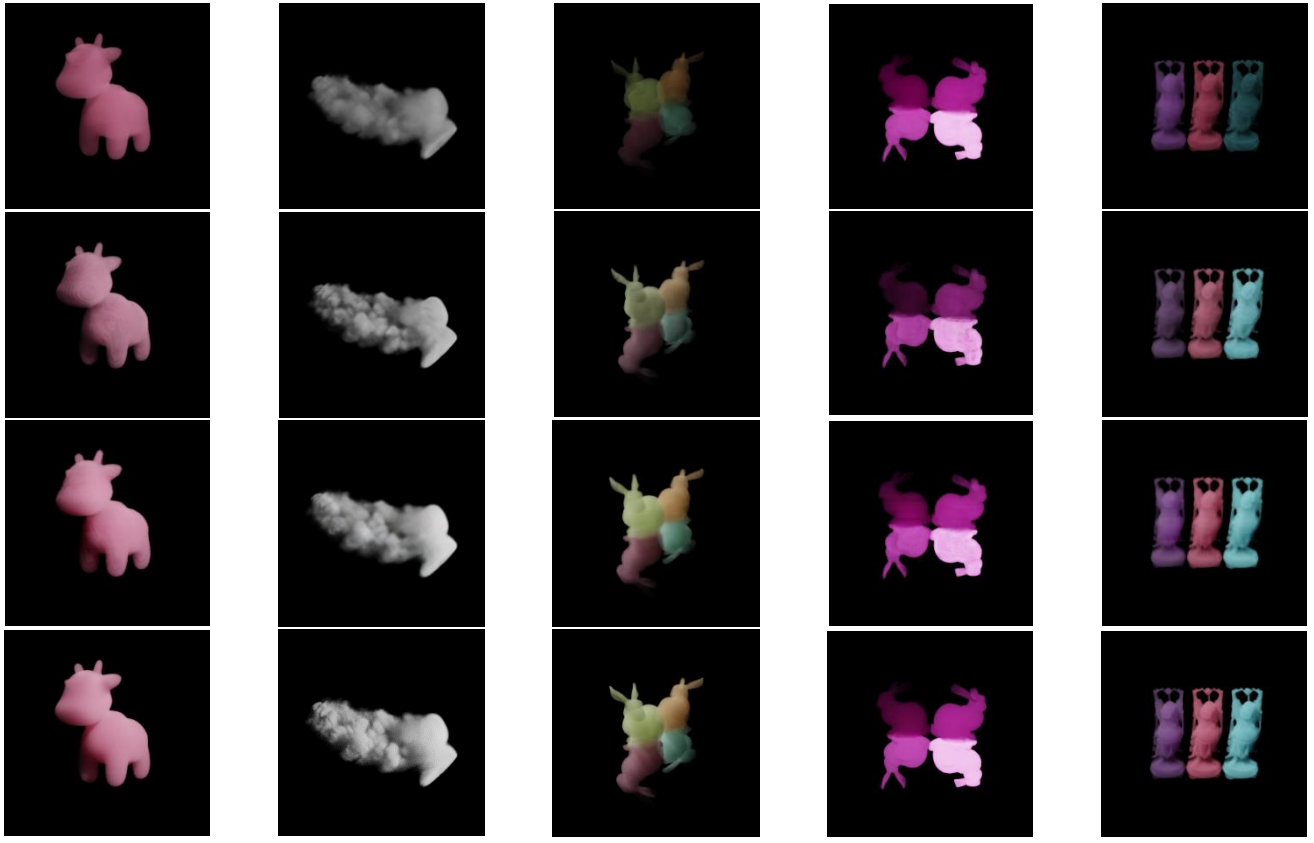
Train on “point + environment light”

Bi et al.

NeRV

Ours

Reference



Quantitative comparisons

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Train on “point”

Point	Cow			Cloud			Bunny4-VaryA			Bunny4-VaryG			Buddha3		
Method	PSNR	SSIM	ELPIPS	PSNR	SSIM	ELPIPS	PSNR	SSIM	ELPIPS	PSNR	SSIM	ELPIPS	PSNR	SSIM	ELPIPS
Bi et al.	24.70	0.958	0.465	20.92	0.921	0.783	27.29	0.960	0.378	29.40	0.971	0.334	29.47	0.970	0.299
NeRV	25.20	0.960	0.540	25.68	0.949	0.526	27.67	0.969	0.306	26.76	0.968	0.419	28.69	0.969	0.315
Ours	**34.20**	**0.983**	**0.184**	**33.51**	**0.974**	**0.302**	**34.75**	**0.980**	**0.189**	**33.86**	**0.981**	**0.257**	**33.77**	**0.975**	**0.245**

Train on “environment light + point”

Env+Point	Cow			Cloud			Bunny4-VaryA			Bunny4-VaryG			Buddha3		
Method	PSNR	SSIM	ELPIPS	PSNR	SSIM	ELPIPS	PSNR	SSIM	ELPIPS	PSNR	SSIM	ELPIPS	PSNR	SSIM	ELPIPS
Bi et al.	24.84	0.960	0.501	22.18	0.934	0.709	26.65	0.958	0.464	30.03	0.974	0.285	23.41	0.938	0.679
NeRV	27.83	0.974	0.413	26.07	0.950	0.476	28.18	0.968	0.301	27.97	0.975	0.339	28.99	0.969	0.299
Ours	**33.32**	**0.982**	**0.209**	**32.64**	**0.969**	**0.353**	**34.47**	**0.979**	**0.191**	**34.09**	**0.982**	**0.243**	**34.03**	**0.975**	**0.261**

PSNR↑ SSIM↑ ELPIPS↓

Relighting – Bunny scene

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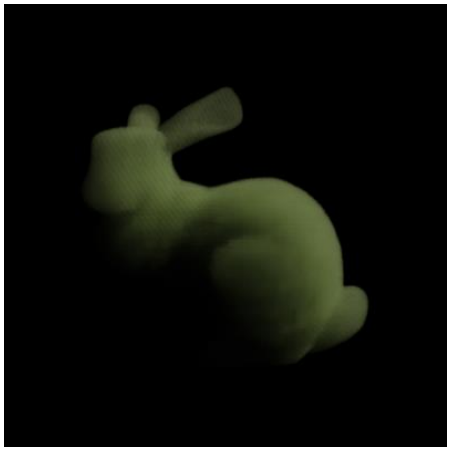
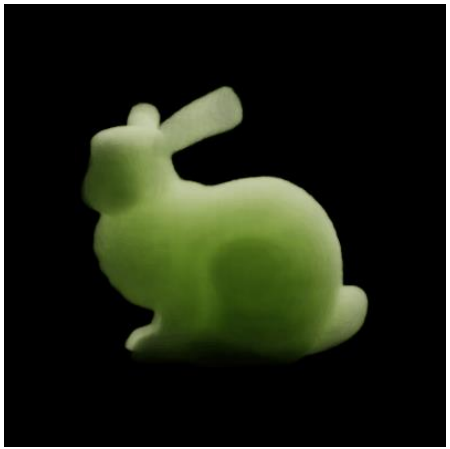


Bi et al.

NeRV



Ours

Reference

Relighting – Buddha scene

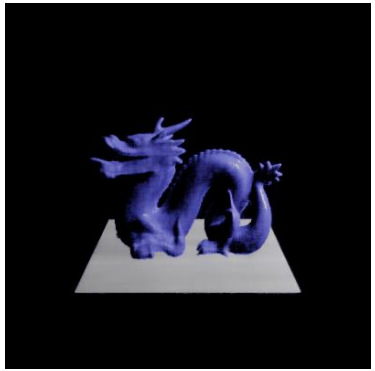
Bi et al.

NeRV

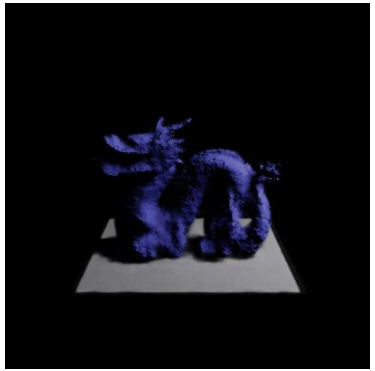
Ours

Reference

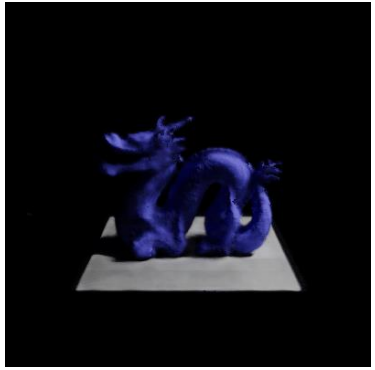
Relighting – Dragon scene



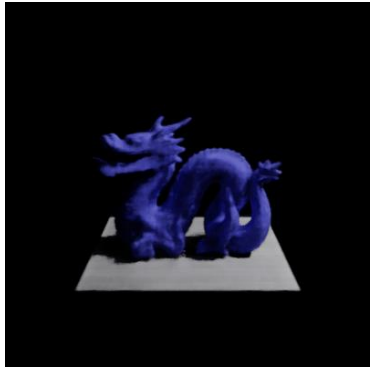
Bi et al.



NeRV



Ours + BRDF



Ours

Reference

Scene editing – Cloud

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Our learnt cloud

After tuning down density

After editing the albedo

Scene composition 1

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Original scene

Insert our learnt results

Reference

Scene composition 2

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Original scene

Insert our learnt results

Reference

Summary

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- Learn disentangled neural representations for participating media
- Deal with both single scattering and multiple scattering in a principled way
- Allow flexible usage for relighting, editing and scene compositions

Thank you for watching