Ref-GS: Directional Factorization for 2D Gaussian Splatting

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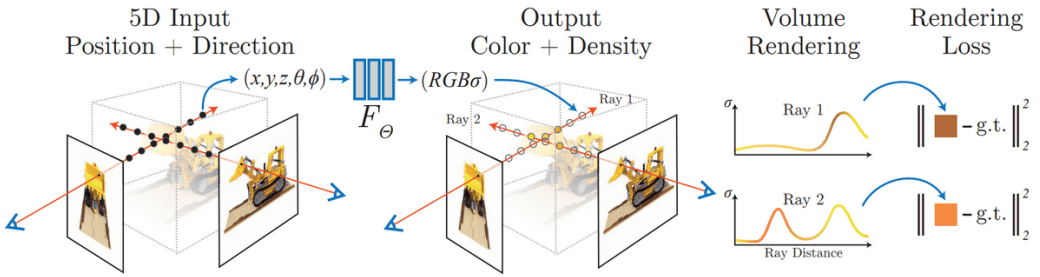
About me

Youjia Zhang (张由甲)

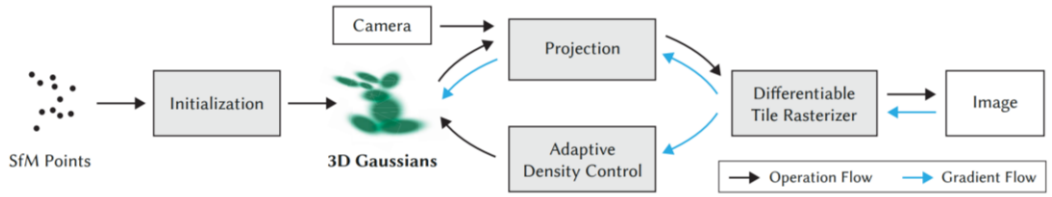
I am currently a second-year Ph.D. student of Huazhong University of Science and Technology (HUST), School of CS, supervised by Prof. Wei Yang.

My research interests lie in **neural rendering**, **inverse rendering**, and **3D AIGC**

Neural Radiance Fields

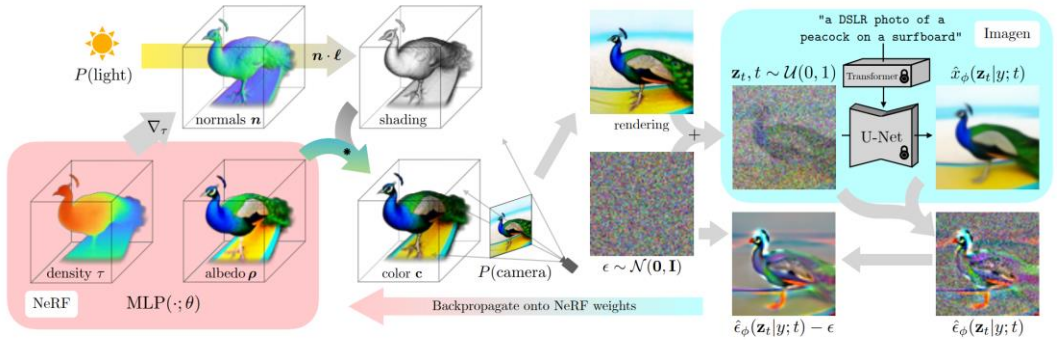


3D Gaussian Splatting



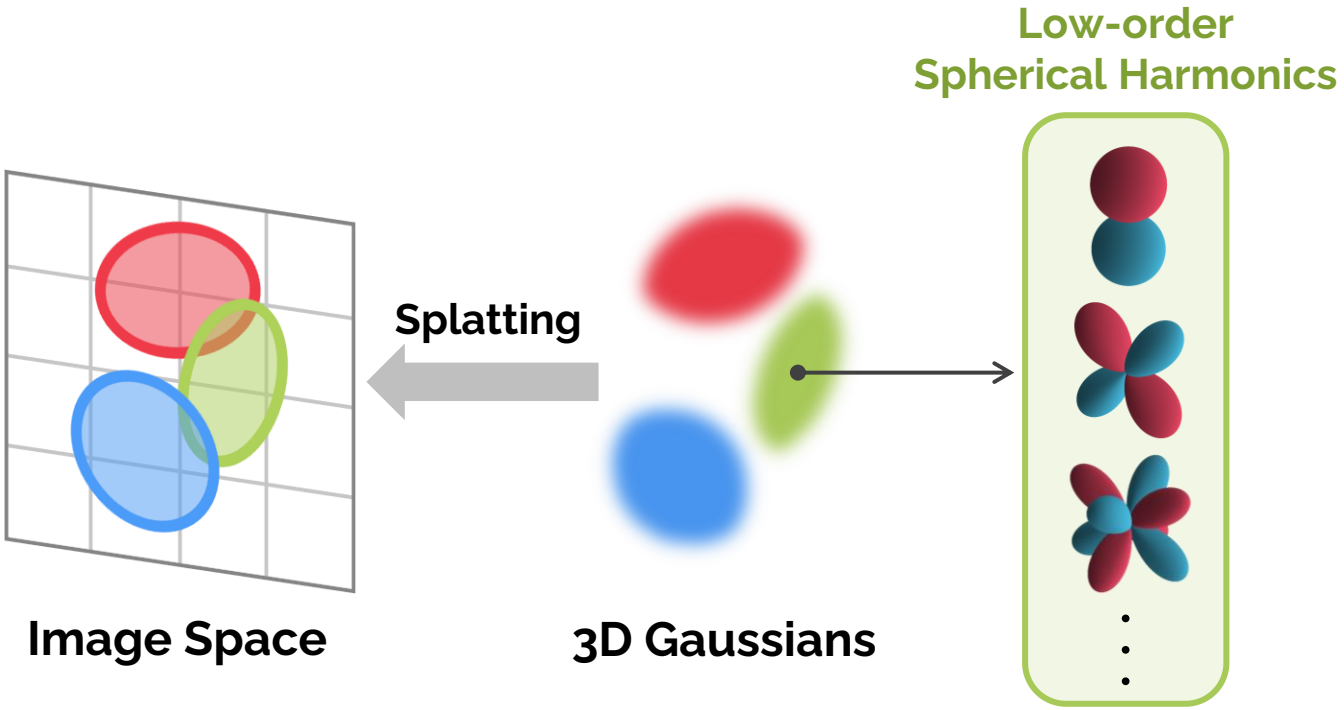
Inverse Rendering

Score Distillation Sampling



Motivation

Gaussian Splatting

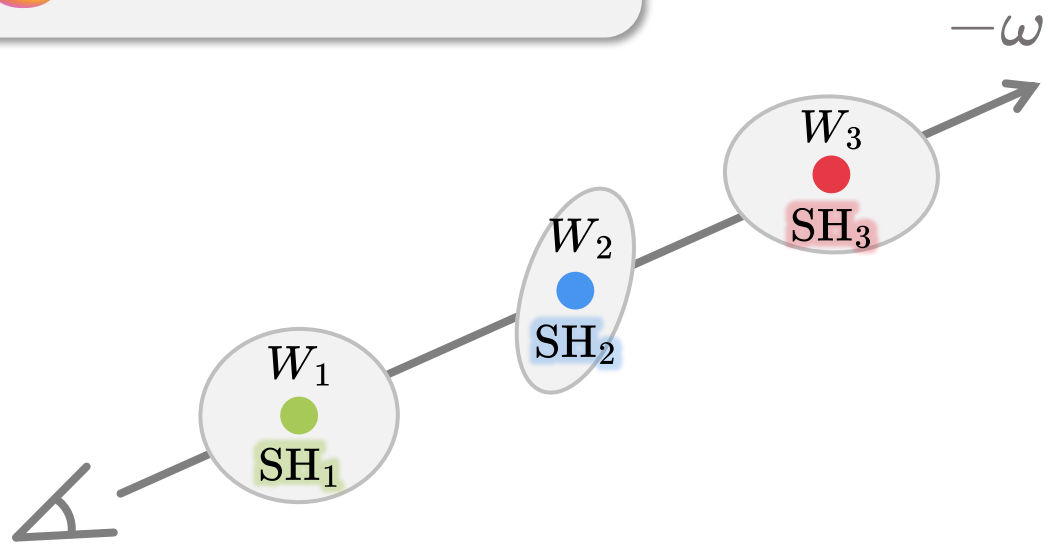


😟 **Low-order SH cannot model high-frequency details.**

Motivation

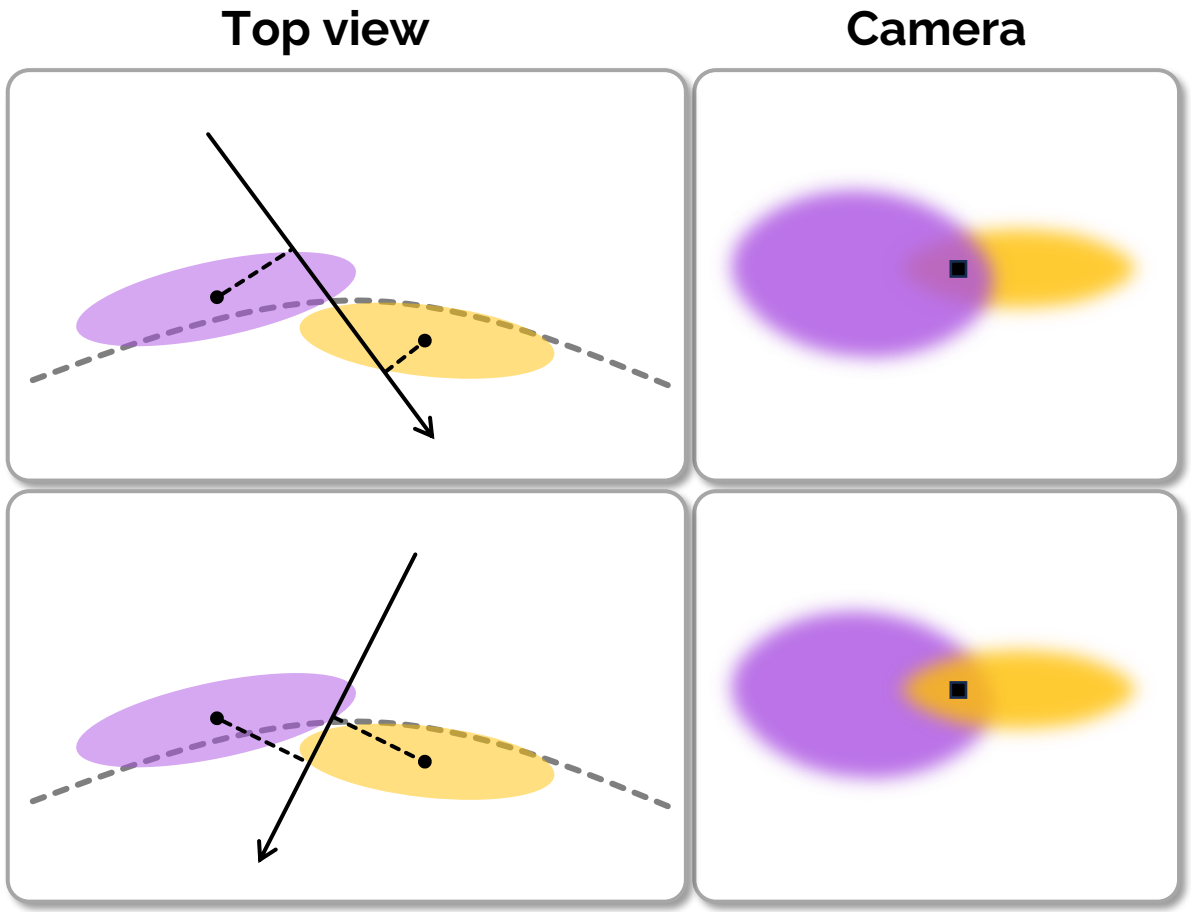
Forward Shading

😟 **Popping artifacts**



$$\mathbf{c}(\mathbf{r}) = \mathrm{SH}_1(\omega)W_1 + \mathrm{SH}_2(\omega)W_2 + \mathrm{SH}_3(\omega)W_3$$

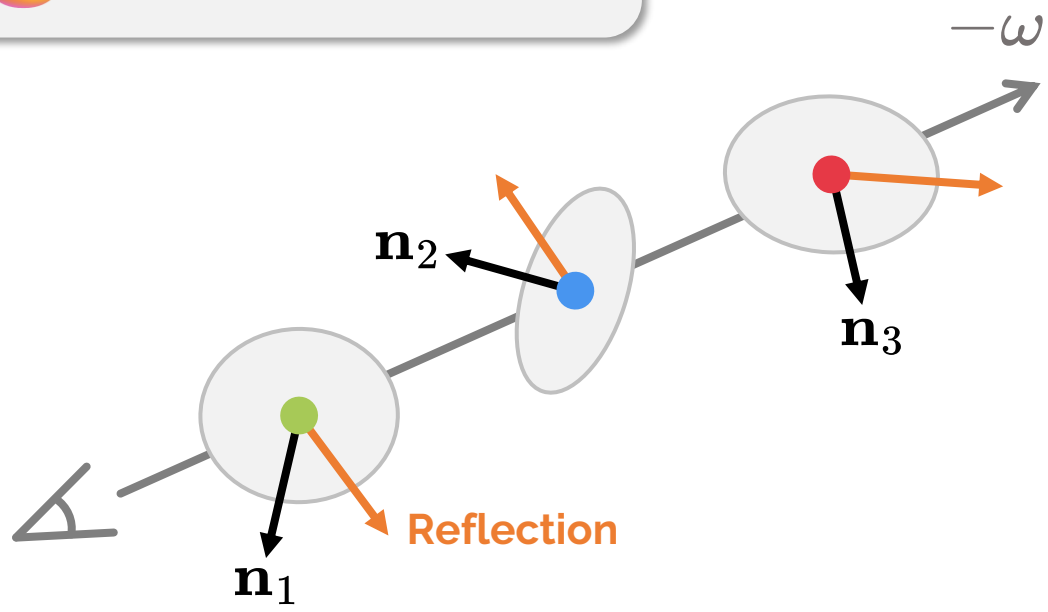
NeRF [Mildenhall et al., 2020]	**3DGS** [Kerbl et al., 2023]



Motivation

Forward Shading

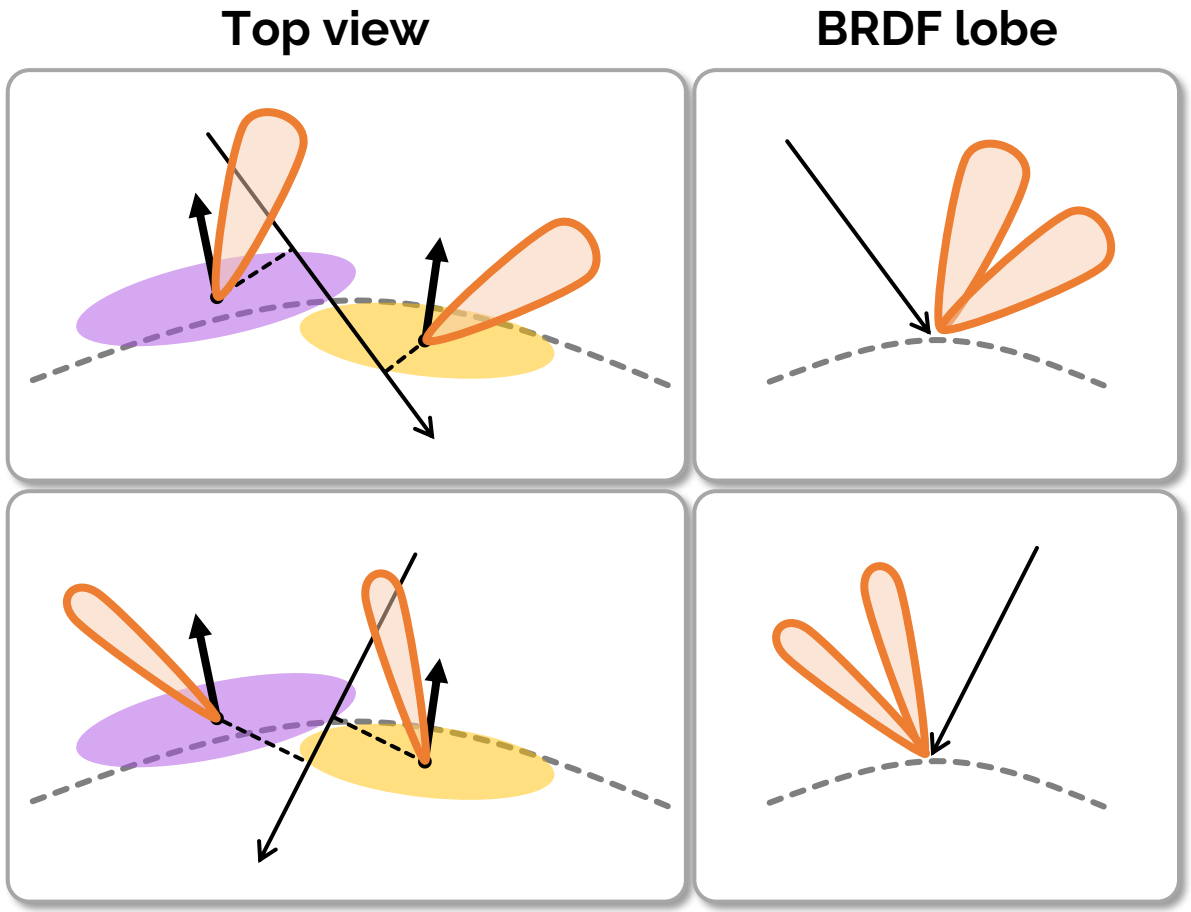
😟 **Blurry rendering**



$$\mathbf{c}(\mathbf{r}) = \mathrm{SH}_1(\omega, \mathbf{n}_1)W_1 + \mathrm{SH}_2(\omega, \mathbf{n}_3)W_2 + \mathrm{SH}_3(\omega, \mathbf{n}_3)W_3$$

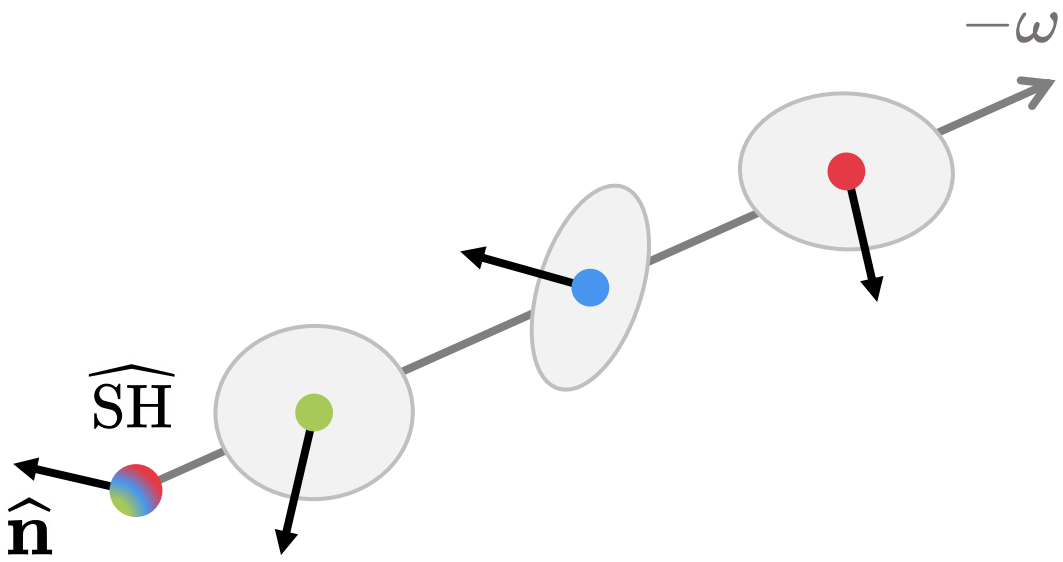
Ref-NeRF
[Verbin et al., 2022]

GaussianShader
[Jiang et al., 2024]



Motivation

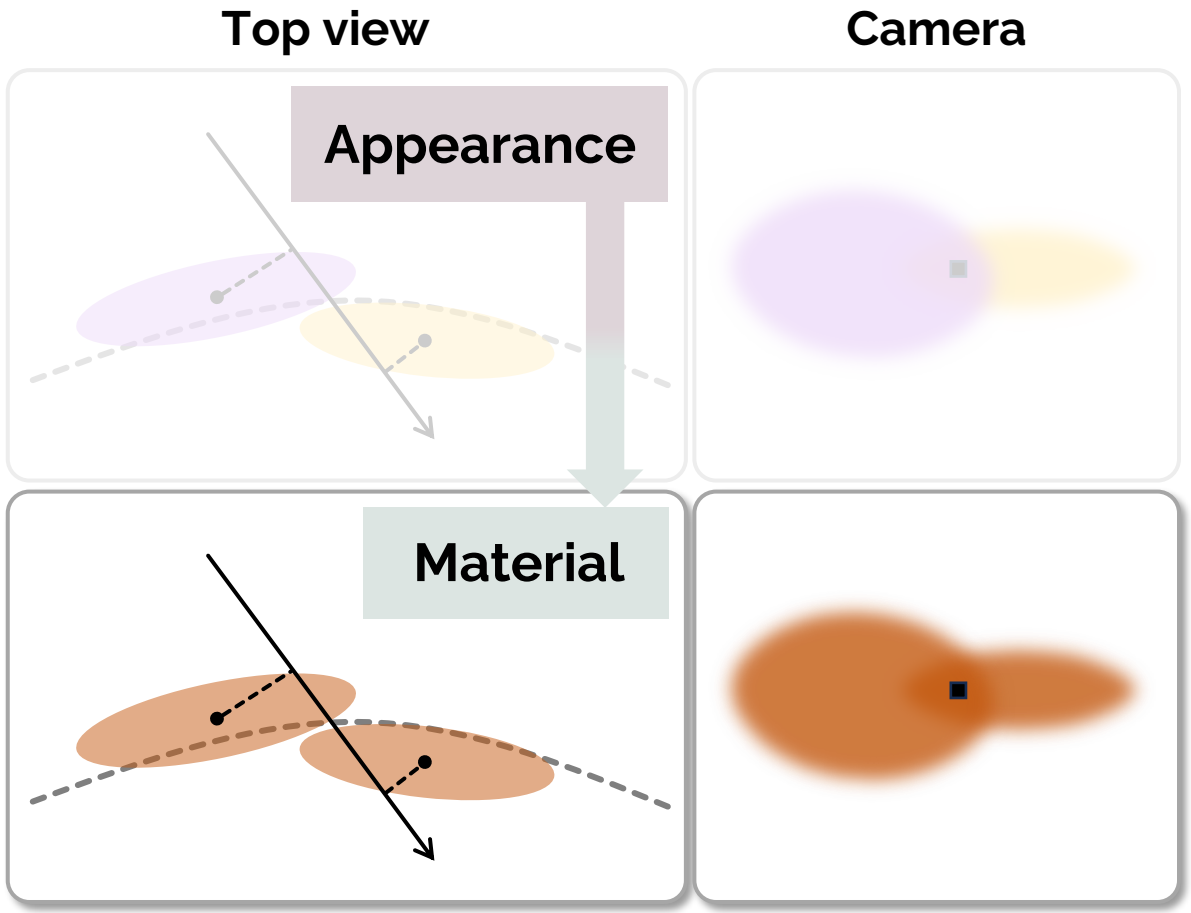
Deferred Shading



$$\hat{\mathbf{n}} = \mathbf{n}_1 W_1 + \mathbf{n}_2 W_2 + \mathbf{n}_3 W_3$$

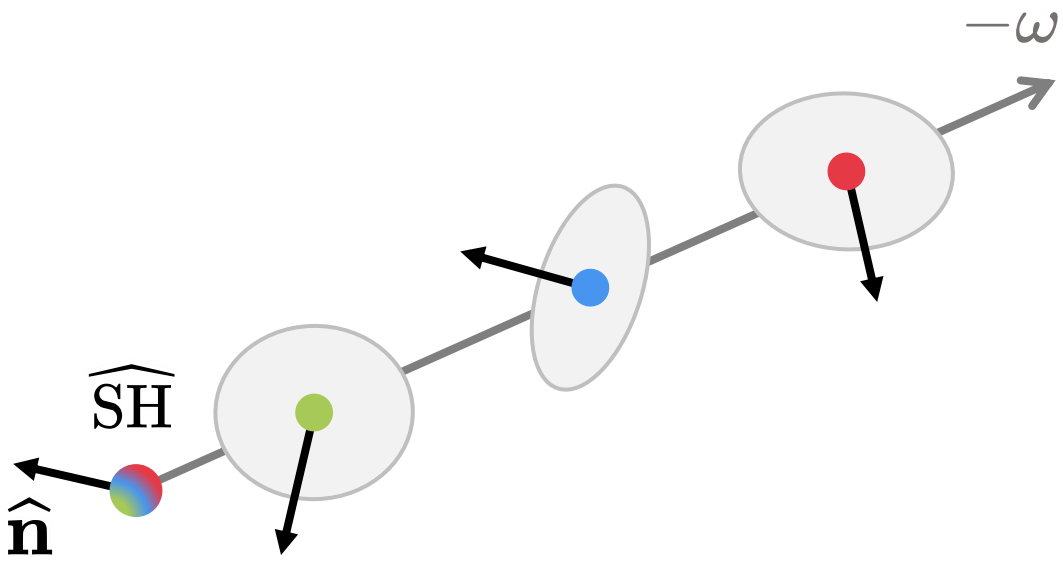
$$\widehat{\mathrm{SH}} = \mathrm{SH}_1 W_1 + \mathrm{SH}_2 W_2 + \mathrm{SH}_3 W_3$$

$$\mathbf{c}(\mathbf{r}) = \widehat{\mathrm{SH}}(\omega, \hat{\mathbf{n}})$$



Motivation

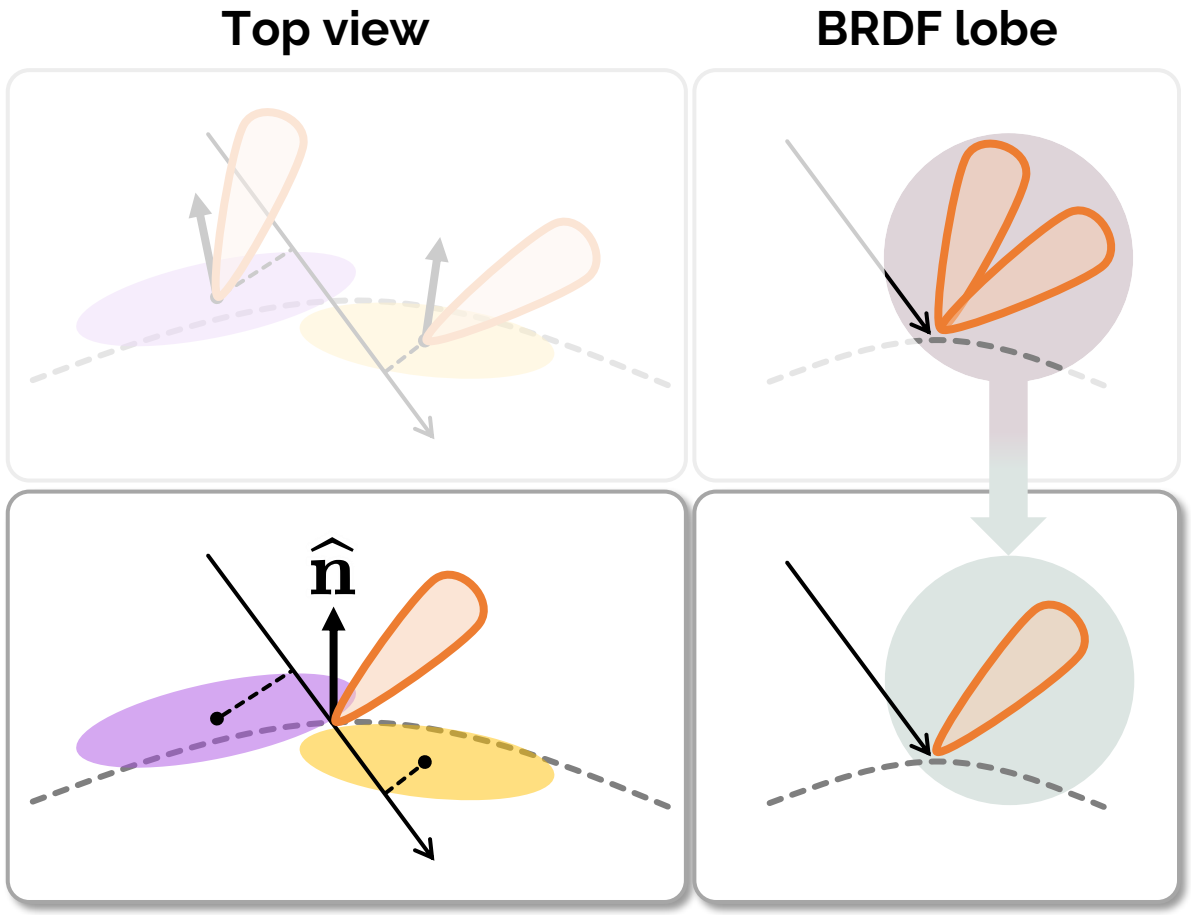
Deferred Shading



$$\hat{\mathbf{n}} = \mathbf{n}_1 W_1 + \mathbf{n}_2 W_2 + \mathbf{n}_3 W_3$$

$$\widehat{\mathrm{SH}} = \mathrm{SH}_1 W_1 + \mathrm{SH}_2 W_2 + \mathrm{SH}_3 W_3$$

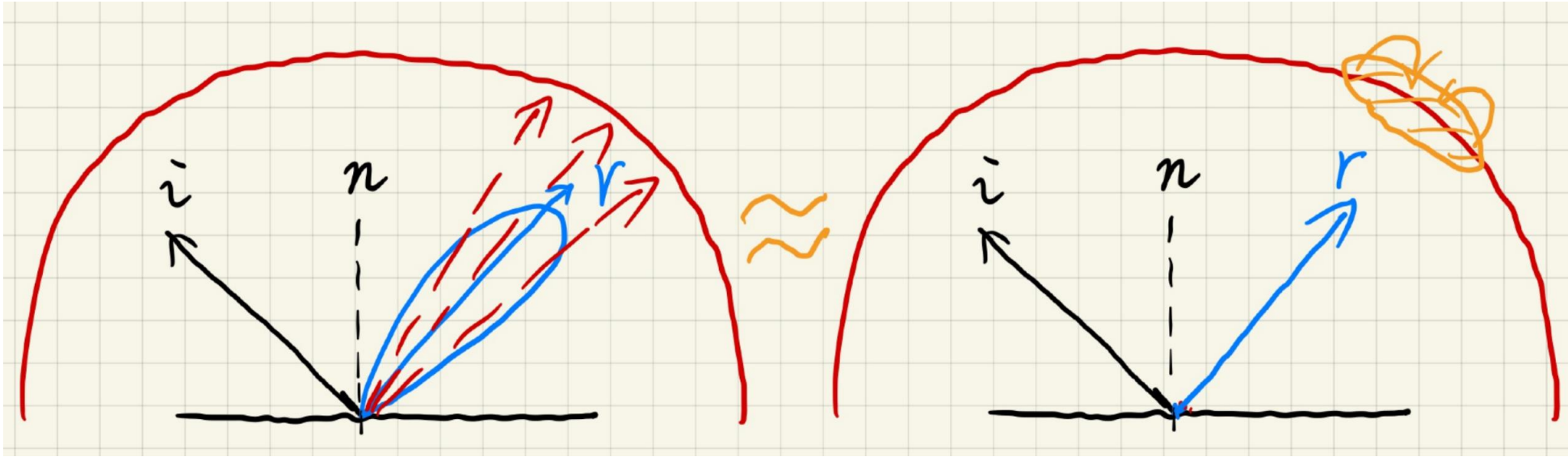
$$\mathbf{c}(\mathbf{r}) = \widehat{\mathrm{SH}}(\omega, \hat{\mathbf{n}})$$



Motivation

Pre-integrated Lighting

Brute-force integrals over the lighting are expensive 😳



$$\int_\Omega f(x)g(x)\,dx \approx \frac{\int_\Omega f(x)\,dx}{\int_\Omega dx} \cdot \int_\Omega g(x)\,dx$$

https://sites.cs.ucsb.edu/~lingqi/teaching/resources/GAMES202_Lecture_05.pdf

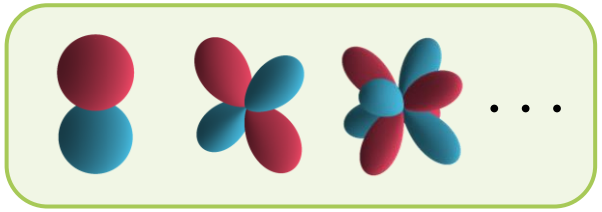
Motivation

Pre-integrated Lighting

Ref-NeRF
[Verbin et al., 2022]

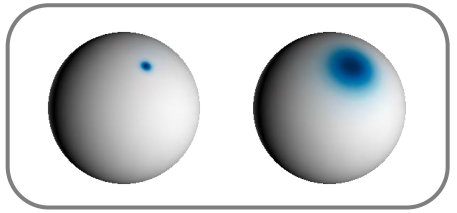
Implicit

Spherical Harmonics
Directional Encoding



*

Pre-filter
(von Mises-Fisher distribution)



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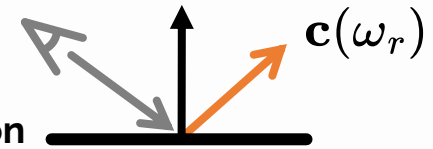
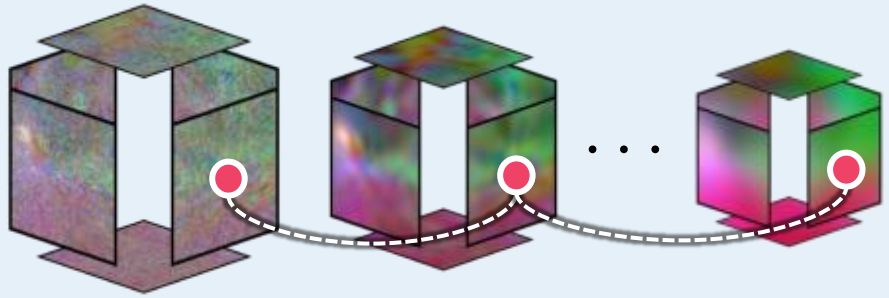
Reflection
Direction
Parameterization



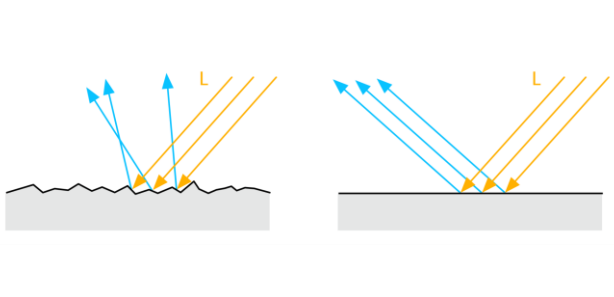
NDE
[Wu et al., 2024]

Explicit

Cubemap Grid
Directional Encoding

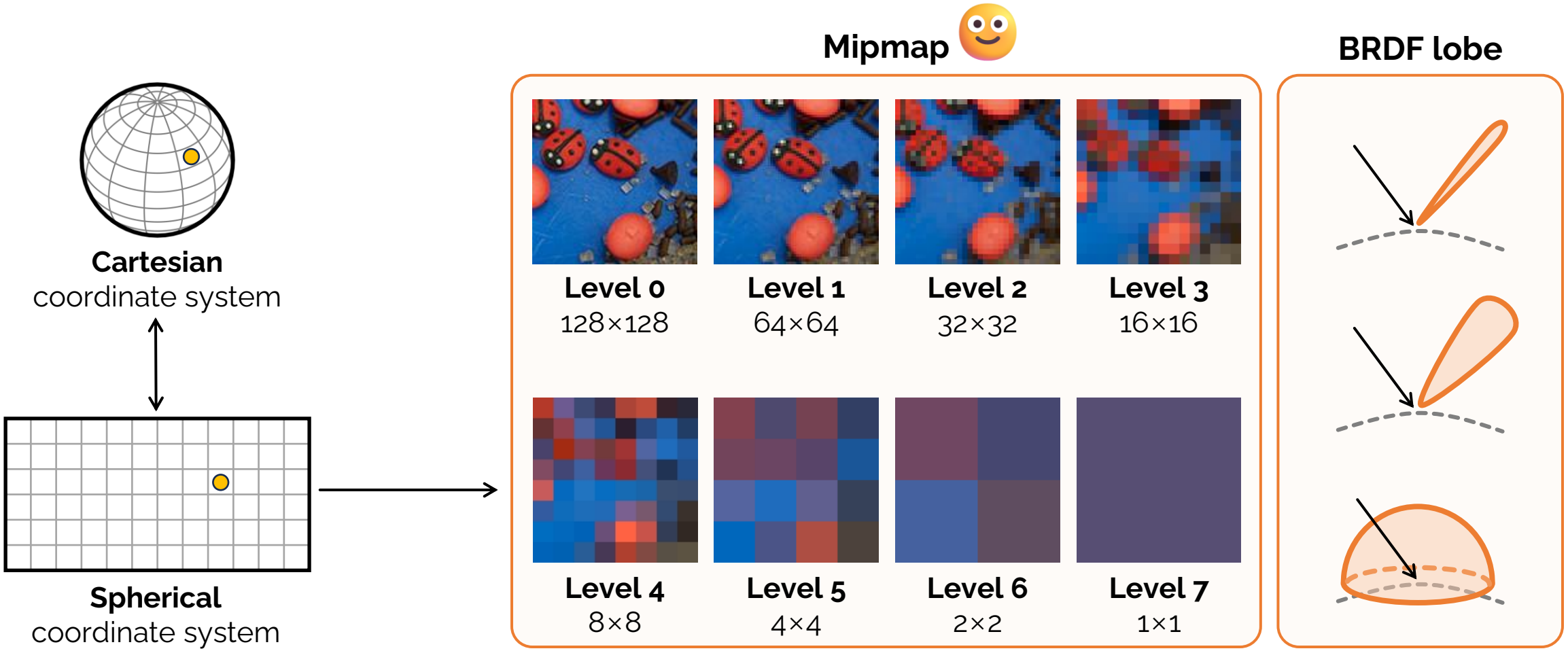


Pre-filter
(GGX distribution)



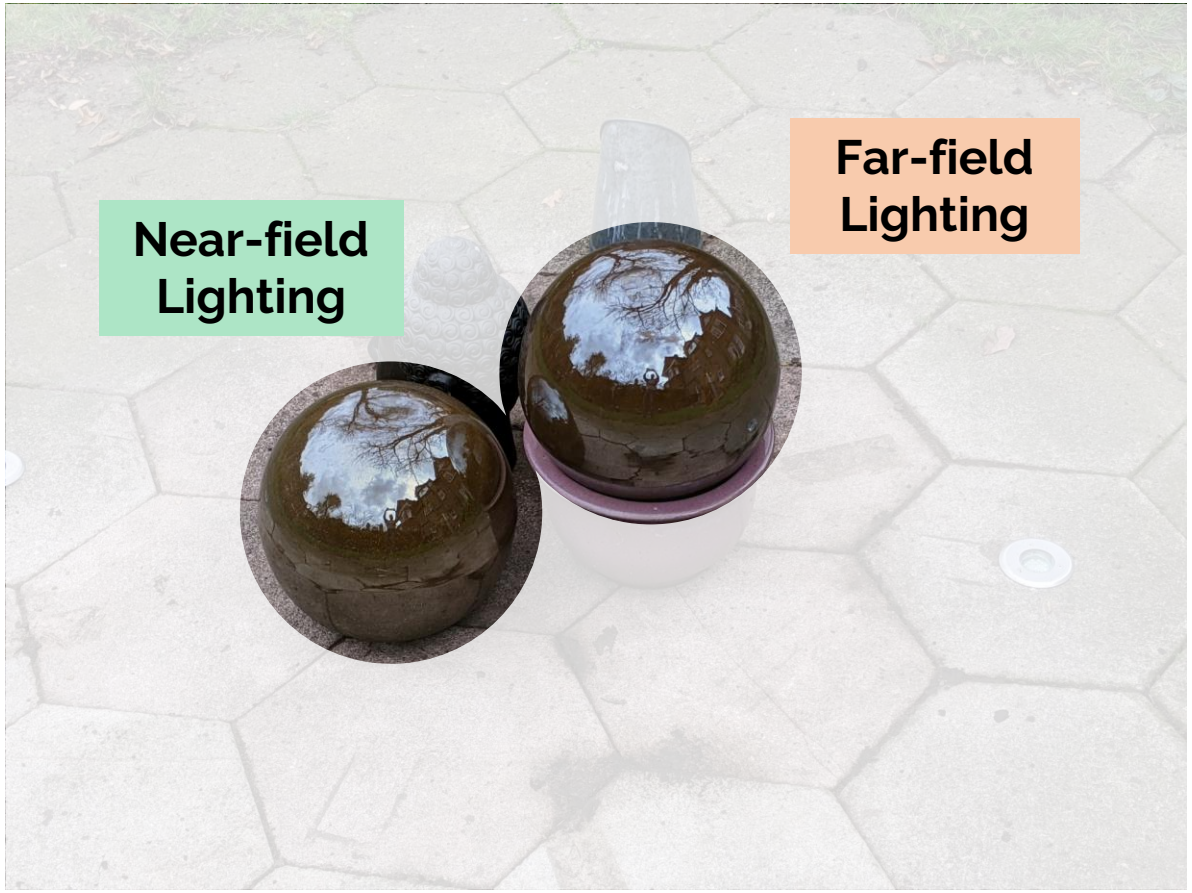
Motivation

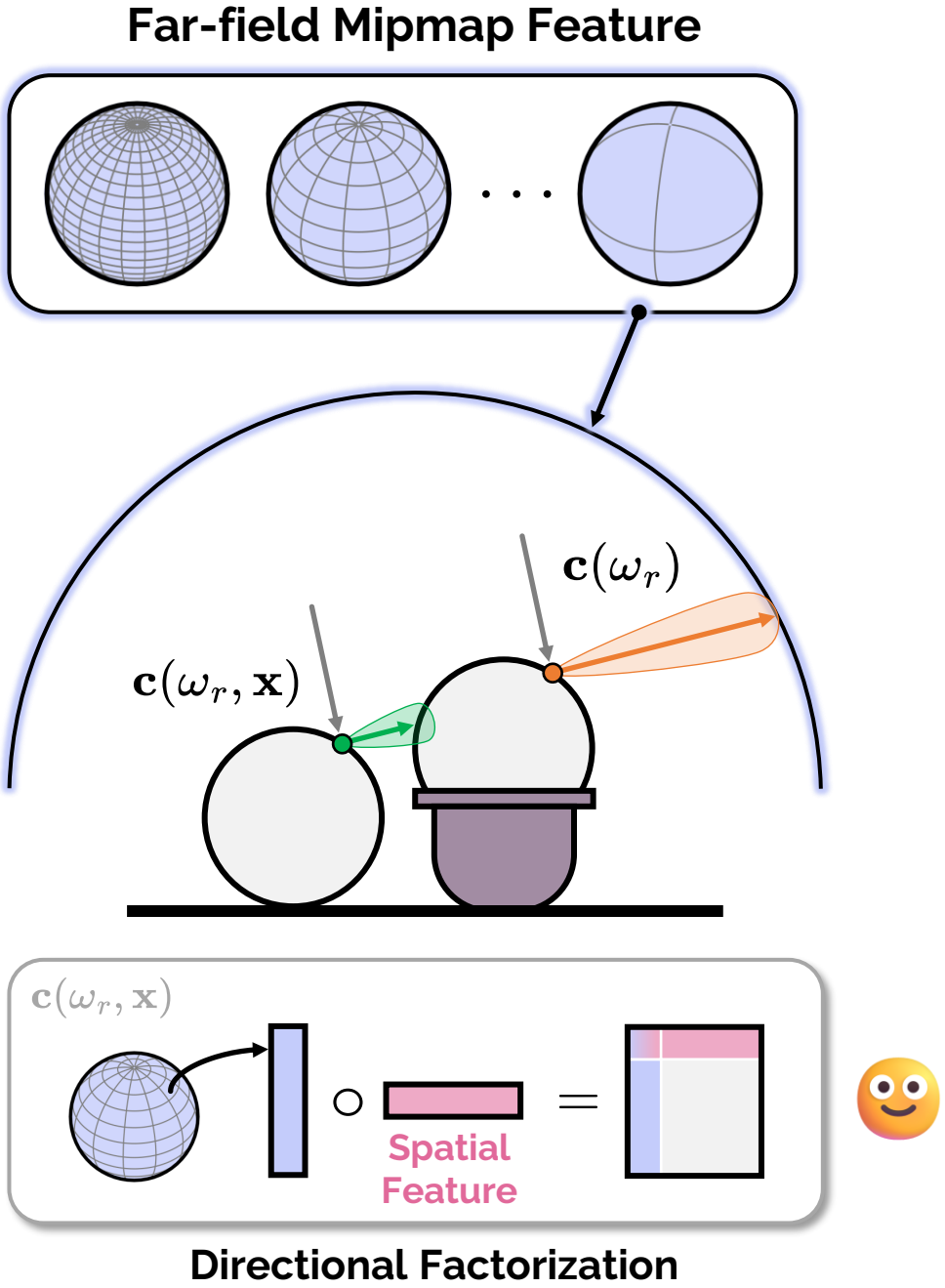
Pre-integrated Lighting



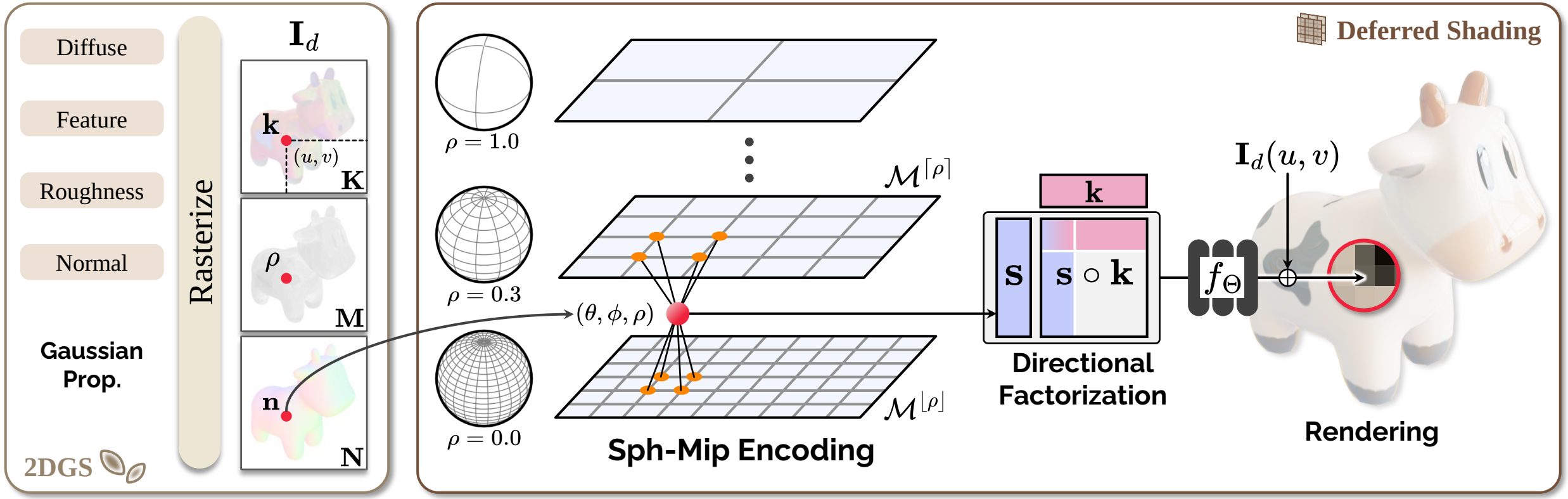
Motivation

Near-field Lighting ?

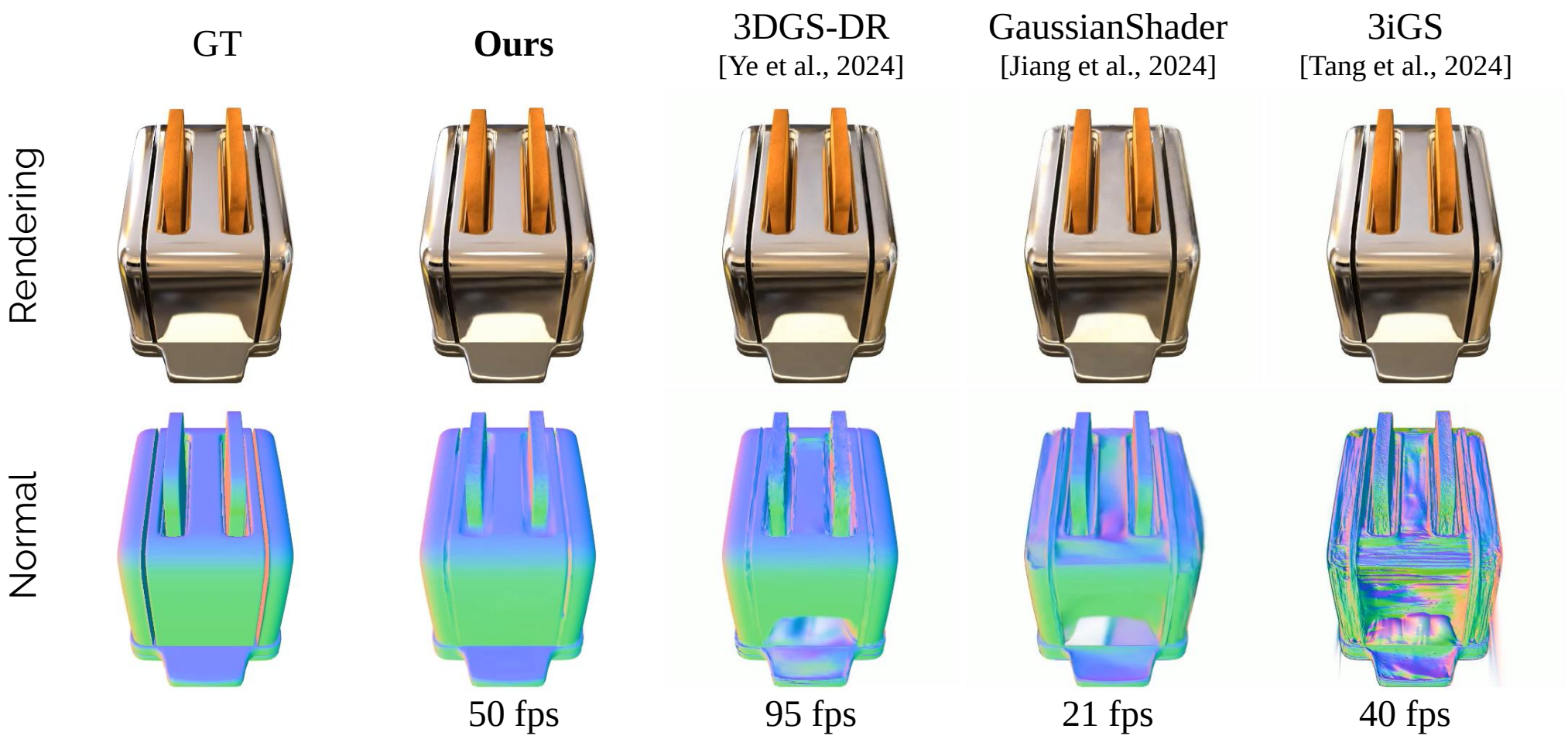




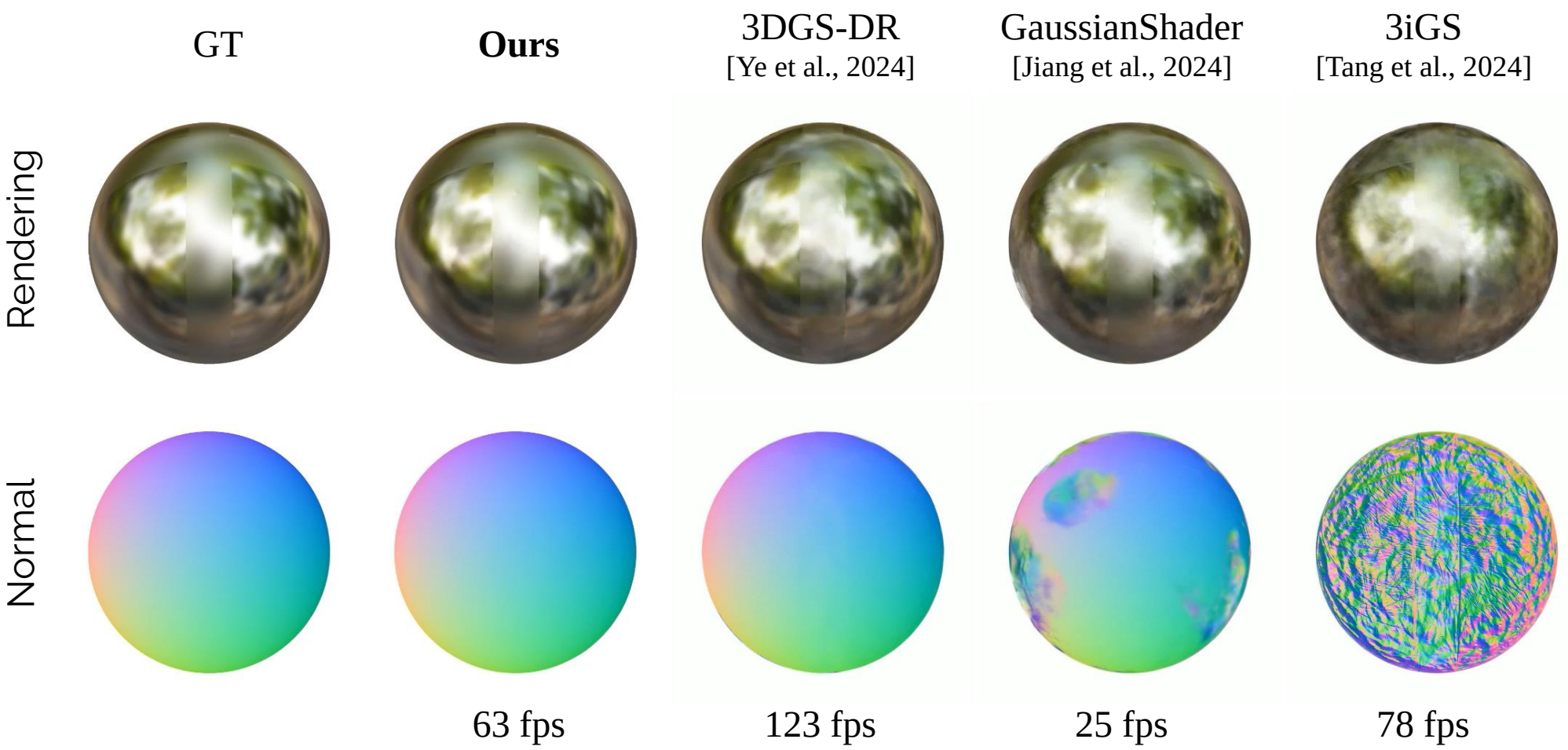
Method


Diffuse
Feature
Roughness
Normal
Gaussian Prop.
2DGS
Rasterize
$\mathbf{I}_d$
k
(u, v)
K
ρ
M
n
N
$\rho = 1.0$
$\rho = 0.3$
$\rho = 0.0$
$\mathcal{M}^{\lceil\rho\rceil}$
$\mathcal{M}^{\lfloor\rho\rfloor}$
(θ, ϕ, ρ)
Sph-Mip Encoding
k
S
s ∘ k
Directional Factorization
f_Θ
$\mathbf{I}_d(u, v)$
Deferred Shading
Rendering

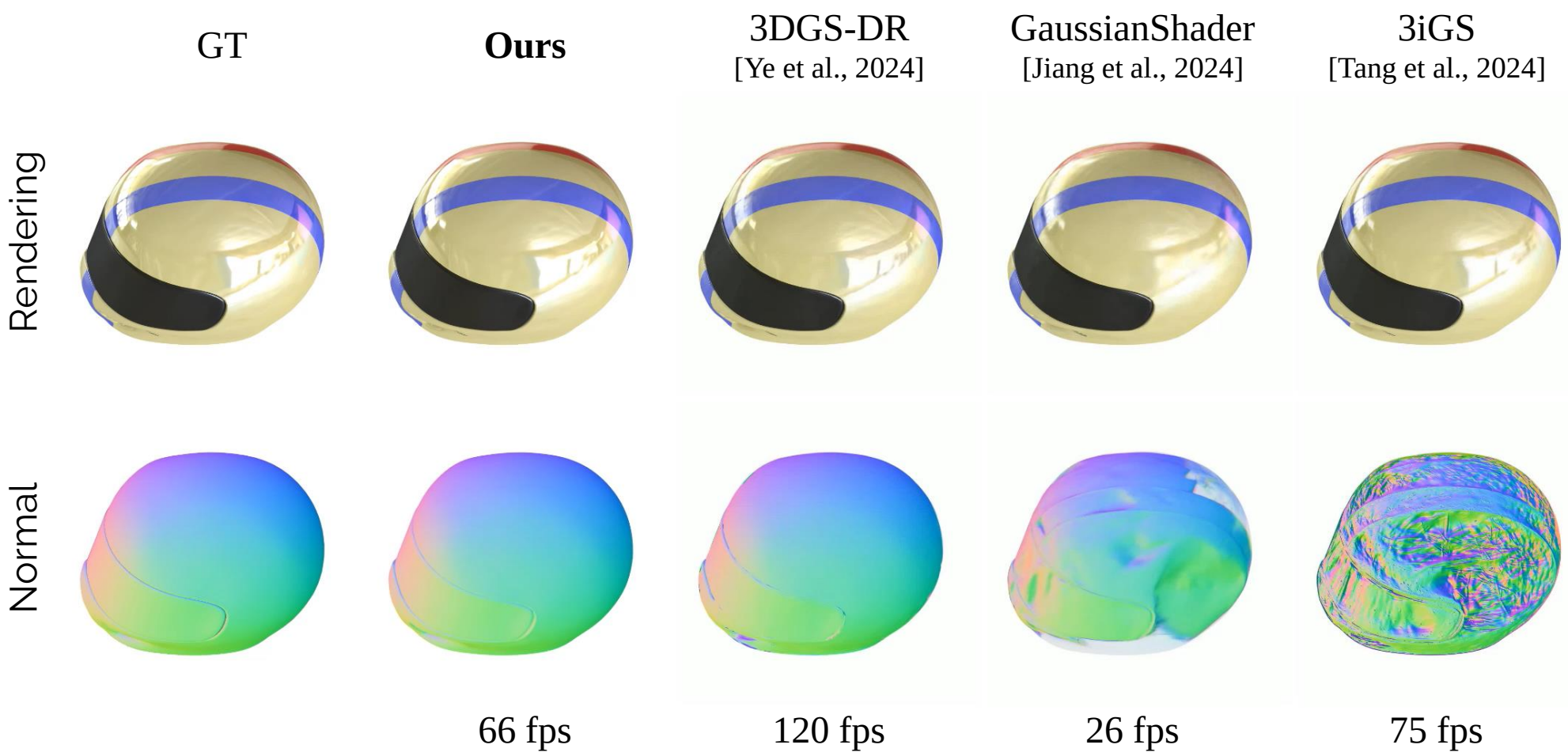
Result


GT
Ours
3DGS-DR
[Ye et al., 2024]
GaussianShader
[Jiang et al., 2024]
3iGS
[Tang et al., 2024]
Rendering
Normal
50 fps
95 fps
21 fps
40 fps

Result


GT
Ours
3DGS-DR
[Ye et al., 2024]
GaussianShader
[Jiang et al., 2024]
3iGS
[Tang et al., 2024]
Rendering
Normal
63 fps
123 fps
25 fps
78 fps

Result


GT
Ours
3DGS-DR
[Ye et al., 2024]
GaussianShader
[Jiang et al., 2024]
3iGS
[Tang et al., 2024]
Rendering
Normal
66 fps
120 fps
26 fps
75 fps

Result

w/o Deferred Shading

😟 **Popping artifacts**
Blurry rendering

Result

w/o Directional Factorization

😟 **Near-field Light**

Thanks for Listening!