

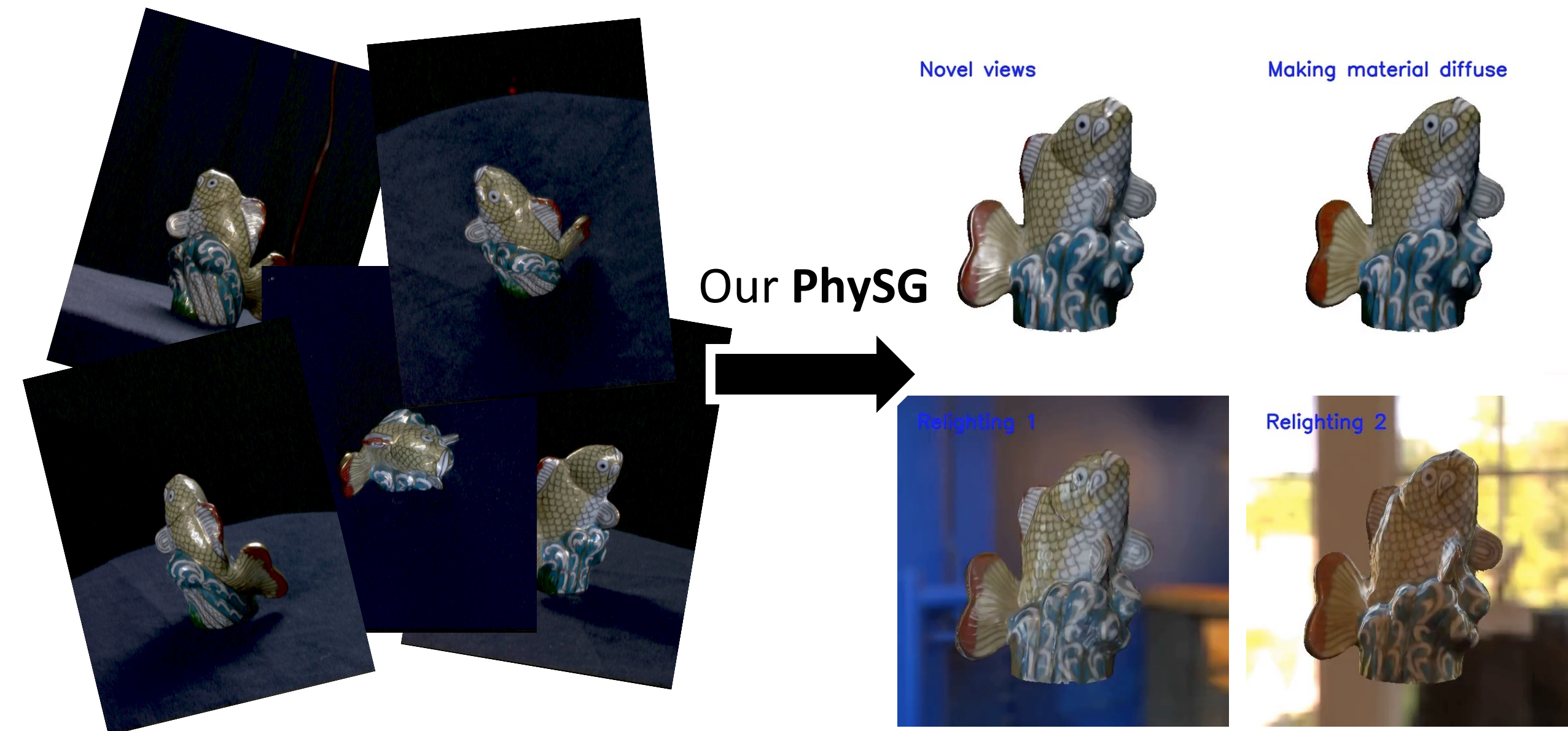
PhySG: Inverse Rendering with Spherical Gaussians for Physics-based Relighting and Material Editing

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Motivation: view synthesis + relighting + material editing



Our contribution: An efficient, differentiable framework for inverse rendering.

Assumptions: simplified rendering model.

We start from the rendering equation:

$$L_o(\omega_o; \mathbf{x}) = \int_{\Omega} L_i(\omega_i) f_r(\omega_o, \omega_i; \mathbf{x}) (\omega_i \cdot \mathbf{n}) d\omega_i$$

Approximate each term (lighting, material, cosine angle) with mixture of spherical Gaussians G in *closed-form*:

Incoming light

$$L_i(\omega_i) = \sum_{k=1}^M G(\omega_i; \xi_k, \lambda_k, \mu_k)$$

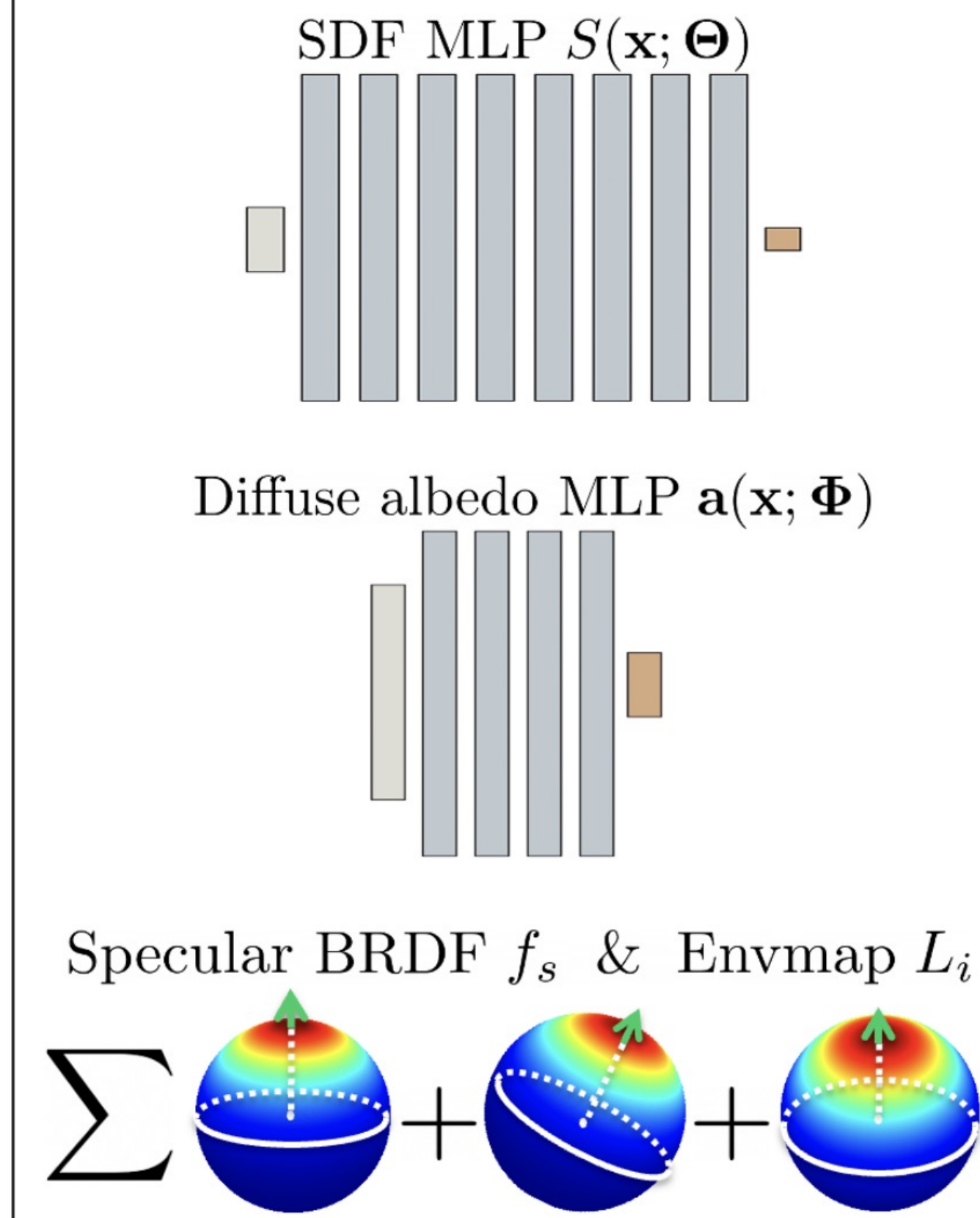
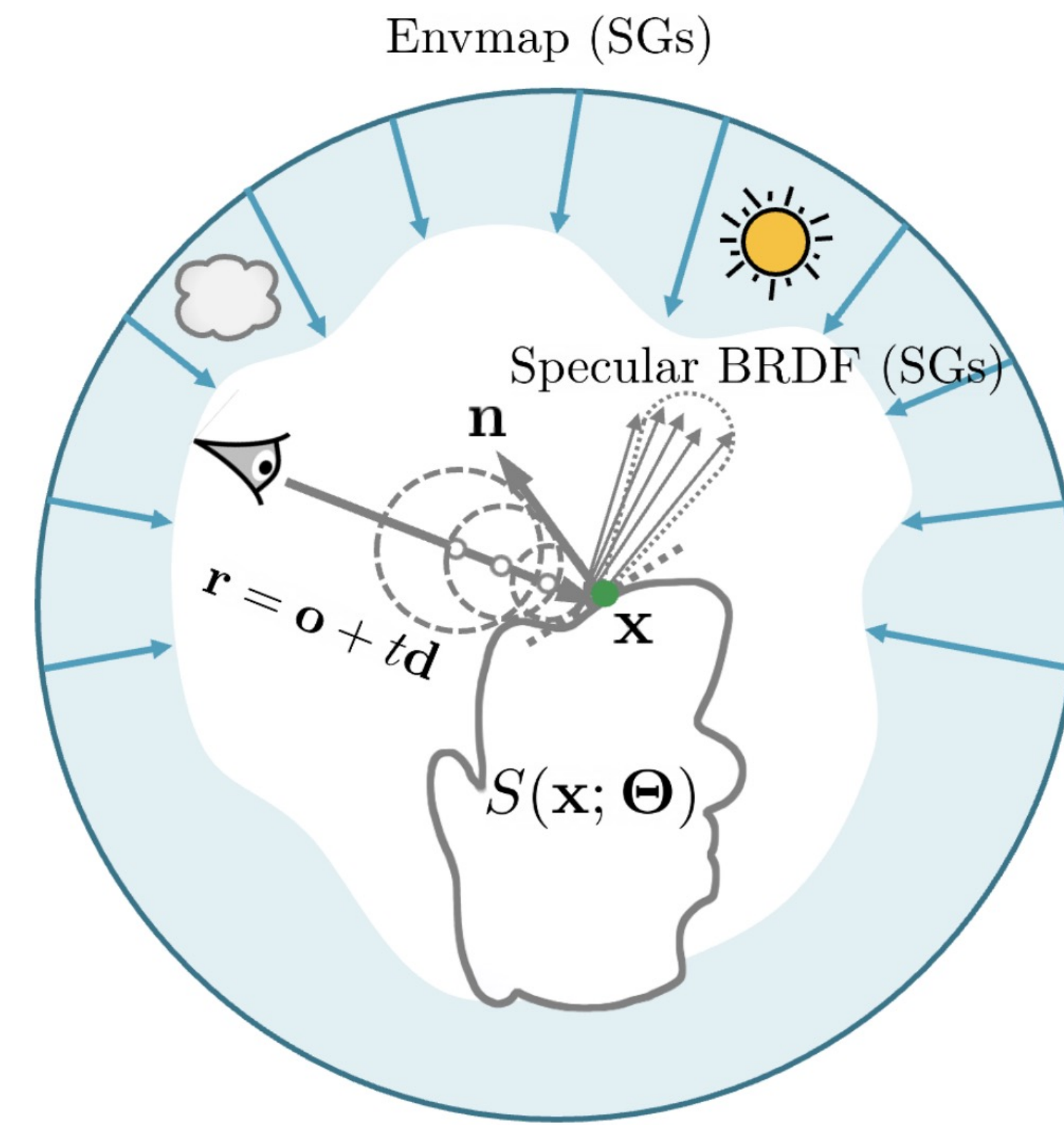
Surface reflectance

$$f_s(\omega_o, \omega_i; \mathbf{x}) = G(\mathbf{h}; \mathbf{n}, \frac{\lambda}{4\mathbf{h} \cdot \omega_o}, \mathcal{M}_{\mathbf{x}}\mu)$$

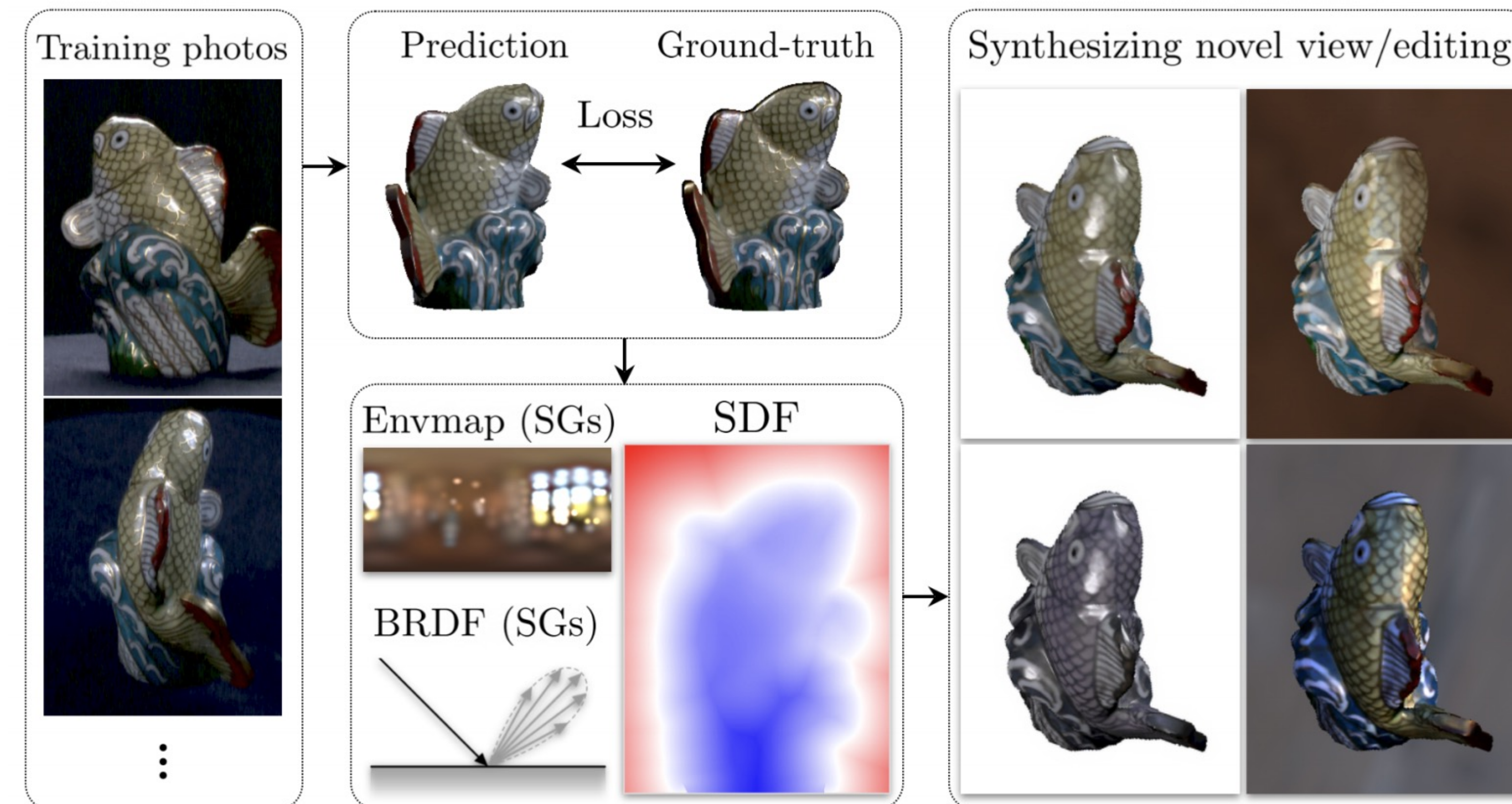
Cosine term

$$\omega_i \cdot \mathbf{n} \approx G(\omega_i; 0.0315, \mathbf{n}, 32.7080) - 31.7003$$

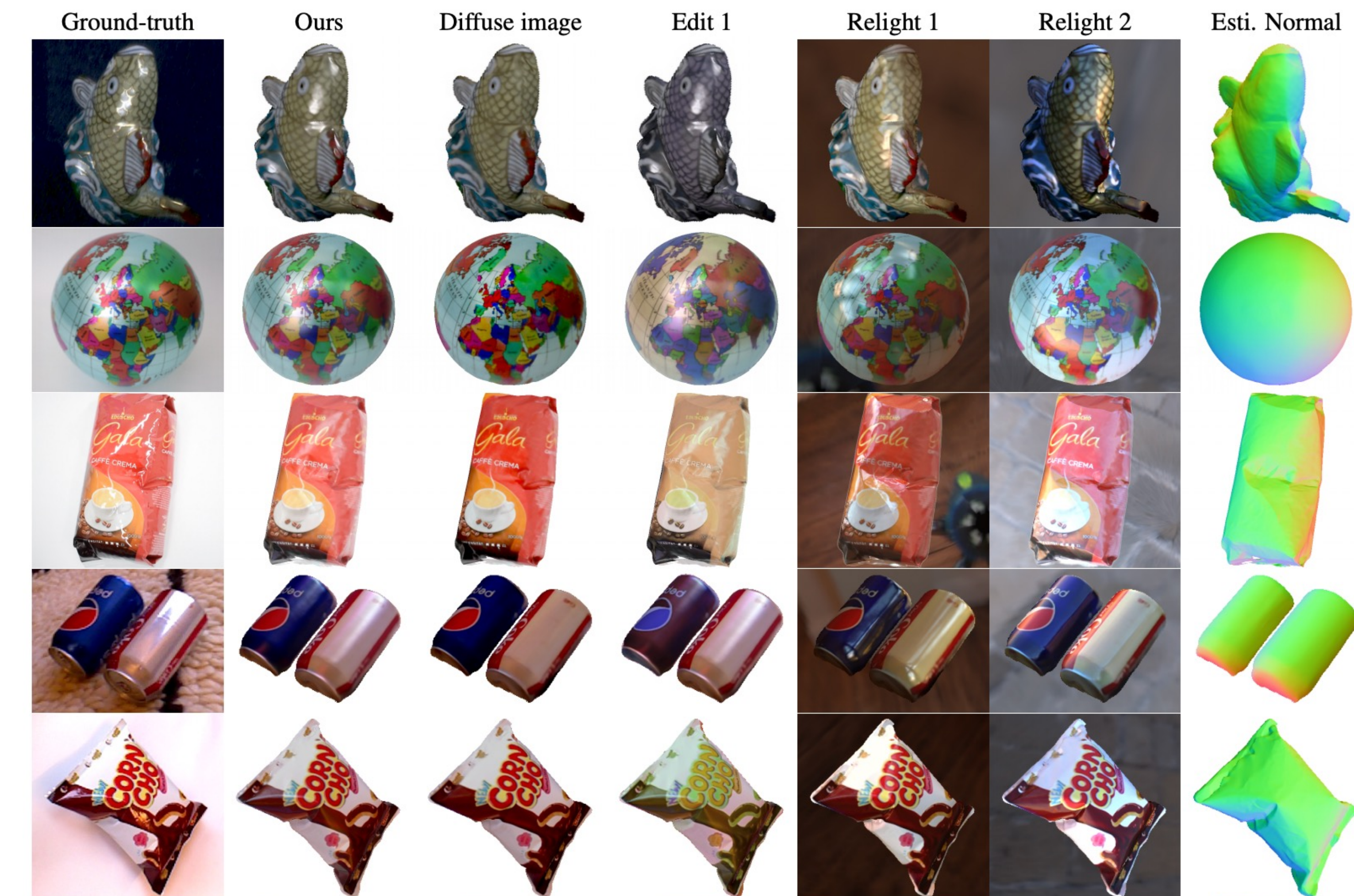
The PhySG rendering system:



PhySG enables efficient end-to-end differentiable inverse rendering.



Results and comparisons:



Comparison of view extrapolation

	↓ LPIPS
DVR	0.1300
NeRF	0.0534
IDR	0.0188
Our PhySG	0.0170

Comparison of surface normal error

	↓ Surface normal error (°)
DVR	38.90
NeRF	36.05
IDR	2.207
Our PhySG	2.528

Limitations:

- Lack modelling of self-occlusion and indirect illumination
- Specular BRDF is not spatially-varying
- Require object segmentation masks

Acknowledgements

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Code available!
Project website:

tinyurl.com/PhySG-web

