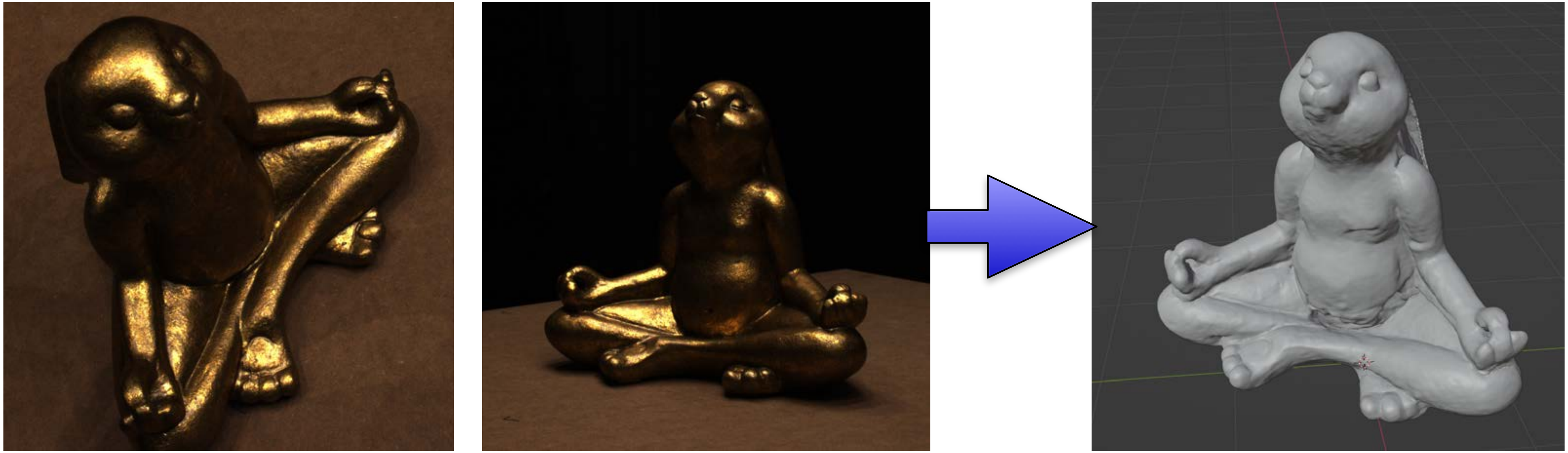
Neural Radiance Fields and Surfaces

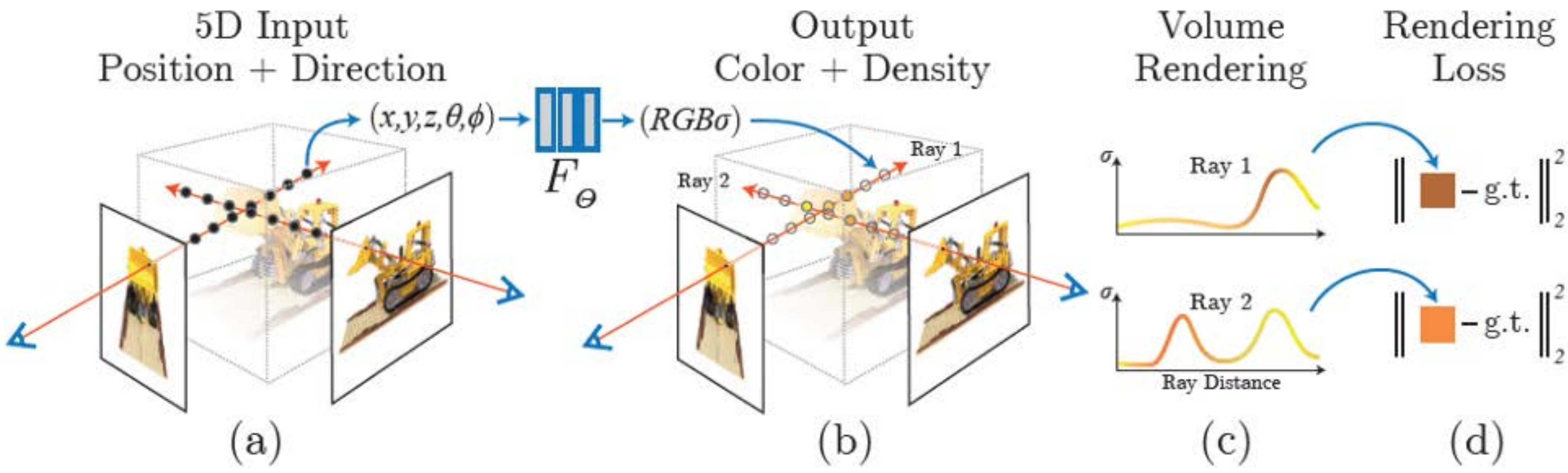


Neural Radiance Fields

Multiple views of a complex scene

Mildenhall et al., ECCV'20

Neural Radiance Fields



A. Sampling 5D coordinates---location x, y, z and viewing direction θ, ϕ---along camera rays.
B. Feeding those locations into an MLP to produce a color and volume density.
C. Using volume rendering techniques to composite these values into an image.
D. Optimizing scene representation by minimizing the residual between synthesized and ground truth images.

Physically Inspired Volume Rendering

For a ray $\mathbf{r}(t) = \mathbf{o} + t\mathbf{d}$, the rendered color can be computed as

$$C(\mathbf{r}) = \int_{t_n}^{t_f} T(t)\sigma(\mathbf{r}(t))\mathbf{c}(\mathbf{r}(t), \mathbf{d})dt$$

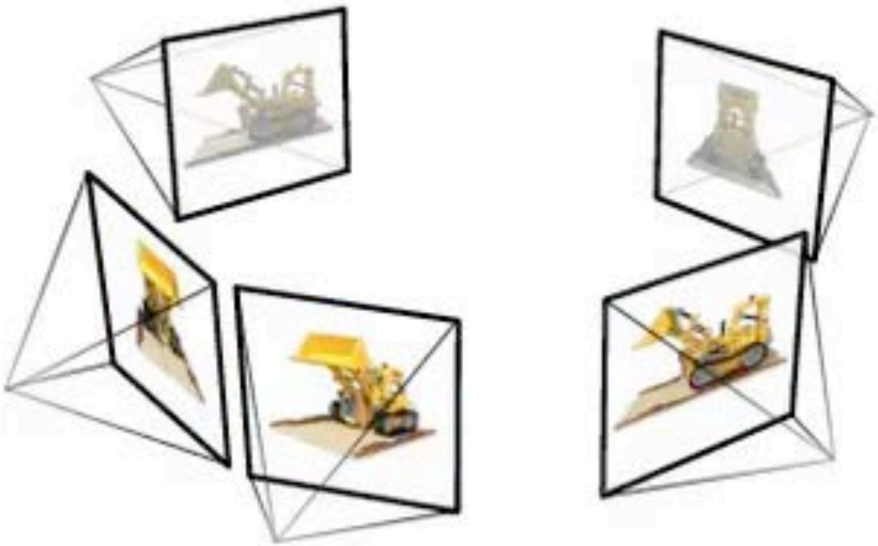
Density

Color

with $T(t) = \exp\left(-\int_{tn}^{t_f} \sigma(\mathbf{r}(s))ds\right)$

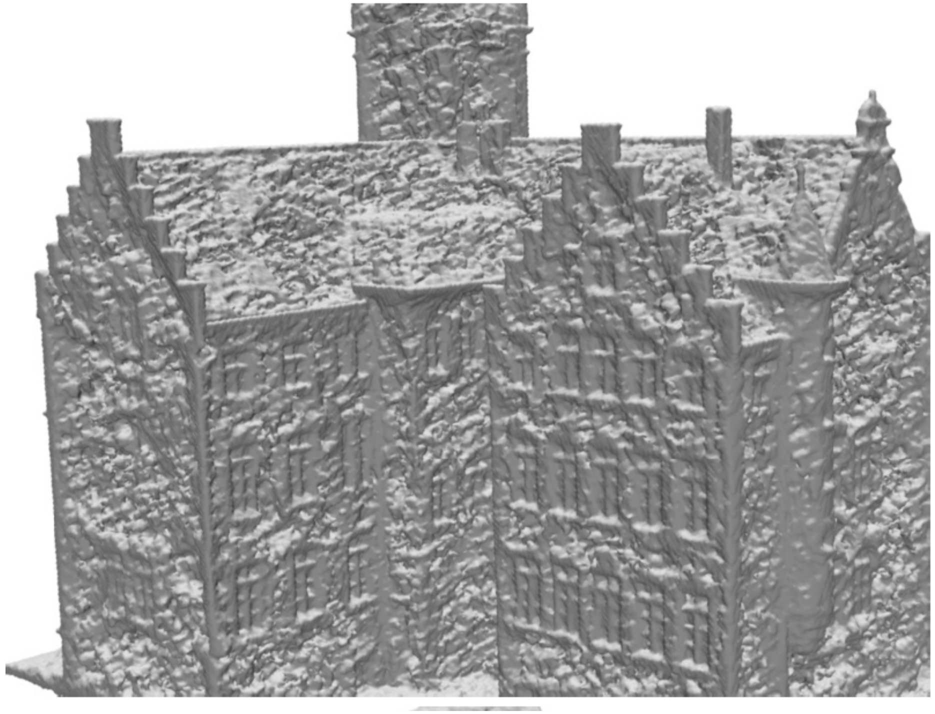
Transparency

Neural Rendering



Given a few images of a tractor

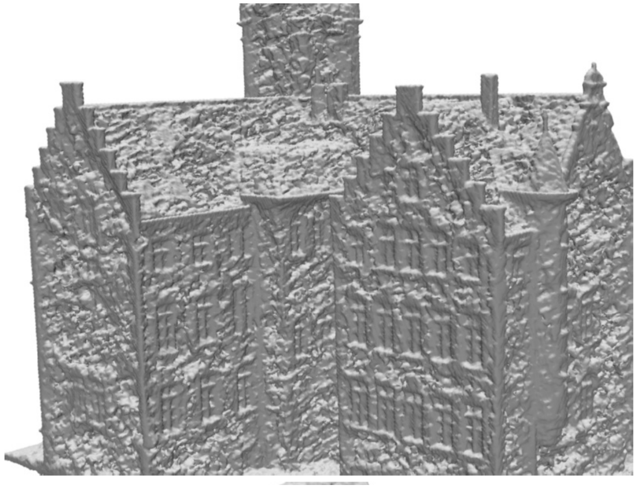
Thresholding the Density



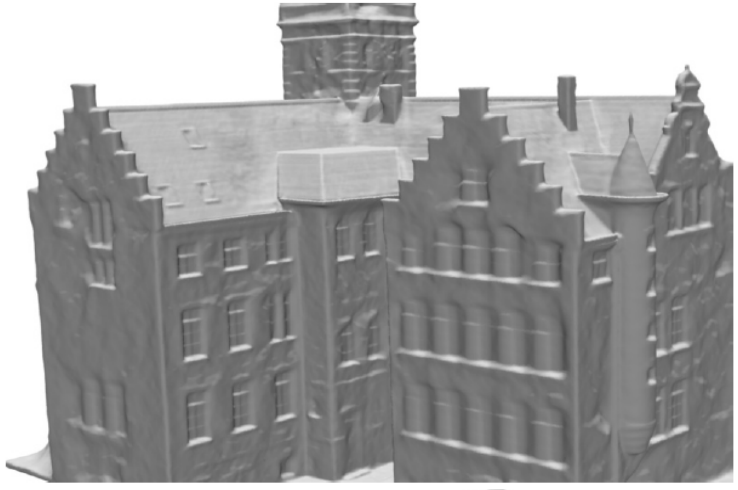
- Surfaces obtained by thresholding the density
- Choosing the threshold can be problematic

From NerF to NeuS

Image



NeRF



NeuS

- Volume density is expressed a function of an SDF
- The reconstructed surfaces are smoother

From Interpolation to Reconstruction

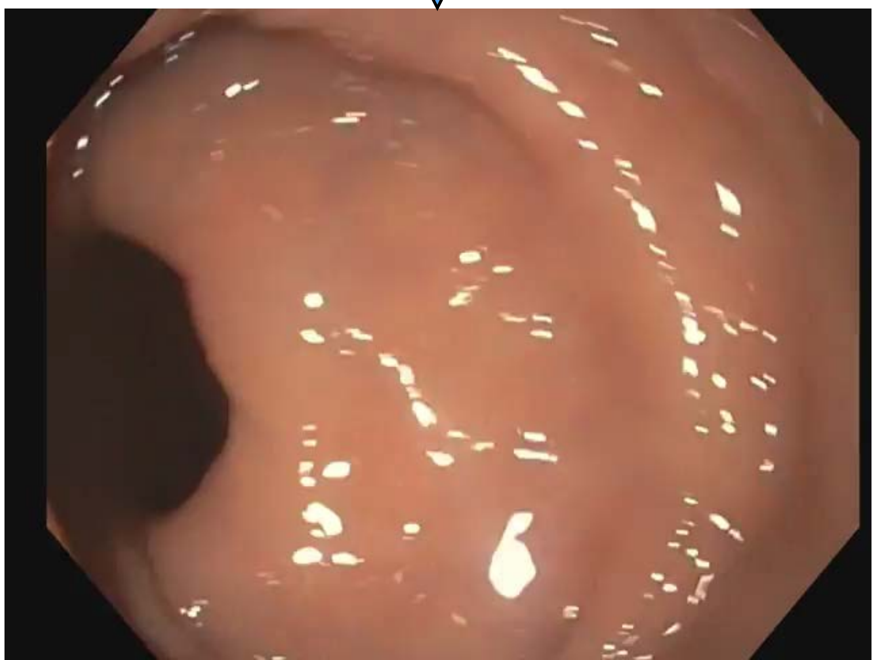

Images of a shiny statue

View Interpolation

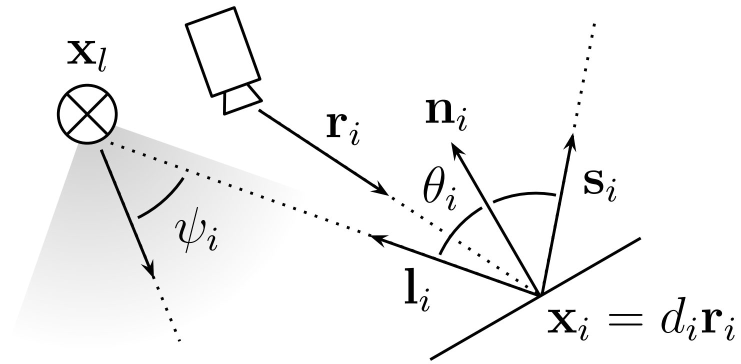
3D Reconstruction

Reminder: Colonoscopy

+



Reminder: Endoscopic Lighting Model

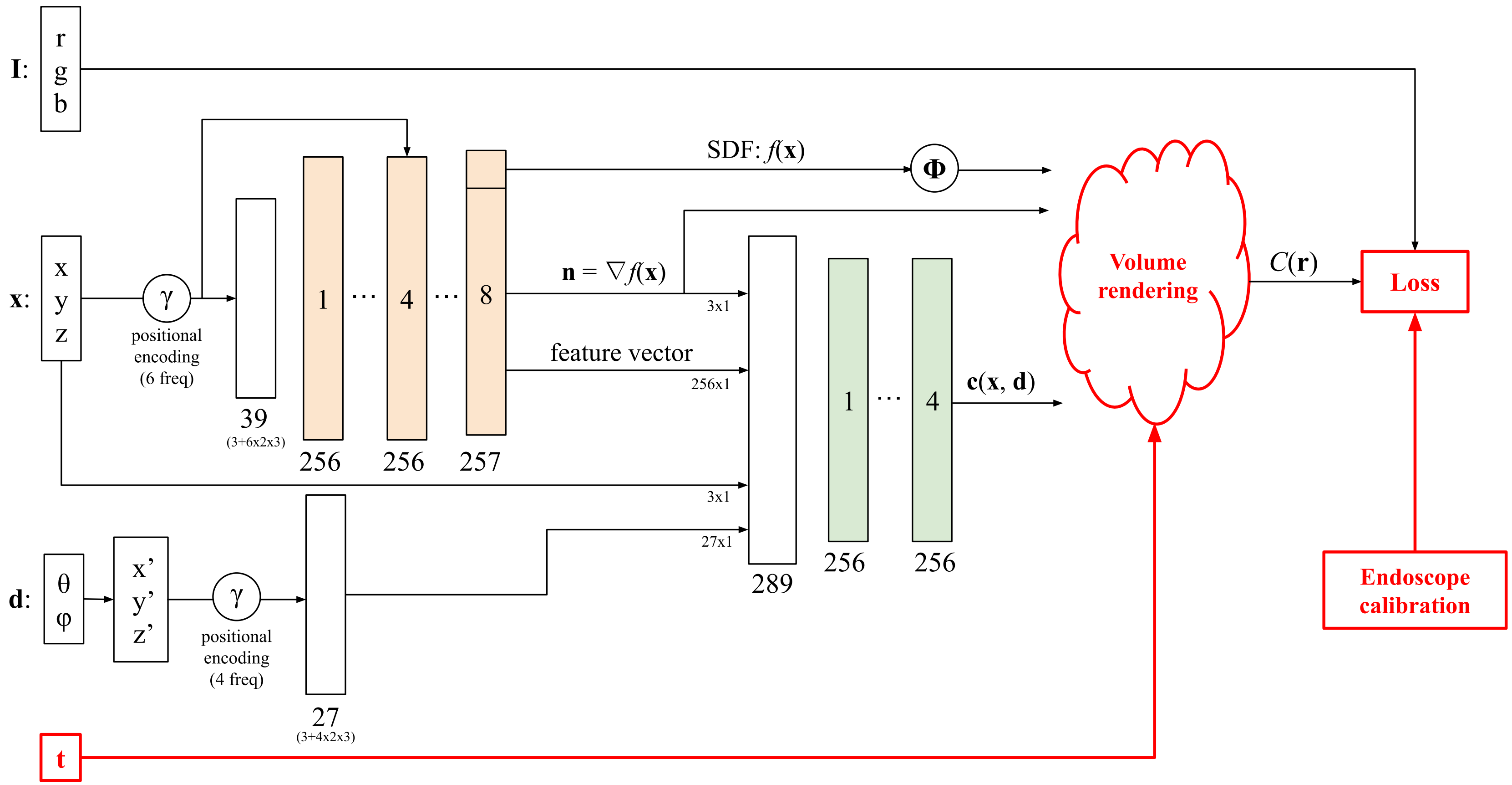


$$\mathcal{I}(d_i, \rho_i, g) = \left(\frac{\sigma_0}{\|\mathbf{x}_i - \mathbf{x}_l\|^2} R(\psi_i) \cos\left(\theta_i\right) \; \rho_i \; g \right)^{1/\gamma}$$

- The light source is a spotlight that is co-located with the camera.
- It is close to the target surfaces.

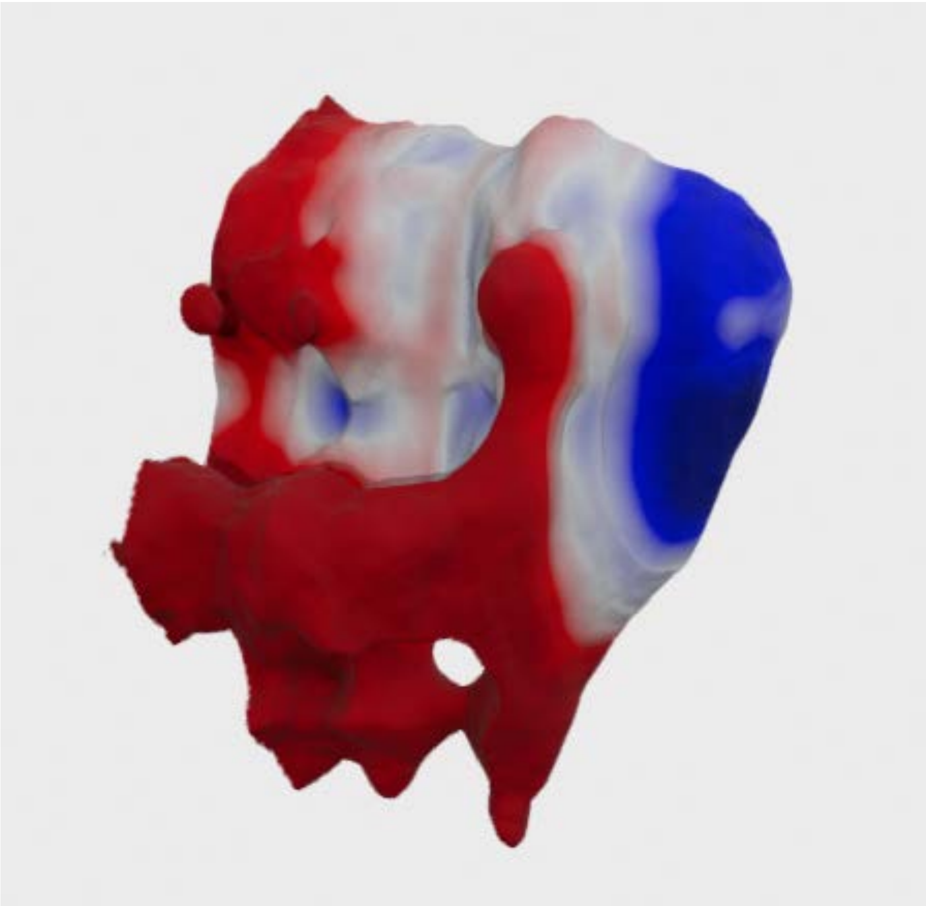
—> Intensity decay as a function of $\dfrac{1}{d^2}$.

NeuS Pipeline

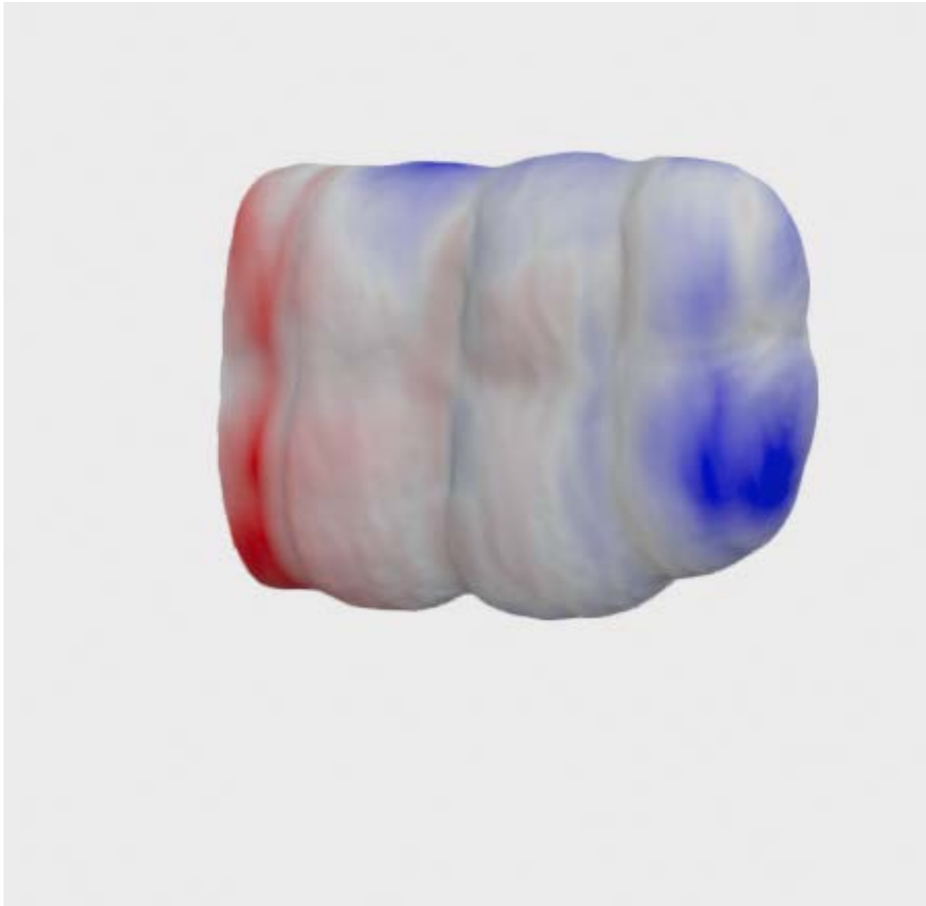


- Calibrating the endoscope.
- Explicitly incorporating light decay into the NeuS renderer.

Importance of Light Decay



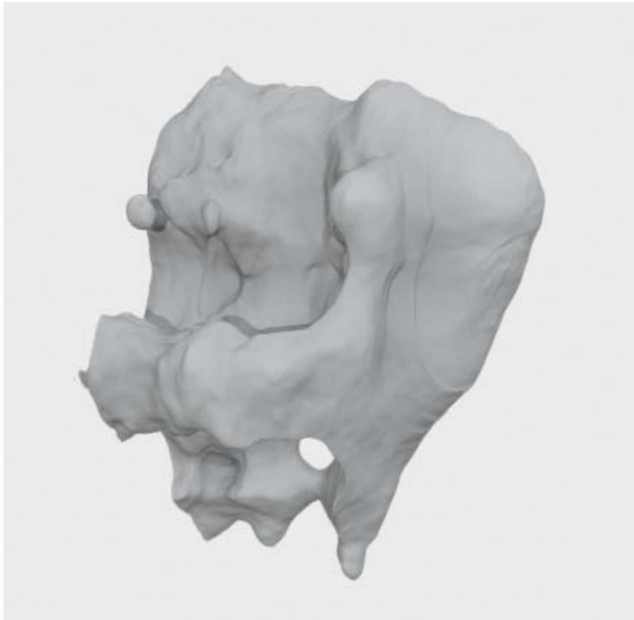
Without LD



With LD

Importance of Light Decay

Ground truth



Without LD

With LD

Properly modeling the physics matters!