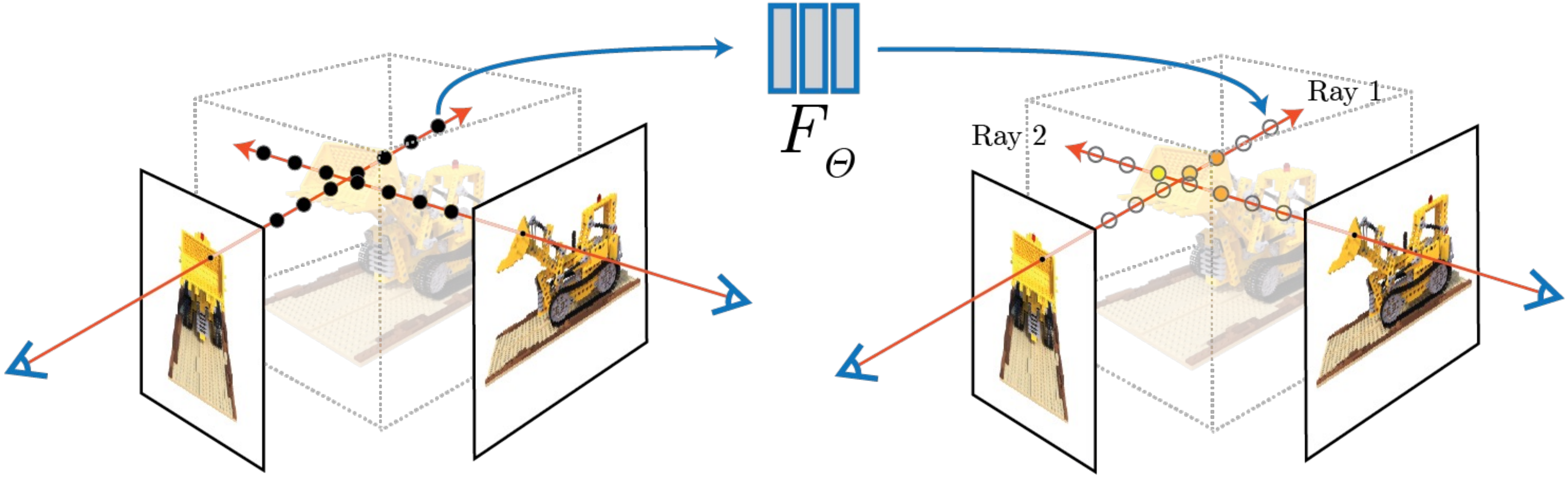
POINTNERF

POINT-BASED NEURAL RADIANCE FIELDS

2022, Xu et al.,
University of Southern California and Adobe Research

NERF



NeRF: Representing scenes as neural radiance fields for view synthesis
2020, Mildenhall et al.

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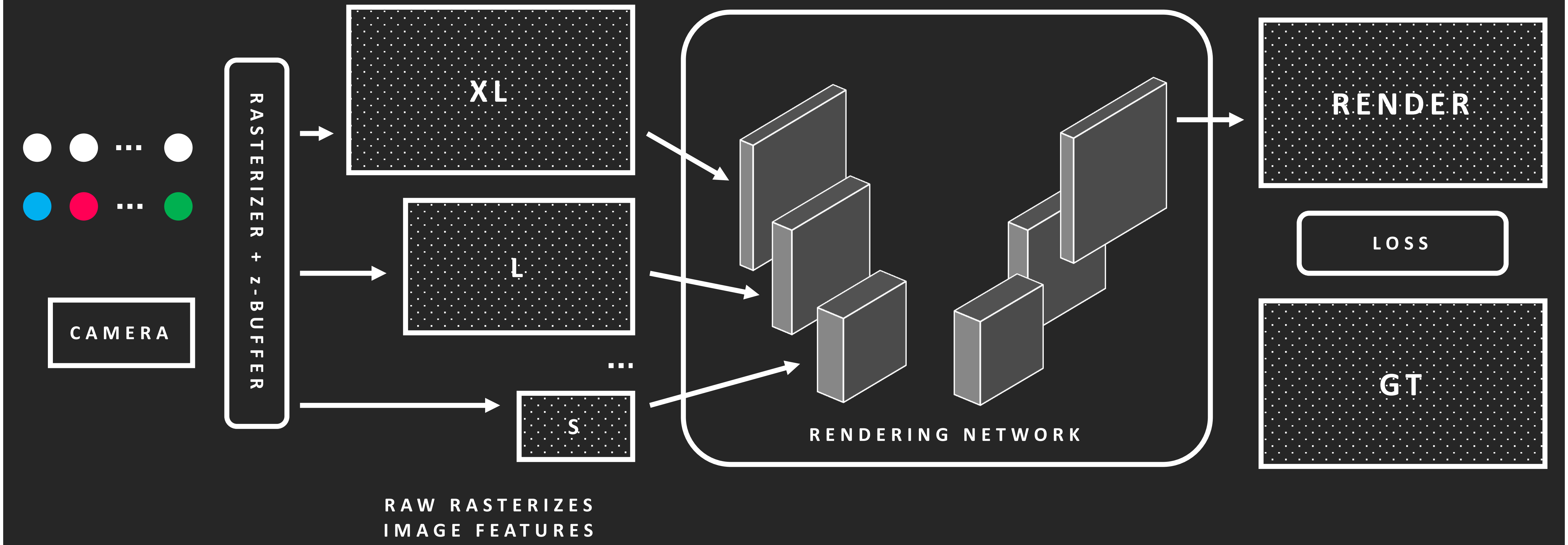
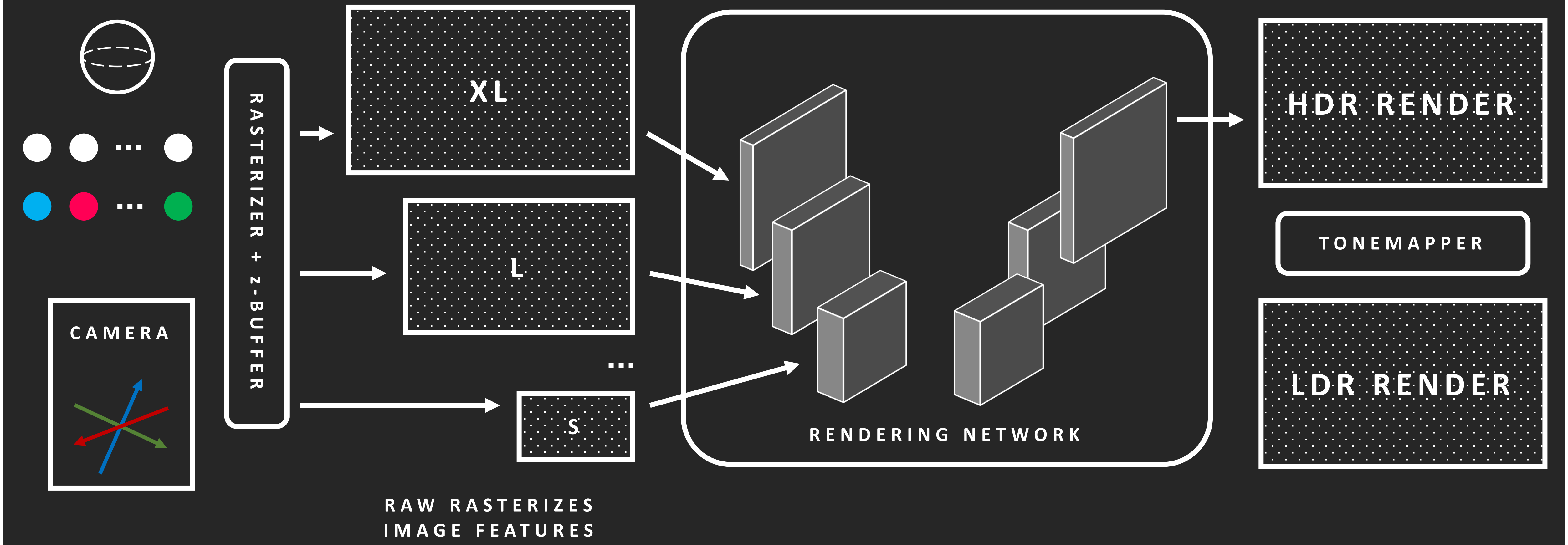
PointNeRF: Point-based Neural Radiance Fields
2022, Xu et al.

NEURAL PBG



Neural Point-based Graphics
2020, Aliev et al.

ADOP



ADOP: Approximate Differentiable One-pixel Point Rendering
2022, Rückert et al.

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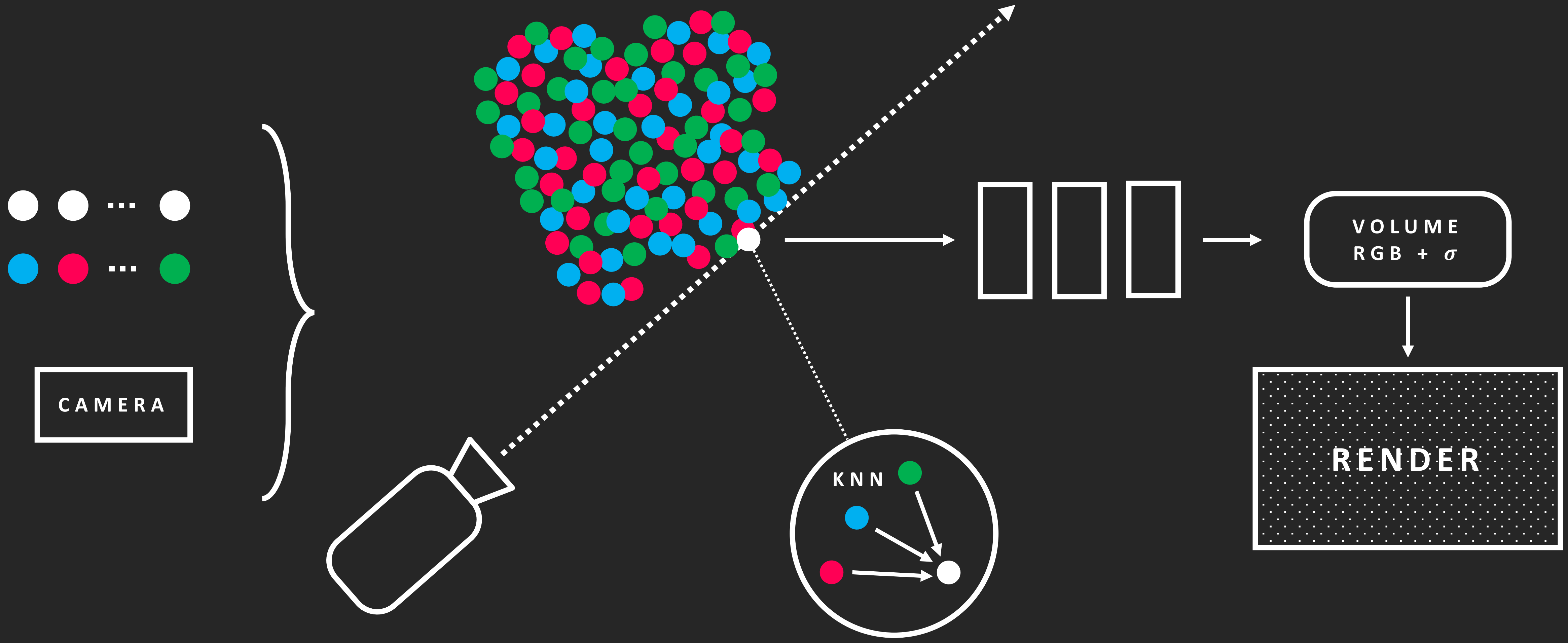

PointNeRF: Point-based Neural Radiance Fields
2022, Xu et al.

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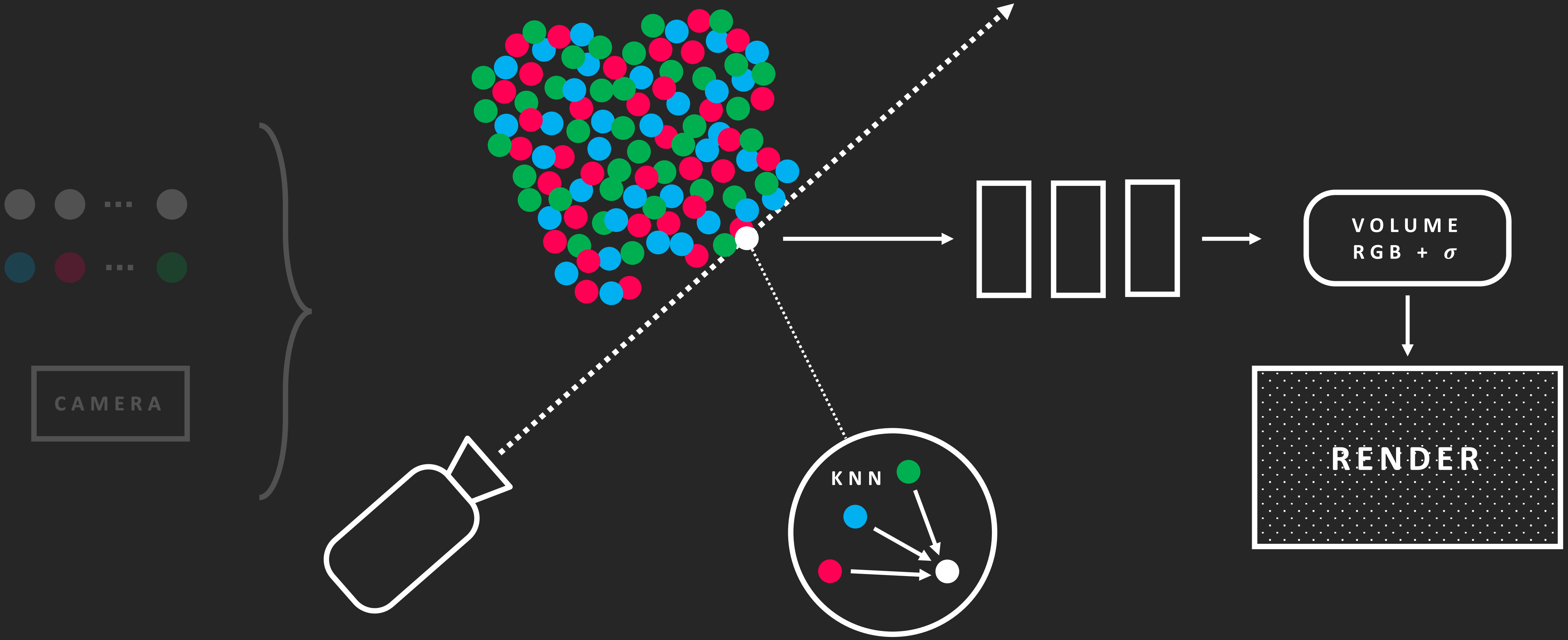

PointNeRF: Point-based Neural Radiance Fields
2022, Xu et al.

VOLUME RENDERING AND RADIANCE FIELDS

$$c = \sum_{M} \tau_j (1 - exp(-\sigma_j \Delta_j)) r_j , \qquad \tau_j = exp(-\sum_{t=1}^{j-1} \sigma_t \Delta_t)$$

Accumulated radiance c from M sampled shading points x_j along a ray

$$C = \int_0^T \tau(t) \sigma(t) r(t) dt , \qquad \tau(t) = exp(-\int_0^t \sigma(s) ds)$$

$$c = \sum_{M} (\tau_j - \tau_{j+1}) r_j$$

Local and Global Illumination in the Volume Rendering Integral
Section 2.3, 1998, Max and Chen

POINT-BASED RADIANCE FIELD

$$P = \{(p_i, f_i, \gamma_i) \mid i = 1, \ldots, N\}$$

$$(\sigma, r) = PointNeRF(x, d, p_1, f_1, \gamma_1, \ldots, p_K, f_K, \gamma_K)$$

$$f_{i,x} = F(f_i, x - p_i) \ \rightarrow \ f_x = \sum_i \gamma_i \frac{\omega_i}{\sum_t \omega_t} f_{i,x}, \qquad \omega_i = \frac{1}{\| p_i - x \|}$$

$$r = R(f_x, d)$$

$$\sigma_i = T(f_{i,x}) \ \rightarrow \ \sigma = \sum_i \gamma_i \frac{\omega_i}{\sum_t \omega_t} \sigma_i, \qquad \omega_i = \frac{1}{\| p_i - x \|}$$

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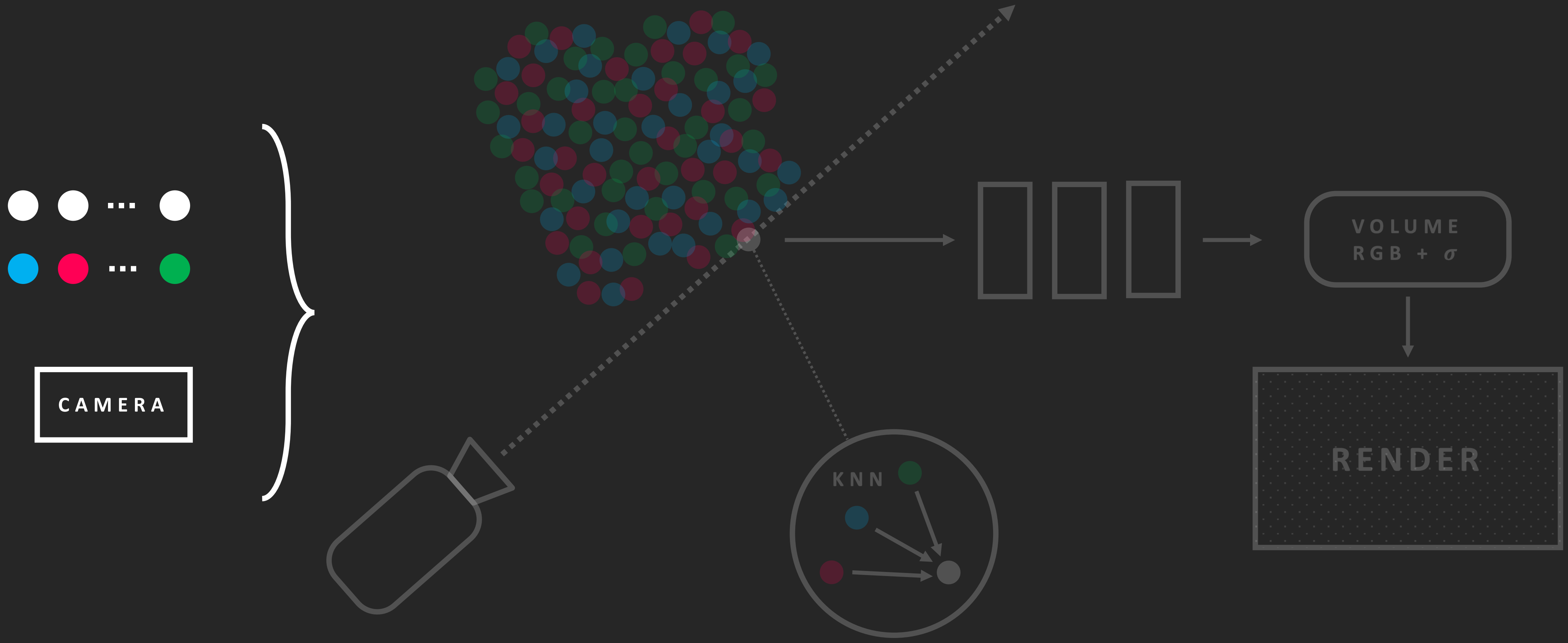
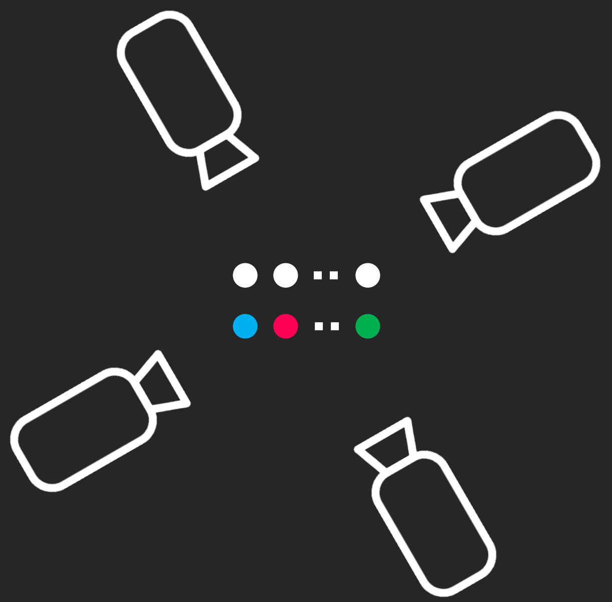
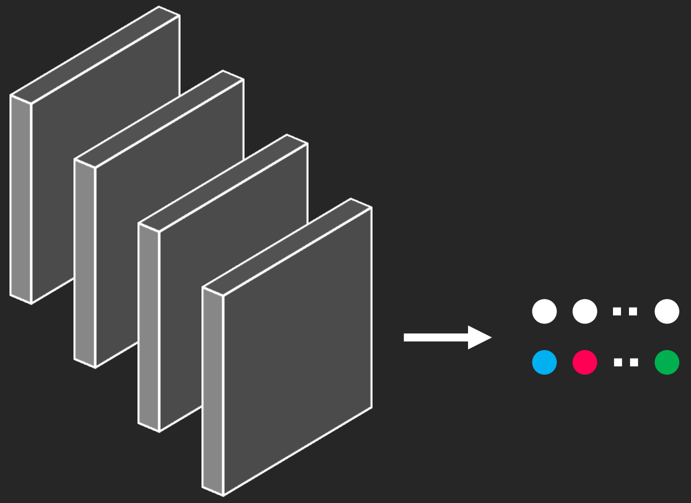


PointNeRF: Point-based Neural Radiance Fields
2022, Xu et al.

INITIAL POINT-BASED RADIANCE FIELDS





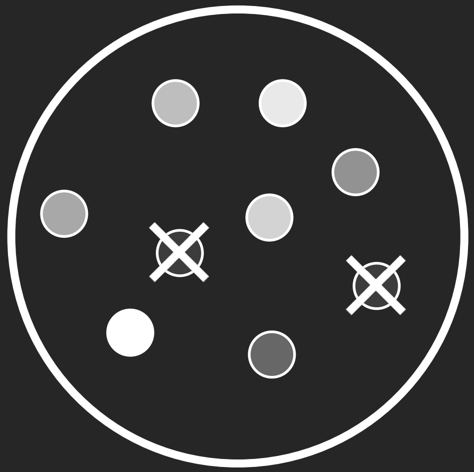
COLMAP POINT INITIALISATION

POINT PRUNING

Prune points in low density regions

Prune if $\gamma_i < 0.1$, every 10k iterations

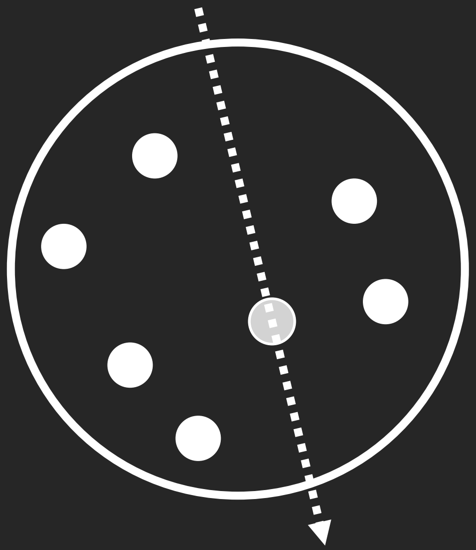
For COLMAP, start with $\gamma_i = 0.3$ for all points



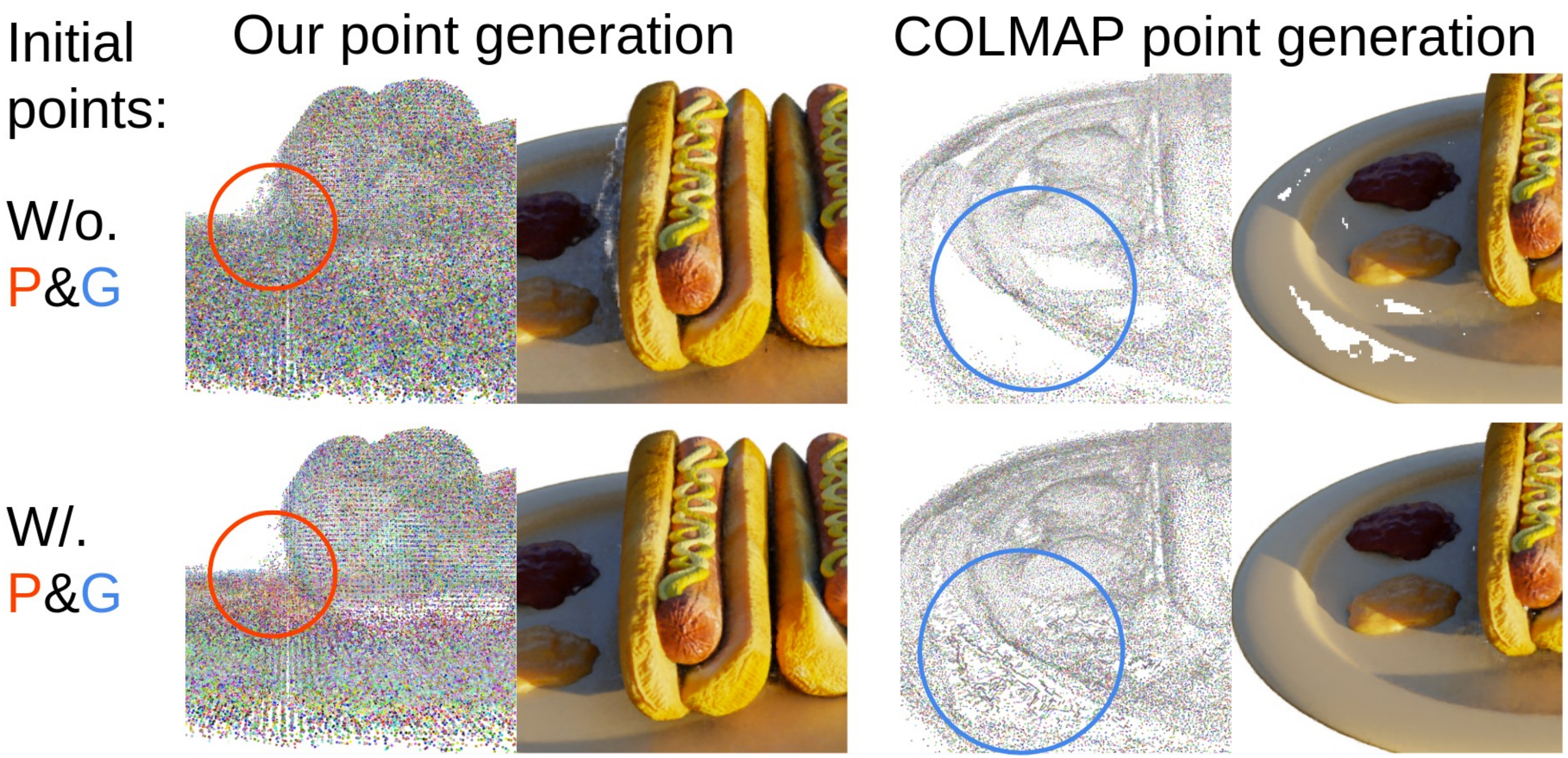
POINT GROWING

Grow point near the surface boundary in high volume density regions

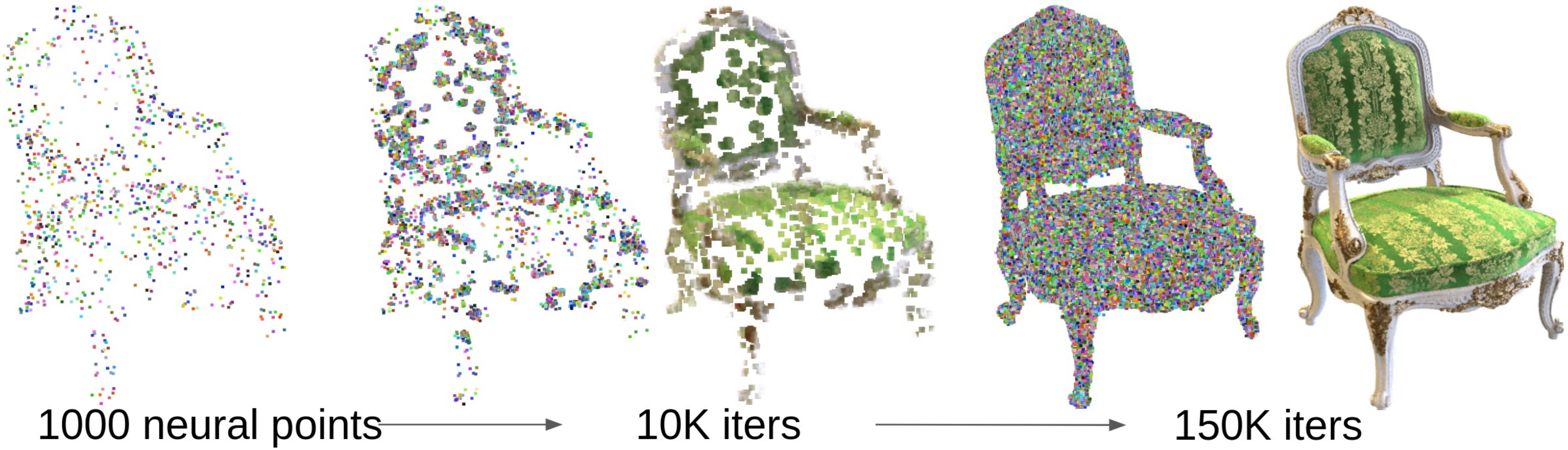
Grow if σ_{max} along the ray for shading point x $> T_{opacity}$
and the nearest neural point $> T_{distance}$



POINT PRUNING AND GROWING



POINT PRUNING AND GROWING



NETWORK PREDICTION POINT INITIALISATION

MVSNET

Multi-view stereo depth map inference from images network, then unprojected to 3D

$$\{p_i, \gamma_i\} = G_{p,\gamma}(I, \phi)$$

VGG NETWORK

Point features obtained from CNN 2D image feature map extractor

$$\{f_i\} = G_f(I)$$

Combine points from all views into a unique per scene point cloud

FULL PIPELINE

End to end training on the DTU[1] dataset

Fast and good neural point initialization + reasonable MLP weights

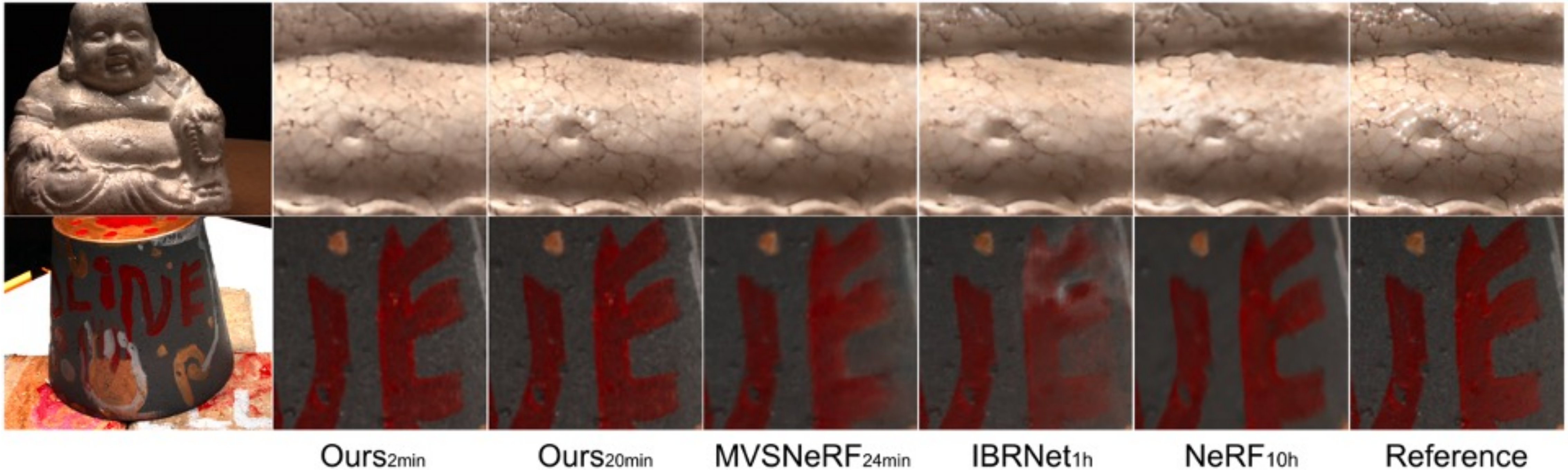
Optimization for 20k iterations ~ 40 min

$$\mathcal{L} = \mathcal{L}_{render} + \alpha \mathcal{L}_{sparse}$$

$$\mathcal{L}_{sparse} = \frac{1}{|\gamma|} \sum_i log(\gamma_i) + log(1 - \gamma_i)$$

[1] Large scale multi-view stereopsis evaluation
2014, Jensen et al.

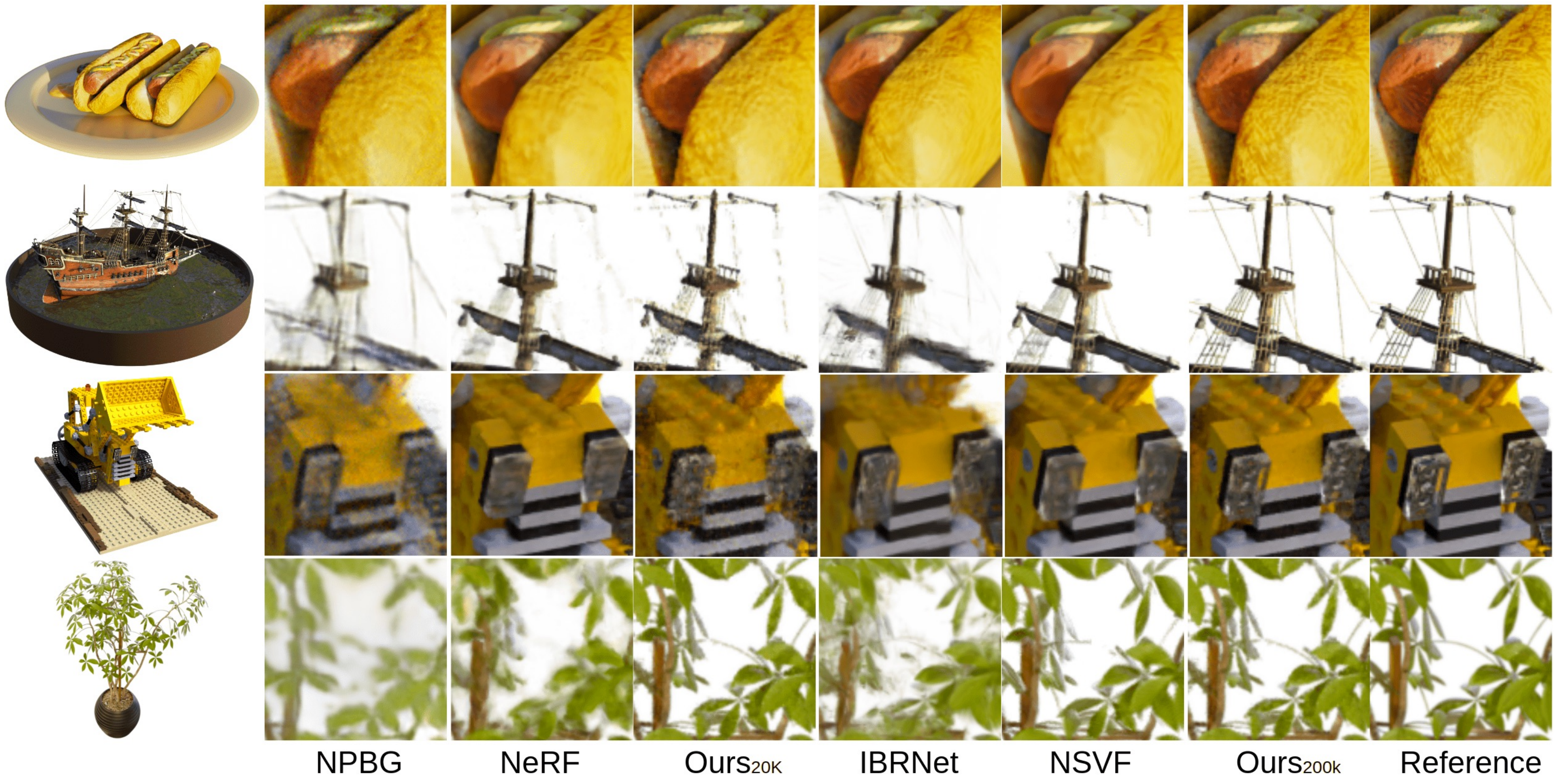
EVALUATION DTU



EVALUATION DTU

	$PointNeRF_{1k}$	$PointNeRF_{10k}$	$MVSNeRF_{10k}$	$IBRNet_{10k}$	$NeRF_{200k}$
PSNR ↑	28.43	30.12	28.50	31.35	27.01
SSIM ↑	0.929	0.957	0.933	0.956	0.902
$LPIPS_{VGG}$ ↓	0.183	0.117	0.179	0.131	0.263
Time ↓	2min	20min	24min	1h	10h

EVALUATION SYNTHETIC



EVALUATION SYNTHETIC

	NPBG	NeRF	$PNRF_{20k}$	IBRNet	NSVF	$PNRF_{200k}$	$PNRFC_{200k}$
PSNR ↑	24.56	31.01	30.71	28.14	31.75	33.31	31.77
SSIM ↑	0.923	0.947	0.967	0.942	0.964	0.978	0.973
$LPIPS_{VGG}$ ↓	0.109	0.081	0.081	0.072	-	0.049	0.062
$LPIPS_{Alex}$ ↓	0.095	-	0.050	-	0.047	0.027	0.040

QUESTIONS?