😈BAD-NeRF: Bundle Adjusted Deblur Neural Radiance Fields

Peng Wang, Lingzhe Zhao, Ruijie Ma, Peidong Liu

Motivation

Neural Radiance Fields (NeRFs) learns photo-metric 3D scene representations from **accurately posed high-quality** images. However, in real-world scenarios, image degradations like **motion blur** are common.

Challenges

Motion blur images
a) violate NeRF's assumption (images are sharp);
b) make it difficult to obtain accurate poses.

Input blurry images

NeRF

BAD-NeRF

Our Method

$(\mathbf{x}, \mathbf{d})$ → color, density

$$\mathbf{B}(\mathbf{x}) \approx \frac{1}{n}\sum_{i=0}^{n-1}\mathbf{I}_i(\mathbf{x}) \quad \oplus \text{averaging}$$

virtual images
virtual cameras
captured image
loss
exposure time
$\mathbf{T}_{start}$ $\mathbf{T}_{end}$

$$\mathbf{T}_t = \mathbf{T}_{start}\cdot\exp\left(\frac{t}{\tau}\cdot\log\left(\mathbf{T}_{start}^{-1}\cdot\mathbf{T}_{end}\right)\right)$$

- - ▶ **Image Formation Model**
- - ▶ **Linear Motion Trajectory**
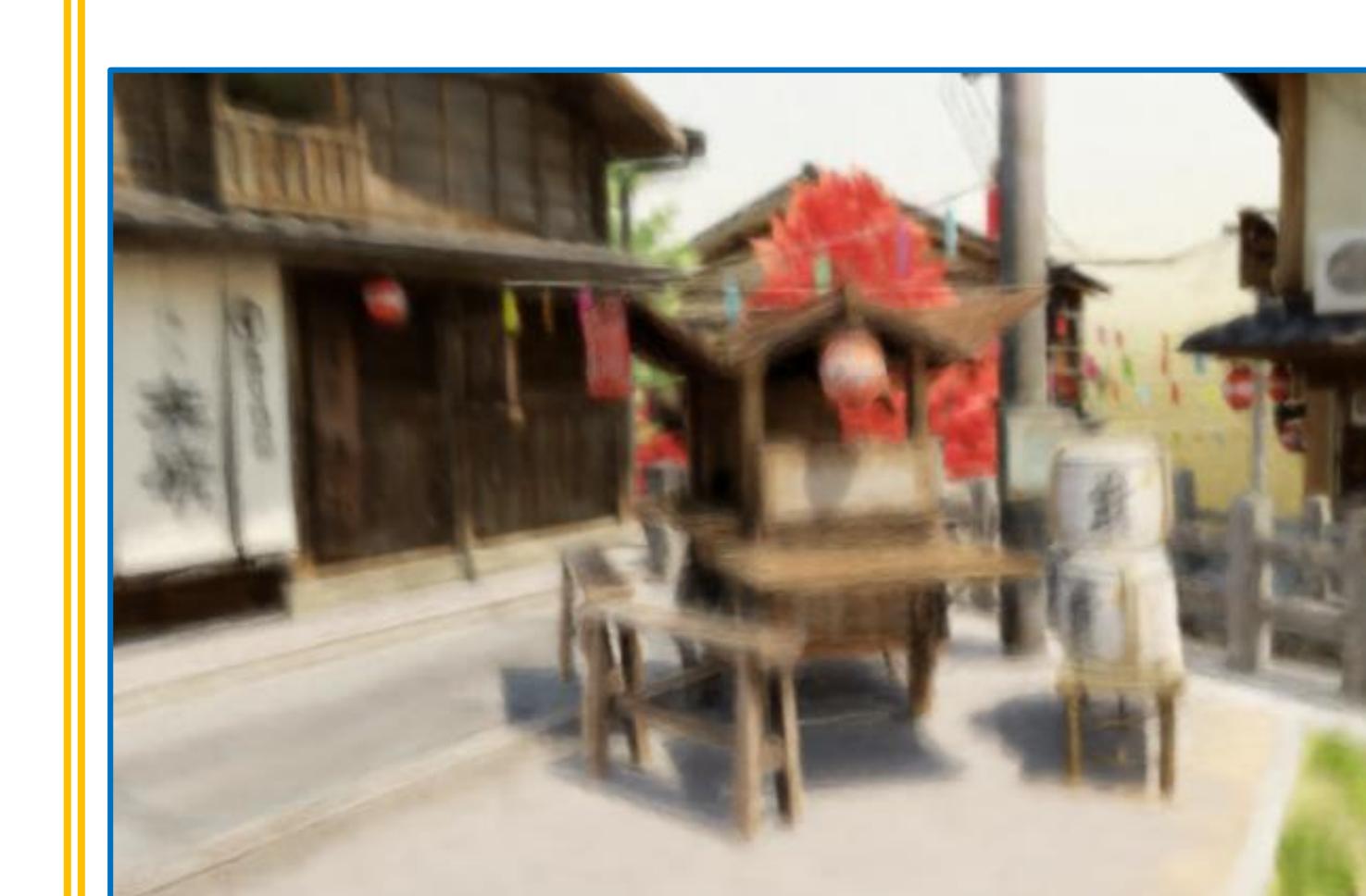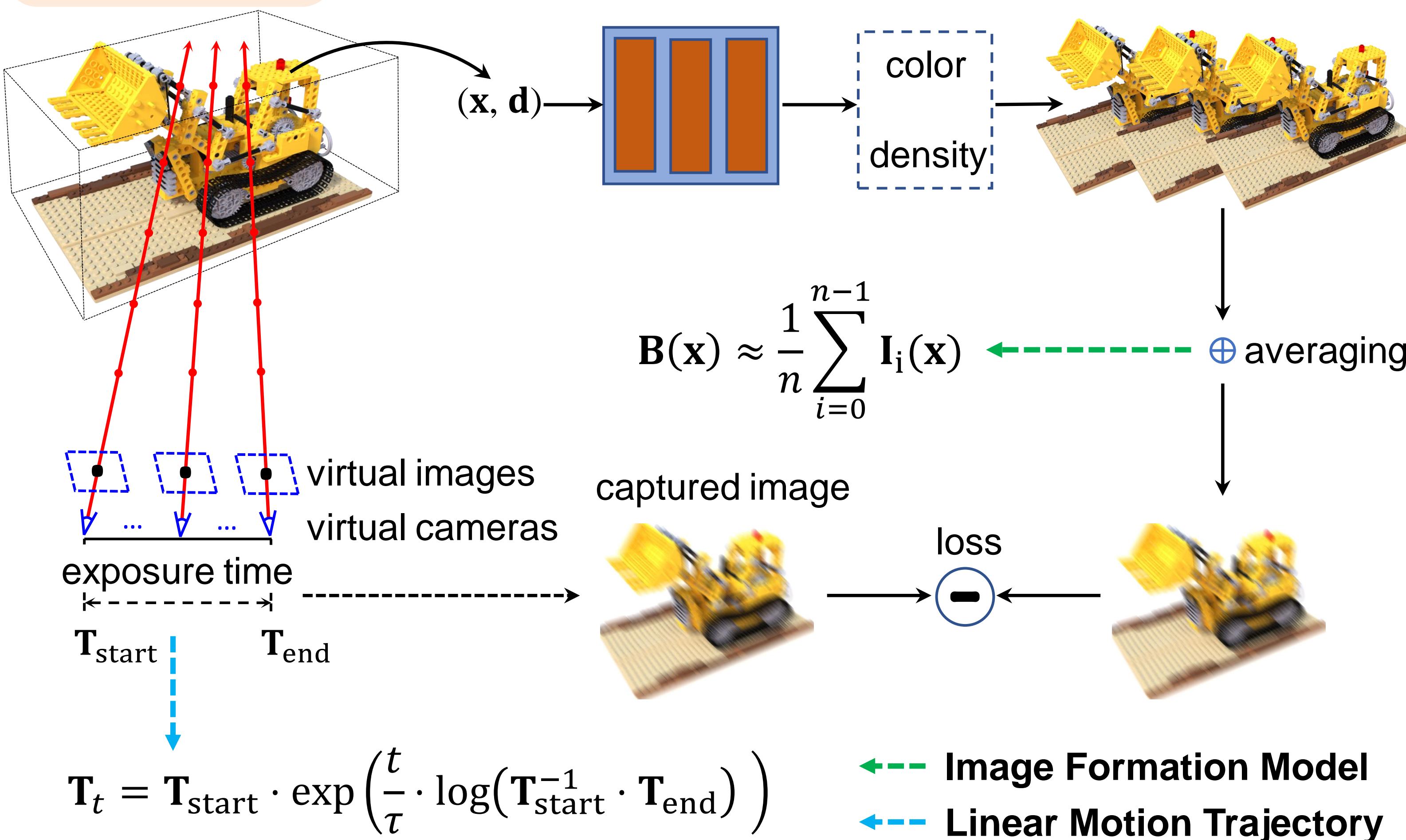
Cubic B-Spline Formulation

$$\mathbf{T}(u) = \mathbf{T}_0 \cdot \prod_{j=0}^{2}\exp\left(\widetilde{\mathbf{B}}(u)_{j+1}\cdot\log\left(\mathbf{T}_j^{-1}\cdot\mathbf{T}_{j+1}\right)\right)$$
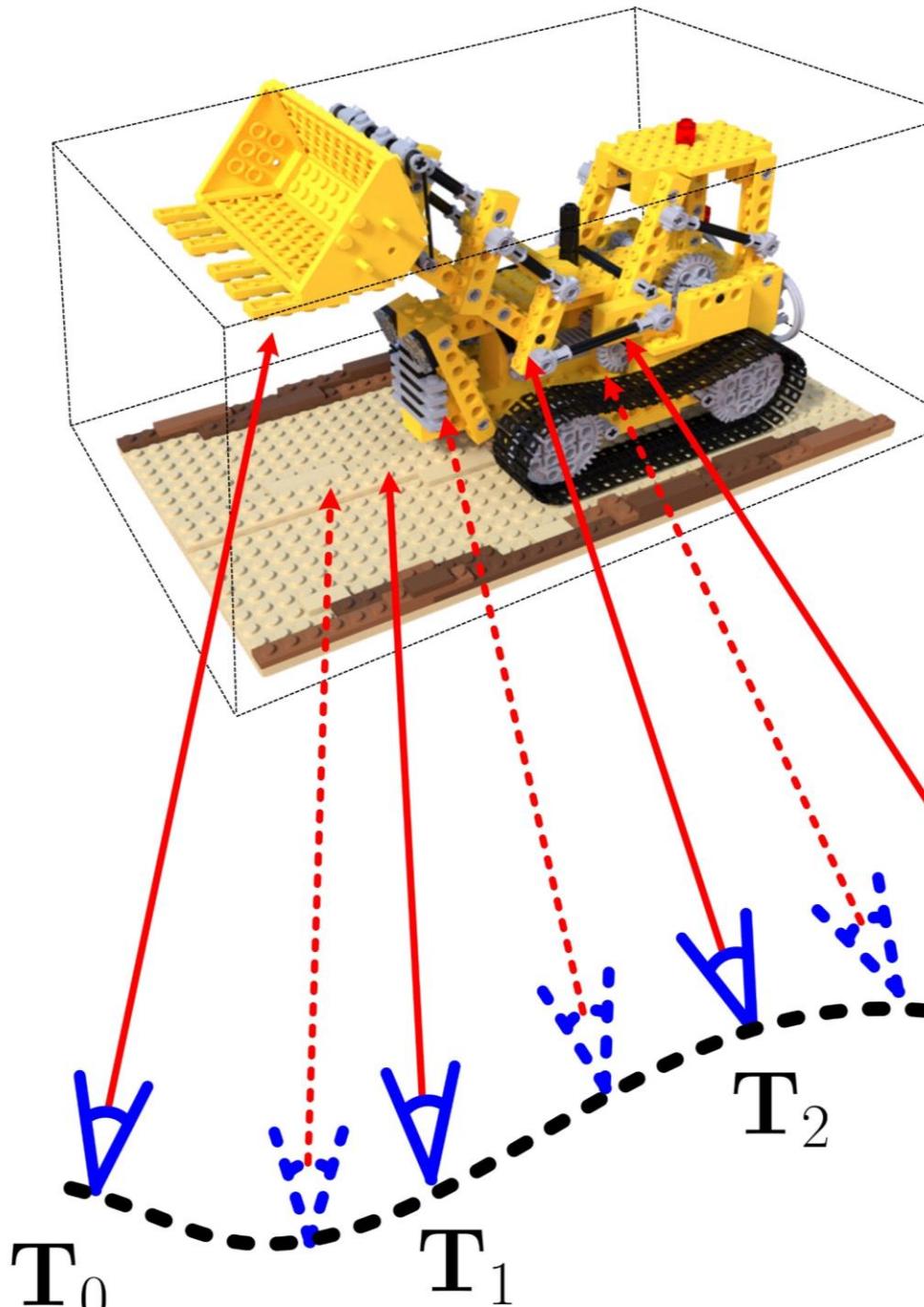
╱ **Complex Camera Trajectory**
∠ **Four Control Knots**
⋰ **Interpolated poses**

$\mathbf{T}_0$ $\mathbf{T}_1$ $\mathbf{T}_2$ $\mathbf{T}_3$

Code
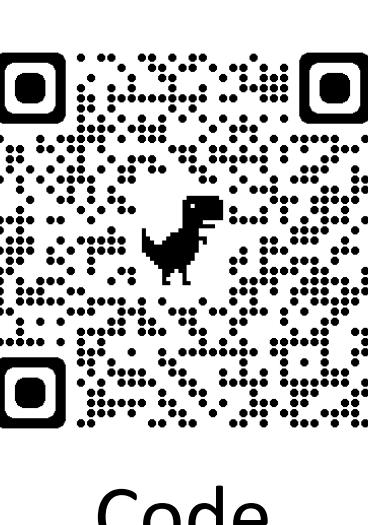
Results

Image Deblurring
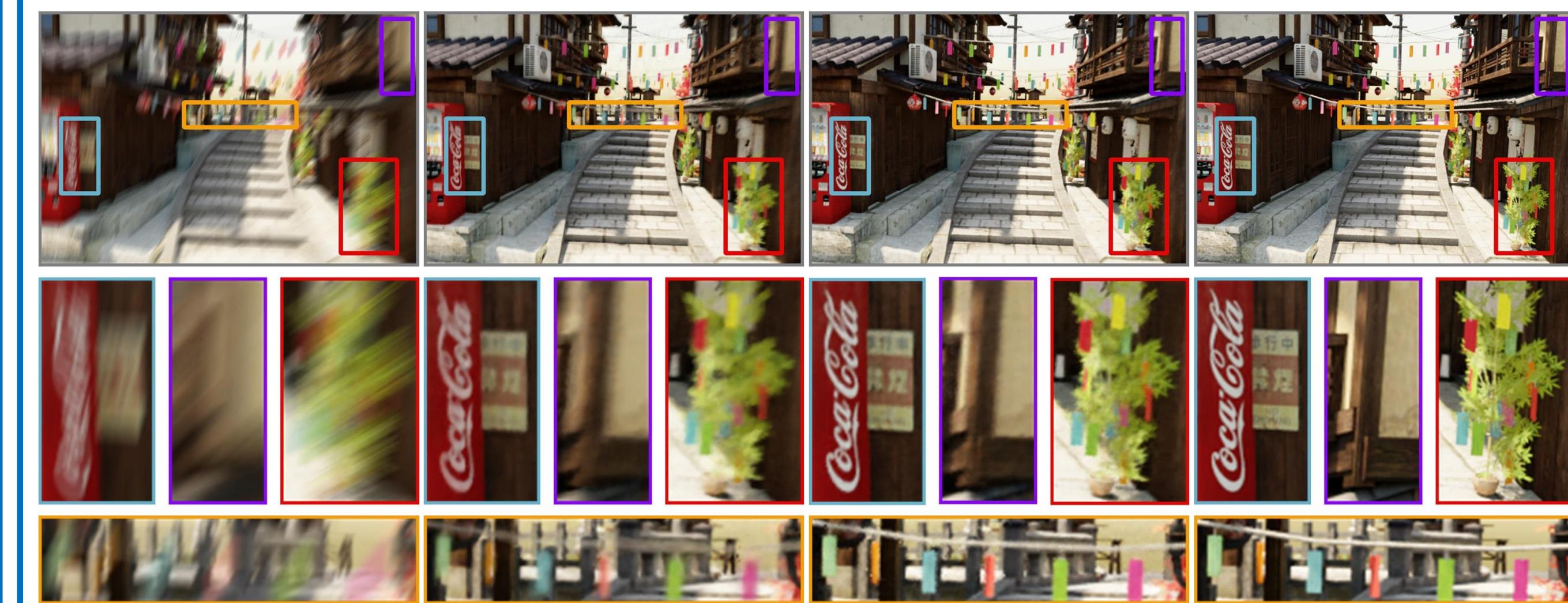
Input blurry image Deblur-NeRF BAD-NeRF Ground truth

Novel View Synthesis

	Cozy2room			Factory			Pool			Tanabata			Trolley		
	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓
NeRF+Park	23.44	0.7024	0.2634	20.83	0.5041	0.4133	28.69	0.7512	0.2865	19.29	0.5317	0.4342	20.73	0.6012	0.3804
NeRF+MPR	27.17	0.8334	0.1196	23.78	0.6375	0.2499	31.15	0.8402	0.1837	21.24	0.6914	0.2801	26.14	0.8154	0.1979
NeRF+PVD	26.26	0.7977	0.1764	23.88	0.6450	0.3074	29.02	0.7792	0.2287	21.03	0.6566	0.3406	23.96	0.7502	0.2772
NeRF+SRNDeblur	27.27	0.8321	0.1261	26.19	0.7494	0.2274	31.09	0.8375	0.1770	21.46	0.6943	0.2839	25.01	0.7883	0.2077
Deblur-NeRF	26.05	0.8084	0.1072	25.17	0.7253	0.2447	30.97	0.8447	0.1554	21.77	0.7172	0.2515	24.45	0.7785	0.2088
Deblur-NeRF*	29.88	0.8901	0.0747	26.06	0.8023	0.2106	30.94	0.8399	0.1694	22.56	0.7639	0.2285	25.78	0.8122	0.1797
BAD-NeRF(ours)	**30.97**	**0.9014**	**0.0552**	**31.65**	**0.9037**	**0.1228**	**31.72**	**0.8580**	**0.1153**	**23.82**	**0.8311**	**0.1378**	**28.25**	**0.8727**	**0.0914**

Trajectory Estimation (ATE)

	Cozy2room	Factory	Pool	Tanabata	Trolley
COLMAP-blur	.128 ± .090	.148 ± .093	.057 ± .026	.103 ± .090	.045 ± .042
BARF	.291 ± .111	.145 ± .088	.083 ± .036	.203 ± .091	.244 ± .074
BAD-NeRF	.050 ± .025	.033 ± .012	.020 ± .007	.016 ± .008	.007 ± .004

--- groundtruth
— BARF
— COLMAP
— BAD-NeRF

Factory

Tanabata

Y(m) X(m)