HDR-GS: Efficient High Dynamic Range Novel View Synthesis at 1000x Speed via Gaussian Splatting

Yuanhao Cai , Zihao Xiao, Yixun Liang, Minghan Qin,
Yulun Zhang, Xiaokang Yang, Yaoyao Liu, Alan Yuille

Johns Hopkins University

JOHNS HOPKINS UNIVERSITY

NEURAL INFORMATION PROCESSING SYSTEMS

- Introduction
- Method
- Experiment

JOHNS HOPKINS UNIVERSITY

NEURAL INFORMATION PROCESSING SYSTEMS

- Introduction
- Method
- Experiment

Low Dynamic Range Images

Value range [0, 255]

limited compared to human eyes

High Dynamic Range Images

Value range [0, +infinity]

Can render more vivid details and light change

Low Dynamic Range

High Dynamic Range

Existing 3D HDR Imaging methods

Based on NeRF

The speed is very slow due to volume rendering

This work develops the first 3D Gaussian Splatting based framework for 3D HDR imaging

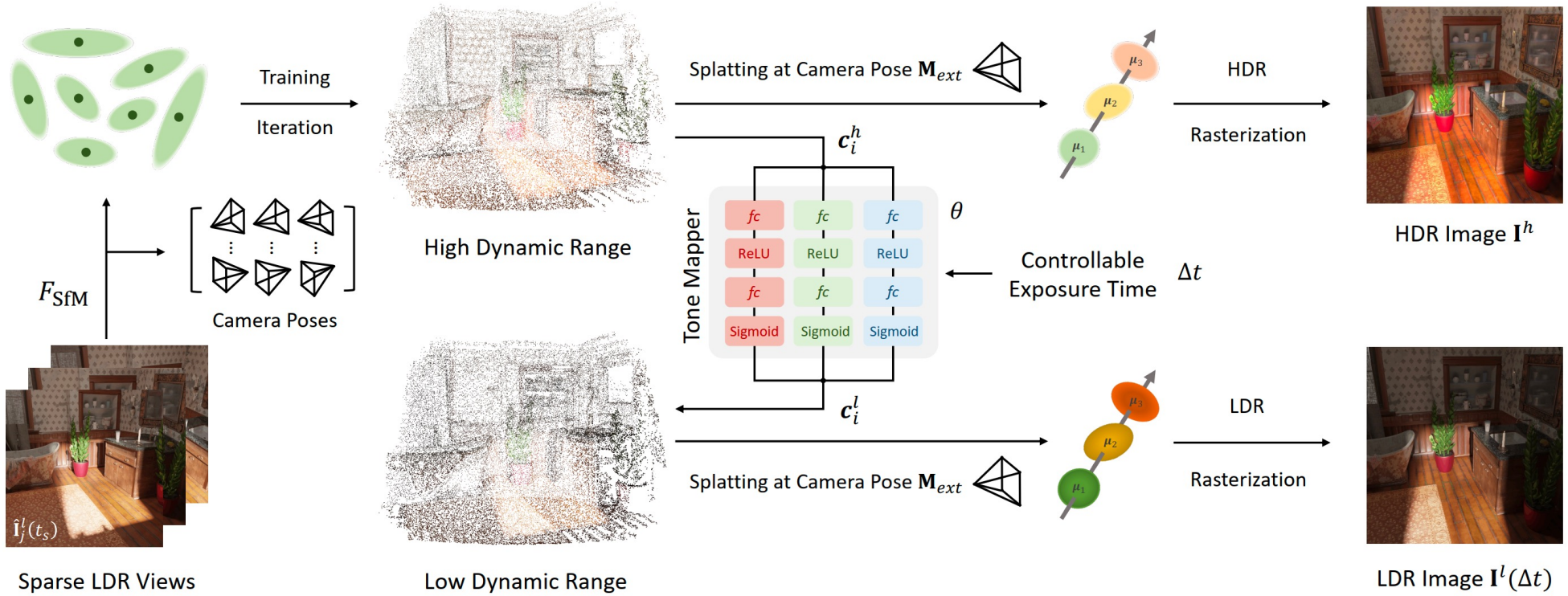
JOHNS HOPKINS UNIVERSITY

NEURAL INFORMATION PROCESSING SYSTEMS

- Introduction

- Method

- Experiment



(a) Recalibration and Initialization (b) Dual Dynamic Range Gaussian Point Cloud Model (c) Parallel Differentiable Rasterization

(a) We use colmap to run the Structure-from-Motion to recalibrate the data $\mathbf{M}_{int},\ \{\mathbf{M}_{ext}^j\}_{j=1}^{N_v},\ N_p,\ \{\boldsymbol{\mu}_i\}_{i=1}^{N_p} = F_{\text{SfM}}(\{\hat{\mathbf{I}}_j^l(t_s)\}_{j=1}^{N_v})$

(b) We design a Dual dynamic range Gaussian point cloud model with HDR and LDR color by an MLP tone-mapper

(c) Two rasterization processes are performed to render the HDR and LDR images

JOHNS HOPKINS UNIVERSITY

NEURAL INFORMATION PROCESSING SYSTEMS

- Introduction
- Method
- Experiment

JOHNS HOPKINS UNIVERSITY

NEURAL INFORMATION PROCESSING SYSTEMS

Synthetic Dataset

Method	Training Time (min)	Inference Speed (fps)	LDR-OE (t_1, t_3, t_5) PSNR↑	LDR-OE (t_1, t_3, t_5) SSIM↑	LDR-OE (t_1, t_3, t_5) LPIPS↓	LDR-NE (t_2, t_4) PSNR↑	LDR-NE (t_2, t_4) SSIM↑	LDR-NE (t_2, t_4) LPIPS↓	HDR PSNR↑	HDR SSIM↑	HDR LPIPS↓
NeRF [13]	405	0.190	13.97	0.555	0.376	14.51	0.522	0.428	—	—	—
3DGS [15]	38	121	19.46	0.690	0.276	18.97	0.778	0.309	—	—	—
NeRF-W [80]	437	0.178	29.83	0.936	0.047	29.22	0.927	0.050	—	—	—
HDR-NeRF [14]	542	0.122	39.07	0.973	0.026	**37.53**	0.966	0.024	36.40	0.936	0.018
HDR-GS (Ours)	**34**	**126**	**41.10**	**0.982**	**0.011**	36.33	**0.977**	**0.016**	**38.31**	**0.972**	**0.013**

Real Dataset

Method	LDR-OE (t_1, t_3, t_5) PSNR↑	LDR-OE (t_1, t_3, t_5) SSIM↑	LDR-OE (t_1, t_3, t_5) LPIPS↓	LDR-NE (t_2, t_4) PSNR↑	LDR-NE (t_2, t_4) SSIM↑	LDR-NE (t_2, t_4) LPIPS↓
NeRF [13]	14.95	0.661	0.308	14.44	0.731	0.255
3DGS [15]	17.19	0.806	0.103	19.50	0.727	0.152
NeRF-W [80]	28.55	0.927	0.094	28.64	0.923	0.089
HDR-NeRF [14]	31.63	0.948	0.069	31.43	0.943	0.069
HDR-GS (Ours)	**35.47**	**0.970**	**0.022**	**31.66**	**0.965**	**0.030**

JOHNS HOPKINS UNIVERSITY

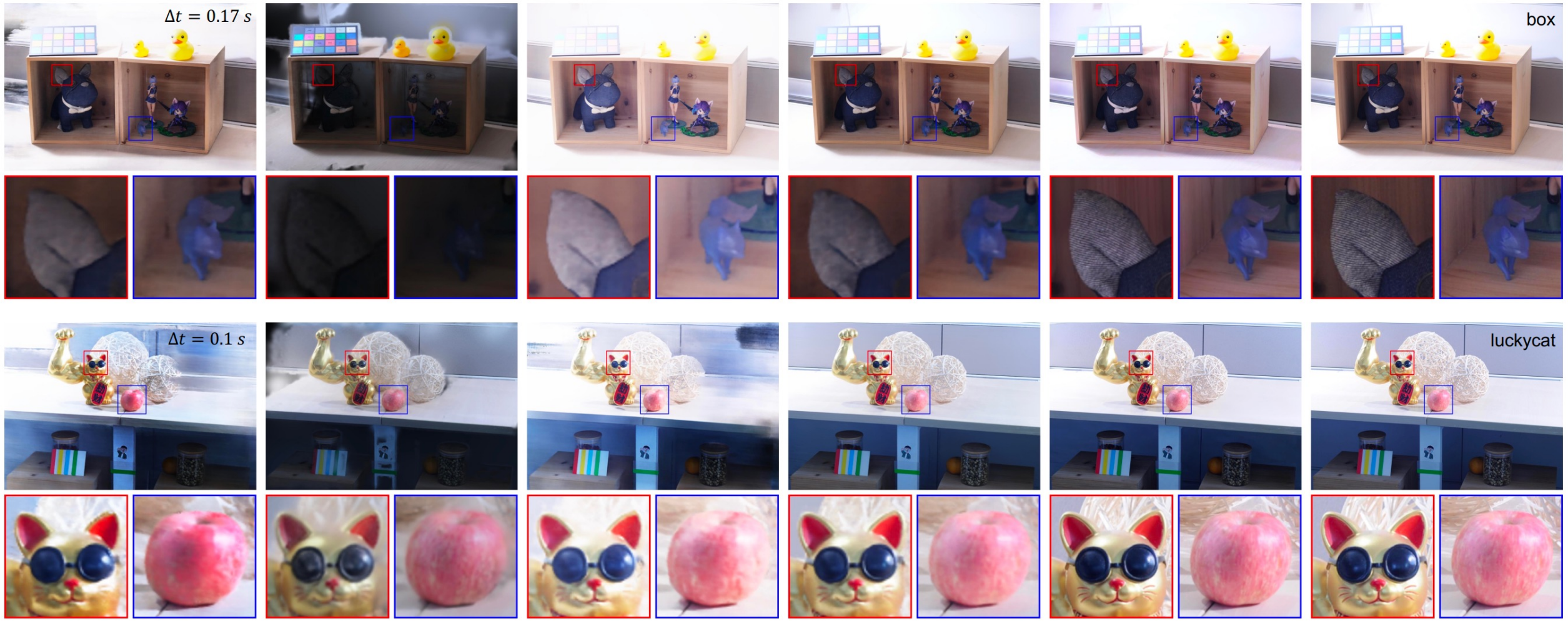
NEURAL INFORMATION PROCESSING SYSTEMS

LDR imaging comparison on the synthetic dataset

JOHNS HOPKINS UNIVERSITY

NEURAL INFORMATION PROCESSING SYSTEMS

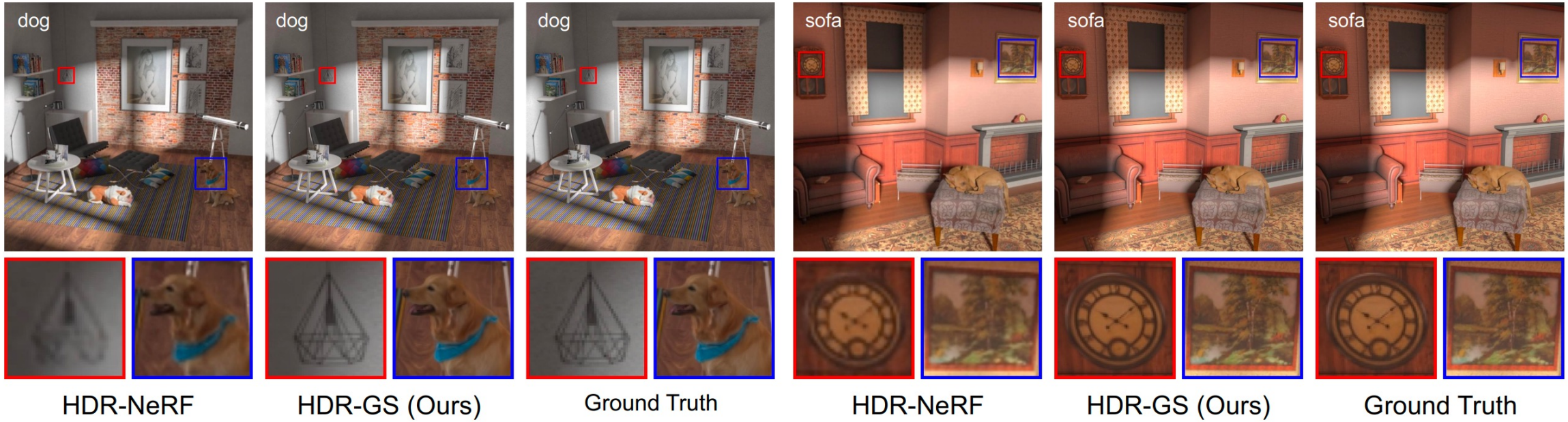
LDR imaging comparison on the real dataset

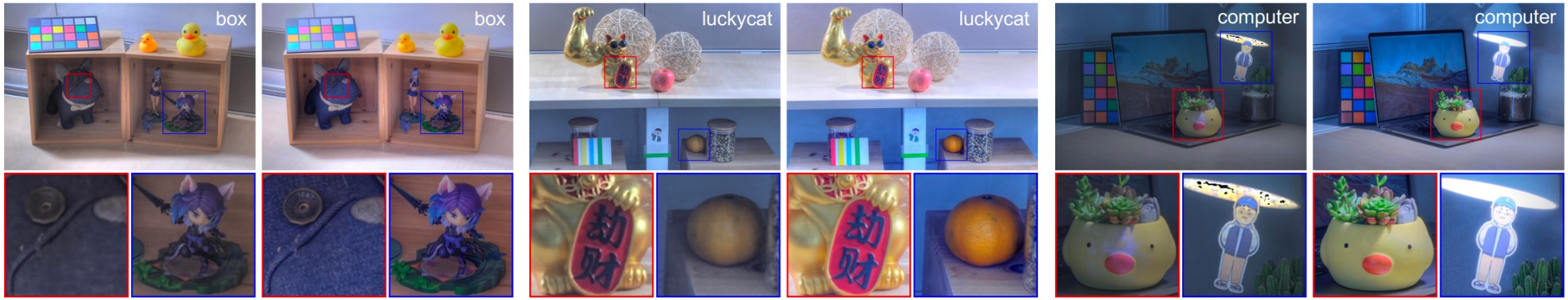


JOHNS HOPKINS UNIVERSITY

NEURAL INFORMATION PROCESSING SYSTEMS

HDR imaging comparison





JOHNS HOPKINS UNIVERSITY

NEURAL INFORMATION PROCESSING SYSTEMS

Code and data are publicly available at

https://github.com/caiyuanhao1998/HDR-GS