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RestorGS: Depth-aware Gaussian Splatting for Efficient 3D Scene Restoration

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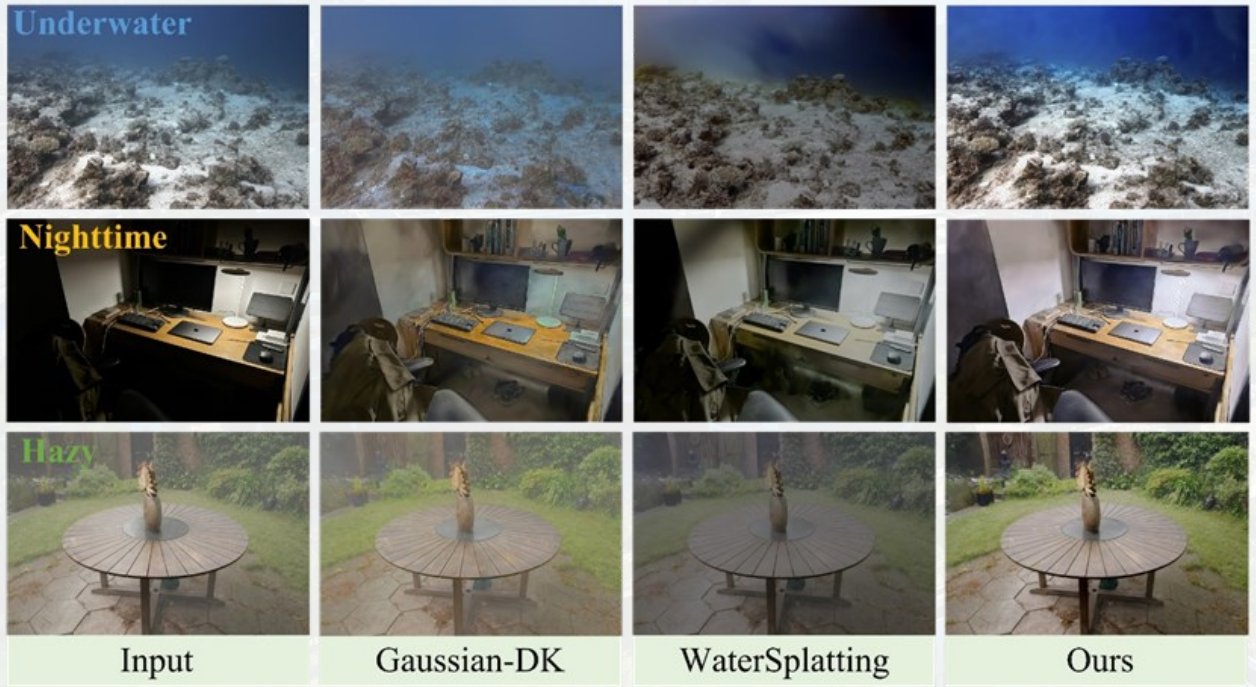
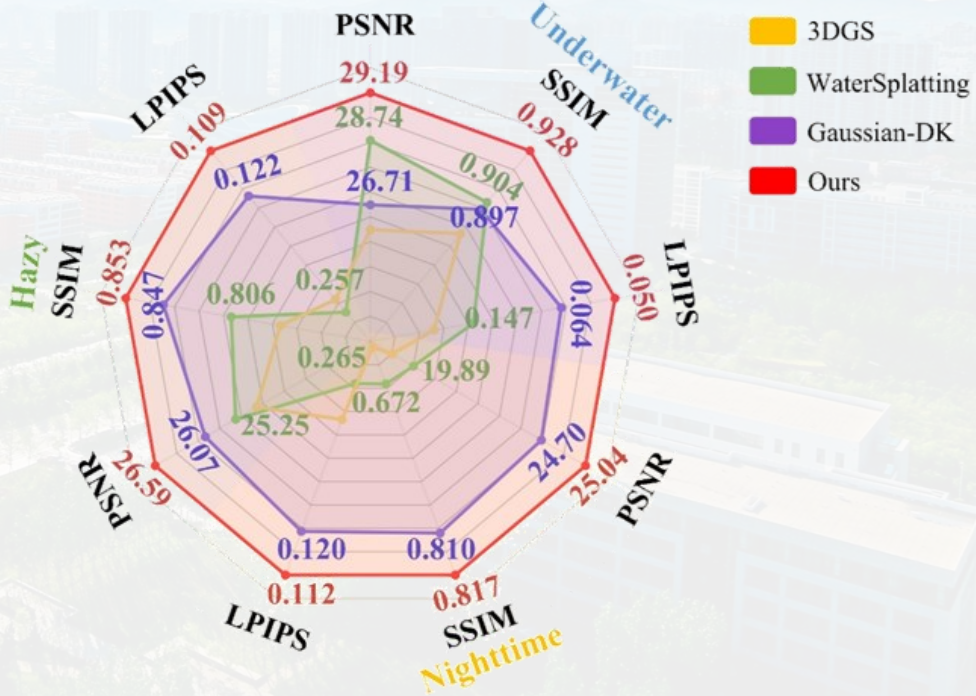
Motivation

- Existing methods rely heavily on high-quality data for rendering and struggle to handle degraded scenes with multi-view inconsistency, leading to inferior rendering quality.
- Can we restore various 3D degraded scenes with a unified framework?

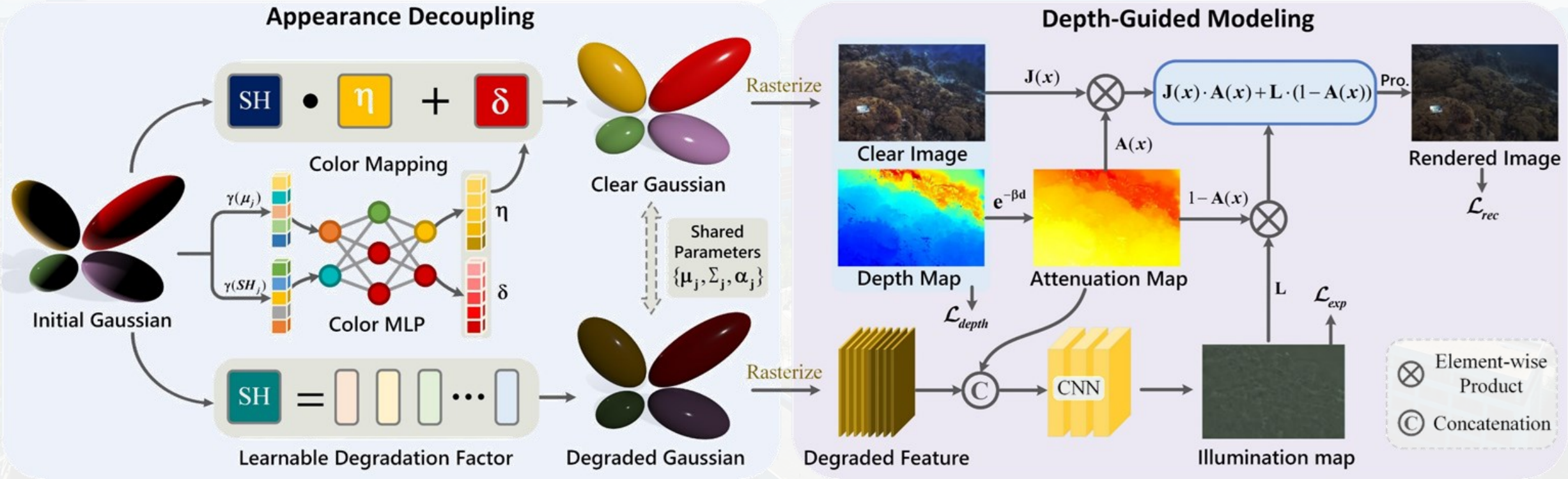


(a) Visual Results



(b) Quantitative Scores

- We propose RestorGS, a novel Depth-aware Gaussian Splatting for efficient 3D scene restoration. RestorGS consists of two core designs: Appearance Decoupling and Depth-Guided Modeling.

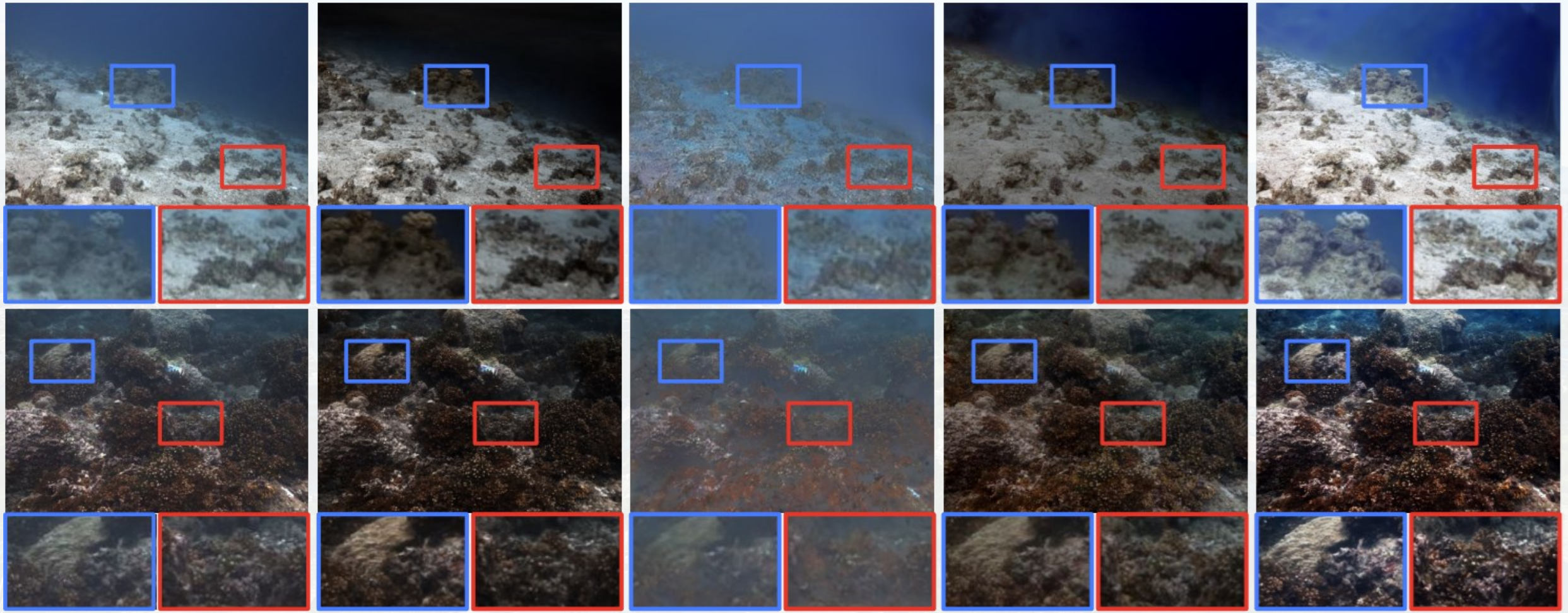


Experiments

Method	Curacao			IUI3 Red Sea			Panama			J.G. Red Sea		
	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓
SeaThru-NeRF [20]	30.19	0.873	0.210	25.90	0.785	0.304	27.84	0.834	0.224	21.84	0.767	0.249
SeaThru-NeRF-NS [20]	30.95	0.915	0.133	26.75	0.826	0.168	31.27	0.937	0.071	23.28	0.876	0.111
ZipNeRF [3]	19.95	0.442	0.421	16.93	0.474	0.412	19.01	0.349	0.482	19.02	0.349	0.483
3DGS [16]	28.31	0.873	0.221	22.98	0.843	0.245	29.20	0.893	0.152	21.49	0.854	0.216
Gaussian-DK [39]	30.76	0.935	0.060	28.19	0.950	0.032	24.67	0.831	0.091	23.21	0.875	0.074
WaterSplatting [21]	29.36	0.915	0.147	29.89	0.892	0.211	32.51	0.941	0.084	23.22	0.869	0.149
Ours	31.95	0.944	0.055	29.97	0.952	0.028	30.79	0.932	0.046	24.05	0.882	0.071

Method	Garden			Bicycle		
	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓
3DGS [16]	25.82	0.891	0.084	22.35	0.712	0.215
Gaussian-DK [39]	27.74	0.886	0.071	24.39	0.807	0.172
WaterSplatting [21]	27.82	0.885	0.128	22.67	0.726	0.386
Ours	28.32	0.897	0.056	24.86	0.809	0.162

Experiments



(a) Input (b) SeaThru-NeRF (c) Gaussian-DK (d) WaterSplatting (e) Ours

Experiments

(a) Input (b) 3DGS (c) Gaussian-DK (d) WaterSplatting (e) Ours

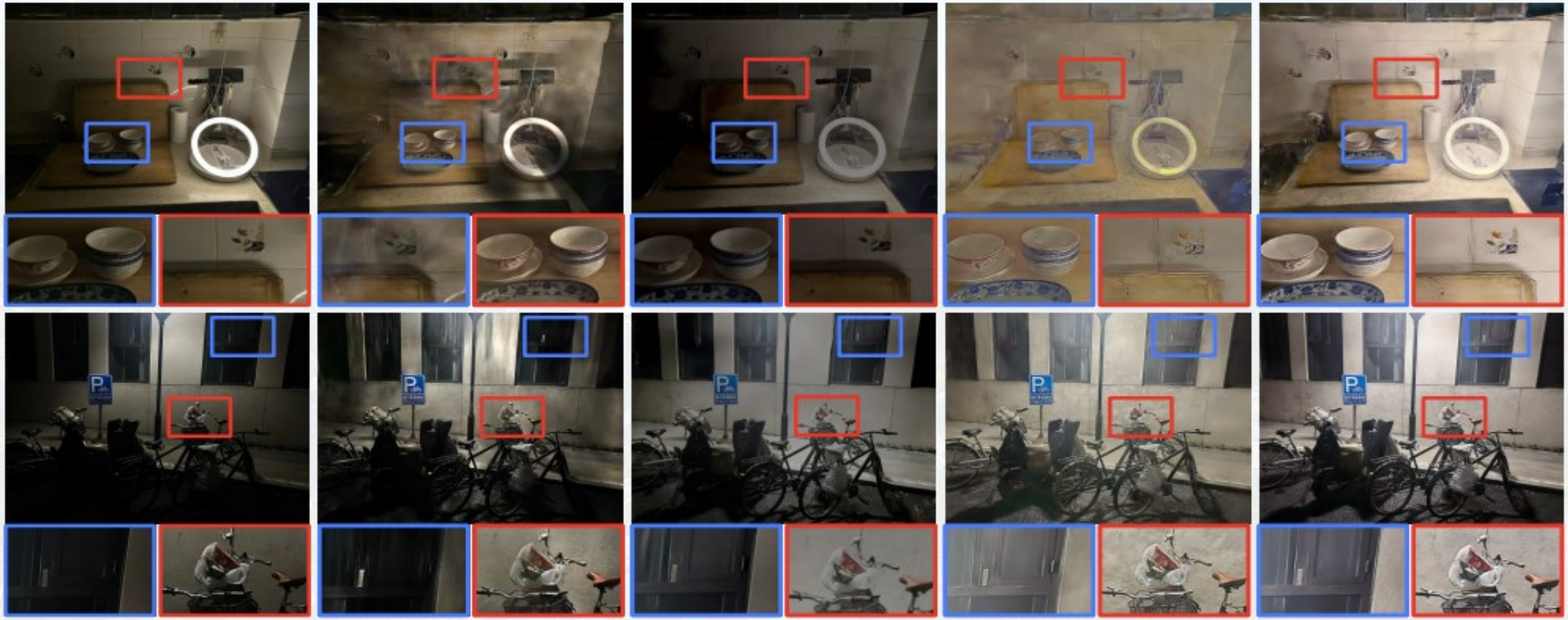
Experiments

Method	Alley			Fence			Livingroom			Staircase		
	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓
NeRF-W [28]	21.59	0.646	0.331	23.97	0.724	0.214	22.43	0.749	0.243	23.96	0.809	0.115
HDR-NeRF [11]	17.87	0.558	0.488	19.66	0.578	0.372	20.77	0.651	0.385	18.07	0.566	0.343
3DGS [16]	16.44	0.602	0.232	18.99	0.588	0.226	19.97	0.728	0.167	18.30	0.583	0.198
WaterSplatting [21]	19.16	0.696	0.256	20.45	0.624	0.288	21.25	0.767	0.209	18.17	0.643	0.232
Gaussian-DK [39]	21.91	0.773	0.140	24.94	0.801	0.131	24.41	0.826	0.125	26.10	0.885	0.068
Ours	22.18	0.781	0.138	25.05	0.803	0.128	24.73	0.830	0.088	27.02	0.882	0.067

Method	Bicycle			Flower			Piano			Tree		
	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓
NeRF-W [28]	23.56	0.717	0.238	21.66	0.662	0.223	25.44	0.803	0.157	21.66	0.649	0.260
HDR-NeRF [11]	19.95	0.608	0.267	18.54	0.517	0.359	21.52	0.682	0.240	18.58	0.504	0.397
3DGS [16]	19.27	0.624	0.220	16.17	0.541	0.226	18.78	0.527	0.248	19.87	0.597	0.195
WaterSplatting [21]	22.67	0.726	0.387	18.40	0.632	0.227	20.17	0.683	0.274	18.88	0.546	0.288
Gaussian-DK [39]	24.80	0.809	0.131	21.50	0.728	0.135	27.31	0.833	0.106	23.30	0.765	0.134
Ours	24.93	0.811	0.127	21.97	0.742	0.127	27.37	0.837	0.103	23.89	0.793	0.123

Method	Dormitory			Kitchen			Street			Average		
	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓
NeRF-W [28]	24.51	0.820	0.149	24.84	0.812	0.205	22.85	0.638	0.293	23.32	0.730	0.221
HDR-NeRF [11]	21.23	0.684	0.279	22.27	0.757	0.338	21.20	0.577	0.424	19.97	0.607	0.354
3DGS [16]	20.53	0.686	0.161	18.68	0.699	0.196	17.04	0.542	0.271	18.55	0.611	0.213
WaterSplatting [21]	20.23	0.724	0.212	20.73	0.770	0.241	18.66	0.586	0.307	19.89	0.672	0.265
Gaussian-DK [39]	25.64	0.857	0.087	25.54	0.844	0.117	26.23	0.789	0.142	24.70	0.810	0.120
Ours	25.95	0.859	0.088	25.86	0.854	0.099	26.44	0.793	0.141	25.04	0.817	0.112

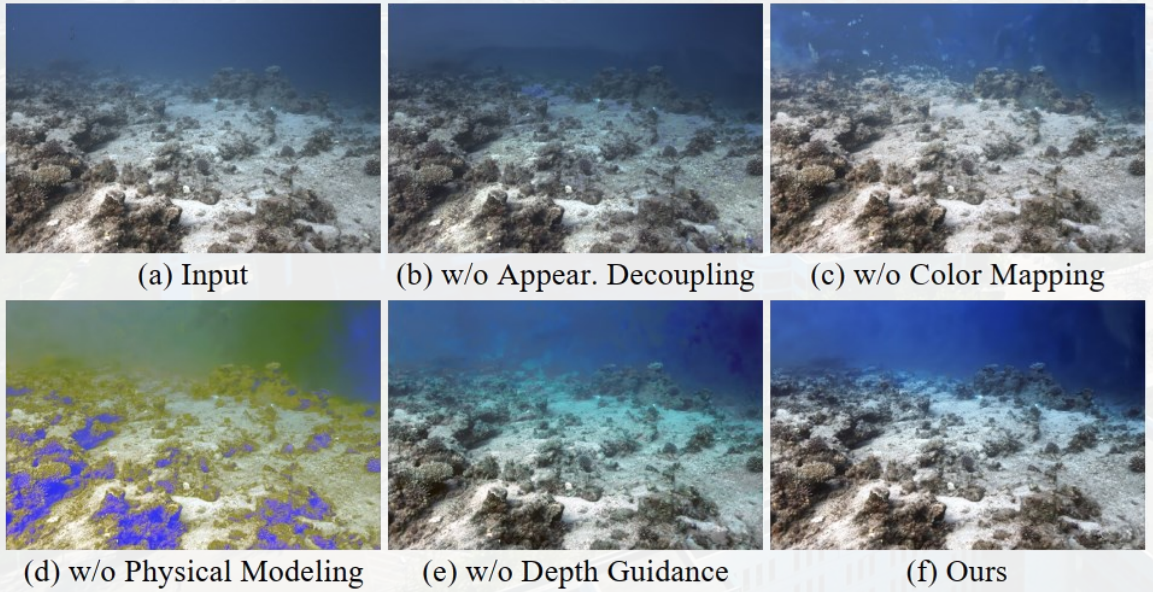
Experiments



(a) Input (b) 3DGS (c) WaterSplatting (d) Gaussian-DK (e) Ours

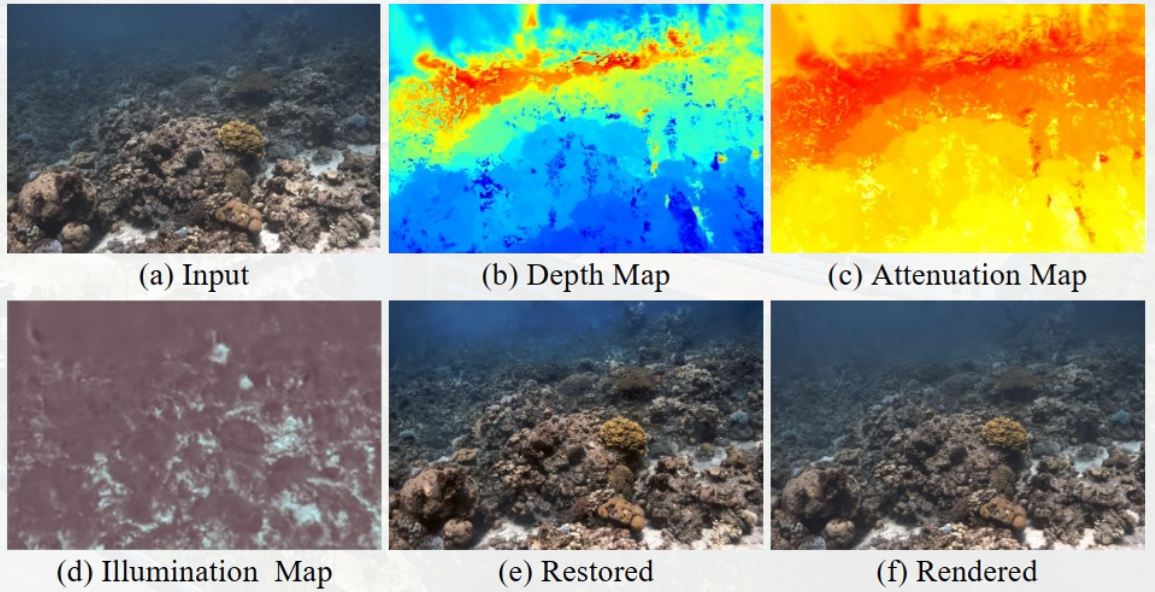
Experiments

Ablation	PSNR↑	SSIM↑	LPIPS↓
w/o Appear. Decoupling	28.46	0.918	0.071
w/o Color MLP	28.83	0.922	0.067
w/o Physical Modeling	28.62	0.919	0.064
w/o Depth Guidance	29.05	0.926	0.055
Full model (Ours)	29.19	0.928	0.050



(a) Input (b) w/o Appear. Decoupling (c) w/o Color Mapping

(d) w/o Physical Modeling (e) w/o Depth Guidance (f) Ours



(a) Input (b) Depth Map (c) Attenuation Map

(d) Illumination Map (e) Restored (f) Rendered

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THANKS FOR LISTENING

Reported by **Yuanjian Qiao**

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