DMiT: Deformable Mipmapped Tri-Plane Representation for Dynamic Scenes -Supplementary Material-

Jing-Wen Yang^{1,2}[©], Jia-Mu Sun^{1,2}[©], Yong-Liang Yang³[©], Jie Yang¹[©], Ying Shan⁴[©], Yan-Pei Cao^{5,4}[©], and Lin Gao (⊠)^{1,2}[©]

 ¹ Beijing Key Laboratory of Mobile Computing and Pervasive Device, Institute of Computing Technology, Chinese Academy of Sciences, China
 ² University of Chinese Academy of Sciences, China
 ³ Department of Computer Science, University of Bath, United Kingdom
 ⁴ Tencent AI Lab, China
 ⁵ VAST, China

In the supplementary material, we will first present some additional implementation details of our proposed method **DMiT** in Appendix A. More rendering results from both synthetic and real-world datasets as well as the corresponding per-scene evaluation metrics will be provided in Appendix B. Moreover, we will conduct a detailed analysis on our decomposed canonical space in Appendix C. Finally, more ablation results (Appendix D) as well as further discussion including failure cases (Appendix E) will be provided respectively.

A Implementation Details

A.1 Deformation Network

To construct the projection from each observation to a shared canonical space, a deformation network is employed, which is built upon the tiny-cuda-nn framework [16]. The deformation network is configured with a width parameter of W = 128 and a depth parameter of D = 8. The input of the network consists of the positions of the sample points obtained using the cone-casting approach outlined in the main paper, together with their respective timestamps. To address the issue of overfitting in the deformation network, we employ a frequency annealing strategy in the context of positional encoding. This strategy is discussed in detail in Section 3.3 of the main paper. To provide more clarification, the D-NeRF and multi-scale D-NeRF experiments have established a maximum encoding dimension of 10 for space and 6 for time. In the HyperNeRF dataset, spatial information is represented using a maximum dimension of 10, while time is represented using a maximum dimension of 8. This annealing strategy is set to terminate at iteration 10K for synthetic experiments and 80K for real-world experiments. In D-NeRF experiments, an additional one-layer network is employed for time encoding. This network transforms the time-embedded feature into a time-aware feature with a dimension of 30. Subsequently, the featurized spatial

Corresponding author is Lin Gao(gaolin@ict.ac.cn).

and temporal information is fed into the Multi-Layer Perceptron (MLP) to forecast the spatial displacement of each sampled point. As a result, the relationship between the observation space and canonical space can be established.

A.2 Tiny MLP in Canonical Space

The shallow MLP responsible for predicting density σ and color **c**, is implemented using the tiny-cuda-nn library [16] due to its efficient inference capabilities, as mentioned in [7]. The MLP has a width W of 128 and a depth D of 6 layers. The initial two layers are specifically designed to estimate the density value σ and a geometric feature vector \mathbf{f}_{geo} with a dimension of 15. These layers take the Tri-Mip encoded feature \mathbf{f} as input, as explained in Section 3.2 of the main paper. The channel dimension of the mipmapped planes \mathcal{M} is set to 16, resulting in a concatenated feature dimension of 48. Subsequently, the last layers of the MLP will predict the associated color \mathbf{c} based on the provided geometric feature \mathbf{f}_{geo} and the encoded view direction \mathbf{d} , represented by spherical harmonics.

A.3 Optimization

The trainable parameters of the whole framework consist of the model weights Θ_d derived from the deformation network Φ_d , the model weights Θ_c obtained from the canonical MLP along with parameters of the time encoding network, and the mipmapped tri-plane features \mathcal{M} . The networks in this study are initialized following the approach proposed by [6]. Additionally, the mipmap features are uniformly initialized within the range from -0.01 to 0.01. To optimize the static components of the canonical representation, we employ the AdamW optimizer [13] with a base learning rate of 1×10^{-3} . For the joint deformation and geometry refinement (Sec. 3.3 of the main paper), the three mipmap feature planes undergo bilinear upsampling. Additionally, a distinct AdamW optimizer is employed to enable a more adaptable schedule. The initial learning rate of this optimizer is 1×10^{-2} (*i.e.*, $10 \times$ the learning rate of the static optimizer) for faster convergence and reconstruction. The scheduling of both optimizers is performed by the MultiStepLR function from the PyTorch library [20]. To ensure a consistent number of sampled spheres for cone casting, a dynamic batch-size method is employed, as described in [17]. In our pipeline, the deformable components are optimized using an AdamW optimizer, which incorporates a warmup step and a cosine-decayed scheduler.

B Detailed Results

Apart from the results shown in the main paper, we additionally provide more quantitative and qualitative results to further demonstrate the competitiveness of our method against other state-of-the-art methods. Detailed per-scene metrics and visual comparisons of rendering results on each dataset can be found in the following pages.

Methode	Train				PS	$NR\uparrow$				
Methods	1ram. ↓	lego	jumpingjack.	s bouncingballs	hook	standup	trex	hellwarrior	mutant	Average
D-NeRF [21]	1d	21.76	32.56	38.20	29.49	33.47	31.45	24.90	31.25	30.39
TiNeuVox [3]	28m	24.56	33.61	39.80	30.54	34.45	31.22	27.00	31.82	31.63
K-Planes-hybrid [4]	1h	25.21	31.06	39.31	27.85	32.60	30.15	23.97	32.38	30.32
K-Planes-explicit [4]	1h	25.25	29.63	37.53	27.33	31.66	29.71	23.82	32.08	29.63
Tensor4D [22]	10h	23 21	25.33	30.94	26.09	26.62	25.46	21 74	26.30	25.71
4DGS [27]	40m	24.82	33.50	38 72	31.23	35.60	32.23	26.37	35.96	32.30
D3DGS [30]	35m	24.02	37.42	41.24	37 31	44 25	37.84	41.30	42 56	38 35
SC-CS [8]	1h	25.00	38 11	13.48	36.60	40.28	38.87	32.40	30.43	36.78
BealTime4DCS [†] [20]	111	25.00	56.11	40.40	<u>30.03</u>	40.20	30.01	52.40	05.40	34.00
V4D [5]	6h		24.04	41.97	20.02	- 25.14	22.24	26.12	22.20	29.27
V4D [0]	11	20.19	20.05	41.07	29.93	20.14	20.91	20.12	22.05	20.20
	111	24.79	30.95	39.07	27.04	32.87	30.21	23.30	32.05	30.20
Ours	<u>30m</u>	24.72	34.19	43.04	33.03	37.17	35.25	29.16	37.10	34.22
Mathada	Tusin I				SS	IM ↑				
Methods	i rain. ↓	lego	jumpingjacks	bouncingballs	hook	standup	trex	hellwarrior	mutant	Average
D-NeRF [21]	1d	0.836	0.974	0.983	0.961	0.980	0.971	0.948	0.971	0.953
TiNeuVox [3]	28m	0.904	0.977	0.992	0.959	0.979	0.966	0.963	0.960	0.963
K-Planes-hybrid [4]	1h	0.947	0.970	0.993	0.947	0.978	0.972	0.947	0.971	0.966
K-Planes-explicit [4]	1h	0.946	0.963	0.989	0.940	0.973	0.970	0.944	0.969	0.962
Tensor4D [22]	10h	0.890	0.948	0.978	0.939	0.959	0.936	0.931	0.940	0.940
4DGS [27]	40m	0.931	0.981	0.993	0.970	0.986	0.980	0.964	0.986	0.974
D3DGS [30]	35m	0.942	0.989	0.995	0.986	0.995	0.993	0.986	0.995	0.985
SC-GS [8]	1h	0.941	0.992	0.996	0.990	0.996	0.993	0.985	0 995	0.986
BealTime4DGS [†] [20]	-	0.541	0.002	0.000	-	0.000	-	0.000	0.000	0.980
V4D [5]	6h	0.945	0.980	0.006	0.961	0.085	0.080	0.961	0.072	0.073
UovPlana [2]	11	0.945	0.980	0.990	0.901	0.965	0.980	0.901	0.972	0.975
	20	0.935	0.912	0.995	0.949	0.979	0.970	0.940	0.907	0.904
Ours	<u>30m</u>	0.942	0.986	0.996	0.984	0.992	0.989	0.978	<u>0.990</u>	0.982
		-								
Methode	Train				LPI	$PS_v \downarrow$				
Methods	Train. \downarrow	lego	jumpingjack.	s bouncingballs	LPI hook	$PS_v \downarrow \\ standup$	trex	hellwarrior	mutant	Average
Methods D-NeRF [21]	Train.↓ 1d	<i>lego</i> 0.167	jumpingjack. 0.043	s bouncingballs 0.112	LPI hook 0.121	$PS_v \downarrow$ standup 0.022	trex 0.042	hellwarrior 0.071	mutant 0.028	Average 0.076
Methods D-NeRF [21] TiNeuVox [3]	Train.↓ 1d 28m	lego 0.167 0.107	jumpingjack 0.043 0.041	s bouncingballs 0.112 0.044	LPI hook 0.121 0.061	$PS_v \downarrow$ standup 0.022 0.032	trex 0.042 0.052	hellwarrior 0.071 0.080	mutant 0.028 0.048	Average 0.076 0.058
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4]	Train.↓ 1d 28m 1h	<i>lego</i> 0.167 0.107 0.047	jumpingjack: 0.043 0.041 0.051	s bouncingballs 0.112 0.044 0.035	LPI hook 0.121 0.061 0.070	$\begin{array}{r} PS_v \downarrow \\ \hline standup \\ \hline 0.022 \\ 0.032 \\ 0.033 \end{array}$	trex 0.042 0.052 0.036	hellwarrior 0.071 0.080 0.090	mutant 0.028 0.048 0.037	Average 0.076 0.058 0.050
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4]	Train. ↓ 1d 28m 1h 1h	<i>lego</i> 0.167 0.107 0.047 0.049	jumpingjack 0.043 0.041 0.051 0.062	s bouncingballs 0.112 0.044 0.035 0.044	LPI <i>hook</i> 0.121 0.061 0.070 0.075	$PS_v \downarrow standup 0.022 0.032 0.033 0.042$	trex 0.042 0.052 0.036 0.039	hellwarrior 0.071 0.080 0.090 0.094	mutant 0.028 0.048 0.037 0.040	Average 0.076 0.058 0.050 0.056
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22]	Train. ↓ 1d 28m 1h 1h 1h 10h	<i>lego</i> 0.167 0.107 0.047 <u>0.049</u> 0.132	jumpingjack 0.043 0.041 0.051 0.062 0.079	s bouncingballs 0.112 0.044 0.035 0.044 0.067	LPI 	$PS_v \downarrow $ standup 0.022 0.032 0.033 0.042 0.061	0.042 0.052 0.036 0.039 0.089	hellwarrior 0.071 0.080 0.090 0.094 0.118	mutant 0.028 0.048 0.037 0.040 0.087	Average 0.076 0.058 0.050 0.056 0.091
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27]	Train. ↓ 1d 28m 1h 1h 10h 40m	<i>lego</i> 0.167 0.107 0.047 <u>0.049</u> 0.132 0.064	jumpingjack: 0.043 0.041 0.051 0.062 0.079 0.028	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031	LPI . hook 0.121 0.061 0.070 0.075 0.093 0.034	$\begin{array}{r} PS_v \downarrow \\ \hline standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \end{array}$	0.042 0.052 0.036 0.039 0.089 0.029	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056	mutant 0.028 0.048 0.037 0.040 0.087 0.021	Average 0.076 0.058 0.050 0.056 0.091 0.036
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30]	Train. ↓ 1d 28m 1h 1h 1h 10h 40m 35m	lego 0.167 0.107 0.047 <u>0.049</u> 0.132 0.064 0.049	jumpingjack: 0.043 0.041 0.051 0.062 0.079 0.028 0.018	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020	LPI . hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019	$\begin{array}{r} PS_v \downarrow \\ \hline standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ 0.010 \end{array}$	0.042 0.052 0.036 0.039 0.089 0.029 0.013	$\begin{array}{c} hellwarrior \\ 0.071 \\ 0.080 \\ 0.090 \\ 0.094 \\ 0.118 \\ 0.056 \\ 0.034 \end{array}$	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.007	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h	lego 0.167 0.107 0.049 0.132 0.064 0.049 0.051	jumpingjack: 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022	LPI 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.013	$\begin{array}{r} \text{IPS}_{v} \downarrow \\ \hline standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.010 \\ 0.007 \end{array}$	trex 0.042 0.052 0.036 0.039 0.089 0.029 0.013 0.015	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 <u>0.034</u> 0.027	<i>mutant</i> 0.028 0.048 0.037 0.040 0.087 0.021 0.007 0.008	Average 0.076 0.058 0.050 0.056 0.091 0.036 <u>0.021</u> 0.019
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [30] SC-GS [26]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h	<i>lego</i> 0.167 0.107 0.047 0.132 0.064 <u>0.049</u> 0.051	jumpingjack: 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022	LPI 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.013	$\begin{array}{c} \text{IPS}_{v} \downarrow \\ \hline standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.010 \\ 0.007 \\ \hline \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.013 0.015	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.027	<i>mutant</i> 0.028 0.048 0.037 0.040 0.087 0.021 0.007 <u>0.008</u>	Average 0.076 0.058 0.050 0.056 0.091 0.036 <u>0.021</u> 0.019
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS ⁺ [29] V4D [5]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h	lego 0.167 0.107 0.047 0.049 0.132 0.064 0.049 0.051 - 0.049	jumpingjack: 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022	LPI 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.013 -	$\begin{array}{c} \text{IPS}_{v} \downarrow \\ \hline standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.010 \\ 0.007 \\ \hline 0 \\ 0.023 \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.013 0.015	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 <u>0.034</u> 0.027	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.007 0.008 - 0.008	Average 0.076 0.058 0.050 0.056 0.091 0.036 <u>0.021</u> 0.019 - 0.038
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HeyPlane [2]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1b	$\begin{array}{r} \hline lego\\ 0.167\\ 0.107\\ 0.047\\ 0.049\\ 0.132\\ 0.064\\ 0.049\\ 0.051\\ \hline 0\\ 0.064\\ \hline 0.049\\ 0.064 \end{array}$	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012 - 0.031 0.046	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 - 0.022 0.022	LPI : hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.013 0.053 0.064	$PS_v \downarrow$ standup 0.022 0.032 0.033 0.042 0.061 0.020 0.010 0.007 - 0.023 0.023 0.023	0.042 0.052 0.036 0.039 0.089 0.029 0.013 0.015 - 0.029 0.044	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 <u>0.034</u> 0.027 - 0.065 0.081	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.007 0.007 0.008 0.036 0.043	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.019 - 0.038 0.050
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2]	Train.↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 30m	lego 0.167 0.047 0.049 0.132 0.064 0.049 0.051 - 0.049 0.064 0.049	jumpingjack: 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012 - 0.031 0.046 0.022	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 - 0.022 0.029 0.029	LPI : hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.013 0.053 0.064 0.019	$\begin{array}{c} \text{PSv} \downarrow \\ \underline{standup} \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ \underline{0.010} \\ 0.007 \\ \hline 0.003 \\ 0.032 \\ 0.013 \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.013 0.015 - 0.029 0.042	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.027 - 0.065 0.081 0.081	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.007 0.008 - 0.036 0.043 0.012	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 30m	$\begin{array}{r} lego\\ 0.167\\ 0.107\\ 0.047\\ 0.049\\ 0.132\\ 0.064\\ 0.051\\ -\\ 0.049\\ 0.064\\ 0.049\\ 0.064\\ 0.049\\ 0.064\\ 0.049\\ \end{array}$	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.018 0.013 0.031 0.046 0.022	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.022 0.029 0.023	LPI . hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.053 0.064 0.019	$\begin{array}{c} \mathrm{PS_v} \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ 0.010 \\ \hline 0.007 \\ \hline 0.003 \\ 0.032 \\ 0.013 \end{array}$	trex 0.042 0.052 0.036 0.039 0.049 0.029 0.013 0.029 0.029 0.029 0.044	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.034 0.065 0.081 0.038	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.007 0.008 - 0.008 0.043 0.012	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-hybrid [4] Hensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS ⁺ [29] V4D [5] HexPlane [2] Ours Methods	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h <u>30m</u> Train	$\begin{array}{c} lego\\ 0.167\\ 0.107\\ 0.047\\ 0.049\\ 0.132\\ 0.064\\ 0.051\\ -\\ 0.049\\ 0.064\\ 0.064\\ 0.049\\ 0.064\\ 0.049\\ \end{array}$	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012 - 0.031 0.046 0.022	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.022 0.029 0.023	LPI <i>hook</i> 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.053 0.064 0.019 LPI	$\begin{array}{c} \mathrm{PS_v} \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.020 \\ \hline 0.020 \\ \hline 0.023 \\ 0.032 \\ \hline 0.032 \\ \hline 0.013 \\ \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.013 0.012 0.029 0.029 0.029 0.029 0.029 0.029 0.029	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.027 - 0.065 0.081 0.038	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.007 0.008 - 0.036 0.043 0.012	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours Methods	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h <u>30m</u> Train. ↓	lego 0.167 0.107 0.049 0.132 0.064 0.049 0.051 - 0.049 0.064 0.049 0.064 0.049 0.064 - 0.049 0.064 0.049	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.012 - 0.031 0.046 0.022 jumpingjacks	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.022 0.029 0.023 bouncingballs	LPI hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.013 0.064 0.019 LPI hook	$\begin{array}{c} \mathrm{PS_v} \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.010 \\ 0.010 \\ \hline 0.023 \\ 0.032 \\ \hline 0.032 \\ \hline 0.013 \\ \hline \mathrm{PS_a} \downarrow \\ standup \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.013 0.015 0.029 0.044 0.018	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.065 0.081 0.038 hellwarrior	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.007 0.008 - 0.036 0.043 0.012 mutant	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.038 0.050 0.024 Average
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h <u>30m</u> Train. ↓ 1d	lego 0.167 0.107 0.049 0.132 0.064 0.049 0.051 - 0.049 0.051 - 0.064 0.064 0.064 0.064 0.064	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012 - 0.031 0.046 0.022 jumpingjacks 0.029	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.029 0.023 bouncingballs 0.027	LPI hook 0.121 0.061 0.070 0.075 0.093 0.034 0.013 0.053 0.064 0.019 LPI hook 0.027	$\begin{array}{c} \mathrm{PS_v} \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.032 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.010 \\ 0.007 \\ \hline 0.023 \\ 0.032 \\ \hline 0.013 \\ \hline \mathbf{PS_a} \downarrow \\ standup \\ \hline 0.013 \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.013 0.013 0.029 0.044 0.018 trex 0.024	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.027 0.065 0.081 0.038 hellwarrior 0.041	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.008 0.036 0.043 0.012 mutant 0.016	Average 0.076 0.058 0.050 0.056 0.091 0.021 0.019 - 0.038 0.050 0.024 Average 0.030
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3]	Train. ↓ 10 18 28 1h 1h 10 40m 35m 1h - 6h 1h 30m Train. ↓ 1d 28m	lego 0.167 0.107 0.049 0.132 0.064 0.049 0.051 - 0.049 0.051 - 0.049 0.051 - 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012 - 0.031 0.046 0.022 jumpingjacks 0.023	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.022 0.029 0.023 bouncingballs 0.027 0.014	LPI hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.013 0.053 0.064 0.019 LPI hook 0.027 0.027 0.042	$\begin{array}{c} \mathrm{PS_v} \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.032 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.010 \\ 0.020 \\ \hline 0.007 \\ \hline 0.003 \\ 0.032 \\ \hline 0.013 \\ 0.021 \\ \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.013 0.015 0.029 0.044 0.018 trex 0.024 0.024	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.027 - 0.065 0.081 0.038 hellwarrior 0.041 0.059	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.008 0.036 0.043 0.012 mutant 0.016 0.039	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.038 0.050 0.024 Average 0.030 0.039
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 30m Train. ↓ 1d 28m 1h	lego 0.167 0.047 0.047 0.049 0.051 - 0.049 0.051 - 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.051 - 0.049 0.051 - 0.049 0.051 - 0.049 0.051 - 0.049 0.051 - 0.049 0.051 - 0.064 0.0049 0.051 - 0.0049 0.0060 0.0000	jumpingjack: 0.043 0.041 0.051 0.062 0.079 0.028 0.012 - - 0.031 0.046 0.022 jumpingjacks 0.029 0.031 0.031	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.022 0.022 0.029 0.023 0.023 0.027 0.014 0.013	LPI hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.013 0.064 0.019 LPI hook 0.027 0.049	$\begin{array}{c} PS_v \downarrow \\ standup \\ 0.022 \\ 0.033 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ 0.001 \\ 0.020 \\ 0.0007 \\ - \\ 0.023 \\ 0.032 \\ 0.013 \\ \hline PS_a \downarrow \\ standup \\ 0.013 \\ 0.021 \\ 0.021 \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.013 0.015 0.029 0.044 0.018 trex 0.024 0.024 0.041 0.030	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.065 0.081 0.038 hellwarrior 0.041 0.059 0.072	mutant 0.028 0.040 0.037 0.040 0.087 0.021 0.007 0.0036 0.043 0.012 mutant 0.036 0.036 0.012	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.019 - 0.030 0.024 Average 0.030 0.035
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [30] SC-GS [30] SC-GS [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4]	Train. ↓ 1d 28m 1h 1h 10h 35m 1h - 6h 1h 30m Train. ↓ 1d 28m 1h 1h 1h	lego 0.167 0.107 0.047 0.049 0.132 0.064 0.049 0.051 - 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.064 0.049 0.064 0.066 0.066 0.066 0.066 0.066 0.066 0.066 0.066 0.063 0.066 0.063 0.053 0.053 0.055	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.012 - 0.031 0.046 0.022 jumpingjacks 0.029 0.031 0.037 0.049	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.022 0.022 0.023 0.023 0.027 0.014 0.013 0.020	LPI hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.013 0.053 0.064 0.019 LPI hook 0.027 0.042 0.049 0.027	$\begin{array}{c} PS_v \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.010 \\ \hline 0.007 \\ \hline 0.032 \\ 0.013 \\ \hline 0.013 \\ 0.021 \\ 0.021 \\ 0.030 \\ \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.015 0.029 0.044 0.018 trex 0.024 0.024 0.030 0.031 0.034	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.065 0.081 0.038 hellwarrior 0.041 0.059 0.072 0.075	mutant 0.028 0.040 0.087 0.021 0.007 0.0036 0.036 0.012	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024 Average 0.030 0.039 0.035
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 30m Train. ↓ 1d 28m 1h 1h 10h	lego 0.167 0.047 0.047 0.049 0.132 0.064 0.049 0.051 - 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.066 0.068 0.063 0.063 0.063 0.063 0.063 0.063 0.014 0.063 0.063 0.063 0.014 0.014 0.064 0.064 0.068 0.063 0.014	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012 - - 0.031 0.046 0.022 jumpingjacks 0.029 0.031 0.037 0.049 0.049 0.093	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.029 0.023 0.023 0.027 0.014 0.013 0.020 0.024 0.024	LPI . hook 0.121 0.061 0.075 0.093 0.034 0.019 0.013 0.053 0.064 0.019 LPI hook 0.027 0.042 0.042 0.049 0.053 0.0101	$\begin{array}{c} PS_v \downarrow \\ standup \\ 0.022 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ 0.010 \\ 0.020 \\ 0.010 \\ 0.020 \\ 0.013 \\ 0.032 \\ 0.013 \\ 0.021 \\ 0.021 \\ 0.030 \\ 0.063 \end{array}$	trex 0.042 0.052 0.039 0.039 0.029 0.013 0.029 0.015 0.029 0.044 0.018 trex 0.024 0.024 0.030 0.034 0.034	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.027 - 0.065 0.081 0.038 hellwarrior 0.041 0.059 0.072 0.075 0.149	mutant 0.028 0.040 0.037 0.040 0.087 0.021 0.000 0.0036 0.036 0.036 0.012 mutant 0.016 0.039 0.027 0.0300	Average 0.076 0.058 0.050 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024 - Average 0.039 0.035 0.041 0.095
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS ⁴ [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 30m Train. ↓ 1d 28m 1h 1h 1h 10h 40m	lego 0.167 0.047 0.047 0.049 0.051 - 0.064 0.049 0.051 - 0.064 0.049 0.064 0.049 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.061 0.062 0.012 0.012	jumpingjack: 0.043 0.041 0.051 0.062 0.079 0.028 0.012 - - 0.031 0.046 0.022 jumpingjacks 0.029 0.031 0.037 0.049 0.093 0.018	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.029 0.023 bouncingballs 0.027 0.014 0.013 0.020 0.021	LPI . hook 0.061 0.061 0.075 0.093 0.034 0.013 0.053 0.053 0.064 0.019 LPI hook 0.027 0.042 0.042 0.049 0.057 0.021	$\begin{array}{c} PS_v \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.0010 \\ \hline 0.020 \\ 0.010 \\ \hline 0.023 \\ 0.032 \\ \hline 0.013 \\ \hline 0.021 \\ 0.021 \\ 0.021 \\ 0.030 \\ 0.061 \\ 0.061 \\ \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.013 0.015 0.029 0.044 0.018 trex 0.024 0.024 0.024 0.030 0.034 0.030	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.065 0.081 0.081 0.041 0.059 0.072 0.075 0.149 0.036	mutant 0.028 0.040 0.087 0.040 0.087 0.001 0.003 0.003 0.0040 0.005 0.006 0.036 0.039 0.027 0.030 0.021	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024 0.030 0.030 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.021 0.025 0.021 0.025 0.025 0.021 0.025 0.025 0.021 0.025 0.025 0.021 0.025 0.025 0.025 0.021 0.025 0.025 0.025 0.021 0.025 0.025 0.025 0.021 0.025 0.025 0.025 0.021 0.025 0.025 0.025 0.021 0.025 0.025 0.025 0.021 0.025 0.025 0.025 0.025 0.025 0.025 0.021 0.025 0.035 0.025 0.035 0.02
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [5] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 30m Train. ↓ 1d 28m 1h 1h 1h 10h 35m 1h 1h 35m 1h 1h 35m 1h 1h 35m 1h 35m 1h 35m 1h 35m 1h 35m 1h 35m 1h 35m 1h 35m 1h 35m 1h 35m 1h 35m 1h 35m 1h 35m 30m 1h 35m 30m 1h 35m 35m 1h 30m 35m 1h 30m 35m 1h 35m 30m 35m 1h 30m 35m 1h 30m 35m 1h 30m 35m 1h 30m 35m 1h 30m 35m 1h 30m 35m 1h 30m 1h 30m 1h 30m 35m 1h 30m 35m 1h 30m 1h 30m 35m 1h 30m 1h 35m 1h 30m 1h 35m 1h 30m 1h 35m 1h 1h 35m 1h 35m 1h 1h 1h 1h 1h 1h 1h 1h 1h 1h	lego 0.167 0.107 0.049 0.132 0.064 0.049 0.051 0.064 0.049 0.064 0.064 0.049 0.064 0.068 0.068 0.032 0.114 0.043	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.012 - 0.031 0.046 0.022 - jumpingjacks 0.029 0.031 0.037 0.049 0.093 0.018	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.022 0.022 0.022 0.023 0.023 0.027 0.014 0.013 0.020 0.046 0.012 0.004	LPI hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.019 0.053 0.064 0.019 LPI hook 0.020 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.045 0.025 0.053 0.053 0.055 0.042 0.042 0.002 0	$\begin{array}{r} PS_v \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.033 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.010 \\ 0.007 \\ \hline 0.023 \\ 0.032 \\ \hline 0.013 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.001 \\ 0.001 \\ 0.005 \end{array}$	trex 0.042 0.052 0.036 0.039 0.039 0.013 0.013 0.013 0.029 0.044 0.028 trex 0.024 0.044 0.041 0.030 0.041 0.041 0.041 0.041	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.065 0.081 0.038 hellwarrior 0.041 0.059 0.072 0.075 0.149 0.036 0.019	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.007 0.0037 0.0040 0.0040 0.007 0.008 0.012 mutant 0.016 0.027 0.030 0.027 0.030 0.090 0.011	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024 Average 0.030 0.035 0.041 0.095 0.041 0.095 0.021
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DG5 [†] [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8]	Train. ↓ 1d 28m 1h 1h 10 40m 35m 1h - 6h 1h 30m Train. ↓ 1d 28m 1h 10h 40m 35m 1b 10h 40m 35m 1b	lego 0.167 0.047 0.049 0.132 0.064 0.051 - 0.064 0.051 - 0.064 0.064 0.051 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.064 0.031 0.032 0.114 0.034 0.034 0.034	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012 - 0.031 0.046 0.022 jumpingjacks 0.029 0.031 0.037 0.049 0.038 0.012 0.093 0.012 0.007	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.029 0.023 bouncingballs 0.027 0.014 0.013 0.020 0.046 0.012 0.004 0.012 0.004	LPP 1 hook 0.121 0.061 0.070 0.070 0.093 0.034 0.019 0.013 0.064 0.019 LPI hook 0.027 0.042 0.049 0.057 0.049 0.057 0.049 0.057 0.049 0.057 0.049 0.057 0.049 0.057 0.049 0.057 0.049 0.057 0.049 0.057 0.049 0.057 0.049 0.057 0.049 0.057 0.044 0.057 0.044 0.057 0.057 0.054 0.057 0.054 0.057 0.054 0.057 0.055 0.054 0.055 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.057 0.044 0.057 0.049 0.057 0.059 0.057 0.049 0.057	$\begin{array}{r} \mathrm{PS_v} \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.032 \\ 0.042 \\ 0.061 \\ 0.020 \\ \hline 0.020 \\ 0.010 \\ \hline 0.020 \\ \hline 0.023 \\ 0.032 \\ \hline 0.032 \\ \hline 0.032 \\ \hline 0.013 \\ \hline \mathrm{PS_a} \downarrow \\ standup \\ 0.013 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.030 \\ 0.063 \\ 0.011 \\ \hline 0.003 \\ \hline 0.003 \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.013 0.015 - 0.029 0.044 0.041 0.030 0.044 0.041 0.030 0.034 0.034 0.034 0.034	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.027 0.065 0.081 0.038 hellwarrior 0.041 0.059 0.072 0.075 0.149 0.036 0.019 0.014	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.007 0.008 - 0.036 0.043 0.016 0.039 0.027 0.030 0.090 0.011 0.003	Average 0.076 0.058 0.050 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024 Average 0.039 0.035 0.035 0.035 0.035 0.035 0.095 0.091 0.095 0.091 0.019
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [20]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 30m Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 1h 1h	lego 0.167 0.107 0.049 0.132 0.064 0.051 - 0.064 0.064 0.064 0.064 0.064 0.060 0.0631 0.032 0.033 0.034	jumpingjack: 0.043 0.041 0.051 0.062 0.079 0.028 0.012 - 0.031 0.046 0.022 - - 0.031 0.046 0.022 - 0.031 0.037 0.049 0.031 0.037 0.049 0.093 0.018 0.012 0.009 0.0031 0.031 0.031 0.031 0.031 0.041 0.051 0.052 - - - - - - - - - - - - -	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.029 0.023 bouncingballs 0.027 0.014 0.013 0.020 0.021 0.021 0.021 0.024 0.027 0.014 0.014 0.013 0.020 0.027 0.014 0.021 0.024 0.029 0.023 0.024 0.029 0.023 0.024 0.029 0.023 0.024 0.029 0.023 0.024 0.029 0.029 0.023 0.024 0.029 0.029 0.023 0.027 0.014 0.029 0.029 0.029 0.029 0.021 0.029 0.029 0.029 0.029 0.029 0.027 0.014 0.020 0.029 0.029 0.029 0.029 0.029 0.029 0.027 0.014 0.020 0.029 0.029 0.029 0.029 0.029 0.029 0.029 0.027 0.014 0.020 0.027 0.014 0.020 0.027 0.021 0.029 0.029 0.027 0.014 0.020 0.027 0.014 0.020 0.027 0.014 0.020 0.029	LPP hook 0.121 0.061 0.070 0.075 0.093 0.019 0.013 0.064 0.019 1.P1 hook 0.027 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.041 0.027 0.042 0.042 0.042 0.042 0.041 0.042 0.041 0.041 0.041 0.05 0.041 0.05 0.041 0.05 0.041 0.05 0.041 0.05 0.041 0.05 0.041 0.05 0.041 0.05 0.041 0.05 0.041 0.05 0.041 0.05 0.041 0.05 0.041 0.05 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.042 0.045 0.042 0.057 0.042 0.057 0.042 0.057 0.042 0.057	$\begin{array}{r} PS_v \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.032 \\ 0.042 \\ 0.061 \\ 0.020 \\ 0.001 \\ 0.020 \\ 0.001 \\ 0.023 \\ 0.032 \\ 0.032 \\ \hline 0.032 \\ 0.031 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.030 \\ 0.063 \\ 0.001 \\ 0.003 \\ \hline 0.003 \\ \hline \end{array}$	trex 0.042 0.052 0.036 0.039 0.029 0.041 0.013 0.029 0.044 0.013 trex 0.024 0.044 0.034 0.034 0.034 0.034 0.034 0.010 0.034	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.027 - 0.065 0.081 0.038 hellwarrior 0.041 0.059 0.075 0.149 0.036 0.014	mutantt 0.028 0.048 0.048 0.021 0.021 0.021 0.036 0.036 0.036 0.036 0.036 0.036 0.036 0.036 0.036 0.030 0.030 0.030 0.030 0.043 0.043 0.043 0.043 0.043 0.048	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.019 - 0.038 0.050 0.022 0.030 0.039 0.035 0.041 0.095 0.021 0.012 0.010
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5]	Train. ↓ 1d 28m 1h 1h 1h 10h 40m 35m 1h - 6h 1h 30m Train. ↓ 1d 28m 1h 1h 1h 0h 40m 35m 1h - 6h 1h 1h 0h 40m 35m 1h - 6h 1h 1h - 6h 1h 1h - 6h 1h - 6h 1h - 6h 1h - 6h 1h - 6h - 1h - 6h 1h - 6h 1h - 6h - 1h - 6h - 1h - 6h - 1h - 6h - 1h - 6h - 1h - - 6h - - - - - - - - - - - - -	lego 0.167 0.047 0.047 0.047 0.051 - 0.064 0.049 0.051 - 0.049 0.051 - 0.049 0.051 - 0.049 0.051 - 0.049 0.052 0.032 0.033 0.034 - - 0.032 0.034 - - 0.032 0.034	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.012 - 0.031 0.046 0.022 - jumpingjacks 0.029 0.031 0.037 0.049 0.037 0.049 0.033 0.012 0.007 - - 0.019	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.022 0.029 0.023 0.023 0.027 0.014 0.014 0.012 0.024 0.046 0.012 0.024 0.024 0.024 0.025	LPI hook 0.121 0.061 0.070 0.070 0.034 0.019 0.053 0.053 0.053 0.064 0.019 LPI hook 0.022 0.049 0.042 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.011 0.022 0.012 0.025 0	$\begin{array}{r} PS_v \downarrow \\ standup\\ 0.022\\ 0.032\\ 0.032\\ 0.042\\ 0.061\\ 0.020\\ \hline 0.007\\ \hline 0.023\\ 0.023\\ 0.032\\ \hline 0.003\\ \hline 0.013\\ 0.021\\ 0.003\\ 0.011\\ 0.003\\ 0.013\\ 0.003\\ 0.013\\ 0.003\\ 0.0$	trex 0.042 0.052 0.036 0.039 0.029 0.029 0.029 0.029 0.024 0.024 0.024 0.024 0.024 0.030 0.030 0.030 0.034 0.010 0.030 0.030 0.034 0.012 0.030 0.034 0.030 0.034 0.042 0.052 0.029 0.024 0.024 0.024 0.036 0.024 0.020 0.024 0.020 0.020 0.020 0.024 0.020 0.020 0.020 0.020 0.029 0.029 0.024 0.0200 0.0200 0.0200 0.0200000000	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.0027 - 0.065 0.081 0.038 hellwarrior 0.041 0.059 0.072 0.041 0.059 0.072 0.072 0.041 0.036 0.034 - - - - - - - - - - - - -	mutant 0.028 0.048 0.037 0.040 0.087 0.021 0.087 0.030 0.043 0.043 0.043 0.012 mutant 0.016 0.039 0.030 0.030 0.030 0.030 0.030 0.030 0.030 0.030 0.030 0.030 0.024	Average 0.076 0.058 0.050 0.056 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024 Average 0.030 0.039 0.035 0.041 0.095 0.021 0.012 0.019 - 0.024
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-sexplicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 30m Train. ↓ 1d 28m 1h 10h 40m 35m 1h 10h 40m 11h 11h 10h 40m 11h 11h 11h 11h 11h 11h 11h 11h 11h 11	lego 0.167 0.047 0.047 0.047 0.047 0.047 0.049 0.051 0.049 0.064 0.049 0.064 0.049 0.064 0.049 0.064 0.032 0.034 0.032 0.034 0.034 0.034 0.034 0.034 0.034 0.034	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.012 0.031 0.046 0.022 jumpingjacks 0.029 0.031 0.037 0.049 0.093 0.012 0.007 0.012 0.007 0.012 0.007 0.012 0.012 0.007 0.012 0.012 0.007 0.012 0.012 0.012 0.012 0.012 0.012 0.012 0.012 0.012 0.029 0.031 0.029 0.031 0.029 0.031 0.049 0.012 0.012 0.012 0.029 0.031 0.029 0.031 0.029 0.031 0.029 0.031 0.029 0.031 0.029 0.031 0.029 0.031 0.029 0.031 0.049 0.012 0.012 0.012 0.012 0.029 0.031 0.037 0.049 0.012 0.012 0.012 0.012 0.037 0.012 0.037 0.012 0.037 0.012 0.037 0.037 0.012 0.037 0.037 0.037 0.037 0.037 0.037 0.037 0.037 0.031 0.037 0.037 0.037 0.031 0.037 0.037 0.037 0.037 0.039 0.037 0.039 0.037 0.039 0.037 0.039 0.037 0.039 0.037 0.039 0.037 0.039 0.037 0.039 0.037 0.039 0.032 0.039 0.032 0.032 0.032 0.032 0.037 0.049 0.032 0.	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.029 0.023 bouncingballs 0.027 0.014 0.013 0.020 0.046 0.012 0.004 0.004 0.004 0.005 0.005 0.00112 0.005 0.005 0.00112 0.005 0	LPP hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.019 0.019 1.001 0.027 0.042 0.042 0.042 0.057 0.042 0.057 0.042 0.057 0.042 0.057 0.051 0.027 0.027 0.021 0.034 0.019 0.034 0.019 0.034 0.027 0.034 0.027 0.034 0.021 0.034 0.042 0.042 0.042 0.045 0.042 0.045 0.042 0.042 0.045 0.057 0.042 0.042 0.045 0.057 0.042 0.042 0.057 0.057 0.042 0.057 0.057 0.057 0.057 0.057 0.042 0.057 0.007	$\begin{array}{r} PS_{v} \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.032 \\ 0.042 \\ 0.061 \\ 0.020 \\ 0.061 \\ 0.020 \\ 0.010 \\ 0.023 \\ 0.032 \\ 0.032 \\ 0.013 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.030 \\ 0.063 \\ 0.011 \\ 0.005 \\ 0.003 \\ 0.013 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.$	trex 0.042 0.052 0.036 0.039 0.029 0.029 0.044 0.018 trex 0.024 0.044 0.034 0.034 0.034 0.034	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.027 0.065 0.081 0.038 hellwarrior 0.041 0.059 0.072 0.072 0.075 0.149 0.036 0.019 0.014 - 0.045 0	mutant 0.028 0.028 0.048 0.037 0.040 0.021 0.007 0.008 0.021 0.007 0.003 0.021 0.030 0.023 0.023 0.023 0.023	Average 0.076 0.058 0.050 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024 Average 0.030 0.039 0.035 0.041 0.095 0.021 0.019 - 0.038 0.050 0.024 - - 0.035 0.024 - - 0.035 0.035 0.024 - - 0.035 0.024 - - 0.035 0.035 0.024 - - 0.035 0.035 0.024 - - 0.035 0.035 0.024 - - 0.035 0.035 0.024 - - - - - - - - - - - - -
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] SC-GS [8] RealTime4DGS [†] [29] V4D [5] HexPlane [2]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 30m Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h - 6h 1h 1h 20m	lego 0.167 0.047 0.047 0.051 0.064 0.047 0.051 0.064 0.049 0.064 0.049 0.064 0.049 0.060 0.068 0.032 0.034 0.032 0.032 0.032 0.032	jumpingjack. 0.043 0.041 0.051 0.062 0.079 0.028 0.018 0.012 - 0.031 0.046 0.022 0.031 0.046 0.022 0.031 0.037 0.049 0.031 0.049 0.012 0.007 - 0.018 0.012 0.007 - 0.018 0.012	s bouncingballs 0.112 0.044 0.035 0.044 0.067 0.031 0.020 0.022 0.029 0.023 0.023 0.027 0.014 0.013 0.020 0.024 0.014 0.012 0.004 0.004 0.004	LP1 hook 0.121 0.061 0.070 0.075 0.093 0.034 0.019 0.013 0.053 0.064 0.019 LP1 hook 0.027 0.042 0.027 0.042 0.010 0.027 0.042 0.019 0.027 0.027 0.027 0.027 0.034 0.027 0.034 0.044 0.019 0.027 0.027 0.027 0.034 0.027 0.034 0.042 0.034 0.044 0.019 0.027 0.027 0.027 0.027 0.027 0.027 0.027 0.027 0.034 0.027 0.034 0.007 0.007 0.007 0.027 0.007 0.027 0	$\begin{array}{r} PS_v \downarrow \\ standup \\ 0.022 \\ 0.032 \\ 0.032 \\ 0.042 \\ 0.061 \\ 0.020 \\ 0.001 \\ 0.020 \\ 0.001 \\ 0.020 \\ 0.023 \\ 0.022 \\ \hline 0.013 \\ 0.021 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.001 \\ 0.003 \\ 0.$	trex 0.042 0.052 0.036 0.039 0.029 0.029 0.044 0.018 trex 0.024 0.044 0.018 trex 0.024 0.044 0.034 0.034 0.004 0.034 0.010 0.020 0.020 0.021 0.020 0.021 0.022	hellwarrior 0.071 0.080 0.090 0.094 0.118 0.056 0.034 0.027 - - 0.065 0.081 0.038 - 0.065 0.081 0.038 0.041 0.059 0.072 0.075 0.149 0.036 0.014 - 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.038 - 0.045 0.038 - 0.041 0.059 0.075 0.041 0.038 - 0.041 0.038 - 0.041 0.038 - 0.041 0.041 0.038 - 0.041 0.041 0.041 0.045 0.041 0.045 0.045 0.041 0.045 0.041 0.045 0.041 0.045 0.045 0.041 0.045 0	mutantt 0.028 0.048 0.037 0.040 0.087 0.021 0.007 0.036 0.043 0.012 0.036 0.012 0.036 0.043 0.012 0.030 0.010 0.010 0.039 0.030 0.040 0.012 0.048 0.048 0.021 0.048 0.021 0.021 0.021 0.021 0.021 0.021 0.021 0.021 0.021 0.021 0.021 0.021 0.021 0.021 0.036 0.037 0.021 0.036 0.037 0.021 0.036 0.031 0.021 0.036 0.031 0.036 0.031 0.036 0.031 0.030 0.031 0.036 0.031 0.036 0.031 0.036 0.031 0.030 0.031 0.030 0.030 0.036 0.039 0.030 0.030 0.030 0.030 0.030 0.030 0.012 0.030	Average 0.076 0.058 0.050 0.091 0.036 0.021 0.019 - 0.038 0.050 0.024 - 0.039 0.035 0.041 0.095 0.021 0.035 0.041 0.092 0.010 - 0.024 0.035 0.021 0.035 0.035 0.035 0.035 0.035 0.035 0.035 0.038 0.035 0.041 0.035 0.035 0.041 0.035 0.035 0.041 0.035 0.041 0.035 0.041 0.035 0.041 0.035 0.041 0.035 0.041 0.035 0.041 0.035 0.041 0.035 0.041 0.035 0.041 0.035 0.041 0.036 0.041 0.035 0.041 0.035 0.041 0.035 0.041 0.036 0.041 0.035 0.041 0.035 0.041 0.034 0.041 0.045 0.041 0.044 0.045 0.041 0.044 0.045 0.045

Table 1: Quantitative per-scene results on the test set of the original D-NeRF dataset.**Bold** means the best performance and <u>underline</u> means the second best performance.

Single-scale D-NeRF Dataset We conducted an evaluation of several approaches using three metrics: Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index (SSIM) [25], and Learned Perceptual Image Patch Similarity (LPIPS) [32]. The results are presented in Tab. 1. All methods are trained with full-resolution images (800×800) from the training set and rendered at full resolution for both quantitative evaluation and qualitative comparisons. The cost of training time is achieved from our experiments on one NVIDIA GeForce RTX 3090 GPU. For method marked with "[†]" [29], we directly use the metrics from their paper. In the single-scale dataset, though anti-aliasing feature is not a dominant factor of the final rendering results, our method consistently surpasses all NeRF-based baseline methods [2–5,21,22] across all measured criteria, thanks to its ability to reconstruct high-quality details. However, concurrent works [8, 27, 29, 30] utilized 3DGS [9] along with its differentiable rasterizer, achieving efficient dynamic scene representation. Our proposed method outperforms [27, 29], but not [8, 30]. Though these two works have greatly enhanced the rendering quality on the monocular single-scale synthetic dataset, they suffer from aliasing artifacts on the multi-scale dataset captured at various distances, as mentioned in [9]. Please refer to the section below for comparisons on the multi-scale D-NeRF dataset. Although TiNeuVox [3] requires slightly less training time compared to our method, our proposed method (**DMiT**) demonstrates a significantly faster inference time, almost $7 \times$ faster than TiNeuVox. This speed improvement is achieved while maintaining a higher rendering quality, which may be attributed to the efficiency and compactness of our deformable and mipmapped tri-plane representation. While achieving impressive efficiency as a NeRF-based framework, the rendering speed is not in real-time like 3DGS-based methods [8, 27, 29, 30].

Multi-scale D-NeRF Dataset To demonstrate the effectiveness of our method for anti-aliasing, we list per-scene results in Tab. 2 by averaging over four resolutions. In addition, we present the comparison of rendering results of both fullresolution and low-resolution with baseline methods [3, 4, 21, 22, 27, 30]. These comparisons are illustrated in Fig. 1 and Fig. 2, where K-Planes-H denotes the hybrid architecture of K-Planes [4] and K-Planes-E denotes the explicit architecture. We also provide a low-resolution rendering comparison labeled with the corresponding PSNR/SSIM metrics in Fig. 3. The proposed methodology accurately depicts dynamic scenes with enhanced level of details at varying distances, closely approximating the ground truth (GT). Other baseline methods either lose fine-grained details or suffer from noticeable artifacts. 3DGS-based methods [27, 30] generate blurry images when rendering high-resolution images (corresponding to small capture distances) and dilated objects when rendering low-resolution images (corresponding to large capture distances) as shown in Fig. 1 and Fig. 2. These artifacts have been thoroughly discussed in [31]. Our supplementary video provides a more comprehensive observation of the improved visual quality achieved by the utilization of anti-aliasing techniques in dynamic scene rendering.

 Table 2: Quantitative per-scene results on the test set of the multi-scale D-NeRF dataset. Bold means the best performance and <u>underline</u> means the second best performance.

 PSNR ↑

Methods	Train. ↓				1.					
	****	lego	jumpingjacks	bouncingballs	hook	standup	trex	hellwarrior	mutant	Average
D-NeRF [21]	1d	23.46	30.18	28.75	29.69	33.36	28.39	23.79	31.99	28.70
TiNeuVox [3]	28m	25.14	33.27	36.74	30.94	34.11	32.12	27.77	32.74	31.60
K-Planes-hybrid [4]	1h	24.95	26.47	31.32	27.02	29.24	29.22	21.90	30.69	27.60
K-Planes-explicit [4]	1h	25.04	25.90	30.53	26.52	28.98	28.69	21.60	30.54	27.23
Tensor4D [22]	10h	23.21	25.38	29.32	25.78	26.14	26.34	21.81	25.95	25.49
4DGS [27]	40m	25.11	32.73	36.16	29.14	32.27	30.43	26.82	31.29	30.49
D3DGS [30]	35m	25.67	34.91	38.54	31.34	34.57	34.28	29.14	32.96	32.68
HexPlane [2]	1h	25.04	27.58	33.72	27.11	30.85	29.76	22.84	31.54	28.56
V4D [5]	6h	25.20	33.13	36.36	29.87	34.19	32.88	26.59	33.45	31.46
SC-GS [8]	1h	23.16	35.41	38.47	31.79	34.46	25.94	29.26	32.83	31.42
RealTime4DGS [29]	-	24.34	30.95	33.84	27.98	32.20	29.31	23.84	31.80	29.28
Ours	30m	25.92	35.30	42.63	34.29	38.17	37.47	30.04	38.37	35.27
					ç	SIM +				
Methods	Train. \downarrow	logo	iumpin aia aka	hour ain aballa	hook	atan dun	trica	hallugarrian	mutant	Anorago
D N-DE [01]	1.1	1ey0	<u>јитринујиск</u> з	0.059	0.046	0.072	0.052	0.025	0.069	Averuge
D-Nenr [21]	28	0.807	0.901	0.958	0.940	0.972	0.955	0.955	0.902	0.944
I Invention [5]	2011	0.920	0.981	0.970	0.972	0.985	0.975	0.907	0.977	0.908
K-Planes-hybrid [4]	11	0.935	0.947	0.959	0.949	0.970	0.962	0.918	0.974	0.952
K-Planes-explicit [4]	101	0.934	0.937	0.955	0.942	0.966	0.959	0.912	0.973	0.947
Tensor4D [22]	10h	0.876	0.935	0.947	0.939	0.954	0.932	0.924	0.942	0.931
4DGS [27]	40m	0.915	0.980	0.976	0.964	0.981	0.971	0.963	0.974	0.966
D3DGS [30]	35m	0.935	0.988	0.988	0.978	0.989	<u>0.987</u>	0.975	0.984	<u>0.978</u>
HexPlane [2]	1h	0.931	0.951	0.963	0.951	0.978	0.966	0.935	0.976	0.957
V4D [5]	6h	<u>0.936</u>	0.982	0.969	0.970	0.988	0.979	0.963	0.983	0.971
SC-GS [8]	1h	0.915	0.989	0.988	0.980	0.989	0.943	0.976	0.984	0.970
RealTime4DGS [29]	-	0.896	0.972	0.977	0.958	0.982	0.966	0.939	0.978	0.958
Ours	<u>30m</u>	0.948	<u>0.988</u>	0.995	0.988	0.993	0.992	0.979	0.993	0.985
		$LPIPS_v \downarrow$								
Mathada	The in 1				LP	$IPS_v \downarrow$				
Methods	Train. \downarrow	lego	jumpingjacks	bouncingballs	LP hook	$IPS_v \downarrow \\ standup$	trex	hellwarrior	mutant	Average
Methods D-NeRF [21]	Train.↓ 1d	<i>lego</i> 0.095	jumpingjacks 0.060	bouncingballs 0.066	LP hook 0.063	$IPS_v \downarrow \\ standup \\ 0.033$	trex 0.049	hellwarrior 0.085	<i>mutant</i> 0.041	Average 0.062
Methods D-NeRF [21] TiNeuVox [3]	Train.↓ 1d 28m	<i>lego</i> 0.095 0.077	jumpingjacks 0.060 0.030	bouncingballs 0.066 0.054	LP hook 0.063 0.044	$\frac{\text{IPS}_{v} \downarrow}{standup}$ 0.033 0.024	trex 0.049 0.044	hellwarrior 0.085 0.063	mutant 0.041 0.033	Average 0.062 0.046
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4]	Train.↓ 1d 28m 1h	<i>lego</i> 0.095 0.077 0.056	jumpingjacks 0.060 0.030 0.059	bouncingballs 0.066 0.054 0.057	LP hook 0.063 0.044 0.069	$\frac{\text{IPS}_{v} \downarrow}{standup}$ 0.033 0.024 0.031	trex 0.049 0.044 0.049	hellwarrior 0.085 0.063 0.119	mutant 0.041 0.033 0.031	Average 0.062 0.046 0.059
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4]	Train.↓ 1d 28m 1h 1h	lego 0.095 0.077 0.056 0.058	jumpingjacks 0.060 0.030 0.059 0.086	bouncingballs 0.066 0.054 0.057 0.062	LP hook 0.063 0.044 0.069 0.076	$\frac{\text{IPS}_{v} \downarrow}{standup}$ 0.033 0.024 0.031 0.040	0.049 0.044 0.049 0.049 0.056	hellwarrior 0.085 0.063 0.119 0.123	mutant 0.041 0.033 0.031 0.033	Average 0.062 0.046 0.059 0.067
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22]	Train. ↓ 1d 28m 1h 1h 1h 10h	<i>lego</i> 0.095 0.077 0.056 0.058 0.105	jumpingjacks 0.060 0.030 0.059 0.086 0.076	bouncingballs 0.066 0.054 0.057 0.062 0.078	LP hook 0.063 0.044 0.069 0.076 0.076	$IPS_v \downarrow$ standup 0.033 0.024 0.031 0.040 0.050	0.049 0.044 0.049 0.056 0.077	hellwarrior 0.085 0.063 0.119 0.123 0.102	mutant 0.041 0.033 0.031 0.033 0.069	Average 0.062 0.046 0.059 0.067 0.079
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27]	Train. ↓ 1d 28m 1h 1h 10h 40m	lego 0.095 0.077 0.056 0.058 0.105 0.078	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045	LP hook 0.063 0.044 0.069 0.076 0.076 0.042	$\begin{array}{c} \text{IPS}_{v} \downarrow \\ \hline standup \\ \hline 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \end{array}$	0.049 0.044 0.049 0.056 0.077 0.037	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051	mutant 0.041 0.033 0.031 0.033 0.069 0.034	Average 0.062 0.046 0.059 0.067 0.079 0.042
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30]	Train. ↓ 1d 28m 1h 1h 1h 10h 40m 35m	lego 0.095 0.077 0.056 0.058 0.105 0.078 0.051	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029	LP hook 0.063 0.044 0.069 0.076 0.076 0.076 0.042 0.028	$\begin{array}{c} \mathrm{IPS_v} \downarrow \\ \hline standup \\ \hline 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ 0.015 \end{array}$	0.049 0.044 0.049 0.056 0.077 0.037 0.020	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038	mutant 0.041 0.033 0.031 0.033 0.069 0.034 0.022	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h	lego 0.095 0.077 0.056 0.058 0.105 0.078 <u>0.051</u> 0.059	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 <u>0.019</u> 0.048	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052	LP hook 0.063 0.044 0.069 0.076 0.076 0.076 0.042 0.028 0.057	$\begin{array}{c} \text{IPS}_{v} \downarrow \\ \hline standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ \hline 0.024 \\ \hline 0.015 \\ 0.025 \end{array}$	trex 0.049 0.044 0.049 0.056 0.077 0.037 0.020 0.043	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.081	$\begin{array}{c} mutant\\ 0.041\\ 0.033\\ 0.031\\ 0.033\\ 0.069\\ 0.034\\ \underline{0.022}\\ 0.033 \end{array}$	$\begin{array}{c} Average \\ 0.062 \\ 0.046 \\ 0.059 \\ 0.067 \\ 0.079 \\ 0.042 \\ \underline{0.028} \\ 0.050 \end{array}$
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h 6h	lego 0.095 0.077 0.056 0.058 0.105 0.078 <u>0.051</u> 0.059 0.054	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 <u>0.019</u> 0.048 0.025	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049	LP hook 0.063 0.044 0.069 0.076 0.076 0.042 0.028 0.057 0.042	$\begin{array}{r} \mathrm{IPS_v} \downarrow \\ \hline standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ \hline 0.024 \\ 0.015 \\ \hline 0.025 \\ 0.019 \end{array}$	trex 0.049 0.044 0.049 0.056 0.077 0.037 0.020 0.043	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.081 0.056	$\begin{array}{c} mutant\\ 0.041\\ 0.033\\ 0.031\\ 0.033\\ 0.069\\ 0.034\\ \underline{0.022}\\ 0.033\\ 0.027\end{array}$	Average 0.062 0.046 0.059 0.067 0.079 0.042 <u>0.028</u> 0.050 0.038
Methods D-NeRF [21] TiNenVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h 6h 1h	lego 0.095 0.077 0.056 0.058 0.105 0.078 0.051 0.059 0.054 0.082	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 <u>0.019</u> 0.048 0.025 0.018	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 0.028	LP hook 0.063 0.044 0.069 0.076 0.076 0.042 0.028 0.057 0.042 0.027	$\begin{array}{r} \mathrm{IPS_v} \downarrow \\ \hline standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ \underline{0.015} \\ 0.025 \\ 0.015 \\ 0.015 \end{array}$	trex 0.049 0.044 0.049 0.056 0.077 0.037 0.020 0.043 0.032 0.068	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.081 0.056 0.037	mutant 0.041 0.033 0.031 0.033 0.069 0.034 <u>0.022</u> 0.033 0.027 0.024	Average 0.062 0.046 0.059 0.067 0.079 0.042 <u>0.028</u> 0.050 0.038 0.037
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-publicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h 6h 1h	lego 0.095 0.077 0.056 0.058 0.105 0.078 0.051 0.059 0.054 0.082 0.102	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 <u>0.019</u> 0.048 0.025 0.018 0.042	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 0.028 0.028 0.045	$\begin{array}{c} \text{LP}\\ \hline hook\\ 0.063\\ 0.044\\ 0.069\\ 0.076\\ 0.076\\ 0.042\\ 0.028\\ 0.057\\ 0.042\\ 0.027\\ 0.042\\ 0.027\\ 0.053\\ \end{array}$	$\begin{array}{l} \mathrm{IPS_v} \downarrow \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ 0.015 \\ 0.025 \\ 0.015 \\ 0.015 \\ 0.015 \\ 0.022 \end{array}$	trex 0.049 0.044 0.049 0.056 0.077 0.037 0.020 0.043 0.032 0.068 0.041	hellwarrior 0.085 0.063 0.119 0.123 0.02 0.051 0.038 0.081 0.056 0.037 0.080	mutant 0.041 0.033 0.031 0.033 0.069 0.034 0.022 0.033 0.022 0.033 0.022 0.033 0.027 0.024 0.028	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.050 0.038 0.037 0.052
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h 6h 1h - 30m	lego 0.095 0.077 0.056 0.058 0.105 0.078 0.051 0.059 0.054 0.082 0.102 0.036	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 <u>0.019</u> 0.048 0.025 0.018 0.042 0.019	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 <u>0.028</u> 0.045 0.049 <u>0.028</u> 0.045 0.045	LP hook 0.063 0.044 0.069 0.076 0.076 0.042 0.028 0.057 0.042 <u>0.027</u> 0.042 <u>0.027</u> 0.053 0.016	$\begin{array}{c} \mathrm{IPS}_{\vee} \downarrow \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ \underline{0.015} \\ 0.025 \\ 0.019 \\ \underline{0.015} \\ 0.025 \\ 0.020 \\ 0.010 \\ \end{array}$	trex 0.049 0.044 0.049 0.056 0.077 0.037 0.020 0.043 0.032 0.068 0.041	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.051 0.081 0.081 0.086 0.080 0.080	mutant 0.041 0.033 0.031 0.033 0.069 0.034 0.022 0.033 0.027 0.028 0.028 0.008	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.050 0.038 0.037 0.052 0.019
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h 6h 1h - <u>30m</u>	lego 0.095 0.077 0.056 0.058 0.105 0.078 0.051 0.059 0.054 0.082 0.102 0.036	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 <u>0.019</u> 0.048 0.042 0.019 0.042 0.019	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 0.028 0.045 0.045 0.016	LP hook 0.063 0.044 0.069 0.076 0.042 0.028 0.057 0.042 <u>0.027</u> 0.053 0.016	$\begin{array}{c} \mathrm{IPS}_{\vee} \downarrow \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ \underline{0.015} \\ 0.025 \\ 0.019 \\ \underline{0.015} \\ 0.020 \\ 0.020 \\ \hline 0.020 \\ \hline \end{array}$	trex 0.049 0.044 0.056 0.077 0.037 0.020 0.043 0.032 0.068 0.041	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.081 0.056 0.037 0.080 0.034	$\begin{array}{c} mutant\\ 0.041\\ 0.033\\ 0.031\\ 0.033\\ 0.069\\ 0.034\\ \underline{0.022}\\ 0.033\\ 0.027\\ 0.024\\ 0.028\\ \hline 0.008 \end{array}$	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.050 0.038 0.037 0.052 0.019
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-hybrid [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h 6h 1h - <u>30m</u> Train. ↓	lego 0.095 0.077 0.056 0.058 0.105 0.078 0.051 0.059 0.054 0.022 0.102 0.036	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019 0.048 0.025 0.018 0.042 0.019	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 <u>0.028</u> 0.045 0.045 0.045	LP hook 0.063 0.044 0.069 0.076 0.076 0.042 0.028 0.027 0.053 0.016 LPI	$\begin{array}{c} \text{IPS}_{\vee} \downarrow \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ 0.015 \\ 0.025 \\ 0.015 \\ 0.022 \\ \hline 0.010 \\ \hline 0.010 \\ \hline \textbf{PS}_{\vee} \downarrow \end{array}$	trex 0.049 0.044 0.056 0.077 0.037 0.020 0.043 0.032 0.068 0.041	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.081 0.056 0.037 0.080 0.034	mutant 0.041 0.033 0.031 0.033 0.069 0.034 0.022 0.033 0.027 0.024 0.028 0.008	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.050 0.038 0.037 0.052 0.019
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D M DD [21]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h 6h 1h - <u>30m</u> Train. ↓	lego 0.095 0.077 0.056 0.058 0.105 0.078 0.051 0.059 0.054 0.082 0.102 0.036 lego	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019 0.048 0.025 0.018 0.042 0.019 jumpingjacks	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 <u>0.028</u> 0.045 0.045 0.045 0.045 0.016	LP hook 0.063 0.044 0.069 0.076 0.076 0.042 0.028 0.057 0.042 0.027 0.053 0.016 LPI hook	$\begin{array}{c} \mathrm{IPS_v} \downarrow \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.025 \\ 0.015 \\ 0.025 \\ 0.015 \\ 0.022 \\ \hline 0.010 \\ \hline 0.010 \\ \mathbf{PS_v} \downarrow \\ standup \\ standup \\ 0.011 \\ \hline \mathbf{PS_v} \downarrow \\ standup \\ 0.011 \\ \hline \mathbf{PS_v} \downarrow \\ \mathbf{standup} \\ stand$	trex 0.049 0.044 0.056 0.077 0.037 0.020 0.043 0.032 0.068 0.041 0.010	hellwarrior 0.085 0.063 0.119 0.123 0.002 0.051 0.038 0.056 0.037 0.080 0.034	mutant 0.041 0.033 0.031 0.033 0.069 0.034 0.022 0.033 0.027 0.024 0.028 0.008 mutant	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.038 0.037 0.052 0.019 Average
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] D-NeRF [21] Trailut [2]	Train.↓ 1d 28m 1h 1h 10h 40m 35m 1h 6h 1h - <u>30m</u> Train.↓ 1d	lego 0.095 0.077 0.056 0.058 0.105 0.071 0.052 0.073 0.059 0.054 0.052 0.102 0.036 lego 0.065	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 <u>0.019</u> 0.048 0.025 0.018 0.042 <u>0.019</u> jumpingjacks 0.044	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 0.028 0.045 0.049 0.028 0.045 0.016 bouncingballs 0.047	LP hook 0.063 0.044 0.069 0.076 0.042 0.028 0.057 0.042 <u>0.027</u> 0.053 0.016 LPI hook 0.050 0.050	$\begin{array}{c} \mathrm{IPS}_{v} \downarrow \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ 0.015 \\ 0.025 \\ 0.019 \\ 0.015 \\ 0.022 \\ \hline 0.010 \\ \hline \mathbf{PS}_{v} \downarrow \\ standup \\ 0.031 \\ 0.031 \\ 0.031 \\ 0.031 \\ \end{array}$	trex 0.049 0.044 0.049 0.056 0.077 0.037 0.020 0.043 0.032 0.043 0.043 0.043 0.043 0.041 0.041 trex 0.042 0.042	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.081 0.056 0.037 0.080 0.034	mutant 0.041 0.033 0.031 0.033 0.069 0.034 0.022 0.033 0.024 0.025 0.008	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.050 0.038 0.037 0.059 0.012 0.050 0.051 0.051 0.051 0.051 0.051 0.051
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] TiNeuVox [3] [4]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h 6h 1h - <u>30m</u> Train. ↓ 1d 28m 30m	lego 0.095 0.077 0.056 0.058 0.105 0.058 0.059 0.059 0.054 0.082 0.102 0.036 lego 0.065 0.048 0.048	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019 0.048 0.025 0.018 0.042 0.019 jumpingjacks 0.044 0.020 0.044	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 0.028 0.045 0.045 0.045 0.047 0.022 0.047 0.022 0.041	LP hook 0.063 0.044 0.069 0.076 0.042 0.022 0.057 0.042 0.057 0.042 0.053 0.016 LPI hook 0.050 0.050 0.023 0.0050	$\begin{array}{c} \mathrm{IPS}_{\vee} \downarrow \\ \underline{standup} \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.025 \\ 0.025 \\ 0.025 \\ 0.019 \\ \underline{0.015} \\ 0.020 \\ \hline \textbf{0.010} \\ \hline \textbf{PS}_{\vee} \downarrow \\ \underline{standup} \\ \underline{standup} \\ 0.031 \\ 0.031 \\ 0.031 \end{array}$	trex 0.049 0.044 0.049 0.056 0.077 0.020 0.043 0.032 0.043 0.043 0.044 0.043 0.043 0.044 0.043 0.043 0.041 0.041 0.042 0.042 0.042	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.081 0.056 0.037 0.080 0.034	mutant 0.041 0.033 0.031 0.033 0.069 0.034 0.022 0.033 0.027 0.024 0.028 0.008	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.025 0.038 0.037 0.052 0.019 Average 0.047 0.027 0.027
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4]	Train. ↓ 1d 28m 1h 1h 1h 40m 35m 1h 6h 1h - <u>30m</u> Train. ↓ 1d 28m 1h 1h	lego 0.095 0.077 0.056 0.058 0.105 0.078 0.059 0.054 0.082 0.022 0.036 lego 0.065 0.048 0.043 0.043	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019 0.048 0.025 0.018 0.042 0.019 jumpingjacks 0.044 0.020 0.044	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.052 0.045 0.052 0.045 0.052 0.045 0.052 0.045 0.052 0.045 0.052 0.045 0.045 0.052 0.045 0.045 0.045 0.052 0.045 0.047 0.047 0.047 0.052 0.047 0.052 0.047 0.052 0.047 0.052 0.047 0.052 0.047 0.052 0.047 0.052 0.047 0.052 0.047 0.052 0.047 0.052 0.047 0.052 0.047 0.052 0.047 0.052 0.055 0	LP hook 0.063 0.044 0.076 0.076 0.042 0.028 0.057 0.042 0.053 0.042 0.053 0.053 0.053 0.012 hook 0.050 0.023 0.023	$\begin{array}{l} \mathrm{IPS}_{\vee}\downarrow\\ standup\\ 0.033\\ 0.024\\ 0.031\\ 0.040\\ 0.050\\ 0.024\\ 0.015\\ 0.025\\ 0.015\\ 0.022\\ \hline \textbf{0.010}\\ \hline \textbf{0.010}\\ \hline \textbf{PS}_{\vee}\downarrow\\ standup\\ 0.014\\ 0.021\\ 0.021\\ \hline \textbf{0.011}\\ \hline \textbf{0.021}\\ \hline 0.0$	trex 0.049 0.044 0.056 0.077 0.037 0.020 0.043 0.032 0.043 0.043 0.043 0.043 0.043 0.043 0.043 0.043 0.043 0.043 0.043 0.043 0.041 0.041 0.042 0.031 0.039	hellwarrior 0.085 0.063 0.119 0.123 0.002 0.051 0.038 0.056 0.037 0.080 0.080 0.034	mutant 0.041 0.033 0.033 0.033 0.033 0.033 0.023 0.023 0.024 0.028 0.008 mutant 0.032 0.021 0.020	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.050 0.038 0.052 0.019 Average 0.047 0.027 0.040
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4]	Train. ↓ 1d 28m 1h 1h 1h 1h 40m 35m 1h 6h 1h 1h 28m 1d 28m 1h 1h 1h 1h 1h 1h 1h 1h 1h 1h	lego 0.095 0.077 0.056 0.058 0.105 0.078 0.059 0.054 0.082 0.102 0.036 0.065 0.048 0.043 0.044 0.024	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019 0.048 0.025 0.018 0.042 0.019 jumpingjacks 0.044 0.020 0.044 0.020 0.044 0.020	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 0.028 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.052 0.049 0.052 0.045 0.052 0.052 0.054 0.052 0.045 0.045 0.052 0.045 0.045 0.045 0.052 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.029 0.052 0.045 0.045 0.045 0.028 0.045 0.045 0.045 0.045 0.045 0.028 0.045 0.045 0.045 0.028 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.046 0.045 0.046 0.046 0.046 0.046 0.047 0.022 0.047 0.022 0.034 0.037 0	LP hook 0.063 0.044 0.076 0.076 0.042 0.028 0.057 0.042 0.053 0.016 LPI hook 0.050 0.023 0.038 0.043 0.043	$\begin{array}{c} \mathrm{IPS}_{v} \downarrow \\ standup\\ 0.033\\ 0.024\\ 0.031\\ 0.040\\ 0.050\\ 0.025\\ 0.015\\ 0.025\\ 0.019\\ 0.012\\ \hline \textbf{0.010}\\ \hline \textbf{PS}_{v} \downarrow \\ standup\\ 0.031\\ 0.021\\ 0.021\\ 0.027\\ 0.027\\ 0.027\\ \hline \textbf{0.012}\\ \hline \textbf{0.027}\\ 0.027\\ \hline \textbf{0.012}\\ \hline \textbf{0.027}\\ 0.027\\ \hline \textbf{0.027}\\ 0.027\\ \hline \textbf{0.027}\\ \hline \textbf$	trex 0.049 0.049 0.040 0.041 0.056 0.077 0.037 0.042 0.043 0.042 0.043 0.032 0.041 0.010 trex 0.031 0.032 0.031 0.039 0.044	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.081 0.056 0.037 0.080 0.034 hellwarrior 0.058 0.035 0.076 0.080	mutant 0.041 0.033 0.031 0.033 0.034 0.035 0.024 0.028 0.028 0.028 0.021 0.021 0.021	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.050 0.038 0.037 0.052 0.019
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [2] Tensor4D [22]	Train. ↓ 1d 28m 1h 1h 10 40m 35m 1h 6h 1h - 30m Train. ↓ 1d 28m 1h 1h 10 10 10 10 10 10 10 10 10 10	lego 0.095 0.077 0.0556 0.058 0.058 0.059 0.059 0.052 0.059 0.052 0.082 0.102 0.036 0.065 0.048 0.043 0.044 0.087 0.054	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019 0.048 0.042 0.019 jumpingjacks 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.045 0.045 0.059 0.086 0.030 0.059 0.086 0.030 0.059 0.086 0.030 0.019 0.048 0.0588 0.0588 0.0588 0.0588 0.0588 0.05	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 0.028 0.045 0.049 0.028 0.045 0.016 bouncingballs 0.047 0.022 0.034 0.037 0.051	LP hook 0.063 0.044 0.069 0.076 0.042 0.028 0.057 0.042 0.053 0.042 0.053 0.041 hook 0.050 0.023 0.038 0.038 0.043 0.069	$\begin{array}{c} \mathrm{IPS}_{v} \downarrow \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ \hline 0.015 \\ 0.025 \\ 0.019 \\ \hline 0.015 \\ 0.022 \\ \hline 0.010 \\ \hline \textbf{0.010} \\ \hline \textbf{0.010} \\ \hline \textbf{0.031} \\ 0.031 \\ 0.014 \\ 0.021 \\ 0.027 \\ 0.052 \end{array}$	trex 0.049 0.049 0.040 0.056 0.077 0.037 0.032 0.043 0.043 0.044 0.045 0.041 0.042 0.031 0.032 0.031 0.031 0.033 0.039 0.044 0.080	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.081 0.056 0.037 0.080 0.034	mutant 0.041 0.033 0.033 0.033 0.022 0.033 0.022 0.033 0.022 0.033 0.022 0.033 0.022 0.033 0.024 0.028 0.008 mutant 0.035 0.021 0.022 0.021 0.021	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.037 0.052 0.019 Average 0.047 0.047 0.045 0.045 0.045 0.045
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-hybrid [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] 2DGS	Train. ↓ 1d 28m 1h 1h 1h 40m 35m 1h 6h 1h - 30m Train. ↓ 1d 28m 1h 10h 40m	lego 0.095 0.076 0.056 0.058 0.105 0.058 0.059 0.059 0.054 0.059 0.054 0.082 0.102 0.036 0.065 0.044 0.044 0.044 0.057 0.057	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019 0.048 0.025 0.018 0.042 0.019 jumpingjacks 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.042 0.042 0.044 0.020 0.042 0.042 0.042 0.044 0.020 0.042 0.042 0.042 0.044 0.020 0.042 0.042 0.044 0.020 0.042 0.042 0.044 0.020 0.042 0.042 0.044 0.020 0.044 0.020 0.042 0.042 0.044 0.020 0.044 0.042 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.042 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.047 0.047 0.047 0.048 0.047 0.047 0.048 0.047 0.047 0.048 0.047 0.048 0.047 0.048 0.047 0.048 0.047 0.048 0.058 0.047 0.058 0.	bouncingballs 0.066 0.057 0.057 0.062 0.078 0.045 0.029 0.052 0.049 0.052 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.045 0.052 0.045 0.052 0.045 0.052 0.052 0.045 0.052 0.045 0.052 0.045 0.052 0.045 0.052 0.045 0.052 0.045 0.045 0.045 0.029 0.045 0.045 0.045 0.029 0.045 0.052 0.034 0.037 0.055 0.055 0.052 0.034 0.055 0.055 0.037 0.055 0	LP hook 0.063 0.044 0.069 0.076 0.076 0.022 0.027 0.042 0.027 0.053 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.042 0.050 0.043 0.043 0.0457 0.043 0.0457 0.043 0.0457 0.0457 0.043 0.0443 0.047 0.0457 0.047 0.0457 0.047 0.0457 0.047 0.0457 0.047 0.0457 0.047 0.0457 0.0477 0.0457 0.0477 0.0457 0.0477 0.0457 0.0477 0.0457 0.0477 0.0457 0.0	$\begin{array}{c} \mathrm{IPS}_{\vee} \downarrow \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.052 \\ 0.025 \\ 0.025 \\ 0.025 \\ 0.019 \\ 0.015 \\ 0.022 \\ \hline \textbf{0.010} \\ \hline \textbf{0.010} \\ \hline \textbf{PS}_{\vee} \downarrow \\ standup \\ 0.031 \\ 0.014 \\ 0.021 \\ 0.022 \\ 0.052 \\ 0.$	trex 0.049 0.044 0.056 0.077 0.037 0.022 0.043 0.032 0.043 0.032 0.043 0.032 0.043 0.041 0.010 trex 0.042 0.031 0.039 0.044 0.080 0.037	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.056 0.037 0.080 0.034 hellwarrior 0.055 0.076 0.080 0.076 0.080 0.111 0.056 0.056	mutant 0.041 0.033 0.031 0.069 0.034 0.022 0.033 0.022 0.033 0.024 0.025 0.027 0.028 0.020 0.021 0.020 0.021 0.063 0.063	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.038 0.037 0.059 0.019
Methods D-NeRF [21] TiNeuVox [3] K-Planes-seybirid [4] K-Planes-seybirid [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-sexplicit [4] Fensor4D [22] 4DGS [27] D3DGS [23]	Train. ↓ 1d 28m 1h 1h 10h 40m 35m 1h 6h 1h - 30m Train. ↓ 1d 28m 1h 1h 1h 40m 35m 1h 1h 1h 1h 1h 40m 35m 1h 1h 1h 1h 1h 1h 1h 1h 1h 1h	lego 0.095 0.077 0.056 0.058 0.105 0.051 0.052 0.054 0.052 0.036 0.036 0.048 0.043 0.044 0.043 0.047 0.057 0.036	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019 0.048 0.025 0.018 0.042 0.019 jumpingjacks 0.044 0.020 0.044 0.020 0.047 0.068 0.082 0.047	bouncingballs 0.066 0.054 0.057 0.062 0.078 0.045 0.029 0.052 0.049 <u>0.028</u> 0.045 0.045 0.045 0.045 0.045 0.047 0.022 0.034 0.037 0.051 0.022 0.034	LP hook 0.063 0.044 0.069 0.076 0.042 0.057 0.042 0.057 0.042 0.057 0.042 0.057 0.042 0.053 0.016 LPI hook 0.050 0.038 0.038 0.043 0.053 0.044 0.053 0.044 0.053 0.044 0.059 0.044 0.059 0.057 0.042 0.059 0.057 0.059 0.057 0.059 0.057 0.059 0.057 0.059 0.059 0.059 0.059 0.059 0.059 0.057 0.059 0.059 0.059 0.059 0.059 0.057 0.059 0.059 0.059 0.059 0.059 0.057 0.059 0.059 0.059 0.057 0.059 0.057 0.059 0.059 0.057 0.059 0.057 0.059 0.057 0.059 0.057 0.053 0.057 0.053 0.059 0.059 0.053 0.059 0.050 0.059 0.053 0.053 0.050 0.059 0.053 0.053 0.050 0.053 0.059 0.053 0.059 0	$\begin{array}{l} \label{eq:result} IPS_v \downarrow \\ standup \\ 0.031 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ \hline 0.015 \\ 0.025 \\ 0.019 \\ \hline 0.015 \\ 0.021 \\ \hline 0.010 \\ \hline 0.011 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.022 \\ \hline 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.022 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.022 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.022 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.022 \\ 0.017 \\ \hline 0.021 \\ 0.021$	trex 0.049 0.044 0.044 0.056 0.077 0.032 0.043 0.032 0.041 0.010 trex 0.041 0.032 0.041 0.030 0.041 0.031 0.032 0.043 0.039 0.044 0.037 0.037 0.037	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.056 0.034 hellwarrior 0.058 0.035 0.056 0.035 0.056 0.035 0.056 0.036	mutant 0.041 0.033 0.033 0.033 0.069 0.033 0.069 0.034 0.022 0.033 0.027 0.024 0.028 0.008 mutant 0.020 0.021 0.036 0.022	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.050 0.038 0.037 0.052 0.017 0.027 0.047 0.040 0.040 0.040 0.040
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2]	$\begin{array}{c} {\rm Train.} \downarrow \\ 1d \\ {\bf 28m} \\ 1h \\ 1h \\ 10h \\ 40m \\ 35m \\ 1h \\ 6h \\ 1h \\ - \\ 30m \\ \hline \\ {\bf 30m} \\ \hline \\ {\bf Train.} \downarrow \\ 1d \\ {\bf 28m} \\ 1h \\ 10h \\ 40m \\ 35m \\ 1h \\ 1h \end{array}$	lego 0.095 0.057 0.056 0.058 0.051 0.051 0.052 0.053 0.054 0.055 0.052 0.052 0.052 0.052 0.036 0.043 0.034 0.036 0.036 0.036	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019 0.048 0.025 0.018 0.042 0.019 jumpingjacks 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.044 0.020 0.045 0.045 0.042 0.019 0.048 0.042 0.019 0.048 0.042 0.019 0.048 0.047 0.048 0.048 0.047 0.068 0.033 0.021 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.036 0.	bouncingballs 0.066 0.057 0.062 0.078 0.045 0.029 0.052 0.049 0.028 0.045 0.049 0.028 0.045 0.016 bouncingballs 0.047 0.022 0.034 0.037 0.051 0.026 0.034 0.037 0.051 0.026 0.049 0.045 0.049 0.045 0.045 0.045 0.049 0.045 0.045 0.045 0.049 0.045 0.045 0.045 0.049 0.045 0.045 0.045 0.049 0.045 0.045 0.045 0.049 0.045 0.045 0.045 0.045 0.049 0.045 0.045 0.045 0.045 0.049 0.045 0.047 0.022 0.034 0.025 0.045 0.047 0.022 0.034 0.026 0.026 0.037 0.026 0.026 0.026 0.037 0.026 0.026 0.026 0.037 0.026 0.026 0.026 0.026 0.037 0.026	LP hook 0.063 0.044 0.076 0.076 0.042 0.028 0.028 0.028 0.053 0.016 LPI hook 0.053 0.016 0.028 0.023 0.023 0.023 0.023	$\begin{array}{r} \mathrm{IPS}_{\vee} \downarrow \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ \hline 0.050 \\ 0.025 \\ 0.025 \\ 0.022 \\ \hline 0.015 \\ 0.022 \\ \hline 0.015 \\ 0.022 \\ \hline 0.015 \\ 0.021 \\ \hline 0.031 \\ 0.014 \\ 0.021 \\ 0.027 \\ 0.052 \\ 0.028 \\ 0.017 \\ 0.017 \\ \hline \end{array}$	trex 0.049 0.056 0.077 0.020 0.043 0.037 0.020 0.043 0.040 0.031 0.039 0.031 0.039 0.044 0.031 0.032 0.034	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.081 0.056 0.037 0.080 0.034 hellwarrior 0.058 0.035 0.076 0.080 0.111 0.056 0.038 0.053	$\begin{array}{c} mutant\\ 0.041\\ 0.033\\ 0.031\\ 0.069\\ 0.034\\ 0.022\\ 0.034\\ 0.027\\ 0.024\\ 0.028\\ \textbf{0.008}\\ \hline \textbf{0.008}\\ \hline \textbf{0.008}\\ \hline \textbf{0.001}\\ 0.035\\ 0.021\\ 0.020\\ 0.021\\ 0.063\\ 0.022\\ 0.021\\ 0.022\\ 0.021\\ \hline \end{array}$	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.050 0.037 0.052 0.019 Average 0.047 0.042 0.047 0.044 0.045 0.074 0.024 0.033
Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-hybrid [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5]	Train. ↓ 1d 28m 1h 1h 1h 40m 35m 1h 6h 1h - 30m Train. ↓ 1d 28m 1h 10h 40m 35m 1h 6h	lego 0.095 0.077 0.056 0.055 0.105 0.054 0.052 0.054 0.054 0.054 0.054 0.054 0.054 0.054 0.054 0.054 0.044 0.047 0.043 0.043 0.043	$\begin{array}{c} jumpingjacks\\ 0.060\\ 0.030\\ 0.059\\ 0.086\\ 0.076\\ 0.030\\ 0.019\\ 0.048\\ 0.025\\ 0.018\\ 0.048\\ 0.025\\ 0.018\\ 0.048\\ 0.025\\ 0.018\\ 0.042\\ 0.019\\ \hline jumpingjacks\\ 0.042\\ 0.019\\ \hline jumpingjacks\\ 0.042\\ 0.020\\ 0.047\\ 0.068\\ 0.082\\ 0.033\\ 0.021\\ 0.036\\ 0.016\\ \hline \end{array}$	$\frac{bouncingballs}{0.066}\\ 0.057\\ 0.057\\ 0.062\\ 0.078\\ 0.045\\ 0.029\\ 0.052\\ 0.049\\ 0.052\\ 0.045\\ 0.045\\ 0.045\\ 0.016\\ \hline \hline bouncingballs\\ 0.047\\ 0.022\\ 0.034\\ 0.037\\ 0.051\\ 0.022\\ 0.023\\ 0.022\\ 0.022\\ \hline \end{tabular}$	LP hook 0.064 0.074 0.054 0.076 0.042 0.028 0.042 0.027 0.042 0.023 0.042 0.053 0.016 LPI hook 0.050 0.033 0.033 0.043 0.047 0.023 0.033	$\begin{array}{r} \mathrm{IPS}_{v} \downarrow \\ standup\\ 0.033\\ 0.024\\ 0.031\\ 0.050\\ 0.050\\ 0.025\\ 0.025\\ 0.015\\ 0.025\\ 0.015\\ 0.025\\ 0.010\\ \hline \textbf{PS}_{v} \downarrow \\ \hline standup\\ 0.031\\ 0.021\\ 0.021\\ 0.021\\ 0.022\\ 0.028\\ 0.017\\ 0.011\\ \hline \textbf{0.011} \end{array}$	trex 0.049 0.054 0.054 0.054 0.054 0.049 0.057 0.032 0.033 0.032 0.049 0.041 0.040 0.041 0.041 0.032 0.042 0.031 0.034 0.034 0.034 0.034 0.034 0.034 0.034 0.034 0.034 0.037 0.034 0.034 0.035	hellwarrior 0.085 0.063 0.119 0.123 0.102 0.051 0.038 0.056 0.037 0.080 0.034 hellwarrior 0.035 0.076 0.080 0.111 0.056 0.038 0.076 0.080 0.111 0.0553 0.030	$\begin{array}{c} \hline mutant\\ 0.041\\ 0.033\\ 0.069\\ 0.034\\ 0.022\\ 0.033\\ 0.027\\ 0.024\\ 0.028\\ \hline \textbf{0.008}\\ \hline \hline \textbf{mutant}\\ 0.035\\ 0.021\\ 0.020\\ 0.021\\ 0.020\\ 0.021\\ 0.036\\ 0.022\\ 0.021\\ 0.036\\ 0.022\\ 0.021\\ \hline \textbf{0.014}\\ \hline \end{array}$	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.038 0.037 0.059 0.019 Average 0.047 0.040 0.047 0.040 0.045 0.074 0.045 0.023
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-hybrid [4] K-Planes-hybrid [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8]	Train. ↓ 1d 28m 1h 1h 1h 10h 40m 35m 1h 6h 1h 1h 1h 1h 7 30m Train. ↓ 1d 28m 1h 1h 1h 6h 1h 1h 1h 1h 6h 1h 1h 1h 6h 1h 1h 1h 6h 1h 1h 1h 6h 1h 1h 1h 6h 1h 1h 1h 6h 1h 1h 6h 1h 1h 6h 1h 1h 6h 1h 1h 6h 1h 1h 6h 1h 1h 6h 1h 1h 6h 1h 1h 1h 6h 1h 1h 1h 6h 1h 1h 1h 1h 6h 1h 1h 1h 1h 1h 1h 1h 1h 1h 1	lego 0.095 0.077 0.056 0.058 0.105 0.051 0.052 0.054 0.052 0.053 0.054 0.052 0.042 0.043 0.044 0.047 0.047 0.047 0.047 0.047 0.043 0.043 0.039 0.070	jumpingjacks 0.060 0.030 0.059 0.086 0.076 0.030 0.019 0.048 0.025 0.018 0.042 0.019 jumpingjacks 0.044 0.020 0.047 0.068 0.082 0.033 0.021 0.036 0.016 0.019	$\frac{bouncingballs}{0.066}\\0.054\\0.057\\0.062\\0.078\\0.045\\0.029\\0.045\\0.049\\0.045\\0.049\\0.045\\0.045\\0.045\\0.045\\0.045\\0.047\\0.022\\0.034\\0.037\\0.051\\0.022\\0.034\\0.037\\0.051\\0.022\\0.015\\0.023\\0.022\\0.014\\0.022\\0.022\\0.014\\0.022\\0.022\\0.014\\0.022\\0.022\\0.014\\0.022\\0.022\\0.014\\0.022\\0.022\\0.014\\0.022\\0.022\\0.022\\0.014\\0.022\\0.02$	LP hook 0.063 0.076 0.076 0.042 0.028 0.027 0.042 0.027 0.053 0.016 LPI hook 0.050 0.023 0.033 0.069 0.043 0.069 0.043 0.069 0.043 0.069	$\begin{array}{r} PS_v \downarrow \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.025 \\ 0.025 \\ 0.025 \\ 0.015 \\ 0.025 \\ 0.015 \\ 0.025 \\ 0.015 \\ 0.022 \\ 0.0105 \\ 0.011 \\ 0.021 \\ 0.021 \\ 0.011 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.021 \\ 0.012 \\ 0.013 \\ 0.011 \\ 0.021 \\ 0.012 \\ 0.013 \\ 0.013 \\ 0.011 \\ 0.012 \\ 0.028 \\ 0.017 \\ 0.011 \\ 0.$	trex 0.049 0.054 0.054 0.054 0.049 0.050 0.037 0.020 0.043 0.036 0.041 0.058 0.041 0.031 0.032 0.042 0.031 0.032 0.042 0.037 0.037 0.025 0.073	$\begin{array}{r} \hline hellwarrior\\ 0.085\\ 0.063\\ 0.119\\ 0.123\\ 0.102\\ 0.051\\ 0.038\\ 0.081\\ 0.056\\ \underline{0.037}\\ 0.080\\ 0.080\\ \hline \textbf{0.034}\\ \hline \hline hellwarrior\\ 0.058\\ 0.035\\ 0.076\\ 0.080\\ 0.111\\ 0.056\\ 0.038\\ 0.035\\ 0.076\\ 0.038\\ 0.035\\ 0.076\\ 0.080\\ 0.111\\ 0.056\\ 0.038\\ 0.033\\ \underline{0.030}\\ 0.041\\ \hline \end{array}$	$\begin{array}{r} mutant\\ 0.041\\ 0.033\\ 0.031\\ 0.033\\ 0.069\\ 0.034\\ 0.022\\ 0.033\\ 0.027\\ 0.024\\ 0.028\\ 0.008\\ \hline mutant\\ 0.035\\ 0.020\\ 0.021\\ 0.020\\ 0.021\\ 0.063\\ 0.036\\ 0.022\\ 0.021\\ 0.024\\ \hline \end{array}$	Average 0.062 0.046 0.059 0.067 0.079 0.042 0.028 0.050 0.038 0.037 0.052 0.017 0.027 0.047 0.040 0.044 0.045 0.074 0.040 0.040 0.040 0.040 0.033 0.023 0.033
Methods D-NeRF [21] TiNeuVox [3] K-Planes-explicit [4] K-Planes-explicit [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29] Ours Methods D-NeRF [21] TiNeuVox [3] K-Planes-hybrid [4] K-Planes-hybrid [4] Tensor4D [22] 4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [27] D3DGS [30] HexPlane [2] V4D [5] SC-GS [8] RealTime4DGS [29]	$\begin{array}{c} {\rm Train.} \downarrow \\ 1d \\ {\bf 28m} \\ 1h \\ 1h \\ 10h \\ 40m \\ 35m \\ 1h \\ 6h \\ 1h \\ - \\ 30m \\ 1h \\ 1d \\ {\bf 28m} \\ 1h \\ 1h \\ 10h \\ 40m \\ 35m \\ 1h \\ 6h \\ 1h \\ - \\ - \\ \end{array}$	lego 0.095 0.077 0.056 0.055 0.057 0.050 0.054 0.052 0.054 0.055 0.054 0.055 0.054 0.055 0.054 0.0636 0.064 0.043 0.043 0.036 0.043 0.036 0.043 0.043 0.036	$\begin{array}{c} jumpingjacks\\ 0.060\\ 0.030\\ 0.059\\ 0.086\\ 0.076\\ 0.030\\ 0.019\\ 0.048\\ 0.025\\ \textbf{0.019}\\ 0.048\\ 0.025\\ \textbf{0.018}\\ 0.042\\ 0.019\\ \hline \hline \\ jumpingjacks\\ 0.044\\ 0.020\\ 0.047\\ 0.068\\ 0.082\\ 0.033\\ 0.021\\ 0.036\\ 0.016\\ 0.019\\ 0.046\\ \hline \end{array}$	$\begin{array}{r} \hline bouncingballs\\ 0.066\\ 0.054\\ 0.057\\ 0.062\\ 0.078\\ 0.045\\ 0.029\\ 0.052\\ 0.049\\ 0.028\\ 0.045\\ \hline \hline \textbf{0.016}\\ \hline \hline \textbf{0.0016}\\ \hline \hline \textbf{0.0016}\\ \hline \hline \textbf{0.022}\\ 0.034\\ 0.037\\ 0.051\\ 0.026\\ 0.015\\ 0.022\\ \hline \textbf{0.015}\\ 0.022\\ \hline \textbf{0.014}\\ \hline \textbf{0.030}\\ \hline \end{array}$	LP hook 0.063 0.074 0.059 0.076 0.042 0.027 0.053 0.042 0.057 0.053 0.042 0.057 0.053 0.042 0.057 0.053 0.042 0.023 0.038 0.043 0.023 0.024 0.029 0.038 0.024 0.029 0.038 0.024 0.025 0.00	$\begin{array}{r} \mathrm{IPS}_{v} \downarrow \\ standup \\ standup \\ 0.033 \\ 0.024 \\ 0.031 \\ 0.040 \\ 0.050 \\ 0.024 \\ 0.015 \\ 0.025 \\ 0.019 \\ 0.015 \\ 0.022 \\ 0.022 \\ 0.015 \\ 0.021 \\ 0.011 \\ 0.031 \\ 0.014 \\ 0.021 \\ 0.027 \\ 0.022 \\ 0.028 \\ 0.017 \\ 0.017 \\ 0.017 \\ 0.0118 \\ 0.025 \end{array}$	trex 0.049 0.044 0.049 0.054 0.054 0.049 0.041 0.032 0.043 0.043 0.043 0.043 0.043 0.041 0.041 0.041 0.041 0.041 0.042 0.031 0.032 0.044 0.039 0.044 0.034 0.025	$\begin{array}{r} \hline hellwarrior\\ 0.085\\ 0.063\\ 0.119\\ 0.123\\ 0.102\\ 0.051\\ 0.038\\ 0.081\\ 0.056\\ 0.037\\ 0.080\\ \hline 0.036\\ 0.034\\ \hline \hline hellwarrior\\ 0.058\\ 0.035\\ 0.035\\ 0.035\\ 0.076\\ 0.080\\ 0.111\\ 0.056\\ 0.038\\ 0.053\\ 0.038\\ 0.053\\ 0.030\\ 0.041\\ 0.083\\ \hline \end{array}$	$\begin{array}{c} mutant\\ \hline 0.041\\ 0.033\\ 0.031\\ 0.069\\ 0.034\\ \hline 0.022\\ 0.034\\ 0.022\\ 0.034\\ 0.028\\ \hline 0.024\\ 0.028\\ \hline 0.028\\ \hline 0.028\\ \hline 0.021\\ 0.035\\ 0.021\\ 0.020\\ 0.021\\ 0.022\\ 0.021\\ 0.022\\ 0.021\\ 0.024\\ 0.024\\ 0.024\\ 0.026\\ \hline \end{array}$	Average 0.062 0.046 0.059 0.067 0.028 0.050 0.033 0.042 0.050 0.037 0.052 0.019



(a)



Fig. 1: Qualitative comparison of reconstruction results between our method and baseline methods on the multi-scale D-NeRF dataset.



(a)



Fig. 2: Qualitative comparison of low-resolution rendering results between our method and baseline methods on the multi-scale D-NeRF dataset for visualization of the antialiasing effects.



Fig. 3: Qualitative comparison of low-resolution rendering results between our method and baseline methods on the multi-scale D-NeRF dataset with PSNR/SSIM metrics shown at the bottom.

HyperNeRF Dataset Per-scene evaluation metrics under PSNR, LPIPS [32] and MS-SSIM [26] are provided in Tab. 3 with additional results of several highly related methods on this dataset for detailed comparisons. Metrics marked with "†" are adopted from the corresponding paper. The quantitative experiments were conducted following the procedures in [3,19], with training and rendering performed at a resolution of 960x540 pixels, which is half of the standard 1080p resolution. In addition, it should be noted that the images used for qualitative comparisons undergo training and rendering processes at the same resolution as those used in quantitative tests. This is due to limitation of our experimental device, which has a memory capacity of 24GB, preventing the successful loading of full-resolution images for testing.

Despite requiring $32 \times$ less training time compared to HyperNeRF [19], our method produces comparable high-quality rendering results with fine details and glossy appearance well represented, as shown in Fig. 6 of the main paper. In contrast, TiNeuvox 3 tends to provide blurry results and have limitations in accurately restoring intricate textual patterns with high-frequency components, despite its somewhat faster convergence rate. When compared to synthetic scenes like the D-NeRF dataset, inaccuracies in camera parameters provided by the HyperNeRF dataset may negatively impact reconstruction quality. However, the experiments also demonstrate the effectiveness of our method in handling scenes with inaccurate camera registration. Furthermore, previous works [3, 19]have shown that metrics such as PSNR and MS-SSIM may not accurately reflect the perceptual quality of images. Conversely, LPIPS has been found to align closely with human perception. Our approach demonstrates superior performance in terms of average PSNR while being comparable to HyperNeRF [19] and Nerfies [18] using the LPIPS metric with 'ALEX' as the underlying backbone. Additionally, our **DMiT** requires much less training time and enables faster inference.

NeRF-DS Dataset We further evaluate our method on monocular real-world dataset NeRF-DS [28], which consists of common dynamic specular scenes. The detailed per-scene metrics PSNR, LPIPS [32] and SSIM [25] against several SOTA baselines [3, 8, 27, 28, 30] are provided in Tab. 4. More qualitative ren-



(a) split-cookie



(b) vrig-chicken



(c) torchocolate

Fig. 4: Qualitative comparison of time interpolation and novel view synthesis results between our method and baseline methods on three scenes from the HyperNeRF dataset.

Table 3: Quantitative per-scene results on the test set of 5 scenes from the HyperN-eRF dataset. **Bold** means the best performance and <u>underline</u> means the second best performance.

Mathods	Train. \downarrow	PSNR ↑							
Methods		torchocolate	hand	cut-lemon	3d printer	chicken	Average		
HyperNeRF [†] [19]	\sim 32h	28.00	30.07	31.80	20.00	26.90	27.35		
Neural Volumes [†] [12]	hours	24.60	29.30	28.80	16.20	17.60	23.30		
$NSFF^{\dagger}$ [11]	hours	22.30	24.90	28.00	27.70	26.90	25.96		
Nerfies [†] [18]	hours	<u>27.8</u> 0	29.90	30.80	20.60	26.70	27.16		
4DGS [27]	3h	27.61	27.72	29.69	21.85	28.36	27.05		
D3DGS [30]	2.5h	27.52	29.09	28.10	20.35	22.78	25.57		
TiNeuVox [3]	40m	26.85	27.41	28.49	22.77	28.37	26.78		
V4D [5]	8h	26.26	27.60	29.41	23.34	28.48	27.02		
NeRFPlayer [†] [23]	-	-	-	-	22.90	26.30	24.60		
Ours	<u>1.5h</u>	26.34	29.62	<u>30.94</u>	22.21	29.88	27.80		
Mathada	Train	$SSIM \uparrow$							
Methods	11aiii. ↓	torchocolate	hand	cut-lemon	3d printer	chicken	Average		
HyperNeRF [†] [19]	\sim 32h	0.962	0.950	0.956	0.821	0.948	0.927		
Neural Volumes [†] [12]	hours	0.917	0.912	0.951	0.665	0.615	0.812		
$NSFF^{\dagger}$ [11]	hours	0.883	0.797	0.904	0.947	0.944	0.895		
Nerfies [†] [18]	hours	0.959	0.940	0.946	0.830	0.943	0.924		
4DGS [27]	3h	0.957	0.877	0.927	0.808	0.929	0.900		
D3DGS [30]	2.5h	0.959	0.935	0.917	0.759	0.727	0.859		
TiNeuVox [3]	40m	0.933	0.856	0.887	0.820	0.916	0.882		
V4D [5]	8h	0.933	0.875	0.911	0.840	0.930	0.898		
NeRFPlayer [†] [23]	-	-	-	-	0.810	0.905	0.858		
Ours	<u>1.5h</u>	0.953	0.943	0.958	0.823	0.954	0.926		
Methoda	Thesis	$LPIPS_a \downarrow$							
Methods	11aiii. ↓	torchocolate	hand	cut-lemon	3dprinter	chicken	Average		
HyperNeRF [†] [19]	\sim 32h	0.172	0.150	0.210	0.111	0.079	0.144		
Neural Volumes [†] [12]	hours	0.189	0.213	0.190	0.330	0.336	0.252		
$NSFF^{\dagger}$ [11]	hours	0.253	0.329	0.238	0.125	0.106	0.210		
Nerfies [†] [18]	hours	0.169	0.171	0.223	0.108	0.078	0.150		
4DGS [27]	3h	0.199	0.299	0.337	0.271	0.226	0.266		
D3DGS [30]	2.5h	0.162	0.163	0.310	0.290	0.194	0.224		
TiNeuVox [3]	40m	0.306	0.417	0.463	0.338	0.347	0.374		
V4D [5]	8h	0.291	0.334	0.378	0.312	0.247	0.312		
NeRFPlayer [†] [23]	-	-	-	-	-	-	-		
Ours	1.5h	0.186	0.139	0.146	0.177	0.115	0.153		



Fig. 5: Qualitative comparison of reconstruction results between our method and baseline methods on the NeRF-DS dataset.

PSNR 1 Methods Train. ↓ basi bell plat sieve Average pres. cupTiNeuVox [40m 21.9720.7922.6020.3120.4624.8821.6221.80NeRF-DS [2] 8h 25.0319.8223.3125.0420.6825.6125.7823.614DGS [27] 3h 25.2719.26 22.78 20.29 23.92 25.2722.10 17.902h23.74 D3DGS [30 25.9819.6125.3524.4720.1625.2125.39SC-GS 3h 19.60 25.1024.50 20.2026.6026.2026.0024.0320.58 Ours 1h 26.4725.4925.3520.7626.5626.1324.48M ↑ Methods Train. ↓ bell basi plate ascuppresssieveAverageTiNeuVox [40m 0.8350.818 0.814 0.798 0.862 0.826NeRF-DS [28 8h $\underline{0.883}$ 0.817 0.817 0.875 0.813 0.8750.888 0.8534DGS [27] 3h 0.8530.7630.808 0.7090.7330.8030.8540.789D3DGS [30 2h0.8740.7820.802 0.8570.869 0.844 0.8440.880 SC-GS 3h 0.897 0.814 0.857 0.885 0.821 0.898 0.889 0.866 Our $^{\rm PS_a}\downarrow$ LPI Methods Train. \downarrow bell basic as cuvplate press sieve Average TiNeuVox [3] 40m0.2930.1380.16'0.250 0.221 0.178 0.241 0.213 NeRF-DS [28] 8h0.128 0.126 0.134 0.118 0.149 0.143 0.099 0.128 0.144 4DGS [27] 3h 0.1530.1550.1420.4020.2990.1820.207D3DGS [30] 2h0.1310.181 0.127 0.1090.1120.130 0.100 0.127 SC-GS [8] 3h 0.104 0.101 0.106 0.118 0.115 Ours 0.12 0.1520.100

 Table 4: Quantitative per-scene results on the test set of all scenes from NeRF-DS dataset.

 Bold means the best performance and <u>underline</u> means the second best performance.

dering results are shown in Fig. 5. All methods are trained using full-resolution RGB images with their released official implementation. Metrics of SC-GS [8] are sourced from their paper, where SSIM/LPIPS(ALEX) metrics are not provided. Note that NeRF-DS [28] also utilized GT front masks as additional inputs. Our proposed method restores more intricate details of specular appearance and renders with fewer artifacts while maintaining more stable deformation across frames.

PlenopticVideo Dataset The PlenopticVideo dataset [10] is a multi-view dataset captured using 21 cameras simultaneously. The central camera is used for testing, while 18 selected cameras are used for training. Following [10], we evaluate our methods using the first 300 frames downscaled by a factor of 2. PSNR, MS-SSIM [26] and LPIPS [32] are chosen as evaluation criteria. Please refer to Tab. 5 for per-scene metrics of all scenes excluding *coffee martini*. Due to our machine's limited CPU memory, we did not evaluate all baseline methods ourselves except for HyperReel [1], 4DGS [27] and RealTime4DGS [29](marked with "*"). Note that NeRFPlayer [23] only reported metrics on SSIM [25] instead of MS-SSIM [26]. Our proposed method is trained every 60 frames due to insufficient CPU memory for loading all training data simultaneously. As demonstrated in [1], the reported SSIM may be higher than expected due to inconsistent evaluation libraries or inappropriate parameter settings. Despite SSIM metrics being less reliable, our proposed method still outperforms other baselines in PSNR and MS-SSIM. Though [10] has a lower LPIPS score than our method, it requires approximately 1344 GPU hours to train one full model, while our methods only need 1.5 hours for each training on 60 frames. In addition, more rendering results

Mothodo	PSNR↑								
methods	$cook \ spinach$	cut roasted beef	flame salmon	flame steak	sear steak	Average			
K-Planes-E [4]	32.19	31.93	28.71	31.80	31.89	31.30			
LLFF [15]	-	-	23.24	-	-	23.24			
DyNeRF $[10]$	-	-	29.58	-	-	29.58			
MixVoxels-L [24]	31.61	31.30	29.92	31.21	31.43	31.09			
HexPlane [2]	31.86	32.71	29.26	31.92	<u>32.09</u>	31.57			
NeRFPlayer [23]	30.58	29.35	31.65	31.93	29.13	30.53			
HyperReel [*] [1]	31.98	32.88	28.37	32.12	32.34	31.54			
4DGS* [27]	31.42	32.04	26.03	30.24	28.85	29.71			
RealTime4DGS* [29]	32.58	32.69	29.38	<u>32.02</u>	31.99	31.73			
Ours	32.24	32.52	<u>30.05</u>	31.82	32.02	31.73			
	SSIM ↑								
Methods	cook spinach	cut roasted beef	flame salmon	flame steak	sear steak	Average			
K-Planes-E [4]	0.968	0.965	0.942	0.970	0.971	0.963			
LLFF [15]	-	-	0.848	-	-	0.848			
DyNeRF [10]	-	-	0.961	-	-	0.961			
MixVoxels-L [24]	0.965	0.965	0.945	0.970	0.971	0.963			
HexPlane [2]	0.966	<u>0.970</u>	0.960	<u>0.976</u>	0.972	<u>0.969</u>			
NeRFPlayer [23]	0.929	0.908	0.940	0.950	0.908	0.927			
HyperReel [*] [1]	0.965	0.964	0.945	0.974	<u>0.976</u>	0.965			
4DGS* [27]	0.967	0.968	0.919	0.971	0.962	0.957			
RealTime4DGS* [29]	0.972	0.975	<u>0.961</u>	0.970	0.970	<u>0.969</u>			
Ours	0.975	0.975	0.966	0.977	0.978	0.974			
Mathada	$LPIPS_a \downarrow$								
Methods	$cook\ spinach$	$cut\ roasted\ beef$	flame salmon	flame steak	$sear\ steak$	Average			
K-Planes-E $[4]$	-	-	-	-	-	-			
LLFF [15]	-	-	0.235	-	-	0.235			
DyNeRF $[10]$	-	-	0.083	-	-	0.083			
MixVoxels-L [24]	0.122	0.088	0.116	0.088	0.080	0.099			
HexPlane [2]	0.097	0.094	0.097	<u>0.081</u>	<u>0.079</u>	0.090			
NeRFPlayer [23]	0.113	0.144	0.098	0.088	0.138	0.116			
HyperReel [*] [1]	0.104	0.098	0.151	0.093	0.089	0.107			
4DGS* [27]	0.110	0.111	0.160	0.097	0.109	0.117			
RealTime4DGS* $[29]$	0.099	0.097	<u>0.084</u>	0.110	0.115	0.101			
Qurs	0.090	0.089	0.094	0.080	0.078	0.086			

Table 5: Quantitative per-scene results on the test set of the PlenopticVideo dataset.**Bold** means the best performance and <u>underline</u> means the second best performance.



Fig. 6: Qualitative comparison of reconstruction results between our method and baseline methods on the PlenopticVideo dataset.



Fig. 7: Comparisons between the learned canonical geometry and mixing of renderings across all training time steps of T-Rex scene from D-NeRF.



Fig. 8: Canonical geometry visualization of one real-world scene *cup* from NeRF-DS [28](Fig. 8a) and one real-world scene *cook spinach* from Plenop-ticVideo [10](Fig. 8b).

and comparisons are provided in Fig. 6. Our proposed method can recover more fine-grained details and generate rendering results closest to the ground truth.

C Canonical Space Analysis

As shown in Fig. 4(b) in the main paper, the learned canonical geometry of our proposed method outperforms baseline methods for two main reasons. Firstly, the powerful encoding scheme from Tri-MipRF [7] effectively generates intricate and highly detailed geometry, as demonstrated in Fig. 4 of their main paper. Secondly, our effective joint refinement strategy enables the separation of motion and geometry, resulting in a valid and detailed canonical space and better deformation results. In contrast, D-NeRF [21] produces poor canonical results even with an explicitly defined canonical frame. Since this frame only constitutes



Fig. 9: Ablation of joint refinement. Zoom in for details.

a small portion of the training set, D-NeRF struggles to represent canonical geometry aligned with the chosen canonical frame. Please refer to Fig. 4(b) in the main paper for the comparison of canonical spaces between the two methods.

To gain a deeper comprehension of the learned canonical space, we fused it with the novel-view-synthesis results of the T-Rex scene from D-NeRF at all training timestamps, while maintaining a consistent camera position. Please refer to Fig. 7 for visualizations comparing the canonical geometry to the mixed renderings across all time steps. The learned canonical space does not represent a specific time step in the training set but rather serves as an "average" of all time steps. This averaged canonical space enables effective deformation convergence and the decoupling of motion and geometry. Additionally, we provide more canonical geometry visualization results of real-world scenes in Fig. 8. Note that the geometry results from PlenopticVideo seem squashed due to the application of NDC contraction, as done in previous works [1, 2, 4]. The quality of geometry reconstruction is not the main contribution of our work, as it is not built upon SDF. The primary purpose of the canonical geometry visualizations is to verify the efficacy of the suggested method in separating dynamics from static geometry. As shown in Fig. 8, floaters or specular appearance severely affect the quality of canonical geometry. We leaver this for the future work to achieve higher-quality canonical geometry reconstruction of dynamic scenes with specular objects or objects undergoing complex non-rigid motions.

D Additional Ablation results

We further provide visualized ablation results to evaluate the warm-up stage and the joint-refinement strategy introduced in Sec. 3.3 of the main paper. We present reconstruction results of T-Rex from D-NeRF in Fig. 9 demonstrate the impact of the proposed joint-refinement strategy. Results without joint refinement exhibit noticeable fuzzy artifacts and deformation inaccuracies, as highlighted in red boxes. Note that the warm-up stage of deformation does not aim to resolve the convergence gap between deformation and geometry. The progressive resolution growth of tri-miplanes has already applied implicit regularization to address the fast convergence of canonical space. The warm-up stage is designed to prevent instability in deformation during the upsampling of tri-miplanes, which may otherwise lead to inferior renderings, as shown in Fig. 10.



Fig. 10: Comparisons between *hellwarrior* scene from D-NeRF using the proposed methods without deformation warm-up stage(a), with deformation warm-up stage(b) and zoom-in of GT(c).



Fig. 11: Qualitative comparison between our rendering result and GT of scene *flame* steak from the PlenopticVideo dataset [10] with zoom-in comparison of the wall. Our proposed method generate a darker wall color compared to the GT.

E Discussions

Overfitting issues compared to multiplane methods. Methods like Hexplane [2] and K-Planes [4] also suffer from overfitting but for different reasons. These methods are based on time-conditioned representations rather than deformation-based approaches utilizing a canonical space, thus avoiding the coupling issue between deformation networks and canonical space geometry. However, the time-conditioned multi-plane features and functions can still overfit the input viewpoints and timesteps. Despite employing Total Variational loss regularization and a coarse-to-fine strategy to mitigate this, overfitting artifacts persist, as shown in Appendix B and the failure cases of Hexplane in their supplementary material.

Failure cases. As discussed in Sec. 5 of the main paper, our proposed method may produce false color when using unconstrained input. Please refer to Fig. 11 for a comparison between our rendering results and the GT images of the *flame steak* scene from the PlenopticVideo dataset [10]. The color of the white wall in our renderings appears slightly darker than in the GT images. This discrepancy is primarily due to non-uniform lighting conditions across different camera views in this dataset, leading to inconsistent wall colors in the training images. To address issues caused by unconstrained training data, it might be beneficial to

assign an appearance latent code as in [14] or introduce an explicit illumination model.

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- 22 J. Yang et al.
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