LumiMotion: Improving Gaussian Relighting with Scene Dynamics

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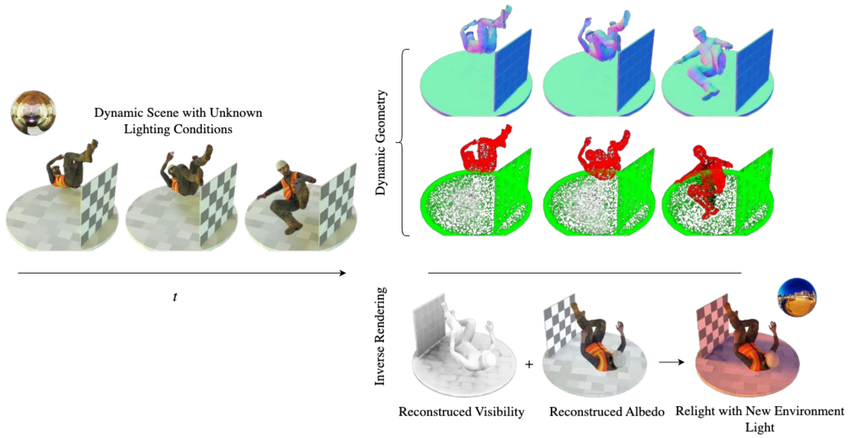
Motivation

Existing Gaussian Splatting-based methods primarily target static scenes and often assume simplified or moderate lighting to avoid entangling shadows with surface appearance. This limits their ability to accurately separate lighting effects from material properties, particularly in real world-conditions.

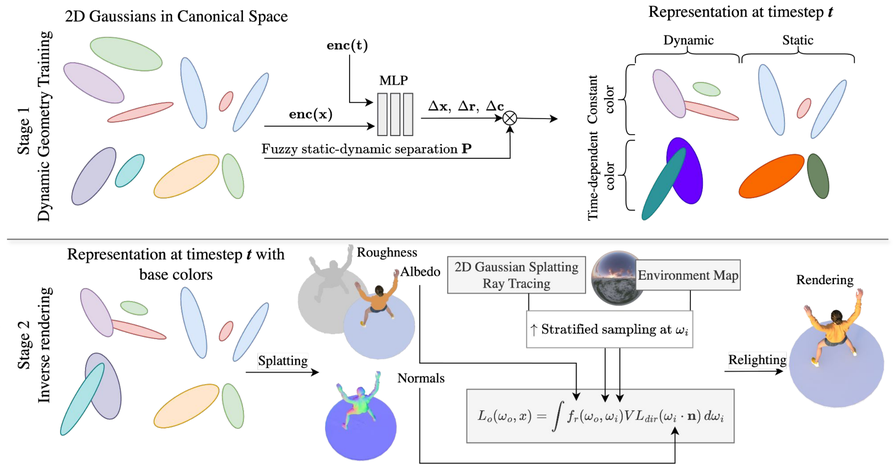
Solution

- we introduce method that learns a **dynamic 2D Gaussian Splatting** representation that promotes smooth normals and temporal surface consistency
- we introduce a set of novel constraints we introduce a set of novel constraints on the deformation network, which encourage dynamic regions to deform while keeping static regions stable
- we release a new synthetic benchmark comprising five scenes under four lighting conditions, each in both static and dynamic variants



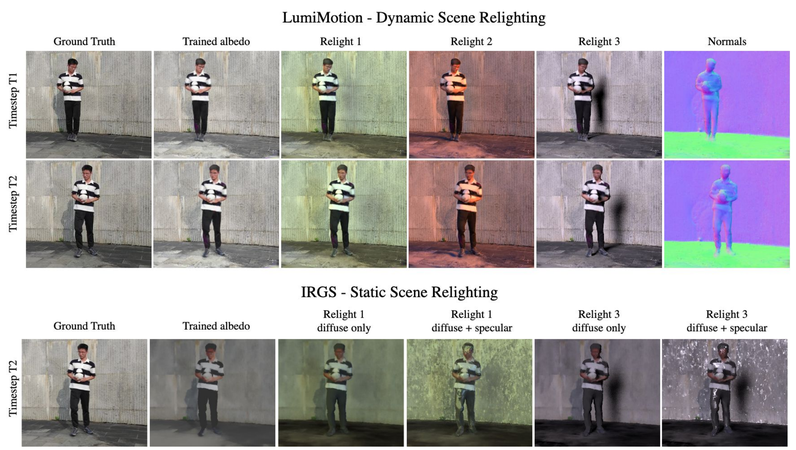
- Gu, C.; Wei, X.; Zeng, Z.; Yao, Y.; and Zhang, L. 2024. Irgs: Inter-reflective gaussian splatting with 2d gaussian ray-tracing.
- Kaleta, J.; Kania, K.; Trzcinski, T.; and Kowalski, M. 2025. LumiGauss: Relightable Gaussian Splatting in the Wild.
- Huang, B.; Yu, Z.; Chen, A.; Geiger, A.; and Gao, S. 2024a. 2D Gaussian Splatting for Geometrically Accurate Radiance Fields

Method overview

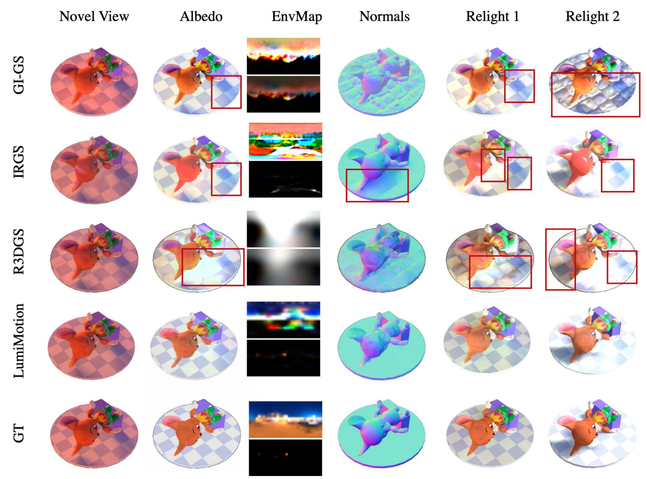


In ***Stage 1***, a dynamic representation of 2D Gaussians, tailored for the relighting task, is trained. The estimated base color from Stage 1 serves as a starting point for albedo and is further optimized in Stage 2, together with roughness and the unknown environment map.

In ***Stage 2***, we rasterize the albedo, roughness and normal maps, then perform stratified sampling from the environment map and apply ray tracing to compute per-pixel visibility V



Results



Our method not only achieves competitive relighting capabilities and effectively removes shadows from albedo, but also estimates lighting more accurately.

Method	Albedo			Relight		
	PSNR ↑	SSIM ↑	LPIPS ↓	PSNR ↑	SSIM ↑	LPIPS ↓
Dam Wall → Harbour Sunset						
R-3DGS	20.744 ± 0.661	0.900 ± 0.013	0.128 ± 0.031	21.220 ± 1.843	0.915 ± 0.016	0.112 ± 0.028
GI-GS	20.943 ± 1.747	0.906 ± 0.014	0.105 ± 0.023	18.434 ± 1.681	0.868 ± 0.023	0.139 ± 0.032
IR-GS	22.888 ± 1.559	0.936 ± 0.013	**0.076** ± 0.023	**26.177** ± 1.606	**0.953** ± 0.011	**0.064** ± 0.018
LumiMotion	**26.800** ± 0.896	**0.946** ± 0.006	0.083 ± 0.020	25.440 ± 0.424	0.924 ± 0.009	0.071 ± 0.014
Chapel Day → Golden Bay						
R-3DGS	22.463 ± 2.001	0.927 ± 0.017	0.096 ± 0.038	22.282 ± 2.806	0.943 ± 0.012	0.081 ± 0.030
GI-GS	24.733 ± 2.862	0.955 ± 0.014	0.056 ± 0.016	22.673 ± 1.513	0.880 ± 0.015	0.125 ± 0.022
IR-GS	23.769 ± 2.732	0.956 ± 0.015	0.053 ± 0.017	**28.157** ± 1.978	**0.966** ± 0.009	0.046 ± 0.020
LumiMotion	**29.520** ± 2.520	**0.967** ± 0.009	**0.0458**± 0.013	27.790 ± 0.564	0.937 ± 0.010	**0.043** ± 0.006
Golden Bay → Dam Wall						
R-3DGS	19.945 ± 1.124	0.899± 0.0184	0.133 ± 0.041	19.563 ± 1.874	0.918 ± 0.013	0.118 ± 0.033
GI-GS	21.295 ± 2.930	0.932 ± 0.020	0.087 ± 0.025	17.636 ± 2.293	0.823 ± 0.029	0.132 ± 0.030
IR-GS	20.910 ± 1.379	0.937 ± 0.013	0.082 ± 0.024	25.009 ± 1.615	**0.955** ± 0.011	0.060 ± 0.014
LumiMotion	**26.811** ± 2.342	**0.954**± 0.010	**0.066** ± 0.018	**25.025** ± 0.671	0.930 ± 0.014	**0.054** ± 0.010