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# Fitting Spherical Gaussians to Dynamic HDRI Sequences

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## Problem

- **Compressed representations of HDRIs** are important for efficient rendering applications.
- Compression of high quality should retain **low and high frequency** information using a **minimal number of parameters**.
- The compressed representation should be **temporally consistent** for a **time-varying HDRI**.
- The representation should allow easy **user controllability**.

## Related Work / Motivation

- Tsai et al. [2006] proposed an algorithm to fit HDRIs using spherical isotropic gaussians (**SGs**).
- Xu et al. [2013] extended this algorithm to spherical anisotropic gaussians (**ASGs**).

Current algorithms **lack temporal consistency** and do not ensure energy conservation.

## Our Approach / Solution

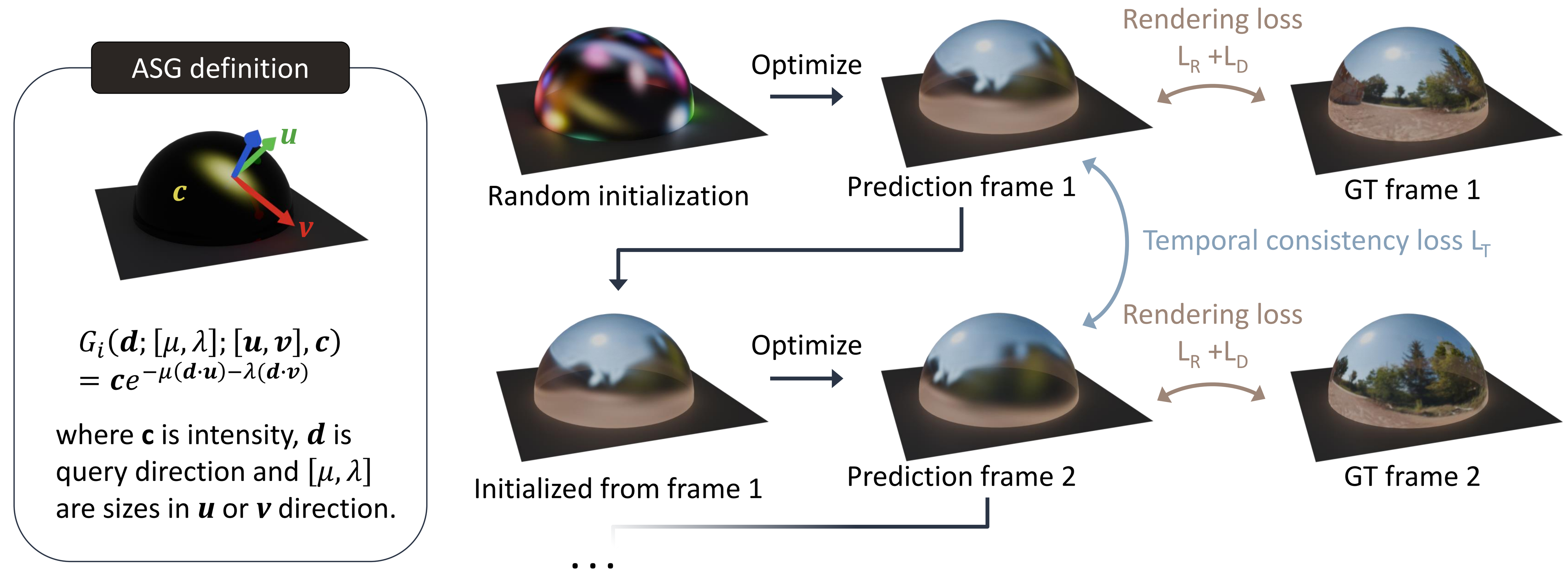
- Fit HDRIs with **ASGs** for **user control** and optimal compression **quality**.
- Use a combination of **reconstruction and diffuse loss** for high quality fit and energy conservation.
- Use a **time-dependency loss** for **time-consistency**.

## References


Yu-Ting Tsai and Zen-Chung Shih. 2006. All-frequency precomputed radiance transfer using spherical radial basis functions and clustered tensor approximation. ACM Trans. Graph. 25, 3 (2006), 967–976.

Kun Xu, Wei-Lun Sun, Zhao Dong, Dan-Yong Zhao, Run-Dong Wu, and Shi-Min Hu. 2013. Anisotropic spherical Gaussians. ACM Trans. Graph. 32, 6 (2013), 209:1–209:11.


## Method




- We densely sample 256×512 pixels from the HDRI with equirectangular projection, and optimize the Gaussian parameters $g_i^0$ for the **initial frame** by **minimizing the sum of a reconstruction loss $L_R$ and a diffuse loss $L_D$.**

$$L_R = \|I_{pred} - I_{GT}\|_1,\ L_D = \|D_{pred} - D_{GT}\|_1,$$

where $D_{pred}$ and $D_{GT}$ denote the predicted and ground truth intensities of a diffused HDRI

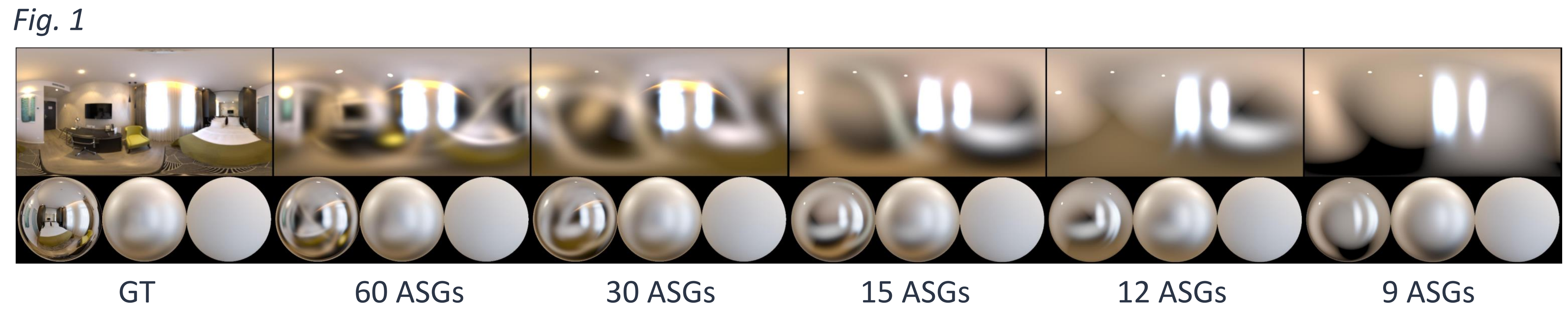
- For each **consecutive frame** $t$, we initialize the ASG parameters $g_i^t$ with those from the previous frame $g_i^{t-1}$ and then optimize the Gaussian parameters using an **additional temporal consistency loss $L_T$ for temporal stability**.

$$L_T = \sum_i \left\|(g_i^t - g_i^{t-1}) / \max_i(g_i^{t-1})\right\|_2$$

## Results

With a low number of ASGs, we achieve a **high quality of the rendered balls** at most levels of roughness and an **effective reconstruction of the HDRI for a broad range of frequencies**.

*Fig. 1*




Our **temporal consistency loss $L_T$ is key to maintaining temporal stability**. Fig. 2 displays time variation vertically for a selected row from the latlong map horizontally; The use of this loss prevents strong flickering (see also video).

*Fig. 2*

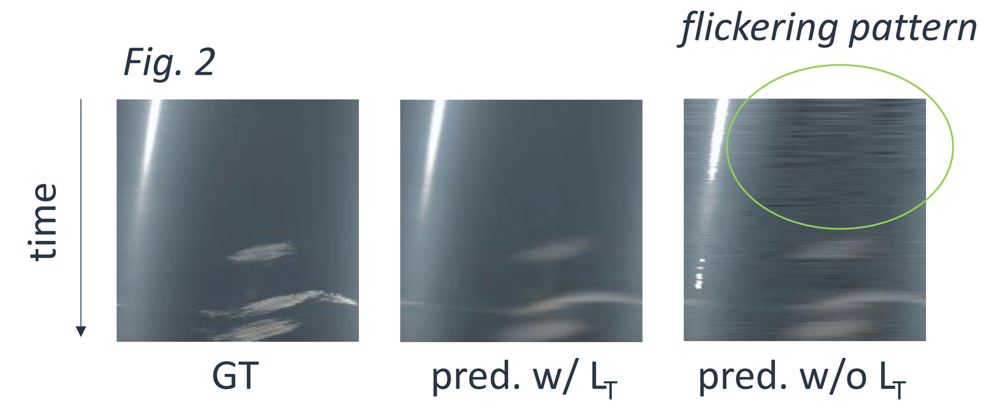
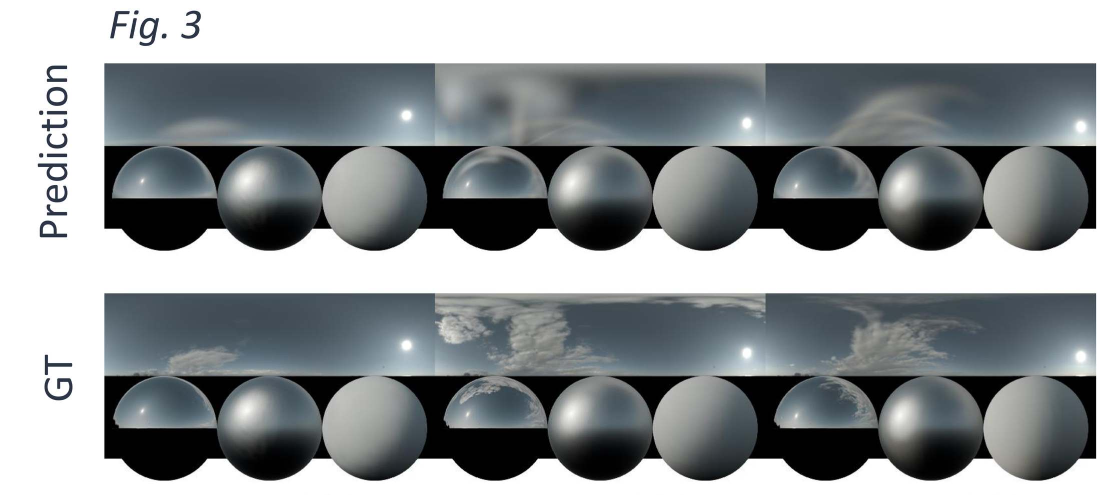



*Fig. 3*




**Using the diffuse loss $L_D$ allows accurate recovery of low-frequency lighting** and preservation of the high-frequency information, as diffuse loss is important for preserving the global energy of the HDRI. **Using L1 loss improves our results significantly compared to using L2 loss**, even with HDRI intensity preprocessing through functions like log or sRGB.

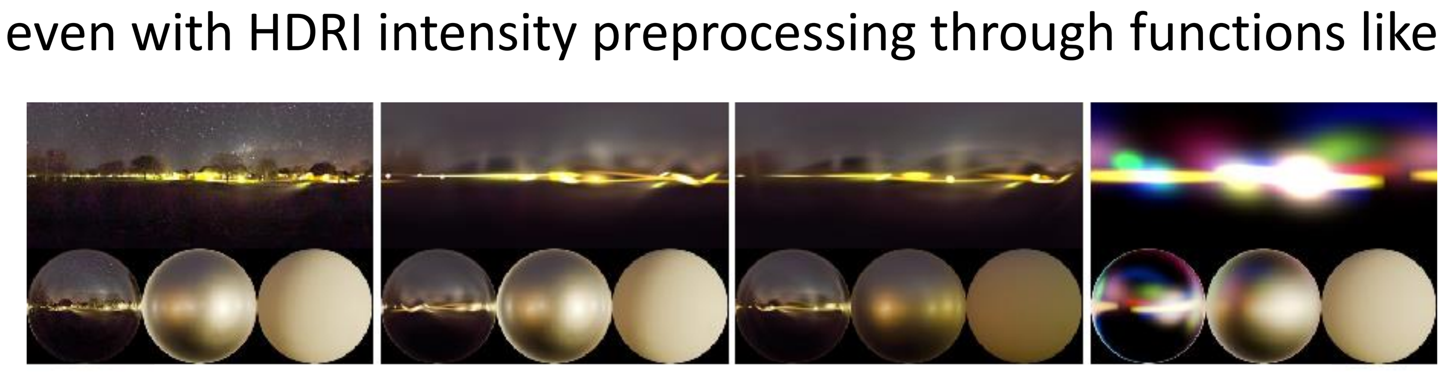



*Fig. 4*