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Multi-Date Earth Observation NeRF

The Detail Is in the Shadows

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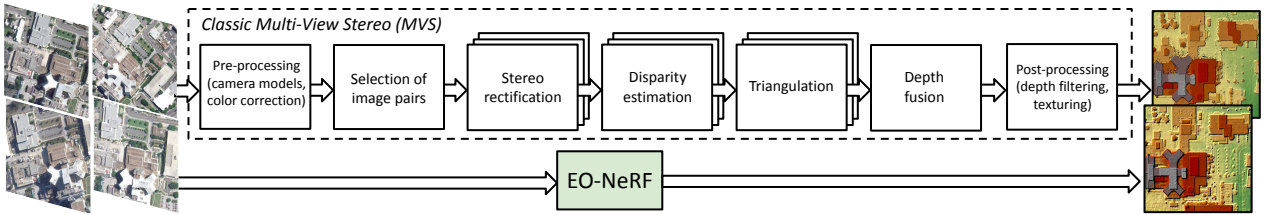
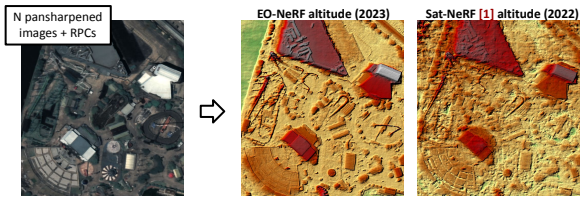


EO-NeRF Main Contributions

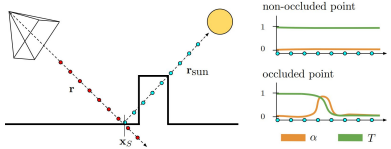
1. Geometrically consistent shadow rendering that outperforms the state-of-the-art in NeRF for multi-date satellite image collections.

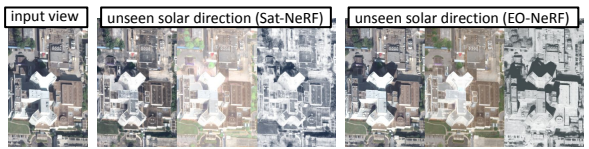
2. Addition of network parameters to handle raw satellite images.



Geometrically Consistent Shadow Rendering

The geometrically consistent shadows are computed by projecting auxiliary rays from the surface boundary towards the sun. They provide hints to refine the geometry, which in turn refines the shadows.





Network Architecture and Irradiance Model

EO-NeRF adresses 3D modeling and novel view synthesis. Same ray casting and optimization as NeRF[2], but different irradiance model.

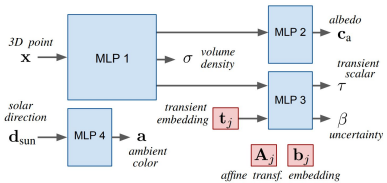
rendered color

$$\mathbf{c}(\mathbf{r}) = \mathbf{A}_j \left(\ell(\mathbf{r}) \cdot \sum_{i=1}^{N} T_i \alpha_i \mathbf{c}_{\text{a}} \right) + \mathbf{b}_j$$

irradiance model

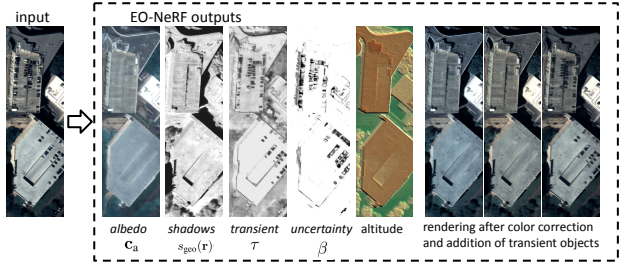
$$\ell(\mathbf{r}) = s(\mathbf{r}) + (1 - s(\mathbf{r}))\mathbf{a}$$

$$s(\mathbf{r}) = s_{\text{geo}}(\mathbf{r})\tau(\mathbf{r}) = T(\mathbf{r}_{\text{sun}}(t_N)) \sum_{i=1}^{N} T_i \alpha_i \tau(\mathbf{x}_i)$$



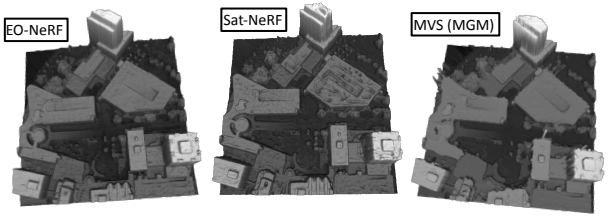
Like NeRF in the wild [3] the model seeks to separate the permanent components of the scene (albedo, volume density) from the transient or image-specific phenomena (shadows, cars, color biases).

Radiometric Decomposition of the Scene

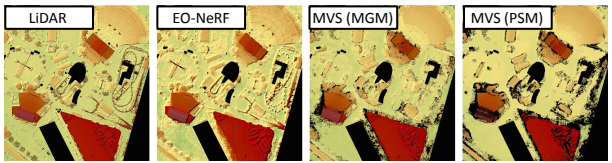


Accurate Digital Surface Model (DSM) Generation

Check out our online videos! Novel view synthesis with different camera angles, sun position and automatic transient object removal.
https://rogermm14.github.io/eonerf



EO-NeRF reveals geometry details that are often lost due to the strong regularization of stereo-based 3D reconstruction. It is less affected by irregularities than Sat-NeRF and comes close to the level of detail of LiDAR DSMs. We tested it on 2 different cities, in 7 areas of interest of 256x256m, using 10-30 WorldView-3 satellite images (30cm/px), pre-processed (uint8) and raw pansharpened (float32).



(average metrics)	Jacksonville areas (uint8)		Buenos Aires areas (float32)	
	PSNR	MAE [m]	PSNR	MAE [m]
Sat-NeRF [1]	27.47	1.62	31.70	2.38
Ours	27.12	1.27	32.16	1.28
MVS (10 pairs, MGM) [4]		2.08		1.74
MVS (10 pairs, PSM) [5]		1.65		1.29

[1] Marí, Roger et al. "Sat-NeRF". *CVPR Workshops*, 2022.
[2] Mildenhall, Ben, et al. "NeRF: Representing scenes as neural radiance fields for view synthesis." *ECCV*, 2020.
[3] Martin-Brualla, Ricardo et al. "NeRF in the wild". *CVPR*, 2021.
[4] Facciolo, Gabriele et al. "MGM: A significantly more global matching for stereovision." *BMVC*, 2015.
[5] Chang, Jia-Ren, and Yong-Sheng Chen. "Pyramid stereo matching network." *CVPR*. 2018.