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SparseSat-NeRF: Dense Depth Supervised Neural Radiance Fields for Sparse Satellite Images

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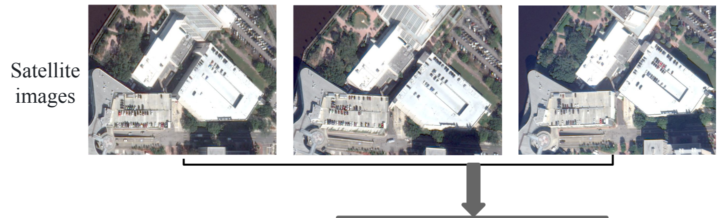
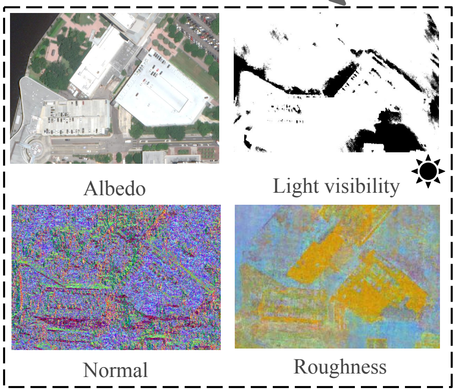
Won the **best paper award** in ISPRS GSW2023

Code Youtube video

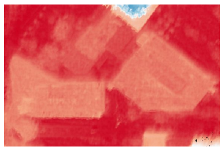
★ Responsable CNES: Felix Perosanz

Context

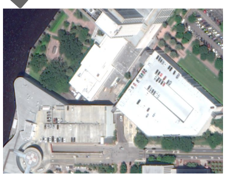




(1) BRDF
(Bi-directional Reflectance Distribution Function)



(2) Depth / 3D model



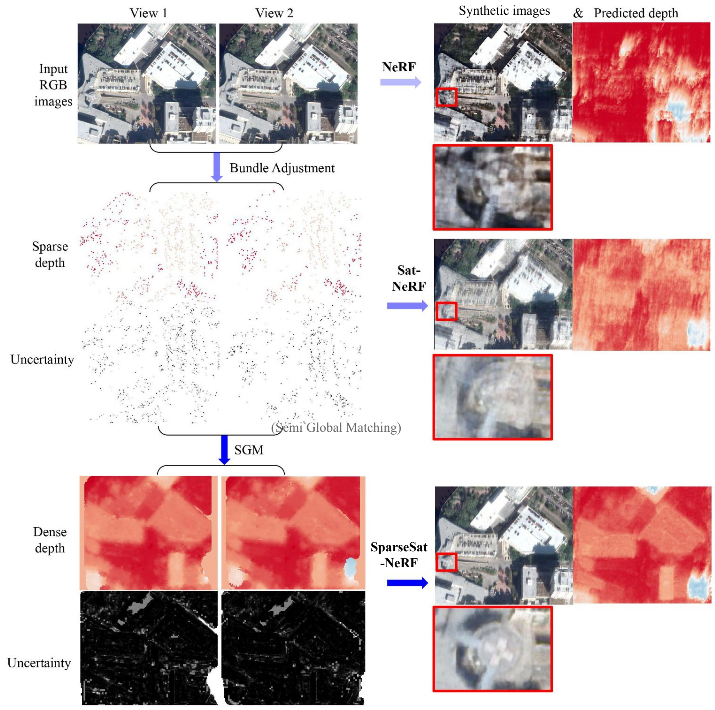
(3) Synthetic images

Goal: From a **few satellite images**, we want to **recover the BRDF and 3D model** of the scene using deep learning method NeRF (Neural radiance fields), and further generate **synthetic images** under new viewing angle and illumination.

Applications:

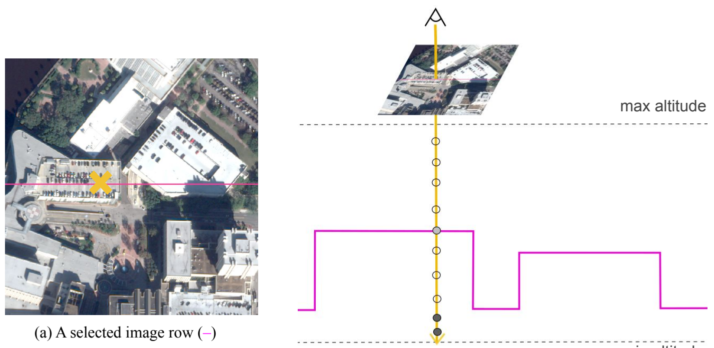
1) Change detection;
2) land cover classification;
3) Earth radiation budget for climate studies… …

SparseSat-NeRF



Workflow:

1) Input 2 satellite images;
2) Refine image poses with bundle adjustment;
3) Get dense depth and uncertainty with SGM scale4;
4) Recover 3D model and synthetic image using SparseSat-NeRF.



(a) A selected image row (–)

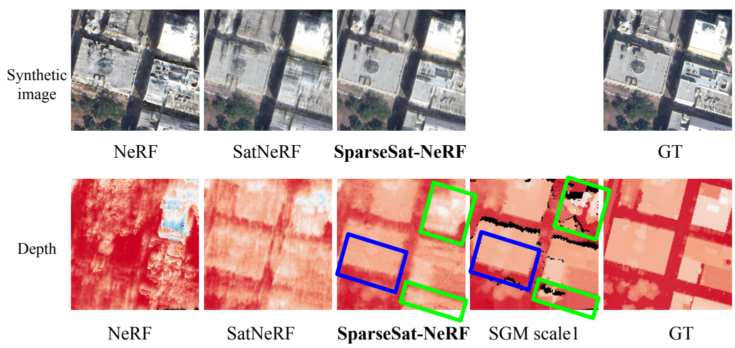
(b) cross section

Training details:

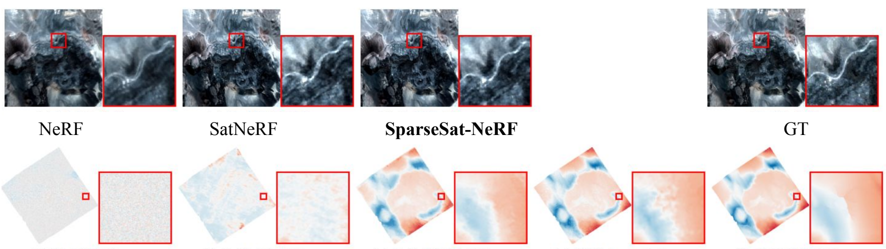
1) For each pixel in an image, we trace a ray from the camera into the scene, and sample points along the ray.
2) For each point, we input the position and view direction to SparseSat-NeRF to predict the rgb color and volume density.
3) For each ray, we accumulate the points on the ray to get the predicted rgb color and depth of the pixel.

Preliminary Results

(1.1) Qualitative result, dataset DFC



(1.2) Qualitative result, dataset Dji



(2) Quantitative result of MAE (mean altitude error):
*best and second best performing are indicated in blue and magenta.

	MAEin ⬇		MAEout ⬇
	DFC	Dji	DFC
NeRF	9.51	9.72	13.2
Sat-NeRF	5.89	9.51	11.75
SparseSatNeRF	3.02	1.57	7.77
SGM scale1	2.77	1.15	9.82

MAE*in*: valid pixels defined by SGM
MAE*out*: occluded and poorly textured areas

- Compared to NeRF and Sat-NeRF, SparseSat-NeRF renders sharper image and more informative DSM.
- Compared to SGM scale1, SparseSat-NeRF is better at reconstructing vegetation and at handling building outlines near occlusions, while SGM is better at roofs and edges.

References:
Zhang, L., Rupnik, E, 2023. SparseSat-NeRF: Dense Depth Supervised Neural Radiance Fields for Sparse Satellite Images, ISPRS Annals.
Marı et al., 2022. Sat-NeRF: Learning multi-view satellite photogrammetry with transient objects and shadow modeling using RPC cameras. CVPRW, 1311–1321.