Thermal Radiance Fields

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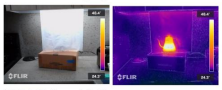
Motivation

Thermal Imaging

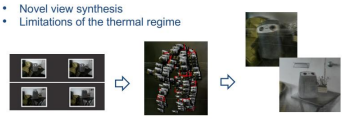


RGB (left), Thermal (right)

- Surveillance & defense
- Infrastructure inspection

3D Radiance Field Reconstruction

- Novel view synthesis
- Limitations of the thermal regime

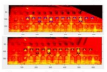


A set of input images | Optimized NeRF | Rendered novel views

→ *Improve 3D thermal reconstruction using information from the visible spectrum*

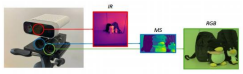
Related Work

Point Clouds [4]



Nearest-neighbor (top), bilinear interpolation (bottom)

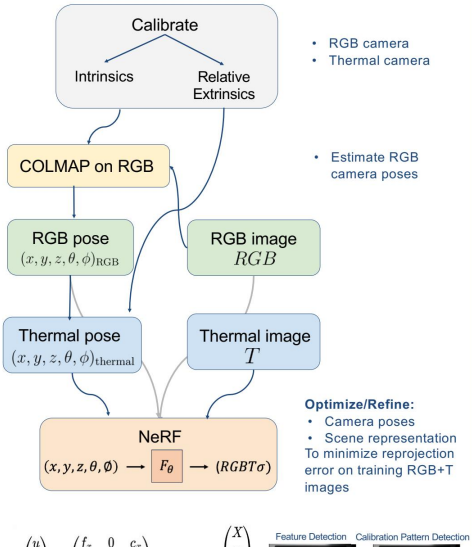
X-NeRF [3]



References

[1] Mildenhall, Ben, et al. "Nerf: Representing scenes as neural radiance fields for view synthesis." Communications of the ACM 65.1 (2021): 99-106.
[2] Tancik, Matthew, et al. "Nerfstudio: A modular framework for neural radiance field development." ACM SIGGRAPH 2023 Conference Proceedings. 2023.
[3] Poggi, Matteo, et al. "Cross-spectral neural radiance fields." 2022 International Conference on 3D Vision (3DV). IEEE, 2022.
[4] Biswanath, Manoj Kumar, Ludwig Hoegner, and Uwe Stilla. "Thermal Mapping from Point Clouds to 3D Building Model Facades." Remote Sensing 15.19 (2023): 4830.

Thermal-NeRF



- RGB camera
- Thermal camera

- Estimate RGB camera poses

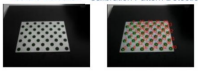
Optimize/Refine:

- Camera poses
- Scene representation

To minimize reprojection error on training RGB+T images

$$s\begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = \underbrace{\begin{pmatrix} f_x & 0 & c_x \\ 0 & f_y & c_x \\ 0 & 0 & 1 \end{pmatrix}}_{\text{Intrinsic matrix}} \underbrace{\begin{pmatrix} R & t \end{pmatrix}}_{\text{Extrinsic matrix}} \begin{pmatrix} X \\ Y \\ Z \\ 1 \end{pmatrix}$$

Feature Detection | Calibration Pattern Detection

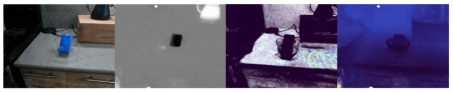


$$x' = x(1 + k_1 r^2 + k_2 r^4 + k_3 r^6) + 2p_1 xy + p^2(r^2 + 2x^2)$$
$$y' = y(1 + k_1 r^2 + k_2 r^4 + k_3 r^6) + p_1(r^2 + 2y^2) + 2p_2 xy$$

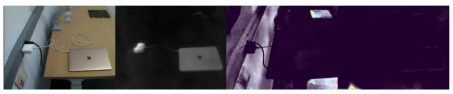
Calibration

Experimental Results

RGB | Thermal | RGB Depth | Thermal Depth



PSNR: 22.08 | 21.23; SSIM: 0.68 | 0.95; LPIPS: 0.41 | 0.12



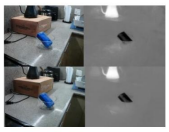
PSNR: 24.26 | 20.98; SSIM: 0.87 | 0.73; LPIPS: 0.34 | 0.13

PSNR: 18.42 | 26.33; SSIM: 0.39 | 0.97; LPIPS: 0.58 | 0.07

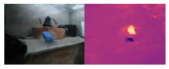
Baseline Comparisons

	RGB	Thermal
RGB only	22.57	-
Thermal only	-	18.03
Shared Density	21.53	20.78
Lower Density	21.23	21.37
X-NeRF	21.54	29.26

Baseline comparisons of PSNR using Pyrex Dataset



Lower density (top)



X-NeRF