Designing Realistic Digital Twins of Urban Environment

Procedural Generation of 3D Environments

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Neural Radiance Field (NeRF)

- A machine learning technique that generates 3D representation of complex object and scenes from some sparse set of input images [1]
- The input is a continuous 5D coordinate (location (x, y, z), angle (θ, ϕ))
- The output is the volume density and view-dependent emitted radiance
- Use classic volume rendering to project the color and densities into an image

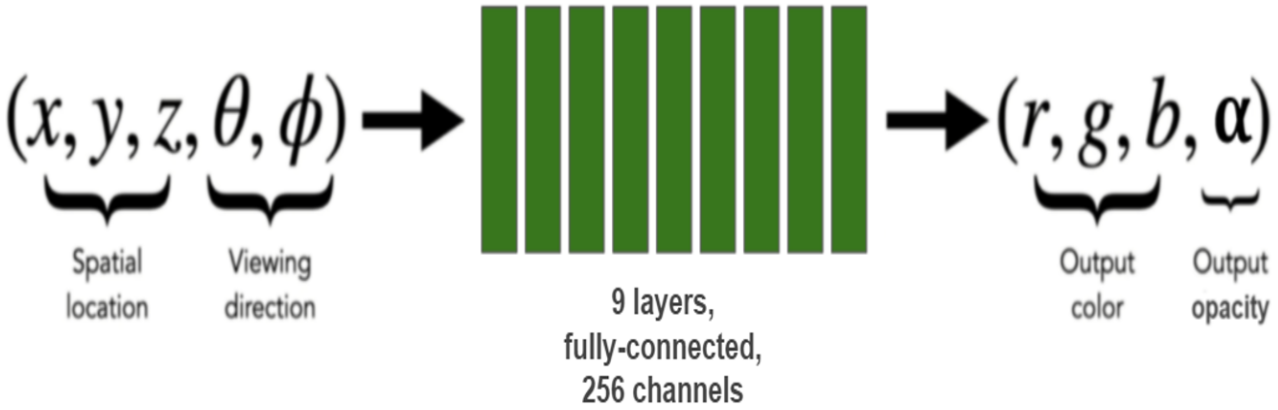

Figure: Architecture

[1] NeRF and What Happens When Graphics Becomes Differentiable.Medium, 30 Aug. 2021, towardsdatascience.com/nerf\-and\-what\-happens\-when\-graphics\-becomes\-differentiable\-88a617561b5d\\

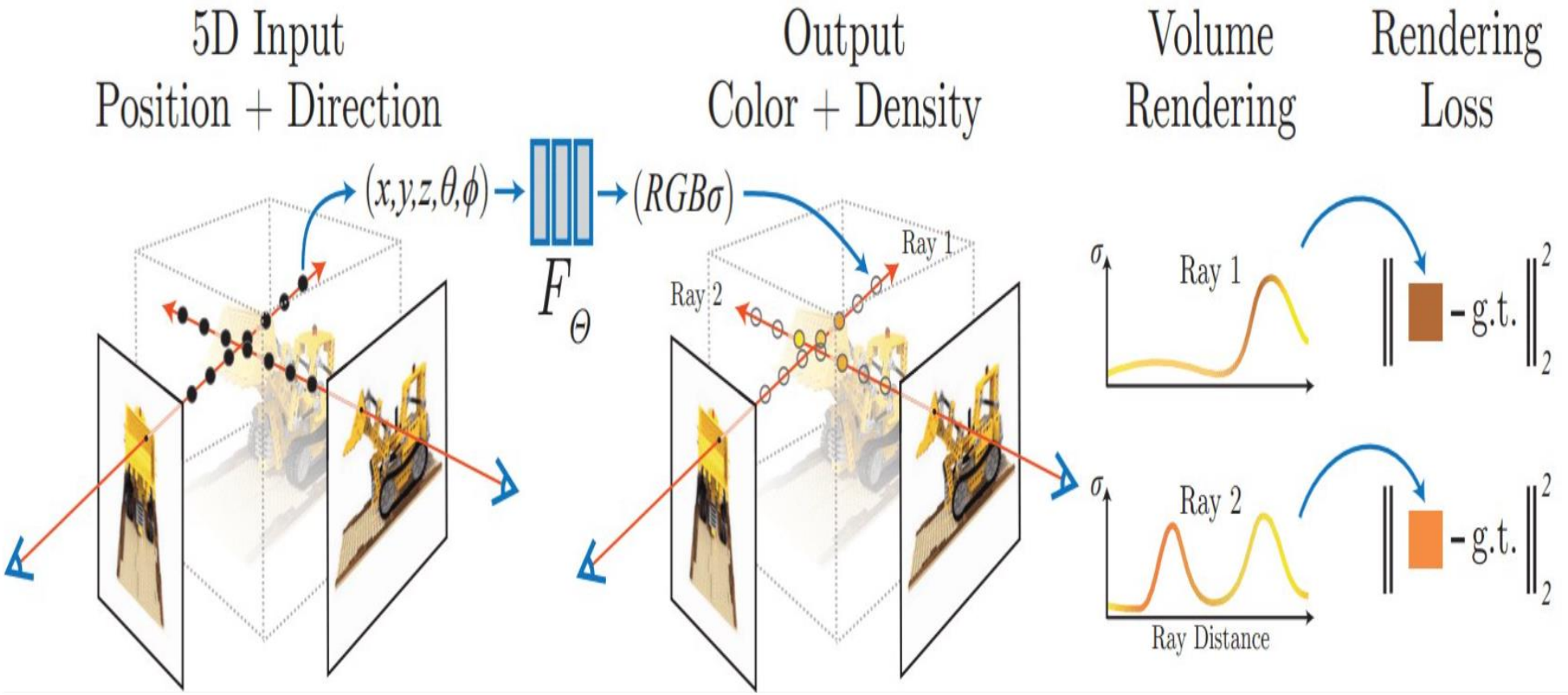

Figure. Block Diagram

[2] Mildenhall, B., Srinivasan, P. P., Tancik, M., Barron, J. T., Ramamoorthi, R., & Ng, R. (2021). Nerf: Representing scenes as neural radiance fields for view synthesis. *Communications of the ACM*, *65*(1), 99-106.

Neural Radiance Field (NeRF) for View Synthesis

Figure: Novel View Synthesis

[3] Liang, H., Wu, T., Hanji, P., Banterle, F., Gao, H., Mantiuk, R., & Oztireli, C. (2023). Perceptual Quality Assessment ofNeRF and Neural View Synthesis Methods for Front-Facing Views. arXiv preprint arXiv:2303.15206.

NeRF in Unconstrained Outdoor Environment

- Complexity of Outdoor Environment
- Computational Overheads
- Restricted Viewpoints
- Lightning Variability

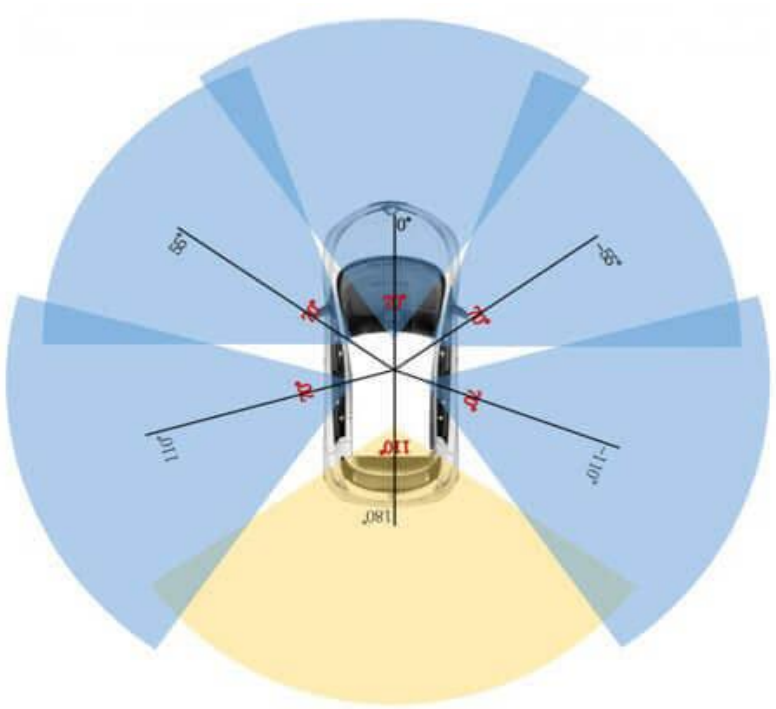

Figure: Cameras over Car

[4] Caesar, H., Bankiti, V., Lang, A. H., Vora, S., Liong, V. E., Xu, Q., Krishnan, A., Pan, Y., Baldan, G., & Beijbom, O. (2020). nuScenes: A multimodal dataset for autonomous driving. https://www.nuscenes.org/nuscenes

CARLA Simulator

- Open-source simulator for autonomous driving research [5].
- Set an ego vehicle mounting multiple cameras for capturing data.

[5] Dosovitskiy, A., Ros, G., Codevilla, F., Lopez, A., & Koltun, V. (2017, October). CARLA: An open urban driving simulator. In Conference on robot learning (pp. 1-16). PMLR.

Dataset: NAPLab Real-world Data

- A real-world dataset captured with an autonomous vehicle of the NTNU Autonomous Perception Laboratory (NAPLab) [6].

[6] NTNU Autonomous Perception. (n.d.). Vehicles. Retrieved from https://www.ntnu.edu/idi/naplab/vehicles

Use Case

Conclusions and Future Works

- We still working in progress to finetune our environment
- Incorporate multi-modal data sources to improve accuracy and realism.
- We will benchmark our dataset of our own city.

End