

The closed-form physical projection can be summarized as follows: The spatial means and covariances of each extracted major virtual scatter in the 3D Cartesian coordinate system can be directly projected into a spherical coordinate system, with the BS as the origin, based on geometric relationships. From this projection, we can derive each scatter's angles of departure (AoDs), corresponding to the angles of active paths relative to the BS[A1]. Given that the BS is equipped with phased antenna arrays, it can generate multiple beams using a predefined codebook and steer them to transmit signals in specific directions[A2]. By incorporating the array steering vector and the predefined codebook, the final RSS can be obtained by summing all the rendered signals across all potential active paths by the model-based projection[A3]. However, in real-world scenarios, acquiring the predefined codebook and array steering vector relative to the BS is challenging, as they depend on antenna gain patterns, beamforming patterns, and radiation patterns—proprietary information held by communication operators. Moreover, even if these patterns are accessible, inevitable errors still exist.

Table 1: Performance Comparison on Synthetic Dataset.

Methods	MAE(dB)	Inference Time(s)	Training Time(s/one epoch)
RadSplatter(physical projection)	12.218	0.010	26.412
RadSplatter	7.564	0.004	1.652

Table 2: Performance Comparison on Real-world Dataset.

Methods	MAE(dB)	Inference Time(s)	Training Time(s/one epoch)
RadSplatter(physical projection)	11.894	0.022	2.964
RadSplatter	7.035	0.018	1.094

[A1]K. Haneda et al., "5G 3GPP-like channel models for outdoor urban microcellular and macrocellular environments," in Proc. IEEE 83rd VTC Spring, May 2016, pp. 1–7

[A2]P. Stoica et al., Spectral analysis of signals. Pearson Prentice Hall Upper Saddle River, NJ, 2005, vol. 452.

[A3]Zhao, X. et al., 2023, October. Nerf2: Neural radio-frequency radiance fields. In Proceedings of the 29th Annual International Conference on Mobile Computing and Networking (pp. 1-15).

