GSRF: Complex-Valued 3D Gaussian Splatting for Efficient Radio-Frequency Data Synthesis

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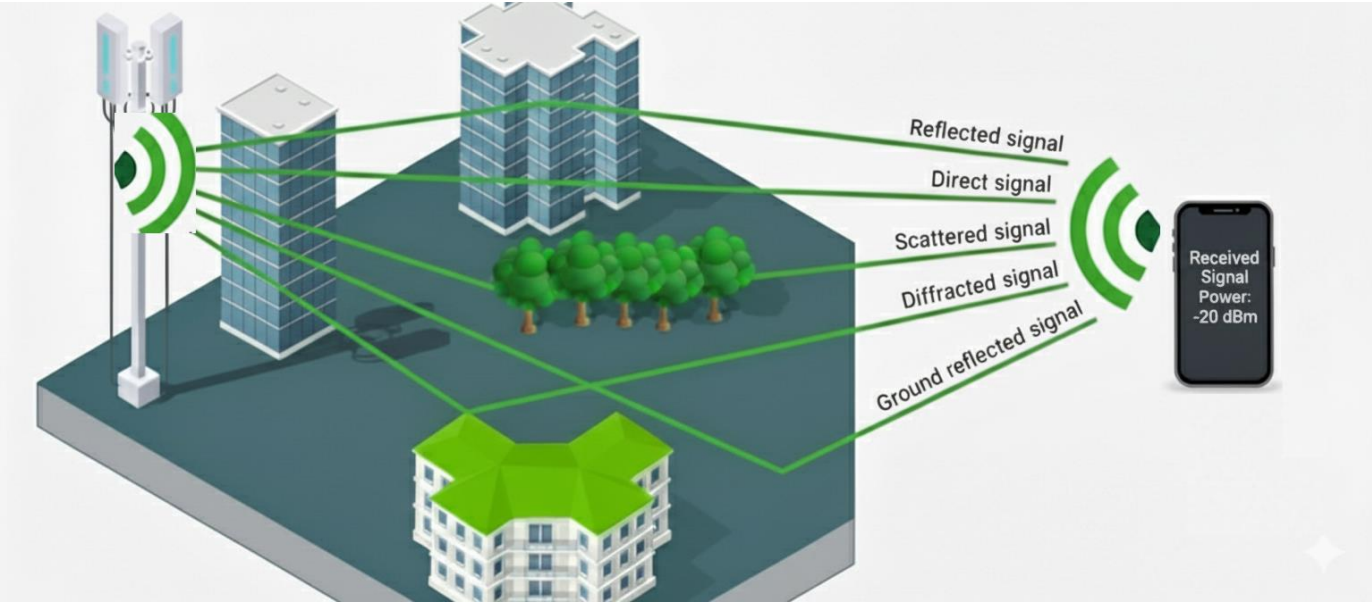
Radio-Frequency (RF) Data Synthesis

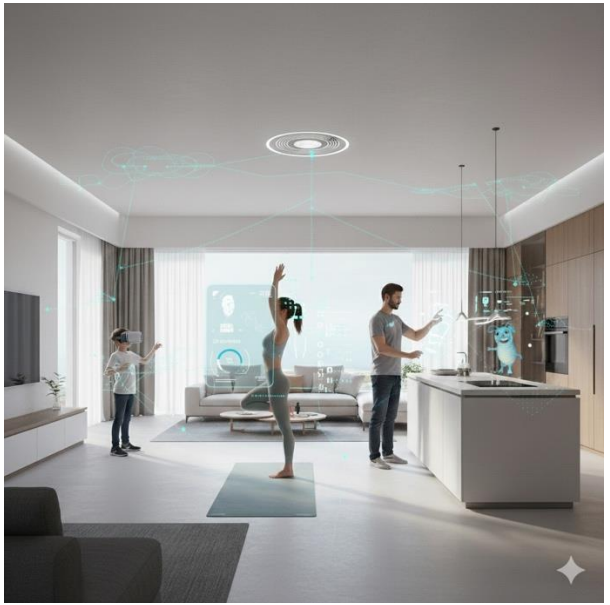
- Simulating how RF signals propagate from a transmitter to a receiver, accounting for environmental effects such as reflection, diffraction, and scattering



Images are generated by Nano-Banana

Empowering Connectivity and Sensing

- **Reliable service anywhere:** Stable Wi-Fi connections in dynamic environments;
- **Better indoor experiences:** Activity recognition improve smart home automation



Driving Advantage for Enterprises

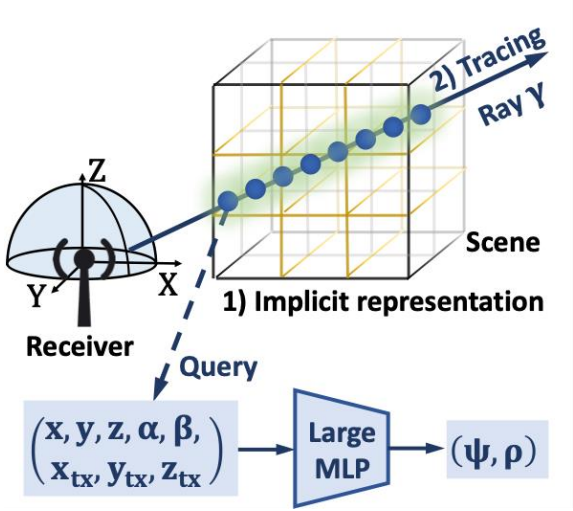
- **Lower Costs and Faster Deployment:** Faster rollout of new wireless services;
- **Dual-Purpose Networks:** Unified communication and sensing, cuts out separate systems

Massive RF Datasets

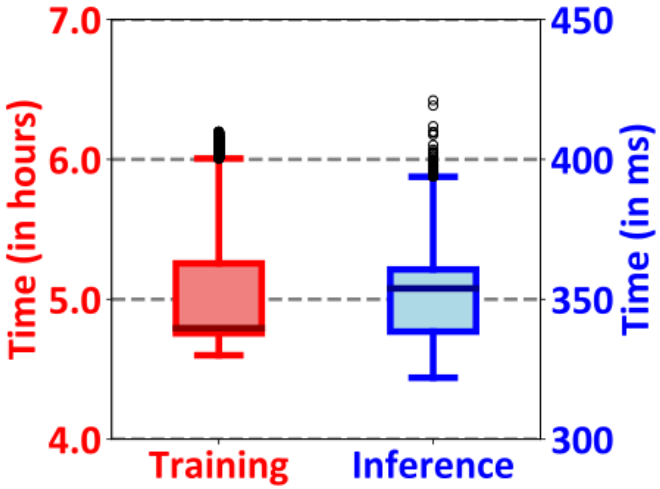
- Next generation wireless systems need massive RF datasets for reliable communication and sensing, yet real-world collection is costly and time-consuming

Neural Radiance Field (NeRF)-based methods

- High-fidelity RF data synthesis but high training time and long inference latency



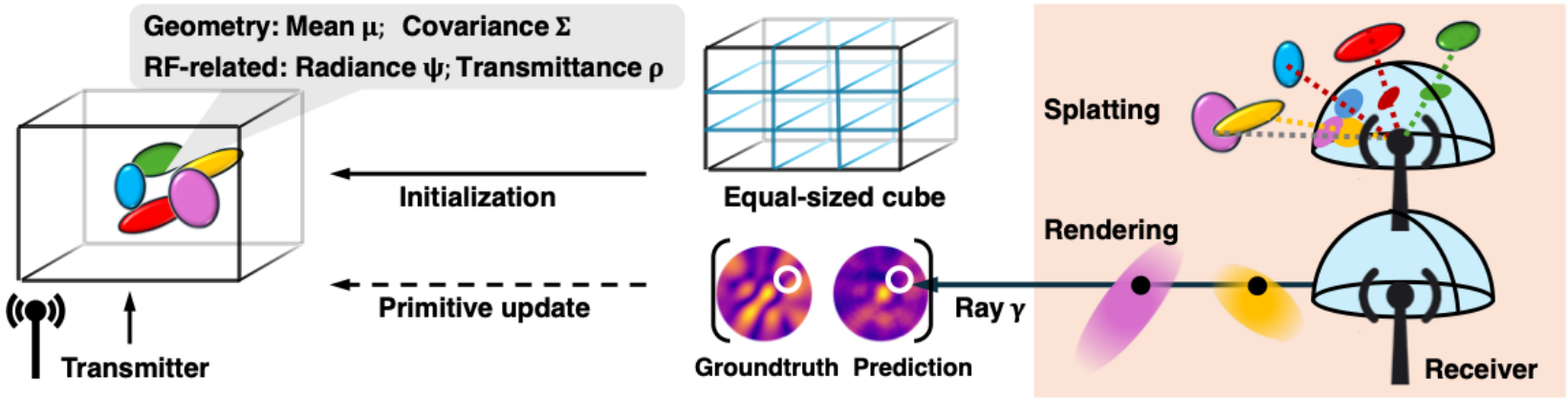
NeRF-based method



Low efficiency

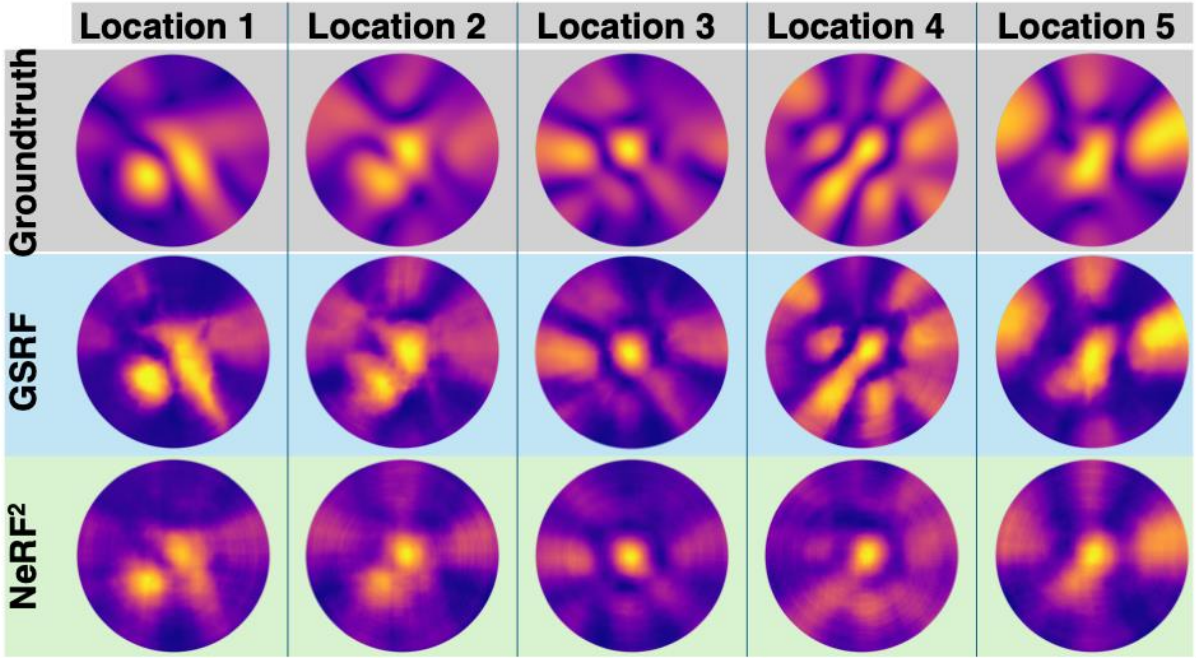
Complex-Valued 3D Gaussian Splatting

- **Fourier–Legendre Radiance Fields** for four Gaussian properties
- **Orthographic Splatting** for ray–Gaussian intersection determination
- **Complex-Valued Ray Tracing** for synthesizing RF data



Qualitative Results

- Spatial Spectrum: Pixels show the signal power on the receiver sphere (1° azimuth/elevation)



Quantitative Results

- Sparse training (0.8 meas./ft³): GSRF exceeds NeRF-based methods by +21.2% PSNR
- Reduces training time by 18.6× and inference time by 84.4×