

GeRaF: Neural Geometry Reconstruction from Radio Frequency Signals

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Radio frequency offers advantages to vision in many scenarios

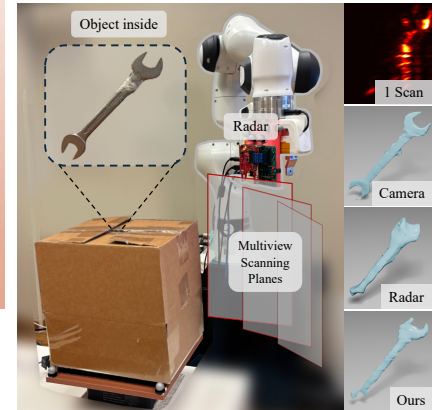
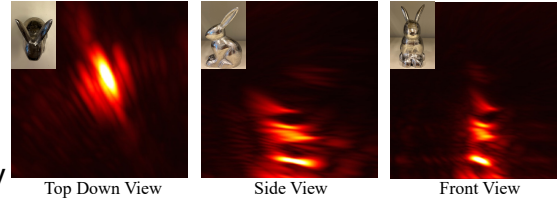
Radio frequency...

- Can see through occlusions
- Works regardless of visibility
- Safe for humans!

However...

- Low spatial resolution
- Huge computational complexity

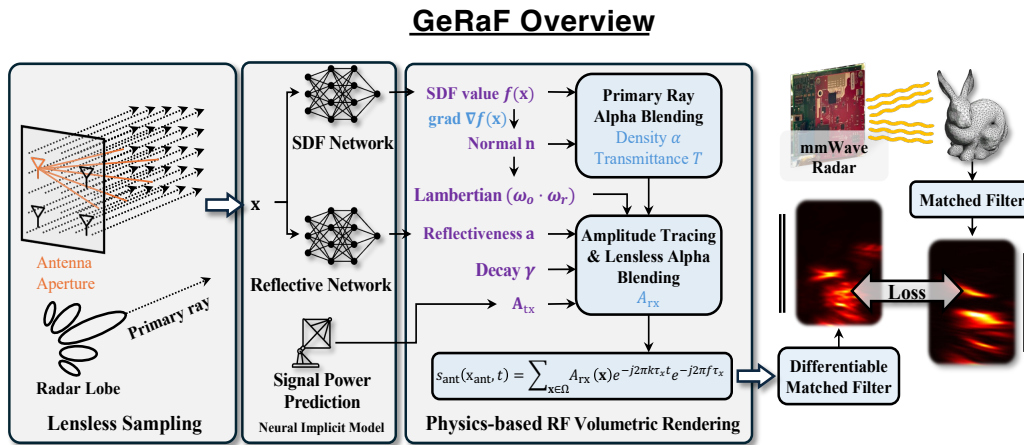
Radio Frequency (RF) heatmaps are not informative enough



Our System: Multiplane radar image scans to enable 3D reconstruction

Challenges in RF Implicit Models

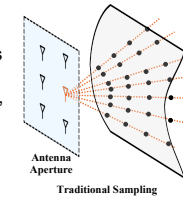
- 1) Use *lensless imaging* models instead of the pinhole model
- 2) Dominated by *specular reflections* instead of diffused reflections
- 3) RF rendering has huge *computational complexity*



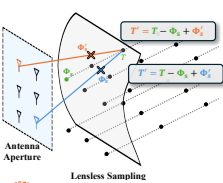
GeRaF is composed of: (1) **Lensless sampling** to replace ray-based sampling methods commonly used in vision. (2) A **neural implicit model** predicts geometry, reflectivity, and power. (3) **RF volumetric rendering** simulates physical signal propagation. (4) **Matched filtering** produces radio frequency power images (heatmaps). (5) An **L2 loss** compares the rendered and ground truth power for end-to-end training.

Computation Optimization

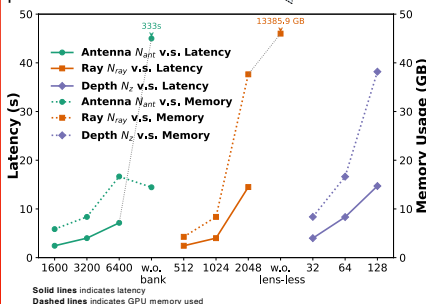
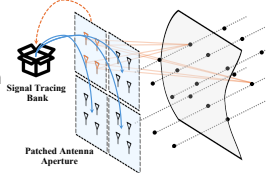
Naïve sampling: traces rays across the entire space for each antenna, resulting → highest computational complexity



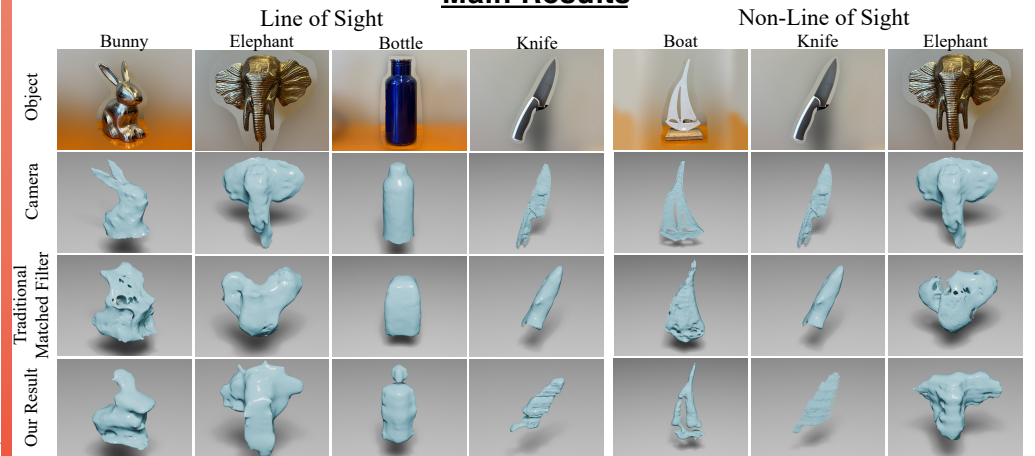
Lensless sampling: samples points along the radar's primary direction and reuses network predictions across antennas



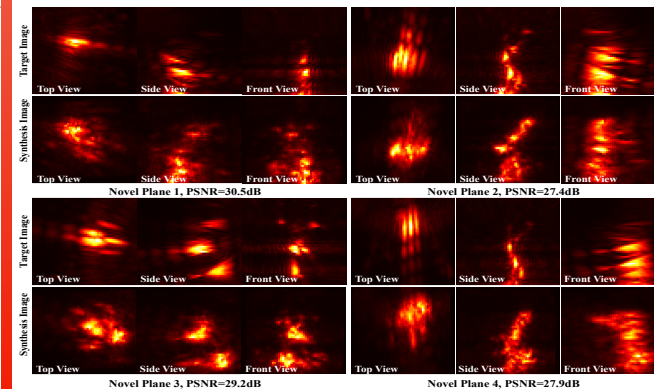
Signal Tracing Bank: subset of antennas is processed in each iteration, reducing computation for forward/backward passes



Main Results



New View Synthesis



With and without Radio Physics

