DART

Implicit Doppler Tomography for Radar Novel View Synthesis

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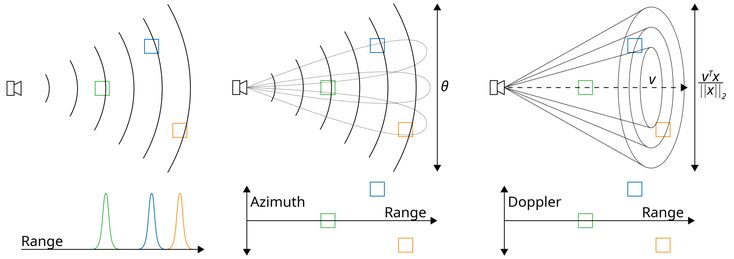
Inspired by NeRF, we develop *Doppler-Aided Radar Tomography (DART)* for radar novel view synthesis and 3D reconstruction. DART can synthesize realistic radar images for use as a radar simulator, generate improved tomography compared to analytical baselines, and opens future opportunities for multi-modal sensing.

Doppler: FMCW radar measures the range of objects in a scene by listening for echoes from chirps (left). Large antenna arrays are typically used to measure angular information (center). We instead use doppler (right), which captures angular information via the relative velocity of objects in a static scene.



Radar Rendering: We devise a differentiable range-Doppler radar renderer which accounts for a variety of physical effects.

Antenna Gain — Occlusion

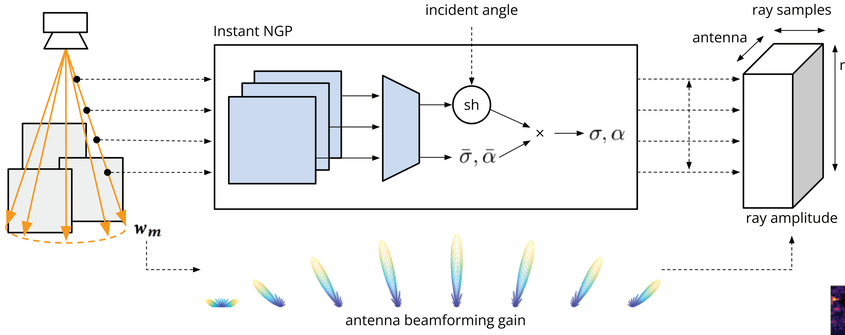
$$C(i,k,\boldsymbol{w}) = g_k(\boldsymbol{A}^{-1}\boldsymbol{w})\frac{\sigma(\boldsymbol{x}+r_i\boldsymbol{w})}{r_i^2}\prod_{i'=1}^{i-1}\alpha(\boldsymbol{t}_{i'})^2,$$

Angular Bin Size — Signal Attenuation

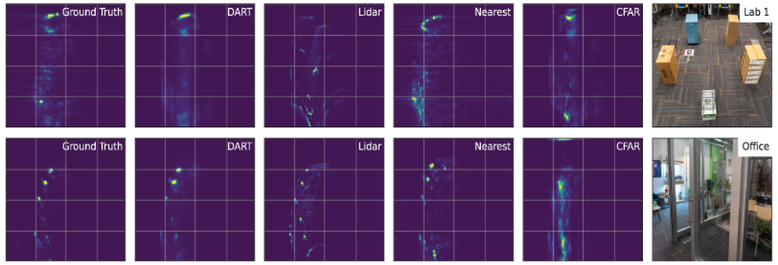
$$\boldsymbol{Y}(r_i,d_j,k) \propto \frac{r_i^2}{M||\boldsymbol{v}||_2}\sum_{m=1}^{M} C(i,k,\boldsymbol{w_m}).$$

Doppler Bin Size — Stochastic Integration

Method: we combine our differentiable range-Doppler renderer with an Instant NGP-based representation to learn a view-dependent scene representation using gradient descent.



Results: DART generates high quality range-Doppler images from novel views (position, orientation, and/or velocity), and can be sampled to generate tomographic maps with higher resolution than is possible with traditional techniques.



Data Collection Rig: we construct a data collection rig with raw ADC data collection capabilities as well as a Lidar and IMU in order to get sensor poses via Cartographer SLAM.