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Revisiting Radar Perception With Spectral Point Clouds

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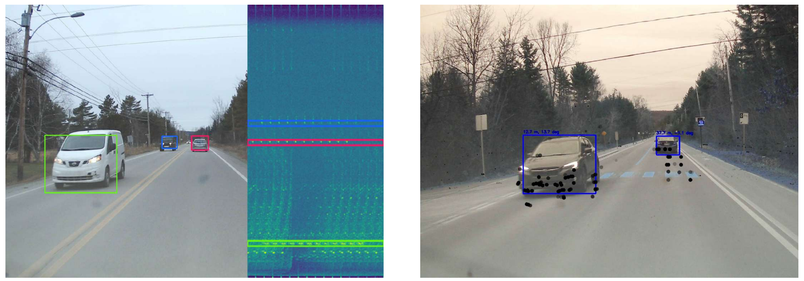
1. Introduction

- ***Foundation models*** require a standard input representation to benefit from ***transfer***. There is no consensus on such a standard for ***radar perception***.
- Experts use various kinds of radar inputs: range-Doppler (RD) spectra, range-azimuth-Doppler tensors, point clouds, etc.
- Dense spectra maximize ***spectral info***, but they can ***vary significantly*** across radar sensors.
- Point clouds are ***uniform*** across radar sensors, but they may lack rich spectral info.

How to guarantee a standard and efficient input for radar perception without throwing away relevant information?



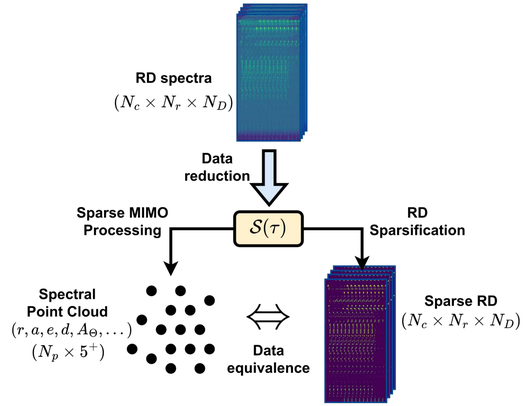
RD Spectra → ***Sparse MIMO Processing*** → **Point Cloud**

Our Solution ⟶ *Spectral Point Clouds*

Input	Uniform Representation	Spectral Info	Efficient Architectures
Point Cloud	✅	❌	✅
Dense Spectra	❌	✅	–
Spectral Point Cloud	✅	✅	✅

2. Spectral Point Clouds

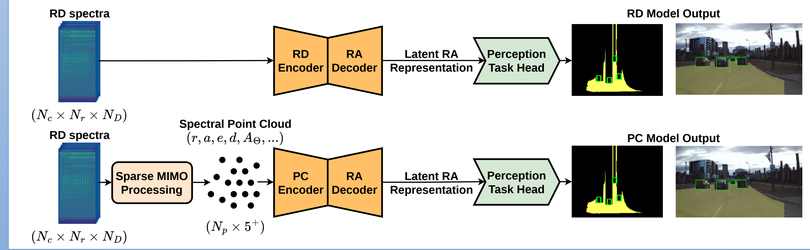
Point clouds are processed from information peaks derived from radar spectra. This induces ***data equivalence***.



Spectral point clouds → Radar point clouds are compressed spectrally-extensible representations of the radar spectra.

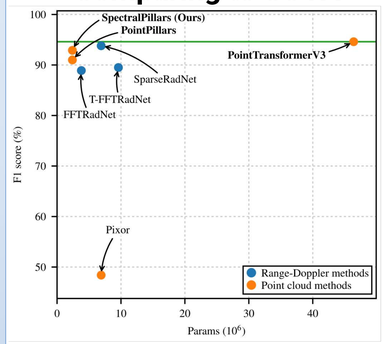
Point clouds need not underperform compared to radar spectra. ***Spectral point clouds*** enable scalable radar perception in the era of ***foundation models***.

3. Experiment Pipeline

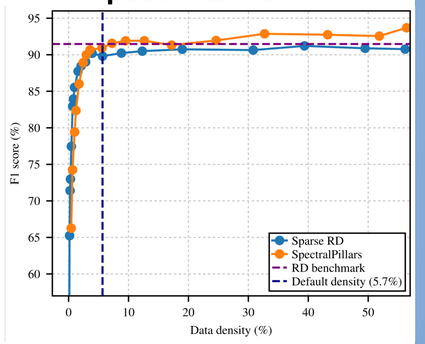


4. Results

Comparing to SOTA



Spectral Enrichment



Model Throughput

Model	Base Density	Base F1	SpectralPillars Density	SpectralPillars F1	FPS
FFTRadNet	100	91.5	-	-	169
PointPillars	0.7	81.0	0.7	74.3	279
PointPillars	1.6	86	1.8	86.0	276
PointPillars	5.7	90.2	5.6	90.9	264
PointPillars	8.8	90.2	7.2	91.6	258
PointPillars	19.0	90.5	17.2	91.3	232
PointPillars	30.8	91.5	32.7	92.9	207
PointPillars	56.2	92.8	56.4	93.7	192

Spectral point clouds are competitive with RD methods while using fewer parameters and exhibiting higher throughput. Spectral enrichment improves their performance.

5. Takeaway Message

Spectral point clouds can match and surpass RD-based detectors while being ***faster***, ***lighter***, and more ***robust to sensor-specific differences***. They are a practical and principled step toward unified radar perception and ***future radar foundation models***.