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Signal Processing for Practical Wireless Intelligence

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8 first-author IEEE journal/conference papers; 15 published papers

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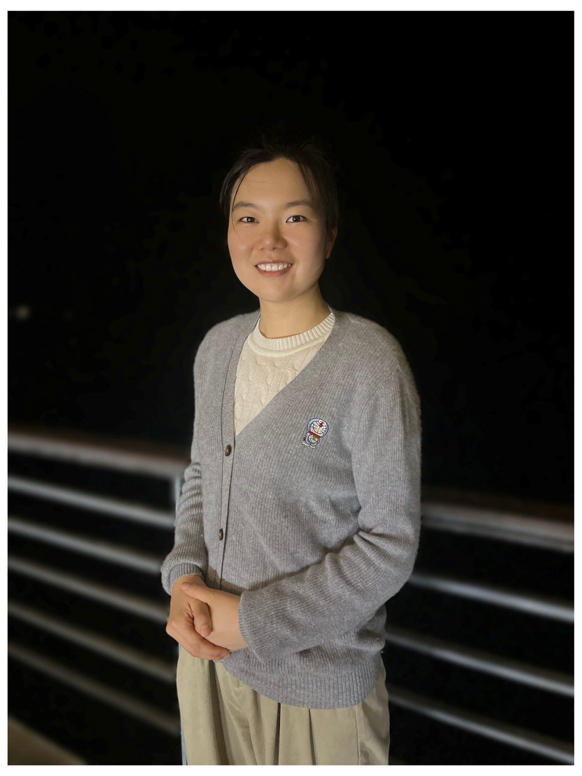
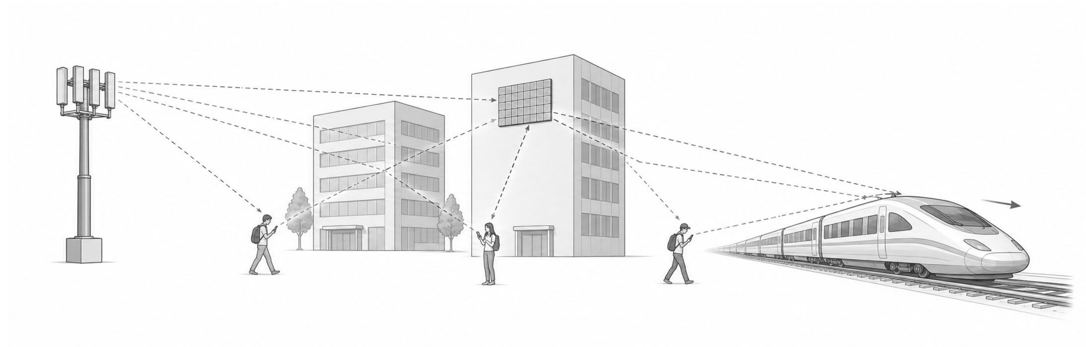


How can wireless systems obtain reliable information with limited hardware and measurements, even as the environment changes?



Signals travel along paths that reflect from buildings and change as devices move. These paths shape the wireless channel.

Networks measure these signals to estimate channels for communication and infer object positions or speeds for sensing.

My research improves how this information is acquired under practical constraints.

01 Observation quality — Signal design and sensing hardware

02 Observation cost — Pilot design and compressed recovery

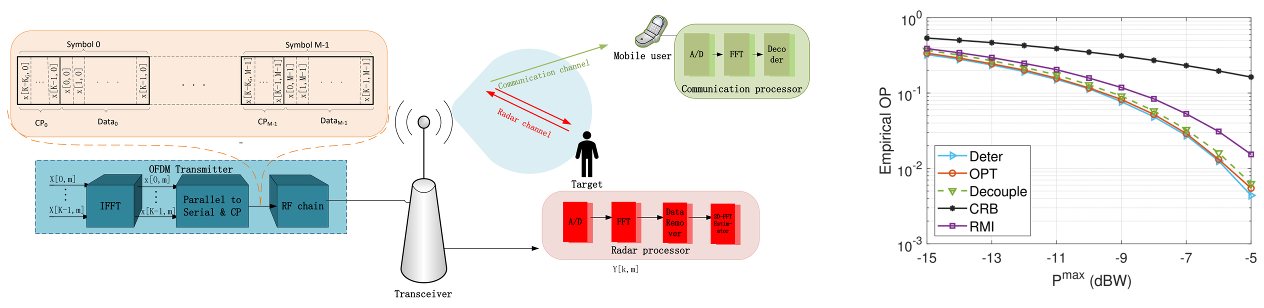
03 Information timeliness — Scene knowledge and fresh pilots

01 Observation quality

Wireless sensing depends on what we transmit and where we sense. Integrated sensing and communication (ISAC) uses the same radio signals to carry data and locate objects [1].

Signal design: account for motion [2]

Motion shifts radio frequencies through the Doppler effect. I design transmitted OFDM signals around range–speed errors, using time–frequency decoupling to simplify optimization.

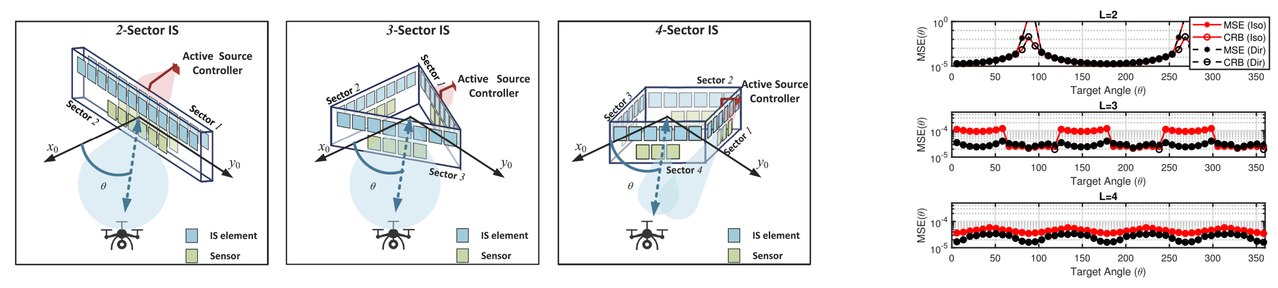


ISAC System and the Performance

- Lower wrong-cell probability than the compared CRB/RMI designs at 2.12 bits/s/Hz.
- The simplified design stays close to full optimization.

Surface design: arrange sensing hardware [3]

Hardware geometry determines which directions we can sense accurately. I study sector arrangements and interconnected surfaces to balance coverage, accuracy and controller complexity.



Proposed multi-sector RIS architecture and the performance

- 4 sectors avoid two-sector blind directions in the tested 360° azimuth model.
- 1 shared controller with interconnected surfaces, versus one controller per independent sector.

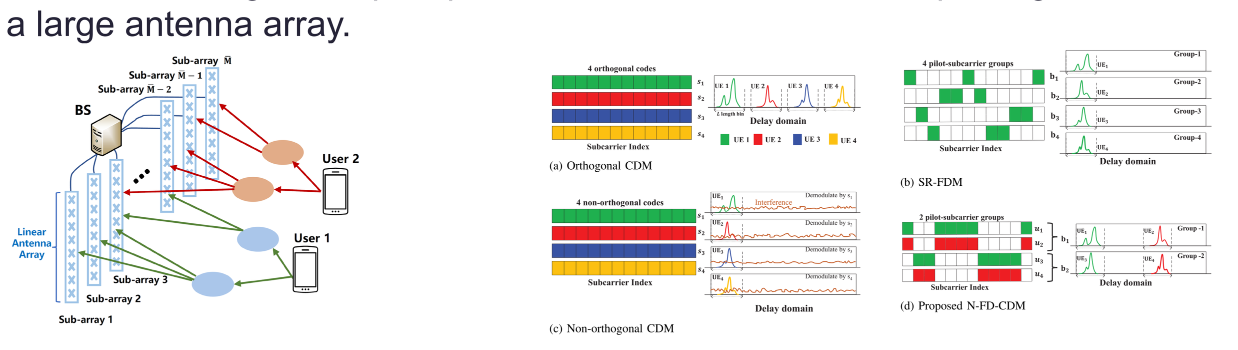
As more users connect, obtaining reliable observations must consume fewer measurements.

02 Observation cost

Each user sends known pilot symbols so a base station can learn the radio channel. My pilot design lets users share resources, and compressed recovery separates their overlapping signals.

Pilot design: share measurement resources [4]

I group users and design their pilot patterns to reuse resources, exploiting their different visibility across a large antenna array.



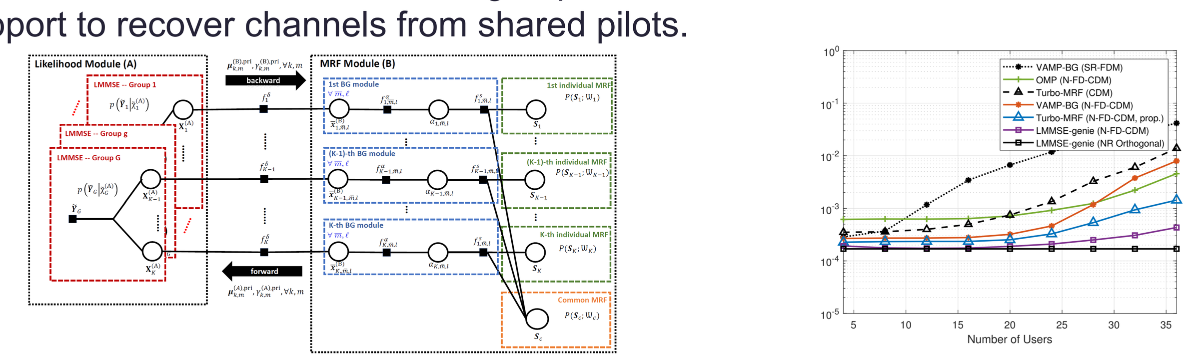
Dense User Wireless Scenarios

Proposed Pilot Scheme

- 1 rather than 3 pilot symbols for 24 users: 67% less pilot-symbol overhead.

Compressed recovery: separate users [4]

My Turbo-MRF method combines group-wise estimation with a 2-D model of clustered channel support to recover channels from shared pilots.



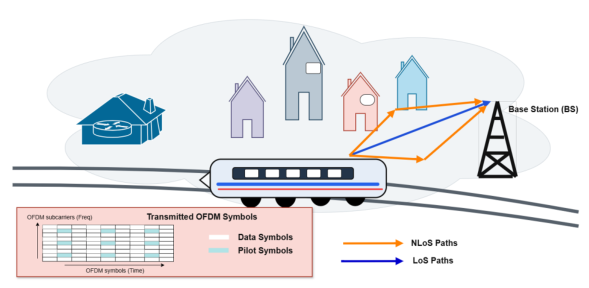
Proposed Bayesian based-compressed sensing algorithm and the performance

- At error 10^{-3}: at least 32 users, versus about 28 with VAMP-BG and 20 with OMP.

With high mobility, even an accurate estimate can become outdated before the next measurement.

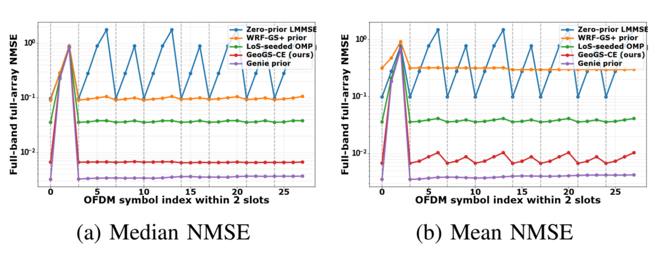
03 Information timeliness

GeoGS-CE addresses this timing problem by reusing knowledge of the environment. It learns a geometry-conditioned propagation prior, then combines that prior with fresh, sparse pilots [5].



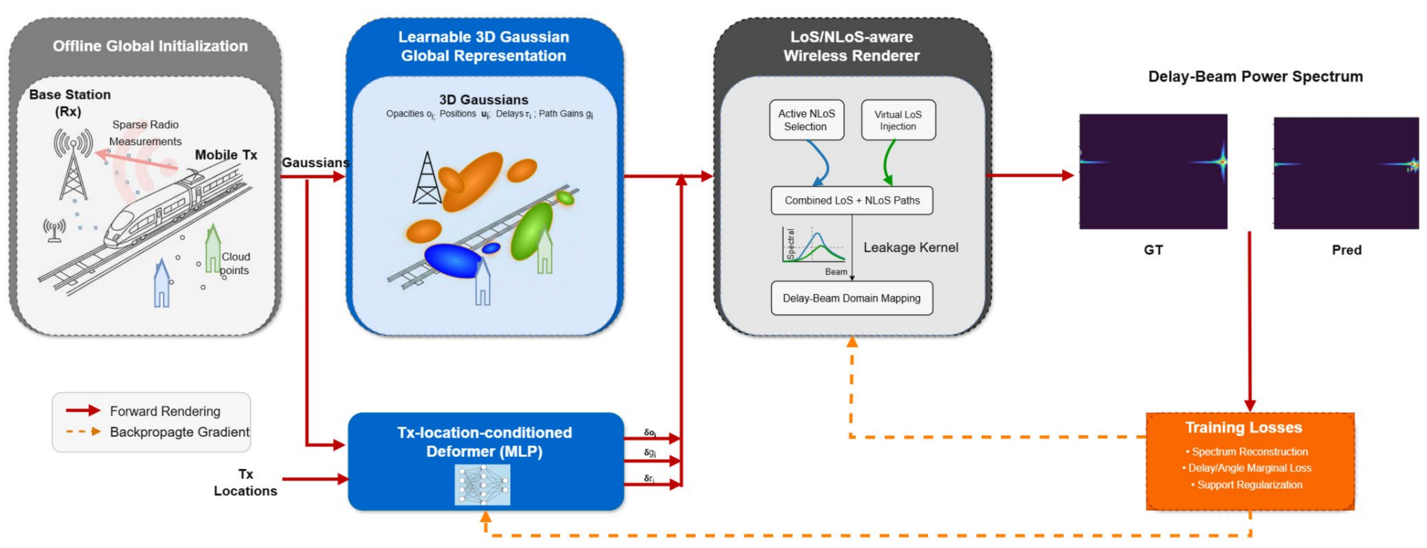
350 km/h railway simulation

100 antennas; 72/1,024 pilot tones on 4/14 OFDM symbols. Sionna RT.



Online recovery between pilot updates. [5, Fig. 4]

3D Gaussians capture reusable scene structure



Offline: learn how scene geometry shapes propagation.
Online: combine the learned prior with fresh, sparse pilots.

- Mean NMSE: −14.07 dB; −12.32 dB after removing initialization and explicit LoS. Ablation study [5, Table I].

FUTURE DIRECTION **When is existing knowledge reliable enough to avoid measuring again?**

My next step is to jointly manage observation quality, measurement cost and information age, using uncertainty to decide when and where to acquire fresh measurements.

REFERENCES

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[5] Y. Zhang, J. Guo, C. Wen, C. Bian, and J. Zhang, "GeoGS-CE: Learning delay–beam channel priors with 3D Gaussians for high-mobility scenarios," 2026, arXiv:2605.16094, doi: 10.48550/arXiv.2605.16094.

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