Towards Sensing with NextG Open RAN

Presenter: Dr. Tianxin Wang
Advisor: Prof. Mahesh Marina
The University of Edinburgh

Integrated Sensing and Communication (ISAC) aims to turn cellular infrastructure into a dual-purpose platform for communication and environmental sensing. By observing multipath changes in the channel impulse response and Doppler shifts from moving targets, base stations (BSs) can detect people, vehicles, or unmanned aerial vehicles without dedicated radar hardware or cameras [2]. 3GPP has identified such services as part of future mobile networks [1], making ISAC attractive for pervasive sensing at cellular scale. However, translating these use cases into working systems remains difficult. Proprietary cellular BSs and user equipment (UE) rarely expose the low-level channel measurements needed for sensing, forcing many prototypes to rely on non-cellular radios or software-defined cellular testbeds [2]. This limits practical deployment in cellular networks and restricts the collection of real-world datasets for diverse sensing tasks. Open Radio Access Network (O-RAN) addresses this gap through standardized open interfaces and disaggregated RAN functions that can expose 5G reference-signal measurements and physical-layer internals, enabling commercial-grade ISAC experimentation on programmable cellular infrastructure [3].

Our work exploits this opportunity by pairing a commercial, unmodified 5G UE with an O-RAN-compliant commercial BS in a live outdoor network. To our knowledge, this is the first demonstration of such a commercial-grade, O-RAN-compliant sensing scenario in a *live 5G outdoor network*, the primary deployment setting of cellular systems. We focus on *uplink bistatic sensing*, where the UE transmits Sounding Reference Signals (SRS) and the BS-side distributed unit (DU) performs sensing, because this design is inherently network-centric: DUs can receive SRS from multiple UEs, combine observations across BSs, and use edge compute for real-time inference. This positions ISAC as an *AI-on-RAN* application—an AI-enabled service that runs on RAN infrastructure rather than merely optimizing it. In this work, we take a first concrete step through a single-link feasibility study on Campus5G, a campus-scale private O-RAN testbed with 20 O-RAN-compliant BSs [3].

Concretely, an unmodified Samsung phone with a Quectel 5G modem transmits SRS every 320 ms, and a Benetel O-RU at 3.95 GHz with 100 MHz bandwidth forwards the received signal through Open Fronthaul to an srsRAN DU. The DU extracts per-subcarrier channel estimates; SRS is suitable because it supports periodic uplink configuration with flexible timing. We evaluate static presence, straight-line walking, circular walking, and hand waving near the phone. The processing is deliberately lightweight: walking detection uses a line-of-sight-aligned short-time Fourier transform to form a micro-Doppler spectrogram, and indoor–outdoor comparison uses a channel frequency response (CFR) quotient between two receive antennas to suppress shared phase and frequency offsets before aggregation.

The preliminary studies examine motion separability and environmental robustness. In Figure 1, static activity concentrates energy near zero Doppler, straight-line walking creates a clear band consistent with typical human walking speeds, and circular walking produces a distinct profile as radial velocity changes. These results show that uplink SRS has enough temporal resolution and channel quality to distinguish simple human motion classes outdoors.

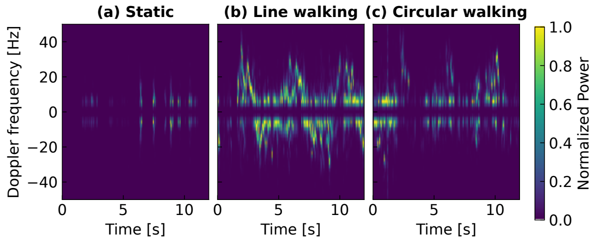

Figure 1: Doppler spectrograms for (a) static, (b) straight-line walking, and (c) circular walking.

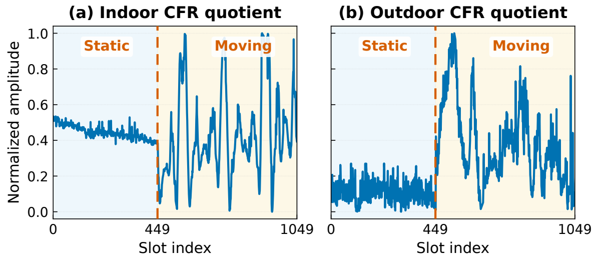

Figure 2: CFR quotient amplitude aggregated across subcarriers over time for (a) indoor (b) outdoor.

Figure 2 compares indoor and outdoor sensing stability using the CFR-quotient metric. The indoor trace is stable when static and periodic during hand motion, whereas the outdoor trace fluctuates more and shows weaker periodicity. This confirms that outdoor cellular sensing is harder because clutter and uncontrolled motion can mask target-induced variation.

Overall, these preliminary studies show that an unmodified 5G UE and an O-RAN-compliant BS can expose useful sensing signatures through uplink SRS in a live outdoor network. We see three immediate directions. First, systematic benchmarking should quantify how sensing performance changes across indoor/outdoor sites, weather, UE models, O-RU vendors, SDR baselines, and 5G/Wi-Fi links. Second, the system should scale from one link to network-centric sensing with multiple BSs, multiple UEs, and multiple reference signals. Third, AI-based inference can be leveraged at the RAN edge to separate weak target signatures from clutter and support more complex outdoor activities.

References

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