Heuristic-Informed Neural Surrogate on Wireless Network Representations

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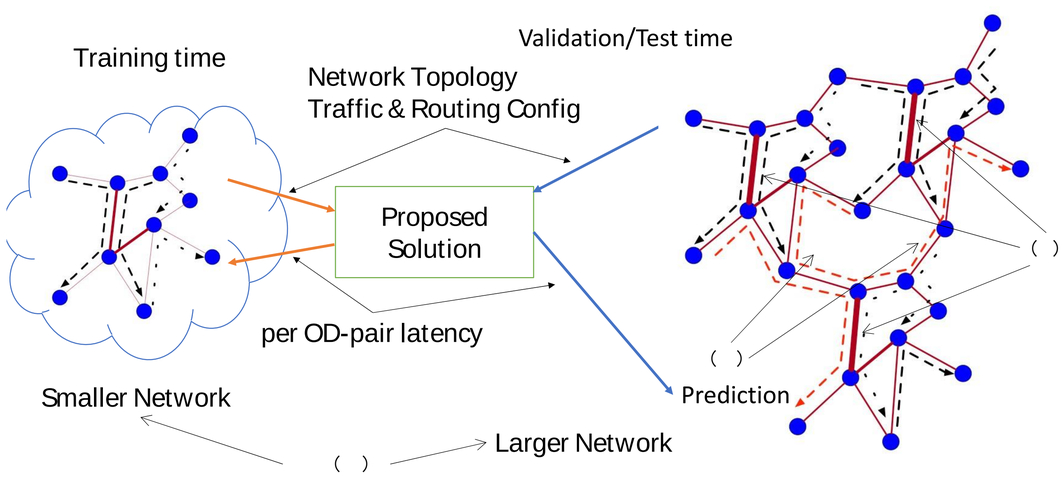
Motivation

- Wireless networks are inherently rich in representation, encompassing topology, graph structures, and inter-relations.
- Learning from these representations facilitates the development of **heuristic-informed neural surrogates**, which generalize effectively across diverse scenarios.
- Integrating the radio environment into the surrogate model makes it environment-aware, enhancing adaptability to real-world conditions. Conversely, such models open new frontiers in **joint communication and sensing (JCAS)**.
- These representations introduce a new data modality for over-the-air (OTA) learning and computing, paving the way toward **zero-cost sensing & localization** capabilities.



Learn to Generalize towards "Open Input":

- **Challenge**: Extrapolate the training scenario on expanding networks, when user increases, network capacity extension and user's usage pattern drifts.

(+) Award winning solution in ITU-AI/ML in 5G Challenge, against 140+ competing institute and competing commercials.

(+) Real-time estimation on traffic congestion and E2E latency, with both precision ($\times 4.3$ more accurate) and speed (> 30s for baseline)

Link to paper

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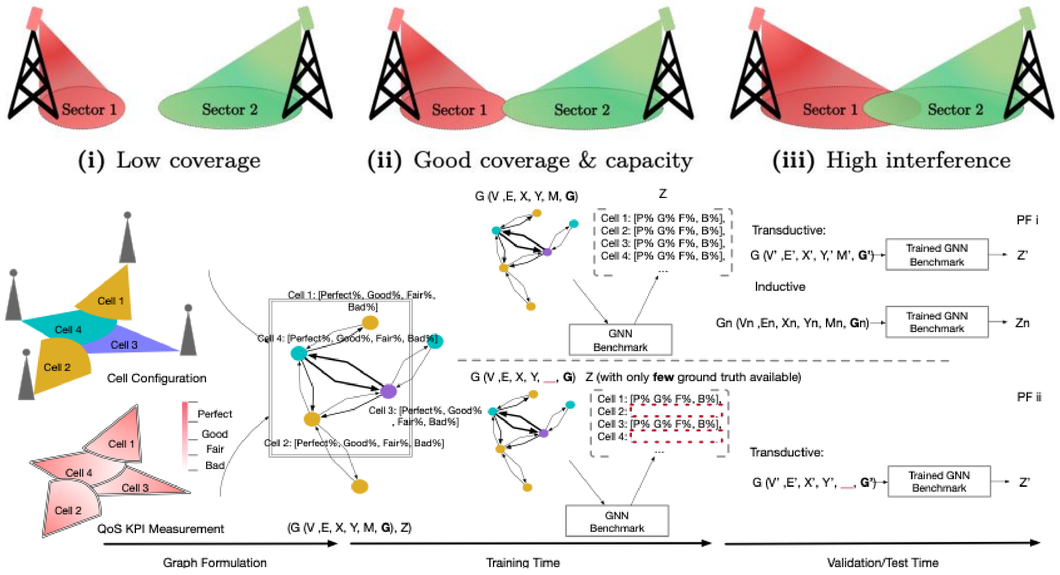

Learn to Generalize towards geo-coordinates, orientation and weakly-informed representation:

- **Challenge**: Generalize the training outcome on weakly-supervised radio coverage topology, while learning the rich spatial attributes in non-Euclidean representation.

(+) Real-time radio coverage estimation & optimization, faster than commercial simulator (> 8h)

(+) Performance keep resilient when only 2.5% of user measurement is supplied in training

Link to paper

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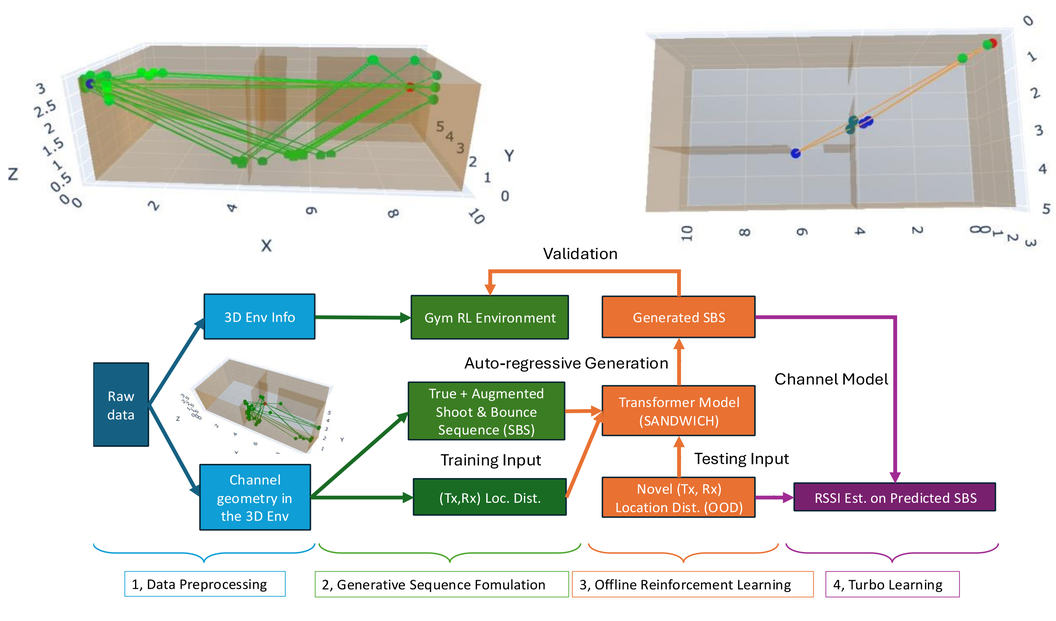


Learn RF environment through GenAI:

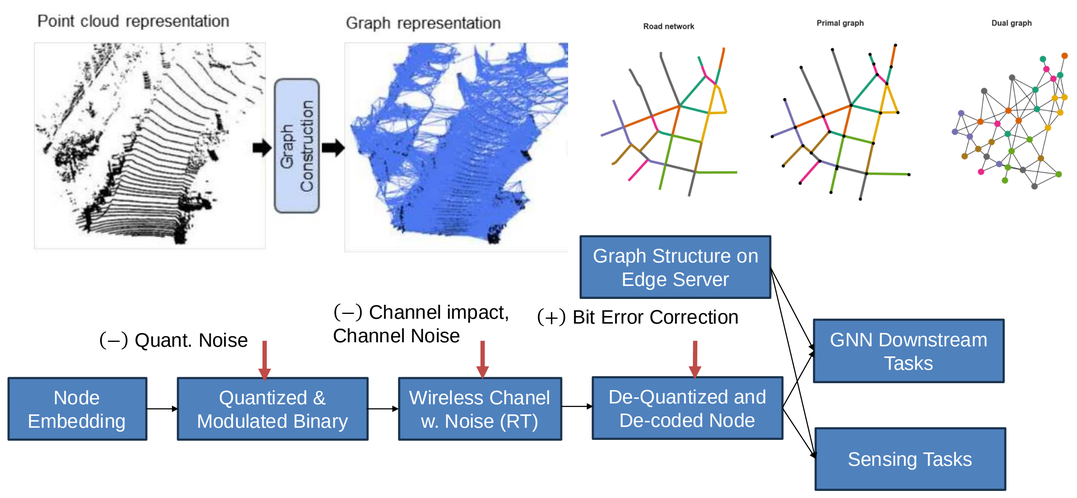
- **Challenge**: Using Generative method to learn wireless ray's shot & bounce propagation geometries, inspired by text generation for GPTs.

(+) We developed 1st Offline, Differentiable, Fully-Trainable Wireless Neural Ray-Tracing Surrogate.

(+) Our generated wireless ray sequence shows comparable performance with ground truth ray-tracer in Signal strength, Phase, Angle of Arrival/Departure estimation, with a generalized performance on novel user & base station location.

Link to paper

Link to slides



Graph as a data modality empowers 6G communication more than "bit pipes":

- **Challenge:** Graph can serve as a "semantic self-correction" scheme.
- Through over-the-air-learning scheme, graph representation learning shows more resilient performance than bit-wireless precision.

(+) We proved that graph as a new communication modality, can bear more dynamics & noise in data, while retain its downstream task performance.

Link to paper

(In submission)

Link to slides

(In submission)

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