

MEDUSA: Mid-band Environmental sensing capability for Detecting incUmbents during Spectrum sharing

(NSF CNS # 2229444)

Website: <https://sites.google.com/view/medusa-swift>



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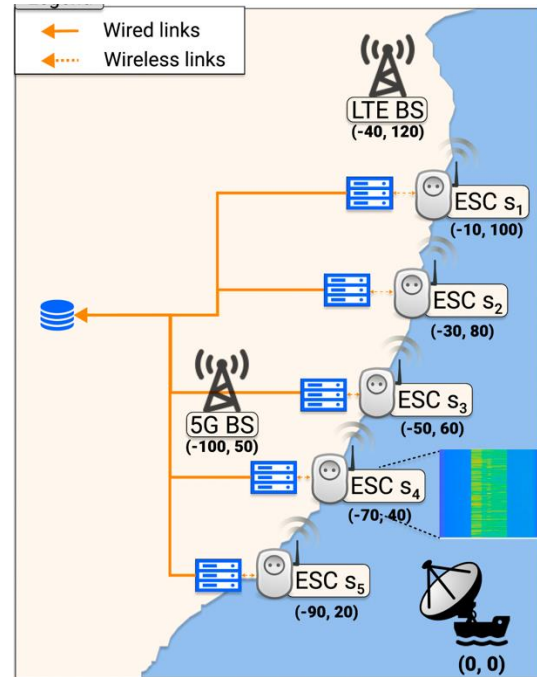
Motivation

The problem: FCC opened up CBRS band to solve the spectrum scarcity, but severely limits the transmission power for LTE/5G operators, enforcing the *whisper zones*.

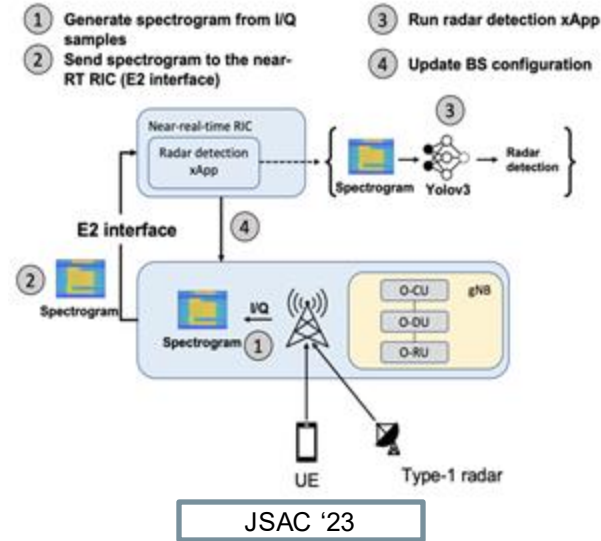
Effect of the problem: Concern of timely detection of high-power Radar pulses has stymied opening remaining 3.1-3.55GHz band.

Vision of MEDUSA: Design an improved ESC sensors, namely ESC+ to detect radar pulses within existing 5G/4G-LTE signal with powers stronger than FCC-mandated levels by 5 dB.

Potential impact of MEDUSA: Approximately 1120, 2250, 3250* more users can potentially be served by each PAL base-station when the proposed ESC+ sensors are deployed along the coastal regions of Massachusetts, New York, and New Jersey, respectively.

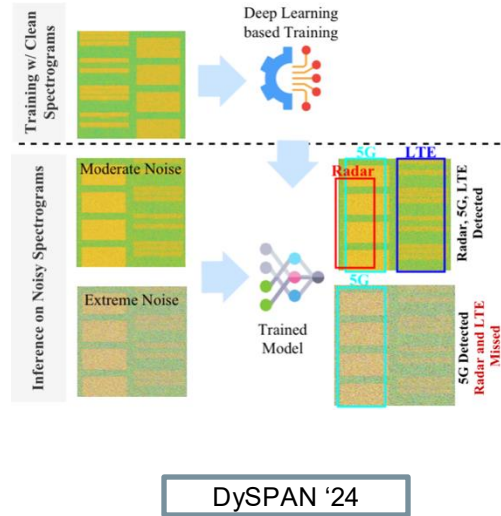


MEDUSA Thust 1 (Cont.)



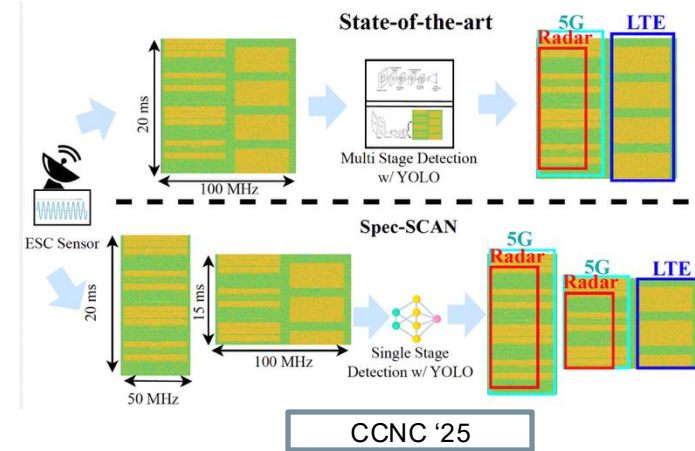
Open RAN integrated sensing

1. xApp that uses spectrograms to decide signal 5G/LTE type and presence of radar
2. OTA demonstrations, datasets



Stress-testing w/ added Noise:

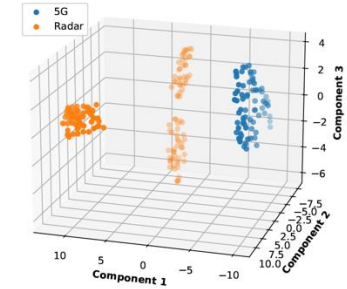
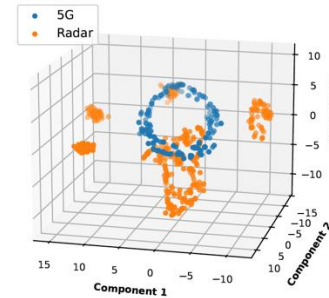
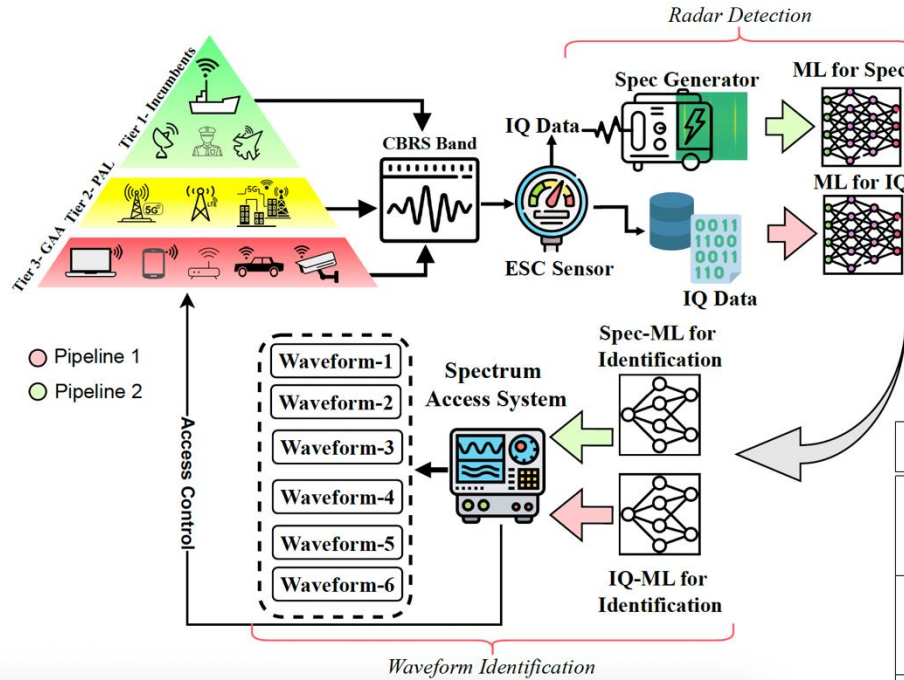
1. Trained on clean spectrogram, tested on noisy
2. 99% radar recall with added Speckle noise w/ variance 0.012



Stress-testing w/ time and frequency range:

1. Single-stage YOLO → 2X improvement in inference time than SOTA
2. 100MHz spectrum within a 15ms timeframe

MEDUSA Thust 1 (Cont.)



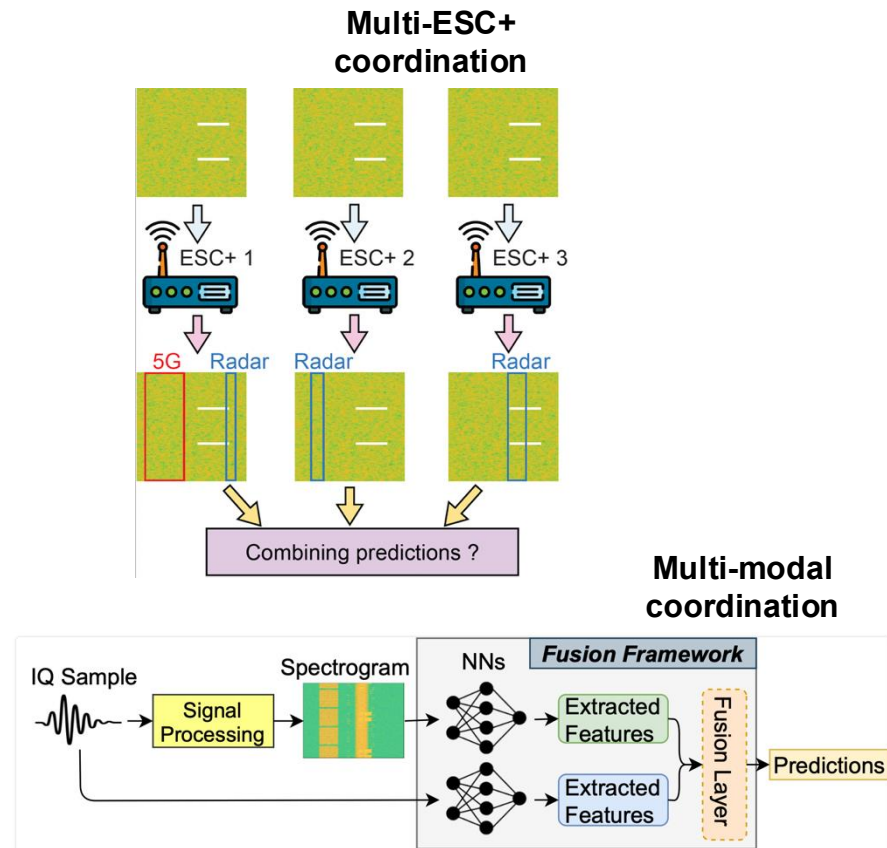
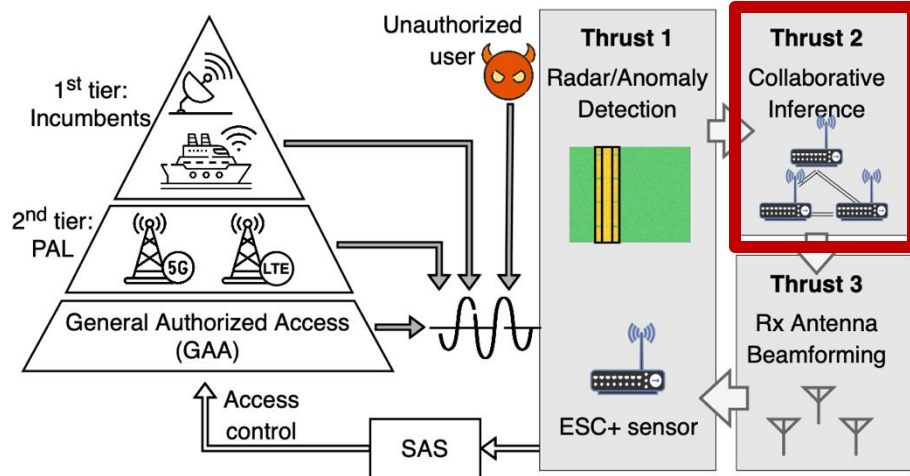
Signal	Metrics (%)	Spectrograms	IQ Samples
		Pipeline 2	Pipeline 1
SINR 5 dB	Overall Accuracy	99.8	98.02
	Radar Precision	99.6	100
	False Positives	0	0
	Recall	99.5	94.17
SINR 0 dB	Overall Accuracy	99.7	97.64
	Radar Precision	99.6	99.5
	False Positives	0	0
	Recall	99.5	93.27
SINR -5 dB	Overall Accuracy	99.5	96.54
	Radar Precision	99.5	98.25
	False Positives	0	0
	Recall	99.5	91.17
Real Data	Overall Accuracy	99.5	91.10
	Radar Precision	99.6	97.40
	False Positives	0	0
	Recall	99.5	88.20

**Meets FCC
requirement of 99%
radar detection recall**

Comparison of radar detection performance using **IQ** and **Spectrograms** as separate modalities

MEDUSA Thrust 2

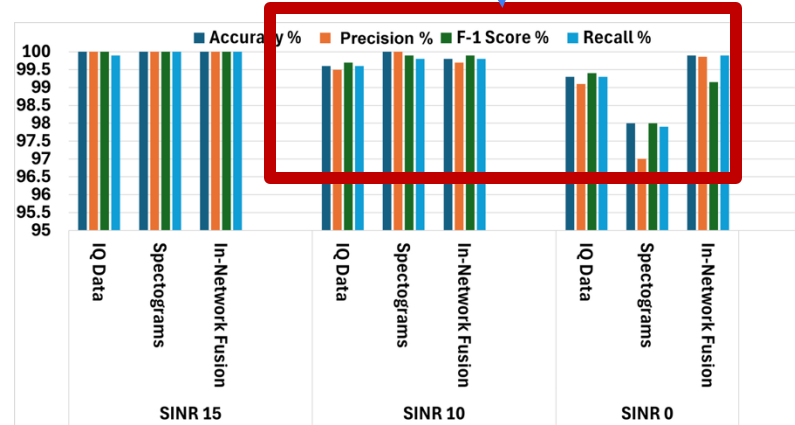
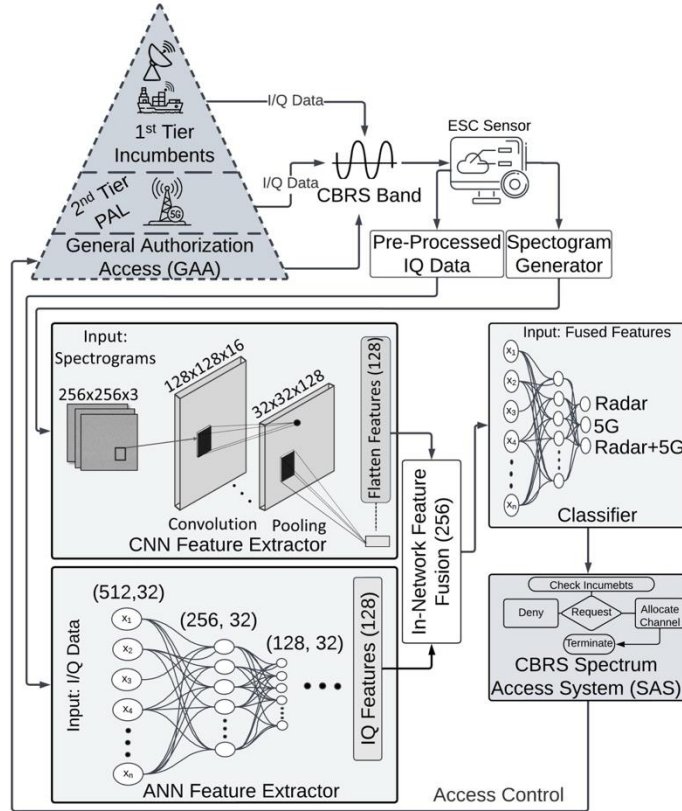
Thrust2: Collaborative Inference using Multi-ESC+ coordination for improved performance by trading off the computation cost.



MEDUSA Thrust 2 (Cont.)

Multi-modal coordination for improved radar detection performance

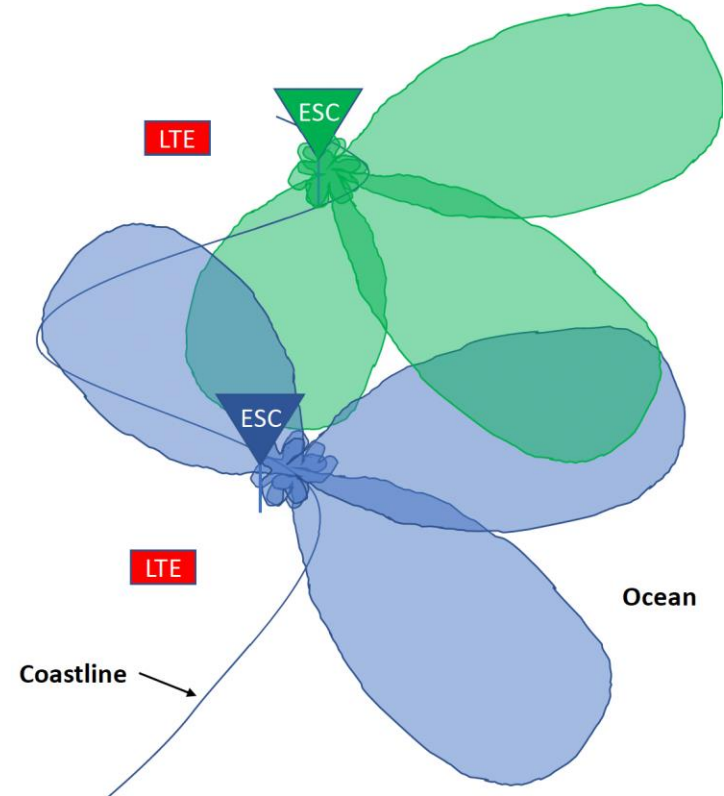
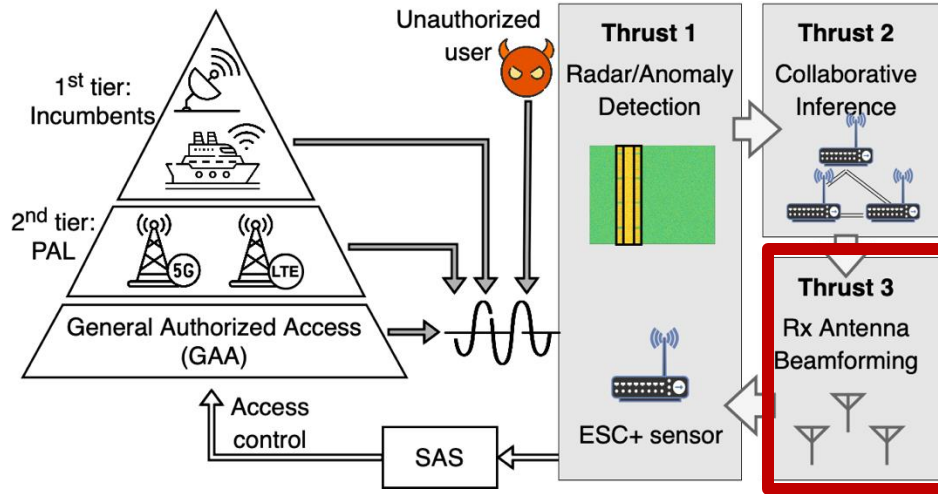
Noticeable improvement for fusion at lower SINR



Multi-ESC+ coordination (under review)

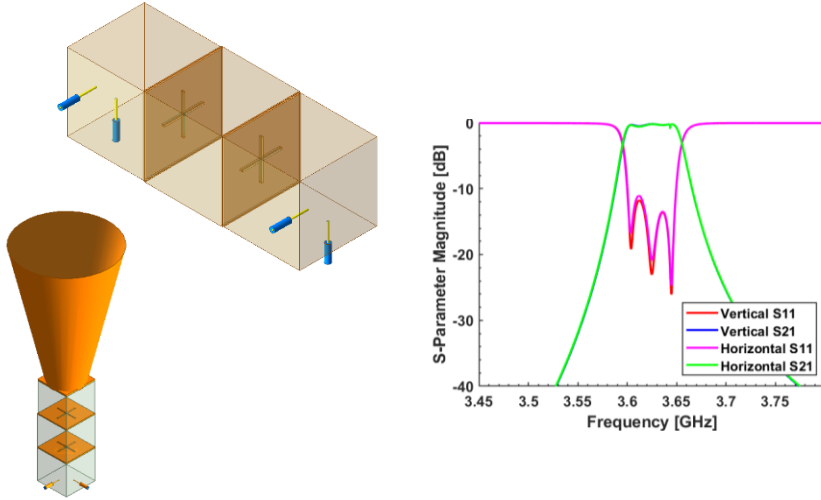
MEDUSA Thrust 3

Thrust3: Frequency and spatial filtering antennas for physical layer interference resilience and improved sensing capability.

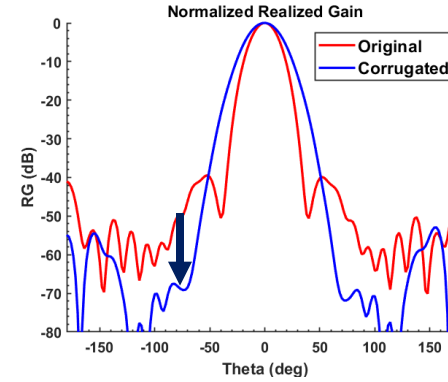


MEDUSA Thrust 3 (Cont.)

Frequency Filtering



Spatial Filtering



Peak side lobe levels reduced by over 20 dB

Original

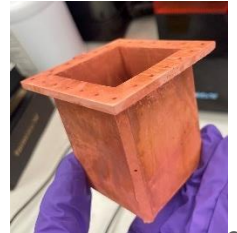
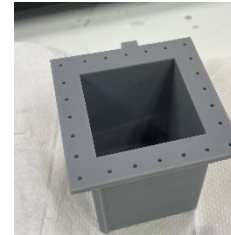
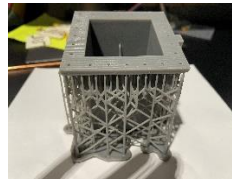


Corrugated



Fabrication

- Stereolithography (SLA)
 - Traditional polymers are too porous for electroplating
 - Formlabs Form 3/4
- Electro-plated with copper
 - Electroless used as seed layer



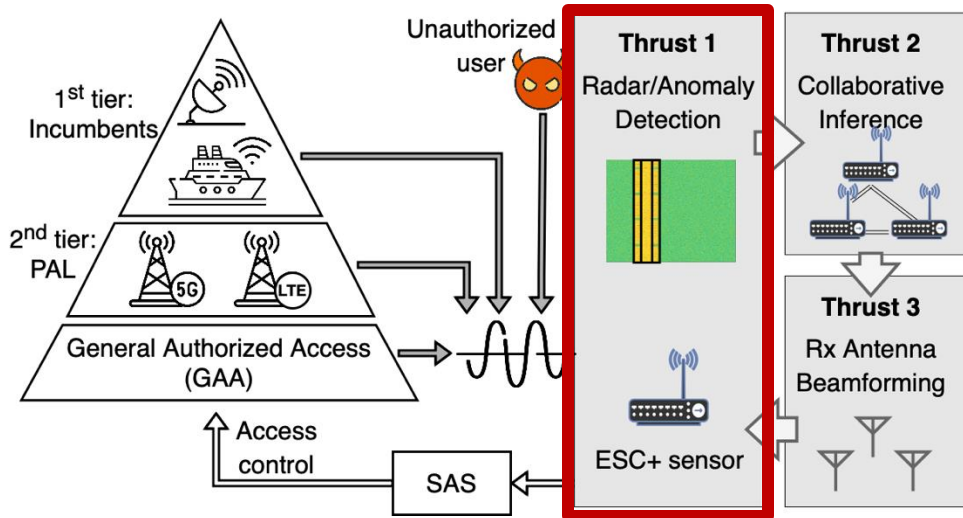


Thank you!

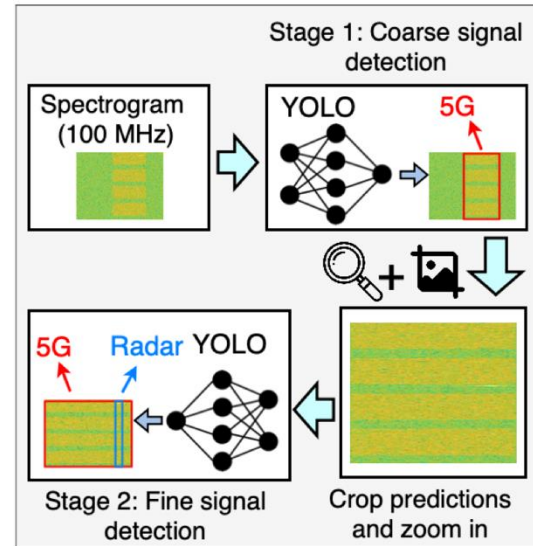
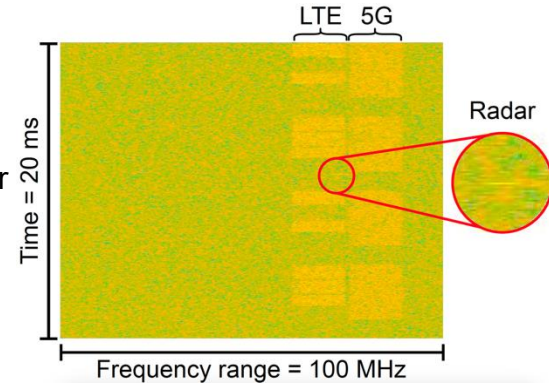


MEDUSA Thust 1

Vision: Interference-resilient and privacy preserving ML for radar and anomalous signal detection in low signal-to-interference-plus-noise ratio (SINR).



Detecting Radar pulse from Spectrogram



Waldo Dataset Description:

1. 1300+ spectrograms
2. Three Signal types: Radar, LTE, 5G
3. Noise and interference level: -104 to -109 dBm/MHz
4. Radar peak power: -89 to -79 dBm/MHz

Publications

- [1] Shafi Ullah Khan, Michel Kulhandjian, and **Debashri Roy**, "*Pushing the Boundaries in CBRS Band: Robust Radar Detection within High 5G Interference.*," In IEEE International Conference on Military Communications (MILCOM), October 2025. [Accepted]. [\[Code\]](#)
- [2] Rahul Vanukuri, Shafi Ullah Khan, Talip Tolga Sari, Gokhan Secinti, Diego Patiño, and **Debashri Roy**, "*Waves of Imagination: Unconditional Spectrogram Generation using Diffusion Architectures*," In IEEE International Conference on Military Communications (MILCOM), October 2025. [Accepted]. [\[Code\]](#)
- [3] Michel Kulhandjian, Hovannes Kulhandjian, **Debashri Roy**, and Michael Rahaim, "Detection and Parameter Estimation of Pulsed LFM Radar for Opportunistic Resource Sharing in Radar-Cellular Coexistence" In Asilomar Conference on Signals, Systems, and Computers, October 2025. [Accepted]
- [4] Shafi Ullah Khan, Michel Kulhandjian, and **Debashri Roy**, "In-Network Fusion for High Interference Signal Detection within CBRS Band," In IEEE International Conference on Computer Communications (INFOCOM) Poster, May 2025. [\[Code\]](#)
- [5] Raju Hazari, *Gaurav Singh*, Devika Renjith, Divya Krishnan, Pavanitha B, Habeeb Olufowobi, and **Debashri Roy**, "Spec-SCAN: Spectrum Learning in Shared Channel using Neural Networks," In CCNC WKSHPs: International Workshop on Communication and Networking for Swarms Robotics (ROBOCOM'25), Jan 2025. [\[Code\]](#)
- [6] Mohammad Hasibur Rahman, Gaurav Singh, and **Debashri Roy**, "Speclearn: Spectrum Learning in Shared Band under Extreme Noise Conditions," In IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN), POSTER, May 2024. [\[Code\]](#)
- [7] Gullem Reus-Muns, Pratheek Upadhyaya, Utku Demir, Nathan Stephenson, Nasim Soltani, Vijay Kumar Shah, and **Kaushik Roy Chowdhury**, "SenseORAN: O-RAN based Radar Detection in the CBRS Band," IEEE Journal on Selected Areas in Communications (JSAC), vol. 42, no. 2, August 2023.
- [8] Nasim Soltani, Vini Chaudhary, **Debashri Roy**, and **Kaushik Roy Chowdhury**, 'Finding Waldo in the CBRS Band: Signal Detection and Localization in the 3.5 GHz Spectrum', *IEEE GLOBECOM*, December 2022.

Citizen Broadband Radio Service (CBRS) - Regulations

CBRS band is:

- Between 3.55 and 3.7 GHz
- Originally allocated to Federal applications in the US

Hierarchical access priority structure:

- Incumbent (Shipborne Radar)
- Priority Access License (PAL) users
- General Authorized Access (GAA)

Spectrum Access System (SAS) grants access based on the hierarchical structure.

Environmental Sensing Capability (ESC)

