Nexcepta

Driving creative solutions through innovation

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Nexcepta, Inc.

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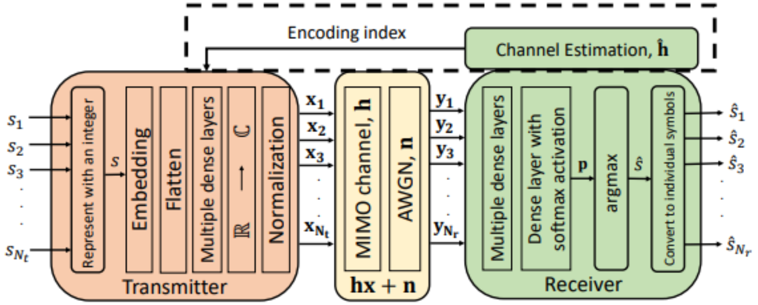
Nexcepta Overview

- A non-traditional R&D small business based in Gaithersburg, Maryland.
- >10 scientists and engineers.
- Executing R&D projects for different DoD agencies (Army, Air Force, MDA, Navy, and OUSD) and large prime companies.
- Technical Expertise
  - NextG Communications and Spectrum Access
  - AI/ML, Generative AI and Data Analytics
  - Network Systems
  - Cyber Security
- Nexcepta team:
  - Prior leadership positions in Government, Industry, and Academia.
  - > 400 publications in related fields.
  - Participated in related **DARPA SPiNN**, **IARPA SCISRS**, **DARPA TRIAD**, **Army QADE**, **Army Shiftguard**, **Air Force DiffusionRF** programs.
- Have capabilities and interest for **both TA-1 and TA-2.**

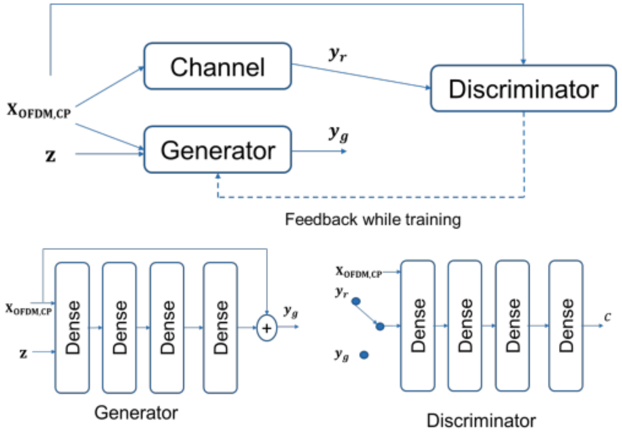
Waveform Generation with Autoencoders

- Designed and implemented novel autoencoder (AE)-based waveforms to improve the performance of both **single-** and **multi-antenna** systems.
  - Communications in **complex channel environments**.
  - Communications with the aid of **reconfigurable intelligent surface** (RIS).
  - Data augmentation using **generative adversarial networks** (GAN).
  - Improved performance in low signal-to-noise ratio (SNR) regime.

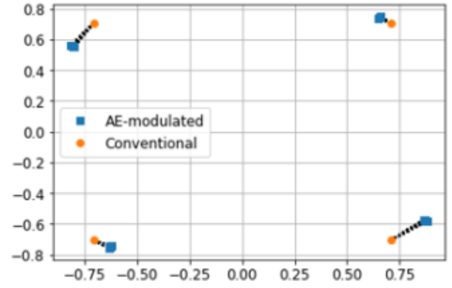
AE-based MIMO Comm. System



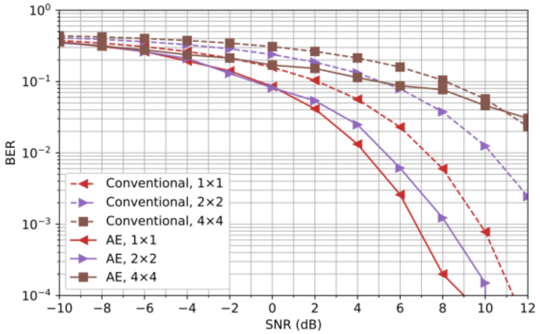
Conditional Wasserstein GAN with gradient penalty loss for synthetic data generation



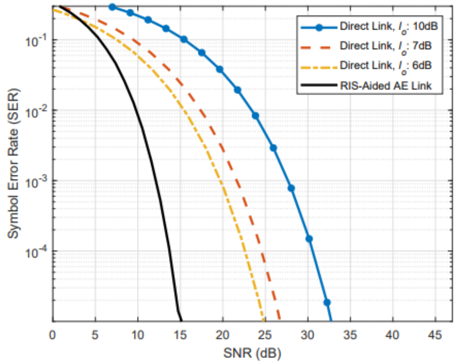
Learned constellation



AE-based vs. Conventional SISO and MIMO system performance

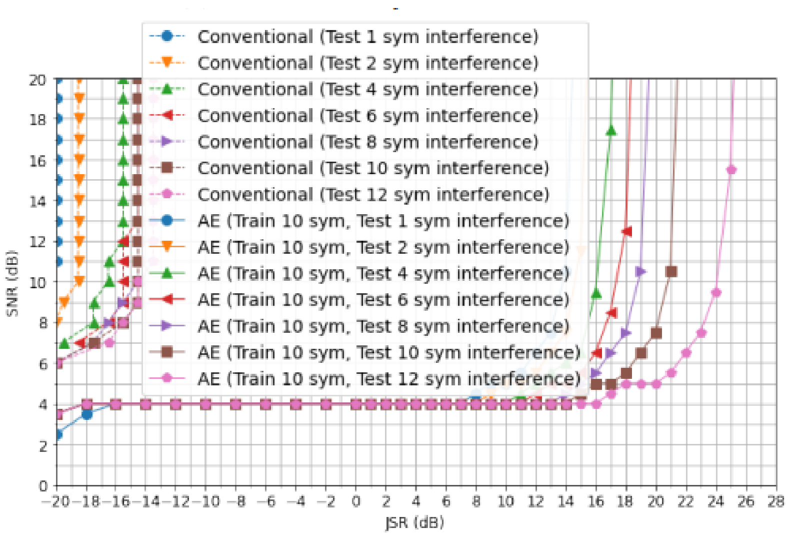


RIS-aided AE link vs. Direct Link performance

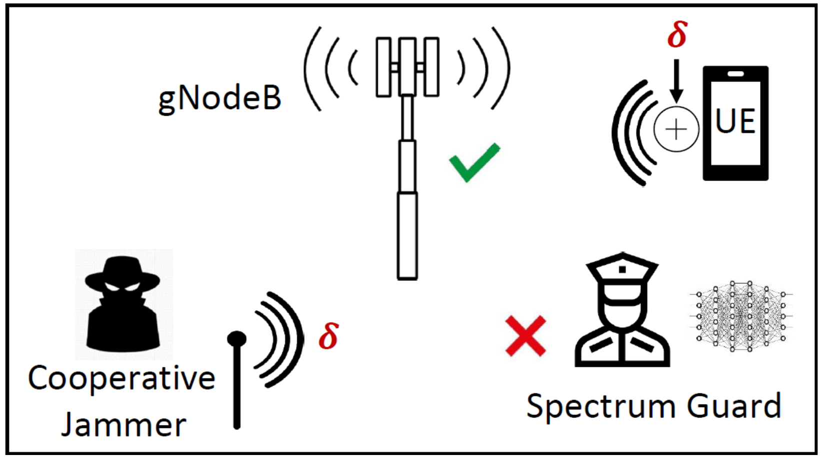


Interference-Resistant and Covert Waveform Generation

- Designed and implemented AE-based communications algorithms in the presence of strong interference.
  - *Interference training* with and without interference.
  - Interference is unknown during test time.
  - Up to 36 dB interference suppression is achieved with interference training and randomized smoothing for AE.



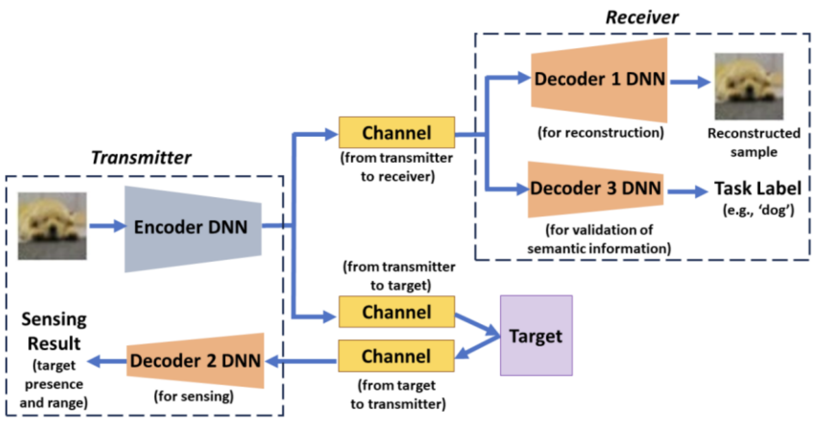
- Designed and implemented AI-based waveforms for covert (LPI/LPD) communications.
  - Adding perturbations to waveforms or GAN-based waveform design.
  - Waveform manipulation at the transmitter or over the air.
  - Fool eavesdroppers while sustaining high communication performance.



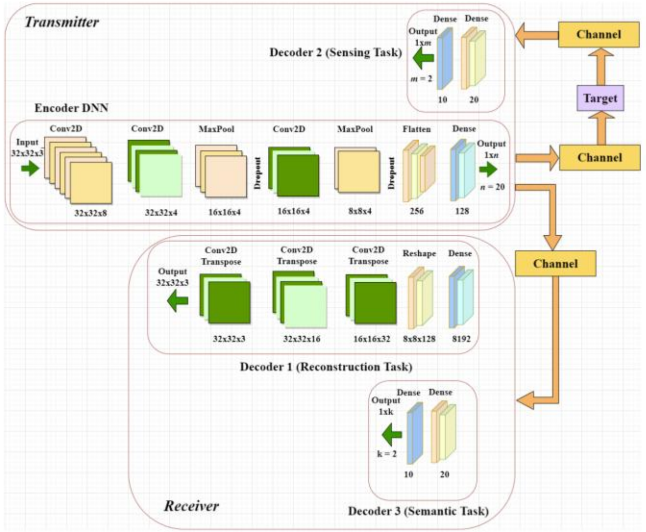
Multi-Task Waveform Learning

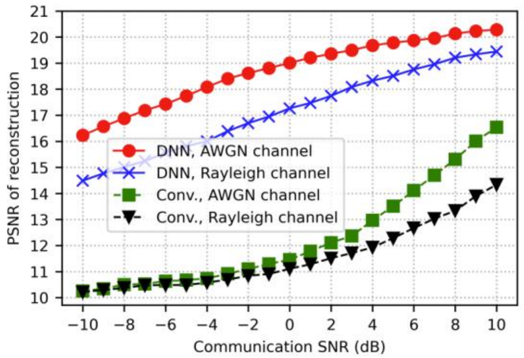
- Deep learning (DL)-based waveform generation to preserve meaning and complete tasks via semantic and task/goal-oriented communications.
- Developed multi-task learning solutions integrate deep learning with integrating sensing and communications (ISAC).
  - Processing multi-modal data (e.g., images and RF signals).

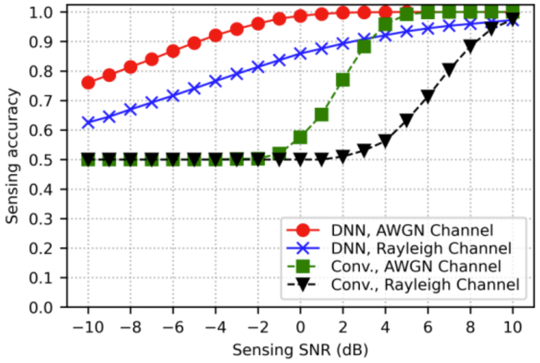
MTL framework for ISAC

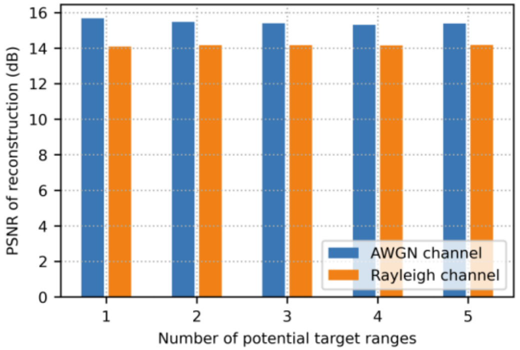


DNN Architectures for the transmitter and receiver









Generative AI for Communication Systems

- GAN for learning waveform channel, and radio effects for signal spoofing.

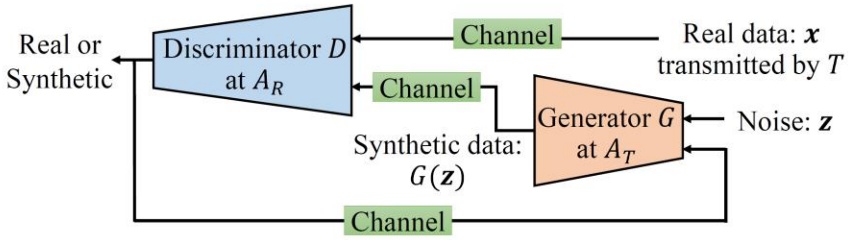


Fig. 1. GAN structure trained for spoofing attack.

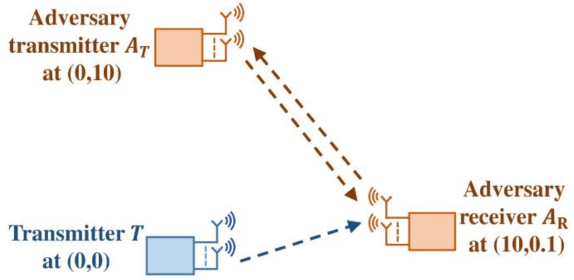


Fig. 2. Network topology during the training process for spoofing attack.

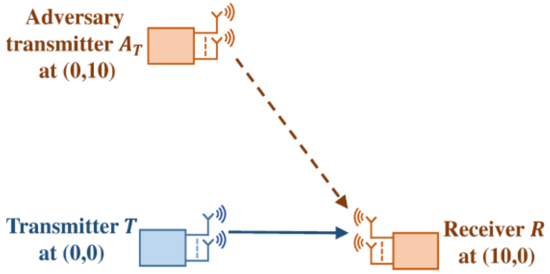
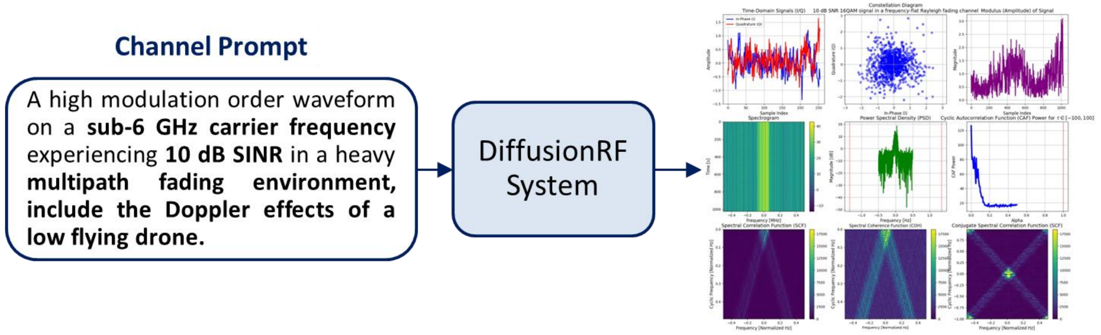
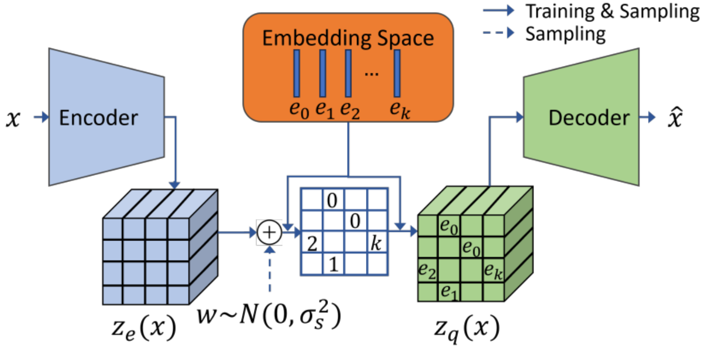


Fig. 3. Network topology during the spoofing attack.

- Diffusion models for text-guided waveform generation



- VQ-VAE-based waveform generation



Full Protocol Stack and SDR Development

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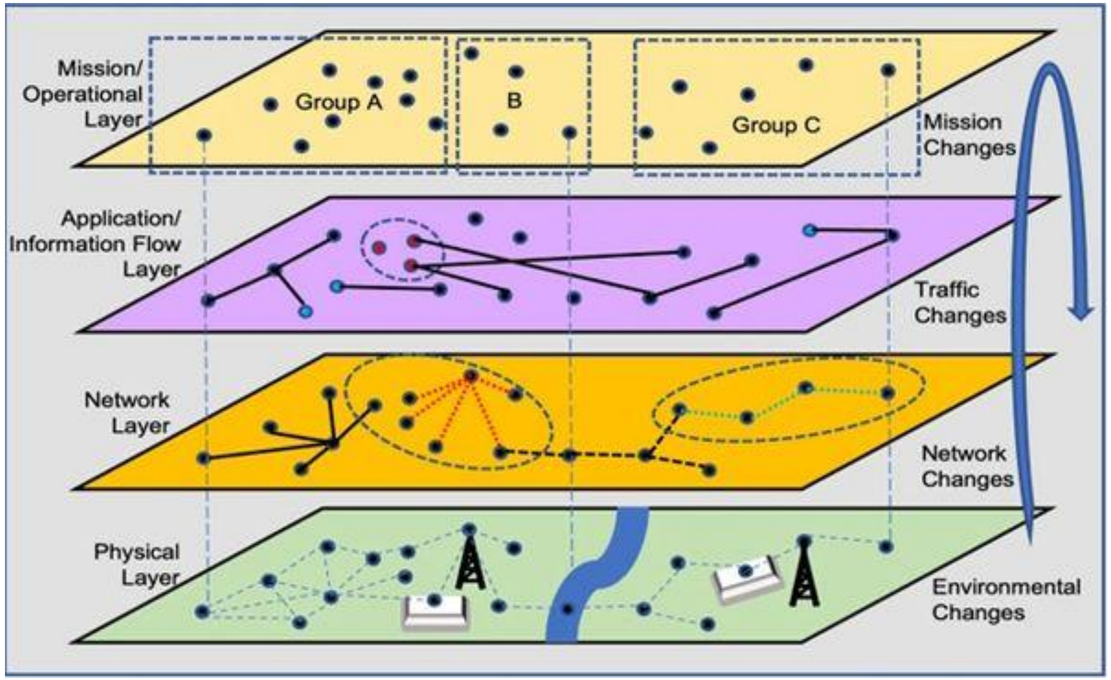
- MAC and network layer algorithm development and implementation using software-defined radios (SDRs).
  - Designed joint PHY, MAC, and network layer solutions.
  - Developed novel solutions for commercial and tactical waveforms.
  - Executed high-fidelity CORE and EMANE for simulation and emulation tests.
  - Implemented AI-based waveform generation on embedded hardware platforms (NVIDIA Jetson Nano, Jetson AGX Xavier GPU and Xilinx Zynq UltraScale+ XCZU9EG FPGA Implementation, etc.)
  - Implemented on both commercial (USRP, HackRF, etc.) and tactical radio platforms.
  - Participated in field test and experimentation campaigns.



Related Publications of Nexcepta

- T. Erpek, Y. Sagduyu, et al, “Deep Learning for Wireless Communications” in Development and Analysis of Deep Learning Architectures, Springer, 2020.
- T. Erpek, Y. Sagduyu, et al, “Autoencoder-based Communications with Reconfigurable Intelligent Surfaces,” IEEE DySPAN, 2021.
- K. Davaslioglu, T. Erpek, and Y. Sagduyu, “End-to-End Autoencoder Communications with Optimized Interference Suppression,” Physical-Layer Security for 6G, Wiley Press, pp. 153-184, 2024.
- Y. Sagduyu, T. Erpek, et al, “Joint Sensing and Semantic Communications with Multi-Task Deep Learning,” IEEE Communications Magazine, 2024.
- Y. Sagduyu, et al, “Low-Latency Task-Oriented Communications with Multi-Round, Multi-Task Deep Learning,” ACM Mobicom Workshop on Machine Learning for NextG Networks, 2024.
- Y. Sagduyu, T. Erpek, et al, "Joint Sensing and Task-Oriented Communications with Image and Wireless Data Modalities for Dynamic Spectrum Access," IEEE DySPAN,2024.
- S. Kompella, K. Davaslioglu, Y. Sagduyu, et al, “Augmenting Training Data With Vector-Quantized Variational Autoencoder for Classifying RF Signals,” IEEE MILCOM, 2024.
- Y. Sagduyu, T. Erpek, et al, “A Unified Solution to Cognitive Radio Programming, Test and Evaluation for Tactical Communications,” IEEE Communications Magazine, 2017.
- T. Erpek, Y. Sagduyu, et al, “Network Control and Rate Optimization for Multiuser MIMO Communications,” Ad Hoc Networks Journal, 2019.
- T. Erpek, K. Davaslioglu, Y. Sagduyu, et al, “QoS and Jamming-Aware Wireless Networking Using Deep Reinforcement Learning,” IEEE MILCOM, 2019.
- Y. Sagduyu, T. Erpek, et al, “Real-Time Experimentation of Deep Learning-based RF Signal Classifier on FPGA,” IEEE DySPAN, 2019.
- K. Davaslioglu, Y. E. Sagduyu, et al, "Generative Adversarial Network in the Air: Deep Adversarial Learning for Wireless Signal Spoofing," IEEE Transactions Cognitive Communications and Networking, 2021.
- Y. E. Sagduyu, et al, “Deep Learning for Signal Classification in Unknown and Dynamic Spectrum Environments,” IEEE DySPAN, 2019.
- Y. Sagduyu,T. Erpek, et al, "Adversarial Machine Learning for NextG Covert Communications using Multiple Antennas," Entropy 2022.
- B. Kim, T. Erpek, Y. E. Sagduyu, and S. Ulukus, "Covert Communications via Adversarial Machine Learning and Reconfigurable Intelligent Surfaces," IEEE WCNC, 2022.
- K. Davaslioglu, Y. Sagduyu, et al, "Machine Learning in NextG Networks via Generative Adversarial Networks," IEEE Transactions on Cognitive Communications and Networking, 2022.
- K. Davaslioglu, Y. E. Sagduyu, et al, “Generative Adversarial Network for Wireless Signal Spoofing,” ACM WiseML, 2019.
- Y. Shi and Y. E. Sagduyu, "Sensing-Throughput Tradeoffs with Generative Adversarial Networks for NextG Spectrum Sharing," IEEE MILCOM, 2022.

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