Ryan Dreifuerst

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https://ryandry1st.github.io/

Education

North Carolina State University GPA: 4.0/4.0 — Raleigh, North Carolina
Ph.D in Electrical Engineering — Jan. 2022 - May 2024
Advisor: Prof. Robert W. Heath Jr.
  Thesis: "Machine Learning-Based Codebook Design for Beam Management"

The University of Texas at Austin GPA: 3.9/4.0 — Austin, Texas
M.S. in Electrical Engineering — Aug. 2019 - Jan. 2022
Advisor: Prof. Robert W. Heath Jr.
  Thesis: "Multi-Resolution Sinusoidal Decomposition and Estimation"

Technische Hochschule Lübeck GPA: 4.0/4.0 — Lübeck, Germany
B.S. in Electrical and Communications Engineering — Sept. 2017 - May 2019

Milwaukee School of Engineering GPA: 4.0/4.0 — Milwaukee, Wisconsin
B.S. in Electrical Engineering — Sept. 2015 - May 2019
Ranking: 1/647

Graduate Courses

Signal processing and machine learning for advanced MIMO systems, Space-time communication theory, Digital communications, Data mining, Statistical machine learning, Probability and stochastic processes, Statistical estimation theory, Autonomous robots, Convex optimization, Wireless communications

Work Experience

Research Intern NVIDIA — *Remote, Germany*

○ **Wireless NeRF** — May. 2023 - Aug. 2023
  - Proposed an integration of light transport and neural rendering for wireless propagation modeling
  - Investigated the sample efficiency and generalizability of a wireless neural radiance field (NeRF)
  - Presented and received first place in the company-wide internship presentations

AI Wireless Research Intern Samsung Research America — *Remote, Dallas*

○ **Extreme MIMO Systems** — May. 2022 - Aug. 2022
  - Designed a system-level simulator for extreme MIMO systems for efficient large scale simulation
  - Evaluated multiple hardware configurations and precoding algorithms for 6G massive MIMO

- Researched the relationship between hybrid architectures, limited feedback, and performance for next generation mobile broadband networks

Modem Systems Intern Qualcomm   *Remote, Boulder*

○ **Uplink Performance Analysis**   June. 2021 - Aug. 2021

- Characterized uplink control information and share channel performance in PUCCH and PUSCH
- Optimized control information performance through LLR rescaling and algorithmic debiasing
- Presented findings in two site-wide presentations to more than 60 stakeholders

Research Assistant Meta   *Remote, Menlo Park*

○ **Intelligent Radio Access Network Algorithms**   June. 2020 - Sept. 2020

- Developed mobile coverage map simulator for open source radio access networks using Quadriga
- Exponentially reduced simulation time for multi-sector networks
- Designed a neural network for predicting live network coverage from limited information

Digital Hardware Design Intern Plexus Corp.   *Neenah, Wisconsin*

○ **MRI communication protocol**   July. 2018 - Sept. 2018

- Designed a communication protocol based on the first four layers of the OSI model
- Constructed data aggregation, packetization and serdes system in Verilog for distributed 2 Gbps MRI data

Digital Hardware Design Intern Plexus Corp.   *Neenah, Wisconsin*

○ **Medical device schematic capture**   June 2017 - Sept. 2017

- Created ISO 13485 certified medical device schematic in Altium
- Led two customer schematic reviews and one internal review

Academic Experience

Graduate Research Assistant   Sponsor: NSF
Supervisor - Prof. Robert W. Heath Jr.   Jan. 2023 - May. 2023

○ **5G CSI in Sub-6GHz**

- Investigated how beamforming and feedback impact 5G performance
- "CSI Type-II Codebook of Codebooks" accepted at IEEE SPAWC 2023
- Submitted "ML Codebook Design for Initial Access and CSI Type-II Feedback in Sub-6GHz 5G NR" to IEEE Trans. Wireless Communications

Graduate Research Assistant   Sponsor: NSF
Supervisor - Prof. Robert W. Heath Jr.   Aug. 2022 - Jan. 2023

○ **Massive MIMO in 5G**

- "SignalNet: A Low Resolution Sinusoid Decomposition and Estimation Network" published in IEEE Trans. Signal Processing

- Submitted "Massive MIMO in 5G: How Beamforming, Codebooks, and Feedback Enable Larger Arrays" to IEEE Communications Magazine

Graduate Research Assistant   Sponsor: Facebook
Supervisor - Prof. Robert W. Heath Jr.   Jan. 2022 - May. 2022

○ **Wideband 5G SSB Beam Management**

- Extended simulations to wideband OFDM settings with realistic 5G resource management
- Demonstrated wireless environment impact on 5G FR1 and FR2 codebook design
- Presented "Massive MIMO Codebook Design in Sub-6 GHz 5G NR" at IEEE VTC 2022

Graduate Research Assistant   Sponsor: Facebook
Supervisor - Prof. Robert W. Heath Jr.   Aug. 2021 - Jan. 2022

○ **ML-assisted SSB Codebook-Based Beam Training**

- Developed a 5G initial access simulator for beam training
- Proposed a neural network for codebook learning using beamspace observations
- "Massive MIMO Codebook Design in Sub-6 GHz 5G NR" accepted at IEEE VTC 2022

Graduate Research Assistant   Sponsor: Facebook
Supervisor - Prof. Robert W. Heath Jr.   Jan. 2021 - May. 2021

○ **Universal Simulation Development Platform**

- Developed a unified platform for simulating wireless networks
- Integrated multiple tiers of statistical, ray-tracing, and geographic simulators
- "Load Balancing and Handover Optimization in Multi-band Networks using Deep Reinforcement learning" accepted at Globecom 2021.

Graduate Research Assistant   Sponsor: Facebook
Supervisor - Prof. Robert W. Heath Jr.   Aug. 2020 - Jan. 2021

○ **Frequency Synchronization in Low-Resolution Millimeter-wave**

- Proposed a deep learning feedback network for generating pilot sequences for CFO estimators
- Developed a jointly optimized neural network for one-bit CFO estimation in multi-tap channels
- Presented at Asilomar Conference on Signals, Systems, and Computers 2020
- "Optimizing Coverage and Capacity in Cellular Networks using Machine Learning" Accepted at ICASSP 2021

Graduate Research Assistant   Sponsor: Samsung
Supervisor - Prof. Robert W. Heath Jr.   Jan. 2020 - May 2020

○ **Low Resolution Sinusoid Detection and Frequency Estimation using Deep Learning**

- End-to-end detection and estimation of sinusoid frequencies from noisy, few-bit samples
- Jointly optimized spectral component detection and estimation
- Proposed hierarchical algorithm utilizing time-frequency representations

Graduate Research Assistant   Sponsor: Samsung

Supervisor - Prof. Robert W. Heath Jr.   Aug. 2019 - Jan. 2020

- **Deep Learning-based Carrier Frequency Offset Estimation with One-Bit ADCs**
  - Low resolution training strategy proposed for single sinusoid frequency estimation from one-bit quantized data
  - Outperforms traditional signal processing techniques with fewer samples, lower signal to noise ratios, and faster execution time
  - Presented at Signal Processing Advances for Wireless Communications Workshop 2020

Undergraduate Tutor

- **Lead Tutor**   Aug. 2016 - May 2019
  - Upper division tutor for courses in DSP, embedded systems, and wireless propagation
  - Oversaw and mentored new electrical engineering tutors

Journal Papers

- **Ryan M. Dreifuerst** and Robert W. Heath Jr., "Neural Codebook Design for MIMO Network Beam Management", *Submitted to IEEE Trans. on Wireless Communications*, Mar. 2024.

- **Ryan M. Dreifuerst** and Robert W. Heath Jr., "Hierarchical ML Codebook Design for Extreme MIMO Beam Management", *Submitted to IEEE Trans. on ML in Commun. and Networking*, Nov. 2023.

- **Ryan M. Dreifuerst** and Robert W. Heath Jr., "Machine Learning Codebook Design for Initial Access and CSI Type-II Feedback in Sub-6GHz 5G NR", *IEEE Trans. on Wirel. Commun.*, Oct. 2023.

- Cleverson Nahum, Victor Hugo Lopes, **Ryan M. Dreifuerst**, Pedro Batista, Ilan Correa, Kleber V. Cardoso, Aldebaro Klautau, and Robert W. Heath Jr., "Intent-based Radio Resource Scheduling in a RAN Slicing Scenario using Reinforcement Learning", *IEEE Trans. on Wirel. Commun.*, 2023.

- Victor Hugo Lopes, Cleverson Nahum, **Ryan M. Dreifuerst**, Aldebaro Klautau, Kleber V. Cardoso, Robert W. Heath Jr., "Deep Reinforcement Learning-Based Scheduling for Multiband Massive MIMO", *IEEE Open Access*, 2022.

- **Ryan M. Dreifuerst** and Robert W. Heath Jr., "SignalNet: A Low Resolution Network for Sinusoid Detection and Estimation", *IEEE Trans. on Signal Process.*, 2022.

Conference Papers

- **Ryan M. Dreifuerst**, I. Kilinc, and R.W. Heath, "Context-aware Codebook Design for 6G Extreme MIMO Systems", *Submitted to IEEE SPAWC 2024*.

- I. Kilinc, **Ryan M. Dreifuerst**, J. Kim, and R.W. Heath, "Beam Training in mmWave Vehicular Systems: Machine Learning for Decoupling Beam Selection", *Submitted to IEEE BlackSeaCom 2024*.

- **Ryan M. Dreifuerst** and R.W. Heath, "CSI Type-II Codebook of Codebooks", *in Proc. of IEEE SPAWC 2023*.

- **Ryan M. Dreifuerst**, Robert W. Heath Jr., and Ali Yazdan, "Massive MIMO Codebook Design in Sub-6 GHz 5G NR", *in Proc. of IEEE Vehicular Technology Conference*, Jan. 2022.

- Manan Gupta, **Ryan M. Dreifuerst**, Ali Yazdan, Po-Han Huang, Sanjay Kasturia, Jeffrey G. Andrews, "Load Balancing and Handover Optimization in Multi-band Networks using Deep Reinforcement Learning", *in Proc. of IEEE Globecom 2021*.

- **Ryan M. Dreifuerst**, S. Daulton, Y. Qian, P. Varkey, M. Balandat, S. Kasturia, A. Tomar, A. Yazdan, V. Ponnampalam, R.W. Heath, "Optimizing Coverage and Capacity in Cellular Networks using Machine Learning", *in Proc. of IEEE ICASSP 2021*.

- **Ryan M. Dreifuerst**, Robert W. Heath Jr., Mandar Kulkarni, and Jianzhong Charlie Zhang, "Frequency Synchronization in Low-Resolution Millimeter-wave", *in Proc. of Asilomar Conference on Signals, Systems, and Computers*, Dec. 2020.

- **Ryan M. Dreifuerst**, A. Graff, C. Unger, Sidharth Kumar, and D. Bray, "End-to-End Radio Fingerprinting with Neural Networks", *Preprint available*.

- **Ryan M. Dreifuerst**, Robert W. Heath Jr., Mandar Kulkarni, and Jianzhong Charlie Zhang, "Deep Learning-based Carrier Frequency Offset Estimation with One-Bit ADCs", *in Proc. of IEEE SPAWC 2020*, Apr. 2020.

Magazine Papers

- **Ryan M. Dreifuerst**, R.W. Heath, "Massive MIMO in 5G: How Beamforming, Codebooks, and Feedback Enable Larger Arrays", *IEEE Communications Magazine*, Aug. 2023.

Projects

- **Wrist Rescue** - wearable fall detection and assistance   Aug. 2018 - May 2019
  - Led a team of four through the product development lifecycle
  - Implemented random forest algorithm on real-time 9 axis sensor data
  - Served as primary data scientist, system programmer, and PCB designer

- **One Shot Whale Fluke Classification**   Nov. 2018 - Jan. 2019
  - Designed a neural network to classify over 5000 different whales by their tails (flukes)
  - Used image augmentation and Siamese networks to achieve over 70% accuracy

- **FPGA Climate Control System**   Oct. 2016 - Jan. 2017
  - Controlled a fan, windows, and VGA output based on environment sensors and user input
  - Implemented on soft core FPGA combining C and VHDL software

Honors and Awards

- Three-year NSF grant investigation on heterogeneous device beam management   Aug. 2022
- Second place Cypress Bluetooth Design Competition   Jul. 2019
- First place Senior Design Competition   Apr. 2019
- Theodore Batterman Foundation Scholar   Oct. 2016-2019

Professional Activities

- IEEE JSAC Reviewer
- IEEE STSP Reviewer x2
- IEEE TMC Reviewer
- IEEE Wirel. Letters Reviewer x2
- IEEE TWC Reviewer x2
- IEEE TV Reviewer x3
- IEEE TCOM Reviewer x5
- IEEE Globecom Reviewer x2
- IEEE Wireless Magazine Reviewer
- IEEE Communications Magazine Reviewer
- Computer Networks Reviewer
- PHYCOM Reviewer
- IEEE VTC Session Chair
- UT SAVES Editor
- Tau Beta Pi Honor Society
- IEEE Eta Kappa Nu Honor Society

- IEEE Communication Society
- IEEE Signal Processing Society
- HAM radio technician class (KD9IGM)

Technical Skills

- **Programming languages:** Python, Matlab, C++, VHDL, Verilog, TCL
- **Frameworks:** Tensorflow, Numpy, Numba, Sci-kit learn, Sionna, Quadriga, PyTorch, Jax
- **Design tools:** Altium, Cadence, Simulink, Quartus, Pspice
- **Hardware Experience:** SDR, embedded linux devices, DSP, FPGA