COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

Paul Gorday

for the degree of Doctor of Philosophy (Ph.D.)

"Machine Learning Demodulator Architectures for Power-Limited Communications"

June 22, 2020, 2 p.m.
Virtual Dissertation

DEPARTMENT:
Computer & Electrical Engineering and Computer Science

ADVISOR:
Nurgun Erdol, Ph.D.

PH.D. SUPERVISORY COMMITTEE:
Nurgun Erdol, Ph.D., Chair
Hanqi Zhuang, Ph.D.
Valentine Aalo, Ph.D.
Xingquan Zhu, Ph.D.

ABSTRACT OF DISSERTATION
Machine Learning Demodulator Architectures for Power-Limited Communications

The success of deep learning has renewed interest in applying neural networks and other machine learning techniques to most fields of data and signal processing, including communications. Advances in architecture and training lead us to consider new modem architectures that allow flexibility in design, continued learning in the field, and improved waveform coding. This dissertation examines neural network architectures and training methods suitable for demodulation in power-limited communication systems, such as those found in wireless sensor networks. Such networks will provide greater connection to the world around us and are expected to contain orders of magnitude more devices than cellular networks. A number of standard and proprietary protocols span this space, with modulations such as frequency-shift-keying (FSK), Gaussian FSK (GFSK), minimum shift keying (MSK), on-off-keying (OOK), and orthogonal M-ary modulation (M-orth). These modulations enable low-cost radio hardware with efficient nonlinear amplification in the transmitter and noncoherent demodulation in the receiver.

The dissertation proposes a novel complex neural network demodulator architecture suitable for such systems. Mathematical derivation of the backpropagation equations for the proposed architecture provide insights into its applicability to either coherent or noncoherent demodulation, and experimental results demonstrate its performance and suitability for a variety of modulation formats. When trained in nominal AWGN channel conditions, the proposed architecture learns comparable, and in some cases better, performance than traditional demodulators. It is also flexible enough to learn improved tolerance to radio or channel impairments that are difficult or intractable to include in mathematical derivations. When combined with a trainable modulator, the proposed demodulator can also learn new, spectrally efficient waveform coding tailored to a specific channel. An added benefit of the proposed architecture is continued learning in the field, and we examine the challenges of incremental learning and identify areas of future research. It is hoped that this work will lead to a future common demodulator architecture that can support the wide range of modulation formats in this space and realize the additional benefits offered by machine learning.

BIOGRAPHICAL SKETCH
Born in Clearwater, Florida
BSEE, University of Florida, Gainesville, FL, 1987
MSEE, University of Florida, Gainesville, FL, 1989
Distinguished Member of the Technical Staff, Motorola (1990-2009)
Co-Founder & Chief Scientist, Sunrise Micro Devices, (2009-2015)
Sr. Principal DSP Architect, ARM Ltd., (2015-2018)

Independent Consultant, Waveform Science LLC (2019-Present)

CONCERNING PERIOD OF PREPARATION
& QUALIFYING EXAMINATION

Time in Preparation: 2016 - 2020

Qualifying Examination Passed: Fall 2016

Published Papers:

P. Gorday, N. Erdol, and H. Zhuang, “Flexible FSK learning demodulators”, IEEE Annual Ubiquitous Computing, Electronics and Mobile Communication Conf., New York, NY, 2018, pp. 633-639.

P. Gorday, N. Erdol, and H. Zhuang, “LMS to deep learning: how DSP analysis adds depth to learning”, IEEE Int. Conf. Acoustics, Speech, and Signal Processing, Brighton, UK, 2019, pp. 7765-7769.

P. Gorday, N. Erdol, and H. Zhuang, “GFSK demodulation using learned sequence correlation”, IEEE 10th Annual Computing and Communication Workshop and Conf., Las Vegas, NV, 2020, pp. 698-704.

P. Gorday, N. Erdol, and H. Zhuang, “Complex-valued neural networks for noncoherent demodulation,” IEEE Open Journal of the Communications Society, vol. 1, pp.217-225, January 2020.