

MUHAMMAD ZULQARNAIN

Signal Processing Researcher

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SUMMARY

I am a Fulbright scholar and a PhD candidate currently enrolled in the Rutgers ECE department, performing research on representation learning, Bayesian sampling and performative prediction in distributed systems, with particular emphasis on high-dimensional streaming data.

EDUCATION

Doctoral | Electrical & Computer Engineering | Rutgers University | GPA : 3.94 Sep 2020 - Present

Advised by: Prof. Waheed U. Bajwa

Major: Signal Processing & Machine Learning

Key Courses Undertaken: Stochastic Optimization, Machine Learning for Engineers, High Dimensional Models in DSP and ML, Detection & Estimation theory, Wireless Communication, Math Analysis, Non-Linear Optimization, Convex Optimization.

Honorary Fellow

Pre-Doctoral Leadership Development Academy | Rutgers University Sep. 2023 - May. 2024

Key Courses: Leadership Higher Education, Higher Education Leadership Special Topics

Master | Electrical Engineering | LUMS, PK | GPA : 3.89 Aug. 2015 - Jul. 2017

Placed on Deans Honor Roll

Major: Communications

Thesis: Investigation of trade-off between coding rate and reliability for low-latency applications using ARQ and Hybrid ARQ mechanisms.

Key Courses Undertaken: Discrete-Time Modem Design for Wireless Communication, Digital Communication, Digital System Design, Advance Digital Signal Processing.

Bachelor | Electrical Engineering | University of the Punjab, PK | GPA : 3.81 Dec 2010 - Feb 2015

Key Courses Undertaken: Digital Signal Processing, Microwave Devices, Calculus, Numerical Analysis, Differential Equations, Probability and Random Processes, Wave Propagation and Antennas, Communication System.

SKILL SETS

Leadership Skill set

- Deep understanding of Leadership issues and challenges, especially in Higher Ed. Attended Pre-Doctoral Leadership Development Academy and SciPhD Leadership and Business Skills for Scientists.
- Team Management skills.
- Organizational skills, managed and organized Signal and Information processing (SIP) seminars at Inspire Lab, Rutgers University (Sept 2021 - May 2023).

Wireless Modem Design

- Three years of experience working with Software-Defined Radios (SDR), USRPs, HackRF-one, and RTL-SDR.
- Deep understanding and Hands-on experience with wireless modem design in discrete-time, GNU-Radio, MATLAB communication toolbox.

Data Analysis and visualization

- 5 years of experience working with Python, and MATLAB.
- Proficient in visualization toolboxes such as Matplotlib.
- Deep understanding of and hands-on experience on real-life datasets including MNIST, CIFAR and ImageNet.

Programming and computing clusters

- Seven years of experience in Python and Matlab.
- Two years of experience in Amarel/AWS (EC2) computing clusters and two year of experience in Orbit testbed.
- Experience in many IDE/APIs such as Pycharm, Virtual Studio, GitHub, and Jupyter Notebook.

General skills

- Equipped with teamwork skills such as critical thinking, problem-solving, collaboration, and leadership.
- Proficient in both English and Mandarin.
- Proficient in LaTeX, Word, Excel, and PowerPoint.

PROFESSIONAL EXPERIENCE

Research Assistant | INSPIRE LAB at Rutgers with Prof. Bajwa

Sep 2020 - Present

- Design and evaluation of distributed and decentralized algorithms for data representation for resource-constrained devices.
- Developed mathematical and statistical analysis skills of algorithm convergence.
- Reviewed papers for Journal of Parallel and Distributed Computing, ICASSP, EUSIPCO, NeurIPS2023 Deep Inverse Workshop.

Lecturer | University of the Punjab, PK | Department of Electrical Engineering

Dec 2018 - Aug 2020

- Served as the instructor of Digital Communication (Spring 2020, Spring 2019), Linear Algebra (Fall 2019) and Numerical Analysis (Spring 2019).
- Incharge of designing and evaluating lab experiments for Digital Communications (Spring 2020 and Spring 2019), and Signals & Systems Lab (Fall 2018).
- Held weekly office hours to ensure students have a good learning experience.
- Graded lab reports, quizzes, homework, and exams in time and proctored several exams.
- Coordinator and academic advisor for the class of 2018, helping students with their academic needs.

Research Assistant | LUMS, PK | Department of Electrical Engineering

Aug 2015 - Nov 2018

- Design of a system for ATC voice relay system using software-defined radio for UAV applications. Sponsored by the National Engineering and Scientific Commission, Pakistan.
- Design of framework and machine learning based system to handle patient cohort for chances of survival prediction in Intensive Care Unit setting using MIMIC dataset.
- Implementation of Direct Sequence Spread Spectrum using RF-NoC on software-defined radio.

Teaching Assistant | LUMS, PK | Department of Electrical Engineering

Jan 2016 - May 2017

- Teaching assistant of the course Digital Signal Processing (Spring 2016 and Spring 2017).
- Design MATLAB based lab experiments. Proctored and graded exams and quizzes.

PROJECTS

Research Projects

ATC Voice Relay System for UAV Applications

Aug 2017 - Nov 2018

Toolset: MATLAB, Vivado, software-defined radios

AdCom Lab at LUMS, PK

Collaborators: National Science and Engineering Commission of Pakistan (NESCOM)

- Conducting research on implementation of direct sequence spread spectrum on FPGA of USRP X310 using RF-NoC.
- Design of wireless system to conduct end-to-end encrypted voice transmission for unmanned aerial vehicle drones.
- Implementation of above system using MATLAB and successfully simulated the system using AES encryption and QPSK as modulation technique.

Code Rate Optimization for Low-Latency Applications

Aug 2015 - Jul 2017

Toolset: MATLAB, Probability theory

AdCOM Lab at LUMS, PK

- Conducting literature review on critical machine type communication (C-MTC) for low latency applications.
- Study the impact of choosing optimal channel coding rate under a finite block length regime for low-latency applications.
- Theoretical bounds for choosing optimal code rate given reliability constraints under ARQ and Hybrid ARQ schemes.
- Evaluating the derived bounds in MATLAB and verifying theoretical results under different SNR regimes.

Selective Course Projects

Estimation of Inverse Covariance Matrix

Jan. 2022 - May 2022

Rutgers ECE department

- Conducted research and theoretical analysis for estimation of inverse covariance matrix in high dimensional probabilistic graphical models.
- Presented the findings to other groups in the class.

Estimation and Detection in a Communication Radio

Jan. 2021 - May 2021

Rutgers ECE department

- Conducted research and explanation on how detection and estimation theoretical tools are useful in designing practical communication radio.
- Presented the findings to other groups in the class.

Resource profiling for 5G using Open Air Interface | Linux, iperf

Sep. 2020 - Dec. 2020

Rutgers ECE department

- Investigate the usage of resources at C-RAN under docker container and using Open Air Interface as a 5G test case.
- Performed experimental evaluation and showcase that TCP communication requires more resource consumption than UDP.

Data transmission over GSM voice call | MATLAB

Jan 2014 - Feb 2015

LUMS, Department of Electrical Engineering

- Design of a wireless discrete modem system to transmit data packets over GSM voice call. This is useful in rural areas, where internet service is not available.
- The proposed proto-type uses Frequency Shift Keying (FSK) and the rate of 307bps was achieved during real-time experimental system using MATLAB.

Final Year Project - Smart Home Automation | C++, C#, MATLAB, Arduino

Jan 2014 - Feb 2015

University of the Punjab, Department of Electrical Engineering

- Design and implementation of policy based smart home automation system.
- The system collects data from various sensors (PIR motion sensor, Temperature, Humidity, LDR) and make decisions for smart home application (controlling HVAC, theft protection) using Arduino as a central controller.
- The system is connected to internet to update the usage logs and enabled with Windows Phone app to allow the user to remotely control the system.

PUBLICATIONS

C-DIEGO: An Algorithm with Near-Optimal Sample Complexity for Distributed, Streaming PCA

Mar 2023

M. Zulqarnain, A. Gang and W. U. Bajwa

57th Annual Conference on Information Sciences and Systems

DOI: 10.1109/CISS56502.2023.10089668

- Part of the first group is to develop algorithm for handling high-dimesnional streaming data in distributed setting.
- Part of the first group is to derive the convergence rate for proposed DIEGO algorithm for PCA using Oja method as a baseline framework. The theoretical result provides finite sample complexity results for estimating top eigenvector in distributed setting.
- The paper proposes a Consensus based method for DIEGO algorithm to estimate the top eigenvector without the aid of central coordinator by allowing nodes to have consensus.
- Delivered lower bound for number of consensus rounds require to achieve the same optimal rate and validate the theory using extensive experimental results using synthetic and real-life dataset such as MNIST.

Recent advancement in smart grid technology: Future prospects in the electrical power network

Mar 2021

O.M. Butt, M.Zulqarnain, T.M. Butt

Ain Shams Engineering Journal

- Comprehensive overview of smart grid technology, covering key features and capabilities.
- Analysis of global smart grid investments and initiatives, highlighting policies and projects.
- Discussion of future research directions in smart grids, including optimization and automation.

ACHIEVEMENTS & CERTIFICATIONS

- Fulbright award for doctoral studies from Rutgers University (Aug 2020- Jul 2025).
- Pre-Doctoral Leadership Development Academy from Office of the Organizational Leadership, Rutgers University (Sept 2023 - May 2024).
- Fulbright virtual English program for graduate studies from Drexel University (Aug 2020).
- Deans Honor Roll for outstanding academic performance at MS EE, Lahore University of Management Sciences (LUMS), Pakistan.
- Merit scholarship for outstanding academic performance at BS EE, University of the Punjab, Pakistan.
- Medal award for outstanding academic performance at B. S.c Electrical Engineering, University of the Punjab, Pakistan.
- Member of IEEE.
- Member of Pakistan Engineering Council: ELECT/47107.
- Training certificate of Harassment Prevention for US Managers and US Employees, Rutgers University (Jul 2024).
- Training certificate of Title IX for Higher Education (Jul 2024).
- Training Certificate of Teaching the Teachers workshop by Prof. Asad Ali. Abidi on *Electronic Circuits for Measurement and Instrumentation* (Aug 2018)
- Training Certificate of Teaching the Teachers workshop by Prof. Asad Ali. Abidi on *Communications System* (Dec 2016)
- Training Certificate of Teaching the Teachers workshop by Prof. Asad Ali. Abidi on *Feedback Control Systems* (Aug 2015)
- Training Certificate on CCNA+HCNA from Corvit Institute, Lahore, Pakistan (Aug 2013)

REFERENCES

- Waheed U. Bajwa
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Relationship: My Ph.D. advisor, the ECE graduate program director, and the co-principal investigator for the RINGS project
- Anand Sarwate, Ph.D.
Associate Professor, Department of Electrical and Computer Engineering
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94 Brett Rd, Piscataway, NJ 08854, USA
Office: EE-215
Phone: (848)-445-2164
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Relationship: Instructor of my course on Detection & Estimation Theory, High Dimensional Probability, and principal investigator for the RINGS project.
- Momin Ayub Uppal, Ph.D.
Associate Professor, Department of Electrical Engineering
Syed Babar Ali School of Science and Engineering,
Lahore University of Management Sciences,
DHA, Lahore Cantt. 54792,
Lahore, Pakistan momin.uppal@lums.edu.pk

Relationship: Served as instructor of my courses during masters in electrical engineering from LUMS, and my MS thesis advisor, and principal investigator of ATC voice relay system for UAV based applications.