ANUJ KESHAVA NAYAK

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As a Ph.D. student, I am exploring the fundamental limits of fault tolerance in quantum computing and storage. My past academic and professional background includes a strong foundation in information theory, applied probability, signal processing, and wireless communications. Recently, I have developed a good understanding of quantum information theory, quantum algorithms, and machine learning.

EDUCATION

University of Illinois, Urbana-Champaign, IL 06/09/2021 - 05/15/2025 (Expected)
PhD in Electrical and Computer Engineering (CGPA: 4.0), Advisor: Dr. Lav Varshney.

North Carolina State University, Raleigh, NC 08/10/2016 - 07/31/2018
M.S. in Electrical Engineering (CGPA: 4.0), Advisor: Dr. Huaiyu Dai.
Defended Thesis on 07/20/2018, Degree conferred on 12/15/2018.

PES Institute of Technology, Bengaluru, India 08/15/2010 - 09/15/2014
B. E. in Electronics and Communication Engineering (CGPA: 8.81/10).

RELEVANT COURSEWORK

@ UIUC: Manipulating Quantum Systems (ECE 498), **Quantum Information Processing Theory** (ECE498), **Quantum Channels** (MA595), Random processes (ECE534), Introduction to Optimization (ECE490), Generative AI Models (ECE 598), Statistical Reinforcement Learning (CS542).

@NCSU: Information Theory (ECE752), Detection and Estimation Theory (ECE751), Probabilistic Graphical Modeling (ECE765), Signal Processing for Communications and Networking (ECE766), Wireless Communications (ECE582).

@PESIT: Linear Algebra (10MA201), Advanced Digital Signal Processing (10EC376).

RESEARCH/ACADEMIC EXPERIENCE

Graduate Research Assistant, University of Illinois, Urbana-Champaign 06/2021 - Present

Theoretical works on quantum information processing:

· Fundamental limits of reliability and storage capacity in **quantum memories** (in progress).
Derived bounds on storage capacity: proved achievability using quantum expander codes, and obtained upper bounds using converse arguments from quantum channel coding theorem.

· Studied the limits of **fault-tolerant quantum computing** (FTQC) for classical problems.
Derived minimum required redundancy for FTQC using one-shot communication bounds.
Proposed provably convergent optimization algorithms to obtain fault-tolerance noise thresholds.

Quantum error correction project:

· Simulation of belief propagation with quantum messages in **Qiskit** (github link).

· Performed Monte-Carlo simulations on HPCs to study the effects of circuit noise on quantum advantage.

Deep learning approach to study the neural correlates of intelligence:

· Trained a graph neural network (GNN) to predict general intelligence using functional MRI scans of 200 brain regions in Pytorch using a small dataset of 271 individuals.

Graduate Research Assistant, NC State University 05/2017 - 08/2018

· Thesis: Information Spreading in Dynamic Networks (link).

· Theoretical study of information spreading in Markovian time-varying graphs.

· Opinion maximization in social networks: proposed 4 algorithms for opinion maximization through smart information spreading. Demonstrated through simulations the better performance of our centralized and Q-learning-based distributed algorithms on both synthetic and real-world graphs (Facebook ego network).

PROFESSIONAL EXPERIENCE

Modem Systems Engineer, Wireless R&D, Qualcomm, San Diego, CA 01/2019 - 05/2021

· 5G-NR Uplink Tx evaluator: phase/frequency offset compensation, PRACH detector and MIMO equalizer.
· SmartTx evaluator in Matlab for maximum permissible radiation exposure control.
· Signal processing lab support to software/test teams for Snapdragon X55 modem bring-up.

Design Engineer (Algorithm), Signalchip Innovations, Bengaluru, India 08/2014 - 06/2016

· LTE and WCDMA Downlink Receiver - Designed fixed point algorithms for cell search, channel equalization, demodulation, and phase/frequency synchronization.
· Large-scale Monte-Carlo simulations using HPCs to ensure compliance with 3GPP specifications.

SELECTED PUBLICATIONS

Link to Google scholar page for the full list of papers: google scholar link.

- "**Reliable Quantum Memories with Unreliable Components**." (work in progress).
- Uthirakalyani. G, Anuj K. Nayak, Chatterjee. A, and Varshney. L. "**Limits of fault tolerance on resource-constrained quantum circuits for classical problems**." Physical Review A, vol. 108, p. 052425, Nov 2023.
- Uthirakalyani. G, Anuj K. Nayak, and Avhishek Chatterjee. "**A Converse for Fault-tolerant Quantum Computation**." Quantum 7 (2023): 1087.
- Anuj K. Nayak, Hosseinalipour, S, and Dai, H. "Smart Information Spreading for Opinion Maximization in Social Networks." IEEE International Conference on Computer Communications (INFOCOM), 2019.
- Anuj K. Nayak, Hosseinalipour. S, Dai. H. "Dynamic Advertising in VANETs using Repeated Auctions." IEEE Global Communications Conference (GLOBECOM) 2017.
- S. Hosseinalipour, Anuj K. Nayak and H. Dai, "Power-Aware Allocation of Graph Jobs in Geo-Distributed Cloud Networks," IEEE Transactions on Parallel and Distributed Systems, April 2020.

COURSE PROJECTS, TRAININGS AND CERTIFICATIONS

- **Quantum GANs** - simulated effects of noise and circuit depth on its performance in **Qiskit** (github).
- Stochastic Blockmodels for Time-Evolving Social Networks - simulated a Kalman filter-based model of time-evolving network on real networks (Enron network, MIT reality mining dataset) in Matlab.
- **US Quantum Information Science Summer School**, Fermilab, Batavia, IL (05/08/2023 to 15/08/2023).
- Illinois Quantum Applications Program (01/2023 to 05/2023).
- **EdX: Quantum Computing for Everyone I and II** (Certificate: link).
- Coursera: **Deep Learning Specialization** (5 courses, Certificate: link).
- Undergraduate Thesis, PES Institute of Technology: Speaker detection of 28 individuals using linear predictive coding and mel-frequency cepstral coefficients as features, classified using decision trees, fuzzy clustering, and Gaussian Mixture Model (EM algorithm) in **Matlab**. (01/2014 to 05/2014)
- Undergraduate Research Internship, Michigan State University: Implemented an adaptive notch filter in FPGA to reduce power-line interference affecting GMR sensor measurement. (05/2014 to 08/2014)

CODING SKILLS

Proficient: Python, Qiskit, PyTorch, Matlab, Version control (github and SVN).
Intermediate: C, C++.

AWARDS AND FELLOWSHIPS

- Qualstar award, Qualcomm, San Diego, CA.
- ECE Department Merit Fellowship, North Carolina State University.
- Prof. MRD Merit Scholarship, PES Institute of Technology.