Mohsen Moradi

Email: m.moradi@northeastern.edu
Phone: 575-650-5532
Website: moradi-coding.github.io/
LinkedIn: linkedin.com/in/moradi-coding
Google Scholar: scholar.google.com

Research Interests

Wireless Communications, Error Correcting Codes, Signal Processing, Quantum Error Correction, Information Theory, Machine Learning, Deep Learning, Network communication, Cryptography, Linear Systems, Reinforcement Learning

Education

Bilkent University Ankara, Turkey
Ph.D. in Electrical and Electronics Engineering (Coding Theory), 2017–2022

- Thesis: "**Performance and Computational Analysis of Polarization-Adjusted Convolutional (PAC) Codes**"
- Advisor: Prof. **Erdal Arıkan**: 2019 Claude E. Shannon Award winner and 2018 IEEE Richard W. Hamming medal recipient, father of polar codes.

Tehran Polytechnic (Amirkabir University of Technology) Tehran, Iran
M.S. in Coding Theory, 2011–2013

- Thesis: "Construction of Polar Codes for Capacity-Achieving of Channel"
- Advisor: Dr. **Mohammad-Reza (Rafsanjani) Sadeghi**.

Experience

- **Information Theory:** Serves as the foundational framework for the majority of my research and projects. I have derived fundamental results relating tree-search decoding algorithms for polar-like codes to channel parameters such as capacity, cutoff rate, and varentropy. These insights have significantly reduced decoding complexity and latency, with direct implications for real-time communication systems.
- **Quantum Error Correction:** Implemented quantum LDPC codes and designed a reinforcement learning–enhanced belief propagation (BP) decoder to address the challenges posed by short cycles. I have also studied topological surface codes and generalized stabilizer codes to deepen my understanding of fault-tolerant quantum computing.
- **Error-Correcting Codes (Coding Theory):** Extensive experience with polar codes, LDPC codes, Reed–Solomon codes, and other classical block and convolutional codes. I have published multiple papers that advance the theoretical and practical aspects of these codes, focusing on improving error correction capability, reducing decoding complexity, and minimizing latency. Notably, I have developed constant-complexity polar code decoders that approach theoretical limits at short blocklength regimes.
- **Machine Learning for Communications:** Explored both deep learning and reinforcement learning in the context of communications. I have published a novel reinforcement learning-based decoder for polar codes, leveraging LDPC-inspired BP dynamics, achieving up to 1 dB gain over conventional BP. Additional works include optimization-driven code construction under theoretical constraints based on cutoff rate polarization. Also done research by integrating information-theoretic principles into AI.
- **Cryptography and Post-Quantum Security:** Developed a secret sharing scheme based on channel coding principles. During my M.Sc., I studied lattice-based cryptography. I have recently gotten interested in post-quantum cryptography, where my background in algebraic coding theory can be instrumental in analyzing and constructing secure schemes.

- **Algorithms and Data Structures:** Completed advanced algorithms coursework during my Ph.D. and pursued many online specializations. In my research, I have implemented and developed a variety of tree-search algorithms and designed tailored data structures for efficient execution in constrained environments.
- **Communication Network Analysis:** Completed graduate-level coursework on queueing theory and network. Designed simulation projects demonstrating superior latency and throughput performance compared to state-of-the-art models. Areas of focus was scheduling, load balancing, and congestion control.
- **Wireless Communications:** Hands-on experience with fading and multipath channel modeling, modulation and demodulation techniques (e.g., QAM, OFDM), and multiple access schemes (e.g., TDMA, OFDMA, NOMA). Developed simulation and analysis pipelines for MIMO systems and spectrum sharing scenarios. Worked on physical-layer enhancements using learning-based beamforming and channel estimation techniques.
- **Data Compression and Source Coding:** Studied a wide range of source coding techniques with a focus on low-complexity, near-capacity compression schemes. I have conducted research on LDPC codes for data compression and implemented projects using Polar codes and PAC (Polarization-Adjusted Convolutional) codes for lossy and lossless compression. These works explore the use of source polarization, entropy alignment, and capacity-achieving transforms for efficient encoding of correlated and memoryless sources. My expertise includes understanding the rate-distortion trade-offs and designing encoders that approach theoretical bounds.
- **Signal Processing:** With a strong mathematical foundation, I am deeply engaged in signal processing, both theoretically and practically. I have played a key instructional role in university-level signal processing courses, including leading labs, guiding student projects, and delivering select lectures. Much like information theory, I view signal processing as a core enabler for modern data science and machine learning—especially in areas such as feature extraction, time-frequency analysis, and real-time system design.

PostDoc Experience

Northeastern University - Electrical and Computer Engineering Boston, US
Post Doctoral Research Associate 2024 (March) – Current

- Topic:
  - **High Rate Channel Coding (Fair-Density Parity-Check Codes, PAC Codes, LDPC Codes)**
  - **Quantum Error Correction**
- Advisor: Prof. **Hessam Mahdavifar**

New Mexico State University - Electrical and Computer Engineering Las Cruces, US
Post Doctoral Research Associate 2023 (March) – 2024 (Feb)

- Topic:
  - **Data Compression and Channel Coding**
  - **Enhancing Belief Propagation Decoding of Polar Codes: A Reinforcement Learning Approach**
  - **A Reinforcement Learning Approach for Decoding Quantum LDPC Codes (currently in progress)**
- Advisor: Prof. **David G. M. Mitchell**

Bilkent University - Electrical and Electronics Engineering Ankara, Turkey
Post Doctoral Research Associate 2022–2023

- Topic:
  - **Massive Access Solutions for Next Generation Wireless Communication Systems**
  - **Iterative Decoding for PAC Codes**
- Advisor: Prof. **Tolga M. Duman**

Publications

Dissertation

1. Dissertation. (2022). **Performance and Computational Analysis of Polarization-Adjusted Convolutional (PAC) Codes.**

Journal

2. Mohsen Moradi, Sheida Rabeti, and Hessam Mahdavifar. (2025). "**On the High-Rate FDPC Codes: Construction, Encoding, and a Generalization**", Submitted to IEEE Communications Letters. Available on arXiv preprint https://arxiv.org/abs/2506.11345.

3. Mohsen Moradi, Salman Habib, and David G. M. Mitchell. (2024). "**Enhancing Belief Propagation Decoding of Polar Codes: A Reinforcement Learning Approach**", IEEE Communications Letters (DOI 10.1109/LCOMM.2025.3559466)

4. Moradi, M., Mozammel, A.(2025). **A Monte-Carlo Based Construction of Polarization-Adjusted Convolutional (PAC) Codes.** Physical Communication (https://doi.org/10.1016/j.phycom.2024.102578).

5. Moradi, Mohsen and Hessam Mahdavifar. (2024). "**PAC codes with Bounded-Complexity Sequential Decoding: Pareto Distribution and Code Design**", Submitted Journal: IEEE Transactions on Information Theory

6. Moradi, Mohsen and Hessam Mahdavifar. (2024). "**On Fast SC-based Polar Decoders: Metric Polarization and a Pruning Technique**", Submitted Journal: IEEE Transactions on Communications

7. Moradi, Mohsen and Mozammel Amir.(2023). "**A Tree Pruning Technique for Decoding Complexity Reduction of Polar Codes and PAC Codes.**" IEEE Transactions on Communications (DOI 10.1109/TCOMM.2023.3255254)

8. Moradi, Mohsen. (2023). "**Application of Guessing to Sequential Decoding of Polarization-Adjusted Convolutional (PAC) Codes.**" IEEE Transactions on Communications (DOI 10.1109/TCOMM.2023.3280548)

9. Moradi, Mohsen. (2023). "**Polarization-Adjusted Convolutional (PAC) Codes as a Concatenation of Inner Cyclic and Outer Polar- and Reed-Muller-like Codes.**" Finite Fields and Their Applications 93 (2024): 102321.

10. Moradi, Mohsen. (2021). "**On Sequential Decoding Metric Function of Polarization-Adjusted Convolutional (PAC) Codes.**" IEEE Transactions on Communications (DOI 10.1109/TCOMM.2021.3111018)

11. Moradi, M., Mozammel, A., Qin, K., and Arikan, E. (2020). **Performance and Complexity of Sequential Decoding of PAC Codes**. arXiv preprint arXiv:2012.04990.

12. Moradi, M. and Sadeghi, M.R. (2017). **Combining and Steganography of 3-D Face Textures**. Journal of Electrical and Computer Engineering Innovations (JECEI)

Conference

13. Mohsen Moradi, and Hessam Mahdavifar. (2025). "**PAC Codes With Bounded-Complexity Sequential Decoding: Pareto Distribution and Code Design**", Accepted ISIT 2025 Conference.

14. Mohsen Moradi, and Hessam Mahdavifar. (2025). "**On Fast SC-Based Polar Decoders: Metric Polarization and a Pruning Technique**", Accepted ISIT 2025 Conference.

15. Sheida Rabeti, Mohsen Moradi, and Hessam Mahdavifar. (2025). "**Bounds and New Constructions for Girth-Constrained Regular Bipartite Graphs**", Accepted ISIT 2025 Conference. Available on arXiv preprint https://arxiv.org/abs/2506.11268

16. Moradi, Mohsen and David G. M. Mitchell. (2024). "**PAC Code Rate-Profile Design Using Search-Constrained Optimization Algorithms.**", ISIT 2024 (DOI: 10.1109/ISIT57864.2024.10619683)

17. Moradi, M., Mozammel, A.(2022). **Concatenated Reed-Solomon and Polarization-Adjusted Convolutional (PAC) Codes**. 2022 IEEE International Black Sea Conference on Communications and Networking (BlackSeaCom)

18. Moradi, Mohsen. (2022). **Bit-Flipping for Stack Decoding of Polarization-Adjusted Convolutional (PAC) Codes.** 2022 Tenth International Workshop on Signal Design and its Applications in Communications (IWSDA). IEEE, 2022.

19. Moradi, M. (2017). Training Neural Networks Based on Imperialist Competitive Algorithm for Predicting Earthquake Intensity. International Conference on the New Horizons in the Basic and Technical Sciences and Engineering

Posters

20. Mohsen Moradi, Hessam Mahdavifar. (Summer 2025). LiteFEC. Center for Ubiquitous Connectivity (CUbiC) under the JUMP 2.0 program.

21. Mohsen Moradi, Salman Habib, and David G. M. Mitchell. (2025). Learning Sequential BP Decoding of Short Blocklength Codes for URLLC. NSF project meeting held at Qualcomm.

22. Mohsen Moradi, Hessam Mahdavifar. (Summer 2024). LiteFEC. Center for Ubiquitous Connectivity (CUbiC) under the JUMP 2.0 program.

23. Mohsen Moradi, and David G. M. Mitchell. (2023). PAC Code Rate-Profile Design Using Search-Constrained Optimization Algorithms. 2023 North American School of Information Theory (NASIT).

Invited Talks

- Munich Workshop on Shannon Coding Techniques to present our invited talk "Learning Sequential BP Decoding of Short Blocklength Codes" (co-authored with Salman Habib and David Mitchell)
- Theme 1 Liaison Meeting Spring 2025 (April 2) "Lightweight Forward Error Correction (LiteFEC): New Codes and Decoding Algorithms" (joint talk with Hessam Mahdavifar)

Programming languages and skills

- **Programming Languages:** MATLAB, C++, C, Python
- **Deep Learning and Machine Learning Frameworks:** TensorFlow, PyTorch, Keras
- **Libraries & Tools:** NumPy, Pandas, Scikit-learn, linear regression, logistic regression, decision trees, random forests, K-means, hierarchical clustering, dimensionality reduction (PCA, t-SNE), CNN, RNN, optimization algorithms like gradient descent, stochastic gradient descent (SGD), Adam, RMSProp, and their variants.
- **Other Topics:** Computer Science, Data Analysis, Data Science, Digital Transformation, Algorithm, Signal Processing, Telecommunications, Cryptography, Linear Systems, Linear Algebra, Optimization, Communication Network Analysis.

Reviewer for

- IEEE Transactions on Communications
- IEEE Transactions on Vehicular Technology
- IEEE Transactions on Information Theory
- IEEE Journal on Selected Areas in Information Theory
- IEEE Communications Letters
- IEEE Wireless Communications Letters
- Electronics Journal
- IEEE Global Communications Conference
- IEEE International Symposium on Information Theory (ISIT)
- IEEE International Conference on Communications (ICC)
- IEEE Wireless Communications and Networking Conference (WCNC)
- IEEE 2022 14th International Conference on Wireless Communications and Signal Processing (WCSP 2022)
- IEEE 2023 International Symposium on Topics in Coding (ISTC 2023)
- Journal of Electrical and Computer Engineering Innovations (JECEI)

Teaching and Teaching Assistantship

- Probability and Statistics (Lecturer: Prof. Erdal Arıkan) 10 Semesters
- Introduction to Data Science 1 Semester
- Control and Optimization of Stochastic Systems 1 Semester
- Signals and Systems 2 Semesters
- Engineering Mathematics 2 Semesters

Courses

Ph.D. : Detection and Estimation Theory, Digital Communications Theory, Linear System Theory, Communication Network Analysis, Random Processes, Wireless Communications, Information Theory, Algorithms II, Algorithms I, Introduction to Robotics.
Ph.D. Qualification Exam: Engineering Mathematics I, Engineering Mathematics, Probability and Statistics, Circuit Theory, Electronic Circuit Design, Signals and Systems, Feedback Control Systems, Engineering Electromagnetics.
M.S. : Special Topics (Topics in Decoding Algorithms Implementation), Special Topics (Advanced Coding Theory), Coding Theory, Applied Algebra (Information Theory), Special Topics (Coding Theory and Applications of Algebraic Geometry), Advanced Algebra, Real Analysis I, Seminar, Geometry of Manifolds I, Machine Learning, Deep Learning.
Online Courses and Bootcamps: Optimization Problems and Algorithms, MATLAB Parallel Programming on GPUs, Cores and CPUs, Introduction to Genetic Algorithms: Theory and Applications, Practical AI with Python and Reinforcement Learning, Python for Data Science and Machine Learning Bootcamp Machine Learning Specialization (3 courses), Deep Learning Specialization (5 courses), Complete Tensorflow 2 and Keras Deep Learning Bootcamp, Machine Learning, Data Science and Deep Learning with Python.