Anthony Polloreno, Ph.D.

Ph.D. Machine Learning & Physics, CU Boulder
B.A. Computer Science, Math, Physics, UC Berkeley

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Software and data engineer with over a decade of hands-on experience in software development, data analysis, and system optimization across industry, academia and government.

Technical Expertise and Tools

Development Languages & Frameworks: Python, Julia, C++, Lisp, Java, SQL, Mathematica, Scikit-Learn, NumPy, PyTorch, Jax, SQLAlchemy; distributed computing with Slurm and MPI; optimization with scipy and CVXOPT; and big data frameworks including Hadoop.

Database & Storage Technologies: HDFS, PostgreSQL and Redis.

Data Pipeline & Workflow Management: Luigi and carrot.

High-Performance Computing Using: OpenMP and AWS

Visualization & Reporting Tools: Matplotlib and Seaborn.

Code Versioning & Collaborative Tools: Git, GitHub, GitLab, Bitbucket, JIRA and Confluence.

Work and Research Experience

2023 — Machine Learning Researcher at JILA

Noise-Resilient Data Architectures in Deep Learning Systems

Developed robust data infrastructures for analyzing the impact of stochastic disturbances on the efficacy of reservoir computing models, focusing on Echo State Networks (ESNs) for high-stakes time series analysis. Engineered and implemented distributed data processing workflows to facilitate the evaluation of ESN configurations under Gaussian noise. Conducted sophisticated data analytics leading to new insights on signal noise scalability, thereby solidifying the viability of ESNs in noisy data environments. Enhanced machine learning operations via Python programming, leveraging the Jax library, and executed resource-intensive computations on parallelized AWS EC2 instances equipped with V100 tensor core GPUs to ensure computational efficiency and reduced model training periods. Extended foundational theoretical concepts for reservoir computing limitations and probed their integrative use with reinforcement learning paradigms.

2021 - 2023 — Statistical Analysis Intern at Sandia National Laboratories

Quantum Error Characterization and Prediction

Pioneered a breakthrough data engineering methodology to extend the characterization capacity of quantum computing systems, increasing qubit analysis throughput by 10x and achieving operational speeds 100x faster than existing methods. Provided a detailed predictive model for quantum circuit operations through advanced statistical analysis. Uncovered and quantified discrepancies in error rates, pinpointing that logical operation discrepancies are significantly more impactful, prompting strategic data-driven enhancements. Designed and maintained robust data pipelines for the capture, transformation, and efficient storage of quantum state information, employing best practices for data hygiene and integrity. Employed data visualization tools to communicate complex error characterization findings to interdisciplinary teams, enhancing strategic decision-making based on data-driven insights. Authored internal reports and documentation on data engineering processes.

2019 - 2021 — Optimization Graduate Researcher at JILA and University of Colorado, Boulder

Scalability and Optimization in Quantum Information Processes

Applied multi-node programming and SLURM workload management to develop data-intensive solutions for scaling quantum computations in Penning trap systems, significantly exceeding current qubit processing capabilities by an order of magnitude. Utilized parallel computing and high-performance computing clusters to manage and process large volumes of data, ensuring timely insights and scalability. For the optimization of the $p = 1$ QAOA process, utilized evolutionary strategies and simulated annealing, achieving a computational speed increase by 10000x, which facilitated rapid optimization in a neutral atom quantum computer environment. Advanced the field of broadband sensing with data-centric optimization algorithms, enhancing axion detection rates by 10x or greater.

2019 — Data Engineering Consultant at Ψ-inf

Data Analysis and Storage for Scientific Experiments

Developed tools for storing, structuring and retrieving data from various experiments (Python/SQLAlchemy). Migrated data to backwards compatible Postgres database and collaborated with in-house scientists to automate data storage and retrieval. Improved engineer analysis productivity 2x with structured data logging and retrieval.

2016 - 2019 — Full Stack Software Engineer at Rigetti Computing

Control Software, Data Analysis, Data Storage and Tooling

Implemented a novel machine learning algorithm using implicit kernels on the quantum processor, improving the error rate by .7% over a baseline of a linear classifier on the MNIST data set. Developed internal experimental pipeline for serializing large experimental data sets, queuing advanced statistical analyses and managing data storage and faults. Primary maintainer and developer of control software suite for experiments and largest internal repository, reviewing and merging 100s of pull requests. Refactored routines used in automated device calibration using a Python DSL for expressing pulse sequences, increasing engineering development speed by more than 2x. Implemented matched filtering of RF signals (C++) to reduce data transfer overhead by more than 10x during experiments. Refactored a statistical analysis technique (randomized benchmarking) into a server (Lisp) to speed up experiment generation time by more than 10x.

2015 - 2016 | Optimization Student Intern at Sandia National Laboratories

Control Theory and Convex Optimization

Used optimal control theory to robustly reduce errors on quantum logical gates by more than an order of magnitude, both in simulation and experiment with real hardware at Rigetti Computing. By formulating the problem as an instance of convex optimization, I demonstrated a reduction of the number of required FPGA controls by 90%, improved the simulability of the controls by 10x, and showed a 5x increase in gate performance over 87.5% of feasible operating parameter values. Generated controls by linearizing the problem, averaging over trajectories with Gaussian quadrature and using gradient descent.

2014 - 2015 | Student Intern at Lawrence Berkeley National Laboratory

Generation of Reflection Zone Plates for Lithography

Engineered a Python and MATLAB software solution to create reflection zone plates, by generating a specialized data format for lithography on a Heidelberg machine. This effort involved devising elliptical pattern designs, capable of enabling two-dimensional focusing using a singular reflective mirror, enhancing the efficiency of beamline optics.

Publications

1. Anthony M. Polloreno. Limits to reservoir learning. *arXiv preprint arXiv:2307.14474*, 2023
2. Anthony M. Polloreno et al. The impact of markovian errors on random circuits. *in progress*, 2023
3. Anthony M. Polloreno et al. A theory of direct randomized benchmarking. *arXiv preprint arXiv:2302.13853*, 2023
4. Anthony M. Polloreno et al. A note on noisy reservoir computation. *arXiv preprint arXiv:2302.10862*, 2023
5. Anthony M. Polloreno et al. Opportunities and limitations in broadband sensing. *Physical Review Applied*, 19(1), January 2023
6. Anthony M. Polloreno et al. The qaoa with few measurements. *arXiv preprint arXiv:2205.06845*, 2022
7. Ariel Shlosberg et al. Towards demonstrating fault tolerance in small circuits using bacon-shor codes. *arXiv:2108.02079*, 2021
8. Anthony M. Polloreno et al. Individual qubit addressing of rotating ion crystals in a penning trap. *Physical Review Research*, 4(3), July 2022
9. Anthony M. Polloreno et al. Robustly decorrelating errors with mixed quantum gates. *Quantum Science and Technology*, 2021
10. Sabrina S. Hong et al. Demonstration of a parametrically activated entangling gate protected from flux noise. *Physical Review A*, 101(1), January 2020
11. C. M. Wilson et al. Quantum kitchen sinks: An algorithm for machine learning on near-term quantum computers. *arXiv:1806.08321*, 2018
12. S. A. Caldwell et al. Parametrically activated entangling gates using transmon qubits. *Physical Review Applied*, 10(3), September 2018
13. Matthew Reagor et al. Demonstration of universal parametric entangling gates on a multi-qubit lattice. *Science Advances*, 4(2):eaao3603, February 2018

Patents

1. Michael Justin Gerchick Scheer et al. Modular quantum processor architectures, November 4 2021. US Patent App. 17/119,089
2. Alexander Papageorge et al. Operating a quantum processor having a three-dimensional device topology. Library Catalog: Google Patents