Joseph Li

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Office: ATL 3258 in QuICS Suite

I am a graduate student in computer science at the University of Maryland and the Joint Center for Quantum Information and Computer Science (QuICS). I am fortunate to be advised by Professor Xiaodi Wu.

I am broadly interested in quantum information from the computer science perspective, and my main research interest is the design and resource-efficient implementation of quantum algorithms on near- and intermediate-term devices. In particular, my goal is to develop methods that enable practical implementations of Hamiltonian-based quantum algorithms (e.g. for quantum simulation, differential equations, etc.) for both digital and analog devices.

Education

January 2022 - Present
University of Maryland, College Park - *Ph.D. student in Computer Science*
August 2018 - December 2021
University of Maryland, College Park - *B.S. in Mathematics, B.S. in Computer Science, Physics Minor*

Research

- Quantum Hamiltonian Descent. Jiaqi Leng, Ethan Hickman, Joseph Li, and Xiaodi Wu. Manuscript, 2023. (Website, arXiv)
  - We propose a Hamiltonian-based quantum algorithm for continuous optimization and develop benchmarks for its performance on 2D nonconvex objective functions. In addition, we develop an analog implementation using the quantum Ising model and experimentally benchmark its performance for quadratic programming up to dimension 75 on the D-Wave annealing QPU.
- Expanding hardware-efficiently manipulable Hilbert space by Hamiltonian embedding. Jiaqi Leng*, Joseph Li*, Yuxiang Peng, and Xiaodi Wu. Manuscript, 2024. (arXiv, poster, APS March Meeting slides)
  - We develop a unifying framework for embedding a target problem Hamiltonian into the larger embedding Hamiltonians, enabling more efficient manipulation and implementability on real devices. We perform a systematic resource analysis showing significantly reduced gate counts for a variety of applications. In addition, we perform experimental demonstrations of quantum walks on graphs, spatial search, and the real-space Schrödinger equation on the IonQ ion trap and QuEra neutral atom devices.

Work Experience

February 2022 - Present
University of Maryland - Graduate research assistant

February 2019 - May 2021
University of Maryland - Grader for various undergraduate math courses

- MATH310 Introduction to Mathematical Proof (Fall 2019)
- MATH402 Algebraic Structures (Fall 2020)
- STAT410 Introduction to Probability Theory (Spring 2019, Spring 2020, Spring 2021)

February 2019 - December 2019
University of Maryland - Undergraduate Research Assistant
FIRE: The First-Year Innovation & Research Experience
Engineering Biosensors Lab Research Advisor: Dr. Catherine Spirito

- Constructed a chemostat to test microcompartment formation in pdu *E. coli* in continuous culture
- Assisted in the development of an aptamer-based biosensor for detection of *E. coli* in water samples using gold nanoparticles
- Developed professional lab procedures and reports for operation of chemostat

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Skills · Tools · Miscellaneous

- General purpose programming languages: C/C++, Python, MATLAB, Java, HTML, JavaScript, Ruby
- Parallel processing software: MPI, OpenMP, Eigen
- Optimization software: CPLEX, Gurobi
- Participated in 2021 ICPC Quantum Computing Challenge - 79th best score of 246 participants
- Occasional contributor to open-source software, usually related to quantum information (e.g. toqito)

Graduate Coursework

- CMSC754 Computational Geometry with Prof. Dave Mount — Fall 2023
- CMSC858V Quantum Control & Metrology with Prof. Murphy Niu — Fall 2023
- CMSC858C Randomized Algorithms with Prof. Aravind Srinivasan — Spring 2023
- CMSC858L Quantum Complexity with Prof. Daniel Gottesman — Spring 2023
- CMSC660 Scientific Computing I with Prof. Howard Elman — Fall 2022
- CMSC858O End-to-End Quantum Applications with Prof. Xiaodi Wu — Fall 2022
- CMSC764 Advanced Numerical Optimization with Prof. Tom Goldstein — Spring 2022
- CMSC828L Deep Learning with Prof. David Jacobs — Spring 2022
- BMGT830 Linear Programming with Prof. Raghu Raghavan — Autumn 2021
- STAT650 Applied Stochastic Processes with Prof. Eric Slud — Spring 2020

Academic Service

- Reviewer for NeurIPS, ICML, ICLR (2023, 2024)

Older Personal and Course Projects

- Developed a simulation that approximates the distribution for the number of matches of 3 or more orbs in a line in any $m \times n$ board, inspired by the mobile game *Puzzle and Dragons*. Designed a dynamic programming algorithm to count matches in $O(mn)$ time. Computed combinatorially the exact distribution for a 2×2 board with matches of 2 orbs in a line and verified correctness using simulation.
  https://jli0108.github.io/old-site/pad_simulation/
- Implementation of Gale-Shapley algorithm for stable matching in Ruby
  https://github.com/jli0108/gale-shapley
- Undergraduate course projects and assignments covering various topics (can be made available upon request)
  - Object-oriented programming (Java)
  - Systems programming (C, MIPS assembly)
  - Regular expressions, finite automata, lexical analysis (OCaml)
  - Signal processing transforms, including DFT, FFT, Haar wavelet (MATLAB)
  - Machine learning algorithms, including decision trees, perceptron, gradient descent, etc. (Python)
  - Data structures, including AVL trees, AA trees, k-d trees (Java)
  - Simulation of Hadamard walk with Qiskit (Python)
  - Diamond-square algorithm, Loop subdivision algorithm, shader programming (Java, GLSL)
- Implementation of simplex algorithm for linear programs in Python
  https://github.com/jli0108/simplex