Zhaohui Yang

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Education

Department of Electronic and Computer Engineering, HKUST — **Hong Kong**
Ph.D. student in Electronic and Computer Engineering *(Advisor: Dr. Yuan Xie)* — *Sep 2024 – 2026 (expected)*

Department of Computer Science, UC Santa Barbara — **Santa Barbara, CA, US**
Ph.D. student in Computer Science *(Advisor: Dr. Yuan Xie)* — *Sep 2022 – Jun 2024*

Department of Electrical and Computer Engineering, The University of Arizona — **Tucson, AZ, US**
M.S. in Electrical and Computer Engineering *(Advisor: Dr. Zheshen Zhang)* — *Aug 2021 – May 2022*

Department of Modern Physics, University of Science and Technology of China — **Hefei, Anhui, China**
B.S. in Physics — *Sep 2017 – Jun 2021*
B.E. in Computer Science — *Sep 2017 – Jun 2021*

Skills

Language: C/C++, Python, R, Rust, Java, JavaScript
Framework: PyTorch, MLIR/LLVM, CUDA, MPI/OpenMP
Web/App: Qt, AJAX, Django/FastAPI, Postgres/MySQL
Other: Verilog, Mathematica, PyG/DGL, Qiskit/QuTiP

Publications & Patents

Zhaohui Yang, Chaohan Cui. *Reconfigurable Quantum Internet Service Provider*. IEEE ICC, 2023.

Yongzhou Xue, Michael Titze, John Mack, **Zhaohui Yang**, Liang Zhang, Shei S. Su, Zheshen Zhang, Linran Fan. *Selective Generation of V2 Silicon Vacancy Centers in 4H-Silicon Carbide*. Nano Letters, 2024.

Zhaohui Yang, David Ding, Qi Ye, Cupjin Huang, Jianxin Chen, Yuan Xie. *Reconfigurable Quantum Instruction Set Computers: Toward Ultimate Performance with Realization Feasibility. (under review)*

Zhaohui Yang, David Ding, Chenghong Zhu, Jianxin Chen, Yuan Xie. *Phoenix: Pauli-based High-level Optimization Engine for Instruction Execution on NISQ Devices. ACM/IEEE Design Automation Conference (DAC), 2025.*

Zhaohui Yang, Jian Singh, Dawei Ding, Yuan Xie. *A Highly-effective Quantum Program Compilation Framework Targeting* $\mathrm{SU}(4)$ *Gate Set*. APS March Meeting 2025.

Work Experiences

Research Internship
DAMO Academy, Alibaba Group, Hangzhou, China — *Jul 2023 – Sep 2023*

- Join the theory team of this quantum laboratory, harnessing systems methodologies to contribute to development of dedicated fault-tolerant quantum computer systems, particularly qubit control systems and decoding modules.
- Analyze the feasibility and required hardware resources for implementing distributed quantum error correction Union-Find decoding algorithms on FPGA by emulation in Python. Also, develop a GPU-version distributed Union-Find decoding algorithm, which shows less latency than monolithic CPU decoding in large-scale decoding scenarios.
- Develop the universal qubit routing module (leveraging the SABRE algorithm) to map logical circuits onto physical devices, building on Alibaba quantum computing compilation suite that is based on MLIR/QCOR.

Web Development Internship
Authentic8 Inc., Redwood City, CA — *Jun 2022 – Aug 2022*

- Assist in work of backend web architecture migration, from Python 2.7 to Python 3.10, from Django to FastAPI/Pydantic in Docker container. *(Python/FastAPI, PostgreSQL, JsonRPC, Docker)*
- Refactor FastAPI view functions about users' data logging and querying with complete test suits, i.e., Test-Driven Development; Refactor projects with Python Async/Await primitives; Assist project deployment with Docker.

Research Internship

Baidu Research, Baidu Inc., Beijing, China *Apr 2021 – Aug 2021*

- Focus on algorithm development on quantum noise mitigation research in the Baidu Quantum AI team.
- Develop the Zero-Noise Extrapolation (ZNE) Error-Mitigation module building on Quanlse (pulse-control part of Baidu Quantum Platform) and circuit-level ZNE module in Quantum Leaf (cloud environment of BQP).
- Co-initiate the Quantum Error Processing (QEP) project, a universal Python SDK, for software-level quantum error characterization and mitigation (e.g., gate noise, measurement noise, tomography, randomized benchmarking).
- Co-propose and verify a new pulse-level ZNE schema, with a patent output.

Recent Projects

VQA Application-Specific Compiler based on BSF and Clifford Formalism *Feb 2024 – Sep 2024*

- Developed a high-level Pauli-based IR compilation framework for Hamiltonian simulation programs, outperforming SOTA VQA compilers across various programs, ISAs, and hardware topologies.
- Utilized the binary symplectic form (BSF) to represent Pauli strings and reformulated IR synthesis as column weight reduction through Clifford transformations.
- Designed a heuristic BSF simplification algorithm that sequentially applies 2Q Clifford operators to simplify the BSF until it can be synthesized with basic 1Q and 2Q gates.
- Designed a Tetris-like IR group ordering strategy to optimize gate cancellation, circuit depth, and qubit routing.

A Compilation Framework for $\mathrm{SU}(4)$-based Quantum ISA *Otc 2023 – Jun 2024*

- Demonstrated that various quantum hardware platforms can be transformed into "Reconfigurable Quantum Instruction Set Computers" (ReQISC), challenging conventional CNOT/CZ-based quantum ISAs. Key contributions are the series of compilation passes tailored to $\mathrm{SU}(4)$ primitives, achieving optimal circuit execution performance.
- The comprehensive compilation workflow features two program-aware synthesis passes for high-level IRs, a radical program-agnostic circuit-level optimization pass, and a $\mathrm{SU}(4)$-aware qubit routing pass.
- Experimental results show the ReQISC compiler outperforms state-of-the-art compilers (Qiskit, TKet, BQSKit) in reducing 2Q gate count, circuit depth, qubit mapping overhead and fidelity losses, while maintaining low calibration and routing overhead with scalable performance.

Continuous-Variable Quantum Normalizing Flow *Feb 2023 – Dec 2024*

- Anticipate a quantum-version normalizing flow model (a comparable generative model in contrast to GAN or AutoEncoder) building on photonic quantum computing instead of the qubit model, cause the former shows advantages in representing continuous-variable data and natural linear/nonlinear transformation primitives.
- Leverage the recent continuous-variable quantum machine learning framework to design such an invertible QML generative model, including data encoding/decoding, variable transformation and training/generating procedures.
- It is anticipated to be executed on real photonic quantum computers and now has been verified feasible by emulating on our implemented symplectic neural network by PyTorch. Still on evaluating and further numeric simulating.

A Hybrid Fault-Tolerant Quantum Computing Architecture Design-Space Exploration *Aug 2022 – Dec 2022*

- Explored hybrid Fault-Tolerant Quantum Computing (FTQC) architectures under the Partial Quantum Error Correction (PQEC) scheme, where logical and bare qubits coexist as a transitional approach from NISQ to FTQC.
- In ISA design, conceive efficient physical-logical qubit interaction primitives and select convenient physical-physical and logical-logical ISAs. In microarchitecture design, perform the two-level architecture design exploration: 1) Adapting existing QEC block design to PQEC architecture; 2) configuration of PQEC components.
- Focused on planar and repetition codes, creating PQEC ISAs, code templates, and communication paradigms to support versatile qubit interactions (logical-logical, bare-bare, logical-bare) using techniques like ancilla factories, lattice surgery, teleportation, and partial fault-tolerance.
- Proposed modular layouts and compiler-driven configuration strategies for basic code blocks (communication/computation-intensive) and high-level code patterns, enabling scalable PQEC architecture and compilation strategies.

Architecture Design, Implementation and Evaluation on Local Quantum Networks *Sep 2021 – May 2022*

- As a core student member of Center for Quantum Networks, NSF Engineering Research Center (CQN-ERC), in charge of software architecture design and development, device design and experimental testing.

- Propose a reconfigurable Quantum Internet Service Provider prototype and perform implementation in the form of a universal Web operation software named *quagent* (Quantum Agent), for application of local quantum networks. It provides PaaS service for multiple users to perform customized experiments. Integrated functionalities consist of Single-Photon Detectors & Entangled-Photon Sources routing, multi-user linkage switching & data acquisition, etc., deployed and tested on the local fiber-based quantum network at UArizona campus. *(Python/Django, JavaScript/AJAX/ECharts)*
- Design and implement an SDK named *odmactor* (ODMR Actor) including pulse-sequence scheduling algorithms and soft-hardware interfaces for solid-state quantum (spin) systems detecting & manipulation. Then develop a user-friendly Desktop operation software building on this SDK and Qt library.

Molecular Properties Prediction Based on Graph Neural Networks (Graduation Thesis) *Dec 2020 – Mar 2021*

- Propose and implement the Deep Molecular Graph Convolutional Network (DMGCN), efficiently modeling the topological & spatial information and atomic interaction of chemical molecules on QM9 dataset, which requires less computational resources while models more reasonably in comparison with SOTA models.
- In addition to implementing this algorithm building on PyTorch and DGL, I attempted to integrate this into the high-level graph machine learning library DIG as well as construct an end-to-end GUI molecular prediction system.

QECCs for Correlated Phase-Flip Error in Spin Systems (Graduation Thesis) *Apr 2020 – Jun 2021*

- Propose a formulated quantum channel to describe the correlated decoherence scenario of multiple qubits suffering from a common fluctuator, verified by both analytical calculation and numeric simulation. *(Mathematica, QuTiP)*
- Design and validate corresponding Approximate Quantum Error Correction channels via Semi-definite Programming.
- Calibrate two-quit and three-qubit Hardware-Efficient QECCs against this decoherence scenario according to practical systems and sample parameters. Design the QEC scheduling process of the overall experimental scheme.

Representative Open-source Projects

unisys *(Python)* An SDK for unitary circuit synthesis, composed of universal quantum gate decomposition, state preparation, qubit mapping, and circuit partitioning algorithms. It has convenient interfaces with Qiskit, Cirq, and TKet.

regulus *(Python)* A highly-effective compiler for ReQISC (Reconfigurable Quantum Instructions Set Computers) tailored to SU(4) ISA. This is a companion repo of a project and is based on unisys.

phoenix *(Python)* A highly-effective VQA (variational quantum algorithm) application-specifc compiler based on BSF (binary symplectic form) of Pauli exponentiations and Clifford formalism.

cvqnf *(Python, PyTorch)* Continuous-variable quantum normalizing flow targeting photonic quantum computers.

netics *(Python, DGL)* Algorithmic decoding for repetition codes and surface codes, highlighted with implementation of distribution Union-Find decoder on CPU and GPU.

odmactor *(Python)* An SDK and its GUI implementation for quantum experiments automation, involving universal scheduling algorithms for Optically Detected Magnetic Resonance (ODMR) experiments and spin manipulation (e.g., Ramsey detection, Rabi oscillation, T1 relaxation measurement, Hahn echo sequence, High-order dynamical decoupling), deployed in Quantum Engineering Lab at UMich (previously at UArizona).

quagent *(Python, Django, JavaScript, AJAX)* A web-based operations software as a reconfigurable framework for local quantum internet service providers, applied in the Tucson Testbed of the NSF Center for Quantum Networks.

dmgcn *(Python, DGL, PyG)* Deep molecular graph convolutional network, with innovative interplaying topological convolutional layers and spatial convolutional layers, implemented through both DGL and PyG.

sslinker *(Python, LIEF)* Simple static linker that links object files into executable files on x86 Linux.

qep *(Python)* A circuit-level quantum error processing toolkit developed by Baidu's quantum AI team, involving quantum error characterization / tomography and mitigation as well as randomized benchmarking methods.

Selected Awards

NSF Student Travel Grant, 2023 IEEE International Conference on Communications *Jun 2023*

Undergraduate Science & Technology Innovation Training Program, Outstanding Award, USTC *May 2021*

Outstanding Student Scholarship, Silver Award, USTC *Oct 2019*

Chung-Yao Chao Talent Program in Applied Physics Scholarship, USTC *Sep 2019*

The 10th Chinese Mathematics Competitions, Preliminary contest, First Prize, Chinese Mathematical Society *Oct 2018*

Outstanding Student Scholarship, Silver Award, USTC *Oct 2018*

Cyrus Tang Scholarship, USTC *May 2018*