How I became a Qiskit Advocate

2022/11/24@Quantum Tokyo

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@Sitong Liu

Liu Sitong

劉　思桐

ABOUT ME

- 慶應義塾大学大学院
  政策･メディア研究科　２年
  先進的 量子アーキテクチャ 研究グループ
- 慶應義塾大学
  環境情報学部　卒業
- **Research Interest:**
  Quantum Computing
  - Quantum Error Correction
  - Quantum compiling
  - Quantum Machine Learning
- Taiyuan (China) ✈️ Kanagawa (Japan)

Twitter: @Sitong25847384

The Beginning of The Story

Me

Professor Rodney Van Meter

I joined *Advancing Quantum Architecture Research Group* at Keio University SFC in 2018.

Advancing Quantum Architecture

専門分野：量子計算、ムーアの法則後のコンピュータ・アーキテクチャ、ディストリビューテド・マス・ストレージ・システム

My Experiences in Quantum Computing

Qiskit Camp Asia 2019
Nov 2019

Conference Paper (co-author)
Dec 2020

IBM Quantum Challenge 2021
May 2021

Bachelor Thesis
Jun, 2021

IBM Quantum Community Advocate Intern
Jul 2021

IBM Quantum Research Student Intern
May 2022

(co-author)
Jun 2020

Became Qiskit Advocate🎉
July 2022

Degree
Oct, 2022

Generating Arbitrary Logical Quantum Graph States with *Lattice Surgery*

Quantum Error Correction

Why I Want to Become a Qiskit Advocate

- Cause I am a Qiskit native! (In quantum computing)
- The people in the Qiskit community

How I Became a Qiskit Advocate (~~or Got 20 points~~)

Research Paper/ Academic projects using Qiskit:

- Research paper “The Present and Future of Discrete Logarithm Problems on Noisy Quantum Computers”
- Quantum machine learning project using Qiskit for my bachelor thesis

Participation of IBM Quantum / Qiskit events

- Qiskit Camp Asia 2019 Honorable Mention
- IBM Quantum Challenge (s)

Contribution to Qiskit community

- Worked as IBM Quantum Community Advocate Intern to develop the IBM Quantum challenge 2021 Fall
- Blog posts I wrote as IBM Quantum Community Advocate Intern
- Qiskit localization

Tier 1—My first (formal) Qiskit event

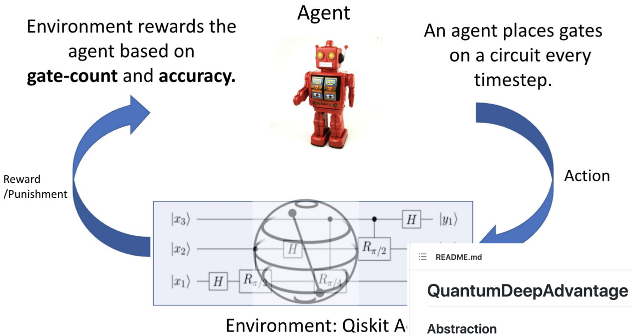
Qiskit Camp Asia 2019

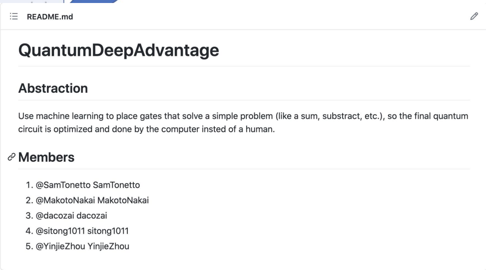
Honorable Mention

Project: Quantum Deep Advantage

Github:

https://github.com/dacozai/QuantumDeepAdvantage




README.md

QuantumDeepAdvantage

Abstraction

Use machine learning to place gates that solve a simple problem (like a sum, substract, etc.), so the final quantum circuit is optimized and done by the computer insted of a human.

Members

1. @SamTonetto SamTonetto
2. @MakotoNakai MakotoNakai
3. @dacozai dacozai
4. @sitong1011 sitong1011
5. @YinjieZhou YinjieZhou

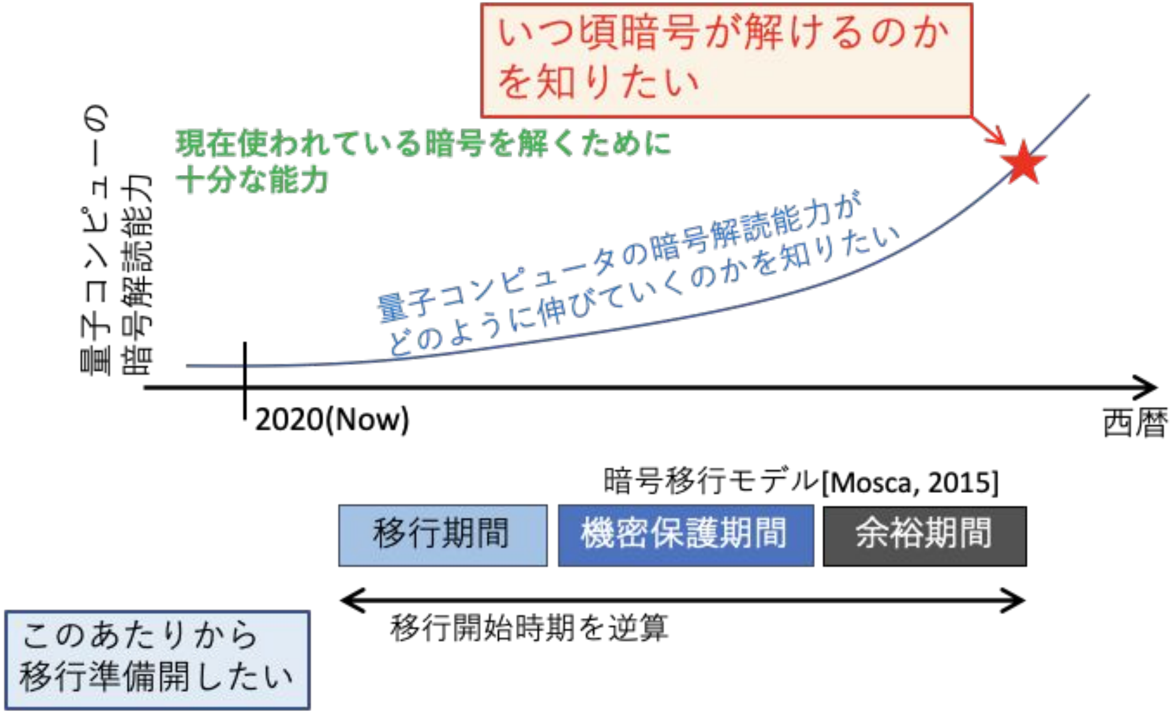
Tier 1—Research Paper (as co-author):

The present and future of discrete logarithm problems on noisy quantum computers

Yoshinori Aono, **Sitong Liu**, Tomoki Tanaka, Shumpei Uno, Rodney Van Meter, Naoyuki Shinohara, and Ryo Nojima.
IEEE Transactions on Quantum Engineering, 3:1–21, 2022.

Abstract

Motivation: Investigating how resilient the classical cryptography algorithms are against quantum computers.
暗号の量子コンピュータに対する安全性評価に向けた問題点の洗い出し



Contributions

- A quantitative measure based on the success probability of the post-processing algorithm to determine whether an experiment on a quantum device (or a classical simulator) succeeded.
- A procedure to modify bit strings observed from a Shor's circuit to increase the success probability of a lattice-based post-processing algorithm.
- A near-term prediction based on required noise levels to solve some selected small DLP and integer factoring instances.

Result:
Part of the 2-bit DLP can be seen as being able to solved by Shor's algorithm.

Tier 1—Contribution to Qiskit Community

Developed the IBM Quantum Challenge 2021 Fall as IBM Quantum Community Advocate Intern

Tier 1—IBM Quantum Challenge Fall 2021

IBM Quantum Challenge Fall 2021

Challenge 4: Battery revenue optimization

We recommend that you switch to **light** workspace theme under the Account menu in the upper right corner for optimal experience.

Introduction to QAOA

When it comes to optimization problems, a well-known algorithm for finding approximate solutions to combinatorial-optimization problems is **QAOA (Quantum approximate optimization algorithm)**. You may have already used it once in the finance exercise of Challenge-1, but still don't know what it is. In this challlenge we will further learn about QAOA----how does it work? Why we need it?

First off, what is QAOA? Simply put, QAOA is a classical-quantum hybrid algorithm that combines a parametrized quantum circuit known as ansatz, and a classical part to optimize those circuits proposed by Farhi, Goldstone, and Gutmann (2014)[1].

It is a variational algorithm that uses a unitary $U(\boldsymbol{\beta}, \boldsymbol{\gamma})$ characterized by the parameters $(\boldsymbol{\beta}, \boldsymbol{\gamma})$ to prepare a quantum state $|\psi(\boldsymbol{\beta}, \boldsymbol{\gamma})\rangle$. The goal of the algorithm is to find optimal parameters $(\boldsymbol{\beta}_{opt}, \boldsymbol{\gamma}_{opt})$ such that the quantum state $|\psi(\boldsymbol{\beta}_{opt}, \boldsymbol{\gamma}_{opt})\rangle$ encodes the solution to the problem.

The unitary $U(\boldsymbol{\beta}, \boldsymbol{\gamma})$ has a specific form and is composed of two unitaries $U(\boldsymbol{\beta}) = e^{-i\boldsymbol{\beta} H_B}$ and $U(\boldsymbol{\gamma}) = e^{-i\boldsymbol{\gamma} H_P}$ where H_B is the mixing Hamiltonian and H_P is the problem Hamiltonian. Such a choice of unitary drives its inspiration from a related scheme called quantum annealing.

The state is prepared by applying these unitaries as alternating blocks of the two unitaries applied p times such that

$$|\psi(\boldsymbol{\beta}, \boldsymbol{\gamma})\rangle = \underbrace{U(\boldsymbol{\beta})U(\boldsymbol{\gamma})\cdots U(\boldsymbol{\beta})U(\boldsymbol{\gamma})}_{p \text{ times}}|\psi_0\rangle$$

Challenge 4: Battery revenue optimization
with Bo Yangさん, Hyungseok Changさん, and Kifumi Numataさん

Tier 3—Blog Posts I wrote for IBM Quantum Challenge

Liu Sitong

Oct 25, 2021 · 3 min read · Listen

Why Should Beginner in Quantum Programming Participate in IBM Quantum Challenge Fall 2021 — My Story

In 2019, I have participated in my first IBM Quantum Community Event, 2019 Qiskit Camp Asia. At that time, I was literately a quantum rookie — the first time I learned about quantum computing was in the spring semester of 2019 when I joined the Advancing Quantum Architecture Research Group at Keio University SFC as a freshman. Before that, I was just a student who is interested in programming and machine learning and didn't know a word about quantum computer; and it is also the first Hackathon I participated in.

I thought it would be a hard time for me, but the truth is I really enjoyed the event. Not only because of what I have learned from the Hackathon, but also the connection with others: t 51 have been involved in a

Tier 3—Qiskit Documentation Translation

Export

劉思桐 liusitong

Translator

Chinese Simplified

Translator

$ 0.00

Translated Words	5417
Approved Words	0
Translated by MT, words	357
Target Language Words	8268
TM Savings	
Pre-translated Words	0

Internship Project（おまけ）

Development and implementation of frequency-aware qubit layout algorithm

2022 Summer @IBM

Background

Goal: Advancing *Qiskit transpiler passes* for *large scale* quantum devices: What happens in the next few years when quantum devices have more that 1000 qubits?

— Reducing qubit frequency collisions through designing optimal layout

More qubits, more qubit frequency collisions?

What is frequency collision?

Frequency collision, also known as "frequency crowding", occurs due to the unwanted degeneracy of qubits, which leads to the degradation of control fidelity for native gates in a given architecture.

Types of frequency collisions:

- Hertzberg, J.B., Zhang, E.J., Rosenblatt, S. *et al.* Laser-annealing Josephson junctions for yielding scaled-up superconducting quantum processors. *npj Quantum Inf* **7**, 129 (2021). https://doi.org/10.1038/s41534-021-00464-5

Type	Definition	Participants	Bounds
1	$f_{j,01} = f_{k,01}$	Nearest-neighbor qubits Q_j, Q_k	± 17 MHz
2	$f_{j,02} = 2f_{k,01}$	Control qubit Q_j, target qubit Q_k	± 4 MHz
3	$f_{j,01} = f_{k,12}$	Nearest-neighbor qubits Q_j, Q_k	± 30 MHz
4	$f_{k,01} < f_{j,12}$ or $f_{j,01} < f_{k,01}$	Control qubit Q_j, target qubit Q_k	—
5	$f_{i,01} = f_{k,01}$	Q_j is control to Q_i and/or Q_k & is nearest-neighbor to both.	± 17 MHz
6	$f_{i,01} = f_{k,12}$ or $f_{i,12} = f_{k,01}$	Q_j is control to Q_i and/or Q_k & is nearest-neighbor to both.	± 25 MHz
7	$f_{j,02} = f_{k,01} + f_{i,01}$	Q_j is control to Q_i and/or Q_k & is nearest-neighbor to both.	± 17 MHz

$f_{qubit,\ ij}$: Degeneracies among the |0>→|1>, |1>→|2> and |0>→|1> transitions, where i, j = 0,1,2

Pull Request to Qiskit (Work in Progress)

Add frequency collision-aware layout passes #8621

New issue

Draft **sitong1011** wants to merge 2 commits into `Qiskit:main` from `sitong1011:vf2post-freq`

Conversation 4 | Commits 2 | Checks 7 | Files changed 1 | +350 −0

sitong1011 commented on Aug 26

Summary

Add three transpiler pass to detect and minimizes the use of layouts that are subject to frequency collision, which impairs the gate fidelity [1]. Two parts are included:

1. An analysis pass for detecting frequency collision based on the calibrations data provided by backends and the types of frequency collisions in the research paper "Laser-annealing Josephson junctions for yielding scaled-up superconducting quantum processors" [1].
2. VF2LayoutFreqAware and VF2PostLayoutFreqAware pass based on the existing layout passes to find a better layout with the awareness of the frequency collisions (To be done).

[1] Hertzberg, J.B., Zhang, E.J., Rosenblatt, S. et al. Laser-annealing Josephson junctions for yielding scaled-up superconducting quantum processors. npj Quantum Inf 7, 129 (2021). https://doi.org/10.1038/s41534-021-00464-5

TODOs:

- [ ] Add VF2LayoutFreqAware pass
- [ ] Add VF2PostLayoutFreqAware pass
- [ ] Add tests
- [ ] Improve docs

Reviewers

terra-core

At least 1 approving review is required to merge this pull request.

Assignees

No one assigned

Labels

Community PR

Projects

None yet

Milestone

No milestone

Development

Preparation for Qiskit Developer Certification

- Chapter 1-2 of Qiskit Textbook
  https://qiskit.org/textbook/preface.html
- Daikiさんのサンプル問題解説と準備すべきことの解説
  https://www.investor-daiki.com/it/qiskit-exam-commentary
  https://www.investor-daiki.com/it/preparation_qiskit-advocate
- Guide to a Quantum Computing Certification
  http://www.primaryobjects.com/2021/09/15/the-ultimate-guide-to-a-quantum-computing-certification-with-qiskit/
- Slide by javafxpert
  https://slides.com/javafxpert/prep-qiskit-dev-cert-exam#/18
- Mitsunori Nakamotoさんの受験記録
  https://qiita.com/32nakamoto/items/5c598afd302241381f7e

May 11th — **Scheduled the exam**

May 30th — **Started prepare for the exam**

June 5th — **Exam Date**

June 30th — **Application deadline**

Tips for Becoming a Qiskit Advocate

1. Actively participate in Qiskit/IBM quantum events
2. Contribution to Qiskit
3. Research experience (Optional)