

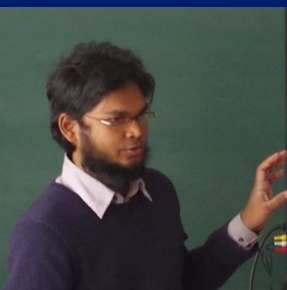
Qiskit Mentorship Program Checkpoint

Advanced Quantum Monte Carlo Simulation

github: <https://github.com/qiskit-community/qiskit-advocate-mentorship-program/issues/31>



---Mentee---
Yuma Nakamura
IBM Japan, Data Scientist



---Mentee---
Md Maruf Hossain
IBM Japan, Data Scientist



===Mentor===
Amira Abbas
IBM South Africa, Researcher

10am GMT, Thu, April 1st

Project Overview

Research Outline

- Apply Quantum Monte Carlo (QMC) with multiple-option pricing

“Option Pricing using Quantum Computers”

→ Tutorial available:

https://qiskit.org/documentation/tutorials/finance/06_basket_option_pricing.html

- Understand and reproduce newly proposed QMC

“Reduction of Qubits in Quantum Algorithm for Monte Carlo Simulation by Pseudo-random Number Generator”

PRA, K. Miyamoto, 102, 022424 (2020)

→ Enable QMC with fewer qubit by Pseudo-random Number Generator (PRNG)

- Use Quantum Random Number Generator (QRNG)

“Practical randomness and privacy amplification” arXiv:2009.06551

→ library available: <https://qiskit-rng.readthedocs.io/en/latest/>

→ Enable to replace pseudo-random into quantum-random

→ Enable to realize broader multiple-option pricing by reduction of qubit consumption

→ Enable to enhance accuracy of pricing by means of QRNG

→ Try this method with real-world option problem and evaluate the performance

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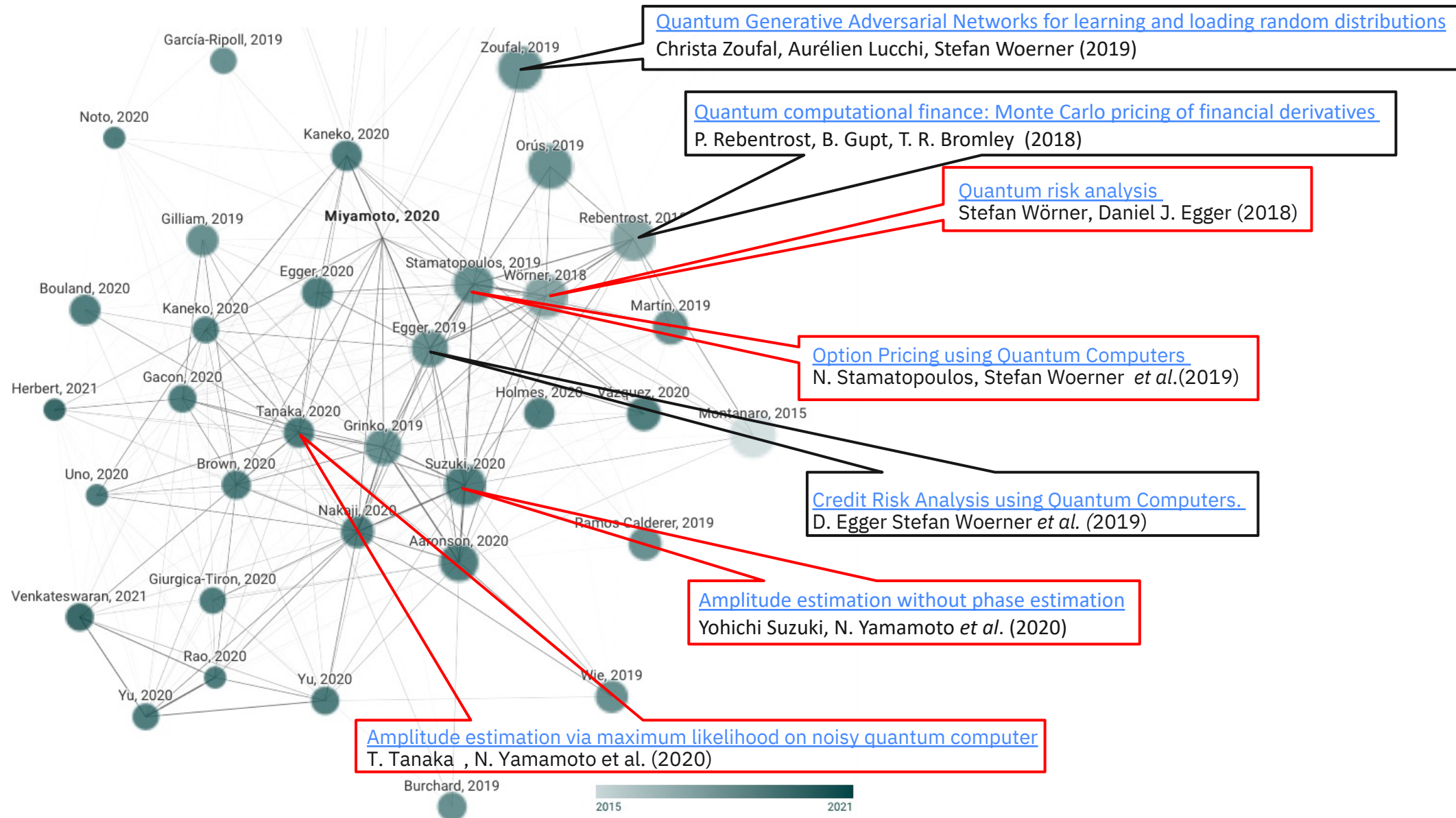
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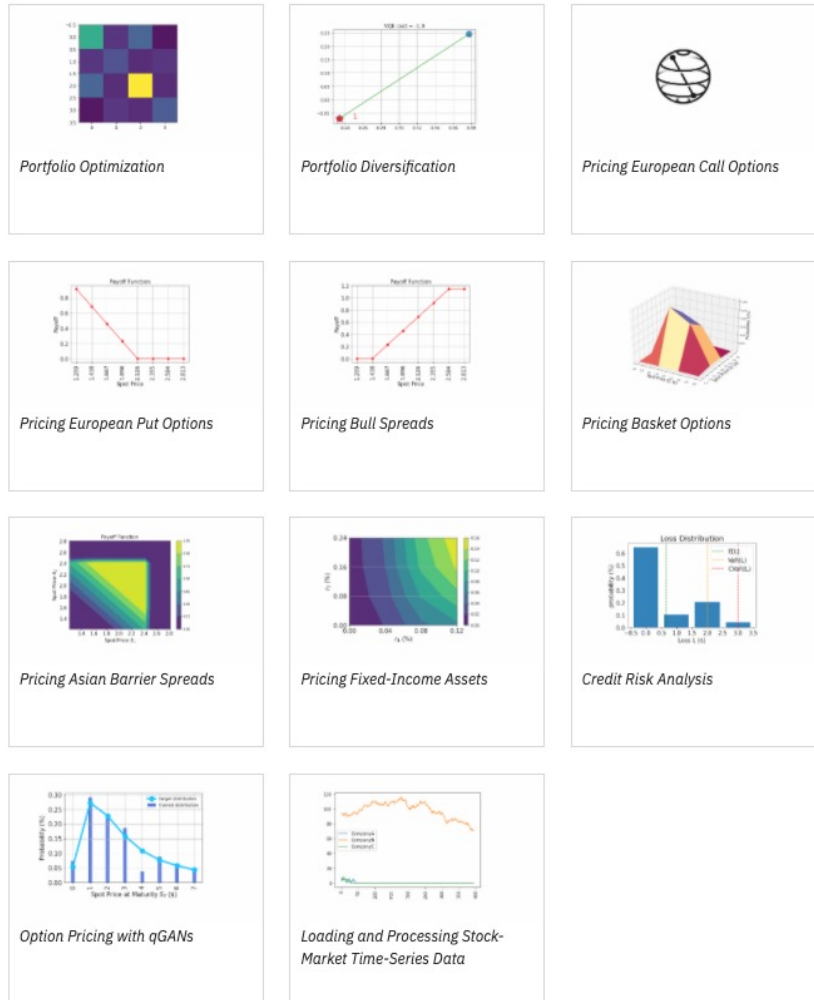
Literature Review



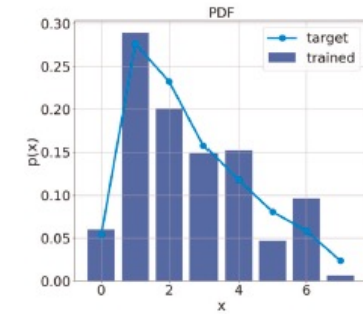
Option Pricing

- Apply QMC with multiple-option pricing
- “Option Pricing using Quantum Computers”

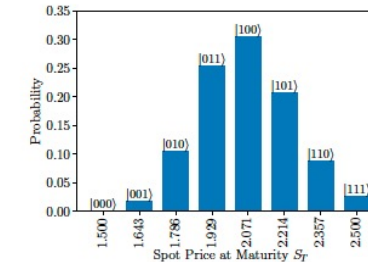
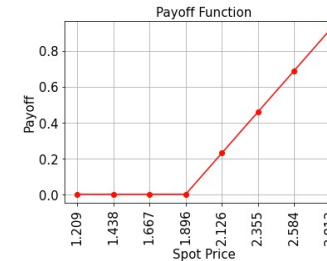
Finance Tutorials



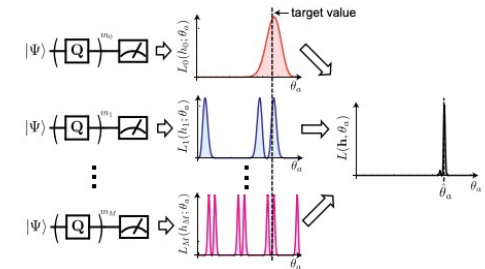
1. encode option price distribution using QGAN



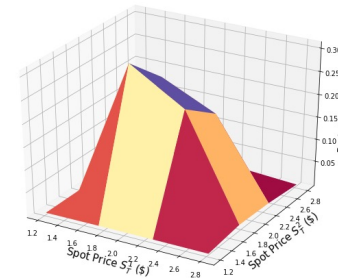
2. encode payoff function



3. Iteration Phase Estimation



4. Apply multiple-option pricing



- Scheduled to show demo April 9th (in Japanese)
- plan to post this slides in English (one of derivable)

Hybrid (Quantum + Classical) Monte Carlo (QMC)

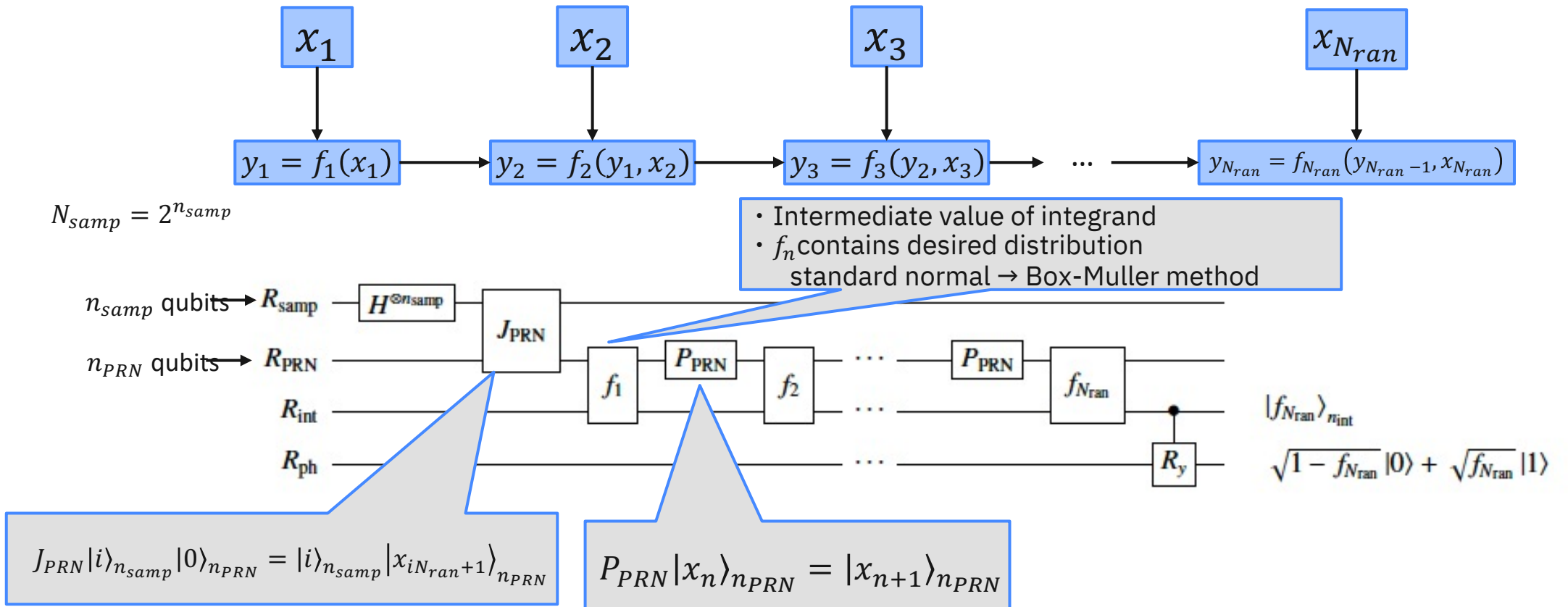
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→ Enable **QMC with fewer qubit** by Pseudo-random Number Generator (PRNG)

PRRN(Pseudo-random Number Generator) sequence:



Quantum Random Number Generator(QRNG)

- Use Quantum Random Number Generator (QRNG)
 - “Practical randomness and privacy amplification” [arXiv:2009.06551](https://arxiv.org/abs/2009.06551)
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 - Enable to **replace pseudo-random into quantum-random**

Original Plan: compare Quantum RNG vs np.random (Pseudo RGN)

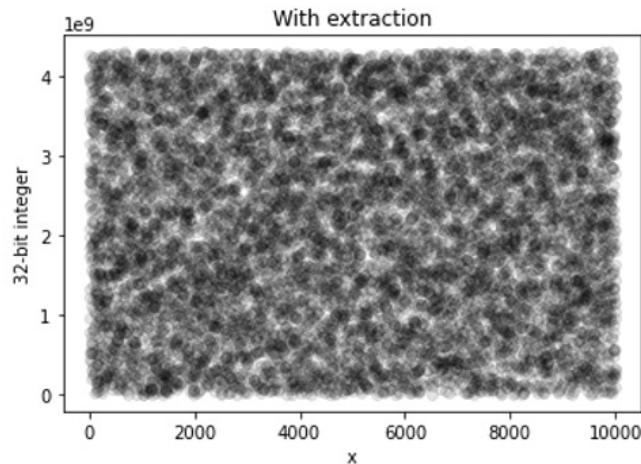
QRNG:

Qiskit RNG (0.2.2) ¶



Caution

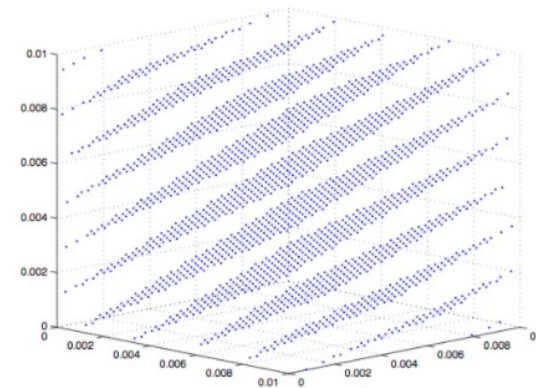
This package is currently provided in beta form and heavy modifications to both functionality and API are likely to occur.



np.random

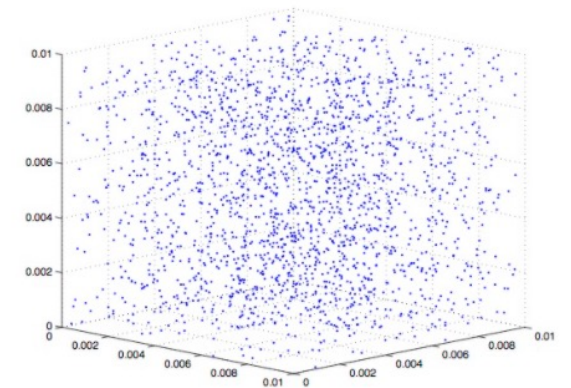
Pseudo RGN is **Mersenne Twister**

- periodic in $2^{19937}-1 \approx 10^{6000}$
- no computational power to reach period
- uniformly distributed within 623 dim



bad RNG, not uniform
(it happens certain seed)

Linear Congruential Generator; LCG



good RNG, uniform
Mersenne Twister

Derailable and Schedule

Planned derivable are some of those

1. SlideShare **(April)**
 - Detail description of option pricing as supplement for qiskit tutorial
2. Blog Post (Japanese first and English then) **(April~May)**
 - Detail of option pricing and newly proposed QMC
3. Qiskit Tutorial **(May-June)**
 - Reproduce the code of newly proposed QMC
4. Qiskit Advocate Demo **(June)**
 - Option pricing using newly proposed QMC
5. Proposal of Quiz for Coming Qiskit Challenge Africa (**~September**)
 - create quiz to be scored in quantum finance field
 - e.x. (iterative) phase estimation, amplitude estimation,
encoding of distribution/payoff