Qiskit Fall Fest 2025

Option pricing using quantum computing

A Mila ⊗ Quandela ⊗ AMF collaboration

AI-generated (Dall-E) image

Background and motivation

Option pricing is an important problem in finance. The goal of this prompt is to explore how quantum circuits can be used to price options either using a quantum random walk or a quantum machine learning (QML) model. This prompt invites teams to explore one of these tracks and produce a working option pricing model.

Note: Participants who are new to Quantum Computing but possess some AI background might find the QML implementation more approachable.

Track 1 - Quantum Random Walk

1.1. Description

The Black-Scholes Partial Differential Equation (PDE) is a fundamental equation in finance that helps calculate the fair price of options. The stock price itself is often modeled as undergoing a kind of random walk (a Brownian motion).

Here, instead of simulating all paths one by one as for a classical random walk, we propose that you implement a "quantum walk" to discretize the Black–Scholes partial differential equation. This technique offers a potentially much faster way to calculate the expected value of an option's payoff by using quantum mechanics to explore all possible future stock price scenarios simultaneously and by extracting useful classical information from this exploration.

1.2. Objectives

Your task is to create a quantum circuit to produce a working option pricing model. More specifically, your goal is to provide a quantum or hybrid circuit that allows the user to calculate or approximate the price of call and put options using the Black-Scholes model with constant interest rate and volatility. The participants have to use a quantum random walk to calculate or approximate the price of options

1.3. Evaluation

A table will be provided with the expected answers using a classical implementation of the Black-Scholes model. We are looking for an algorithm that approximates the answers.

1.4. Resources

- We suggest starting from here:
  - Basics of Quantum Information
  - The Black Scholes model for option pricing
- Some essentials for you to be equipped for this project:
  - IBM tutorial on quantum random walk using Qiskit (link will be provided by Sophy Shin, IBM, who did the tutorial)

• Deep dive into this wonderful project and complementary resources:
  - A recent paper on Quantum Random Walk for financial problems
  - Quantum Random Walk using photonic quantum computing

Track 2 - Quantum Machine Learning

2.1. Description

Unlike quantum walks, which directly simulate the probabilistic paths, Quantum Machine Learning provides an alternate method by learning the distribution of future option prices from historical data. For example, quantum reservoir computing (QRC) is a type of hybrid model. In this model, a fixed quantum circuit extracts non-linear features from the data and feeds them to a trainable classical algorithm.

2.2.Objectives

Your task is to use quantum machine learning (QML) to produce an option pricing model. More specifically, your goal is to implement and train a QML model to predict the price of put and call options. A training dataset will be provided to the participants to train a QML model to price options. The test dataset will be provided at the end of the hackathon for fair and exciting evaluation.

2.3. Evaluation

The test dataset will be provided to the organizers for fair and exciting evaluation based on a predefined metric.

2.4. Resources

• We suggest starting from here:
  - Basics of Quantum Information
  - A blogpost on AI for financial forecasting
  - Quantum Machine Learning with Qiskit

• Some essentials for you to be equipped for this project:
  - IBM tutorial on quantum reservoir using Qiskit (link will be provided by Sophy Shin, IBM, who did the tutorial)

• Deep dive into this wonderful project and complementary resources:
  - Quantum Reservoir for financial forecasting
  - A study on the form of weighted networks
  - Implementation of quantum reservoir using Quantum Machine Learning
  - Bringing Machine Learning to Quantum Computers

Deeper questions on both tracks

How many qubits and depth of circuit are required to have a good approximation of the option price with your quantum or hybrid circuit? Do adding qubits or quantum gates improve the accuracy of your circuit? How long does it take to run your quantum or hybrid circuit? How many parameters are there in your quantum or hybrid circuit? Is your quantum or hybrid circuit tolerant to quantum noise?

Proposed project judging criteria

1. Technical aspects

How accurate is the model? How complex is the quantum algorithm? Is it well optimized? Can the architecture serve users at a reasonable scale? How accessible is the end user application? Is it easy to use and intuitive for end users? Did the team use any significant parts of the Qiskit SDK, Qiskit Runtime, or other parts of the Qiskit ecosystem? Could the quantum algorithm be implemented with realistic hardware constraints and noise? Did the team compare the quantum algorithm to a classical benchmark? Did the team consider creative use of quantum properties?

2. Originality and uniqueness

How unique is this project compared to others? How interesting is it? Did the team attempt something new or difficult?

3. Usefulness and complexity

How useful is the project and how well-designed is it? How functional is it at the time of judging? Can it be used in real-world business applications or serve as a valuable tool for individuals? Are there ways this project could be further built out and refined upon?

4. Presentation

How well did the team present their project? Were they able to explain their decision? Did the entire team have a chance to speak? Did they tell a cohesive story?