Project Proposal: Quantum Computing for Financial Portfolio Optimization

Background

In one of the academic courses at TMU me and my group partner both were exposed to traditional and modern techniques of managing financial portfolios. Managing financial portfolios involves choosing the best mix of assets to balance risk and returns. During the course we were given a little idea of Markowitz's Modern Portfolio Theory (MPT), that is widely used but struggles with large and complex datasets. In this approach there is a consideration that there are no fractional investment which is not the case in actual world. Upon a little research we were able to see that Quantum computing introduces a new way to solve these challenges by using quantum parallelism to process large amounts of data much faster. Recent quantum algorithms, such as the Quantum Approximate Optimization Algorithm (QAOA), show promise in solving difficult optimization problems. This project will explore how these quantum methods can improve financial portfolio management by making calculations faster and more accurate.

Objective

This project aims to explore a quantum-based portfolio optimization system to (1) use quantum algorithms like QAOA to optimize financial portfolios, (2) address the challenges of fractional investments in Markowitz's MPT, where traditional methods face difficulties with mixed-integer quadratic programming (MIQP), (3) compare quantum algorithms with classical ones like Mean-Variance Optimization and Genetic Algorithms in terms of speed and accuracy, and (4) explore the possibility of using quantum solutions in real-world asset allocation and risk management. The goal is to understand if quantum-based portfolio optimization can offer better performance in terms of accuracy than classical methods which could potentially be a useful tool for financial decision-making.

Methods

- To achieve our objective, we plan to use four to six assets that can be used to maximize the expected return while minimizing the risk as low as possible.
- Choose any four to six publicly traded assets (e.g., stocks, ETFs, or cryptocurrencies).
- There are 2 key dataset for each assets and we can get them using Python:
    - Average returns over a period of time.
    - Risk relationship between assets (covariance matrix).
- Using the QUBO model by converting the mean-variance optimization problem, which is compatible with quantum hardware.
- We will be implementing quantum execution using the QAOA algorithm on IBM's quantum simulator and quantum hardware.
- We will try to solve the same problem using classical optimization methods to evaluate the performance of quantum hardware.

- We will be evaluating the classical and quantum methods based on time taken, solution accuracy and scalability.

ExpectedResults

We anticipate achieving the following:

- A basic quantum-based portfolio optimization model that functions correctly and provides reasonable results.
- A demonstration of how quantum algorithms like QAOA can be applied to portfolio optimization.
- A comparison showing that quantum methods can at least match classical approaches in certain scenarios.
- Demonstrate quantum computational efficiency compared to traditional methods.

Conclusion

This study explores the practical application of quantum computing in finance, focusing on small-scale portfolio optimization. While quantum advantage is still emerging, this research provides experience about how IBM Quantum hardware can be leveraged for real-world financial decision-making.

Implications

The impact of this project goes beyond portfolio optimization. It could help show how quantum computing can be useful in finance, especially for tasks like risk management and investment planning. By testing quantum algorithms, we can better understand their strengths and weaknesses compared to traditional methods. This project could also inspire future research in areas like automated trading and financial forecasting. In short, it takes a step toward making quantum computing a practical tool for real-world financial decisions.

Text only submission