Blockchain Mining with Machine Learning

Cheung Yau Shing Jonathan 3035783560

Group: fyp23033

1 Project Background

Blockchain technology is becoming increasingly popular. As a decentralized system, it could increase trust, security, transparency and traceability of data across a business network. It is therefore applied in various industries. In finance, it's used for cross-border payments and smart contracts. In Supply Chain Management, blockchain allows businesses and consumers to track the origin, movement, and authenticity of products. In healthcare, Blockchain could help securely store and share patient medical records.

Mining is a crucial part of blockchain in which new blocks are created and transactions are validated. Miners create blocks by collecting pending transactions, verifying their validity, and constructing the block header by including essential information such as the block hash, previous block hash, Merkle Root and nonce. The first to complete these tasks will mine the block successfully and receive rewards.

Proof of Work (PoW) is a prominent consensus mechanism, where miners will solve the hash problem to ensure nodes agree on the block created. The hash problem in the PoW blockchain involves miners searching for a nonce that, when combined with the block's data, generates a hash value that meets specific criteria, such as having a certain number of leading zeros. Since producing PoW is a random and low-probability process, there's been a long-held belief that brute force is the only feasible and profitable block-mining strategy. This means miners with greater computational resources have a higher capacity to explore a larger number of solutions, thus increasing their chances of winning. As the mining difficulty of PoW blockchain is dynamically adjusted to maintain an average block creation time of approximately 10 minutes, this resource-based competition has led to excessive energy consumption.

The reliance on fossil fuel-based electricity to power mining operations leads to the release of greenhouse gases, exacerbating climate change concerns. Moreover, miners often face the need to constantly upgrade their equipment. This causes the dispose of outdated mining rigs and worsens the growing issue of electronic waste (e-waste). The thereby makes proof-of-work blockchain mining one of the most environmentally detrimental practices.

With the advancement of artificial intelligence, I would like to research the use of machine learning in block mining. By leveraging historical mining data and real-time network conditions, I believe machine learning could help derive an optimal mining strategy. This not only improves mining rewards and efficiency, but most importantly, promotes greater sustainability in mining practices.

2 Project Objective

The project's objective is to explore the potential of integrating machine learning techniques into the block mining process within the blockchain network. More specifically, I'll develop a novel reinforcement learning algorithm that can significantly improve average mining rewards over a designated time period compared to the conventional brute-force mining algorithm. In addition, the proposed machine learning algorithm will exhibit a reduction in the average computational resources expended per mined block. Through developing a more efficient and sustainable block mining strategy, I hope this could serve as an initiative for miners to start adopting more environmentally conscious mining methods and pave the way for a greener future in blockchain mining.

By the end of the project, I aim to complete the following 3 tasks:
1) Research Report: A comprehensive research report will be produced, providing an in-depth analysis of the background, objectives, methodology, and findings of the project. The report will examine and compare existing approaches with the developed algorithm to reflect its effectiveness in mining.
2) Code: The project will provide the entire codebase, including relevant scripts, modules, and libraries utilized in developing the machine learning model and conducting the experiments. This code will enable others to replicate the work, extend it further, and validate the results. Proper documentation and comments within the code will ensure its comprehensibility.
3) Presentation and Demonstration: A comprehensive presentation summarizing the project will be prepared, highlighting the key findings, methodology, and outcomes. Additionally, a demonstration on the machine learning model's functionality and performance will be provided to showcase its practical application in blockchain mining. The presentation and demonstration will be completed in a video format and be uploaded to the project website.

3 Project Methodology

3.1 Literature Review

I will conduct a comprehensive literature review to explore existing research on blockchain block mining with machine learning. "When Blockchain Meets AI: Optimal Mining Strategy Achieved By Machine Learning" [1] is a recently published paper that introduced the application of reinforcement learning in blockchain mining. The author formulated the mining problem as a Markov Decision Process (MDP), and employed multi-dimensional RL to solve it. The final algorithm significantly improves mining gain, with performance approaching that of the optimal mining strategy, developed with prior knowledge of network parameters. In addition, I will explore emerging concepts such as maximal extractable value (MEV) [2, 3] and arbitrage trading strategy, which represent new initiatives aiming to revolutionize the mining game.

3.2 Historical Data collection

I will gather historical blockchain data by accessing publicly available sources, such as blockchain explorers and APIs. This allows me to retrieve block details, including block heights, timestamps, mining difficulty, and the number of transactions in each successfully mined block. This information is essential for the development and testing of my algorithm.

3.3 Blockchain System Setup

My project will be developed based on the Bitcoin blockchain system. Setting up the Bitcoin Regtest and Testnet environment is essential for me to develop, experiment, and validate the algorithm. Regtest is a local testing environment that allows users to create a private, isolated blockchain network. This enables the customization of network parameters and could facilitate my training and development progress. To do so, I'll install the blockchain client software and configure it to Regtest mode. A Testnet is a separate blockchain network that mirrors the Mainnet but operates on a different network with its tokens for testing purposes. This replicates real-life circumstances and, therefore, provides an accurate and fair environment for performance evaluation. To set up a Testnet, I'll configure the connection parameters of the blockchain software to connect to the Testnet network provided by Bitcoin.

3.4 Model Development and Training

Reinforcement learning algorithms can learn from interactions with the environment and make sequential decisions to maximize rewards. In the context of the PoW blockchain, positive rewards are given for successful block additions, while penalties can be assigned for inefficiencies or unsuccessful mining attempts. I believe by referencing existing works, as well as adding my own improvements to it, I can develop a novel reinforcement mining algorithm and uncover effective and sustainable mining strategy.

3.5 Model performance evaluation

The evaluation process will based on the Bitcoin Testnet. I will start by obtaining baseline results from naive brute-force mining and other more optimized mining strategies, serving as reference points. The performance of the reinforcement learning algorithm will then be assessed according to metrics such as expected reward, mining time, and resource utilization. A comprehensive comparison will be conducted to provide valuable insights into the effectiveness and efficiency of the reinforcement learning algorithm in enhancing mining outcomes. Graphs and tables will also be included to present performance metrics, facilitating clear comparison and analysis of different mining strategies.

4 Project Schedule and Milestones

Time	Objectives
Sep 2023 (60 learning hours)	Focus: Project Setup & Detailed Project Plan • Define project objectives, scope, and deliverable. • Develop a detailed project plan, including timelines and resource allocation. • Set up the WordPress website for progress updates Phase 1 Milestones: • Detailed project plan • Project web page
Oct 2023 (60 learning hours)	Focus: Literature Review & Data collection • Research on existing and related works on blockchain block mining with machine learning • Collect historical blockchain data from various sources
Nov 2023 - Jan 2024 (200 learning hours)	Focus: Environment Setup & Model Training • Set up the Bitcoin Regtest and Testnet • Develop and experiment with different reinforcement learning algorithms • Train and fine-tune model parameters. • Define metrics for performance evaluation Phase 2 Milestones: • Preliminary implementation • Detailed interim report • First presentation

Feb - Mar 2024 (150 learning hours)	Focus: Model Evaluation and Improvements • Deploy model on Bitcoin Testnet for evaluation • Perform detailed evaluation on models' performance on defined metrics • Compare with baseline results to derive insights • Explore improvements in the mining algorithm
Apr 2024 (80 learning hours)	Focus: Documentation and Reporting: • Document the project findings, methodologies, and outcomes. • Prepare the final project report and presentation summarizing the research, analysis, and results. Phase 3 Milestones: • Finalized implementation • Final report • Final presentation and project exhibition

Note: The timeline provided is a rough estimate and can be adjusted based on the specific requirements and progress of the project

References

[1] T. Wang, S. C. Liew, and S. Zhang, "When blockchain meets ai: Optimal mining strategy achieved by machine learning," *International Journal of Intelligent Systems*, vol. 36, no. 5, pp. 2183–2207, 2021.

[2] K. Kulkarni, T. Diamandis, and T. Chitra, "Towards a theory of maximal extractable value i: Constant function market makers," *arXiv preprint arXiv:2207.11835*, 2022.

[3] T. Chitra, "Towards a theory of maximal extractable value ii: Uncertainty," *arXiv preprint arXiv:2309.14201*, 2023.