CS 4644/7643: Deep Learning
Project Proposal

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Discussions: https://piazza.com/class/lzhdjcp6u255yf/

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- Write 2-3 paragraphs per section for full credit. The document should not exceed **three pages**, excluding reference.
- There is no late deadline for this assignment. Submissions submitted after the due date will receive a 0.
- Submit this LaTeX document as a PDF to Gradescope.
- Submission: Please submit your proposal as a PDF on Gradescope. Only one person on your team should submit. Please have this person add the rest of your team as collaborators as a "Group Submission".

Project Title: Deep Q-Learning for Modern Cryptocurrency Trading
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1 Project Summary

Our project is in the financial domain, and we decided to specifically focus on cryptocurrency for the project. Cryptocurrency was chosen as our topic as deep learning applications in this field are relatively new, and there are several areas for improvement on existing research. Improving existing usage of deep learning and reinforcement learning to effectively trade cryptocurrency is our main focus. To begin with, we will focus on Bitcoin, but other cryptocurrencies will be explored time permitting.

For our model, our inputs will be the environment for our agent. These include open price, high price, low price, close price, and volume for the last minute. Using this data, the model will seek to maximize long term reward by suggesting whether to buy, hold, or sell. Since we are currently intending on using an RL technique, these actions will be output every minute. Trading is an inherently volatile problem space, so we will have to test several different models and perhaps even change our strategy if needed.

2 Proposed Method

Based on the paper by [Jun24] it seems that the most applicable model to use for this crypto trading based on the minute data we have present would be a DRL model as the paper utilizes a similar dataset for stocks to obtain an optimal trading strategy that outperforms the "Sharpe ratio" and a "cumulative return". We chose to use a DRL because other models such as a Neural Net cannot focus on the long term while a DRL has the ability to have states and actions to focus on the long term and allow for the model to increase value in their portfolio.

The way that we are intending to evaluate our success is through what the earlier paper mentioned in the Sharpe ratio that measures the performance of any investment that takes in factors such as security, profit, etc. and we will also be using Rate of Return which will be determined at the end as we would like to start with 100,000 base dollars and see how much money the model makes or loses by the end of the time scale. Both this paper and [Liu+22] present the idea of using the Sharpe Ratio as apart of the reward function to encourage the model. We will compare these to if we just bought and held the BTC from whichever time period we choose to start at. The most common loss function present as apart of DRL models utilized in trading is usually a Mean Square Loss Function. This means that we would look at the q-value and compare it to what the actual q-value is after the action to determine the loss value.

3 Related Work

Include at least five (5) references to important past research paper or textbook. Discuss who they are related to your problem

Recent research has explored the application of Deep Reinforcement Learning (DRL) in financial markets, particularly in stock trading. Azhikodan et al [ABJ19] have demonstrated the efficacy of DRL in processing extensive datasets, including tens of thousands of news headlines from thousands of companies. In this study, neural networks based on deep deterministic policy gradients, have been trained to make informed decisions regarding stock transactions, including buying, selling, or holding current positions.

The paper written by Liu [Liu+22] is a good way to develop the base of our problem structure as they mention reward functions as well a methodology to determine the success of the model. They mention using formulas such as the Sharpe Ratio as well as comparing the whole model to a BTC buy and hold for the time period which we might also adopt for our paper.

One other paper we use is a survey of deep learning applications in cryptocurrency [Jun24]. This resource helps us gain context for prior works in finance that use deep learning techniques. It provides a few papers that are directly related to the problem we would like to solve in cryptocurrency as well. The survey also provides information on the different models the papers use such as CNN, RNN, DRL.

Many papers have been developed on how to utilize DRL for crypto trading due to its benefits of having states and the amount of data present with the 24/7 trading hours. One such paper [JK24] takes an interesting approach in separating bearish and bullish markets to see how the model performs individually on these markets. They also present a very structured model architec-

ture which we may want to adapt for our problem setting and manipulate for better performance as well as some of their evaluation metrics which are far more advanced that we may consider based on the end goal of our project. We should however consider multiple market scenarios as the paper did rather than just let the model run for time period x to current date to see a better representation of the model in extreme scenarios.

In [Gio19], Lucarelli G. et al investigated the performance of multiple Deep Reinforcement Learning models, including Double Deep Q-Network (D-DQN) and Dueling Double Deep Q-Network (DD-DQN) on the bitcoin market. Then, performance of those models are compared with Deep Q-Network (DQN). Based on their study, the Double Q-learning model using Sharpe ratio reward function (SharpeD-DQN) has the largest return values.

4 Datasets / Environments

At the early stage, we will focus on two most popular cryptocurrencies: Bitcoin (BTC) and Ethereum (ETH). Therefore, it's sufficient to utilize a comprehensive dataset from Kaggle [Gen23], in the OHLCV format (open, high, low, closing prices, and trading volume). The dataset contains 4.2 million data samples across two cryptocurrencies with a granularity of 1-minute bars from 2016 to 2024. This large dataset provides a robust foundation for training and evaluating the deep reinforcement learning model, and ensures sufficient samples for proper batched training.

While the project primarily focuses on historical data, it's worth noting that cryptocurrency markets operate 24/7, allowing for potential real-time data integration to enhance the model's adaptability.

5 Potential Risks

The proposed project has several potential risks. Firstly, the cryptocurrency market is very volatile, which may affect the reliability of the trading model. Secondly, the quality and integrity of available datasets might be a factor that also affects robust analysis and training. Furthermore, we still have limited experience with Deep Reinforcement Learning techniques, which may affect the implementation of the system correctly and efficiently.

References

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[Gen23] Patrick Gendotti. *BTC and ETH 1min Price History*. Kaggle. 2023. URL: https://www.kaggle.com/datasets/patrickgendotti/btc-and-eth-1min-price-history.

[Gio19] Matteo Borrotti Giorgio Lucarelli. "A Deep Reinforcement Learning Approach for Automated Cryptocurrency Trading". In: *HAL* (2019).

[JK24] Liu Jing and Yuncheol Kang. "Automated cryptocurrency trading approach using ensemble deep reinforcement learning: Learn to understand candlesticks". In: *Expert Systems with Applications* 237 (2024), p. 121373. ISSN: 0957-4174. DOI: https://doi.org/10.1016/j.eswa.2023.121373. URL: https://www.sciencedirect.com/science/article/pii/S0957417423018754.

[Jun24] Jiaqi Wen Junhuan Zhang Kewei Cai. "A survey of deep learning applications in cryptocurrency". In: vol. 27. iSciecne, Jan. 2024. DOI: 10.1016/j.isci.2023.108509.

[Liu+22] Xiao-Yang Liu et al. "FinRL: deep reinforcement learning framework to automate trading in quantitative finance". In: New York, NY, USA: Association for Computing Machinery, 2022. ISBN: 9781450391481. DOI: 10.1145/3490354.3494366. URL: https://doi.org/10.1145/3490354.3494366.