PORTFOLIO OPTIMIZATION

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Problem Statement

In the world of stock markets, Optimising portfolios creates a challenge for traders in order to maximize their profits while minimizing risks. Traditional approaches often depend on static models and heuristics, which may not be suitable for dynamic markets. Hence, it is really important to find new innovative solutions that can use advanced technologies to optimize portfolios effectively. One such technology is Reinforcement Learning. The task is to develop a reliable portfolio optimization framework adapted specifically for traders using reinforcement techniques like Q-Learning.

Methodology

1)Data collection and preprocessing:

The dataset is collected from NASDAQ(National Association of Securities Dealers Automated Quotations), an American stock exchange based in New York City. For each stock, historical prices up to the year 2023 are used for training, while prices from the start of 2024 are reserved for testing purposes.The data consists of historical stock prices includes opening, closing, high, low prices and volume of the stock. It also includes few technical indicators like RSI, EMA, etc.

2)Training data using LSTM:

LSTM is an improved version of recurrent neural networks (RNNs). RNNs work like how human learn. LSTMs are a kind of RNNs which remembers the information over a longer period of time which makes them better suited for stock price prediction. The training data, consisting of historical stock prices before 2024, is used to train the LSTM neural network. The LSTM model learns from the temporal patterns and dependencies in the training data to make accurate predictions for future stock prices.

3)Deep Q-Network

The DQN framework, using experience replay, employs a neural network architecture to approximate the Q-function, enabling it to learn optimal actions for portfolio management. By integrating historical data and LSTM predictions, the DQN dynamically adjusts its policy to maximize portfolio returns while effectively managing risk. Through iterative training, the DQN refines its decision-making capabilities, leveraging insights from both past market behavior and anticipated future trends to inform daily buy, sell, or hold decisions for each stock in the portfolio.

State space:

State space is structured as an $k \times 1$ matrix, where each row represents the no.of stocks and the column represents the difference between the present day's closing price and the previous day's closing price.

Action:

The model's actions consist of three options: buying, selling, or holding assets within the portfolio. These actions are determined based on its analysis of the data. The goal is to optimize the portfolio by making decisions that maximize returns while managing risks. Through continuous learning and adaptation, the model refines its decision-making process, leveraging insights from past market behavior and anticipated future trends to guide its actions for each stock in the portfolio.

Reward:

The reward is determined by the actual prices of the stocks. A positive reward is attributed to price increases, while a negative reward is linked to price decreases.

On iterative training, the model gradually refines its decision making process by learning from its past decisions and optimize its decisions gradually. The model adapts to the dynamic real time markets and enhance the ability to make informed decisions for portfolio optimization.

4)Evaluation and Testing:

After integrating LSTM - DQN framework, the framework is evaluated using historical data and tested on unfamiliar data to assess its performance. Using this tested data, a model portfolio is obtained using the DQN framework which consists of stocks and the position of stocks(buy/sell/hold) on a particular day for desired number of days.

5) References:

- Q-Trader
- 181_multivariate_timeseries_LSTM_GE.py
- CodeTrading
- Deep Reinforcement Learning in Action by Brandon B AND Alexander Z