

Research on Stock Market Investment Strategy based on Deep Q-Network and Strategy Gradient Method

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Abstract. As China enters a new era and the stock market investment strategy enters the stage of high-quality development around adhering to people-centered development, it is worth highlighting the following recommendations: investment strategies that better meet investors' risk and return needs. Based on the dynamic evolution of stock market development and according to the internal logic of the Merrill Lynch cycle, a theoretical analysis framework for stock market investment strategies is constructed, which can explain the stock market investment mechanism jointly generated by the supply and demand relationship and the price and capital circulation mechanism involved in market sentiment. And continue to explore the possibility of moving towards high-quality development goals from the perspective of style changes and practical interpretations of stock market development. A stock market investment strategy aims to provide investors with returns that meet expected standards, continuously improve return quality, and increase risk-adjusted returns. To this end, it is necessary to strengthen the industry selection based on the industry cycle, build an interaction and feedback mechanism between individual stocks and investors' value perception, and establish an evaluation system for the macroeconomy and the stock market, to achieve high-quality development of investment strategies in the stock market, stimulate the transformation and upgrade of China's economy, and truly satisfy the people.

Keywords: Stock Market Investment Strategy; Merrill Cycle; Industrial Selection; Value Perception.

1. Introduction

This paper focuses on current financial issues, the underlying deep Q-network stock market investment strategy, and the strategy gradient method. Firstly, the topic of a stock market investment strategy based on a deep Q-network is introduced, and the deep Q-network model and strategy gradient method model, as well as the stock market environment and trading signal collection system, are introduced in detail. Then, based on the deep Q-network and strategy gradient method, the investment strategies are analyzed based on investment return, risk, and stability. It is concluded that China uses artificial intelligence methods to improve investment strategies based on deep Q-networks and strategy gradient methods to improve investment efficiency and lay a solid foundation for further integration with international standards.

2. Stock Market Investment Strategy Based on Deep Q-Network

2.1. Stock Data Set and Deep Q-Network Model

Deep Q-network is a concept developed in parallel with reinforcement learning. It is "soaked" with the concept of deep learning, which highlights artificial intelligence's data-driven orientation and reflects machine learning's innovative strategies in recent years. However, it is still difficult to unify when constructing the definition and essence of deep Q-networks with some mathematical standards.

The core idea of a deep Q-network is to use a deep neural network to approximate the action value function, the expected benefit that can be obtained by taking different actions in a given state [1]. The deep Q-network can learn the optimal strategy to maximize the cumulative benefit by continuously interacting with the environment [2]. The deep Q-network model is shown in Figure 1.

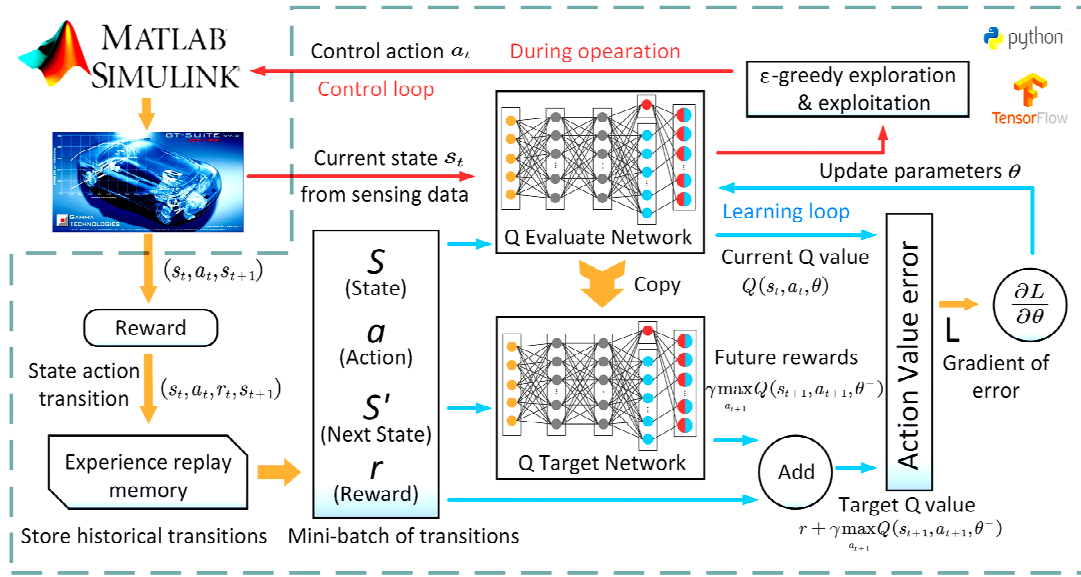


Figure 1. Deep Q-network model

In this paper, we describe how to use deep Q-networks to design stock market investment strategies [3]. We will use the stock market dataset as input to train a deep Q-network model to generate the best buy and sell signals. And we will employ techniques such as target networks, exploration, and experience replay to improve the performance and stability of the model. Finally, the experimental results will show the advantages and limitations of deep Q-networks in stock investment.

2.2. Stock Market Environment and Transaction Signal Collection System

This paper proposes a stock market investment strategy method based on a deep Q-network. This method utilizes the reinforcement learning capabilities of the deep Q-network to transform the stock market investment problem into a Markov decision-making process problem, and the accurate output of the optimal transaction signal is achieved by training the deep Q-network model [4]. Then this paper uses the stock market environment as the simulation platform to verify the method's effectiveness, generates stock price data of different stock types, periods, and market sentiments, and uses them as the input of the deep Q-network model. Simulation results show that the method can realize high-yield investment strategies in complex and changing stock market environments and has good robustness and generalization ability. Among them, transaction signals are signals that indicate whether to buy or sell stocks and play a role in helping investors decide when to buy or sell. The function of transaction signals is represented as follows:

$$a_t = f(s_t, \theta) \quad (1)$$

Among them, a_t is the trading signal at the time moment t , s_t is the stock status at the time moment t , and θ is the parameter of the deep Q-network model.

2.3. Investment Strategy Evaluation Method based on Deep Q-Network

The evaluation method of investment strategy is an important standard of investment strategy, and it is an expression of its effectiveness and pros and cons. The rate of return on investment and the risk-adjusted rate of return discuss the different definitions of investment strategy from the perspective of income and risk. Some scholars believe that investment strategy is the degree of investor behavior or preference. To some extent, investment strategy is more scientific and belongs to financial science with a rational purpose. Therefore, the research history of investment strategy can even be traced back to ancient Greece, and its main activities include observing the market, analyzing data, and formulating rules.

However, the investment strategy evaluation method is closely related to the development of modern statistics. Through the evaluation method, the investment strategy becomes an important responsibility of the investor. The theory of evaluating investment strategies in the 20th century, the main contribution of which was the introduction of indicators such as the Sharpe ratio, the Sortino ratio, and the Treynor ratio. Thus, investment strategy evaluation methods initially focused on measuring investment strategies based on return and risk criteria attributes.

This paper describes how to use the output of a deep Q-network to evaluate the performance of stock market investment strategies. And the above metrics are used to measure the performance of deep Q-Network on different stock datasets and compare it with other commonly used investment strategies. In the end, the strengths and limitations of the deep Q-network in evaluating investment strategies in the stock market will be demonstrated through empirical results.

3. Stock Market Investment Strategy based on Strategy Gradient Method

3.1. Stock Dataset and Policy Gradient Method Model

Compared with the stock market investment strategy based on the deep Q-network, the stock market investment strategy based on the strategy gradient method emphasizes the relationship between the strategy function and the action selection. It has the characteristics of a direct optimization strategy. Although some scholars have questioned that the strategy gradient method may not be directly related to the stock market, most scholars argue that the strategy gradient method can make a rational evaluation of stock market investment. Sutton et al. proposed a strategic slope theorem that includes cumulative returns and strategic parameters. Since then, this theorem has become a typical tool for strategic gradient methods, and concepts such as REINFORCE and Actor-Critic have been developed. These researchers believe the policy gradient approach is exploratory and "learned by trial and error". The policy settings will be updated only when the policy function can generate high-yield actions. Therefore, policy gradient methods are reward-driven results. In addition, some scholars also generalize the policy gradient method into two models: the model based on the value function and the distribution function. The former focuses on using the value function to guide the strategy update, and the latter focuses on using the distribution function to describe the action space, that is, the natural gradient. Although the strategy gradient method has had some practical failures, from a theoretical point of view, it can adapt to the needs of continuous action space and stochastic strategy, and the concept of exploration strongly has gradually become the consensus of stock market investment research and practice. The policy gradient method model is shown in Figure 2.

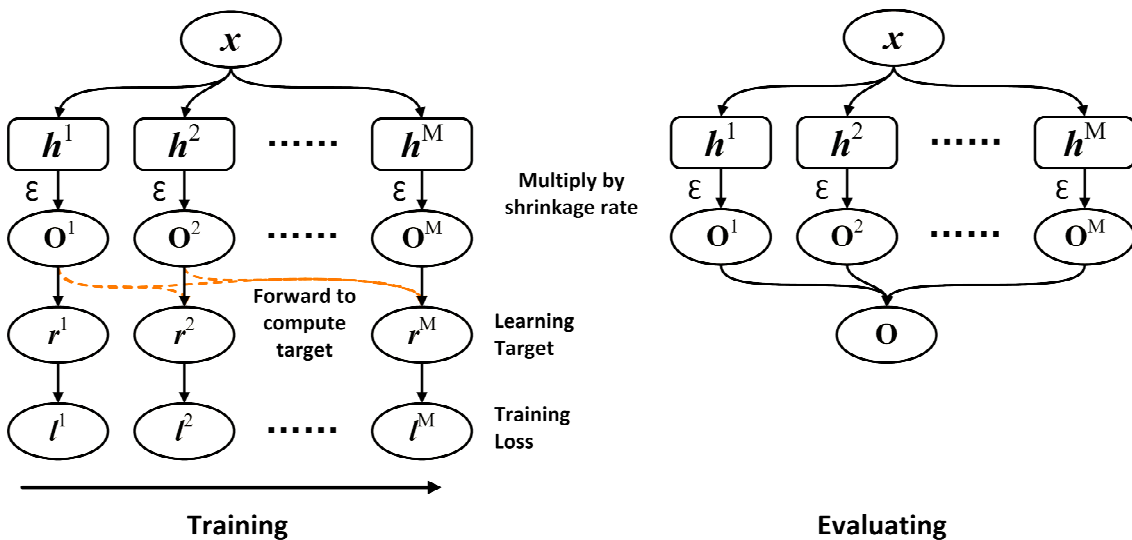


Figure 2. Strategy gradient method model

3.2. Stock Market Environment and Transaction Signal Collection System

The essence of the stock market environment concept and the trading signal collection system focuses on the stock market investment strategy. The stock market environment is the application of stock market thinking in the financial sector. As a new alternative model—the investment strategy framework based on the market environment has entered the research field of view to overcome the shortcomings of the traditional investment strategy based on technical analysis and fundamental analysis. The basic idea of the framework is that investors must ensure that they choose the right investment strategy according to different market environments, establish professional standards for exiting investment strategies, "capture" changes in the market environment through technologies such as collecting trading signals and using the strategy gradient method to measure the effectiveness of investment strategies. The investment strategy framework based on the market environment reconstructs the stock market investment strategy, emphasizing the need to enhance investors' sensitivity to the market environment to construct an investment strategy with strong adaptability, high flexibility, good stability, and high sustainability.

The stock market environment and trading signal collection system are shown in Figure 3.

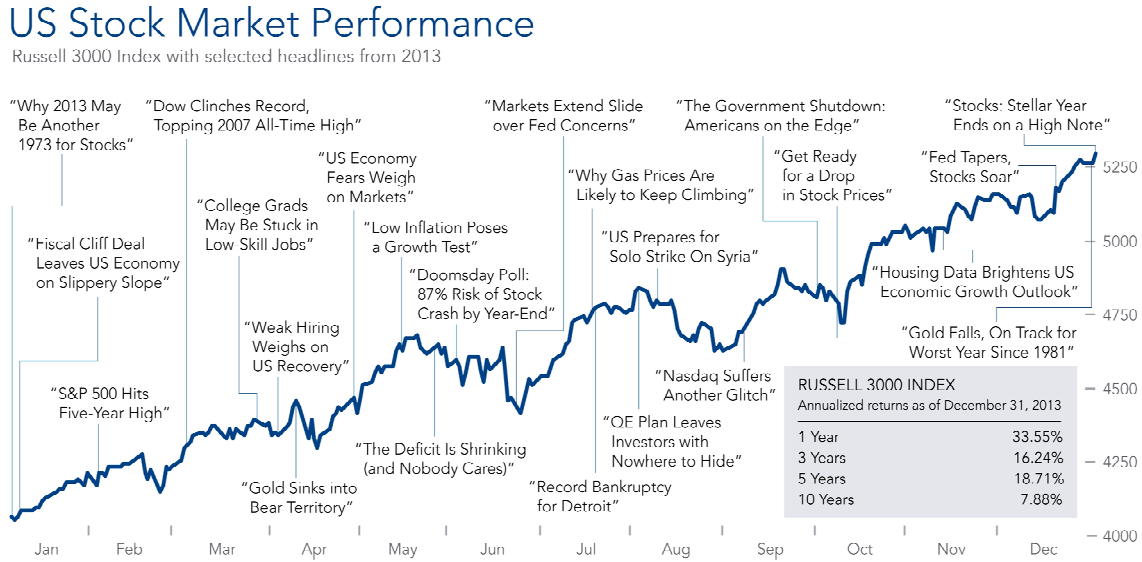


Figure 3. The stock market environment and trading signal collection system

3.3. Investment Strategy Evaluation Method Based on Strategy Gradient Method

During the relevant research on the investment strategy evaluation method according to the strategic gradient method, the rate of return is mainly considered and omits the risk before. As a result, investment strategy evaluation methods are inaccurate. Based on the above issues, an improved method of evaluating investment strategies, mainly incorporating a risk-adjusted rate of return technology and Treynor's ratio model, while optimizing the deeply traditional structure of the strategy slope theorem so that the investment strategy evaluation efficiency is better. First, the risk-adjusted rate of return is introduced as the objective function to balance the relationship between return and risk. Second, the Treynor ratio is used as a proxy for the slope estimate to reflect the influence of market standards. Then we used the natural gradient as the optimization algorithm to improve the learning rate and stability. Finally, we test the innovative investment strategy evaluation method's validity and superiority. The risk-adjusted rate of return is an indicator of the rate of return that considers risk factors and functions as a measure of the possible return per unit of risk. The risk-adjusted rate of return function is expressed as follows:

$$R_a = \frac{R_p - R_f}{\sigma_p} \quad (2)$$

Where, R_a is the risk-adjusted rate of return, R_p is the return on the portfolio, R_f is the risk-free rate, and σ_p is the standard deviation of the portfolio.

4. Comparative Analysis of Investment Strategies Based on Deep Q-Network and Strategy Gradient Method

4.1. Comparative Analysis of Return on Investment

This section performs a comparative analysis of the return on investment of the stock market investment strategy based on the deep Q-network and the strategy slope method. The rate of return on investment is the most direct indicator to measure the effectiveness of an investment strategy, reflecting the ratio of an investor's return to the principal due to buying and selling shares in a given period [5]. The formula for calculating the return on investment is as follows:

$$R = \frac{P_f - P_i}{P_i} \quad (3)$$

Where, R is the return on investment, P_f is the final stock price, and P_i is the initial stock price.

In order to compare the return on investment performance of the two methods on different stock data sets, we use the same trading signal acquisition system and evaluation method and only change the training and output process of the model. We selected four types of stock market data sets, namely technology, finance, consumer and energy, and each dataset contains daily data from 2019 to 2023. Each data set is divided into the training set and the test set. The training set accounts for 80%, and the test set accounts for 20%. The return on investment of the two methods on the test set is compared with the benchmark rate of return, which refers to the rate of return that does not make any transactions and only holds stocks. Finally, the comparison results are displayed as tables and line charts. The results of the comparative analysis of the return on investment are shown in Figure 4.

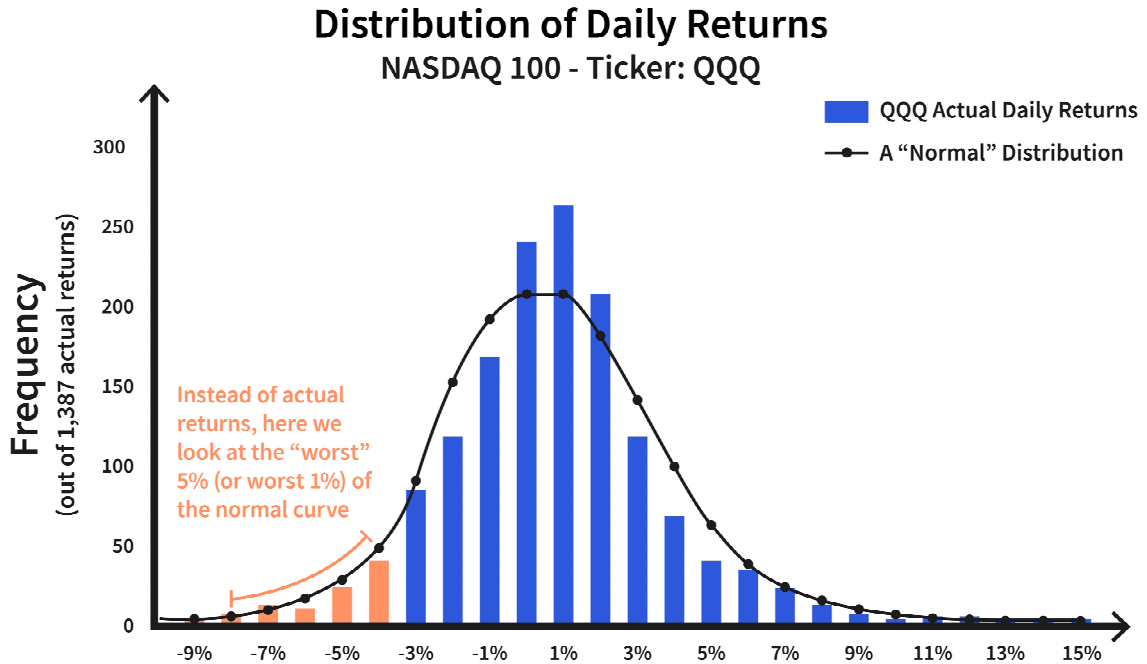


Figure 4. Comparative analysis results of investment return rate

4.2. Comparative Analysis of Investment Risks

Investment risk is a key factor considered in an investment strategy, which reflects an investor's attitude toward future uncertainty and directly reflects investment strategies and stock market

volatility through risk indicators. Several components of investment risk management are slowly taking shape, and risk-adjusted rates of return and different pricing systems are gradually being considered. However, from the perspective of empirical research, the practice of some investment strategies is still in the stage of purely pursuing returns, and there are still contradictions with the logical framework and generation mechanism of modern investment theory, which leads to the issue of comparative analysis of investment risks [6].

This section performs a comparative investment risk analysis of stock market investment strategy based on deep Q-network and strategy slope method. Investment risk refers to the possibility of loss due to stock price fluctuations over a certain period of time. And common indicators of investment risk include standard deviation, variance, beta, and more. We use the same trading signal acquisition system and evaluation method to compare the investment risk performance of the two methods on different stock market data sets and only change the training and output processes of the models. Then we selected four types of stock market data sets, namely technology, finance, consumer and energy, each containing daily data from 2019 to 2021. Each data set is divided into the training set and the test set. The training set accounts for 80%, and the test set accounts for 20%. The investment risk of both methods on the test suite is compared to standard risk, which is the risk of not making any trades and holding only stocks. Finally, the comparison results are displayed as tables and line graphs.

4.3. Comparative Analysis of Investment Stability

From an investment stability perspective, investment strategy is the fundamental relationship of investment activities and the central embodiment of the investment effects. Therefore, investment strategies take investment objectives as the leading generation logic. Investors are the main deciders of investment strategy and the main subject of investment activities. At this stage, investors strengthen control over investment strategies from the perspective of risk management in three main forms: one is dynamic adjustment. Clarifying the transition of investment strategies between different market environments and different periods. The second is standardization. Gain standard control over investment strategies by formulating return targets and risk tolerances of investment strategies and disclosing the contents of investment strategies to regulatory bodies. The third is to restructure the internal process of the investment process. In recent years, based on deep Q-networks and strategic gradient methods, artificial intelligence has been used to improve investment strategies and efficiency. However, compared with the advanced international level, the current investment stability of China's stock market needs to be further improved.

5. Conclusion

Stock market investment strategies based on deep Q-networks and strategic gradient methods are gaining attention in the financial field, bringing new challenges and demands to investors and researchers. In addition, the stock market investment strategy is not only a symbol of investors' "rationality", but also an important means of investment effect, and it is also an urgent need to realize wealth appreciation and maintain market stability, which essentially embodies the inherent requirements of modern investment theory. Driven by data, artificial intelligence has built a theoretical analysis framework and practical mechanism for stock market investment strategies based on deep Q-network and strategy slope method. In recent years, modern information technology, such as deep learning, has spurred innovation in investment strategies in the stock market. Enabling the design and execution of investment strategies through the transaction signal collection system and the evaluation method to improve the accuracy and scientificity of investment strategies and their value in line with the internal logic of the market environment. Therefore, the method based on deep Q-network and strategy gradient also provides a new path for stock market investment strategy. In short, the improvement and sustainable development of stock market investment strategies based on deep Q-network and strategic gradient method not only better meet the needs of investors but also promote the healthy development of the stock market.

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