

Research on The Comprehensive Planning Model of Gold and Bitcoin

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Abstract. In this paper, we preprocessed the data for outliers and added the prices of gold and bitcoin to the training. At the same time, based on the price of the day, we also established a strategy model based on the Sharpe ratio and particle swarm algorithm. We established a comprehensive planning model for cash, gold, and Bitcoin through the planning process. A particle swarm algorithm simulated the optimization process, and the optimal solution was found. Finally, through the sensitivity analysis, we found that as the transaction fee increases, the number of transactions of gold and Bitcoin decreases significantly, and the value decreases.

Keywords: LSTM Neural Network, Sharpe Rate, Particle Swarm Optimization.

1. Introduction

Market traders often buy and sell volatile assets to maximize their total return. There is usually a commission for each sale. Two of these assets are gold and bitcoin. Traders have asked us to develop a model that uses only the daily price stream in the past to date to determine whether traders should buy, hold or sell assets in their portfolio daily [1]. We will start at \$1000 on November 9, 2016. We will use a five-year trading period from November 9, 2016, to October 9, 2021. On each trading day, the trader will have a portfolio consisting of cash, gold, and bitcoin [C, G, B]. Dollars, Troy Ounce and Bitcoin. The initial state is [1000, 0, 0]. The commission cost per transaction (buy and sell) is $\alpha\%$ of the transaction amount. Assume Alpha Gold = 1% and Alpha Bitcoin = 2%. There is no cost to hold the asset.

John Bull Williams believes that the intrinsic value of its business determines the stock price. He also first proposed the mathematical formula of value calculation, which was the prototype of the later dividend discount model. The theory can be defined as all the value of all stocks, bonds, or stocks, depending on inflow and outflows. It is expected to generate over the entire remaining life of an asset. It is discounted to the current amount at the appropriate discount rate. John Bull Williams was the first scholar of the concept of value investing in the securities market [2].

Benjamin Graham is known as the "father of modern securities" he and David Dodd co-published the book "securities analysis" in 1934, the first from the perspective of internal stock evaluation, to find out the internal determinants of stock investment value, put forward the stock investment value analysis theory, that the stock investment value determines the stock price. Graham mainly from the perspective of financial analysis, through the analysis of a planned investment stock balance sheet, profit statement, cash flow sheet, and other related items, to asset quality, profitability indicators as investigation point, get the target stock investment value, but also put forward from the external factors affecting the stock value analysis, get the stock investment value [3]-[4].

Loren Buffett is known as the "father of investment," he is based on Benjamin Graham's value investment theory, combined with Philip Fisher's growth investment analysis theory, through their long-term investment practice and their understanding of stock value investment, summarily put forward the development of growth investment value analysis theory. He insists on his investment philosophy, that is, every investor should regard himself as the actual shareholder and interest winner of the enterprise he wants to invest in so that investors will proceed from their standpoint and take into account the stock development strategy and long-term profit status while considering their interests.

Since November 9, 2016, we have predicted the future price trend of gold and bitcoin based on the neural network model of long-term and short-term memory. Based on the price data of the day, in order to give a daily trading strategy, we can use the neural network model based on the previous data, get the latest price through prediction, and get the best strategy through the optimization of the planning model. Secondly, we need to determine the sensitivity of the strategy to transaction costs. Through sensitivity analysis, we found that the model is in good agreement, especially if the transaction fee increases, the number of transactions of gold and Bitcoin will be significantly reduced, which is consistent with our understanding.

2. Establishment And Solution Of Model

2.1. LSTM neural network

Among various neural network models, recurrent neural networks (RNN) are designed to handle time-series information better. It introduces state variables to store past information and determines the current output and the current input.

For a long time, latent variable models have problems of long-term information preservation and short-term input missing. One of the earliest solutions to this problem was long short-term memory (LSTM). The LSTM neural network structure is shown in Fig.1.

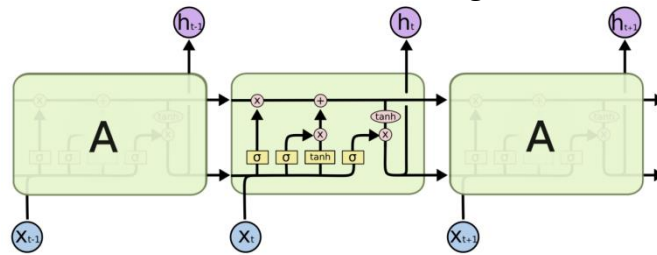


Figure 1 Structural diagram of the LSTM neural network

In the network structure of LSTM [8], the forgetting door is responsible for receiving the previous moment information to the current point, which determines the previous memory unit state can be retained to the current moment. The purpose of the logical unit is to forget the useless information, forgetting door according to the output of the previous moment and the input of the information retention degree: c_t, h_{t-1}, x_t, f_t

$$f_t = \text{sigmoid}(W_f [h_{t-1}, x_t] + b_f) \quad (1)$$

First, the input door is based on the output h of the previous moment and the input x_t for the current moment to figure it out:

$$i_t = \text{sigmoid}(W_i [h_{t-1}, x_t] + b_i) \quad (2)$$

Where W_i is the linear combination of the hidden layer output h_{t-1} at the previous moment and the input x_t at the current moment. The parameter matrix of b_g represents a biased item.

Then the z_t is calculated:

$$z_t = \tanh(W_g [h_{t-1}, x_t] + b_g) \quad (3)$$

Updated current moment memory unit status c_t for:

$$c_t = f_t \cdot c_{t-1} + i_t \cdot z_t \quad (4)$$

Computing the information output degree o_t :

$$o_t = \text{sigmoid}(W_o [h_{t-1}, x_t] + b_o) \quad (5)$$

The final output is the output h_t at the current moment:

$$h_t = o_t \cdot \tanh(c_t) \quad (6)$$

This paper chooses the more common maximum and minimum standardization [5]. In the data preprocessing stage, we map the value of the data to $[0, 1]$, and after the prediction result is obtained, the obtained prediction value is reversed.

The max-min normalized mapping function:

$$y_i = \frac{x_i - \min_{1 \leq j \leq n} \{x_j\}}{\max_{1 \leq j \leq n} \{x_j\} - \min_{1 \leq j \leq n} \{x_j\}} \quad (7)$$

Since the prices of gold and bitcoin are updated every day, we can add the latest prices of gold and bitcoin into our training set every day, and under this, our training set has been expanded, thus Ability to better predict future gold and bitcoin prices.

We bring in the data, add the latest gold and bitcoin prices to the training set every day for continuous training, record the predicted values, and the fitting results are as shown in Fig.2 and Fig.3.

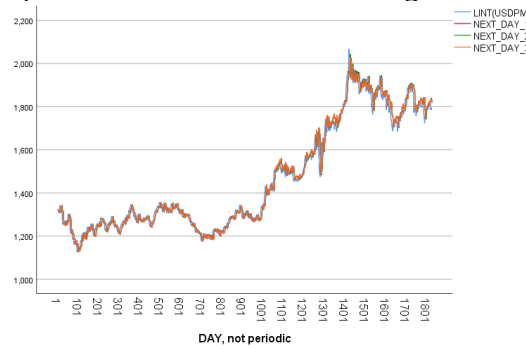


Figure 2 Gold price prediction renderings

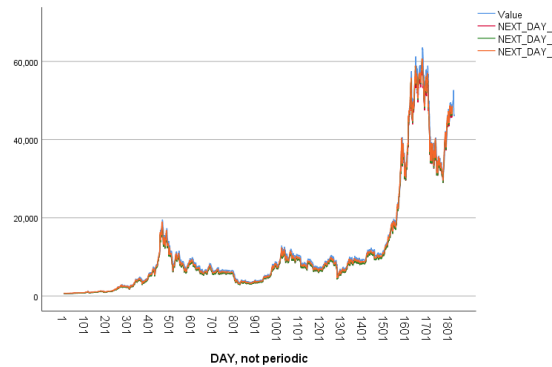


Figure 3 Bitcoin price prediction renderings

2.2. Policy Model

2.2.1. Sharpe ratio

According to the prediction result, on the k th day, we will have the data of the k th day and the prediction result of the k th day. In order to better quantify the relationship between daily investment risk and return, we introduce the Sharpe ratio. The Sharpe ratio (Sharpe, 1966) proposed the Sharpe ratio based on modern portfolio theory. The Sharpe ratio pays attention to the return of the asset and pays attention to the risk of the asset. It measures the return of the asset after adjusting the risk and is the price display of the unit risk. Since the Sharpe ratio comprehensively reflects the risk-return characteristics of the capital market, it has been widely used in evaluating asset portfolios' performance, judging the capital market's operating efficiency, constructing effective asset portfolios, and guiding investment decisions. Its mathematical expression is:

$$E(r_p) = c_k \cdot E(r_c) + g_k \cdot E(r_g) + b_k \cdot E(r_b) \quad (8)$$

$$\delta_p = \sqrt{g_k \delta_g^2 + b_k \delta_b^2 + 2g_k b_k \text{cov}(G, B)} \quad (9)$$

$$SR_p = \frac{E(r_p) - r_f}{\delta_p} \quad (10)$$

In the formula, $E(r_p)$, δ_p , r_f are the expected return, the standard deviation of the return, and the return of the risk-free asset during the observation period, respectively.

According to our assumption, for the function f_k , The amounts will remain the same for the next three days. Therefore, in the following process ΔG_{k+1} and $\Delta G B_{k+1}$ directly equal to 0 until the third day, and then calculate the Sharpe rate of the third day. Constraints: After all operations are performed on the day, the proportion of cash, gold, and Bitcoin in total assets should be greater than or equal to 0.

In seeking the optimal trading strategy, to obtain the optimal solution of the objective function, we use the particle swarm algorithm to simulate the optimization process and seek the optimal solution. The particle swarm algorithm simulates birds in a flock by designing a massless particle. The particle has only two properties: speed and position. The speed represents the movement speed, and the position represents the direction of movement. Each particle independently searches for the optimal solution in the search space and records it as the current individual extremum. It shares the individual extremum with other particles in the entire particle swarm, which finds the optimal individual extremum as the entire article. Then, the current global optimal solution of the swarm, all particles in the particle swarm adjust their speed and position according to the current individual extreme value found by themselves and the current global optimal solution shared by the entire particle swarm [6].

PSO is initialized as a group of random particles (random solution). Then iteratively find the optimal solution. In each iteration, the particle updates itself by tracking two "extremes" (pbest, gbest). After finding these two optimal values, the particle updates its velocity and position by the following formula.

To obtain the optimal value of each variable further, the particle group algorithm (PSO) is introduced to solve it. The idea of particle group algorithm comes from the foraging process of birds and belongs to the category of intelligent algorithms. At first, each bird is randomly in different positions, and they cannot determine the optimal foraging point when each bird's flight speed and direction are random. Over time, the birds transmit foraging information to each other so that each bird can judge the foraging value of the current location based on its own experience and peers and then start in the direction of greater foraging value. The particle swarm algorithm is designed based on the characteristics of birds foraging, abstracts the birds into particles, quantifies the flight direction and speed of the birds as the various dimensions and instantaneous velocity of the particles, and simulates the best decision-making process.

First, this paper initializes the particle population so that the population size is k , and then the particle population can be expressed as:

$$G = \{g_1, g_2, g_3, \dots, g_k\} \quad (11)$$

Each particle in the particle group has the dimensions in n directions, the corresponding coordinates and the instantaneous velocity in each dimension. When the current number of iterations is t , the position and speed of each particle are recorded as:

$$x_i^t = (x_{i_1}^t, x_{i_2}^t, x_{i_3}^t \dots x_{i_n}^t) \quad (12)$$

$$v_i^t = (v_{i_1}^t, v_{i_2}^t, v_{i_3}^t \dots v_{i_n}^t) \quad (13)$$

The second value of the $1i_k$ target corresponds to a particular dimension of the particle. Notably, the position and velocity of the particles in different dimensions need to be limited, i. e:

$$x_{i,j}^t \in [\min dis(j), \max dis(j)] \quad (14)$$

$$v_{i,j}^t \in [\min vel(j), \max vel(j)] \quad (15)$$

Among them, $1 \leq i \leq k$, $1 \leq j \leq n$. In order to calculate the fitness value of the particle, this paper needs to introduce an adaptation function with the particle position as the independent variable, recorded as:

$$fit_value = fit(x_i^t) \quad (16)$$

Where the fit_value is the fit value, when particles iterate, this paper needs to update the optimal position of individual particles and the optimal position of the particle group, recorded as:

$$x_{i_best} = fit^{-1}(\max fit(x_i^r)) \quad (17)$$

$$x_{best} = fit^{-1}(\max fit(x_{i_best})) \quad (18)$$

Where $0 \leq r \leq 1$, the best position of the particle from the number of iterations as the optimal position of the single-particle, and the best one from the optimal position of each particle is the optimal position of the whole population.

Based on the above discussion, the particle velocity and position:

$$v_i^{t+1} = \alpha v_i^t + \beta r_1 (x_i^t - x_{i_best}) + \gamma r_2 (x_i^t - x_{best}) \quad (19)$$

$$x_i^{t+1} = x_i^t + v_i^{t+1} \quad (20)$$

Where α represents the weight of inertia, β the self-learning factor, and γ the group information transfer factor r_1 and, r_2 Represents the random number within the $[0,1]$ range, used to increase the randomness of the search. It should be noted that the position and velocity of the particle are the vectors, and the formula design follows the principle of the vector operation.

The particle group algorithm process is roughly shown in the following Fig.4.

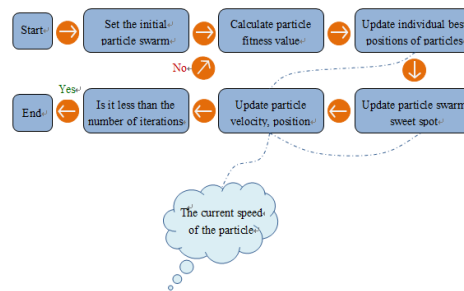


Figure 4 Schematic diagram of the particle group algorithm

3. Model Improvements

In the above model process, when we used the financial Sharpe ratio as the objective function, the investment strategy was too conservative, and we invested as much as possible in gold instead of Bitcoin. It is because Bitcoin is different from traditional financial projects. Its daily fluctuation range is enormous, the variance will be large, and the Sharpe ratio will reject such a considerable risk. Therefore, the final rate of return is not high.

In fact, for investors, different personalities will lead to different investment strategies [7]. In addition to using a single Sharpe ratio as the objective function, we can also use other methods to characterize different people's mental expectations of risks and returns. We Set two types of people as aggressive type (without considering the existence of risk) and stable type (with Sharpe ratio as the objective function) to develop different investment plans.

We use the standard deviation of the predicted values for the next three days σ_k . As a risk assessment value, if the predicted price fluctuations in the next three days are relatively large, the future risk is relatively large.

When building the model for aggressive personality, we set the objective function f_k . Set as the maximum benefit after three days, for stable personality, we set the objective function f_k . Still set to the maximum Sharpe after three days.

In the end, the investment plan and the daily rate of return can get the total investment value of aggressive type is 33234200000 dollars, and the total investment value of a stable investment is 1237.22 dollars.

4. Sensitivity Analysis

As shown in table 1, a_gold and a_bit represent the transaction fee ratio of gold and Bitcoin, respectively, and returns represent the final benefit. As the transaction fee increases, the number of transactions between gold and Bitcoin decreases significantly, and the final value increases. Decrease, as the fee becomes low, the number of transactions of gold and bitcoin increases significantly, and the final value rises.

Table 1 The transaction fee ratio of gold and bitcoin,

a_gold	1%	1.30%	0.70%	1%	1%	0.70%	1.30%
a_bit	2%	2%	2%	1.70%	2.30%	1.70%	2.30%
returns	128675	78214.4	172153.1	458137.1	21249.6	1368392	16653.4

In order to prove that the solution we choose is the optimal local solution, we can consider giving the result a certain disturbance and explain that the result after disturbance is no longer the maximum value of the objective function. Specifically, for our above gold and bitcoin, add the fluctuations of 1%-3% to the buying and selling plan and re-plan the buying and selling plan. The results of multiple tests are shown in Table 2. Therefore, the investment scheme we choose is a local optimum, which is effective.

Table 2 Sensitivity of the strategy to transaction costs

sharp en	OUR_RES ULT	MORE_G OLD	MORE_BIT COIN	ALL_M ORE	LESS_G OLD	LESS_BIT COIN	ALL_L ESS
1%	4.8467	4.4464	4.3358	3.969	4.5724	4.3386	4.6137
2%		4.2836	3.9132	4.1634	4.3219	4.5859	4.5984
3%		4.3151	3.7451	3.85	4.1226	4.6124	4.5626

5. Conclusion

This paper establishes a strategy model based on sharp interest rate and particle swarm optimization algorithm and a comprehensive planning model for cash, gold, and currency. Secondly, an iterative optimization algorithm similar to the genetic algorithm is proposed. The system is initialized to a set of random solutions and iteratively finds the optimal solution. Finally, a sensitivity analysis is performed on the models we consider.

6. References

- [1] I. V. Igor, I. L. Anastasia, S. D. Alissa, A. Alain, Investment Models for Enterprise Architecture (EA) and IT Architecture Projects within the Open Innovation Concept, Journal of Open Innovation: Technology, Market, and Complexity, 2021, 7(1).
- [2] Wang D, Quantitative Investment Model Based on Data Mining, Revista Internacional de Métodos Numéricos para Cálculo y Diseño en Ingeniería, 2020:

- [3] D. J. Fang, The current situation and development trend of deep learning in quantitative investment at home and abroad, *Modern Business*, 2022(01): 120-122.DOI: 10.14097/j.cnki.5392/2022.01.038.
- [4] M. O. Dra, C. H. ILcher, A probabilistically constrained extension of the integrated portfolio investment model, *Energy Reports*,2020,6(Supl.1):
- [5] T. Luo, N. Metawa, Intelligent algorithm of optimal investment model under stochastic interest rate and stochastic volatility, *Journal of Intelligent and Fuzzy Systems*,2019,37(1):
- [6] Y. W. Yi, S. L. P ing, M. B. Qi, Research on Dynamic Cointegration of Gold and Bitcoin: Based on Semiparametric MIDAS Quantile Regression Model, *Systems Science and Mathematics*, 2020, 40(07): 1270 -1285.
- [7] M. Kim, P. Koo. A Study on Big Data Based Investment Strategy Using Internet Search Trends, *Journal of the Korean Operations Research and Management Science Society*,2013,38(4):
- [8] T. Cheng, Research on quantitative investment based on Attention-LSTM deep learning method, *Business News*, 2021(36):155-157.