BP neural network predicts the exchange rate of US dollar against gold

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Abstract. Gold and the US dollar are important currencies, and their price changes reflect changes in the world and North American economies. The gold market has become a financial investment market of equal importance to markets such as stocks, foreign exchange, and bonds. In such a situation, the price change of gold has become an important predictive research object. However, due to the changing world landscape, the randomness of gold price changes, and the existence of exchange rate and other influencing factors, it is very difficult to predict. It is crucial to establish a prediction model for exchange rate changes over time. This topic establishes a neural network model for exchange rate changes over time using the newly developed Back Propagation Neural Network in recent years. Finally, after several experiments, the parameters are adjusted to the optimal state to obtain the minimum error result. Through this study, we can determine that the prediction function of the BP artificial neural network can be applied in certain fields of life, but it also has significant limitations, to make it a complete tool for our daily life or work, it is necessary to further improve this technology.

Keywords: Error back propagation algorithm, Back-Propagation Neural Networks, real-world applications.

1. Introduction

Gold is an extremely special commodity. Its uniqueness is mainly manifested in: firstly, gold is an ideal value carrier that is divisible, difficult to destroy, has high unit value, and is relatively easy to move; Secondly, gold is a highly homogeneous, easily identifiable, widely accepted, and highly liquid asset; Thirdly, the flow of gold is almost negligible relative to its stock, so the price of gold can maintain relatively strong stability. Therefore, for thousands of years, gold has been regarded as the ultimate means of storing value and a safe haven asset in turbulent times. [1]

When the gold price market becomes more and more important, how to establish the prediction model of exchange rate changes with time becomes very important. The Multilayer Perceptron (MLP) network, which has the benefits of a straightforward structure, a minimal number of calculations, and artificial intelligence (AI) neural network technology, has advanced, has gradually stood out from various major technologies. [2]

As a complex regression problem, price forecasting can be solved by using neural network to simulate its complex functional representation. For gold and foreign exchange, their prices at a certain time point in the future are closely related to historical data and have strong time correlation. To study the prediction task of this time related data, we should first consider selecting cyclic neural network as the research direction. [3]

However, thorough investigation revealed that it still has flaws, which restricts its use. The exception (XOR) and several other issues that the simple perceptron could not resolve were resolved by the error back propagation training (BP) method, which was developed by various scientists in the middle of the 1980s and could be used to forecast the price of gold. [4]

The research objective of this topic is to collect data by using metarader4 and establish a neural network model of exchange rate changing with time by using BP neural network, so as to provide reference for investors.

Development status of artificial neural network prediction:

In recent years, with the popularization of big data and high-performance computing, the application scope of neural network technology has continued to expand. In the fields of image recognition, speech recognition, natural language processing and other fields, neural network technology has achieved remarkable results. For example, deep learning models have surpassed humans in image recognition accuracy, and have also made huge breakthroughs in machine translation and intelligent dialogue systems.

2. Method

2.1. Data collection

This article chooses to collect the dollar price of gold from the metatrader4 platform. Through specific data, we can more intuitively feel the fluctuation of the dollar price of gold. After that, we choose the gold dollar price from February 8th, 2023 to July 26th, 2023. Within this range, the gold price of each day can help us relatively accurately predict the next trend of the gold price.

2.2. Data Analyzed

It can be seen from the data that has been collected that the price of gold generally shows a trend of first falling and then rising, which is related to the impact of economic changes in the world and North America on the gold market.

Take the gold dollar price of MT4 platform from June 8, 2022 to November 8, 2022 as the input variable, select the gold dollar price from February 8, 2023 to July 26, 2023 as the output variable, and select the gold dollar price of MT4 platform from February 8, 2023 to July 26, 2023 as the comparative data.

2.3. Model

The BP neural network from Matlab R2023a is used in this paper's simulation experiment.

The BP neural network's performance and network theory have improved. Its primary advantages are flexible network topology and strong nonlinear mapping capacity. The topology of the network impacts how well it performs, and the number of intermediate layers and neurons in each layer of the network on be freely altered depending on the individual situation.[5]

However, the BP neural network also includes the following significant flaws.

1. The rate of learning is slow. Even if the issue is straightforward, machine learning typically needs to be applied hundreds or even thousands of times before it is successful.

2. Accepting the local minimum is simple.

3. There is no equivalent theoretical direction for choosing the quantity of network layers and neurons.

4. The capacity for network promotion is constrained.

There are numerous ways to solve the aforementioned issues, but the area of research that has received the most attention is how to speed up network convergence and prevent the network from entering the local minimum.

The basic principle of neural network: Each neuron multiplies the original input value by a specific weight, adds further input values (and combines more information values), and then calculates a sum. Next, each neuron adjusts its own deviation before standardizing the output value using the excitation function. Basically, neural networks are connected by different computing unit layer by layer. We call the unit of calculation neuron. [6]

These networks can classify data processing, which is the output we want.

The particular steps in BP neural network training are:

1. Following network initialization, configure the error function E, the calculation accuracy, and the maximum learning times. Next, assign each connection weight a random value with a range of [-1, 1];

2. Pick the nth training sample and associated expected result at random;

3. Calculating the hidden layer: determine each hidden layer neuron's input and output;

4. Determine the partial derivative of the error function for every neuron in the output layer by calculating the network's expected and actual outputs;

5. Correction weight: use the partial derivative of the output layer neuron and the output of the hidden layer neuron to correct the link weight;

6. Correction weight: use the partial derivative of hidden layer neurons and the input of input layer neurons to correct the link weight;

7. Calculate the global inaccuracy of the new model once the connection weight of the model has been corrected;

8. Determine whether the present model satisfies the requirements by evaluating the model's logic. If not, choose the subsequent random learning sample and matching predicted result to carry out the subsequent learning.

We need to ensure that the selected model can ensure the efficiency of its prediction in different data sets, and to verify that the performance of other models cannot be improved to the same level as or beyond the selected model, we conducted the second stage of model validation. In this stage, we selected two representative data sets in the real gold and foreign exchange data as the validation objects, On the basis of the training and prediction results of the five kinds of networks designed in detail, their single-layer, two-layer, three-layer and four layer structures are respectively constructed as validation, and the train is verified by comprehensively comparing the parameters of the model, the time loss of training, the loss, the fitting degree of the prediction results and other factors_ Whether the best model performance selected by the model () function meets the requirements. In these two datasets, the performance of different models is shown. Through comparative experiments, train is verified_ The single-layer BP model selected by the model () function has the best performance, so the system price forecasting model finally chooses the single-layer BP network structure.

2.4. Gradient descent technique

In BP, training mistakes are used to gradually alter the input weights and biases between each layer. The least squares approach and the gradient descent method are the two algorithms that serve as the foundation for this adjustment procedure.

The input weight and bias are quadratic functions that describe the training error (loss function). The gradient vector is obtained, together with the partial derivatives of the weight and bias, respectively. The training error grows most quickly in the direction of the gradient vector, and the gradient shrinks most quickly in the opposite direction, making it simpler to locate the minimum of the training error function (loss function) in this direction. [7]

2.5. BP algorithm

The two processes that make up the basic BP algorithm are the forward propagation of signal and the reverse propagation of error. In other words, even though the threshold and weight adjustments are made from input to output, the computation of error output is done the other way around the output node is impacted by the input signal's forward propagation through the buried layer, and the output signal is produced by nonlinen modification. The real output will be passed along to Cheng's back propagation of error in the case that it differs from the expected output.

By retransmitting the output error from the hidden layer to the input layer by layer, assigning the error to each layer's units, and modifying each unit's weight depending on the error signal obtained from each layer, the error back propagation approach can reduce errors. The error decreases in a gradient-like fashion when the connection strength between the input node and the hidden layer node, as well as the connection strength and threshold between the hidden layer node and the output node, are changed. The training is finished once the network parameters (weights and thresholds) matching to the least error have been established through repeated learning and training. Currently, the trained

neural network is capable of processing the input data from comparable samples on its own and the nonlinear transformed data with the least amount of output error. As displayed below.[8]

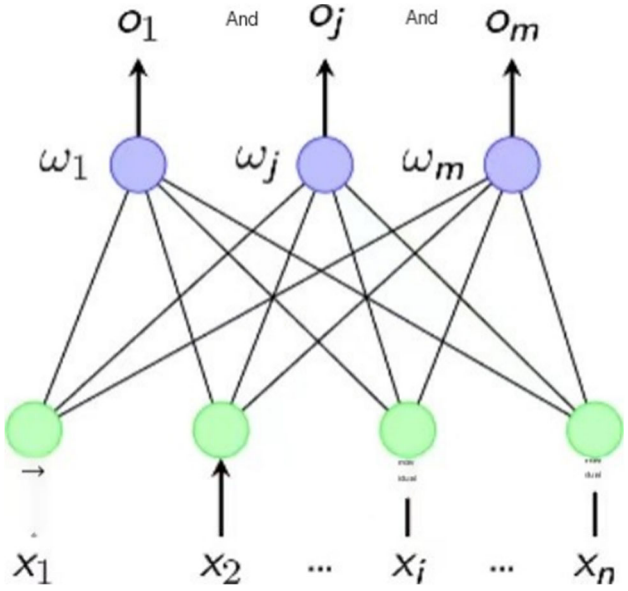

Figure 1. Neuron node

The model in figure 1 is used in this experiment, and the specific parameters are as follows:

Learning rate 0.01

Epoch 1000 in total

2. Results: Compared to the control group, the treatment group's overall effective rate was significantly greater.

3. Result

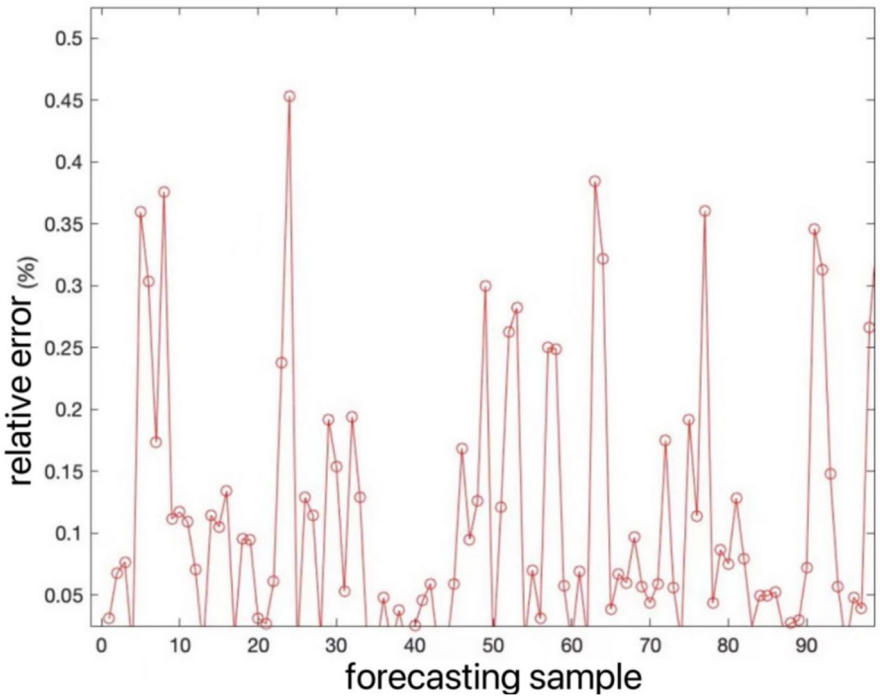

Figure 2. Error chart

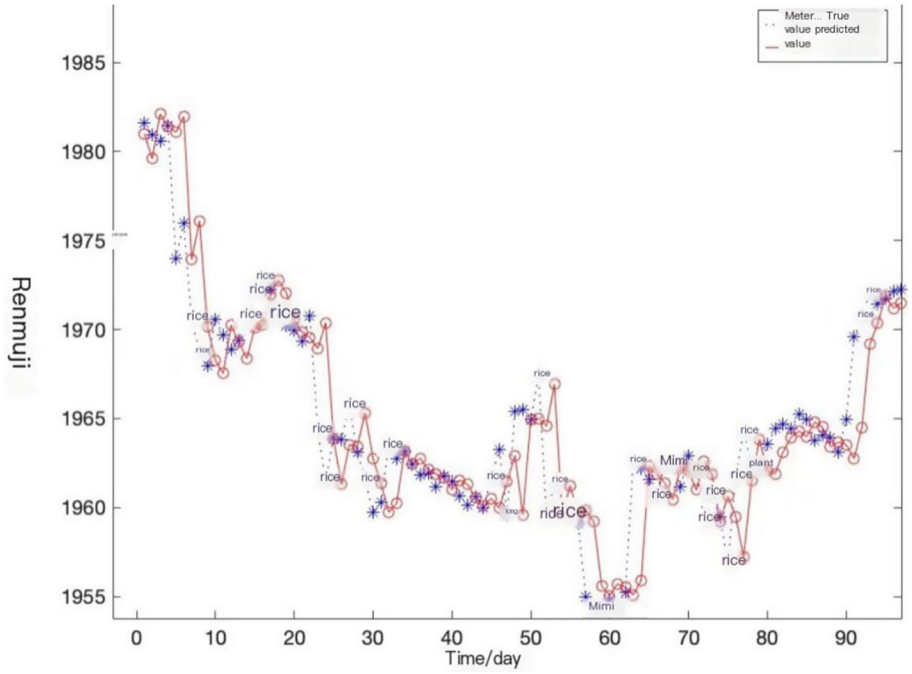

Figure 3. Error chart

3.1. Chart description

The figure 2 and figure 3 shows the change in the US dollar price of gold from February 8, 2023 to July 26, 2023, and the predicted value of BP neural network. It can be seen that the gold price reached its peak at the beginning of the chart, about US $1982, and then suddenly fell by about US $150 to the 10th sample. After a period of relative stability, the price continued to fall until the 31st sample reached US $1960

After a short recovery, the price dropped sharply to $1955. After experiencing a sudden increase of $1962 and a decline during the period of slow growth, it suddenly increased by about $12 in the 94th forecast sample, and finally reached $1973. For the prediction line, according to the actual line, the deviation is very small, just a little ahead of schedule. The chart shows the accuracy of Back-Propagation Neural Network.

3.2. Back-Propagation Neural Network training process

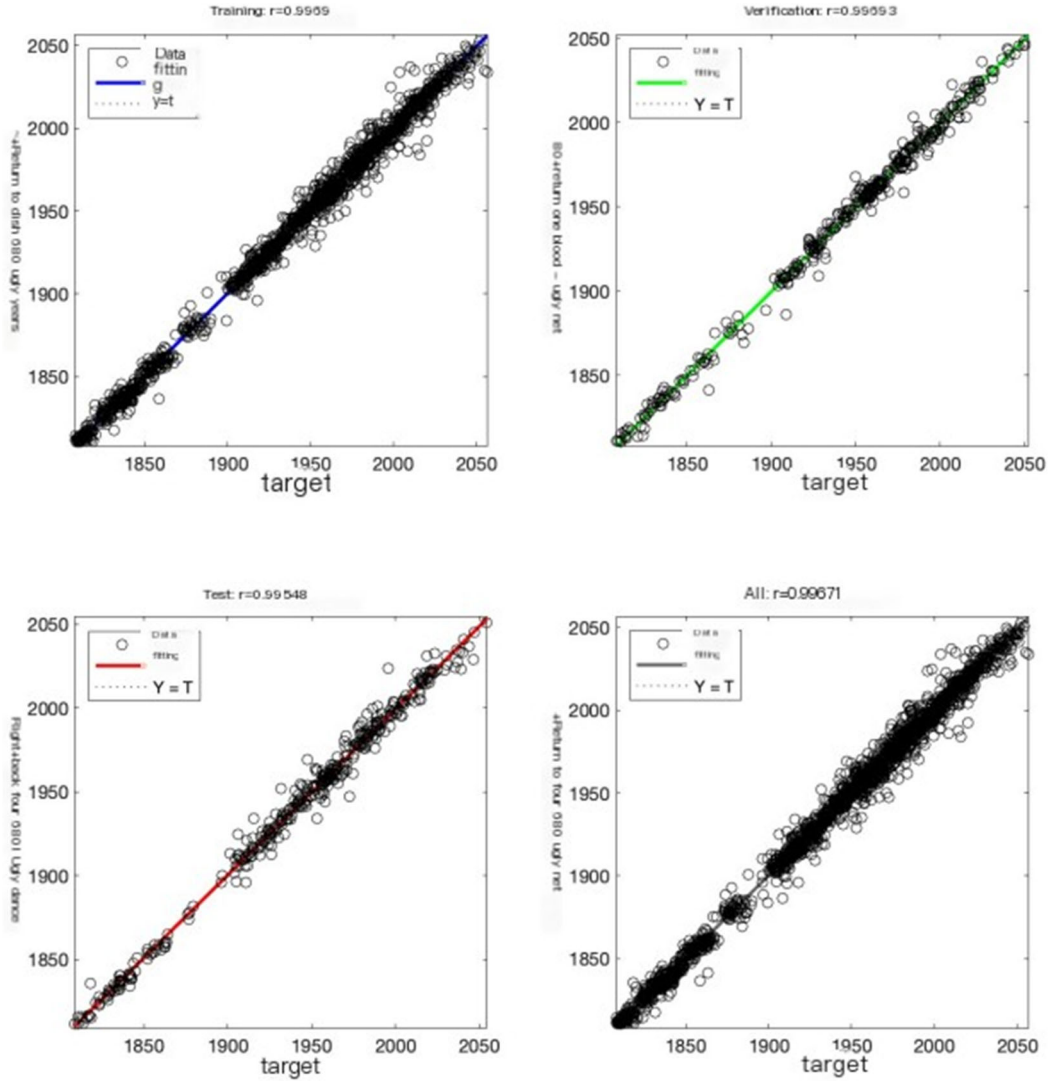

Figure 4. Training Results Chart

The outcome of this neural network's regression analysis is shown by figure 4. In the graph, "R" stands for the correlation between the expected and desired results. The relationship between the forecast and the output data is more closely correlated as the "R" value gets closer to 1. The correlation between the prediction and the output data has a higher degree of randomness the closer the "R" value is to 0. It can be concluded that the best result of the model training is the top right.

Overfitting occurs in the training process, that is, it performs well on the training data, but the error of comparing the training results with the assumed data is large. In the process of using BP neural network, it is too difficult to collect data samples, and various uncertainties need to be considered, such as the change of world pattern and a series of uncontrollable factors. [9]

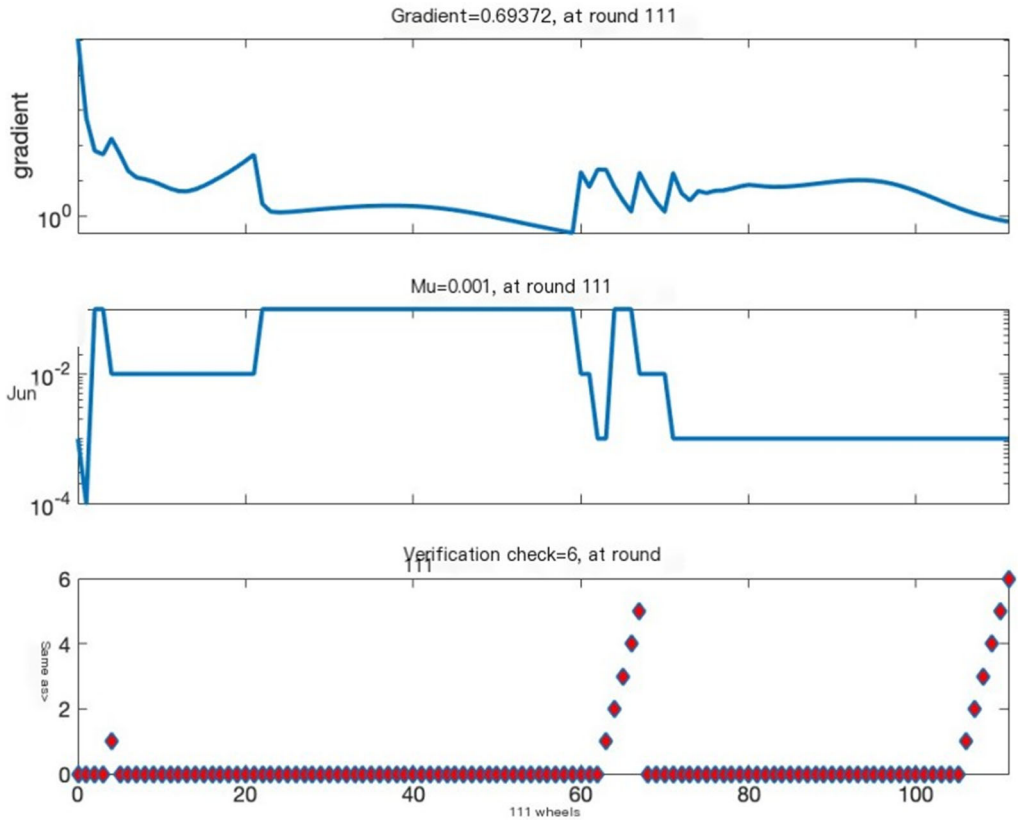

Figure 5. Training gradient chart

The three figures in figure5 represent gradient, error accuracy parameter and confirmation check respectively

In BP neural network prediction, the smaller the gradient of the model is, the smaller the error will be. In the first figure, we can see that the overall trend of the gradient of the model is declining, so the error will gradually decrease.

The second figure shows the error accuracy parameter, which rises rapidly at first, then fluctuates irregularly, then fluctuates after a period of stability, and finally drops to a stable parameter. This process is to find smaller errors. This is the gradient descent method.

Forward propagation of input patterns, inverse propagation of output mistakes, cyclic memory training, and discrimination of learning results make up the core four components of the learning process of BP neural networks. The learning process of this technique involves both the forward propagation and the backward propagation stages. Layer by layer, beginning at the input layer and passing through the hidden layer unit before arriving at the output layer, information is processed as it moves ahead. Only the neurons in the layer above are affected by the state of the neurons in the layer below. If, after switching to backward propagation, the desired output cannot be obtained at the output layer, the error signal is returned along the original connection channel. By modifying the weights of neurons in each layer, the error signal is reduced to the desired level. and then turn to the process of forward propagation. Repeat the iteration until the error is less than the given value.[10]

4. Discussion

BP neural networks are multilayer feedforward neural networks that have been trained using the error back propagation method. This computation technique combines forward and backward computation. The input mode is processed layer by layer using the forward propagation method, beginning at the input layer and continuing through the hidden unit layer, output layer, and output layer. The health of the neurons in the layer above only affects those neurons in that layer. If, after switching to back propagation, the required output cannot be captured at the output layer, the error signal is sent back via the original connection channel. It will be possible to reduce the erroneous

signal by adjusting each neuron's weights. To sum up, we can now divide the known data we collected into two parts according to time - "known data" and "hypothetical data". First, let the neural network train in the "known data" and predict the training results, and then compare the training results with the "hypothetical data", we can get the results similar to the "hypothetical data". It can be seen from the last chart in the "conclusion" above that the error in the BP neural network prediction experiment may be due to over fitting. It is recommended to check whether the training effect is good, but the error between the prediction results and the collected "hypothetical data" is too large. If this happens, it is caused by over fitting. Secondly, if the error is large, you can try to normalize the collected data, which can improve the stability of the BP prediction model. The normalized data loss function is smoother and easier to train. We can also consider collecting and filtering new data on the "gold dollar exchange rate" again, and changing the dimensions of input and output data. However, when using BP neural network, we should also pay attention to its limitations. For this experiment, it is too difficult to collect data samples, so we need to consider a variety of uncertainties, such as the change of the world pattern and a series of uncontrollable factors, or the above-mentioned fitting situation.

In short, to improve the prediction accuracy of the BP, we need to comprehensively consider the learning rate, model structure, data quality and other factors, and adjust and optimize according to the actual situation, so as to improve the prediction effect. In the process of using it, we should also pay attention to its limitations.

5. Conclusion

This paper mainly describes the practical application of BP neural network prediction function and what is BP neural network.

Scientists under the direction of Rinehart and McClelland presented the idea of a back-propagation neural network in 1986. An error backpropagation technique was used to train a multi-layer feedforward neural network, one of the most well-known neural network models.

In this study, we used BP neural network to simulate and predict the actual data of gold to us dollar exchange rate in the past five months, and finally achieved an ideal result (as shown in the result Section 3.1 above).

To sum up, we can determine that the prediction function of BP artificial neural network can be applied to some areas of life, but it also has great limitations. In order to make it a tool for our daily life or work, we need to further improve the technology.

Gold and the US dollar are important currencies, and their price changes reflect the economic changes in the world and North America. The gold market has become a financial investment market with the same importance as the stock, foreign exchange, bond and other markets. Under such circumstances, the price change of gold has become an important prediction research object. However, due to the randomness of gold price changes and the existence of exchange rate and other factors, it is very difficult to predict.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

References

[1] Zhang Ming (2014) The fluctuation trend and influencing factors of global gold prices.

[2] Qiao Ruoyu (2019) A stock prediction model based on neural networks Operations Research and Management, 28 (10), 132.

[3] Zhang Hongjian, &Sun Zhiqiang (2007) Modern testing technology Hua xue gong ye chu ban ye.

[4] Wu Jianhua (2006) Theory and Practice of Comprehensive Automation System for Water Conservancy Engineering China Water Resources and Hydropower Publishing House.

[5] Yu Jing (2015) Evaluation and strategic research on sustainable supply of important mineral resources Economic Daily Publishing House.

[6] Zhou Kaili, &Kang Yaohong (2005) Neural network model and MATLAB simulation program design Tsinghua University Press Co., Ltd.

[7] Zhang Lianying, Zhang Jinping, &Wang Liang (2004) Genetic Algorithm for Resource Balancing in Engineering Projects and Its MATLAB Implementation Journal of Management Engineering, 18 (1), 52 - 55.

[8] Zhou Tao, Wang Yunpeng, Gong Jianzhou, Wang Fang, &Feng Yanfen (2015) Review on Model Revision and Method Improvement of Ecological Footprint Journal of Ecology, 35 (14), 1 - 17.

[9] Qiu Hao, Wang Daobo, &Zhang Huanchun (2004) An improved backpropagation neural network algorithm Journal of Applied Science, 22 (3), 384 - 387.

[10] Wen Xin, ZHANG Xingwang, Zhu Yaping, Li Xin·Intelligent Fault Diagnosis Technology: MATLAB Application·Beijing University of Aeronautics and Astronautics Press·2015. 09.