Forecast of money supply based on ant colony algorithm optimized BP neural network

Zhiyang Wang[1, a], Hailong Chen[2], Haodong Hong[3], Yi Zhang[1], Yuxin Sun[1], Xiang Zhou[4], Yuqi Wu[3]

[1]School of Economics, Hainan University, Haikou, Hainan, 570228, China

[2]School of Computer Science and Cyberspace Security (School of Cryptogram), Hainan University, Haikou, Hainan, 570228, China

[3]Management School of Hainan University, Haikou, Hainan, 570228, China

[4]School of Geological Engineering and Surveying and Mapping, Chang'an University, Xi'an, Shaanxi, 710061, China

[a]1243946863@qq.com

Keywords: Ant colony algorithm; BP neural network; money supply; loan balance of financial institutions; prediction model

Abstract: The money supply is an indicator that reflects the country's economic and financial conditions. Changes in the money supply directly affect the country's economic development and people's lives. Therefore, studying money supply has very important practical value. The money supply mainly depends on the loan balance of the financial institution, but the loan balance of the financial institution and the money supply present a more complicated non-linear relationship, and it is difficult to obtain the specific relationship between them by conventional methods. Based on this, this paper optimizes the weights and thresholds of the BP neural network through the ant colony algorithm, obtains the optimal weights and thresholds of the BP neural network prediction model, and uses the optimal weights and thresholds for the BP neural network training and prediction. The simulation results show that the convergence speed and prediction accuracy of the optimized model have been greatly improved. The money supply can be accurately predicted by this forecasting method, which has very important guiding significance for the rapid development of social economy and the stability of people's lives.

1. Introduction

The money supply is particularly important to my country's economic development. The government can control the money supply through the financial market and then intervene in economic development. This is an important means of the country's macro-control of the market. The money supply is affected by many factors, such as money supply, balance of payments, differences in inflation rates, differences in economic growth rates, differences in interest rates, fiscal revenue and expenditure, and foreign exchange reserves. Among them, the scale of credit has the greatest impact on the money supply. The scale of credit determines the amount of money supply. Therefore, studying the non-linear relationship between the loan balance of financial institutions and the money supply is of great significance to predict the money supply.

Literature [1] established a VAR-based multiple correlated time series prediction model to describe the relationship and influence between variables. The VAR model is used to predict my country's money supply M1 and M2. The prediction accuracy is high, and the The desired effect. Sun Yaxing and Xu Tinglan [2] used the ARIMA model to predict my country's money supply and achieved good prediction results. Literature [3] is based on the STM structured time series model, decomposing the original sequence to obtain the trend, cycle, season and irregular components, on this basis, adding intervention components and expanding it into a complex structured time series model. The forecast is based on China's money supply from 1997 to 2015, and the forecast model

has a good forecasting effect.

Based on this, the ant colony algorithm used in this article has the advantages of high accuracy, strong global optimization, and fast search speed, to solve the shortcomings of BP neural network prediction models that are easy to fall into local optimum, slow training rate, and low prediction accuracy. The weights and thresholds were optimized, and the ant colony algorithm optimized BP neural network prediction model was obtained. The simulation results show that the convergence speed and prediction accuracy of the optimized model have been improved, which can better predict the country's currency supply, which is of great significance to the stable development of my country's economy.

2. Ant colony algorithm optimizes BP neural network

2.1 BP neural network

BP neural network is a multi-layer forward feedback network based on error back propagation algorithm. BP neural network has the advantages of simple structure, strong generalization ability, and strong nonlinear mapping ability. It is often used in predictions in various academic fields. Its network structure mainly includes input layer, hidden layer, output layer, as shown in Figure 1.

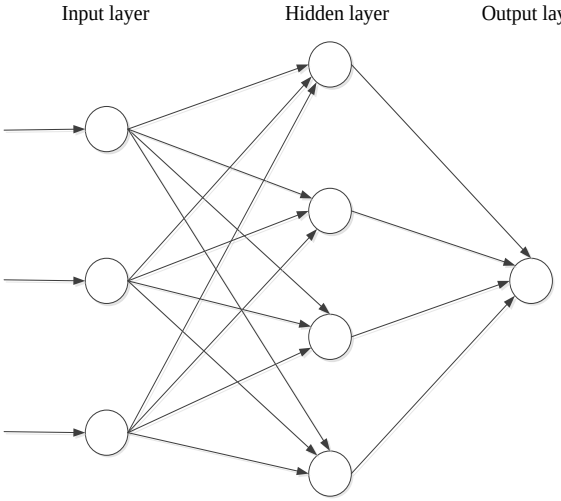

Fig. 1 BP neural network structure

2.2 Ant Colony Algorithm

The ant colony algorithm is a probabilistic algorithm for finding the optimal path in the whole world. It is a heuristic bionic evolution system obtained by simulating the path-finding method of natural ants. When the ant colony is looking for a food source, each ant selects a walking path based on the pheromone concentration released by other ants in a certain range on the path, and releases the pheromone to increase the amount of pheromone on the path. When the pheromone concentration on a certain path gets higher and higher, the probability of it being selected increases. After a period of time, the entire ant colony will eventually follow the path with the highest pheromone concentration. that is to find the food source through the optimal path.

The basic calculation method of the ant colony algorithm is: assuming that the pheromone on the path of the ants are equal, that is $\tau_{ij}(0) = c$ (c is a constant), then at time *t*, the probability of ant *k* transferring from city *i* to city *j* is shown in Equation 1.

$$P_{ij}^{k}(t) = \begin{cases} \dfrac{\left[\tau_{ij}(t)\right]^{\alpha} \bullet \left[\eta_{ij}(t)\right]^{\beta}}{\sum_{s \in J_k(i)} \left[\tau_{is}(t)\right]^{\alpha} \bullet \left[\eta_{is}\right]^{\beta}}, j \in J_k(i) \\ 0, \quad \text{others} \end{cases} \tag{1}$$

Where: $J_k(i)=\{1,2,\mathrm{L}, n\}-l_{t,k}$ is the candidate city for the next step of the ant. The taboo table $l_{t,k}$ records the cities that Ant *k* has walked through. When all the cities are added to the taboo table $l_{t,k}$, Ant *k* has completed a tour. η_{ij} is a heuristic factor that represents the expected degree of ant *k* transferring from city *i* to city *j*, usually the reciprocal of the distance between the two cities. α is the information heuristic factor; β is the expected heuristic factor.

At time *t+n*, when all ants finish a cycle, use Equation 2 to update and adjust the pheromone on each path.

$$\tau_{ij}(t+n)=(1-\rho)\bullet\tau_{ij}(t)+\Delta\tau_{ij} \tag{2}$$

In the formula: ρ is the degree of volatilization of the pheromone on the path, and the value is [0,1], and 1-ρ is the residual degree of the pheromone; $\Delta\tau_{ij}$ is the increase in the total amount of information left by *m* ants on the path after the end of this cycle, as shown in Equation 3.

$$\Delta\tau_{ij}=\sum_{k=1}^{m}\Delta\tau_{ij}^{k} \tag{3}$$

Where: is the amount of information left by ant k on the path in this cycle, calculated by formula (4).

$$\Delta\tau_{ij}^{k}=\begin{cases}\dfrac{Q}{L_k}\\ 0\end{cases} \tag{4}$$

In the formula: Q is a normal number, and Lk is the length of the path that ant k traverses in this cycle.

2.3 Ant colony optimization BP neural network algorithm flow

In this paper, the basic process of optimizing the BP neural network through the ant colony algorithm is: suppose there are m ants, and each ant selects the path according to the state transition probability formula and records the specific parameter values. use these parameter values as the initial weights and thresholds of the BP neural network, calculate the output error of the training sample, and then use the comparison result of the output error and the expected error to adjust the pheromone value and path selection on the path of the ant. Through this method, the optimization is continuously repeated until all the ants converge to the same path, the number of iterations is completed, and then the optimal initial solution is obtained. The optimal initial solution obtained is used as the initial weight and threshold of the BP neural network to further train the network until the calculation error accuracy of the optimized model reaches the expected value.

Suppose that the BP neural network has M weights and thresholds, and each weight or threshold has n values to choose from. The n values of weights and thresholds are randomly generated in the interval [0, 1] to form a set. Let in equation (1), the simplified state transition probability is shown in equation 5.

$$P_j\left(\tau_j^k\left(I_{p_i}\right)\right)=\frac{\tau_j\left(I_{p_i}\right)}{\sum_{s=1}^{n}\tau_s\left(I_{p_i}\right)} \tag{5}$$

Where: $\tau_j\left(I_{p_i}\right)$ is the pheromone value of element *j* in the set.

From equation (2), we get equation 6 for updating each element in the set $I_{p_i}\left(1\le i\le M\right)$.

$$\tau_j\left(I_{p_i}\right)(t+M)=(1-\rho)\bullet\tau_j\left(I_{p_i}\right)(t)+\Delta\tau_j\left(I_{p_i}\right) \tag{6}$$

Where: $\Delta\tau_j\left(I_{p_i}\right)$ is the increment of the pheromone of element j in the set in this cycle. According to formula (3):

$$\tau_j\left(I_{p_i}\right)=\sum_{k=1}^{m}\Delta\tau_j^k\left(I_{p_i}\right) \tag{7}$$

Where: $\Delta\tau_j^k\left(I_{p_i}\right)$ is the amount of pheromone left by the *k*th ant on element *j* in the set I_{p_i} in this cycle. Substituting L_k in formula (5) with e_k, the definition formula of $\Delta\tau_j^k\left(I_{p_i}\right)$ can be obtained as shown in formula 8.

$$\Delta\tau_j^k\left(I_{p_i}\right)=\begin{cases}\dfrac{Q}{e_k}\\ 0\end{cases} \tag{8}$$

Where ek is the error between the actual output and the expected output obtained by the k-th ant training the BP neural network.

3. Money supply forecast

3.1 The establishment of money supply forecast model

This article selects statistics on my country's money supply and loan balances in domestic and foreign currencies from 2000 to 2018 (data from the Statistical Communiqué of the People's Republic of China on National Economic and Social Development from 2000 to 2018). 19 groups are shown in Table 1.

Tab. 1 Money supply data

years	The balance of domestic and foreign currency loans of financial institutions	Actual value /100 million yuan
2000	9.94	5.3
2001	11.23	5.99
2002	14	7.09
2003	17	8.41
2004	18.9	9.6
2005	20.7	10.7
2006	23.9	12.6
2007	27.8	15.3
2008	32	16.6
2009	42.6	22
2010	50.9	26.66
2011	58.2	28.95
2012	67.3	30.37
2013	76.6	33.73
2014	86.8	34.81
2015	99.3	40.1
2016	112.1	48.66
2017	125.6	54.38
2018	141.8	55.17

The simulation parameters of the prediction model are set as follows: For the BP neural network, the number of training times is 2000, the learning rate is 0.01, and the target error is 0.0001. According to the trial and error method, the error is the smallest when the hidden node is 4,

therefore, the implicit node is taken as 4; For the ant colony algorithm, set the number of ants m=25, the pheromone volatilization coefficient ρ=0.3, the pheromone increment intensity coefficient Q=1, and the maximum number of iterations is 1000.

3.2 Simulation results

This paper chooses 14 sets of data from 2000 to 2013 to train the prediction model of this article, and uses 5 sets of data from 2014 to 2018 to predict the money supply through the trained model. BP neural network and ant colony algorithm optimize BP neural network to predict the money supply as shown in Table 2.

Tab. 2 Money supply forecast results

years	Actual value /100 million yuan	CA-BP	error/ %	BP	error/ %
2014	34.81	35.9	3.1	36.3	4.3
2015	40.1	41.1	2.5	44.5	10.9
2016	48.66	47.9	1.6	45.6	6.3
2017	54.38	53.8	1.1	50.5	7.1
2018	55.17	57.2	3.7	59.9	8.6

According to the prediction results, it can be clearly seen from Table 2 that the ant colony algorithm optimized BP neural network has a maximum prediction error of 3.7%, a minimum of 1.1%, and an average error of 2.4%. The BP neural network has a maximum error of 10.9% and a minimum of 4.3%, the average error is 7.4%. The ant colony algorithm is used to find better weights and thresholds, so that the optimized BP neural network has higher prediction accuracy than ordinary BP neural networks.

4. Conclusion

In this paper, the ant colony algorithm is used to optimize the weights and thresholds of the BP neural network to establish a prediction model of the money supply. The model is trained and predicted through the money supply and the balance of domestic and foreign currency loans of financial institutions from 2000 to 2018, then we can get:

1) This paper verifies the establishment of the ant colony algorithm to optimize the prediction model of the BP neural network, which is suitable for the prediction of money supply and has high prediction accuracy. This is of great significance to the country's economic development, the formulation of appropriate monetary policies, and the lives of the people.

2) The ant colony algorithm is used to optimize the BP neural network to obtain the money supply forecast model based on the loan balance of financial institutions. Compared with the traditional BP neural network, its convergence speed and prediction accuracy have been greatly improved.

References

[1] Wang Yan, Zhang Bixia. Application of VAR Model in the Forecast of my country's Money Supply [J]. Journal of Shanghai Lixin University of Accounting and Finance, 2018, (2): 36-44.

[2] Sun Yaxing, Xu Tinglan. The ARIMA model and forecast of my country's money supply [J]. Mathematical Theory and Applications, 2009, (4): 69-74.

[3] Xun Zhijian, Xu Xiaoli. Forecast of my country's Money Supply: Based on the STM Model [J]. Financial Theory and Practice. 2016, (11):46-48.