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Research on Stock Price Prediction Based on Markov-LSTM Neural Network -Take the New Energy Industry as an Example

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Abstract: *With the increasingly close combination of the financial field and the real industry, as a new economic growth point, it is of great significance to study its price fluctuation prediction in the financial stock market. Based on this, we propose a neural network prediction method via Markov chain and LSTM neural network. Then we select three stocks as the research object, K-mean clustering algorithm is used to determine Markov chain's relative states, K was obtained using the cross validation method. The empirical results show that the new method is better than LSTM neural network in the evaluation indexes of average relative error, a posteriori error, mean square error and small robability error of stock price prediction. This shows that under certain conditions, Markov chain-LSTM neural network can make more accurate prediction of stock price, and is more suitable for systems with high volatility and strong randomness. Finally, we discuss some promotion and improvement methods of Markov chain-LSTM neural network, and put forward relevant suggestions for the high-quality development of new energy industry from the perspective of finance.*

Keywords: *New energy industry; Stock price forecast; LSTM neural network; Markov chain*

1. Introduction

With the rapid development of economy and society, the serious energy crisis, prominent environmental problems and declining economic benefits caused by the excessive consumption of fossil energy have prompted people to improve the current energy consumption structure, and new energy industries such as solar energy and wind energy are gradually becoming prosperous. With the support of China's policies, the new energy industry, as a new economic growth point, is not only conducive to the development of green and low-carbon economy, but also improves people's quality of life. In the stock market, more and more people begin to pay attention to the new energy industry, further grasp the prediction and change law of stock price trend, and study its price fluctuation in the financial market, which is of great significance for the stable and efficient growth of national economy and the cross development of financial industry and new energy industry.

At present, researchers' prediction methods for things mainly include: time series method, statistical regression method, BP neural network method, LSTM neural network method, Markov chain, grey prediction method and so on. For example, Chen Zenghui (2008) used Markov chain to predict the trend of Shanghai Composite Index. Under the condition of effective market, the prediction result is more accurate; Ouyang Jinliang (2011) used the improved BP neural network method to predict the stock price of Qingdao Haier; Aiming at the uncertainty of stock return and risk, Wang Jiawei and others (2012) proposed a combined prediction model of Markov chain and genetic algorithm based on neural network to fit the stock price; Liu Zhili (2013) used the grey prediction method to predict the stock price of Neusoft group's three-month average data; Hu Zhenhuan et al. (2018) predicted the trend of house prices in Liuzhou on the basis of Markov chain with the method of mathematical statistics; Cao Bo et al. (2018) achieved high accuracy in the prediction of Expressway short-term traffic flow based on LSTM neural network model in the experiment. According to the actual situation of enterprise financial risk, Lai Maotao (2021) used BP neural network algorithm to predict enterprise financial risk, and established a risk prediction model based on BP neural network. In order to solve the problem of low prediction accuracy of load demand power of electric drive armored vehicles, Liu Chunguang et al. (2021) proposed a combined power prediction method based on Improved Grey Markov chain to predict the main power

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and residual power in the load demand power.

However, most of the above prediction models have many shortcomings in the long-term time series, and considering the uncertain characteristics of stock price, such as rapid change, randomness and large fluctuation, this paper modifies the LSTM neural network by Markov chain based on Kmeans clustering algorithm, and proposes a Markov chain-LSTM neural network, The number of clustering centers K can be obtained by cross validation method. By selecting the closing price data of Tianshun wind energy, Yan'an Bikang and Zhongtian Technology in the new energy industry for empirical analysis, the results show that it has better prediction results with high volatility and strong randomness, and it can provide relevant suggestions for the high-quality development of new energy industry.

2. Research Methodology

2.1. Markov chain-LSTM neural network

Markov chain refers to that under the known present conditions, the past information is independent of the future and has conditional independence. The state space in Markov chain goes through a random process of transition from one state to another, and has no memory function, that is, the probability distribution of the next state can only be determined by the current state, and the events in front of it in the time series have nothing to do with it. Pei tongsong et al. (2021) studied the prediction of highway traffic volume through the modified Markov chain BP neural network, which is conducive to controlling the development trend of highway transportation industry in the future. Based on this, Markov chain is suitable for systems with high volatility and strong randomness, and its modified model can enhance the accuracy of prediction results. In this paper, Markov chain is used to modify LSTM neural network. The specific process is as follows:

The relative value is calculated according to the expected value and actual value predicted by LSTM neural network. The relative value is reasonably divided into several state intervals by Kmeans clustering algorithm (Li Haitao (2002)), and K is obtained by cross validation method. The status interval is:

$$E_i = [Q_{i1}, Q_{i2}], (i = 1,2,\cdots,k) \tag{1}$$

Q_{i1} and Q_{i2} are the upper and lower limits of the state interval respectively. When state E_i is transferred to state E_j through K steps, the number of occurrences is M_{ij}, Mi is the number of occurrences of state E_i, then P_{ij} is the one-step transition probability from state E_i to state E_j, as shown in the following formula:

$$P_{ij} = \frac{M_{ij}}{Mi} \tag{2}$$

In the formula:

$$\begin{cases} 0 \le P_{ij} \le 1 \ \ (i,j = 1,2,\cdots,n) \\ \sum_{i=1}^{n} P_{ij} = 1 \ \ (j = 1,2,\cdots,n) \end{cases} \tag{3}$$

$$P(k) = \begin{bmatrix} P_{11}(k) & \cdots & P_{1n}(k) \\ \vdots & \ddots & \vdots \\ P_{n1}(k) & \cdots & P_{nn}(k) \end{bmatrix} \tag{4}$$

Assuming that the initial state vector is defined as S(0), the vector obtained after transferring K steps will be defined as:

$$S(k) = S(0) \times P(k) \tag{5}$$

When the state of the predicted state sequence E_j is determined, according to each state E_j, combine the clustering center value mean and the predicted value y_k obtained by LSTM neural network model, the predicted value of Markov chain LSTM neural network model can be obtained, as follows:

$$y_k = \frac{y_k}{1+mean} \tag{6}$$

3. Research results

3.1. Real data sources

In this paper adopts the method of random sampling and randomly selects three stocks as the research

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object, namely Tianshun wind energy, Yan'an Bikang and Zhongtian Technology. We selected the data of stock closing price from June 1, 2021 to December 31, 2021, including 146 data from Tianshun technology, 146 data from Yan'an Bikang and 141 data from Zhongtian Technology. Obtain the above stock historical data through Shenzhen Stock Exchange. The three types of data are divided into two groups: training set and test set. Finally, the processed sample data has high reliability and good representativeness. Three stocks are the data of three stocks randomly selected from the stock pool with representativeness and credibility. The three stocks have obvious rise and fall trend and local small-scale fluctuation trend. The purpose of this paper is to study whether our improved model can enhance this ability of LSTM.

3.2. Time series stationarity test of stock price

The time series stationarity test of the three stock prices was carried out by coding in Python. According to the ADF test of the three stock prices of Tianshun wind energy (A1), Yan'an Bikang (A2) and Zhongtian Technology(A3), the ADF statistics were -1.028, -1.565 and -0.898 respectively, and the P values of the significance test were 0.742, 0.501 and 0.788 respectively. Since the P values of the three stocks are greater than 0.05, the autocorrelation does not converge according to the autocorrelation diagram and partial autocorrelation diagram corresponding to the following three stocks. In conclusion, it shows that the price series of the selected three stocks is unstable. Traditional time series models, such as simple average method, ARIMA model and grey prediction method, require that the time series must be stable in the process of establishing the model, and the prediction effect in the short term is more accurate than that in the long term. It is not suitable for stock prices with the characteristics of rapid change, large fluctuation and nonlinearity, it can not be well used to predict the long-term change trend of stock price, so the traditional time series model has some limitations.

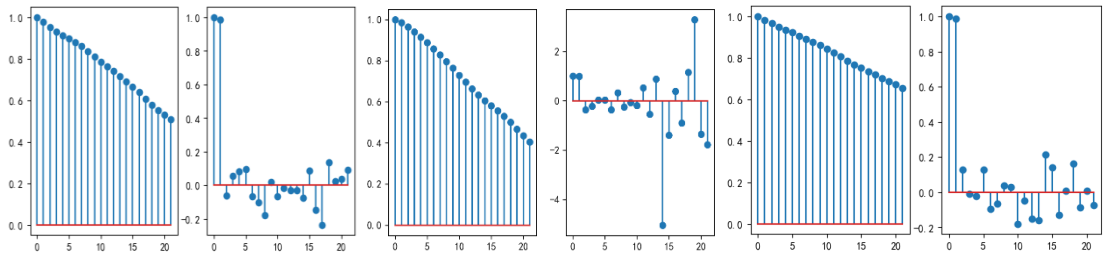

Figure 1: Autocorrelation and partial autocorrelation of three stock prices

3.3. Comparison of results between LSTM neural network and Markov chain LSTM neural network

After modeling and solving in Python and checking the stationarity, the time series data meeting the neural network model should be processed. In order to make the model more applicable to the data in this paper, the parameters in the model are adjusted and optimized. Taking Tianshun wind energy stock as an example, firstly, all 146 data of the stock are divided into training set and test set. The test set is the price data of the last 10 periods, and the training set is the price data of the first 136 periods. As for the prediction accuracy of the model, we use the following four evaluation indicators: average relative error:

$$\Delta = \frac{1}{n}\sum_{t=1}^{n}\frac{|\varepsilon(k)|}{x(k)} \times 100\% \tag{7}$$

Posterior error C:

$$C = \frac{S_2}{S_1} \tag{8}$$

Mean square error MSE:

$$MSE = \frac{SSE}{n} = \frac{1}{n}\sum_{t=1}^{n}\omega_i(y_i - \hat{y}_i) \tag{9}$$

Small probability error P:

$$P = \left\{\left|\varepsilon(k) - \bar{\varepsilon}(k)\right| < 0.6745S_1\right\} \tag{10}$$

Where: is the residual sequence of data; is the average value of the residual sequence; is the standard

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deviation of the relative value sequence; is the standard deviation of the original sequence.

Firstly, we test that the closing price sequences of three stocks meet the Markov chain condition. We use the cross validation method to obtain the optimal number of kmean clustering centers. Then, Python is used to calculate the evaluation results of LSTM neural network and Markov chain-LSTM neural network of three stocks, as shown in Table 1: it can be seen from the table that LSTM neural network and Markov chain-LSTM neural network have achieved good prediction results, but there is a large difference between various indexes. The values of LSTM neural network are in average relative error, posterior error, the mean square error is larger, and its small probability error is smaller than that of Markov chain-LSTM neural network.

Table 1: LSTM and Markov_ LSTM prediction results

Method	Stock name	$\overline{\Delta}$	MSE	C	P
LSTM	A1	0.0480621	4.0461668	0.0210816	0.9583333
	A2	0.0758392	2.4617357	0.0347593	0.9154929
	A3	0.0362047	0.6905950	0.0149009	0.9928057
Markov-LSTM	A1	0.0237019	0.3264533	0.0068996	1.0000000
	A2	0.0198700	0.1007121	0.0074869	1.0000000
	A3	0.0168709	0.0972902	0.0061296	1.0000000

Next, we can use Python programming to get the corresponding prediction comparison of three stocks, as shown in Figure 2-4. The results show that the LSTM neural network modified by Markov chain has higher accuracy and fits the actual value of stock price better.

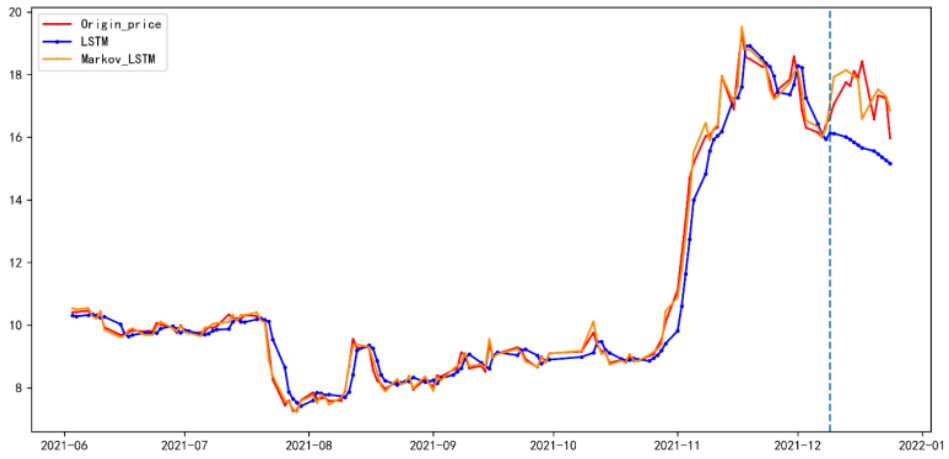

Figure 2: Comparison of A1's closing price forecast

Therefore, compared with LSTM neural network, the prediction effect based on Markov chain-LSTM neural network is better and more suitable for the long-term stock price prediction of new energy industry.

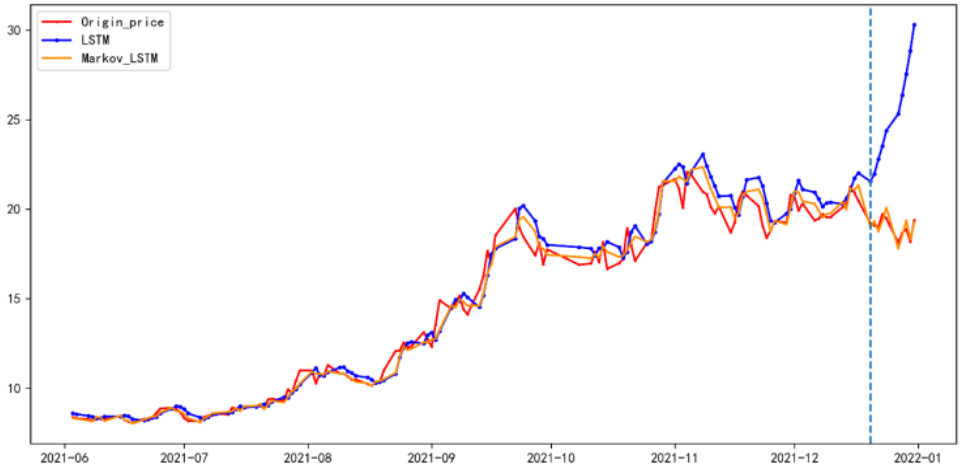

Figure 3: Comparison of A2's closing price forecast

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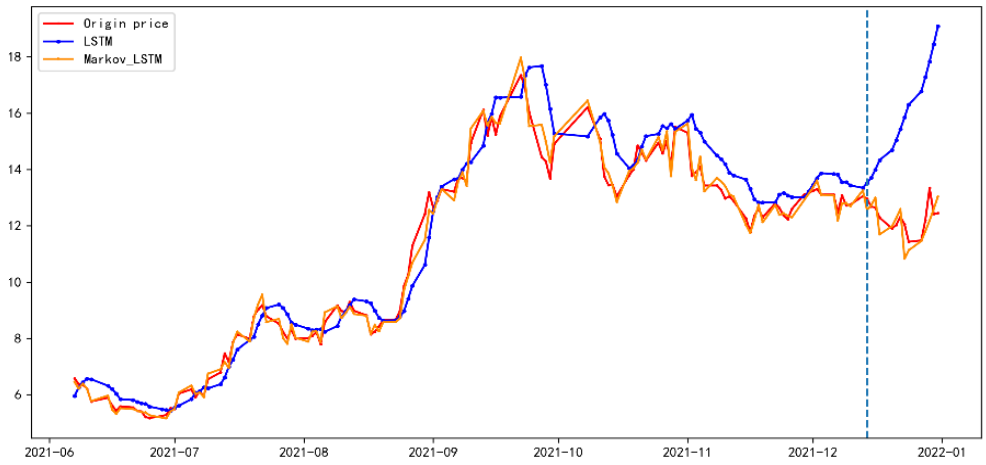

Figure 4: Comparison of A3's closing price forecast

4. Conclusions and discussions

This paper uses Markov chain based on K-means clustering algorithm to modify and optimize LSTM neural network to predict the trend and fluctuation of stock price in new energy industry. According to the autocorrelation and partial autocorrelation coefficient diagrams and the stationarity analysis obtained by ADF statistics, the stock price is selected as the state of Markov chain to predict the trend of stock price in a long time in the future. The results show that the modified Markov chain-LSTM neural network model not only improves the accuracy of each index, but also fits the change of the actual stock price trend well, and its advantages are obviously better than the traditional LSTM neural network model. Therefore, the prediction result of this paper is of certain significance to the new energy industry and has a certain reference value for investors.

However, the new prediction model based on Markov chain-LSTM neural network used in this paper also has limitations: this method itself belongs to probability prediction method, its accuracy is not invariable. There are still many uncertain factors outside the stock market will affect the prediction results. The further improvement of the model in the future can be considered from three aspects :First, the LSTM neural network can be changed into the weighted BP neural network and LSTM neural network, that is, the weighted modified LSTM-BP neural network; Second, Markov chain can consider using weighted Markov chain; Third, the government should give policy support and strictly supervise the illegal behavior in the market; Fourth, some necessary financial risk prevention, such as flexible legal means, strict stock price monitoring and comprehensive risk prevention system, also need to be firmly grasped. Through the prediction of stock price fluctuations, we can monitor the financial market environment of the new energy industry. The more sensitive the prediction system is, the more likely it is to capture the signals of high volatility and strong randomness in the stock market, so that the parties concerned can effectively maintain the market environment of fair competition, strengthen antitrust and prevent the disorderly expansion of capital, and ensure that financial innovation is carried out under the premise of prudent supervision. We will implement deeper financial market and institutional reforms, promote a higher level of financial opening up, smooth the circulation of factors, and stimulate market vitality.

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