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Analysis and Prediction of Housing Prices in Shenyang City Based on Elman Neural Network

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Abstract **Review Article**

In recent years, housing prices across the country have been on a slow upward trend, and the real estate market is crisscrossed, and Shenyang is no exception. This paper chooses the Elman neural network that can process dynamic time series information to predict the trend of average housing prices in Shenyang. The article selects the average house price of Shenyang for 72 months from September 2015 to August 2021 in Shenyang, using 7 months as a set of training samples, the first 6 months as input data, and the seventh month as output data .There are 66 groups in total, the first 58 groups are used as training sets, and the last 8 groups are used as test sets. At the same time, the BP neural network and the RBF neural network are used for the same prediction, and the prediction results of the three are compared and analyzed. It was found that both the Elman neural network and the BP neural network are better than the RBF neural network in predicting performance. In terms of error details, since the Elman neural network can better process time series data, compared to the BP neural network, the predicted value of the Elman neural network is closer to the true value, and the predictability is better.

Keywords: Elman neural network; Housing price prediction; Shenyang housing price.

0. INTRODUCTION

With the gradual improvement of China's economic development, people's demand for housing is also increasing, and the housing problem has become particularly important. In the past five years, prices and housing prices in most areas of our country have been on an increasing trend, and housing prices have attracted great attention from the government and the people. Shenyang is an important economic and trade center in the Northeast, and real estate as a special industry is related to the basic living conditions of the people and the healthy development of the city's economy. Therefore, it is very possible to predict the trend of changes in housing prices in Shenyang necessary.

At present, there are many methods for predicting housing prices in the academic circles.For example, Guo Peijun and Mao Haizhou used gray theory to predict house prices in Wenzhou [1], Hu Zhenhuan and Wang Zhiwen used Markov chains to predict house prices [2], and Chen Shipeng and Jin Shengping used random forest model methods to predict house prices. To make predictions [3], Wang Dongxue and Guo Xiujuan used XGBoost algorithm to make housing price predictions [4] and so on. Although these methods can better predict the trend of housing prices, each prediction method has its own scope of application. In other words, each method has its limitations. The gray theory forecasting method will suddenly increase and attenuate the data trend in the forecast, which is not suitable for forecasting long-term data. The Markov forecasting method is independent of the data state in the future and the data state in the past at the time of forecasting. It is only related to the current data state and is not suitable for long-term data forecasting. Random forest model prediction method in dealing with some noisy regression and classification problems, the result will be over-fitting. XGBoost algorithm is suitable for processing structured data, but not suitable for processing some data with too high dimensionality. Therefore, we need to find a method with strong compatibility, wide application range and good forecasting effect to predict housing prices.

With the rise of machine learning in recent years, the areas of neural network applications have also increased. At present, some scholars have used BP neural network and RBF neural network to predict

housing prices [5-8], and have obtained good expected conclusions. Although the BP neural network has a relatively good performance in predicting housing prices, the BP neural network and the RBF neural network are essentially a static multilayer feedforward neural network. Their operation method is mainly to convert dynamic time series data into static data Operation. The housing price trend data is a typical dynamic time series data. If the type of data does not match the type of the neural network, it may affect the dynamics of the entire neural network, leading to deviations in the predicted results, thereby reducing network performance. This article chooses to use another neural network, Elman neural network, to predict the trend of housing prices. As a typical feedback neural network, Elman neural network can better predict time series dynamic data. It loads a continuation layer on the original BP neural network, which is used to memorize the output value of the hidden layer at the previous moment and reload the new moment, which enhances the utilization of historical data and the correlation between the data, and can be more Good prediction of housing price trends.

At present, Elman neural network has a wide range of applications, such as sensor fault diagnosis research [9], short-term power load forecasting [10], predictive analysis in the stock market [11], air quality prediction and evaluation [12], etc. There has been a lot of research. This paper mainly introduces the Elman neural network to predict the housing price trend in Shenyang, and uses the BP neural network and the RBF neural network to do the same calculation and perform error analysis and comparison. The experimental results show that, relatively speaking, among the three, the Elman neural network has the smallest error in housing price prediction and the best fitting degree. Compared with the other two, it is more suitable for predicting the housing price trend in Shenyang.

1. Elman Neural Network

Elman neural network is a classic dynamic feedback regression network, which has similarities with BP neural network. BP neural network includes three parts: input layer, hidden layer and output layer. Compared with BP neural network, Elman neural network has one more layer. The function of the undertaking layer is to memorize the state of the hidden layer at the previous moment and pass it to the hidden layer together with the input layer signal at the new moment [13]. The structure of the Elman neural network is shown in Figure 1.Because the Elman neural network adds an undertaking layer, it makes the network more stable and has better dynamic information computing capabilities. The expression of Elman neural network is as follows:

$$y(t) = g(k_3 x(t)) \quad \text{(1)}$$

$$x(t) = f(k_1 x_c(t) + k_2(u(t-1))) \quad \text{(2)}$$

$$x_c(t) = x(t-1) \quad \text{(3)}$$

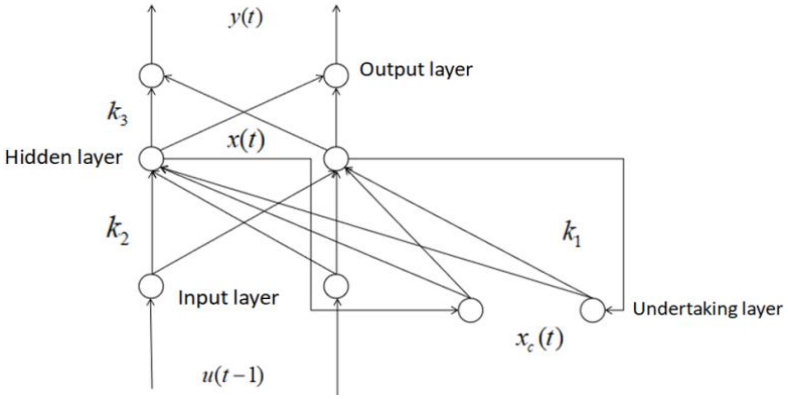

Fig 1: Elman neural network structure diagram

Among them, y represents the output layer vector, x represents the middle layer vector, u represents the input layer vector, x_c represents the feedback vector, k_1 is the weight between the hidden layer and the succeeding layer, and k_2 is the weight between the hidden layer and the input layer. k_3 represents the weight between the output layer and the hidden layer, and t represents the current time value [14].

2 Analysis and forecast of housing prices in Shenyang

2.1 Establish an analysis and prediction model

There are many factors that affect the trend of housing prices, such as a city's GDP, population, average income of residents, residents' savings deposits, total foreign trade imports and exports, average residential land prices, natural conditions, national laws and policies, completed residential housing area, real estate developers Residential investment, inflation rate, etc.However, when these data are collected, there are often missing data in a certain

month, or some influencing factors cannot be measured with exact values at all, which leads to problems in the forecasting process.This article chooses to choose the data for judging the trend from another angle. Since the final results of the above influencing factors are all acting on housing prices, another way of thinking is that you can choose to use past housing price information to predict new housing price trends.

As an important central city in Northeast China, Shenyang is an economic and trade hub in the Northeast, with a huge population flow. Therefore, it is extremely important to analyze the trend of housing prices in Shenyang.This article collects the average house prices in Shenyang for 72 months from October 2015 to September 2021 from the Anjuke website, and sorts them in chronological order. The data selection method adopted here is to select 7 months as a set of data, the housing price data of the first 6 months is the input data, and the data of the 7th month is the output data to construct the data set. A total of 66 sets of data can be established, namely, construct Elman neural network with 6 input nodes and 1 output node. Taking 2016 data as an example, Table 1 shows the average housing prices in Shenyang in December 2016, and Table 2 shows part of the 2016 training sample model.

Table 1: Average house prices in each month of Shenyang in 2020

month	Housing prices in Shenyang (yuan)	month	Housing prices in Shenyang (yuan)
January 2016	6724	July 2016	6872
February 2016	6726	August 2016	6853
March 2016	6752	September 2016	6929
April 2016	6833	October 2016	7001
May 2016	6866	November 2016	7014
June 2016	6877	December 2016	7082

Table 2: Part of the training model sample

Input sample						Output sample
6724	6726	6752	6833	6866	6877	6872
6726	6752	6833	6866	6877	6872	6853
6752	6833	6866	6877	6872	6853	6929
6833	6866	6877	6872	6853	6929	7001
6866	6877	6872	6853	6929	7001	7014
6877	6872	6853	6929	7001	7014	7082

The 66 sets of samples will be taken, and the first 58 sets of data will be used as the training data of the neural network, and the last 8 sets will be used as the test data of the neural network.In order to improve the efficiency of neural network training, it is necessary to normalize the data first, and then perform training processing. The simulation software used in this article is MATLAB2019b.

2.2 Evaluation criteria

In order to more clearly reflect the prediction of housing prices in Shenyang by various neural networks, this paper chooses root mean squared error (RMSE), mean absolute error (MAEr), and mean absolute percentage error (MAPE). These three evaluation standards are used to judge and analyze neural network performance indicators [15, 16]. The expressions of the three evaluation criteria are as follows:

$$RMSE = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(x_{fi} - y_{mi})^2} \quad \text{..... (4)}$$

$$MAE = \frac{1}{m}\sum_{i=1}^{m}\left|x_{fi} - y_{mi}\right| \quad \text{..... (5)}$$

$$MAPE = \frac{100}{m}\sum_{i=1}^{m}\left|\frac{x_{fi} - y_{mi}}{y_{mi}}\right| \quad \text{..... (6)}$$

Where x_f is the predicted housing price in Shenyang, and y_m is the exact housing price in Shenyang.

Among them, the root mean square error (RMSE) is the square root of the ratio of the sum of the squares of the deviation between the observed value and the true value to the number of observations m, and is used to measure the deviation between the observed value and the true value.Mean Absolute Error (MAE) is the average value of absolute error, which can better reflect the actual situation of the predicted value error.Mean Relative Percent Error (MAPE) is a measure of predictive accuracy in the field of statistics.

2.3 Forecasting process and analysis of its results

In experiments, the number of hidden layer nodes is often determined by trial and error. First, the empirical formula is used to select the range of the number of nodes, the empirical formula is:

$$m = \sqrt{n + l} + \alpha \quad \text{..... (7)}$$

Where *m*, *n*, *l*, *a* are the number of hidden layer nodes, the number of input layer nodes, the number of output layer nodes, and the random constants ranging from 1 to 10. According to the previous data, the number of hidden layer nodes can be determined to be 3 to 13. Then, the number of hidden layer nodes is selected by comparing the average error of each node, and finally a neural network with 8 hidden layer neurons, 6 input layer neurons and 1 output layer neuron is determined.In training, select tansig as the transfer function of the hidden layer, purelin as the transfer function of the output layer, and trainingdm as the training function of back propagation. The maximum number of training times is 10000, the learning rate is set to 0.01, the minimum training error is 0.001, and the training interval is 50, and a momentum factor of 0.9 is added.Input the housing price data of Shenyang from February to September 2021 (that is, the data of the last 8 groups) into the trained neural network for prediction, and then compare the predicted result with the actual value for error calculation. To evaluate the performance of the network. At the same time, in order to determine the accuracy of Elman neural network prediction, this paper additionally chooses to use BP neural network and RBF neural network for comparative prediction analysis, and calculate the errors of these two neural networks for comparative analysis. Figure 2 shows the comparison between the predicted and true values of the three neural networks, and Figure 3 shows the comparison of the error values between the three networks.

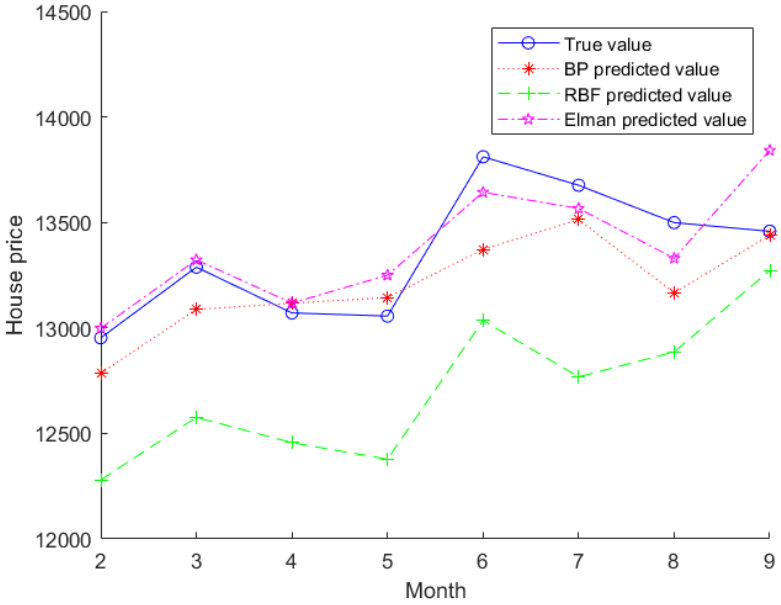

Figure 2: Comparison of predicted and actual values of the three networks

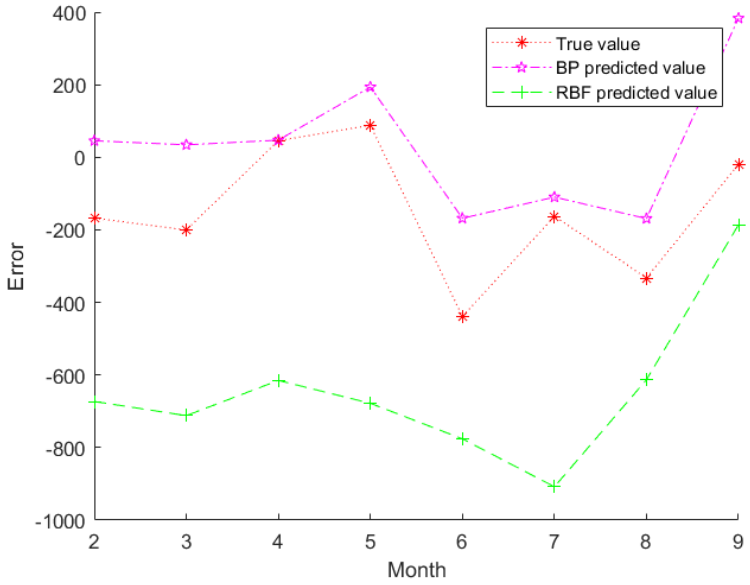

Figure 3: Comparison of the error values of the three networks

It can be seen from Figure 2 and Figure 3 that the effect of RBF (radial basis function) neural network prediction is not very good, and the collective prediction results are significantly lower than the actual value. In contrast, BP neural network and Elman neural network are relatively The fluctuation is smaller and the broken line is closer to the actual value.

Table 3: Three kinds of neural network predicted and actual values

Mouth	Predictive value			Actual value
	Elman	BP	RBF	
2	13000	12790	12280	12950
3	13320	13090	12580	13290
4	13120	13120	12460	13070
5	13250	13140	12380	13060
6	13640	13370	13040	13810
7	13570	13510	12770	13680
8	13330	13170	12890	13500
9	13840	13440	13270	13460

Table 4: Evaluation Index

Evaluation index	Neural Networks		
	Elman	BP	RBF
RMSE	179.8256	225.9146	674.0537
MAE	143.8233	181.9335	645.125
MAPE	1.0715%	1.3503%	4.8292%

It can be seen from Table 3 that the three neural networks can better reflect the housing price trend in Shenyang, but the prediction accuracy is slightly different. From the three evaluation indicators in Table 4, it can be seen that among the three neural networks, the prediction effect of the RBF neural network is relatively inferior, with an average percentage error of 4.8%, which is much higher than the other two neural networks.The average percentage error of the BP neural network and the Elman neural network is about 1%, which is within an acceptable range relative to the price of tens of thousands of housing prices. It shows that the BP neural network and the Elman neural network are relatively suitable for the housing price prediction in Shenyang.According to the average absolute error, the average absolute error of the BP neural network is slightly larger than that of the Elman neural network.Although the BP neural network has a strong ability to process nonlinear data, the convergence speed of the BP neural network is slow, which will cause the algorithm to fall into a local extreme [17], while the Elman neural network does not have this concern, so it takes advantage of the prediction accuracy dvantage.In summary, the prediction accuracy of the Elman neural network is better than the BP neural network and the RBF neural network. According to the actual situation of the prediction results, the Elman neural network is more predictable in the prediction of housing prices in Shenyang. The result is closer to the actual value and can be used as a good forecast choice.

3 CONCLUSION

This article uses matlab to build the Elman neural network, trains it, and substitutes data to predict the trend of housing prices in Shenyang.Through the results of the experiment, it can be seen that the Elman neural network can predict the future housing price trend better, and it can also clearly reflect the changing law of housing prices, which has certain application value.

In addition, this paper also chooses BP, RBF neural network and Elman neural network for comparative analysis.These three neural network models for predicting the trend of housing prices are established respectively, and historical data are used to train and verify them.The results show that the Elman neural network is relatively the best in the overall prediction fitting effect, and the fitted curve is closer to the real curve.

The issue of house price regulation has always attracted national attention. If house prices have been gradually developing according to the current situation, the existing neural network can well observe the development of house prices. However, if the country urgently introduces some control policies, it may lead to large errors in forecasts. In future research, we can consider adding elimination factors to suppress the possible impact on the forecast, in order to adapt to the new housing price trend.

REFERENCES

1. Guo, P., & Mao, H. (2011). Wenzhou housing price prediction model based on grey theory [J]. *Mathematics in Practice and Knowledge*, 41(20), 10-16.
2. Hu, Z., Wang, Z., & Tang, B. (2018). Research on Liuzhou City Housing Price Prediction Based on

Markov Chain [J]. *Journal of Guangxi University of Science and Technology*, 29(4), 79-83.

3. [3]Chen Shipeng,Jin Shengping.House price prediction based on random forest model[J].Science and Technology Innovation and Application,2016(04):52.
4. Wang, D., & Guo, X. (2021). House price prediction model based on XGBoost algorithm [J]. *Northern Architecture*, 6(3), 79-82.
5. Li. Y. (2018). Research on the second-hand housing transaction price prediction in Beijing based on BP neural network [D]. *Capital University of Economics and Business*.
6. Gao, Y., & Zhang, R. (2014). Analysis of housing price prediction based on genetic algorithm and BP neural network [J]. *Computer Engineering*, 40(4), 187-191.
7. Wu, S. (2019). Nanjing City Housing Price Forecast Based on BP Neural Network [J]. *Market Weekly*, (2), 58-60.
8. Ma, Y. (2015). RBF neural network prediction algorithm based on principal component analysis and its application [D]. *Jilin University*.
9. Ding, S., Chang, X., Wu, Q., Yang, Y., & Hu, Q. (2014). Research on sensor fault diagnosis based on Elman neural network [J]. *Foreign Electronic Measurement Technology*, 33(4), 72-75.
10. Guo, J. (2015). Short-term power load forecasting based on improved Elman neural network [D]. *Liaoning University of Technology*.
11. Lin, C., & Zhu, D. (2006). Research on stock price prediction based on Elman neural network [J]. Computer Applications, (2), 476-477+484.
12. Zhang, Q., Xu, Z., & Zhao, K. (2009). Pollution source data prediction based on Elman neural network [J]. *Journal of South China University of Technology (Natural Science Edition)*, 37(5), 135-138.
13. Elman, J. L. (1990). Finding structure in time. *Cognitive science*, *14*(2), 179-211.
14. Li, G., & Zhu, Q. (2020). Port cargo throughput forecast based on Elman neural network [J]. *Journal of Chongqing Jiaotong University (Natural Science Edition*), 39(6), 8-12.
15. Jia, H., & Taheri, B. (2021). Model identification of Solid Oxide Fuel Cell using hybrid Elman Neural Network/Quantum Pathfinder algorithm. *Energy Reports*, *7*, 3328-3337.
16. Zhang, J., Shan, H., Jing, X., Li, C., Zhang, C., & Liu, H. (2021). Prediction method of greenhouse environmental factors based on Elman neural network [J]. *Chinese Journal of Agricultural Machinery Chemistry*, 42(8), 203-208.
17. Liu, H., Li, W., & Zhang, S. (2014). Oil production predicting with modified BP neural network method [P]. Proceedings of the 3rd International Conference on Computer Science and Service System.