The Study of a Sales Forecast Model Based on SA-LSTM

Yuzhen Wang\(^1\), Dan Chang\(^1\) and Chaojin Zhou\(^1\)

\(^1\)School of Information Engineering, Lanzhou University of Finance and Economics, Lanzhou, Gansu, 730020, China

*Corresponding author’s e-mail: wyz70214@163.com

Abstract. Sales forecast is an indispensable link in the business activities of enterprises, and the accuracy of prediction is directly related to the effectiveness of enterprise sales and operation activities. In order to improve the prediction accuracy, a sales forecasting model based on LSTM is proposed. The model uses SA to optimize the initial connection weights of LSTM neural network, which solves the problem that the LSTM neural network converges to the local optimal, thus improving the network performance, and then makes an empirical analysis of the construction of the sales forecasting model based on SA-LSTM. The results show that the sales forecasting model improves the prediction accuracy, also reduces the number of iterations, and obtains a good prediction effect.

1. Introduction
Sales forecast is one of the important links in the business management process. Accurately predicting the sales volume of products can optimize the company’s inventory and minimize the inventory cost, also provide customers with products and services quickly and accurately, optimize the customer experience and improve customer satisfaction. Forecasting model is the key to make scientific and accurate sales forecasts. Therefore, how to construct a reasonable sales forecasting model has become the focus of research in this field. In recent years, relevant scholars have applied neural networks to the field of sales forecasting, which is a major breakthrough. As a nonlinear adaptive dynamic system, neural network has the advantages of extracting the internal features of information through self-learning to apply in economic forecasting, management decision-making and other fields.

2. Related research
In recent years, relevant scholars at home and abroad have focused on forecasting models and methods, including the models based on mathematical statistics, the models based on neural network and a combination of the two models, and applied in related fields, showing a good application prospect. To sum up, the main research results in this field are as follows: Calster T.V et al combined the profit-driven order identification method with the ARIMA model to forecast the sales and simulate it with Coca-Cola dataset to verify the accuracy of the forecast[1]; Lu C.J et al proposed a prediction model based on clustering extreme learning machine (ELM), using K-means algorithm to divide training sales data into multiple clusters, respectively applying the ELM algorithm to construct prediction models. Experiments show that the sales forecast model has improved the prediction accuracy[2]; Kuo R.J et al. merged fuzzy neural network with artificial immune, established a back-propagation neural network model, and predicted sales of laptops sold by a certain company to reduce costs and improve customer satisfaction[3]; Chen Z.Y et al. proposed an algorithm (HGAI) that combines genetic algorithm, immune algorithm and radial basis function (RBF) neural network, and...
used it in personal computer sales forecast. Experimental results show that HGAI algorithm is more predictive than other algorithms in accuracy[4]; Kim H.Y et al. used the LSTM neural network to predict stock prices, and combined the LSTM neural network model with various Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) models to improve the accuracy of stock price forecast[5]; Shikhar S et al. proposed a sales prediction model of furniture products based on deep neural network by studying LSTM neural network, and applied it to solar energy prediction. The results show that LSTM neural network is superior to other methods in prediction accuracy[6].

In summary, at present the innovation of sales forecasting models and methods is the focus of research in this field. Many experts and scholars have widely applied RBF, LSTM and other neural networks to predict and achieve good prediction results. However, few experts and scholars apply LSTM neural network to the field of sales forecasting. Therefore, this paper builds a sales forecasting model based on SA-LSTM neural network. Then, based on the historical sales data of a certain agricultural website, the model was used for experimental analysis.

3. Construction of sales forecasting model based on SA-LSTM neural network

3.1. The Basic theory

3.1.1. Simulated annealing algorithm
The Simulated Annealing (SA) algorithm is a stochastic optimization algorithm based on the Monte-Carlo iterative solution strategy. By accepting the interference solution in a limited way according to the predetermined control strategy[7], so that it can effectively avoid falling into local minimum values and finally realize the optimal serial structure optimization algorithm.

3.1.2. LSTM Neural Network
The Long Short-Term Memory Network (LSTM) is a specific form of RNN, suitable for processing time series and relatively long delay important events, but it is easy to fall into the local optimum. Therefore, this paper uses SA to optimize LSTM neural network, improve the accuracy of prediction.

3.2. Model construction
The basic process of the SA-LSTM neural network model is shown in Figure 1. It can be seen from Fig. 1 that the model first uses SA to find the global optimal solution with the small objective function value and uses it as the initial connection weight of the LSTM neural network to improve the overall performance of the network.
4. Experimental analysis

4.1. Data collection and preprocessing
The raw data used in this paper is the daily sales data of liquid fertilizers in agricultural websites for nearly 5 years. The two attribute values of the fertilizer station and the liquid fertilizer formula are decimal-coded to normalize the data, realizing data standardization, as shown in Table 1 and Table 2. P(i) represents the fertilizer station, F(j) represents the formula of liquid fertilizer.

4.2. Model training

| Table 1. The code of fertilizer station | Table 2. The code of formula of liquid fertilizer |
|----------------------------------------|--------------------------------------------------|
| The name of fertilizer station         | The formula of liquid fertilizer                 |
| Number                                 | Number                                           |
| P1                                     | F1                                              |
| 1                                      | 1                                               |
| …                                      | …                                               |
| P7                                     | F28                                             |
| 7                                      | 28                                              |
4.2.1. Training parameters
Combining the factors of rural population, proportion of rural population, crop planting area, fertilizer application, agricultural land area and other factors affecting liquid fertilizer sales with sales information of the agricultural website, the eight impact factors will be obtained as the input attribute of neural network. Then using the forecasting model based on the SA-LSTM neural network to predict the sales of the products of the agricultural website. The better-selling formula is F11 liquid fertilizer as the training sample data. After several trainings, the main experimental parameters of the sales prediction model based on SA-LSTM neural network are finally determined, as shown in Table 3.

| Number of neurons in the input layer | 8            |
|-------------------------------------|--------------|
| Number of neurons in the hidden layer | 50            |
| Number of neurons in the output layer | 1            |
| Activation function                 | Sigmoid      |
| Evaluation index                    | MSE, RMSE, MAE |
| Learning rate                       | 0.05         |

4.2.2. Comparative analysis
In order to verify the feasibility and superiority of the sales forecasting model based on SA-LSTM neural network, compared with the LSTM and BP neural network to obtain the difference of prediction results. Some results are shown in Figure 2 is a fitted graph of the predicted results.

From Figure 2, it can be intuitively seen that the model proposed in this paper has higher predictive accuracy.

4.2.3. Evaluation indicators
In order to quantitatively and scientifically evaluate the prediction results, MSE, RMSE and MAE as evaluation indicators to evaluate the prediction, the results as shown in Table 4:

| Error | LSTM | SA-LSTM | BP  |
|-------|------|---------|-----|
| MSE   | 104.166 | 31.017  | 247.328 |
| RMSE  | 10.2062 | 5.56929 | 15.7267 |
| MAE   | 7.9931  | 3.48483 | 12.0931 |

4.3. Model application
Applying the SA-LSTM sales forecasting model, predicting the monthly sales of the liquid fertilizers for F11 and F2, in 2019. The specific prediction results are shown in Table 5.
Table 5. Forecast result

| fertilize month | Site category | Forecast sales (kg) | fertilize month | Site category | Forecast sales (kg) |
|-----------------|---------------|---------------------|-----------------|---------------|---------------------|
| 2 1             | 103.5         | 2 1                 | 16.6           |
| 3 7             | 4.89          | 3 1                 | 270.92         |
| 3 1             | 90.02         | 3 7                 | 17.55          |
| 3 4             | 5.29          | 4 7                 | 25.8           |
| 3 5             | 54.49         | 4 5                 | 608.86         |
| 3 2             | 5.27          | 4 4                 | 3.65           |
| 4 7             | 3.36          | 5 6                 | 28.35          |
| 4 4             | 2.2           | 5 5                 | 58.72          |
| 4 1             | 47.47         | 5 7                 | 2.1            |
| 4 5             | 365.95        | 6 6                 | 37.62          |
| 4 6             | 34.04         | 6 4                 | 7.28           |
| 5 6             | 65.66         | 6 2                 | 964.18         |
| 5 5             | 60.99         | 7 6                 | 159.58         |
| 5 1             | 16.78         | 7 4                 | 9.53           |
| 5 4             | 4.28          | 7 3                 | 365.12         |
| 6 6             | 184.42        | 7 6                 | 299.76         |
| 6 7             | 141.55        | 8 6                 | 1821.38        |
| 6 2             | 281.04        | 8 3                 | 55.65          |
| 6 3             | 9.7           | 9 7                 | 4.56           |
| 6 1             | 4.92          | 9 6                 | 144.77         |
| 7 2             | 10.78         | 10 7                | 5.1            |
| 7 3             | 306.67        | 10 5                | 25.89          |
| 8 3             | 397.95        | 11 7                | 2.09           |
| 8 7             | 5.57          | 11 1                | 20.95          |
| 9 7             | 5.21          | 11 3                | 54.84          |

4.4. Analysis of results

According to the forecast results, the specific analysis is as follows:

(1) According to the products, the liquid fertilizer of formula F11 and F2 which is suitable for fertilizing crops in the germination, flowering and seedling stages and helping crops to bloom, have deep demand from March to August. Therefore, these two kinds of liquid fertilizers should be actively stocked during the busy period to meet the needs of farmers in time.

(2) Judging from the affecting factors, by analyzing the fertilizer station 4, in this area the rural population, the amount of fertilizer and the agricultural land are large, but the liquid fertilizers of formula F11 and F2 are less sold and the two fertilizers are not suitable for crops grown in the area. Thus, the agricultural website should consider stopping sale of liquid fertilizers with formulas F11 and F2 at the fertilizer station 4 to reduce the inventory costs.

(3) From the point of view of the fertilizer station, the liquid fertilizer of formula F11 have higher sales in the fertilizer station 3 and the station 5. So the agricultural website should consider storing more fertilizer in the two fertilizer stations to avoid out-of-stock.

(4) From the manager's point of view, the agricultural website should find out the low sales of
fertilizer stations and appropriate to merge, close, to prevent product backlog.

5. Conclusion
This paper firstly combines SA with LSTM neural network to construct a sales forecast model based on SA-LSTM. Then the model is applied to the sales forecast of liquid fertilizer in an agricultural website. The results show that the model can effectively improve the accuracy of the prediction, finally, according to the forecast results, the paper puts forward countermeasures to help the agricultural resources website better control inventory, reduce costs, and achieve precise marketing.

References
[1] Calster T.V., Baesens B., Lemahieu W. (2017) ProfARIMA: A profit-driven order identification algorithm for ARIMA models in sales forecasting. J. Applied Soft Computing., 775-785.
[2] Lu C.J., Kao L.J. (2016) A clustering-based sales forecasting scheme by using extreme learning machine and ensembling linkage methods with applications to computer server. J. Engineering Applications of Artificial Intelligence., 55:231–238.
[3] Kuo R.J., Tseng Y.S., Chen Z.Y. (2016) Integration of fuzzy neural network and artificial immune system-based back-propagation neural network for sales forecasting using qualitative and quantitative data. J. Journal of Intelligent Manufacturing., 6:1191-1207.
[4] Chen Z.Y., Kuo R.J. (2017) Evolutionary Algorithm-Based Radial Basis Function Neural Network Training for Industrial Personal Computer Sales Forecasting. J. Computational Intelligence., 1:56-76.
[5] Kim H.Y., Won C.H. (2018) Forecasting the volatility of stock price index: A hybrid model integrating LSTM with multiple GARCH-type models. J. Expert Systems With Applications., 103:25-37.
[6] Shikhar S., Stefan L. (2018) A comparative study of LSTM neural networks in forecasting day-ahead global horizontal irradiance with satellite data. J. Solar Energy., 162:232-247.
[7] Zhu Y.D., Zhong Y. (2009) An Improved Simulated Annealing Algorithm. J. Computer Technology and Development., 06:32-35.