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# Research on Stock Price Prediction Based on CNN-LSTM Hybrid Neural Network Model

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***Abstract:*** *In today's era of rapid economic development, the stock market plays an increasingly important role in the overall economic system of the country, and the analysis and prediction of stock prices is one of the most attractive research problems in academia. The analysis and prediction of stock prices is one of the attractive research problems in the current academic world. Neither traditional financial models nor traditional machine learning models can achieve the desired results. In this paper, a CNN-LSTM hybrid neural network model is used to analyze and predict stock prices. The model is trained and validated on three years of Ping An of China stock data, and the experimental data show that the model can achieve relatively excellent prediction accuracy.*

***Keywords:*** *CNN; LSTM; stock price prediction*

## 1. Introduction

As China's financial market continues to grow and develop, the financial system system is becoming more and more sound, prompting the public to widely participate in financial market investment, making the demand for financial information services more and more urgent [1]. The rapid development of the Internet in modern society and the improvement of the computer technology system have provided a strong basis and tools to solve the problem of people's financial information needs. The financial market occupies an important position in the economic system of the whole country [2]. Especially in recent years, many fields, such as academia and investment circles, have paid more and more attention to financial market research and tried to use the current advanced or mainstream computer technology to solve the problem of information needs in the financial market.

In recent years, deep learning techniques have developed rapidly in the field of artificial intelligence. As the current cutting-edge artificial intelligence technology, Fischer and Krauss [3] used LSTM networks to predict the movements of S&P 500 constituents from 1992 to 2015 and compared the model predictions with memoryless classifiers such as random forests, deep neural networks and logistic regression. The experiments show that the LSTM network is suitable for stock market research.

Based on this, this paper fuses CNN and LSTM, and designs a CNN-LSTM hybrid neural network model [4] to predict stock prices, taking into account the extraction and analysis of spatial features while taking into account the extraction and analysis of temporal features, and comprehensive feature extraction in terms of both breadth and depth, in order to improve the accuracy of stock prediction. In turn, it provides a more accurate investment strategy and investment direction for stock investment, which helps to boost investors' confidence in the market and create a more positive and healthy capital market, with important theoretical and practical significance.

## 2. Data Analysis

The LSTM model needs to be trained several times to build a better model in the end. Therefore, the training data should not only be sufficient, but also fit the training target better in order to make the prediction of the model more accurate. In order to have representative data, the data of Ping An Bank of China from September 4, 20019 to March 4, 2022 are selected as the modeling data of the original LSTM model, including the opening price, closing price, daily high price, daily low price, and transaction amount, etc. In this paper, the data of Ping An Bank of China from September 4, 2019 to March 4, 2022 are selected as the modeling data of the original LSTM model.

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*Table 1: Ping an Bank of China Three-Year Data Sheet*

| data | open | high | close | low | volume |
|---|---|---|---|---|---|
| 2019-09-04 | 14.32 | 14.50 | 14.44 | 14.31 | 973964.38 |
| 2019-09-05 | 14.56 | 14.85 | 14.58 | 14.55 | 1768051.38 |
| 2019-09-06 | 14.71 | 14.81 | 14.81 | 14.62 | 986432.81 |
| 2019-09-09 | 14.97 | 15.00 | 14.69 | 14.60 | 1299839.12 |
| 2019-09-10 | 14.60 | 14.64 | 14.55 | 14.41 | 796870.62 |
| … | … | … | … | … | … |
| 2022-02-28 | 15.90 | 15.92 | 15.75 | 15.62 | 723990.50 |
| 2022-03-01 | 15.79 | 15.95 | 15.92 | 15.62 | 935040.31 |
| 2022-03-02 | 15.79 | 15.87 | 15.68 | 15.66 | 760760.88 |
| 2022-03-03 | 15.73 | 15.81 | 15.71 | 15.63 | 578285.06 |
| 2022-03-04 | 15.62 | 15.63 | 15.33 | 15.28 | 990935.69 |

## 3. Design of CNN-LSTM hybrid neural network model

Long Short-Term Memory Neural Network [5] (LSTM) is a special kind of RNN, which was originally established to solve the deficiency of RNNs that easily lead to gradient explosion or gradient disappearance. Compared with the traditional RNN cell structure, LSTM creatively introduces the control gate structure, which enables the network model to effectively deal with long-term dependencies in time series, and the historical time information is effectively transferred. Therefore, for the prediction problem of time series, LSTM has a unique advantage in the cell structure.

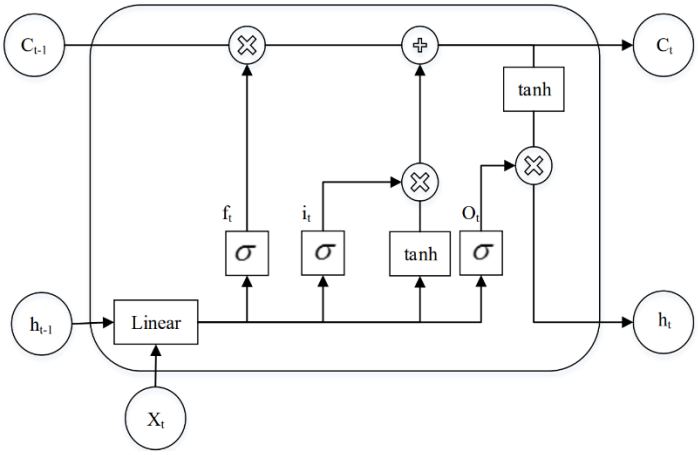


*Figure 1: Structure of LSTM cell*

### *3.1. Data normalization process*

Different types of data have different value ranges, which are not conducive to the training of the model, so normalization is required. This session uses the Min-max normalization method to shadow the data to [0,1], and the calculation of Min-max normalization is shown in Equation (1). Where $x^*$ is the normalized value, $x_{min}$ is the original value, the is the characteristic minimum value, and $x_{max}$ is the characteristic maximum.

$$x^* = \frac{x - x_{min}}{x_{max} - x_{min}} \tag{1}$$

### *3.2 Hidden layer processing*

The hidden processing layer receives the processed data from the data input layer and extracts the spatial features by CNN model first, and then extracts the temporal features by LSTM model.

(1) CNN spatial feature extraction

CNN consists of several convolutional layers and pooling layers, with the convolutional layer responsible for extracting data features and the pooling layer responsible for reducing feature dimensionality. The convolutional layer scans the input data by multiple convolutional kernels and performs a nonlinear mapping by the ReLU activation function to extract the spatial features of the data. The formula for the convolutional layer is shown in Equation (2). where *w* denotes the convolutional

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kernel weight coefficients, and *x* denotes the input variable, the denotes the bias, and $\sigma$ denotes the activation function ReLU, and *h* denotes the output data after the operation.

$$h_i = \sigma(w_i \times x_i + b_i) \tag{2}$$

The pooling layer is mainly used to reduce the computational complexity by reducing the dimensionality of data features, and two methods are usually chosen: maximum pooling or mean pooling. In this study, the maximum pooling method is used, and the formula of the pooling layer is shown in (3). Where $h_{i-1}$ denotes the feature data before pooling, and $h_i$ denotes the feature data after pooling.

$$h_i = \max(h_{i-1}) \tag{3}$$

(2) LSTM timing feature extraction

The LSTM is mainly used to extract the timing features of the data[6], and its cell structure is shown in Figure 1. The LSTM cell is used to extract the timing features of the data through forgetting gates *f*, input gate *i* and output gates *O* The LSTM cell controls the flow of information inside the cell by means of forgetting gates, input gates and output gates. Among them, the forgetting gate determines which information should be discarded from the output of the LSTM cell at the previous moment. which should be discarded in the output of the LSTM cell at the previous moment, which is calculated as shown in Equation (4); the input gate is used to update the cell state and decide which information can be added to the LSTM cell, which is calculated as shown in Equation (5); the state of the current LSTM cell is updated by the previous moment's output and the current input gets updated, and its calculation is shown in Equation (6). And the output gate determines which information is output to the next LSTM cell, thus effectively avoiding gradient explosion and gradient disappearance, and its calculation is shown in Equation (8).

$$f_t = \sigma(w_f \times [h_{t-1}, x_t] + b_f) \tag{4}$$

$$i_t = \sigma(w_i \times [h_{t-1}, x_t] + b_i) \tag{5}$$

$$C_t = f_t \times C_{t-1} + i_t \times tanh(W_c \times [h_{t-1}, x_t] + b_c) \tag{6}$$

$$o_t = \sigma(w_o \times [h_{t-1}, x_t] + b_o) \tag{7}$$

$$h_t = o_t \times \tanh(C_t) \tag{8}$$

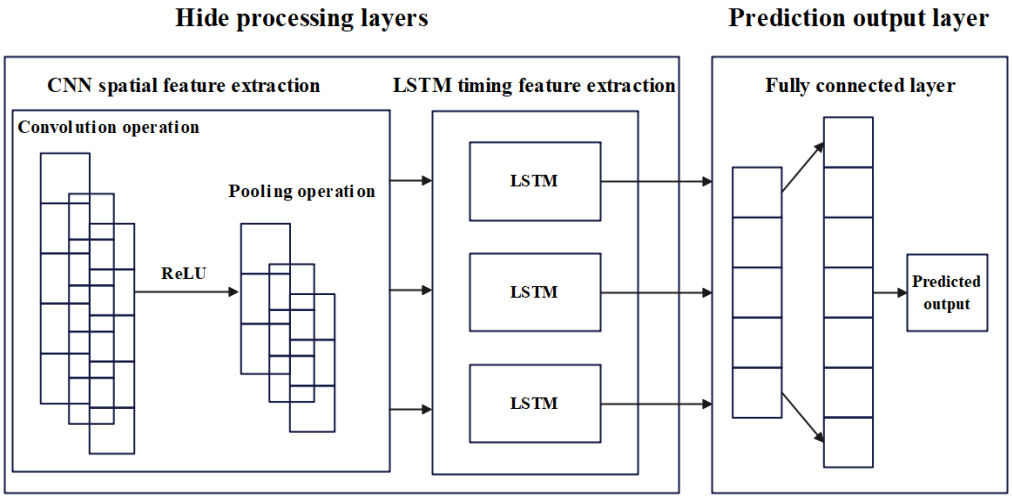


*Figure 2: CNN-LSTM hybrid neural network model diagram*

## 4. Experiments and analysis

In our CNN-LSTM model, the LSTM part consists of sequential layers, followed by 1 LSTM layer and a dense layer with Tanh activation. The overfitting problem is one of the most difficult things to avoid when training neural networks. Overfitting means that the model performs well for the training data, but the predictor is less effective for other data. To avoid the overfitting problem, Dropout[7] is added to the CNN-LSTM model and the regularization term is applied to the weights. Dropout refers to the random discarding of some features to improve the robustness of the model. Regularization refers to adding L2 parametrization to the computation of the loss function, so that some weight values close to 0

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avoid forced adaptation to each feature then it improves the stability and also obtains the effect of feature selection.

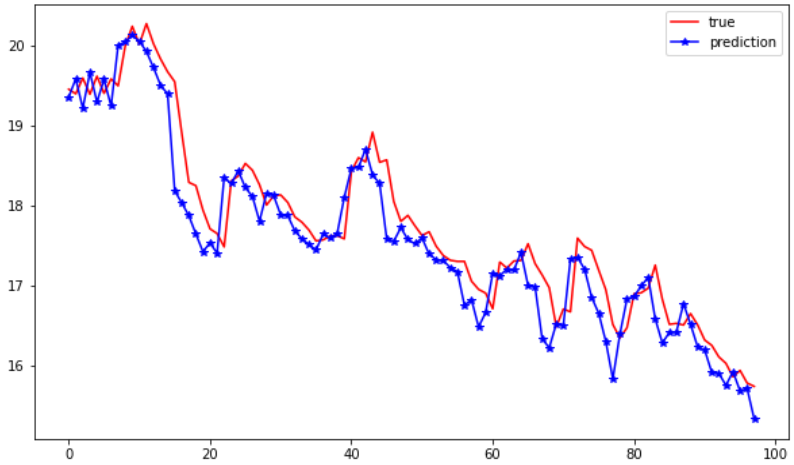


*Figure 3: Prediction result curve of CNN-LSTM hybrid neural network*

Based on the stock historical data of the opening price, closing price, low price, high price, trading volume and other factors, to predict the next day's highest price of the stock. There are 10 element dimensions of data information in this experiment, that is, 10 information data affecting stock prices, including opening price, closing price, lowest price, highest price, trading volume and trading volume, etc.

The experiment is to predict the highest price in the next time period within a relatively short period of time. From the graph, we can see that true is the actual maximum price and prediction is the maximum price predicted by the model, and the predicted maximum price is still close to the true maximum price in a short period of time [8]. It can be found that the blue prediction is very close to the true value represented by the red color, and can effectively predict the future short-term trend of the stock.

## 5. Conclusion

With the rapid development of modern society and economy, stock prediction is a hot topic of economists' attention, and with the booming of information technology, computer technology is also developing rapidly. We apply knowledge such as deep learning to stock price prediction. In this paper, we design a CNN-LSTM hybrid neural network model for stock prediction based on the data generated by Ping An of China stock in the past three years, and from the prediction results, the model has good adaptability and provides a better prediction model that can guide the investment behavior of institutions and individuals to a certain extent, which provides a stock prediction research new ideas.

## References

*[1] Yu Zhang. Analysis of factors influencing stock prices [J]. Times Finance, 2018, (33): 124+129.*
*[2] Jingyu Sun. The impact of macroeconomic factors on stock price volatility [J]. Quality and Markets, 2021, (16): 110-113.*
*[3] Thomas Fischer, Christopher Krauss. Deep learning with long short-term memory networks for financial market predictions [J]. European Journal of Operational Research, 2018, 270(2).*
*[4] Qi X.N., Zhang Y.J., Zheng Y.J., Feng E.Y. Research on deep learning algorithms for stock price prediction [J]. Software, 2021, 42(07): 70-72.*
*[5] Lin P. Research on stock price prediction based on long and short-term memory neural network and gray model[D]. Guizhou University of Finance and Economics, 2021.*
*[6] Wang D, Wang X. P, Yang C. D.. A principal component LSTM model for stock forecasting [J]. Journal of Chongqing University of Technology (Natural Sciences), 2021, 35(02): 282-288.*
*[7] Zhuohui Chen. Research on stock price prediction by 3DCNN-LSTM method based on power absolute value unit [D]. Beijing Jiaotong University, 2021.*
*[8] Du X., Ge S. L., Wang N. X.. Academic prediction based on CNN-LSTM hybrid neural network model [J]. Modern Educational Technology, 2021, 31(12): 69-76.*