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# Python-based stock price prediction using backpropagation neural networks: a case study on ANTM

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**ABSTRACT**

Accurate stock price prediction is critical for informed investment decisions. Today, stock trading has become a popular option as a source of income among people, due to its potential for rapid gains in a short time, but, due to fluctuating stock prices, it can cause great losses in exchange. This study aims to forecast the closing price using the backpropagation neural network algorithm so that it can be used as a decision support for potential investors and traders in this research, the system was built using the Python programming language, and the stock price data used were shares of the company *Aneka Tambang Tbk* (ANTM). The results of this research are root mean squared error (RMSE) values, additional labels for prediction results, and graphs for comparison of the original data with the predicted data. Based on the testing result, the best value of RMSE is 3.786, the mean absolute percentage error (MAPE) value is 0.001 which indicates that the prediction results are very close to the actual value.



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## 1. INTRODUCTION

The development of information technology in this modern era has brought many developments in people's lives, one of which is the development of professions that utilize information technology such as online shops, content writers, remote working, trading, and investment in the capital market [1], [2]. In the capital market, several commodities are traded, one of which is shares. Nowadays, stock trading has become an activity that is starting to be popular with various groups of people [3]. This is because stock trading can produce large profits in a relatively short time, but this is offset by high risks due to fluctuating stock prices which are influenced by various factors such as interest rates, company performance, inflation rate, and government policy [4], [5]. Therefore, it is necessary to have a stock price prediction system that can provide stock price information over several future periods, so that potential investors and traders can make decisions about whether to buy shares, sell them, or hold them [6], [7].

In forecasting, there are many methods used, one of which is the artificial neural network method because this method is dynamic and real-time so it has a fairly low error rate and a fairly good generalization

process [8], [9]. Supported by a multi-layer perceptron (MLP) network architecture and a backpropagation learning algorithm which can adjust weights so that this method is adaptive and can be used to predict data for several future periods based on patterns in a set of data [10], [11]. This research uses a stock technical analysis method, namely an analysis method that uses past stock price data and observes movement patterns to predict future stock prices. Stock prices are a security that proves ownership or equity participation in a company. By purchasing stock, investors become part owners of the company and are entitled to profits or dividends and a say in company decision-making through the general meeting of shareholders (GMS) [12], [13]. Stock prices can also be traded on the stock exchange [14], [15]. This research using *PT. Aneka Tambang Tbk* (ANTM) stock price data as test data. Although there are other shares such as INKP, SMGR, CTRA, UNTR, BRIS, and so on, the choice of ANTM share price data is because ANTM is a state-owned company operating in the raw materials (mining) sector and is a component of the LQ45 stock index, ANTM important producer of quality precious metals, ANTM is majority owned by MIND ID, this company is also considered a stable safe haven investment and has a downstreaming program to support the use of domestic products, and ANTM shares are one of the LQ45 stock indexes and blue chip shares [16], [17]. The LQ45 stock index is an index consisting of 45 company shares selected based on liquidity and market capitalization considerations [18], [19]. Meanwhile, blue chip shares are shares of companies with a very good reputation and are market leaders in each sector [20]. Apart from that, the system was built using the Python programming language which is supported by good performance for implementing artificial neural network algorithms and the existence of several powerful supporting libraries such as scikit-learn [21], [22].

This research aims to implement an artificial neural network algorithm due to the high level of prediction accuracy using the Python programming language to produce a stock price prediction system, as well as to find out how accurate stock price predictions are using a system with a Python-based backpropagation artificial neural network algorithm.

## 2. METHOD

The workflow used in this research is shown in Figure 1. The stages of system implementation that will run are in Figure 1 where after importing data into the system, it continues with preprocessing on the dataset, namely the data normalization process by changing the data to a scale of 0 to 1 and eliminating null values in the dataset. After data preprocessing is complete, the system will then display the dataset in table form, then the user inputs parameters consisting of the number of neurons in the hidden layers, activation function, solver, and the maximum number of iterations. After that, the system will carry out a prediction process using an artificial neural network algorithm and the prediction results along with the root mean squared error (RMSE) and mean absolute percentage error (MAPE) values are displayed in the form of tables and graphs.

To evaluate the performance of artificial neural network algorithms, RMSE and MAPE values are used [23], [24]. The RMSE value is used to measure the difference between the original value and the predicted value, which can be done by calculating the average of all squared residual values and then rooting.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(T_i - P_i)^2}{n}} \quad (1)$$

Where n is the amount of data, T is the actual value of the data or target, and P is the predicted value. Meanwhile, the MAPE value is the average difference between the original value and the predicted value in percent.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right| \quad (2)$$

Where n is the amount of data, $A_t$ is the actual value of the data, and $F_t$ is the predicted value.

Shares are a sign of investor ownership of their investment in a company or limited liability company [25]. Stock trading is the activity of buying and selling shares of a company where traders gain profits by buying share prices when they fall and selling them when the share price rises. Meanwhile, investment is the investment of capital for one or more activities owned within a certain period with the hope of gaining profits in the future [26]. In analyzing stock prices, several analytical methods can be used, one of which is technical stock analysis, namely an analysis method that uses past stock price data and observes movement patterns to predict stock prices in several future periods [27].

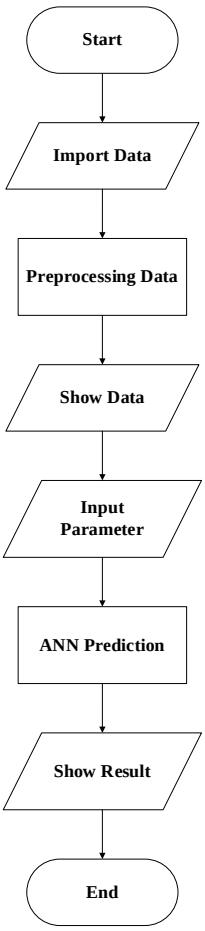


Figure 1. Research workflow

The dataset used is ANTM share price data for the period January 2018 – May 2023 as training data, and the period June 2023 as testing data. This dataset was obtained from the yahoo.finance website with a time frame of 1 day and the attribute that will be predicted is the closing price with other attributes as features. ANTM shares are one of the members of the LQ45 index which consists of 45 company shares selected based on liquidity and market capitalization considerations. Apart from that, these shares are also included as blue chip shares, namely company shares with a very good reputation, and are market leaders in each sector. At the data preprocessing stage there are two stages, namely eliminating null values and normalizing the data. The process of eliminating null values can be done with the help of the Pandas library in Python. The same thing also applies to data normalization using the minmaxscaler library in scikit-learn Python. Using this library the dataset will be changed to a 0-1 scale. This aims to make the artificial neural network calculation process more efficient because the input data will be in the same range as the activation function between 0 and 1. In Tables 1 and 2 it can be seen that the close column was not changed after the data preprocessing stage, this is because the close column is the target column, so the data was not changed to a scale of 0 to 1.

Table 1. Dataset before the preprocessing stage

| Date | Open | High | Low | Close | Adj close | Volume |
|---|---|---|---|---|---|---|
| 01/01/2018 | 625 | 625 | 625 | 625 | 606.2953 | 0 |
| 02/01/2018 | 635 | 645 | 625 | 635 | 615.9961 | 36621000 |
| 03/01/2018 | 635 | 655 | 630 | 630 | 611.1457 | 43607600 |
| 04/01/2018 | 635 | 645 | 535 | 640 | 620.8464 | 15064900 |
| 05/01/2018 | 645 | 660 | 645 | 655 | 635.3975 | 49323700 |
| 08/01/2018 | 660 | 660 | 640 | 650 | 630.5471 | 31920500 |
| 09/01/2018 | 655 | 680 | 650 | 655 | 635.3975 | 51688900 |
| 10/01/2018 | 655 | 665 | 645 | 650 | 630.5471 | 20774300 |
| … | … | … | … | … | … | … |
| … | … | … | … | … | … | … |
| 31/05/2023 | 2470 | 2500 | 2430 | 2460 | 2460 | 118544200 |

Table 2. Dataset after the preprocessing stage

| Date | Open | High | Low | Adj close | Volume | Close |
|---|---|---|---|---|---|---|
| 01/01/2018 | 0 | 0 | 0 | 0 | 0 | 625 |
| 02/01/2018 | 0.00542 | 0.010667 | 0 | 0.005233 | 0.308923 | 635 |
| 03/01/2018 | 0.00542 | 0.016 | 0.00277 | 0.002617 | 0.367859 | 630 |
| 04/01/2018 | 0.00542 | 0.010667 | 0.00554 | 0.00785 | 0.127083 | 640 |
| 05/01/2018 | 0.01084 | 0.018667 | 0.01108 | 0.015699 | 0.416079 | 655 |
| 08/01/2018 | 0.01897 | 0.018667 | 0.00831 | 0.013083 | 0.269271 | 650 |
| 09/01/2018 | 0.01626 | 0.029333 | 0.01385 | 0.015699 | 0.436031 | 655 |
| 10/01/2018 | 0.01626 | 0.021333 | 0.01108 | 0.013083 | 0.175245 | 650 |
| … | … | … | … | … | … | … |
| … | … | … | … | … | … | … |
| 31/05/2023 | 1 | 1 | 1 | 1 | 1 | 2460 |

The prediction process is carried out on a system built using the Python programming language. Forecasting in this system uses the Backpropagation artificial neural network algorithm which is supported by the Scikit learn library. With this system, ANTM share price predictions can be made and produce accuracy values, RMSE, MAPE, close attribute predicted prices, and prediction result graphs.

The stock price prediction system evaluation was tested by making predictions using various existing parameters to find out the parameters with the best results on the ANTM stock price dataset. These parameters include the activation function (logistic, tanh, relu), solver (lbfgs, sgd, adam), number of neurons in hidden layers, and maximum iteration. Previous research that was studied as a basis for this research was stock price predictions needed by investors to be able to see the future investment prospects for company shares using the Backpropagation artificial neural network algorithm to obtain results with an average accuracy level of above 90% [28], [29]. Apart from that, predictions with other algorithms were also studied as a comparison, such as stock predictions with support vector machine, support vector regression, K-Nearest Neighbors, and other algorithms which obtained an average accuracy rate of 80% [30], [31].

## 3. RESULTS AND DISCUSSION

ANTM stock price prediction results using a Python-based stock price prediction system were obtained using parameters for the number of neurons in hidden layers of 220, the activation function includes relu, solver lbfgs, and the maximum number of iterations is 50,000 with an accuracy result of 0.998. The RMSE value is 3.786, and the MAPE value is 0.001. The smaller the RMSE value shows that the prediction results are closer to the original value, while the better the accuracy value, the closer it is to 1. These results can be seen in Figure 2. The implementation of a Python-based stock price prediction system also displays the prediction results in graphical form as in Figure 3 which shows the comparison of the close price in the original data with the predicted price, where in the graph the lines showing the predicted value and the original value coincide with each other, which means the predicted results are very good.

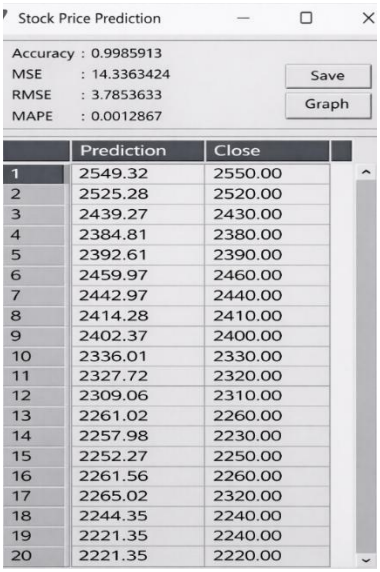


Figure 2. ANTM share price prediction results

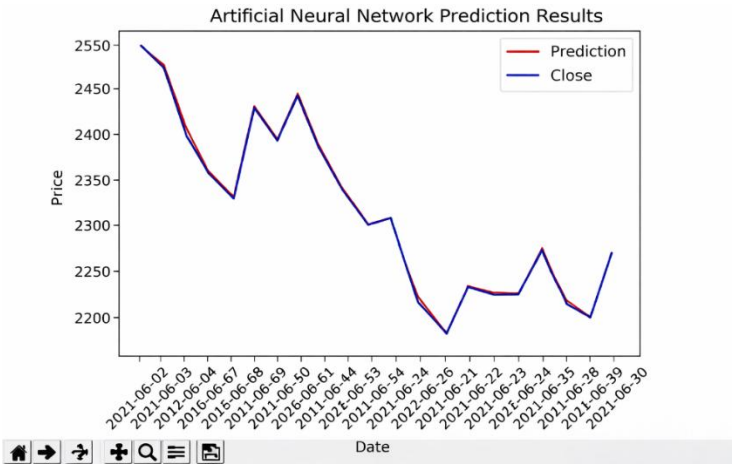


Figure 3. ANTM share price prediction result graph

Testing was carried out to determine the best parameters for ANTM share price predictions. This is because the prediction results greatly influence the suitability of the parameters with the data used so that the best parameter values will vary for each data used. The test results are shown in Table 3. The test was carried out using only the relu activation function parameters because the other activation functions took too long for the prediction process, while the solvers used were lbfgs, sgd, and adam. The total number of iterations is 50,000 and the number of neurons in hidden layers (100, 120, 150, 200, 220, and 250). Testing is carried out to see the parameters with the lowest RMSE values.

Table 3. Testing of stock price prediction system parameters

| Number of neurons | Lbfgs | SGD | Adam |
|---|---|---|---|
| 100 | 8.896 | 9.696 | 1321.593 |
| 120 | 7.086 | 23.439 | 1317.811 |
| 150 | 13.690 | 21.053 | 1935.799 |
| 200 | 5.413 | 12.237 | 1321.879 |
| 220 | 3.786 | 23.937 | 1321.339 |
| 250 | 7.136 | 24.421 | 1321.169 |

Based on the test results in Table 3, it can be explained that the parameter with the lowest RMSE value is the lbfgs solver with several neurons in hidden layers of 220. Apart from that, tests were also carried out to compare the prediction results using RapidMiner with a Python-based stock price prediction system. Testing is carried out with the same data as predictions on Python-based systems. The parameters used are a learning rate of 0.0001, momentum of 0,9, hidden layers size of 220, and training cycle of 50,000 as shown in Table 4. In Table 4, it can be seen that the RMSE value from the test results using RapidMiner Studio is 224.130, which is a very large difference compared to the test results on the Python-based stock price prediction system which has an RMSE value of 3.786.

Table 4. Comparison results of RapidMiner Studio testing with artificial neural network prediction system

| Scoring | RapidMiner studio | Artificial neural network prediction system |
|---|---|---|
| RMSE | 224.130 | 3.786 |
| MSE | 50234.279 | 14.336 |

## 4. CONCLUSION

Based on the test results in this research, it can be concluded that stock price predictions using the backpropagation artificial neural network algorithm can be implemented using the Python programming language to produce ANTM stock price predictions with an accuracy value of 0.998, an RMSE value of 3.786, and a MAPE value of 0.001. Meanwhile, the best parameter for ANTM share price prediction is an activation function such as relu, the lbfgs solver. The number of neurons in the hidden layers is 220 and the maximum number of iterations is 50,000. ANTM stock price prediction results have a better level of accuracy in the Python-based prediction system compared to prediction testing with RapidMiner Studio as shown by the RMSE value in the Python-based prediction system of 3.786 while for RapidMiner Studio the RMSE value is 224.130.

To get the best prediction results on this Python-based system, the advice that can be given for next research is to carry out tests to find the best parameters in each dataset used and compare results with other methods such as LSTM, ensemble models, or hybrid approaches combining technical and fundamental analysis.

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| Christine Dewi | | ✓ | | | ✓ | ✓ | | | | ✓ | | | ✓ | ✓ |
| Eryan Ahmad Firdaus | | ✓ | | | ✓ | ✓ | | | | ✓ | | | ✓ | ✓ |

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

## CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

## DATA AVAILABILITY

This paper does not involve any new data creation or analysis, so data availability is not relevant.

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