Prediction of stock purchase decisions using artificial neural network method

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ABSTRACT

The difficulty of determining a stock purchase decision is a problem to benefit from stock transactions. This study aims to give a person's decision to buy one of the issuer's company shares to get a profit on the same day. The dataset used in this study came from the investing.com website in the form of daily data shares of PT Indofood CBP Sukses Makmur Tbk with ICBP stock code for the period January - September 2019. The attributes used in this study were the opening price, highest price, lowest price, closing price, transaction volume, day representation, and decisions. The dataset that has been collected was normalized using the Min-Max method to facilitate data processing. This research used the backpropagation neural network method and used the 10-Fold Cross Validation and Confusion Matrix for validation. The results of this study indicate that the backpropagation neural network method uses the bipolar activation function with training cycles of 2000 and learning rate of 0.03 has the best performance namely 69.35% of accuracy, 67.65% of precision, 74.19% of recall and 30.65% of error rate for prediction of stock purchase decisions per day in the form of buy or not.

1. Introduction

Each company has a different stock price. Shares are issued by companies in the form of limited liability companies or can be called listed companies. Shares are securities as a form of proof of ownership of a company. When a company has a good performance, it will have a positive impact on shareholders on the benefits obtained [1]. One of the listed companies engaged in consumer goods is PT. Indofood Sukses Makmur Tbk, with shares issued using the ICBP stock code.

The prediction of a stock price is very complicated because there are many factors that influence it such as inflation, political events, economic matters, investor expectations and other environmental factors that might affect stock prices [2]. For a beginner it is very difficult to make a decision in determining whether the stock will be profitable when the shares are bought and sold on the same day, more precisely bought when trading hours begin and sold when trading hours are over. Someone who invests this kind of stock can be said as a trader, where the shareholders make short-term investments by trading transactions as a source of income [3].

Soin research using the artificial neural network method in predicting the purchase decision of shares of PT Indofood CBP Sukses Makmur Tbk or ICBP to obtain profits by using eleven inputs. The output of this research is a decision to buy shares or not. The purpose of this study is to help shareholders gain profit if they buy shares at the opening price and sell at the closing price at the end of the stock trading hour. With this research, it is expected that someone who wants to invest in shares can find out the advantages or disadvantages obtained at the time conditions.

2. Method

2.1. Related Works

Several previous studies that have been conducted are related to this research. In the previous research [4], stock price predictions were performed using the Support Vector Regression method. The advantage of the SVR method was that it could overcome overfitting. However, it had flaws in determining the exact model parameters, one of which was by using a grid search algorithm. The dataset used was the shares of PT. XL Axiata Tbk in the period of 1st January 2013 to 30th September 2014 consisting of 400 training data and 55 test data. The results of the study were considered to be good because they had high accuracy above 80%.

A previous study [5] used the Naïve Bayes algorithm to predict gold prices. It used a gold dataset from the website pegadaian.co.id taken from 1st December 2017 to 1st January 2018 as training data and from 2nd to 17th January. The results showed that the Naïve Bayes algorithm was able to classify the price of the gold well and had an accuracy of above 70%. Naïve Bayes was indeed one of the simplest classification methods and only required a short amount of time. However, this method was less accurate when used in classifying several datasets.

The other related research was research [6] that used the Fuzzy KNN method and Learning Vector Quantization (LVQ) to predict stock prices. The dataset used were Apple, Cisco, Fujitsu, Hewlett-Package and Ericsson. The prediction results were not good. It was below 50% calculated using the Learning Vector Quantization algorithm, while the Fuzzy KNN algorithm was considered to be good with an accuracy above 60%. Fuzzy KNN was a method with a very slow prediction process because it involved the entire training data during the classification process. Whereas Learning Vector Quantization (LVQ) was one of the methods of artificial neural networks that used a single-layer feedforward architecture to produce the classification that had the closest distance.

2.2. Originality

This study proposes an artificial neural network as an algorithm to predict stock purchase decisions in a case study of PT Indofood CBP Sukses Makmur TBK or ICBP in obtaining profit using eleven inputs. The obtained dataset is then processed through the normalization process so that it can be used by a prediction model. This research was implemented in the form of a website application-based system that is easily accessed by users. The artificial neural network model in this study has 16 scenario conditions with different values of training cycles and learning rates, each scenario is tested with 10-fold cross-validation and confusion matrix validation to find out the best prediction. The majority of previous research focused more on stock prices compared to stock purchase decisions. Therefore, the purpose of this research is to give someone a decision to buy one of the issuer's stock companies so that they get a profit on the same day.

2.3. System Design

The methods used in this study consisted of five steps as follows: Based on Figure 1, the following are the detailed explanation about the steps in this study.

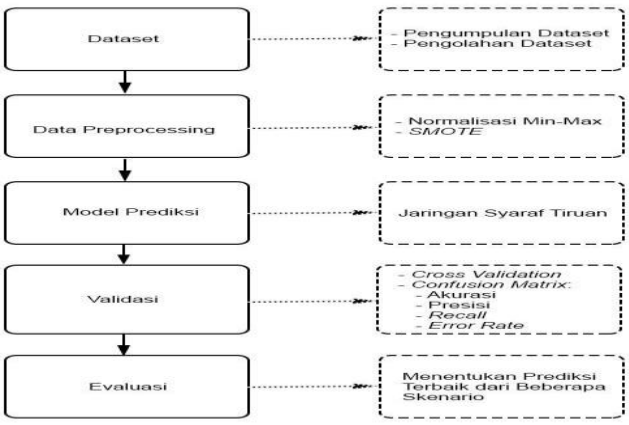


Fig. 1. Research Stages

2.3.1. Dataset

The dataset used in this study was the daily stock data of PT Indofood CBP Sukses Makmur Tbk with the ICBP stock code from 1st January 2019 to 30th September 2019. However, we only used the date when the trading day is opened, which consists of Monday to Friday and not including national holidays. The dataset collected included 182 instances consisting of 7 attributes: date, price, open, high, low, volume and change %. All attributes are real data types, except date attributes that have date data types.

This study only used five of the seven attributes in the dataset, namely by ignoring the Date and Change% attributes. The Date attribute was not used because the prediction was not about time series. The Change% attribute was also not used because it reduced the number of entries to avoid overload entries. Two attributes were added in the form of the Representation of days and Decisions. Representation of the day attribute consisted of five attributes that stood separately namely: Mon, Tue, Wed, Ths, and Fri. The Decision attribute was obtained from the difference between the closing price of shares and the opening price of shares on the same day after deducting the purchase tax of 0.19% and sales tax of 0.29%, if the value was positive then the value of the Decision attribute was Buy, it means the other way around, if the Decision attribute value is No. The value in the Decision attribute was given to the previous day's dataset, so the last-order dataset was not included in the calculation because it did not have a label class on that day. The attributes used in this study areas in Table 1.

Table 1. The Attribute Dataset

Attribute's Name	Explanation of the Attributes	Data Types	Value Range
Price	Stock closing price	Real	Positive value
Open	Stock opening price	Real	Positive value
High	Highest stock price	Real	Positive value
Low	Lowest stock price	Real	Positive value
Vol.	Volume of stock transactions	Real	Positive value
Mon	Monday representation	Integer	0 / 1
Tue	Tuesday representation	Integer	0 / 1
Wed	Wednesday's representation	Integer	0 / 1
Ths	Thursday representation	Integer	0 / 1
Fri	Friday representation	Integer	0 / 1
Decision	Decision to buy shares	Nominal	Purchase/ No

2.3.2. Data Preprocessing

Preprocessing was used to manage data used as evaluations that were processed using certain filters. This stage was useful in improving data quality such as eliminating range values, filling in missing values, combining impossible data and so on before it was processed using the data classification algorithm method [7]. Preprocessing techniques used in this study were normalization and SMOTE.

Normalization was needed before the data mining process was carried out. It was intended to make no parameter domination in calculating the distance between [8]. In normalizing data, this study used the Min-Max normalization method with a range of 0 to 1 using the formula (1). For Min-Max normalization with a certain range, the normalization formula (2) can be used. The results of the normalization carried out in this study can be seen in Table 2.

$$x^i = \frac{(x - \min)}{(max - min)} \quad (1)$$

$$x^i = \frac{(x - \min)(\text{newmax} - \text{newmin})}{(max - min)} + newmin \quad (2)$$

Where x' = new value, x = initial value, newmin = new minimum value, newmax = new maximum value, min = minimum value, and max = maximum value

Table 2. Dataset Attribute after being Normalized

Attribute's Name	Explanation of the Attributes	Data Types	Value Range
Price	Stock closing price	Real	-1 - 1
Open	Stock opening price	Real	-1 - 1
High	Highest stock price	Real	-1 - 1
Low	Lowest stock price	Real	-1 - 1
Vol.	Volume of stock transactions	Real	-1 - 1
Mon	Monday representation	Integer	-1 / 1
Tue	Tuesday representation	Integer	-1 / 1
Wed	Wednesday's representation	Integer	-1 / 1
Ths	Thursday representation	Integer	-1 / 1
Fri	Friday representation	Integer	-1 / 1
Decision	Decision to buy shares	Nominal	Purchase/ No

The next preprocessing stage was to apply SMOTE to the data. SMOTE was used to overcome the imbalance in class label data to produce a good level of accuracy in the prediction model that had been built. The SMOTE results are shown in Table 3.

Table 3. Comparison of the Amount of Original Data to Data + SMOTE

	Purchase	No	Total Data
Original Data	57	124	181
Data + Smote	124	124	248

2.3.3. Neural Artificial Network

Artificial neural network or neural network is one of many branches of science contained in the science of artificial intelligence. Artificial neural network is a method that can solve problems related to grouping or pattern recognition [9].

An artificial neural network is a modeling method that has high capability in terms of adapting to new environments by using data that has been obtained in previous experiments. Artificial neural networks have three different types of architecture such as single neural networks, plural neural networks and neural networks with competitive layers [10]. The basic concept of the model structure of artificial neural network units is illustrated in Figure 2.

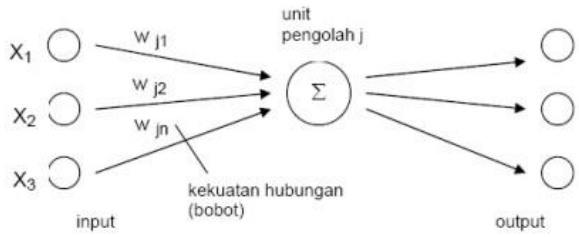


Fig. 2. Basic Concept of Artificial Neural Networks [11]

In artificial neural networks, there are training cycles that are indicators to determine the number of iterations performed at the training stage and learning rate as a training indicator to update the weight value on the wrong prediction. The advantage of this artificial neural network is its ability in classification which can approach a large class with a high degree of accuracy. While the disadvantage of artificial neural network methods is that they must have a lot of training data and cause the process to be slow [12].

Backpropagation: one of the classification techniques using the supervised learning method of artificial neural networks. This method is very good at handling complex and complicated patterns [10].

Activation function: A function that is used to limit output from a calculation so that the output produced is at a predetermined value limit. The characteristic that must be present in the backpropagation activation function is that it is continuous, differentiable, and does not decrease

monotonically [13]. The activation function in artificial neural networks for an output with polynomial data types consists of two types, namely the binary sigmoid activation function with the formula (3) has a range of values from 0 to 1 and the bipolar sigmoid activation function with the formula (4) has a range of values from -1 to 1.

$$Y = f(x) = \frac{1}{1+e^{-x}} \quad (3)$$

$$Y = f(x) = \frac{1-e^{-x}}{(1+e^{-x})} \quad (4)$$

2.3.4. K-fold Cross Validation

Cross-Validation is a method used in calculating a model created for the classification process of certain datasets. Every repetition in the Cross-Validation process, there are training data as the formation of a prediction model, and test data as a validation of the model [14].

The number of repetitions in the K-fold Cross Validation is determined manually at the beginning of the process as desired. K value is the number of repetitions desired in the Cross-Validation validation process. So that the amount of data in each group is determined using the calculation of the total of datasets divided by the value of K. Each group will be the test data once in one of the validation repetition and used as training data in the rest repetition. An illustration of the Cross Validation validation process can be seen in Figure 3.

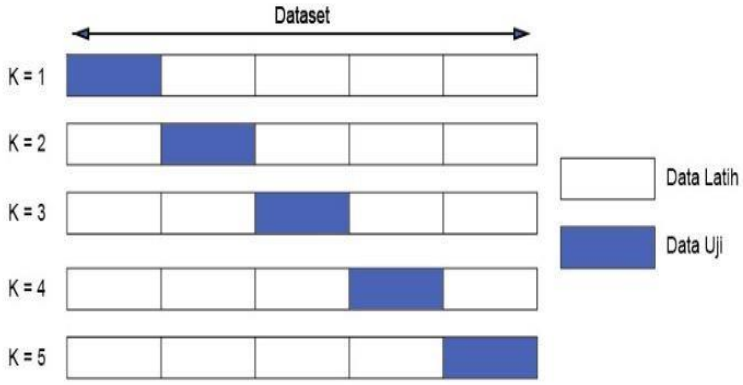


Fig. 3. How K-fold Cross Validation Works

2.3.5. Confusion Matrix

Confusion Matrix is included in the evaluation stage of the classification results. Confusion Matrix is a table that displays the performance of a supervised learning algorithm with each column in the table representing the predicted results and the rows in the table representing the actual results [15]. An explanation of the confusion matrix can be found in Table 4.

Table 4. Confusion Matrix

		Prediction	
		c_1	c_2
Actual	c_1	True Positif	False Negative
	c_2	False Positif	True Negative

Note:

- c_1 = main class
- c_2 = other class
- *True Positif* = the number of correct predictions classified as c1
- *True Negatif* = the number of correct predictions classified as c2
- *False Positif* = number of incorrect predictions classified as c1

- *False Negatif* = number of incorrect predictions classified as c2

Based on that explanation, the calculation of accuracy (5), precision (6), recall (7) and error rate (8) can be calculated using the following formula:

$$Akurasi = TP + \frac{TN}{TP+TN+FP+FN} \times 100\% \quad (5)$$

$$\text{Presisi} = TP + \frac{TN}{TP+FP} \times 100\% \quad (6)$$

$$\text{Recall} = TP + \frac{TN}{TP+FN} \times 100\% \quad (7)$$

$$\text{Error rate} = \frac{TP}{TP+TN+FP+FN} \times 100\% \quad (8)$$

3. Results and Discussion

3.1. Research Findings

This stock purchase decision research used the artificial neural network method with backpropagation technique using binary sigmoid activation with 11-8-2 architecture as in Figure 4 which means the architectural model has 11 input layers, 8 hidden layers, and 2 output layers.

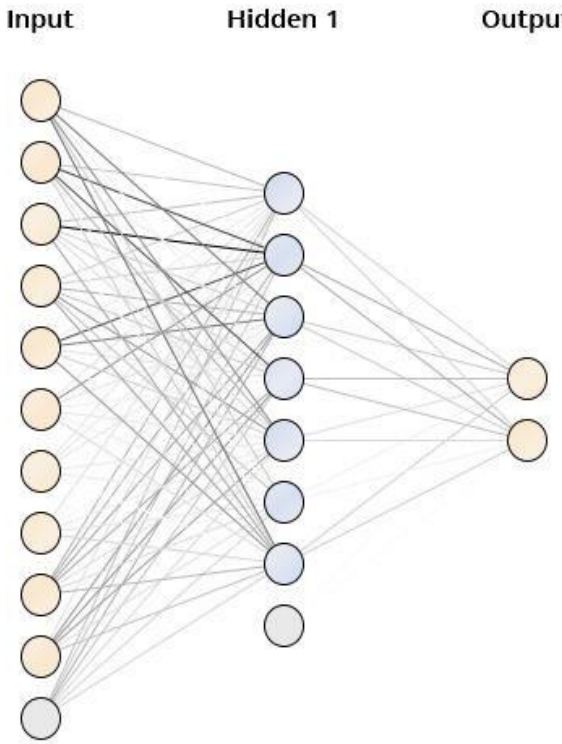


Fig. 4. Arsitektur Backpropagation 11-8-2

Before determining the prediction model that would be used in the system, this study determined several different samples consisting of four training cycles with values of 200, 500, 1000, and 2000 as well as four learning rates with values of 0.01, 0.03, 0.05, and 0.1. The sample was used for comparison in determining initial initialization for training cycles and learning rates with the best predictions on the data + SMOTE. Therefore, the data + SMOTE had 16 different scenario predictions.

All scenarios would be tested to determine the best performance using k-Fold CrossValidation with k = 10 and Confusion Matrix so that the best scenario would be implemented later on the stock prediction system. The results of 16 studies of artificial neural network scenarios using different Training Cycles (TC) and Learning Rate (LR) are shown in Table 5.

Table 5. Scenario Performance Results

Scenario	Training Cycles	Learning Rate	Accuracy	Purchase Precision	Purchase Recall	No Precision	No Recall
Scenario 1	200	0.01	63.31	60.78	75	67.37	51.61
Scenario 2	200	0.03	58.87	56.18	80.65	65.71	37.1
Scenario 3	200	0.05	58.06	55.43	82.26	65.62	33.87
Scenario 4	200	0.1	60.89	57.38	84.68	70.77	37.1
Scenario 5	500	0.01	63.71	61.33	74.19	67.35	53.23
Scenario 6	500	0.03	64.52	61.39	78.23	70	50.81
Scenario 7	500	0.05	63.31	60.12	79.03	69.41	47.58
Scenario 8	500	0.1	61.29	58.54	77.42	66.67	45.16
Scenario 9	1000	0.01	64.92	63.31	70.97	66.97	58.87
Scenario 10	1000	0.03	63.71	62.32	69.35	65.45	58.06
Scenario 11	1000	0.05	64.92	61.64	79.03	70.79	50.81
Scenario 12	1000	0.1	62.9	60.13	76.61	67.78	49.19
Scenario 13	2000	0.01	64.92	63.5	70.19	66.67	59.68
Scenario 14	2000	0.03	69.35	67.65	74.19	71.43	64.52
Scenario 15	2000	0.05	68.15	65.31	77.42	72.28	58.87
Scenario 16	2000	0.1	61.69	59.01	76.61	66.67	46.77

From Table 5, scenario 14 had the best accuracy value of 69.35% with Training Cycles = 2000, while the smallest accuracy value was scenario 3, which was 58.06% with Training Cycles = 200. In line with the accuracy value, scenario 14 also had a higher precision value than other scenarios, namely 67.65%. This shows that the higher the precision value, the prediction has the right goal in choosing a positive class label. On the contrary, scenario 3 became the scenario with the worst precision value. In contrast to accuracy and precision, the best recall value was scenario 4, which was 84.68% and the smallest recall value was scenario 10, with a value of 69.35%. The results also showed that scenario 14 had the lowest error rate value. It indicates that the smaller the value the better the prediction is.

3.2. Analysis

From all scenarios of artificial neural network methods with different Training Cycles (TC) and Learning Rate (LR), it has been concluded that the artificial neural network scenario 14 using Training Cycles (TC) of 2000 and Learning Rate (LR) of 0.03 becomes the best scenario with an accuracy of 69.35%, 67.65% precision, 74.19% recall, and an error rate of 30.65% as shown in Figure 5. Scenario 14 has the best accuracy, precision, and error rate among other scenarios. While the recall value of scenario 14 becomes the fourth-worst scenario. However, scenarios that have high recall values have poor accuracy, precision and error rates.

Fig. 5. Scenario 14's Performance

Of the four different training cycles and four learning rates, it shows that the value of training cycles and the small learning rate do not lead to better predictions, nor does the value of training cycles or large learning rates also produce good predictions. So it can be concluded that using the artificial neural network method must go through many experiments to find the right initial initialization for training cycles and learning rates to get the best accuracy, precision, recall and error rate results.

3.3. Implementation

Based on the best scenario results from backpropagation neural network training, scenario 14 which has a training cycle of 2000 and a learning rate of 0.03 is known to have hidden layer weights with input layers as in Table 6 and output layer weights with hidden layers in Table 7. The weights are applied in the system application to determine the prediction of stock purchase decisions by calculating the testing procedure of the artificial neural network classification backpropagation 11-8-2 using scenario 14.

Table 6. Weight of Hidden Layer with Input Layer

Node	Price	Open	High	Low	Vol.	Mon	Tue	Wed	Ths	Fri	Bias
H1	9.489	3.526	13.532	5.528	17.401	-0.266	-5.784	2.438	15.732	-11.952	3.602
H2	6.684	-6.444	4.467	9	-5.273	-0.282	3.815	-3.974	5.296	8.817	-0.958
H3	9.464	2.64	-5.346	13.07 4	-3.681	-0.958	2.74	13.679	1.438	0.793	-2.299
H4	8.102	-6.892	21.87	8.098	-6.857	-0.102	8.88	-15.69	1.499	4.638	0.517
H5	-3.454	3.248	9.95	13.46 8	-0.88	-0.265	-0.608	3.516	6.024	1.708	-6.237
H6	12.005	-14.98	-8.637	-2.8	0.399	2.956	0.737	5.25	0.283	6.27	-5.11
H7	7.394	-30.475	-13.772	8.197	2.84	1.997	5.021	6.815	7.635	0.738	-7.346

Table 7. Output Layer Weight with Hidden Layer

Node	H1	H2	H3	H4	H5	H6	H7	Bias
O1	-6.157	-5.717	-7.427	-8.622	13.197	-8.184	-8.545	9.002
O2	6.157	5.717	7.427	8.622	-13.197	8.184	8.545	-9.002

This study applies the validation results with the best scenario in the form of a web that users easily access through computer media, laptops, and smartphones. The main function of this application system is located on the home menu of the prediction section. It provides the prediction of the decision to buy ICBP shares the next day after all data from the closing price, opening price, highest price, lowest price, and representation of the day are known. Based on Figure 6, the ICBP stock purchase decision raises predictions with the words "Buy" with a green background or "No" with a red background following the classification that has been made with artificial neural networks.

Home display in the stock data section displays the last 30 days of ICBP stock prices with the date, price, open, high, low, volume and change% attributes as shown in Figure 7. Not only that, but this application also provides a special admin page that is used to provide new data input to the application system. Admin must log in first with an account that has been registered, then the system will display a dashboard page that contains a form like in Figure 8 to input new data by giving values to the date, price, open, high, low, volume and change%.

Fig. 6. Home Display of the Prediction Section

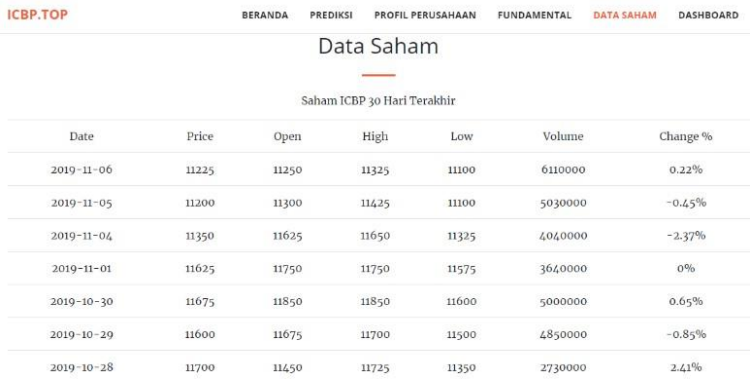


Fig. 7. Home Display of the Data Stock Section

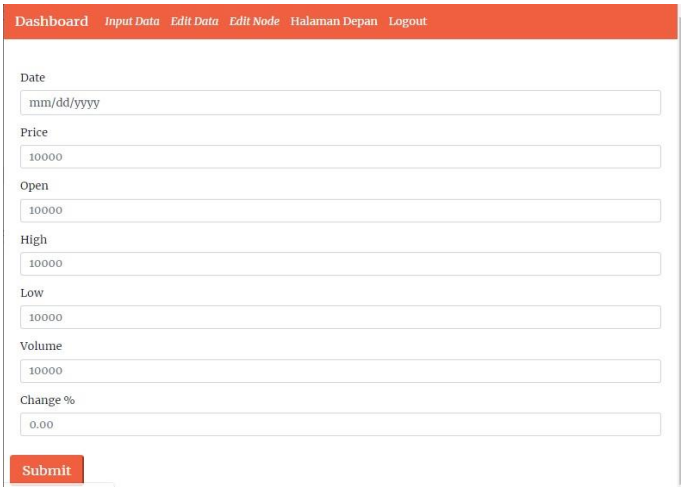


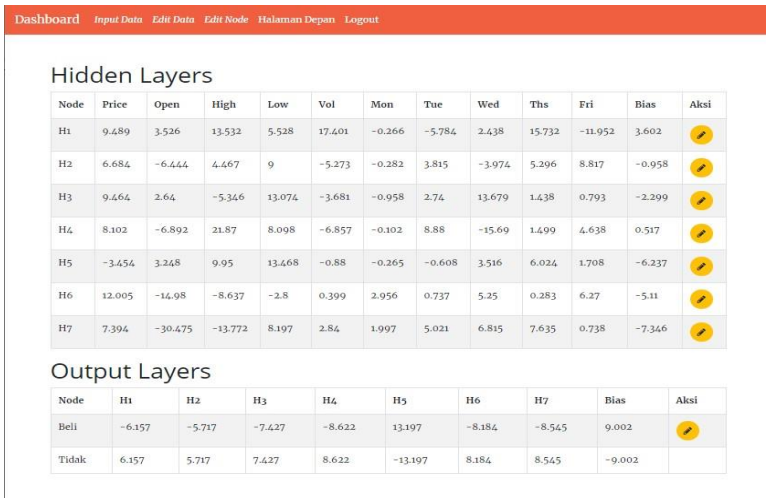
Fig. 8. Display of the Data Input Form

There is also a data edit page to edit or delete data when there are input errors, as shown in Figure 9.

No	Date	Price	Open	High	Low	Volume	Change	Aksi
1	2019-11-04	Rp. 11,350	Rp. 11,625	Rp. 11,650	Rp. 11,325	4,040,000	-2.37%	
2	2019-11-01	Rp. 11,625	Rp. 11,750	Rp. 11,750	Rp. 11,575	3,640,000	0%	
3	2019-10-30	Rp. 11,675	Rp. 11,850	Rp. 11,850	Rp. 11,600	5,000,000	0.65%	
4	2019-10-29	Rp. 11,600	Rp. 11,675	Rp. 11,700	Rp. 11,500	4,850,000	-0.85%	
5	2019-10-28	Rp. 11,700	Rp. 11,450	Rp. 11,725	Rp. 11,350	2,730,000	2.41%	
6	2019-10-25	Rp. 11,425	Rp. 11,575	Rp. 11,700	Rp. 11,200	5,170,000	-1.51%	
7	2019-10-24	Rp. 11,600	Rp. 11,500	Rp. 11,625	Rp. 11,450	8,820,000	0.87%	

Fig. 9. Edit Data Display

This application also provides an edit node page to update the value of the weights of the neural network in the hidden layer with the input layer or the output layer with the hidden layer when there is a change in weights with the display as in Figure 10. In the output layers only need to update the "Buy" node only, because the value "No" node is minus one multiplied by the weight value on the "Buy" node.



Node	Price	Open	High	Low	Vol	Mon	Tue	Wed	Ths	Fri	Bias	Aksi
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H3	9.464	2.64	-5.346	13.074	-3.681	-0.958	2.74	13.679	1.438	0.793	-2.299	
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H5	-3.454	3.248	9.95	13.468	-0.88	-0.265	-0.608	3.516	6.024	1.708	-6.237	
H6	12.005	-14.98	-8.637	-2.8	0.399	2.956	0.737	5.25	0.283	6.27	-5.11	
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Node	H1	H2	H3	H4	H5	H6	H7	Bias	Aksi
Beli	-6.157	-5.717	-7.427	-8.622	13.197	-8.184	-8.545	9.002	
Tidak	6.157	5.717	7.427	8.622	-13.197	8.184	8.545	-9.002	

Fig. 10. The Display of Edit Node

4. Conclusion

Based on this research analysis, it can be concluded that the performance of artificial neural networks is determined by the initial initialization of training cycles and learning rates which are the basis of the calculation of artificial neural network algorithms. Several scenarios with varying values from training cycles and learning rates are needed to get the best results. The dataset used in this study has an imbalance class. Normalization and SMOTE are performed on the data before it is processed. The dataset that has been processed will go through training and testing stages to get predictions with 10-fold crossvalidation and confusion matrix validation. The output of this stock prediction is a buy decision or not. The best performance result is scenario 14, which is a backpropagation neural network method using a binary sigmoid activation function using training cycles of 2000 and the learning rate of 0.03. The performance results obtained in the study "Prediction of Stock Purchase Decisions Per Day Using the Neural Network Method (Case Study of PT Indofood CBP Sukses Makmur Tbk)" with an accuracy value of 69.35%, precision 67.65%, 74.19% recall, and the error rate of 30.65%. While the suggestions that still need to be done for further research are: Can be further developed to increase the value of accuracy, precision, and recall with a value of more than equal to 80% to achieve excellent predictions; The use of the dataset is expanded by utilizing the attributes that have a large influence on share price movements, such as economic factors, political events or other factors that affect stock prices.

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