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Implementation of Artificial Neural Network on Sales Forecasting Application

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ABSTRACT

Sales forecasting is an effort to fulfill customer demands. The existence of a sales forecast, can help trade business owners in carrying out stock management to deal with customer demands in the future. Data owned in the past is used in predicting and estimating a condition in the future. Quantitative data used as a reference in the forecasting process can be time series data based on a certain period containing the number of sales. Artificial Neural Networks (ANN) are one of the human efforts to model the way the human nervous system functions in carrying out certain tasks. This modeling is based on the ability of the human brain to organize brain cells called neurons. Neurons are information processing units that are the basis of artificial neural network operations. ANN can be used to solve forecasting problems based on continuous data such as time series data from a sale based on a certain period. The research stages that will be carried out consist of analyzing needs, training the model, testing the model, forecasting sales.

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1. Introduction

Sales forecasting is an attempt to fulfill customer demand. A sales forecast can assist trading business owners in carrying out stock management to deal with customer demand in the future. This is important because too much inventory compared to demand will cause a condition called dead stock. This condition occurs because stocks become obsolete over time so the goods become unfit for sale, especially goods that have an expiration date. In addition, dead stock conditions can occur due to changes in market tastes (Asana, Kurniadi, et al., 2022; Atmaja & Anandita, 2021). Apart from dead stock, another condition that is avoided in sales is a condition called loss of sales.

Data owned in the past is used in predicting and estimating a condition in the future (Asana, Sudipa, et al., 2022). This data can be in the form of qualitative or quantitative data. This qualitative data can be in the form of ideas or experiences from situations that have occurred before, or can also be in the form of consumer survey results. Quantitative data that is used as a reference in the forecasting process can be in the form of time series data based on a certain period which contains the number of sales.

The Artificial Neural Network (ANN) is one of the human efforts to model the workings of the human nervous system in carrying out certain tasks. This modeling is based on the ability of the human brain

to organize brain cells called neurons. A neuron is an information processing unit that is the basis of the operation of artificial neural networks. Artificial neural networks can be used to solve forecasting problems based on continuous data such as time series data from sales based on a certain period (Aprilianto et al., 2018; Hasan et al., 2019; Satria, 2020).

Several studies related to sales forecasting have been carried out. The research by (Trimulya et al., 2015) explained one of the artificial neural network methods is applied, namely backpropagation with the binary sigmoid activation function for forecasting the closing price of PT. Adaro Energy. Forecasting the closing price of this stock using 6 variables of stock transaction data, including the opening price, the highest price, the lowest price, the closing price, the selling price, and the buying price. While the forecasting results that are the target of the research are the closing price of the stock the next day. Experiments were carried out using 4 different combinations of network architectures. The experiments performed are a combination of the number of neurons in the first hidden screen, the number of neurons in the second hidden screen, and the maximum number of iterations. Another research by (Cynthia & Ismanto, 2017) explained using the Backpropagation algorithm, the previous data was processed which was used as input for predicting the availability of food commodities. The data processed as input variables are harvested area, productivity level, total production, and total consumption needs. While processed food commodities are rice, corn, soybeans, peanuts, green beans, cassava, and sweet potatoes. The data was taken from 2006 to 2013. The years 2006 to 2012 were used as input data, while 2013 was used as target data. Several stages of Backpropagation are by initializing the weights, activating, calculating the input weights and output bias, and changing the weights and biases. These stages will obtain the output to be achieved with the smallest error approach so that predictive results for the availability of food commodities are obtained. The result is a prediction of the amount of availability of food commodities with the training and testing process to produce actual output as the target to be achieved. Research by (Aprilianto et al., 2018), in this study aims to model the ANN computing system with the smallest output error as a chocolate sales forecasting tool in Blitar Regency and analyze the level of accuracy of the forecasting method with data testing compared to the times series version of forecasting. The method used in forecasting in this study is the artificial neural network method. Based on the calculation of demand forecasting using the artificial neural network method, the result is that the forecast for sales of chocolate products at the beginning of the period from July 2017 to August 2017 will experience a decline. The lowest number of sales was in August 2017, which was 2306.22. While the highest number of requests occurred in January 2018 of 2546.93. So that in months that experience a decrease in sales in forecasting,

Based on some of these studies, the research objective is to conduct research by applying artificial neural networks to a sales forecasting application in the hope that the forecasting results will be maximized because in the neural network method there is a learning process to obtain forecasting results with the smallest error value. Sales data is obtained from a trading business which is also used as a research object so that it can help trading business owners in stock management through a forecasting system that is made.

2. Method

2.1. Forecasting

Forecasting is a description of the state of a business in the future(Fachrurrazi, 2015). This description is important for a business because this description can be used as a basis for predicting the steps or policies to be taken in meeting market demand. This forecasting activity is a business function performed to estimate the sales and use of products precisely.

Broadly speaking forecasting can be divided into two categories of forecasting methods(Baktiar et al., 2015), that is :

2.1.1 Qualitative method

In the qualitative method, calculations are not used with definite formulas and methods but are based on opinions from various parties. Qualitative methods are divided into two, namely:

1. Exploratory Method: The Explorative Method starts with the past and present as a starting point and moves toward the future by looking at all the possibilities that exist.
2. Normative Method: The Normative Method starts by setting forthcoming goals and objectives, then works backward to see if these are achievable given the constraints, resources, and available technology.

2.1.2 Quantitative method

The quantitative method is a forecasting method that relies heavily on historical data patterns. The quantitative method uses methods related to statistics and mathematics so that they can be accounted for scientifically. Quantitative methods are grouped into two types, namely:

1. Causal analysis (Causal Methods) which is based on the analysis of the pattern of the relationship between the variables that will be estimated with other variables that influence it.
2. Periodic series analysis (Time Series) which is generally always based on the user analyzing the pattern of the relationship between the variables to be estimated and the time variable. According to Makridakis, et al (1999), data patterns can be divided into 4 types, namely:
    a. Trend pattern (T) occurs when there is a long-term increase or decrease in the data
    b. Cycle patterns (C) occur when the data is influenced by long-term economic frequencies and is related to business cycles
    c. Seasonal pattern (S) occurs when a series is influenced by seasonal factors
    d. A horizontal pattern (H) occurs when data values fluctuate around a constant average value.

The result of the prediction depends on the method used, different methods can produce different prediction results. To find out how the prediction results can be known by measuring the level of prediction error. Forecasting is expected to minimize uncertainty in the future. So the minimum forecasting error value is the goal of the forecasting system(Astuti et al., 2017).

2.2. Artificial Neural Networks (ANN)

The artificial neural network is an attempt to imitate the function of the human brain in completing certain tasks. There are several characteristics of the human brain, namely remembering, calculating, generalizing, adaptation, and low energy consumption. Digital computers can beat the ability to calculate the numbers of the human brain (Abiodun et al., 2018). Meanwhile, the human brain can recognize people quickly in a crowd without significant effort. Artificial neural networks try to imitate the structure and workings of the human brain so that they can replace some of the human work such as pattern recognition, prediction, classification, functional approach, and optimization (Atika et al., 2019; Zai et al., 2021). Artificial neural network modeling is based on the ability of the human brain to organize constituent cells called neurons so that they can carry out certain tasks such as pattern recognition with very high effectiveness (Suyanto, 2014).

2.3. Backpropagation

Artificial neural networks with a single layer have limitations in pattern recognition. This weakness can be overcome by adding one or more hidden layers between the input and output layer s(Cynthia & Ismanto, 2017). This method is called Multi-Layer Perceptron (MLP). The Back Propagation method is an algorithm for training the created MLP (Lillicrap et al., 2020; Lillicrap & Santoro, 2019).

2.3.1. Data Normalization

The data obtained will go through the normalization process first. Normalized data is input data as well as training data. This process aims to map the original data to the same range as the range used in the Artificial Neural Network. The activation function used in this study is Sigmoid (Chamidah et al. 2012) said there are various normalization methods, one of which produces the best accuracy is the Min-max method (Anitescu et al., 2019). By default, min-max will change the data to the range [0:1], in this study the data will be changed to the range [0:1] with Equation (1) (Ogasawara et al., 2010).

$$x' = \left(\frac{x_i - x_{min}}{x_{max} - x_{min}}\right) * (max - min) + min \quad (1)$$

Information:
x' : Normalized data
x_i : Data to$i$
x_{min} : Data with a minimum value
x_{max} : Data with maximum value
max : The maximum range value, in this case, is 1
min : The minimum range value, in this case, is 0

2.3.2. Data Denormalization

The information generated from the network is information with a normalized value. After the training process is complete, the normalized values will be returned to their initial form to obtain the actual values. This process is called the denormalization process. This process can use Equation (2) (Ogasawara et al., 2010).

$$x_i = \left(\frac{x' - min}{max - min}\right) * (x_{max} - x_{min}) + x_{min} \quad (2)$$

Information:
x': The data to be denormalized
x_i : Denormalized data
x_{min} : Minimum value data
x_{max}: Data with maximum value
max : The maximum range value, in this case, is 1
min : The minimum range value, in this case, is 0

2.4. Mean Square Error

The size of the error is the deviation between the actual data and the forecast results(Baktiar et al., 2015). Forecasting error testing is done because forecasting is in the form of an estimate of a value in the future, because it is still an estimate, there is a high probability of an error in the forecast.

Mean Square Error (MSE) is a way to measure the overall forecasting error. MSE is the average of the squared difference between the predicted and observed values (Riyadi, 2015; Walczak, 2019). The equation of MSE can be seen in equation (3) below.

$$MSE = \frac{\sum(A_t - F_t)^2}{n} \quad (3)$$

where :
At = actual value in data t
Ft= forecasting value on t data
n = number of data periods

2.5. Research Flow

The following is an explanation of the existing research flow in Figure 1 below:

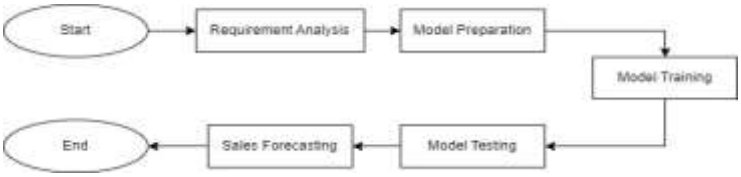

Figure 1. Research Flow

1. Requirement Analysis
   At this stage, a needs analysis is carried out from the research conducted, followed by data collection, both data used in the research and data that support the research being conducted.
2. Modeling
   At this stage, the preparation of the neural network model is carried out, namely determining the number of neurons in the input layer, hidden layer neurons, number of hidden layers, and ANN hyperparameters.
3. Models Training
   At this stage, training is carried out by modeling artificial neural networks made using Multi-Layer Perceptron with the Backpropagation learning method. Training is carried out to obtain weights on ANN that can be used for forecasting with small errors. Model training is stopped if it meets a stopping condition such as the number of epochs or according to the target error.
4. Model Testing
   At this stage, model testing is carried out from the results of the training process. The model will be used in the forecasting process if it already has a forecast with an error value limit. Model testing will be measured using MSE.
5. Sales Forecasting
   The model that is deemed appropriate will be used at this stage. At this stage sales forecasting is carried out based on predetermined inputs.

3. Results and Discussions

3.1. System Overview

The system that will be developed will be able to provide a sales prediction value based on the input provided and the modeling made. The following is a flow chart of the system that will be made as shown in Figure 2.

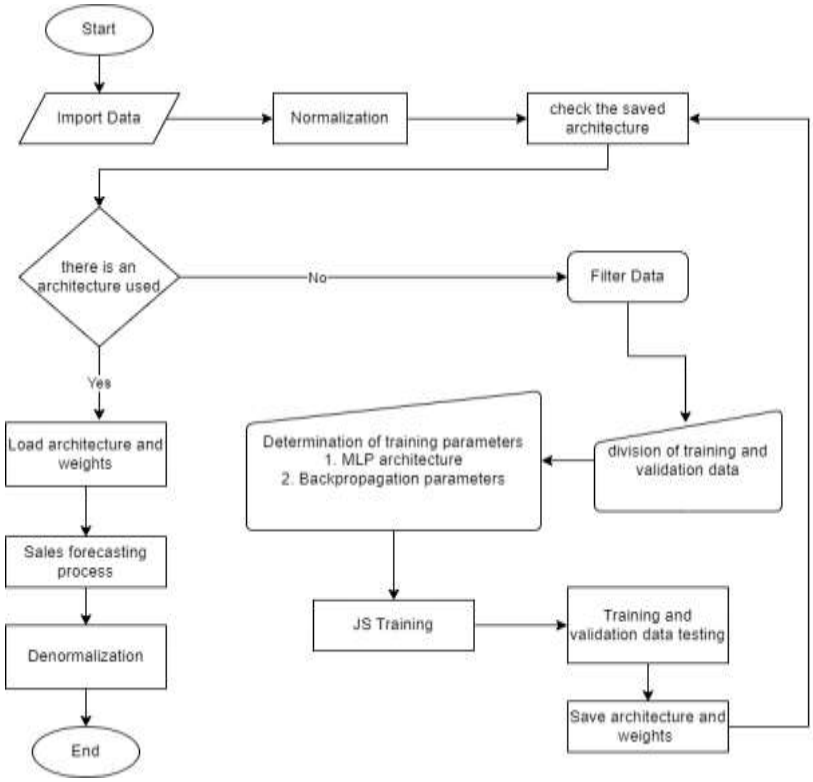

Figure 2. System flow diagram

The preparation of the model of the artificial neural network that will be carried out in this study is shown in Figure 3.

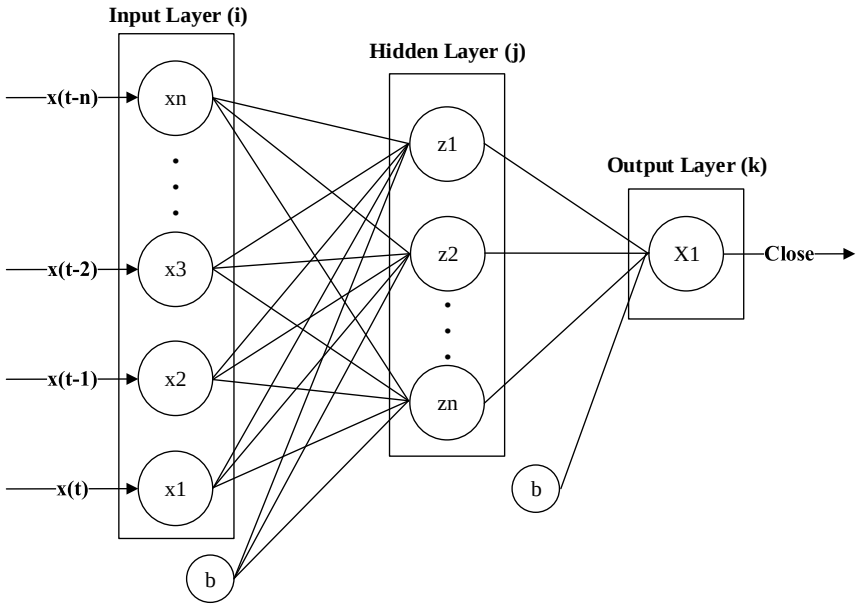

Figure 3. Modeling of an Artificial Neural Network

In Figure 3 it can be seen that the MLP network has 3 layers consisting of an input layer, a hidden layer, and an output layer. The input data for the network depends on the amount of Windows Size required on the data. In the hidden layer, a number of neuron units are used, the number of which will later be determined using the trial and error method to get the minimum error results. The output layer only consists of an output issued in the form of a sales prediction value.

3.2. Implementation

Forecasting implementation is done using google colab. Model building is carried out in two stages, the data training, and data testing stages. The sample data used for forecasting are monthly sales data for 2 liters of cooking oil and coffee with a data span between January 2019 and October 2020. The training data used is 70% of the total data, while the testing data used is 30% of the total data.

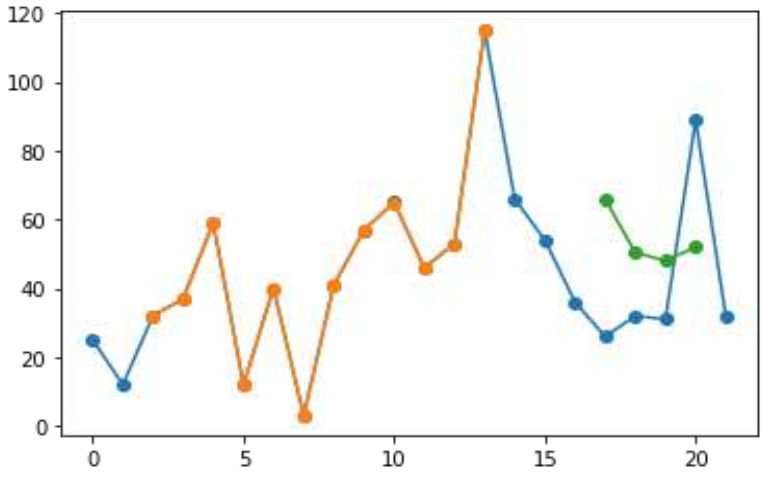

Figure 4. Liter cooking oil forecasting data graph

The results of training data and testing data for forecasting sales of 2 liters of cooking oil are shown in Figure 4. In the training process, the data used is data from January 2019 to October 2020 with a total of 22 training data. The parameters used to find the best model are as follows: a) Maximum epoch: 5,000. b) Target Error : 0.001. After doing the calculations, the smallest MSE value is obtained with a value of 0.71, hidden neurons 40. However, when testing the data, the MSE value is obtained which is quite significant at 26.84

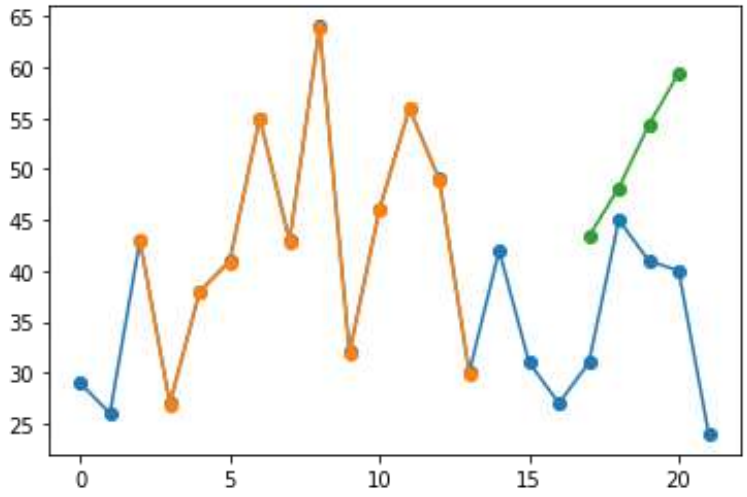

Figure 5. Graph of coffee sales forecasting data

The results of data training and testing of coffee sales forecasting data are shown in Figure 6.2. In the training process, the data used is data from January 2019 to October 2020 with a total of 22 training data. The parameters used to find the best model are as follows: a) Maximum epoch: 5,000. b) Target Error: 0.001. After doing the calculations, the smallest MSE value was obtained with a value of 0.02, hidden neurons 40. However, when testing the data, the MSE value was obtained which was quite significant at 12.41.

4. Conclusion

Based on the results of research on sales forecasting using an Artificial Neural Network with the backpropagation algorithm, it can be concluded that: (1) Product sales forecasting has been designed according to the architecture and backpropagation algorithm of the artificial neural network. (2)The ability of an Artificial Neural Network can be applied to the functional form of the relationship between the independent variables and the dependent variable, even though the relationship is not well-known or difficult to know. (3)The determination of network parameters greatly influences the length of the training process. (4)Additional data is needed for data training to get a minimum error value.

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