



Artificial Neural Networks in Predicting the Number of New Students using the Backpropagation Method (Case Study: Santo Thomas Catholic University Medan)

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ABSTRACT

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An artificial neural network is an information processing designed by imitating how the human brain works in solving problems, namely by carrying out the learning process. Backpropagation is one of the algorithms of artificial neural networks that is often used in predicting because it has a good level of accuracy. Uncertainty in the number of registrants at the Catholic University of Santo Thomas, forecasts or predictions are made. The problem formulation of this research is "How to predict new student admissions using an Artificial Neural Network with the Backpropagation method?". The purpose of this study is to find out how many new students there will be in 2022 in order to plan a strategy to find out the ups and downs of the number of new students.

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1. Introduction

Higher education is an education that carries out higher education, research, and community service. A college cannot be in the form of an academic, polytechnic, and high school or institute or university. Santo Thomas Catholic University, North Sumatra is one of the private universities in the city of Medan and currently has eight faculties with different levels of specialization.[1].

Number of Students Decreases and increases every year because there are not many applicants, so the number of new students is not stable. Predicting the number of students is very important to do to explore innovations or changes as well as good marketing and promotion strategies so that the number of registrations increases. Artificial Neural Network is one of the artificial representations of the human brain which always tries to simulate the learning process of the human brain. In computer science, artificial neural networks are widely used to solve problems related to forecasting or prediction[2].

The method used to make predictions is the Backpropagation method, which is a supervised learning algorithm and is used with many layers to change the weights connected to the neurons in the hidden layer so as to make the prediction results better because it minimizes the total error of the calculated output. by network[3]. In this study, it is hoped that the Backpropagation method can predict the number of new students with smaller error results. The smaller the MSE, the smaller the error in predicting the number of new students[2]. The formulation of the problem in this study is to conduct training and testing on an artificial neural network using MATLAB 2016a. For data on the number of new students from 2018 to 2021 and it is predicted based on the faculty.

2. Method

In the artificial neural network model used is as shown in Figure 1 below:



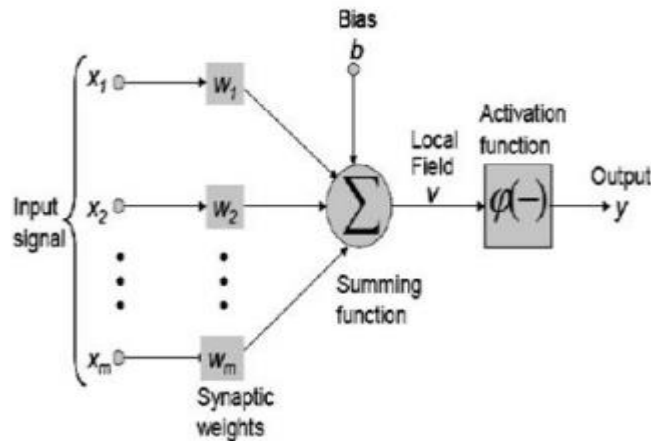


Figure 1. Artificial Neural Network Model.

In figure 1, X_1 up to X_m is the 1st to mth input unit. In the Hidden layer or synaptic weights, there are 4 hidden units, namely W_1 to W_m , while the output in the layer, only consists of an output unit, namely Y . The modeling procedure with ANN (Artificial Neural Network) generally consists of four stages, namely data preparation , architecture selection, learning (learning), and testing (testing). The Backpropagation method is a systematic method for training multilayer artificial neural networks with a supervised learning algorithm and is usually used by perceptrons with many layers to change the weights associated with the neurons in the hidden layer.[2].

In this backpropagation neural network algorithm, a binary sigmoid activation function is used where this function has a value between 0 to 1. However, the binary sigmoid function never reaches 0 or 1. The binary sigmoid activation function is formulated in equation (1) below:[4]

$$f(x) = \frac{1}{1+e^{-ax}} \dots\dots\dots (1)$$

Therefore, the data needs to be normalized first with equation (2)

$$x' = \frac{0.8(x-a)}{(b-a)} + 0.1 \dots\dots\dots (2)$$

The data normalization process aims so that the input data values can be adjusted to the sigmoid activation function that will be used, so that the network does not fail when doing learning (training and testing). Determining the network architecture is carried out several times to get the best network with the following steps:

- a. Collect data, Normalize data, divide the data into two, namely training and testing data, and determine each target and test.
- b. To perform the process using a GUI-based Matlab with the nntool command. Enter the data that has been normalized with the Logsig, Pulerin, and traingdx functions with the following conditions:
 Learning reat value = 0, 1
 Goal Value = 0.001
 Epoch = 2000.

In the feedforward network, training is carried out in order to calculate weights so that at the end of the training good weights will be obtained. During the training process, the weights are iteratively adjusted to minimize errors that occur. The error is calculated based on the mean squared error (MSE). The mean squared error is also used as the basis for calculating the activation function. MSE is calculated using equation (3):

$$MSE = \frac{\sum_{i=1}^n e_i^2}{n} \dots\dots\dots (3)$$

After the forecasting model is obtained, the following steps are taken to determine the prediction of the number of new students as follows:

- a. Prediction is done by using the best network model.
- b. Run the program with the best architecture.



- c. After getting the simulation results, it is then denormalized, that is, returning the predicted network value to the original data form or before it was normalized using the equation (4). [4]

$$Prediksi = \frac{(output-0,1)(b-a)}{0,8} + a \dots \dots \dots (4)$$

In this study using a research framework such as the flowchart in Figure 2 below:

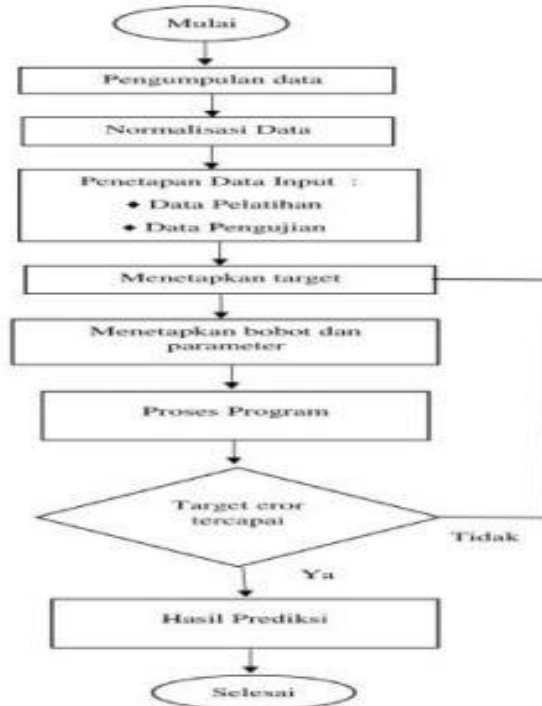


Figure 2. Research Framework Flowchart

3. Result and Discussion

3.1 Data Normalization

After the data is inputted, then the training data will be normalized first with the formula in equation (1). The following is the result of normalization of training data.

Table 1
Data Normalization

Faculty	2018	2019	2020	2021
FK	0.358065	0.347312	0.317204	0.291398
FKIP	0.506452	0.721505	0.674194	0.9
FS	0.123656	0.1	0.136559	0.104301
FT	0.22043	0.231183	0.233333	0.332258
FH	0.327957	0.315054	0.304301	0.41828
FIKOM	0.26129	0.510753	0.508602	0.530108
FE	0.773118	0.850538	0.839785	0.768817

The normalized data will be divided into two parts, namely as training data and test data. The following is an example of 2018 training data that will be trained to achieve the 2019 data target and as test data for prediction results is 2020 data.

Table 2
Training Data

Training Data							
x1	x2	x3	x4	x5	x6	x7	target
0.3581	0.5065	0.1237	0.2204	0.3280	0.2613	0.7731	0.3473
0.5065	0.1237	0.2204	0.3280	0.2613	0.7731	0.3473	0.7215
0.1237	0.2204	0.3280	0.2613	0.7731	0.3473	0.7215	0.1000
0.2204	0.3280	0.2613	0.7731	0.3473	0.7215	0.1000	0.2312
0.3280	0.2613	0.7731	0.3473	0.7215	0.1000	0.2312	0.3151
0.2613	0.7731	0.3473	0.7215	0.1000	0.2312	0.3151	0.5108
0.7731	0.3473	0.7215	0.1000	0.2312	0.3151	0.5108	0.8505

Table 3
Test Data

Test Data							
0.3473	0.7215	0.1000	0.2312	0.3151	0.5108	0.8505	0.3172
0.7215	0.1000	0.2312	0.3151	0.5108	0.8505	0.3172	0.6742
0.1000	0.2312	0.3151	0.5108	0.8505	0.3172	0.6742	0.1366
0.2312	0.3151	0.5108	0.8505	0.3172	0.6742	0.1366	0.2333
0.3151	0.5108	0.8505	0.3172	0.6742	0.1366	0.2333	0.3043
0.5108	0.8505	0.3172	0.6742	0.1366	0.2333	0.3043	0.5086
0.8505	0.3172	0.6742	0.1366	0.2333	0.3043	0.5086	0.8398

After inputting the training data, then conducting data training with various architectural patterns such as table 5.

Table 5
Data Training With Various Network Architecture Patterns

Pattern	Lr	Goal	epoch	Function	MSE	
7 7 1	0.1	0.001	2000	Pulerin	0.022866	
7 6 1	0.1	0.001	2000	Pulerin	0.025394	
7 5 1	0.1	0.001	2000	Pulerin	0.137120	
7 4 1	0.1	0.001	2000	Pulerin	0.000808	0.000808
7 3 1	0.1	0.001	2000	Pulerin	0.121209	
7 2 1	0.1	0.001	2000	Pulerin	0.020139	
7 1 1	0.1	0.001	2000	Pulerin	0.011943	

Data training was carried out several times by trial and error to get the best network by determining the number of neurons 4 and hidden layer 1, the smallest error (MSE) was 0.00808. The best training results for the ANN design were re-tested with the test data that had been prepared. The best weights are prepared for the data testing process in order to get good test results too.

Data testing is carried out to measure the validation of whether the prediction results of the model built from training data do give good results for calculating prediction errors. The test is carried out using the best architectural design that has been obtained from the training results. The network structure used consists of one layer containing 7 input neurons. The first hidden layer consists of 9 input neurons and the output layer consists of 1 neuron. The existing data is converted into a training pattern of 7 training and 7 testing, so that the test data results are obtained as in table 6. Based on table 6, the best model is the 7-4-1 pattern, the smallest error (MSE) is 0.0048784.

Table 6
Testing Data With Various Network Architecture Patterns

Pattern	Lr	Goal	Epoch	Function	MSE	
7 7 1	0.1	0.001	2000	Pulerin	0.018175	
7 6 1	0.1	0.001	2000	Pulerin	0.019257	
7 5 1	0.1	0.001	2000	Pulerin	0.050083	
7 4 1	0.1	0.001	2000	Pulerin	0.004874	0.004874
7 3 1	0.1	0.001	2000	Pulerin	0.020884	
7 2 1	0.1	0.001	2000	Pulerin	0.139046	
7 1 1	0.1	0.001	2000	Pulerin	0.014911	

For the results of testing the data using the regression model for errors, it is obtained as follows:



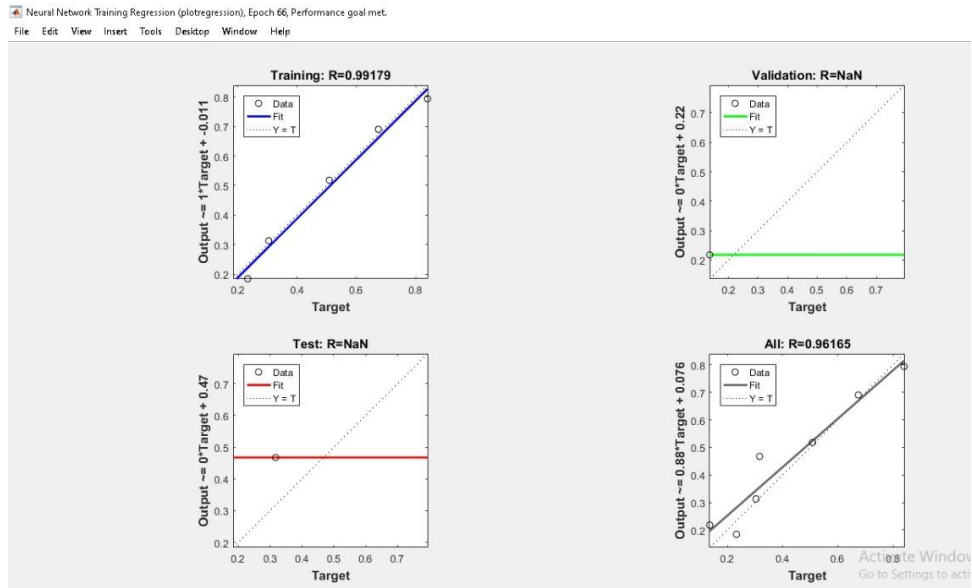


Figure 3. Graph of Testing data for 2019

Figure 3 shows the regression with an R value of 0.99179, which means that the actual variables and the ANN in the test have a good correlation. After that, the MSE value was calculated for the 2029 test with the following results:

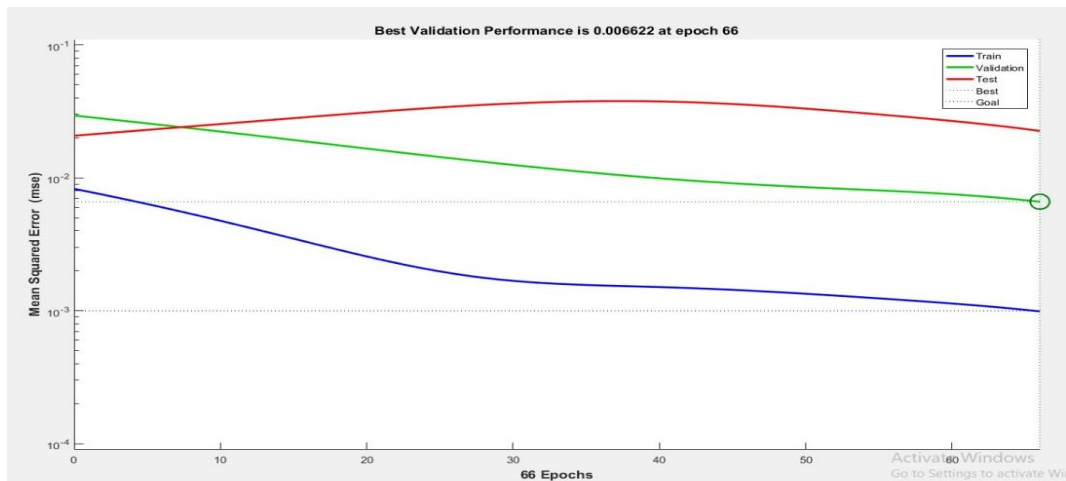


Figure 4. Graph of MSE scores on 2019 test

In Figure 4, the test results are reached at epoch 66 and produce an MSE value of 0.000808. Next, a comparison of the output values of the best ANN modules is carried out, which is the one with the smallest MSE of the 2020 target value as shown in Figure 5 below. In Figure 5, it can be seen from the results of the comparison of the ANN value and the target value for 2020, the MSE value is 0.000808. These results indicate that the predictions for the 2020 data are accurate, because the MSE obtained is small.

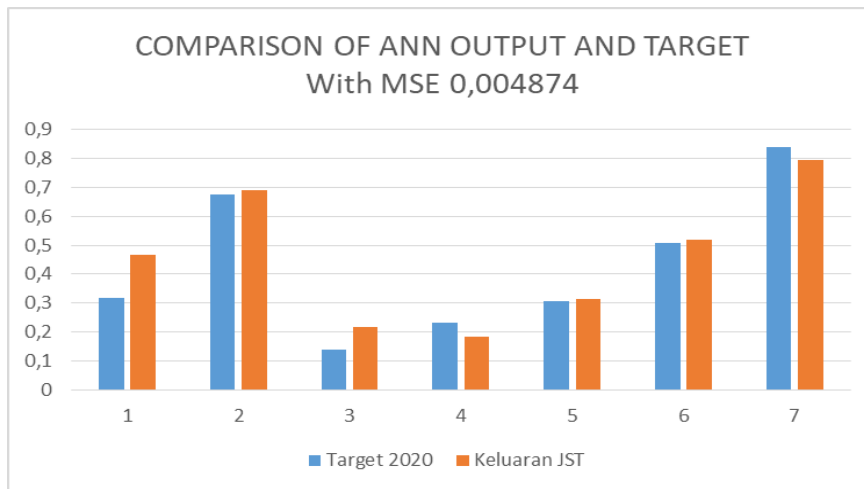


Figure 5. Comparison of ANN Output Value and 2020 Target Value

3.2 Forecasting or predicting data

After training and data testing, student predictions for 2021 are then carried out. This prediction uses the best ANN with a 4-1 neuron architecture design obtained from trial and error in data training, namely learning rate 0.1, binary sigmoid activation function for hidden layer and purelin for the output layer. After being simulated, the JST results are obtained which are the predicted values for new students at the National University in 2021 in each faculty as shown in table 7 below:

Table 7
Prediction Results

Output 7 4 1	Prediction	Actual	Error	Faculty
0,4674	187	105	82	FP
0,6905	291	388	-97	FKIP
0,2179	71	18	53	FS
0,1842	55	124	-69	FT
0,3129	115	164	-49	FH
0,5181	210	216	-6	FIKOM
0,7938	339	327	12	FE

4. Conclusion

Artificial Neural Networks with the Backpropagation Algorithm are able to predict the number of new students according to the pattern being trained based on the input values that are the criteria. The artificial neural network process uses data from the number of new students at the National University for a period of 3 years, where the data will be divided into training and testing. The results of the study show that backpropagation has a good level of accuracy in predicting new students with a 4-1 neuron structure with 1 (one) hidden layer, the learning rate (lr) used is 0.1, the tolerance limit for the MSE value is 0.001. This testing process is stopped at the 66th epoch, where the accuracy seen from the test results has a value of MSE0, 0.000808. Because the goal performance function has been achieved ($MSE = 0.000808 < 0.001$), it shows the relationship between the target and the network output at the time of testing. From testing the test data between the network outputs, the target correlation coefficient (R) is 0, 99179 where the best result is 1. The result of the comparison of the ANN output value and the 2020 target value is the MSE value of 0.000808. For predictions for 2021.

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