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IMPLEMENTATION OF ARTIFICIAL NEURAL NETWORK IN PREDICTING BIRTH RATE IN BATAM CITY USING BACKPROPAGATION METHOD

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Abstract: The population growth in Indonesia is increasing rapidly every year, so to help the government control the population growth through family planning programs, especially in the city of Batam. This study explains and describes one of the Artificial Terms Network methods, namely Backpropagation, where this method can predict what will happen in the future using data and information in the past. This study aims to predict the birth rate in the city of Batam to help the government with the family planning program. The data used is the annual data on the number of births in the city of Batam in 2016-2020 at The Civil Registry Office. To facilitate the analysis of research data, the data were tested using Matlab R2015b. In this study, the training process was carried out using 3 network architectures, namely 4-10-1, 5-18-1, and 4-43-1. Of these 3 architectures, the best is the 4-43-1 architecture with an accuracy rate of 91% and an MSE value of 0.0012205. The Backpropagation method can predict the amount of population growth in the city of Batam based on existing data in the past.

Keywords: artificial neural network; backpropagation; prediction

Abstrak: Pertumbuhan jumlah penduduk diindonesia yang setiap tahun meningkat dengan pesat, maka untuk membantu pemerintah mengendalikan jumlah pertumbuhan penduduk melalui program keluarga berencana khususnya dikota Batam. Penelitian ini menjelaskan dan memaparkan tentang salah satu metode Jaringan Syarat Tiruan yaitu Backpropagation, dimana metode ini dapat memprediksi apa yang akan terjadi masa yang akan datang dengan menggunakan data dan informasi dimasa lalu. Penelitian ini bertujuan untuk memprediksi tingkat kelahiran di kota Batam sehingga membatu pemerintah untuk perencanaan keluarga berencana. Data yang digunakan yaitu data tahunan jumlah kelahiran di kota Batam pada tahun 2016-2020 pada Dinas Kependudukan dan Catatan Sipil. Untuk mempermudah analisis data penelitian maka, data diuji menggunakan Matlab R2015b. Pada penelitian ini dilakukan proses pelatihan menggunakan 3 arsitektur jaringan yaitu 4-10-1, 5-18-1, dan 4-43-1. Dari ke-3 arsitektur ini yang terbaik adalah arsitektur 4-43-1 dengan tingkat akurasi sebesar 91% dan nilai MSE 0,0012205. Metode backpropagation mampu memprediksi jumlah pertumbuhan penduduk di kota Batam berdasarkan data yang ada dimasa lalu.

Kata kunci: backpropagation; jaringan syaraf tiruan; prediksi

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INTRODUCTION

The development of information technology is so fast. One branch of science that can provide information, especially regarding data prediction, is artificial intelligence. artificial intelligence has branches of science, namely Natural Language Processing, Computer Vision, Robotics, Games, and Expert Systems. This study aims to test the results of the prediction of the birth rate in the city of Batam using the backpropagation method.

Prediction of stock prices using the Backpropagation method of Artificial Neural Networks is needed where the company's stock price in the market is very volatile, where the value fluctuates according to market conditions. Based on these facts, stock prices become very difficult to predict or even estimate. Therefore, analysis of stock price movements is very much needed as a reference investment decision for investors. This research uses technical analysis with the Artificial Neural Network Back-propagation method. The data used from 2013-2018 results in predictions using several variations of hidden layer values, namely 10, 20, 30 with variations in SGD values: 0.01, 0.001, and 0.0001 as well as variations in epoch values 100, 200, 300. Produces a model the best is 20-1 with a value of SGD 0.01 and epoch 300 to produce an accurate stock price prediction [1].

Artificial Neural Networks are often used for various computational purposes, one of which is prediction. The artificial neural network method that is often used is Backpropagation. Backpropagation can learn from previous data and recognize data patterns, so Backpropagation can predict what will happen in the future. In this study, the data that will be predicted is the Human Development Index data from 2011-2015. Data sourced from the Central Bureau of Statistics of North Sumatra. This study uses 5 architectures: 3-8-1, 3-18-1, 3-28-1, 3-16-1, and 3-48-1. Of the 5 architectures, the best architecture is 3-48-1 with 100% accuracy, with epoch 5480 and MSE 0.0006386 [2].

The Backpropagation Algorithm is one of the methods of Artificial Neural Networks that can be applied in various fields of human life, one of which is for weather prediction. The backpropagation method can be used to predict because it can check and determine the historical data used for prediction. This study was used to predict rainfall in Ambon city using data from 2011-2015. The test results obtained an 80% accuracy rate with an epoch value of 1100 and an MSE value of 0.022. From these parameters, the prediction of rainfall produced is accurate [3].

Students dropping out of college is a case that must be a concern in higher education because it can reduce the quality of higher education. College dropouts can occur for various reasons, one of which is the length of the learning period. The undergraduate program lasts a maximum of eight years to graduate. This study predicts students dropping out of college using an academic database based on achievement index data each semester and class attendance. The results of the study using the Backpropagation method produced an accuracy rate of 77.78% with 17 epochs. The highest accuracy was obtained using the 8-8-1 architecture [4].

Infectious diseases caused by vectors have occurred in everyday life. Currently, technology can help diagnose

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various infectious diseases. Early diagnosis of disease to ensure appropriate care and treatment for the patient. One of the methods for predicting infectious diseases based on vectors is the backpropagation method of artificial neural networks. With the implementation of backpropagation in the disease diagnosis system, the accuracy level increases. The results of testing data on dengue fever and cholera with an epoch value of 100 showed an accuracy rate of 98.90% for cholera and 98.78% for dengue fever [5].

Solar Energy has become a new energy source. Developing a system that relies on Solar Energy requires a good estimate of the amount of solar radiation obtained. The sunlight obtained is based on several parameters such as seasonal changes, cloud cover, and humidity. Statistical techniques are very prone to errors when making predictions. The results of this study use the backpropagation method to predict solar radiation with an accuracy level of 98.81% and MAPE 2.19 [6].

Life expectancy can be defined as the estimated average per year a person can live. This study aims to predict life expectancy in Maluku province so that the Maluku provincial government can improve the degree of public health services. The method used is backpropagation with an accuracy rate of 99.65% with a MAPE value of 0.0035. The results of forecasting life expectancy in the next 5 years tend to increase [7].

METHOD

This framework is a step-by-step process to solve the problems in this research. The framework can be seen in Figure 1.

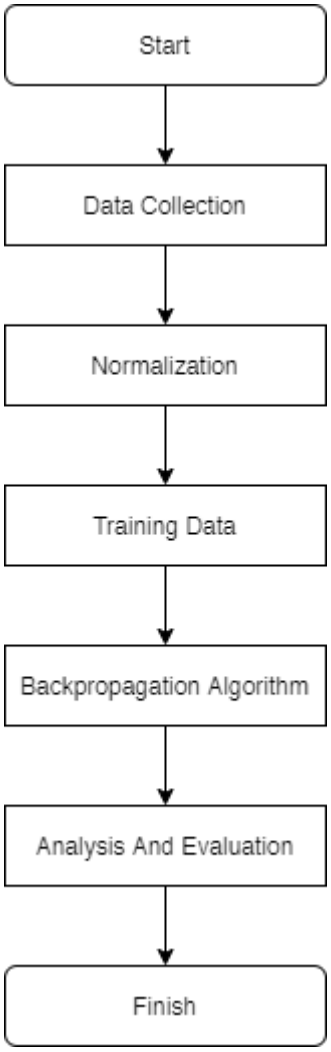

Figure 1. Research Framework

Backpropagation

The method used for prediction in this study is the Backpropagation method. This Backpropagation algorithm is also used on perceptrons with many layers and changes the weights connected to the neurons contained in the hidden layer [8]. Figure 2 is the architecture of Backpropagation [9].

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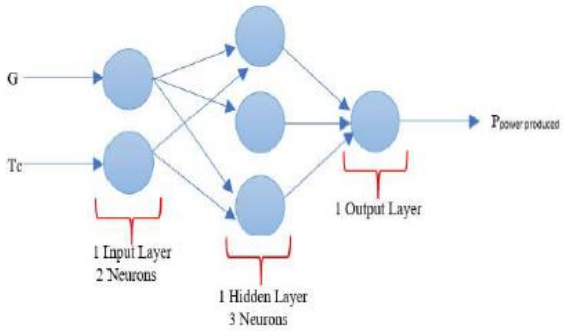

Figure 2. Backpropagation architecture

Data Normalization

Before the data is processed, the data normalization process will be carried out using the sigmoid function. Sigmoid is normalized data that will produce a value between 0 and 1 (where the value cannot be 0 and 1) [10]. The sigmoid function can be seen as formula 1.

$$x' = \frac{0{,}8(x-a)}{b-a} + 0{,}1 \quad (1)$$

Information :

x' = Result of normalization process
x = Data to be normalized
a = Lowest value data
b = Highest value data

Backpropagation Algorithm Stages

Step 0: assign an initial weight value using random numbers.

Step 1: If the termination condition is not met, then perform steps 2-9.

Step 2: For the training data pairing process, steps 3-8 are used.

Step 3: Each input unit will receive the signal and forward it to all units in the hidden layer.

Step 4: Calculate the output signal.

Step 5: Each hidden layer z_j (from unit 1 to unit n and p; i=1,...,n; j=1,...p) the output signal in the hidden layer is processed using an activation function against the result of the sum of the input signals weighted as in the formula 2.

$$Z_j = f(V_{oj} + \sum X_I V_{ij})_{i=1}^{n} \quad (2)$$

Step 6: Each unit at the input y_k (from unit 1 to unit and m; i=1,...,n; k=1,...m) is calculated as the output signal using the activation function of the process of adding weighted input signals as shown in Fig. formula 3.

$$Y = f(W_{ok} + \sum Z_j W_{jk})_{i=1}^{p} \quad (3)$$

Step 7: Each output unit y_k (from unit 1 to unit n and m; i=1,...,n; k=1,...m) gets the target pattern t t_k then the error information from the output layer (δ) is calculatedδ_k forwarded to the lower layer and then implemented to calculate the weight and bias correction ($\Delta w_k \; dan \; \Delta w_{ok}$) between the hidden layer and the output layer as in formula 4.

$$\delta_k = (t_k - y_k) f'$$
$$\Delta w_{jk} = \alpha \; \delta_k Z_j \quad (4)$$
$$\Delta w_{ok} = \alpha \; \delta_k$$

Step 8: Each hidden layer unit (from unit 1 to unit p; i=1,...,n; j=1....p; k=1....m) then calculates the incorrect information in the hidden layer. layers (δ_j). Then calculate the weight and bias correction ($\Delta V_{ij} \; dan \; \Delta V_{oj}$) between the input and hidden layers as in the formula 5.

$$\delta_k = (\sum \delta_k \, Wjk)_{k=1}^{m} f'(V_{oj} + \sum X_i V_{ij})_{i=1}^{n}$$
$$\Delta V_{ij} = \alpha \; \delta_k \, X_i$$
$$\Delta V_{oj} = \alpha \; \delta_j \quad (5)$$

Step 9: Each output unit Y_k (from unit 1 to unit m) is then processed to change the bias and weight (j=0,....p; k=1,...,m); so that the bias and weight values become the new weight values. the process of finding a new weight value as in the 6 . formula.

$$W_{jk}(baru) = W_{jk}(lama) + \Delta V_{ij} \quad (6)$$

In the 1st unit to the p-the unit in the hidden layer, bias and weight changes are

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also carried out [11]. As in the formula 7.

$$V_{jk}(baru) = W_{jk}(lama) + \Delta V_{ij} \quad (7)$$

Step 10: to test the stopping conditions can be tested using the MSE (Mean Square Error) equation [12]. As in the formula 8.

$$MSE = \frac{1}{N} \sum_{i=1}^{n} (Ti - Yi)^2 \quad (8)$$

Where n is the number of training data, Ti is the target and Yi is the output.

RESULTS AND DISCUSSION

The data used in this study is data on the number of births in the city of Batam in 2016-2020 as shown in Table 1.

Data Normalization

The data used in this study is birth data in the city of Batam in 2016-2020 with target data in 2020. The following is data that has been normalized using the sigmoid function as shown in Table 2.

Table 1. Batam City Birth Data

No	Area	Birth 2016-2020				
		2016	2017	2018	2019	2020
1	Belakang Padang	8.688	8.737	9.041	9.456	10.202
2	Batu Ampar	23.270	24.695	28.669	29.871	31.155
3	Sekupang	39.841	44.778	54.009	59.332	68.892
4	Nongsa	22.625	24.823	29.180	31.810	36.957
5	Bulang	4.264	4.452	4.698	4.996	5.565
6	Lubuk Baja	43.965	44.678	48.869	48.521	39.139
7	Sungai Bedok	26.611	29.129	33.487	36.144	41.147
8	Galang	7.721	7.839	8.334	8.861	9.717
9	Bengkong	48.881	51.104	55.992	58.896	62.901
10	Batam Kota	84.552	88.713	95.550	100.354	103.831
11	Sagulung	70.419	76.291	84.747	90.765	99.662
12	Batu Aji	49.113	52.330	58.969	62.417	69.032

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Table 2. Normalization of Data

No	Area	Birth 2016-2020				
		2016	2017	2018	2019	Target
1	Belakang Padang	0,13554	0,13593	0,13838	0,14171	0,14771
2	Batu Ampar	0,25270	0,26415	0,29608	0,30574	0,31606
3	Sekupang	0,38585	0,42552	0,49969	0,54245	0,61927
4	Nongsa	0,24752	0,26518	0,30019	0,32132	0,36268
5	Bulang	0,10000	0,00151	0,10348	0,10588	0,11045
6	Lubuk Baja	0,41898	0,42471	0,45839	0,45559	0,38006
7	Sungai Beduk	0,27955	0,29978	0,33480	0,35614	0,39634
8	Galang	0,12777	0,12872	0,13270	0,13693	0,14381
9	Bengkong	0,45848	0,47634	0,51562	0,53895	0,57113
10	Batam Kota	0,74509	0,77853	0,83346	0,87206	0,90000
11	Sagulung	0,63154	0,67872	0,74666	0,79501	0,86650
12	Batu Aji	0,46035	0,48620	0,53954	0,56724	0,62039

Testing Data Using Matlab

The architecture used to test the data is 4-10-1, 4-18-1, and 4-43-1. Of the 3 architectural models, the best architecture with the highest level of accuracy will be selected.

Architectural Data Testing 4-43-1

Testing the data using the 4-43-1 architecture can be seen as shown in Figure 3.

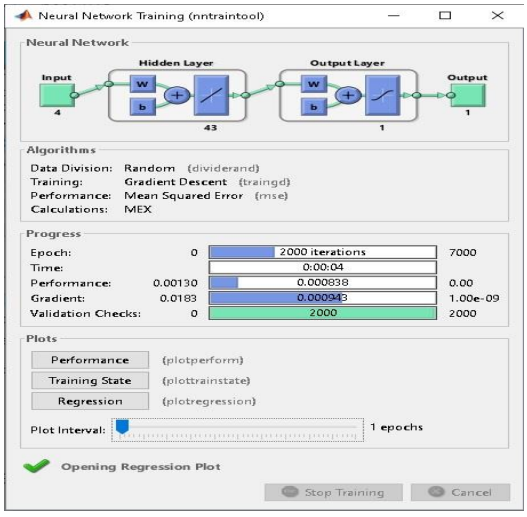

Figure 3. Architectural Testing 4-43-1

In Figure 3 the data tested using the 4-43-1 architecture produces an epoch of 2000 iterations.

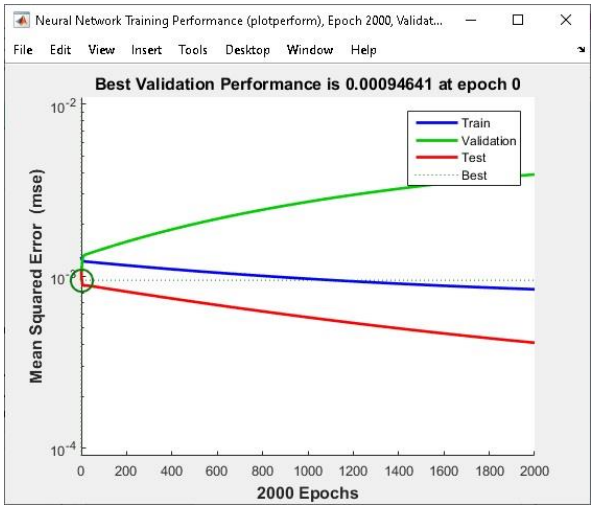

Figure 4. Performance Training with the 4-43-1. model

Figure 4 shows that the Best Validation Performance result is 0.00094641. The results of data testing using the 4-43-1 architecture can be seen in Table 3.

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Table 3. Architectural Training Data 4-43-1

No	Training Data				
	Target	Output	Error	SSE	Result
1	0,14771	0,17046	-0,02275	0,0005176	1
2	0,31606	0,2883	0,027762	0,0007707	0
3	0,61927	0,65408	-0,034811	0,0012118	1
4	0,36268	0,31928	0,043396	0,0018832	1
5	0,11045	0,14858	-0,038127	0,0014537	1
6	0,38006	0,41786	-0,037804	0,0014291	1
7	0,39634	0,35603	0,04311	0,0018585	1
8	0,14381	0,16991	-0,026097	0,0006811	1
9	0,57113	0,56172	0,00941	8,855E-05	1
10	0,9	0,84198	0,058024	0,0033668	1
11	0,8665	0,82959	0,036906	0,0013621	1
12	0,62039	0,62519	-0,0047966	2,301E-05	1
			Total SSE	0,014646	91%
			MSE	0,0012205	

Information :
1= True 0=False

In Table 3 it can be seen that the results of the data test using the 4-18-1 architecture resulted in an accuracy of 91% with an MSE value of 0.0012205.

Architectural Data Testing 4-18-1

In Table 4 it can be seen that the results of the data test using the 4-18-1 architecture resulted in 80% accuracy with an MSE value of 0.0020125.

Table 4. Architectural Training Data 4-18-1

No	Training Data				
	Target	Output	Error	SSE	Result
1	0,14771	0,16292	-0,01521	0,0002315	1
2	0,31606	0,27504	0,041024	0,001683	0
3	0,61927	0,61266	0,006606	4,363E-05	1
4	0,36268	0,29205	0,070632	0,0049889	0
5	0,11045	0,14616	-0,03571	0,0012749	1
6	0,38006	0,47273	-0,09267	0,0085872	1
7	0,39634	0,33349	0,062849	0,00395	1
8	0,14381	0,16117	-0,01736	0,0003015	1
9	0,57113	0,60035	-0,02922	0,0008535	1
10	0,9	0,86647	0,033528	0,0011241	1
11	0,8665	0,84211	0,024387	0,0005947	1
12	0,62039	0,64312	-0,02273	0,0005167	1
			Total SSE	0,0241496	80%
			MSE	0,0020125	

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Table 5. Architectural Training Data 4-10-1

No	Training Data				
	Target	Output	Error	SSE	Result
1	0,14771	0,16627	-0,018564	0,0003446	1
2	0,31606	0,27578	0,040284	0,0016228	0
3	0,61927	0,59393	0,02534	0,0006421	0
4	0,36268	0,29091	0,071772	0,0051512	0
5	0,11045	0,15512	-0,044666	0,0019951	1
6	0,38006	0,45818	-0,078117	0,0061023	1
7	0,39634	0,32877	0,067569	0,0045656	1
8	0,14381	0,16465	-0,020841	0,0004343	1
9	0,57113	0,57433	-0,003198	1,023E-05	1
10	0,9	0,85408	0,045925	0,0021091	1
11	0,8665	0,8258	0,040698	0,0016563	1
12	0,62039	0,61885	0,001538	2,365E-06	1
			Total SSE	0,024636	75%
			MSE	0,002053	

Information :
1= True 0=False

Architectural Data Testing 4-10-1

In Table 5 it can be seen that the results of the data test using the 4-10-1 architecture resulted in an accuracy of 75% with an MSE value of 0.002053.

The results of the comparison test of 3 network architectures, namely 4-10-1, 4-18-1, 4-43-1, then obtained a comparison of the level of accuracy as in Table 6.

Table 6. Comparison of Architectural Accuracy

Arsitektur	Training Data		
	Epoch	MSE	Akurasi
4-10-1	3000	0,002053	75%
4-18-1	5500	0,0020125	80%
4-43-1	2000	0,0012205	91%

From Table 6, it can be seen the results of the predictions for the number of births in the city of Mataram in 5 years, namely from 2016 - 2020. The results of the calculations using the best architecture are 4-43-1 with an accuracy rate of 91%. To find out the forecasting results can use the formula 9 [13]

$$x = \frac{0{,}8(x' - 0{,}1)(xmax - xmin)}{0{,}8} + xmin \qquad (9)$$

Information :

x'= Data normalization
$xmax$ = original max data
$xmin$ = original min data

The prediction results of the number of births in the city of Batam in 2016-2020 can be seen in Table 7.

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Table 7. Predicted Results of Birth Rates in Batam City in 2021

No	Area	JST 2021 Results	Forecasting Results
1	Belakang Padang	0,17046	13033
2	Batu Ampar	0,28830	27700
3	Sekupang	0,65408	73224
4	Nongsa	0,31928	31555
5	Bulang	0,14858	10310
6	Lubuk Baja	0,41786	43824
7	Sungai Beduk	0,35603	36129
8	Galang	0,16991	12965
9	Bengkong	0,56172	61729
10	Batam Kota	0,84198	96610
11	Sagulung	0,82959	95068
12	Batu Aji	0,62519	69628

CONCLUSION

The use of the Backpropagation method can predict the birth rate data in the city of Batam well. The network used is 4-43-1 with a prediction accuracy rate of 91% with an MSE value of 0.0012205. While the 4-10-1 and 4-18-1 architectures have an accuracy rate of 75% and 80%.

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