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Application Of Backpropagation Neural Networks In Predicting Rainfall Data In Ambon City

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ABSTRACT

The Backpropagation algorithm is a method of multilayered Artificial Neural Networks. Backpropagation artificial neural networks can be applied in every area of human life; one of them is in prediction of weather. Artificial neural network can be used for predicting because of having the capability of examining and determining the historical data used for prediction. In this research, we have utilized Backpropagation artificial neural network to predict the rainfall in Ambon City. This research have used monthly rainfall data from 2011 to 2015 and several parameters to predict the rainfall such as: air temperature, air velocity and air pressure. The result shows accuracy level is 80% by using alpha 0.7, iteration number (epoch) 10000 and MSE value is 0.022. Therefore, the result of rainfall prediction system is accurate.

I. Introduction

In the reality, people often face various problems that require people to think and find new things that can facilitate them in solving the problem. Along with the development of science and technology, there are many methods for analyzing, classifying and visualizing certain objects that can provide benefits for human activities. With human intelligence, has created various technologies used in solving various problems in human life. One of them is Artificial Neural Network (ANN) [3]. ANN have been extensively used todays days in various aspects of science and engineering because of its ability to model both linear and non-linear systems without the need to make assumptions as are implicit in most traditional statistical approaches [38]. Artificial Neural Networks is an information processing system that has similar characteristics to biological neural networks in human life (Fig. 1). Neural network first introduced by Waffen McCulloch and Walter Pitts in 1943. By some experts, artificial neural networks have been developed as applications to solve problems in human life [3],[9].

Indonesia is a country passed by the equator and surrounded by two oceans and two continents. This position makes Indonesia as a region that has a variety of climate. Climate is a natural habit that is driven by a combination of several elements like solar radiation, temperature, humidity, rainfall, air temperature, air pressure and wind pressure. The elements are different from one place to another [12],[17].

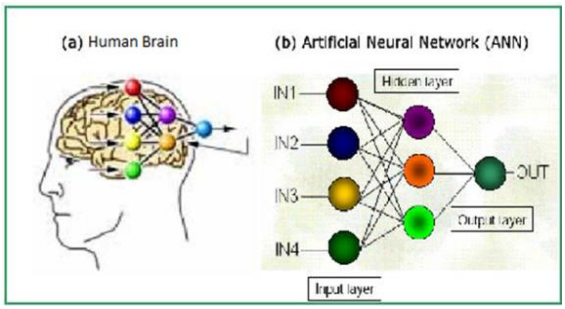

Fig. 1.The Artificial Neural Network has

The difference of weather or climate is due to altitude, latitude, pressure area, ocean currents, and soil surface. Rainfall plays very important role in human life and agriculture, it is very essential for irrigation and rainfall prediction is also useful for sewer management, water management, and flood forecasting [2]. However, too low or too high rainfall can cause disasters [43]. Climate change in the world gives many impacts on changing rainfall patterns. It needs a method that can predict rainfall based on rainfall patterns that occur after climate change. All the disaster can be anticipated with accurate information about how much rainfall will fall somewhere in a certain period of time [18].

Backpropagation is a supervised learning algorithm and is commonly used by Perceptron with multiple layers to change the weights associated with neurons in the hidden layer (Fig. 2 and Fig. 3). Backpropagation algorithm uses output error to change the value of the weights in the backward direction. To get error in this stage, forward propagation must be done first [3].

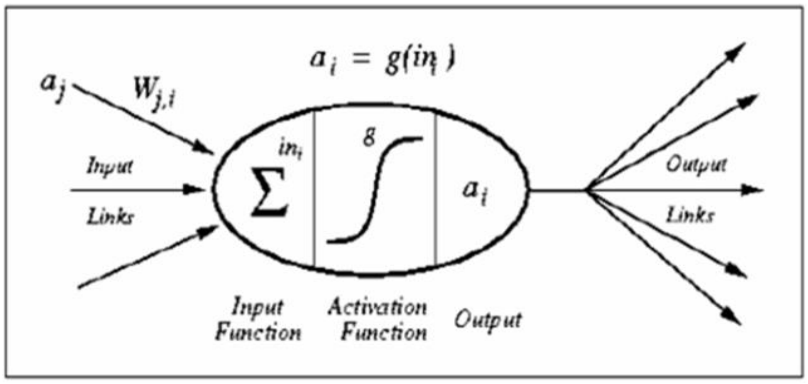

Fig. 2. The system of Artificial Neural Network (ANN)

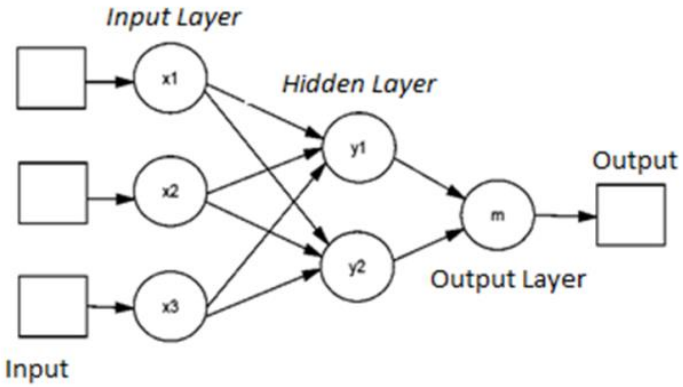

Fig. 3.The Architecture of Multilayer Artificial Neural Network (ANN)

II. Method

research, such as: temperature, wind speed, and air pressure, rainfall. The data of Temperature, wind speed, air pressure and rainfall are obtained from *Badan Meteorologi, Klimatologi, dan Geofisika (BMKG)* at Maluku Province. The data is a monthly data from 2011-2015.

A. Technique of Analysis Data

This research using Backpropagation method, so there are 2 stages such as: training data and testing data. Both of these stages of training and testing like the following flowchart in Fig. 4 and Fig. 5:

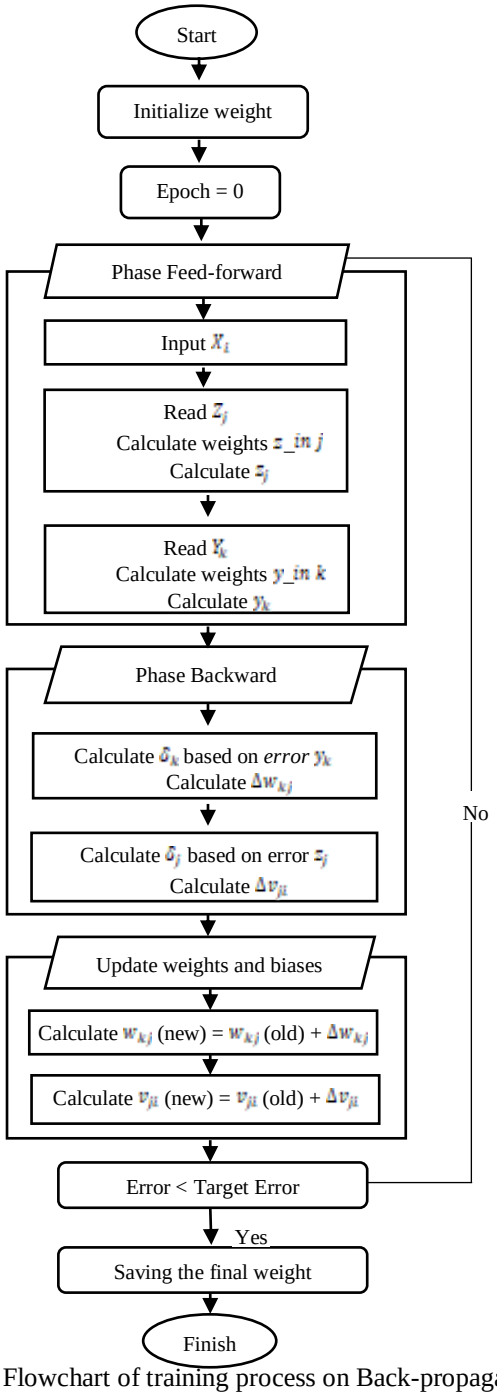

Fig. 4. Flowchart of training process on Back-propagation network

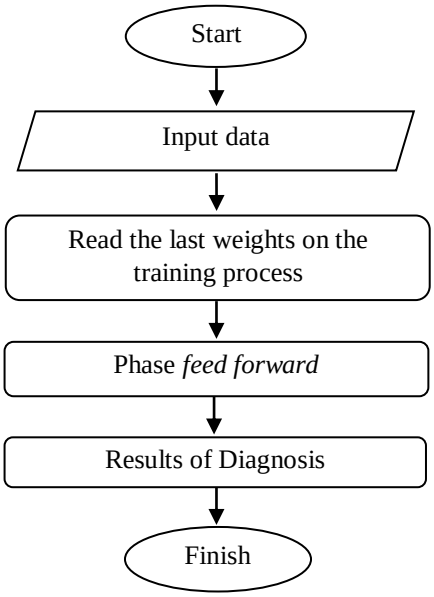

Fig. 5.The flow chart of the testing process of Back-propagation network

After training stage to obtain final weights, then the weights are used for the testing process (the detail algorithm or steps drawn by both flowchart in Fig. 4 and Fig. 5). The paper implements one of these applications by building training and testing data sets and finding the number of hidden neurons in these layers for the best performance [23]. All the data collected are separated into 2 parts of input and output are classified as sequential input data is as follows:

Air temperature as variable X_1

Wind Speed as variable X_2

Air Pressure as variable X_3

Then the rainfall is classified as the desired output or target as variable y.

The number of data that used in this research is 60; consist of 45 data used as training data and 15 data used as testing data. In this research the desired output or target is rainfall with the patterns divided into 5 parts, as follows:

Pattern 1 for the value $b \leq 5$ with the condition very light rain

Pattern 2 for the value $6 \leq b \leq 20$ with the condition light rain,

Pattern 3 for the value $21 \leq b \leq 50$ with the condition moderate rain,

Pattern 4 for the value $51 \leq b \leq 100$ with the condition heavy rain, and

Pattern 5 for the value $b > 100$ with the condition very heavy rain,

Information: b = rainfall.

III. Result

After defined the variables then the data will be analyze by using software MATLAB. By using this method must be done in 3 step of phase to have the rainfall output. These steps are training phase, testing phase and analysis or forecasting phase. To obtain the desired results it is necessary to determine the formation or pattern of input system, like the following:

1) *Net Size: Input Layer: 3 neurons*
   Hidden Layer: 20 neuron 12 neuron 1 neuron 1 neuron and 1 neuron

   Output Layer: 1 neuron

Maximum epoch /iteration: 10000

Learning rate: 0,7

The training phase uses 45 data. From 45 training data obtained the following analysis. For each variation, the maximum number of iterations is similar. The number of iterations (epoch): 10000. The detail result is presented in the following table:

Table 1. Result of data analysis

No	*Alp-ha*	*Epo-ch*	MSE	*Training Result*		*Testing Result*	
				Recog-nized train-ing data	Level of Accu-racy	**Recog-nized testing data**	Level of Accur-acy
1	0,1	10000	0,031	43	95%	9	60%
2	0,2	9420	0,010	44	97%	9	60%
3	0,3	10000	0,034	43	95%	11	73%
4	0,4	10000	0,026	44	97%	11	73%
5	0,7	10000	0,022	44	97%	12	80%
6	0,75	9274	0,0099	44	97%	11	73%
7	0,79	7927	0,0099	44	97%	11	73%
8	0,8	7648	0,0099	44	97%	11	73%
9	0,9	6021	0,0099	44	97%	11	73%

Based on Table 1 above, the best result in the training and testing process is at the time of learning rate 0.7, with maximum iteration of 10000, the value of MSE 0.022 and the level accuracy of data is 97% for the training stage and for the testing stage is 80%.

In the graph below, we will show the result of data analysis from learning rate (α) 0.7. The comparison results between the target (o) and output (*) network, that can be observed by observing the placement of the output of the network (*) position. If the network output (*) occupies the same position as the target (o) then the data analysis is said to be good. For more details information can be seen in Fig. 6, below:

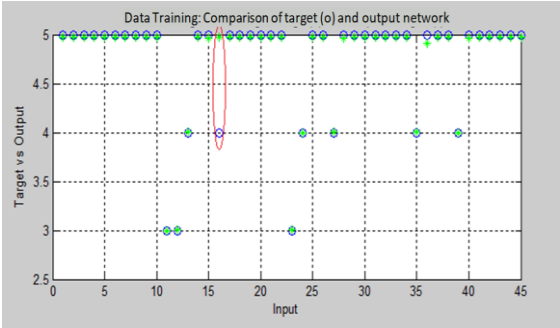

Fig. 6. Result graph of training with *Alpha* 0,7

In Figure 6, show that the comparison between the target (o) and output (*) of the network in the training data with alpha 0.7. It can be seen that most of the output network and target are close together (almost occupying the same position), where there are 44 of (o) and (*) adjacent and only 1 of (o) and (*) on the 16th data is far (in a red circle) therefore the result of training with alpha 0.7 is said to be good.

The following will present the results of the training on the comparison table between the expected target and outcome training targets that have been included in the grouping of predefined data patterns:

Table 2. Grouping of Network Training Results

nth Data	***Output Weight***	**Class**	**Target**	Information
1	4.9762	5	5	Match
2	4.9688	5	5	Match
3	4.9767	5	5	Match
4	4.9768	5	5	Match
5	4.9767	5	5	Match
6	4.9766	5	5	Match
7	4.9766	5	5	Match
8	4.9766	5	5	Match
9	4.9765	5	5	Match
10	4.9746	5	5	Match
11	2.9993	3	3	Match
12	3.0000	3	3	Match
13	4.0056	4	4	Match
14	4.9683	5	5	Match
15	4.9672	5	5	Match
16	4.9747	5	4	Not Match
17	4.9767	5	5	Match
18	4.9766	5	5	Match
19	4.9764	5	5	Match
20	4.9766	5	5	Match
21	4.9764	5	5	Match
22	4.9746	5	5	Match
23	3.0000	3	3	Match
24	3.9997	4	4	Match
25	4.9755	5	5	Match
26	4.9745	5	5	Match
27	4.0003	4	4	Match
28	4.9657	5	5	Match
29	4.9766	5	5	Match
30	4.9763	5	5	Match
31	4.9765	5	5	Match
32	4.9766	5	5	Match
33	4.9762	5	5	Match
34	4.9693	5	5	Match
35	4.0033	4	4	Match
36	4.9074	5	5	Match
37	4.9747	5	5	Match
38	4.9739	5	5	Match
39	3.9997	4	4	Match
40	4.9649	5	5	Match
41	4.9763	5	5	Match
42	4.9767	5	5	Match
43	4.9760	5	5	Match
44	4.9750	5	5	Match
45	4.9762	5	5	Match

After the training phase, then the next phase is testing to determine the results of rainfall prediction of target data and network output. The following (Fig. 7) is presented the graph with Alpha testing 0.7.

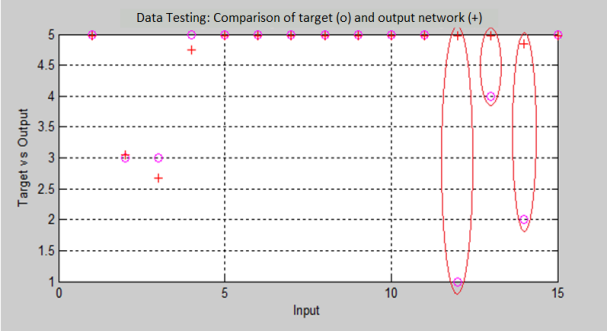

Fig. 7. Result graph of testing with *Alpha 0,7*

In Fig. 7, shows that the comparison between the target (o) with the network output (+) in training data with Alpha 0,7. At the testing phase the number of data is 15, by 12 data targets (o) and the output (+) is close together (almost occupying the same position) and 3 other data are far apart (in red circle). So it can be said that the testing results between training data and targets can be quite good in predicting rainfall.

The following Table 3, will present the testing results between the expected target and the output target results that have been included in the grouping of predefined data patterns:

Table 3. Grouping of network test results

nth Data	***Output Weight***	**Class**	**Target**	**Inform-ation**
1	4.9754	5	5	right
2	3.0452	3	3	right
3	2.6672	3	3	right
4	4.7514	5	5	right
5	4.9762	5	5	right
6	4.9759	5	5	right
7	4.9750	5	5	right
8	4.9760	5	5	right
9	4.9766	5	5	right
10	4.9764	5	5	right
11	4.9765	5	5	right
12	4.9762	5	1	wrong
13	4.9762	5	4	wrong
14	4.8502	5	2	wrong
15	4.9726	5	5	right

The results obtained from this research can be explained that to predict the rainfall can't be measured as a whole only by using rainfall data but also can use other data that influence the state of rainfall. This is seen from the level of accuracy of forecasting results at the training stage 97% and 80% testing stage that causes the forecasting results are said to be good.

IV. Conclusion

From the results of rainfall forecasting using Back-propagation Artificial Neural Network, it can be obtained that the accuracy level of rainfall prediction is 80%, by using *alpha* 0.7, epoch 10000 and MSE value is 0.022. Therefore, it can be concluded that the Backpropagation neural networks show the best result and accurate in forecasting rainfall data both in training and testing phase.

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