Fidelity : Jurnal Teknik Elektro
Vol. 4, No. 2, Mei 2022, page 25-28

p-ISSN: 2686-3650
e-ISSN: 2686-3642

Backpropagation and Radial Basis Function Methods for Predicting Rainfall in Sukabumi City Using Artificial Neural Networks: A Comparative Analysis

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***Abstract*—The weather has a substantial impact on the ability to live organisms to carry out everyday activities, particularly outside activities. Weather data is helpful in various fields, including marine, aviation, and agriculture. The maritime domain is beneficial for establishing the optimal navigation time for a fisherman, the aviation domain helps reduce climate-related mishaps, and the agriculture sector uses weather information to develop harvest season models for agricultural products. Indonesia is a tropical nation with heavy precipitation. Utilized for various objectives, rainfall forecasting models seek the utmost precision, particularly in specialized areas such as flood control. This study is based on two techniques: the Radial Basis Function Neural Network (RBFNN) and Backpropagation Neural Network (BPNN) techniques using multiple training functions. The RBFNN approach yields less accurate results for predicting precipitation, but the multi-practice BPNN method yields more accurate results.**

Keywords—Forecasting, Rainfall, Backpropagation Neural Network, Radial Basis Function Neural Network

I. Introduction

Indonesia is a nation situated between the equator, two seas, and two continents. This position makes Indonesia the confluence of the Meridian (North-South) Circulation known as the Hadley Circulatory and the Neotropical (East-West) Circulation known as the Walker Circulation, which significantly impacts Indonesia's regional climatic variety. The sun's passage from 23.5 degrees north latitude to 23.5 degrees south latitude over the course of the year causes the lunar activity to influence climatic variety [1], [2].

Rainfall patterns may be analyzed using climatic parameter historical data and artificial intelligence algorithms. In previous research, propagation of prediction outcomes using artificial neural networks has been shown to boost accuracy. Hence an artificial neural network approach is used in this study. Hope improves the accuracy of precipitation forecasts.

Rain is a natural event caused by water evaporation from many sources, including seas, lakes, rivers, soil, and plants. When the air temperature reaches a specific level, water vapor condenses, causing it to cool down. Condensation is the process through which water vapor condenses into minute water droplets. The water droplets eventually congregate to form clouds. When these clusters of water droplets are big and heavy enough, they descend to the earth's surface. This is referred to as precipitation, sometimes known as rain. Rainfall may be measured in

millimeters (millimeters) per unit of time [3]-[11]. Rainfall estimates the quantity of precipitation that falls on the earth in a specific time unit.

Prediction is an intentional assessment of what is most likely to occur in the future, based on previous and current information to minimize errors (differences between what happened and the expected outcome). Prediction does not need a clear explanation for future occurrences; instead, it is an effort to identify a solution as near to reality as feasible [12, 13].

Sukabumi City is situated in the southern part of West Java, between the coordinates 106 45'50" East Longitude and 106 45'10" East Longitude, at the base of Mount Gede and Mount Pangrango, which both rise to an altitude of 584 meters above sea level. In 2013, the climate in Sukabumi City tended to be humid. Based on the monitoring data from four stations, three of which are located in Cimandiri, Ciaul, and Canada, it has been concluded that Sukabumi City receives a particular amount of precipitation each month. January is the wettest month at Cimandiri Station, with 461 mm of precipitation and 26 rainy days. Observations made from Situmekar Station [14] indicated no precipitation in September. Four monitoring stations service the city of Sukabumi: Cimandiri, Ciaul, Cisalada, and Situmekar.

Backpropagation Artificial Neural Networks for Rainfall Forecasting in Wonosobo Regency [2] is one of the several research studies conducted to make it simpler to forecast rainfall in the months or years ahead. This research analyzes data from the Wangan Aji Wonosobo Observation Station of the Meteorology, Climatology, and Geophysics Agency (BMKG) from 2009 to 2011 using a Backpropagation Neural Network technique. It was built using a 12–10–1 artificial neural network architecture with 12 inputs. A value represents rainfall data for one year or twelve months, ten neurons in the hidden layer, and a single output value represents rainfall data for the subsequent month. This research indicates that the greater the number of hidden layers in an artificial network, the more precise the forecast. rainfall forecasting is entirely correct using a test with ten buried layers. The number of hidden layers and the number of layers vary based on the number of iterations. Even though more personal data does not always result in better interactions, it increases network performance when coupled with improvements to performance-related variables such as many iterations, error targets, and network design. "Comparative Analysis of Temperature Prediction Using Regression Methods and Back Propagation Neural Network" is the title of the following study. Temperature prediction is compared using Linear Regression, Regression Tree, and Backpropagation Neural Networks. According to the conclusion, the Backpropagation Neural Network approach has a lower MSE value than the Linear Regression and Regression Tree methods [15].

This research aimed to assist BMKG Sukabumi City in forecasting rainfall in Sukabumi City, particularly at Ciaul Sukabumi Station, by comparing rainfall forecasting using data from the previous five years using the Backpropagation Neural Network approach and the radial basis function neural network.

II. RESEARCH METHODS

In this research, seven steps are required to compare BPNN and RBFNN weather forecasting systems. Figure 1 depicts the progression of this study.

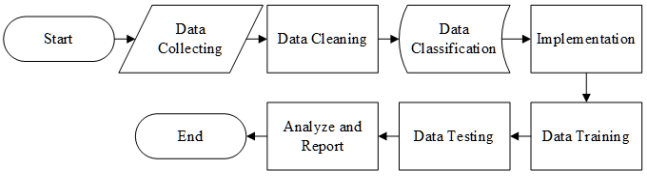

Figure 1. Flowchart of Research Thinking Framework

There are 7 stages of testing in this research:

1) From January 2014 to December 2020, monthly precipitation data for the Ciaul Station region of Sukabumi City are used. The information comes from the Central Bureau of Statistics of the City of Sukabumi, which may be found online at https://sukabumikota.bps.go.id/. The data is included inside an Excel file (.xlsx).

2) Data cleaning examines the quality of data by modifying, updating, or removing data in the database that is erroneous, incomplete, inaccurate, or has the wrong format to provide high-quality data. Data cleansing is sometimes referred to as data scrubbing and data cleansing. Data cleaning is a typical practice in organizations that rely heavily on data, such as banking, insurance, retail, telecommunications, and transportation industries. Data cleansing is used to systematically rectify data using algorithms to save time and money in businesses. Both automatic and manual techniques are used throughout the data cleansing procedure.

3) Counting Data (Enumeration or Counting Data) results from a particular computation or quantity. The computed data includes the percentage of a certain amount. Measurement Data (Measurement Data) is an indicator of something's worth.

4) Implementation: At this point, the design of the created system is initiated. The system design is determined by the categorization of data in the preceding stage. This stage generates a comprehensive system design that will be implemented in the subsequent scene. Using MATLAB software, the design findings will be realized in the form of a simulation. The user will be required to complete this phase.

5) At this step, training data will be evaluated based on data from the previous stage's application of the BPNN and RBFNN Algorithms. The training data span the years January 2014 to December 2017. The training

data are used to train the ANN learning architecture to identify rainfall patterns. Precipitation data from January 2013 to December 2017 are utilized for training purposes. The training target is used to compare the outcomes of the ANN learning architecture training's prediction.

6) Data Testing: Data testing will be done at this step based on the data from the previous stage's application of the Training data test. The test data consists of precipitation information from January 2017 to December 2020. The test data is utilized to evaluate the effectiveness of the prior training architecture. The data from January 2020 to December 2020 is used as a test goal or benchmark for predicting test outcomes.

7) At this step, data testing will be conducted based on the application of the Training data test from the previous stage; the results will then be compared with the accuracy results of BPNN and RBFNN for predicting rainfall in Sukabumi city.

Before data training, data normalization occurs. You must observe the actual input and output data pair during the training process. Input data is needed as network input, while output data is required as network output. The data are normalized before processing. Data normalization is performed so that the network output corresponds to the used activation function. These numbers have been standardized to the interval [0, 1]. In the rainfall prediction, the precipitation value must be positive or zero. It is also connected with the binary sigmoid activation function. Since the sigmoid function is asymptotic (never approaches 0 or 1), the data transformation employs the following equation to reduce the interval [0,1,0, 9] using the following equation:

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

Keterangan:

a is the minimum data,

b is the maximum data,

x is the data to be normalized

x' is data that has been transformed

III. Results and Analysis

Before commencing the training phase of the Radial Basis Function Neural Network, input and target data are normalized on a scale of 0 to 1 before training. This normalisation aims to produce data with reduced file size and accurately reflect the original data without altering its properties.

This prediction procedure utilizes the Radial Basis Function Neural Network approach because, in addition to a high degree of accuracy, the speed of training data in this method is relatively quick compared to other methods. The data used to estimate precipitation from 2014 to 2017

While the objective data utilized is precipitation data for 2020, After being trained in the Radial Basis Function Neural Network system and obtaining the least Mean Square Error (MSE) value, test data from 2017 to 2020 and the net formed in training that generates the smallest MSE are used to forecast rainfall for 2021.

TABLE I. RBFNN Prediction Results

No	Hasil Prediksi Tahun 2021 RBFNN	
	Month	**Predicted Value**
1	January	156,5
2	February	151,3
3	Maret	151,7
4	April	151,3
5	May	151,7
6	June	147,9
7	July	151,7
8	August	147,9
9	September	149,1
10	October	147,9
11	November	149,1
12	December	144,1

The BPNN algorithm employs two hidden layers with 15 and 5 neurons. Table 2 presents the results of the BPNN method's precipitation forecast.

TABLE II. BPNN Prediction Results

No	Hasil Prediksi Tahun 2021 BPNN	
	Bulan	***Nilai Prediksi***
1	Januari	472,2
2	Feburari	113,11
3	Maret	307,55
4	April	164,19
5	Mei	40,04
6	Juni	574,76
7	Juli	610,7
8	Agustus	531,58
9	September	694,79
10	Oktober	189,79
11	November	46,43
12	Desember	531,39

From the two data obtained and analyzed from the two training results without being affected by the range of data outside the study of the two pieces of training, it can be seen that the BPNN method with dual training functions has a higher level of accuracy than the RBFNN method, so the

summation method with many learning functions is superior to the RBFNN method.

IV. Conclusion

Based on the study, it can be inferred that the BPNN technique with multiple training functions is superior to the RBFNN method since the accuracy ratio of the BPNN method is more significant than that of the RBFNN method. The RBFNN approach is based on a one-way network (no loops are found in the BPNN method). The error rate may be reduced and accuracy enhanced by increasing the number of neurons in the BPNN algorithm.

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