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Predicting The Number of Tourists Based on Backpropagation Algorithm

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Abstract

The number of tourists always fluctuates every month, as happened in Kaliadem Merapi, Sleman. The purpose of this research is to develop a prediction system for the number of tourists based on artificial neural networks. This study uses an artificial neural network for data processing methods with the backpropagation algorithm. This study carried out two processes, namely the training process and the testing process with stages consisting of: (1) Collecting input and target data, (2) Normalizing input and target data, (3) Creating artificial neural network architecture by utilizing GUI (Graphical User Interface) Matlab facilities. (4) Conducting training and testing processes, (5) Normalizing predictive data, (6) Analysis of predictive data. In the data analysis, the MSE (Mean Squared Error) value in the training process is 0.0091528 and in the testing process is 0.0051424. Besides, the validity value of predictive accuracy in the testing process is around 91.32%. The resulting MSE (Mean Squared Error) value is relatively small, and the validity value of prediction accuracy is relatively high, so this system can be used to predict the number of tourists in Kaliadem Merapi, Sleman.

Keywords: Artificial Neural Networks, Backpropagation Algorithm, Prediction, Tourist

1. Introduction

The Special Region of Yogyakarta (DIY) has various tourist destinations that continue to invite tourists both foreign and domestic tourists. So that tourism activists must always develop and promote these tourist objects. Based on data from the DIY Tourism Office, from 2017 to 2018, the number of DIY tourists increased from 5.2 million visitors to 5.6 million visitors (107.7%) [1]. The data shows that tourists are getting more enthusiastic about DIY tourism.

DIY has various types of tourism, including natural tourism, cultural tourism, artificial tourism, and tourism villages. Based on topography, DIY is divided into four regional units, namely the southern mountain unit or the thousand mountains located in the Gunungkidul region, the Kulon Progo mountain unit located in the northern part of Kulon Progo, the lowland unit stretching from Kulon Progo to Bantul, and the Mount Merapi unit which is in the Sleman region [2]. Mount Merapi is an active volcano until now. The mountain which has an altitude of 2986 m above sea level is one of the main tourist attractions [3]. The existence of Mount Merapi with its volcanic phenomena, the morphology of mountains and valleys, natural forests with a diversity of flora and fauna and unique socio-cultural conditions is a massive potential for natural tourism activities (ecotourism). However, there are several factors influence the number of tourists on Mount Merapi, namely volcanic activity of Mount Merapi and weather such as rainfall in the Mount Merapi area. The historical record of Mount Merapi shows volcanic activity that can cause disasters that can have a significant impact, including in the tourism sector [4]. Mount Merapi volcanic activity is obtained from the number of seismicity from deep volcanic earthquakes, shallow volcanic earthquakes, and earthquake avalanches. Mountain tourism objects are also one of the tourist objects that are very vulnerable to climate change as an attraction for tourist destinations [5].

Kaliadem Merapi is located on the southern slope of Mount Merapi, Sleman Regency. This tourist destination is a trail of the eruption of Mount Merapi, especially in 2006 and 2010. The location of Kaliadem is at an altitude of more than 2,000 meters above sea level. Tourists can see the prowess of Merapi from a distance of five kilometres. This area combines the history, beauty and natural uniqueness of Mount Merapi with its volcanic phenomena [6]. Various tourist activities can be done at Kaliadem Merapi, such as touring Mount Merapi using a jeep and exploring the bunkers in the area. The fluctuation in the number of tourists visiting Kaliadem Merapi cannot be known by Kaliadem tourism activists.

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So that at this time, what Kaliadem tourism activists need is a prediction system for the number of tourists who will visit Kaliadem Merapi.

There are several studies on prediction systems, such as the prediction system for furniture product demand using the Least Square method by utilizing sales data several years ago [7]. There is also a sales forecasting system for home industrial machinery using the Fuzzy Time Series Ruey Chyn Tsaur method which can be implemented in all forecasting activities that require data analysis which will be immediately used in the framework of the decision making process [8]. In addition, the prediction system for high electricity consumption using the Fuzzy Mamdani method is used for the efficiency of electricity utilization in households [9]. Some of these prediction systems can be used as supporting material in this study.

Based on the description above, this study designs a system that can be used to obtain predictions or estimates of the number of tourists. Therefore, this research was conducted to make a prediction system for the number of tourists based on artificial neural networks (ANN) with the backpropagation algorithm. ANN is a system used to process data by adapting the structure of the human biological neural network in solving a problem [10]. ANN can be used for decision making as humans do with non-rigid thinking [11]. There are various kinds of algorithms in artificial neural networks, one of which is the backpropagation algorithm. The algorithm is a computer science concept that is widely used in the case of analysis, prediction and pattern determination [12]. The backpropagation algorithm is a learning algorithm in ANN to reduce the error rate by adjusting the weight based on the desired output and target differences [13]. Backpropagation is also a multilayer ANN training algorithm which has three layers in its architecture, namely input layer, hidden layer, and output layer. This algorithm has excellent advantages in conducting training, especially on large and complex scale data [14]. The weakness of the backpropagation algorithm is that it takes too long to converge and the weight change can cause the ANN to be trapped at a local minimum [15]. A good combination of architectural parameters, initial weights and initial bias can greatly overcome the weaknesses of the backpropagation algorithm [16]. Single layer architecture has limitations in pattern recognition, but it is overcome by adding one or more hidden layers between the input layer and the output layer with the backpropagation algorithm [17].

2. Research Method

The systematics of this research are shown in Figure 1.

The research carried out consisted of several stages: (1) Literature study, namely tracing library information from books, scientific journals and other sources related to this research. (2) Collecting quantitative data. The data collected in this study are secondary data. Secondary data were obtained from existing sources. This research requires data on the number of tourists, the numbers of seismicity in Mount Merapi, and rainfall. Tourist data obtained by the DIY Tourism Office website. Data on the numbers of seismicity of Mount Merapi is obtained from the website of the Geological Disaster Research and Development Center (BPPTKG). Meanwhile, the rainfall data is obtained from the website of the Yogyakarta Meteorology, Climatology and Geophysics Agency. Research variables are input and output data. The following are the input and output data: the number of tourists in the previous year (X1); the numbers of seismicity in Mount Merapi (X2); rainfall in the predicted year in nm3 (X3); and the number of tourists in the predicted year (Y). (3) Data processing with the process of data entry, data training, data testing, graph making and various statistical analyzes. So that the results / outputs can be compared with the results of using quantitative methods manually. (4) Analysis and evaluation of results by calculating the error value so that the feasibility of this prediction system can be found.

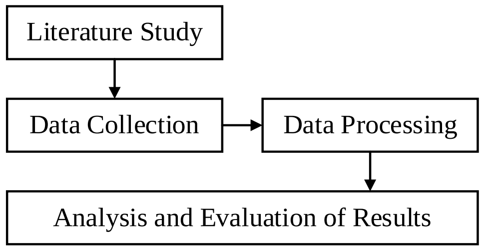

Figure 1. Systematics of research methods

2.1. Artificial Neural Network Method

The method used in data processing is artificial neural networks (ANN). To get the best network architecture, the following steps are taken: First is to collect input and target data. The data is divided into two, namely training data and testing data. Second is normalizing input data (X1, X2, X3) and target (Y). According to [18], data normalization is carried out to transform data into intervals of 0.1 s. 0.9. The formula for data normalization is:

$$X' = \frac{0.8\,(X-b)}{(a-b)} + 0.1 \tag{1}$$

Which X' is normalized data, X is original data / initial data, a is maximum value of original data, and b is minimum value of original data.

Thirdly is to make artificial neural networks for predictions using the GUI (Graphical User Interface) Matlab. And finally, the next process is to enter the training and testing process.

The algorithm used is a backpropagation algorithm. Backpropagation algorithm uses a set of sample data, then compares the predicted value of the network with each sample of data. In each process, the weight of relations in the network is modified to minimize the

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value of Mean Square Error (MSE) between the predicted value of the network with the real value.

2.2. Backpropagation Algorithm Step

The steps taken in the training procedure using backpropagation according are [19]:
Step 0: Initialize the weights between neurons with small random numbers (-0.5 to +0.5).
Step 1: If the stop conditions are not met, complete steps 2 - 9
Step 2: For each input pattern, do steps 3-8
Feedforward: Learning at layer 1
Step 3: Each input neuron (Xi i = 1 ... n) receives the input signal xi and propagates it to all neurons in the hidden layer.
Step 4: Each neuron in the hidden layer (Zj, j = 1 ... p) sums the weights of the input signal

$$z_{in_j} = \sum_{i=1}^{N} x_i v_{ij} \tag{2}$$

apply it to the activation function to calculate the output signal,

$$z_j = f\left(z\_in_j\right) \tag{3}$$

send the results to all neurons in the output layer.

Step 5: Each output neuron (Yk, k = 1 ... m) sums the weight of the incoming signal,

$$y_{in_k} = \sum_{j=1}^{p} z_j w_{jk} \tag{4}$$

and apply its activation function to calculate the signal that it will issue

$$y_k = f(y\_in_k) \tag{5}$$

Backpropagation error:

Step 6: Each output neuron (Yk, k = 1 ... m) receives a target pattern that is related to the training input pattern and calculates the information error by multiplying with the derivative of its activation function

$$\delta_k = (t_k - y_k) f'(y\_in_k) \tag{6}$$

calculate the weight correction (which will be used to correct Wjk later),

$$\Delta w_{jk} = \left(\alpha \delta_k z_j\right) \tag{7}$$

and send k to hidden layer neurons

Step 7: Each hidden neuron (Zj, j = 1 ... p) adds up the weight of each neuron that has been multiplied by the error information,

$$\delta_{in_j} = \sum w_{jk_{k=1}} {}_m \delta_k \tag{8}$$

multiplying by the derivation of its activation function to calculate the error of its information,

$$\delta_j = \delta\_in_j f'\left(z_{in_j}\right) \tag{9}$$

calculate the weight correction (which will be used to fix Vij later)

$$\Delta v_{ij} = \left(\alpha \delta_j x_i\right) \tag{10}$$

Correct the weights for the next process

Step 8: Each output neuron (Yk, k = 1 ... m) fixes its weight (j = 0 ... p)

$$w_{jk}(new) = w_{jk}(old) + \Delta w_{jk} \tag{11}$$

Each hidden neuron (Zj, j = 1 ... p) fixes its weight

$$w_{ij}(new) = v_{ij}(old) + \Delta v_{ij} \tag{12}$$

Step 9: Perform a stop condition test.

After getting the results of the prediction data, the data must be normalized to transform it back into real data with the formula.

$$X = \frac{(X' - 0.1)(a - b)}{0.8} + b \tag{13}$$

Information:
Which X' is normalized data, X is original data / initial data, a is maximum value of original data, and b is minimum value of original data

After that, perform predictive data analysis.

3. Result and Discussion

3.1. Data collection and data normalization

3.1.1. Data Collection

The data collected as input are the number of tourists in the previous year, the numbers of seismicity in Mount Merapi in the predicted year, and the rainfall in the predicted year (nm3). Meanwhile, the target is the number of tourists in the predicted year. Furthermore, the data is divided into two, namely, training data (training) and testing data (testing).

Training data consists of data on the number of tourists in 2017 (X1), seismic data for Mount Merapi in 2018 (X2), and rainfall data for 2018 (X3) as input, as well as data on the number of tourists in 2018 (Y) as a target, as in table 1.

Table 1. Input and Target Data for Training

Months	Number of Tourisms In 2017	Number of Mountain Earthquakes In 2018	Rainfall Data In 2018 (Nm3)	Target (Number of Tourisms In 2018)
Jan	20432	30	727	38583
Feb	19071	25	398	32383
Mar	20237	26	263	35007
Apr	20748	26	307	38001
May	19637	60	28	17111
Jun	18453	60	43	24827
Jul	31145	73	10	46825
Aug	23524	504	14	35371
Sep	22695	495	22	50412
Oct	22319	243	80	25279
Nov	23130	303	431	28947
Dec	38900	269	319	51370

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The test data consists of data on the number of tourists in 2018 (X1), seismic data for Mount Merapi in 2019 (X2), and rainfall data in 2019 (X3) as input, and the number of tourists in 2019 (Y) as targets, as in Table 2.

Table 2. Input and Target Data for Testing

Months	Number of Tourisms In 2018	Number of Mountain Earthquakes In 2019	Rainfall Data In 2019 (Nm3)	Target (Number of Tourisms In 2019)
Jan	38583	518	730	26337
Feb	32383	539	627	20092
Mar	35007	782	525	20851
Apr	38001	870	424	35223
May	17111	681	203	9661
Jun	24827	676	186	37212
Jul	46825	576	94	43225
Aug	35371	665	121	27330
Sep	50412	451	112	39873
Oct	25279	295	164	20200
Nov	28947	310	205	25047
Dec	51370	296	629	38479

3.1.2. Data Normalization

Data must be normalized first because the training uses the sigmoid (binary) activation function, then the data must be normalized into a range between [0,1]. Normalization is done to simplify the training process. By normalizing the data, the minimum data will be 0.1, and the maximum data will be 0.9. From the original data in Table 1 shows the minimum data 10 and the maximum data 51370. Normalization of data is done based on formula 1. The results of data normalization used as backpropagation training data are shown in Table 3.

Table 3. Normalization Results of Input and Target Data as Training Data

Months	Number of Tourisms In 2017	Number of Mountain Earthquakes In 2018	Rainfall Data In 2018 (Nm3)	Target (Number of Tourisms In 2018)
Jan	0.418099688	0.100311526	0.1111682	0.7008255
Feb	0.396900312	0.100233645	0.1060436	0.6042523
Mar	0.415062305	0.100249221	0.1039408	0.6451246
Apr	0.423021807	0.100249221	0.1046261	0.6917601
May	0.405716511	0.100778816	0.1002803	0.3663707
Jun	0.387274143	0.100778816	0.1005140	0.4865576
Jul	0.584968847	0.100981308	0.1	0.8292056
Aug	0.466261682	0.107694704	0.1000623	0.6507943
Sep	0.45334891	0.107554517	0.1001869	0.8850778
Oct	0.447492212	0.103629283	0.1010903	0.4935981
Nov	0.460124611	0.104563863	0.1065576	0.5507320
Dec	0.70576324	0.104034268	0.1048130	0.9

Whereas in the original data Table 2 shows the minimum data 94 and the maximum data 51370. Normalization of data is done based on formula 1. The results of data normalization used as backpropagation testing data are shown in Table 4.

Table 4. Normalization Results of Input and Target Data as Testing Data

Months	Number of Tourisms In 2018	Number of Mountain Earthquakes In 2019	Rainfall Data In 2019 (Nm3)	Target (Number of Tourisms In 2019)
Jan	0.700499259	0.106615181	0.10992277	0.509439114
Feb	0.603767845	0.106942819	0.10831578	0.412005617
Mar	0.644707075	0.110734067	0.10672439	0.423847414
Apr	0.691418987	0.112107029	0.10514860	0.648077073
May	0.365496529	0.109158281	0.10170060	0.249262813
Jun	0.485880334	0.109080271	0.10143536	0.679109135
Jul	0.829089633	0.107520087	0.1	0.772923005
Aug	0.650386146	0.108908651	0.10042125	0.524931742
Sep	0.885053436	0.105569857	0.10028083	0.720625634
Oct	0.492932366	0.10313597	0.10109212	0.413690615
Nov	0.550159919	0.103369998	0.10173180	0.489312739
Dec	0.9	0.103151572	0.10834698	0.698876667

3.2. Design of Artificial Neural Networks

The design of Artificial Neural Networks to predict is made using facilities in the Matlab GUI. Artificial Neural Network Architecture (ANN) that is used is a multi-layer neural network using a backpropagation algorithm using the sigmoid activation function, as in Figure 2.

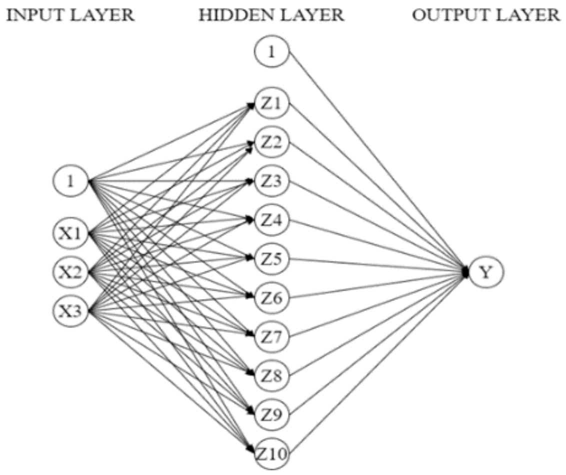

Figure 2. Artificial Neural Network Architecture

The parameters used in artificial neural networks in Matlab are as follows: 10 number of Neurons; Learning Rate of 0.1; 1000 Epochs; Goal of 0.000000001; Tansig as an activation function; trainlm as a Network Learning Function; Adaptive Learning (learngdm); and Performance Function MSE (Mean Square Error). The results of making the system display or GUI (Graphical User Interface) on Matlab as in Figure 3.

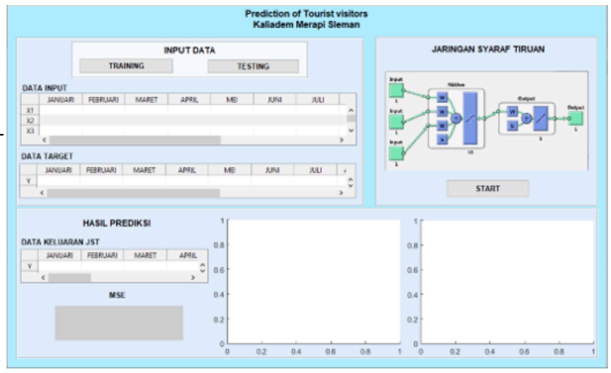

Figure 3. Display of GUI in Matlab

In the Matlab GUI display consists of three parts, namely the appearance of input and target data, artificial neural network architecture used, and prediction results that will display data in tables and graphs. Besides that, in the Matlab GUI display there are three buttons, namely

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training, testing, and start. The training button is used to select the training process as well as to display input data and targets for training. Likewise, the testing button used to select the testing process and display input data and targets for testing. The start button is used to start the training process or testing.

3.3. Training and Testing

3.3.1. Training

After creating an artificial neural network architecture and determining the parameters used, the next is the training process. Training is conducted to validate the artificial neural network model that has been designed. In the Matlab GUI display like Figure 2, the training process step is to press the "TRAINING" button, after the input and target data are displayed, then press the "START" button to carry out the training process. The results of the training process, as shown in Figure 4.

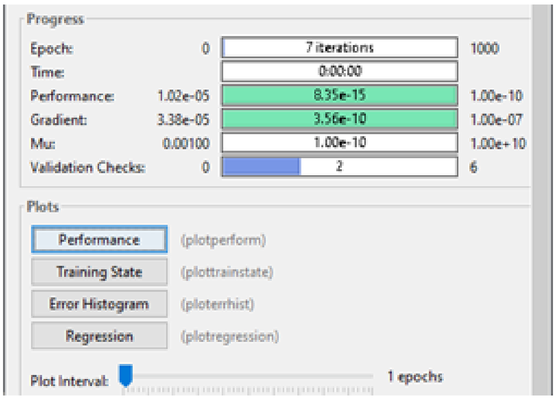

Figure 4. Results of the Training Process

After the training process, the results in the GUI (Graphical User Interface) display, as shown in Figure 5. With the results of the MSE value of 0.0091528.

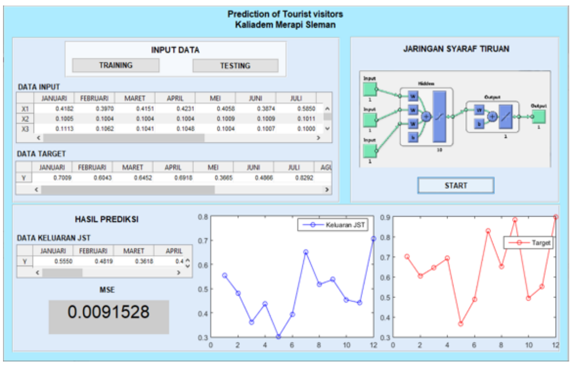

Figure 5. Display of GUI after Training

The comparison curve of the target data with the predicted data is shown in the figure 6. The left curve is the target data and the right curve is the predicted data.

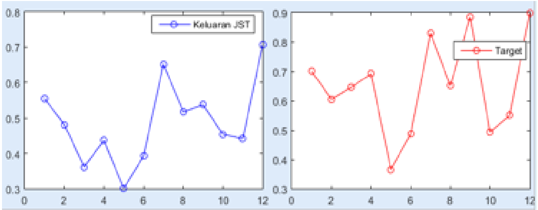

Figure 6. The comparison curve of target data with predicted data

The prediction results generated in the Matlab GUI display in Figure 5 are obtained as shown in Table 5.

Table 5. Predicted Data

Months	Prediction Results (Number of Tourisms In 2018)
January	0.5550
February	0.4819
March	0.3618
April	0.4365
May	0.3018
June	0.3928
July	0.6522
August	0.5171
September	0.5377
October	0.454
November	0.4414
December	0.7058

After getting the prediction results, the predicted data needs to be denormalized to return the data value to the original data. With the data denormalization formula as in formula 13, the results are as in Table 6.

Table 6. Denormalization of Predicted Data

Months	Prediction Results (Number of Tourisms In 2018)
January	29221
February	24528
March	16818
April	21613
May	12966
June	18808
July	35461
August	26788
September	28110
October	22737
November	21928
December	38902

3.3.2. Testing

The testing process is carried out to find out that the design results in the training process have produced the best. In the Matlab GUI display like Figure 2, the step of the testing process is to press the "TESTING" button, after the input and target data are displayed, then press the "START" button to carry out the testing process. The results of the testing process as in Figure 7.

The comparison curve of the target data with the predicted data is shown in the figure 8. The left curve is the target data and the right curve is the predicted data.

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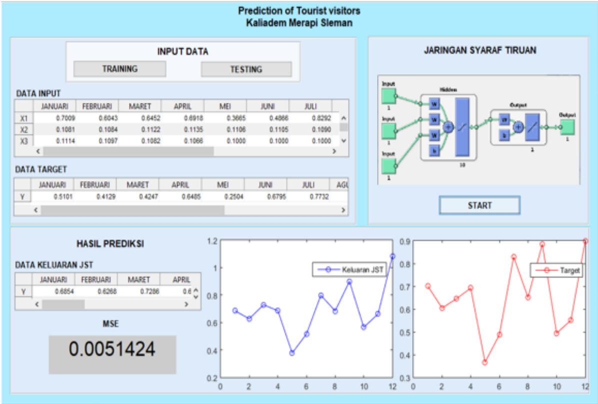

Figure 7. Display of the GUI after Testing

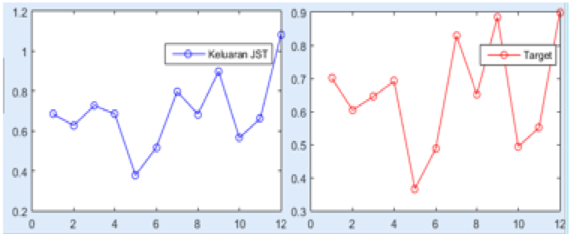

Figure 8. The comparison curve of target data with predicted data

The prediction results generated in the Matlab GUI display in Figure 7 are obtained as shown in Table 7.

Table 7. Predicted Data

Months	Prediction Results (Number of Tourisms In 2019)
January	0.6854
February	0.6268
March	0.7286
April	0.6851
May	0.3772
June	0.5165
July	0.7978
August	0.6836
September	0.8992
October	0.5647
November	0.6618
December	1.0825

After getting the prediction results, the predicted data needs to be normalized to return the data value to the original data. With the data denormalization formula as in formula 13, the results are as in Table 8.

Table 8. Denormalization of Predicted Data

Months	Prediction Results (Number of Tourisms In 2019)
January	27593
February	23831
March	30366
April	37573
May	9806
June	36749
July	44809
August	27477
September	41319
October	19844
November	26078
December	43087

Based on the data testing that has been generated, the next step is to make a comparison between the target value and the predicted results. The difference between the target value and the prediction results in the testing process as in Table 9.

Table 9. The Difference in Target Value and Prediction Results of the Testing Process

Months	Target	Prediction Results	Difference
January	26337	27593	1256
February	20092	23831	3739
March	20851	30366	9515
April	35223	37573	2350
May	9661	9806	145
June	37212	36749	463
July	43225	44809	1584
August	27330	27477	147
September	39873	41319	1446
October	20200	19844	356
November	25047	26078	1031
December	38479	43087	4608

After getting the data, it can be calculated the value of MSE (Mean Squared Error) with the following formula:

$$MSE = \sum_{i=1}^{n} \frac{(y_i - \hat{y}_i)^2}{n} \quad (14)$$

Known: $e = yi - \hat{yi}$

Which yi is initial data, $\hat{yi}$ is final data, and n is amount of data. So, the MSE (Mean Squared Error) formula used is

$$MSE = \frac{\sum_{i=1}^{n} {e_i}^2}{n} \quad (15)$$

Programming in Matlab to calculate the value of MSE (Mean Squared Error) is

error_MSE = (1 / n) * sum (error_ value. ^ 2)

As shown in Figure 5, the MSE (Mean Squared Error) value is 0.0051424. MSE (Mean Squared Error) is the average squared forecasting error. Based on the data in table 9, the validity value of prediction accuracy is around 91.32%. The prediction system is made by utilizing the Matlab Graphical User Interface (GUI) facility to make it easier for users to interact while carrying out prediction activities.

4. Conclusion

In this study, two processes were carried out, namely the training process and the testing process. The value of MSE (Mean Squared Error) in the training process is 0.0091528. Meanwhile, the MSE (Mean Squared Error) value in the testing process is 0.0051424. The smaller the MSE (Mean Squared Error) value, the better the prediction results because the error value is also getting smaller. Besides, the predictive accuracy validity value is around 91.32%. Therefore, based on the results of training and testing of an artificial neural network system architecture with the backpropagation algorithm that has been designed, it produces a relatively small

MSE (Mean Squared Error) value. So, this system can be used by tourism activists to predict the number of tourists in Kaliadem Merapi, Sleman.

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References

[1] Dinas Pariwisata DIY. 2019. Statistik Kepariwisataan 2019 [PDF]. Available at: https://visitingjogja.com/download/statistik-pariwisata/ [Accessed 12 December 2020]

[2] Dinas Pariwisata DIY. 2018. Statistik Kepariwisataan 2018 [PDF]. Available at: https://visitingjogja.com/download/statistik-pariwisata/ [Accessed 12 December 2020]

[3] Kiswiranti, D., & Kirbani, H. 2013. Analisis Statistik Temporal Erupsi Gunung Merapi. *Jurnal Fisika*, *3*(1).

[4] Widodo, E., & Hastuti, H. 2019. Riwayat Aktivitas Gunung Merapi: Potensi dan Ancamannya Bagi Sektor Pariwisata. *Geomedia: Majalah Ilmiah dan Informasi Kegeografian*, *17*(1).

[5] Suwarto, T. 2011. Pengaruh Iklim Dan Perubahannya Terhadap Destinasi Pariwisata Pantai Pangandaran. *Journal of Regional and City Planning*, *22*(1), 17-32.

[6] Surwiyanta, A. 2010. Dampak Ekonomi, Lingkungan Dan Sosial Budaya Masyarakat Di Kawasan Kali Adem. *Media Wisata*.

[7] Sianturi, C. J. M., Ardini, E., & Sembiring, N. S. B. 2020. Sales Forecasting Information System Using the Least Square Method in Windi Mebel. *Jurnal Inovasi Penelitian*, *1*(2), 75-82.

[8] Yudi, Y. 2018. Peramalan Penjualan Mesin Industri Rumah Tangga Dengan Metode Fuzzy Time Series Ruey Chyn Tsaur. *Jurnal Informatika Kaputama*, *2*(1), 53-59.

[9] Haryanto, E. V., & Nasari, F. 2015. Penerapan Metode Fuzzy Mamdani Dalam Memprediksi Tingginya Pemakaian Listrik (Studi Kasus Kelurahan Abc). *SEMNASTEKNOMEDIA ONLINE*, *3*(1), 2-2.

[10] Arifin, F., Robbani, H., Annisa, T., & Ma'Arof, N. N. M. I. 2019. Variations in the Number of Layers and the Number of Neurons in Artificial Neural Networks: Case Study of Pattern Recognition. In *Journal of Physics: Conference Series* (Vol. 1413, No. 1, p. 012016). IOP Publishing.

[11] Lala, H., Karmakar, S., & Ganguly, S. 2018. Fault Detection and Localization using Continuous Wavelet Transform and Artificial Neural Network Based Approach in Distribution System. *International Journal on Electrical Engineering and Informatics*, *10*(2), 203-219.

[12] Yanto, M., Mayola, L., & Hafizh, M. 2020. Neural Network Backpropagation Identification of Jakarta Islamic Index (JII) Stock Price Patterns. *Jurnal RESTI (Rekayasa Sistem dan Teknologi Informasi)*, *4*(1), 90-94.

[13] Lesnussa, Y. A., Mustamu, C. G., Lembang, F. K., & Talakua, M. W. 2018. Application Of Backpropagation Neural Networks In Predicting Rainfall Data In Ambon City. *International Journal of Artificial Intelligence Research*, *2*(2), 41-50.

[14] Siregar, S. P., & Wanto, A. 2017. Analysis of Artificial Neural Network Accuracy Using Backpropagation Algorithm In Predicting Process (Forecasting). *IJISTECH (International Journal of Information System & Technology)*, *1*(1), 34-42.

[15] Suhendra, C. D., & Wardoyo, R. 2015) Penentuan arsitektur jaringan syaraf tiruan backpropagation (bobot awal dan bias awal) menggunakan algoritma genetika. *IJCCS (Indonesian Journal of Computing and Cybernetics Systems)*, *9*(1), 77-88.

[16] Nawi, N. M., Khan, A., & Rehman, M. Z. 2013. A new back-propagation neural network optimized with cuckoo search algorithm. In *International conference on computational science and its applications* (pp. 413-426). Springer, Berlin, Heidelberg.

[17] Cynthia, E. P., & Ismanto, E. 2017. Jaringan Syaraf Tiruan Algoritma Backpropagation Dalam Memprediksi Ketersediaan Komoditi Pangan Provinsi Riau. *Rabit: Jurnal Teknologi dan Sistem Informasi Univrab*, *2*(2), 83-98.

[18] Siang, Jong Jek. 2005. Jaringan Syaraf Tiruan & Pemogramannya Menggunakan Matlab. Yogyakarta: ANDI.

[19] Siang, Jong Jek. 2005. Jaringan Syaraf Tiruan & Pemogramannya Menggunakan Matlab. Yogyakarta: ANDI.

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