

Application of The Levenberg Marquardt Method In Predict The Amount of Criminality in Pematangsiantar City

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Abstract

Criminality is an act that violates the law that can disturb society and even harm society both economically and psychologically. The number of crimes cannot be ascertained over time because the numbers are uncertain. So that the police have difficulty in overcoming criminal acts. With this research, the police can find out the number of criminals that will occur through the prediction that has been made. So that the police can prevent the number of criminals and increase security in Pematangsiantar city. This study uses an artificial neural network with the Levenberg Marquardt method. The research data is sourced from the Pematangsiantar Police Criminal Investigation Agency (Reskrim) in 2014-2019. The data is divided into 2 parts, namely training data and testing data. There are 5 architectural models used in this study, namely 3-30-1, 3-31-1, 3-32-1, 3-36-1 and 3-38-1. Of the 5 architectural models used, the best architecture is 3-36-1 with an accuracy rate of 85%, MSE 0.1465119, and a maximum iteration of 10000, the results obtained from the best architecture in 2020 are 85% with the number of criminals 394 people, in 2021 it is 62 % totaled 238 people, in 2022, namely 69% amounted to 170 people, so this model is good for predicting the number of crimes in Pematangsiantar City.

Keywords: Artificial Neural Networks, Levenberg Marquardt, Prediction, Total Crime

INTRODUCTION

Criminality is behavior and actions that harm society both psychologically and economically that violate the laws of the Indonesian state as well as religious and social norms (Latief, Usmita, & Novarizal, 2016). Forms of criminal acts are persecution, murder, corruption, fraud, gambling, and others. Criminal acts can occur due to hatred, mental pressure, social imbalance, or changes in the environment that occur in society (Astuti, Fardinan, & Suyatno, 2016). Crime is very necessary to be eradicated, care that people feel safe and in every region, city and remote village are maintained, such as in Pematangsiantar city.

The criminal rate in Pematangsiantar city has increased and decreased in crime cases every year from 2014-2019 the number of criminals was 4606 people (Kep Polisi Reskrim Polres Pematangsiantar, 2020). Therefore the police need to see the number of crimes or crimes that will occur in the coming year so that the police can prevent and reduce the crime rate and improve security in Pematangsiantar city. One way to find out the number of criminals in Pematangsiantar city is using computer aids that are supported by artificial neural networks.

“Artificial Neural Network (ANN) is a representation of the performance of the human brain, which simulates the learning process of the human brain” (Giusti, Widodo, & Adinugroho, 2018). “In ANN, there are neurons that are grouped into layers. These neurons will transfer the information received from one neuron to another and the information received by these neurons is stored at a certain value called weight” (Fardani, Wuryanto, & Werdiningsih, 2015). In completing this study using an artificial neural network with the Levenberg Marquardt method. The Levenberg Marquardt method uses training and testing data to get the desired prediction results (Sumarauw, 2016). With that, the author uses the Levenberg Marquardt method to predict the number of criminals in Pematangsiantar city. This method was chosen because Levenberg Marquardt is very efficient in network training.

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LITERATURE REVIEW

As in previous studies related to Levenberg Marquardt, namely "Implementation of Levenberg Marquardt Algorithm Neural Network to Predict That Palm Kernel Oil" from testing investigating the error rate obtained 0.01024 (Zona, 2019).

Furthermore, investigating related to "Implementation of Neural Fuzzy Inference System and Levenberg-Marquardt Training Algorithm for Rainfall Prediction" research results that have been tested NFIS-LM Model produces an MSE of 0.0262050 while the NN-Backpropagation model produces an MSE of 0.0167990 (Ritha & Retantyo, 2016).

Next, research related to "Artificial Neural Networks in Predicting Palm Oil Production at PT. KRE Using Levenberg Marquardt Algorithm" The results of the research that have been tested produce an MSE of 1.1471 (Andriani, Wanto, & Handrizal, 2019).

The next research related to "Optimization of Exponential Smoothing with the Levenberg-Marquardt Algorithm", the results of the research that have been tested produce optimal parameters, namely 0.2201 and 0.0954. The absolute error proportion value is 9.61%, this is good because it is below 10% (Sitompul, 2018).

Next research related to "Gray Double Exponential Smoothing with Levenberg-Marquardt Optimization for Passenger Volume Forecasting at Soekarno-Hatta Airport", the results of research that have been tested. The optimization results of GDES and DES are alpha of 0.8245 and 0.8303 (Primandari, 2020).

The next research related to "Using Algorithm (Levenberg Marquardt) as Activation Function to Prediction Water Quality Index (WQI) in Kastamonu City-Turkey" the results of research that have been tested A better predictive accuracy model is the 4Lm model with $(n + 1)$ for water quality index (WQI) when we use 4 parameters. While the last model with $(2n + 1)$ hidden layer (Imneisi & Aydin, 2015).

The next research related to "Prediction of Sea Wave Height using Levenberg Marquardt algorithm" the results of research that have been tested produce predictions of sea wave height in waters Bintan has an ideal structure with several hidden layers = 2 and neurons on hidden layer = 9. The average error absolute percentage of forecasting with using MAPE is 0.175 (Nikentari, 2016).

The next research related to "Analysis of Clean Water Needs in PDAM Pontianak City Using The Levenberg Marquardt method" the results of research that have been tested produce modeling shows that the best math function social customer class is a function polynomial of order 5 with a correlation coefficient value amounting to 0.905 and the estimated RMSE is 4.77×10^2 . Then for non-commercial customers and commercial customers, math functions best is a polynomial of order 6 with a value the correlation of each customer was 0.956 and 0.878 and an RMSE of 9.25×10^4 and 2.91×10^4 . Furthermore, for industrial customers, the best mathematical function is polynomial order 4 with a correlation value of 0.719 and a RMSE of 8.43×10^2 (Nurrisma, Muliadi, & Sanubary, 2019). It can be ignored that using the Levenberg Marquardt method is suitable and produces a good predictive value.

METHOD

Levenberg Marquardt is a development of the standard backpropagation error algorithm. This method uses the Jacobian matrix approach, therefore Levenberg Marquardt can recognize certain patterns and achieve convergence faster than the usual backpropagation algorithm (Mustafidah, Budiastanto, & Suwarsito, 2019).

The application of the Levenberg Marquardt method data has been obtained and will be carried out to the data normalization stage using the sigmoid activation function, this is done to facilitate the calculation process of the Levenberg Marquardt method (Dewi, Bahri, & Irwansyah, 2019).

1. Levenberg Marquardt algorithm

Here are some of the structure of the Levenberg Marquardt algorithm:

- a. Initialization of weights and bias with random numbers, maximum epoch, minimum goal (performance calculated by MSE)
- b. Determine the required parameters, including:



1. Levenberg Marquardt parameter whose value must be greater than zero
2. Input factor parameters and bias used as parameters are multiplied or divided by the Levenberg Marquardt parameter
- c. Calculate the forward (feedforward) on the hidden and output layers in the backpropagation error algorithm. In step (a) (d).
- d. Calculating the Mean Square Error (MSE) value
- e. Calculate network errors and total errors
 1. The formula for error: $e_r = t_r - y_r$
 r is the r -th input
 2. The formula for calculating the total error:
$$e = [e_1 \ e_2 \ e_3 \ \dots \ e_N]$$
 e is an error vector of size $N \times 1$ which consists of e_r
 $r = 1, 2, 3 \dots N$
- f. Calculating the Jacobian matrix $J(x)$
 x is a matrix that contains the weight and bias values of the entire network.
$$X = [v_{11}, v_{12}, \dots, v_{ij}; v_{01}, v_{02}, \dots; w_{11}, w_{12}, \dots, w_{jk}; w_{01}, w_{02}, \dots, w_{0k}]$$

The Jacobian matrix contains the first derivative of network error concerning network weight and bias.
The formula for finding the Jacobian Matrix, among others. $J = [\partial e_r / \partial w]$
- g. The value of $J(x)$ has been obtained, then the change in the weight and bias correction can be calculated with the following formula:
$$\Delta x = [J(x)^T J(x) + \mu I]^{-1} * \text{Gradient (Gradient: } J(x)^T e)$$
- h. After obtaining the Δx value, the next step is weight correction with the same formula as in the backpropagation error algorithm. In step 1.
- i. Calculate feedforward with new weights and biases. In step (a-d)
- j. Calculates the network MSE with new weights and biases. Then the condition test stops
- k. Then repeat steps e through h.

Where:

e_r = error r t_r = r -th target

y_r = r -th output $J(x)$ = Jacobian matrix

r = r -th input



2 Flowchart Of Levenberg Marquardt In Making Predictions

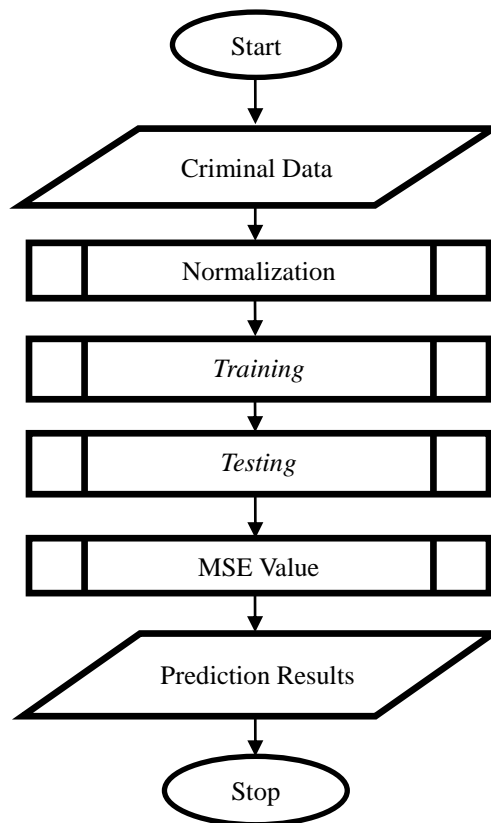


Figure 1. Flowchart Of Levenberg Marquardt

In figure 1 above, it can be explained that the first thing to do is collect criminal data, after that the data will be normalized and a training and testing process will be carried out and then reprocessed to get the MSE value with the MSE value. The denormalization process will be carried out to get the smallest MSE value to get the best prediction of the number of crimes.

DISCUSSIONS

The data in this study are data obtained from the Criminal Investigation Unit (Reskrim) of the Pematangsiantar Police from 2014-2019.

Table1. Data On The Number Of Criminal In Pematangsiantar City

| Case Types | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---------------------------|------|------|------|------|------|------|
| Letter Forgery | 5 | 2 | 7 | 7 | 4 | 6 |
| Gambling | 31 | 66 | 41 | 34 | 25 | 24 |
| Insult | 10 | 11 | 12 | 7 | 1 | 12 |
| Persecution | 152 | 117 | 125 | 111 | 98 | 144 |
| Theft | 317 | 398 | 503 | 368 | 262 | 255 |
| Extortion and Threatening | 9 | 6 | 10 | 9 | 5 | 7 |
| Embezzlement. | 68 | 79 | 88 | 88 | 55 | 49 |



| | | | | | | |
|-------------------|----|----|----|----|----|----|
| Fraud | 75 | 69 | 67 | 53 | 52 | 67 |
| Destruction | 12 | 12 | 12 | 10 | 7 | 9 |
| Child Protection | 65 | 42 | 37 | 44 | 34 | 35 |
| Domestic violence | 31 | 28 | 44 | 25 | 19 | 28 |
| Unpleasant Deeds | 11 | 4 | 1 | 2 | 3 | 6 |
| Fiduciary | 14 | 20 | 17 | 11 | 5 | 7 |

Normalized Criminal data will then be divided into 2, namely data training and data testing, after being divided, normalization is carried out to make it easier to carry out training and testing using the normalization formula which produces values between 0 and 1 can be seen in equation (1):

$$x' = \frac{0.8(x-a)}{b-a} + 0.1 \quad (1)$$

Table 2. Training Of Data After Dinormalization (2014-2016) Target 2017

| Case Types | 2014 | 2015 | 2016 | Target |
|---------------------------|---------|---------|---------|---------|
| Letter Forgery | 0,10637 | 0,10159 | 0,10956 | 0,10956 |
| Gambling | 0,14781 | 0,20359 | 0,16375 | 0,15259 |
| Insult | 0,11434 | 0,11594 | 0,11753 | 0,10956 |
| Persecution | 0,34064 | 0,28486 | 0,29761 | 0,27530 |
| Theft | 0,60359 | 0,73267 | 0,90000 | 0,68486 |
| Extortion and Threatening | 0,11275 | 0,10797 | 0,11434 | 0,11275 |
| Embezzlement. | 0,20677 | 0,22430 | 0,23865 | 0,23865 |
| Fraud | 0,21793 | 0,20837 | 0,20518 | 0,18287 |
| Destruction | 0,11753 | 0,11753 | 0,11753 | 0,11434 |
| Child Protection | 0,20199 | 0,16534 | 0,15737 | 0,16853 |
| Domestic violence | 0,14781 | 0,14303 | 0,16853 | 0,13825 |
| Unpleasant Deeds | 0,11594 | 0,10478 | 0,10000 | 0,10159 |
| Fiduciary | 0,12072 | 0,13028 | 0,12550 | 0,11594 |

Table 3. Testing Data After Dinormalization (2016-2018) 2019 Target

| Case Types | 2016 | 2017 | 2018 | Target |
|---------------------------|---------|---------|---------|---------|
| Letter Forgery | 0,10956 | 0,10956 | 0,10478 | 0,10797 |
| Gambling | 0,16375 | 0,15259 | 0,13825 | 0,13665 |
| Insult | 0,11753 | 0,10956 | 0,10000 | 0,11753 |
| Persecution | 0,29761 | 0,27530 | 0,25458 | 0,32789 |
| Theft | 0,90000 | 0,68486 | 0,51594 | 0,50478 |
| Extortion and Threatening | 0,11434 | 0,11275 | 0,10637 | 0,10956 |
| Embezzlement. | 0,23865 | 0,23865 | 0,18606 | 0,17649 |
| Fraud | 0,20518 | 0,18287 | 0,18127 | 0,20518 |
| Destruction | 0,11753 | 0,11434 | 0,10956 | 0,11275 |
| Child Protection | 0,15737 | 0,16853 | 0,15259 | 0,15418 |
| Domestic violence | 0,16853 | 0,13825 | 0,12869 | 0,14303 |
| Unpleasant Deeds | 0,10000 | 0,10159 | 0,10319 | 0,10797 |
| Fiduciary | 0,12550 | 0,11594 | 0,10637 | 0,10956 |



Best architecture This study uses 5 (five) training architectural models and testing data, namely: 3-30-1, 3-31-1, 3-32-1, 3-36-1, 3-38-1. Based on the 3-30-1 architectural model, it states that 3 is the input layer data, 30 is the hidden layer data and 1 is the output layer data. The training for these 5 models uses Matlab software and there is 1 best architectural model, 3-36-1, which can be seen in figure 2.

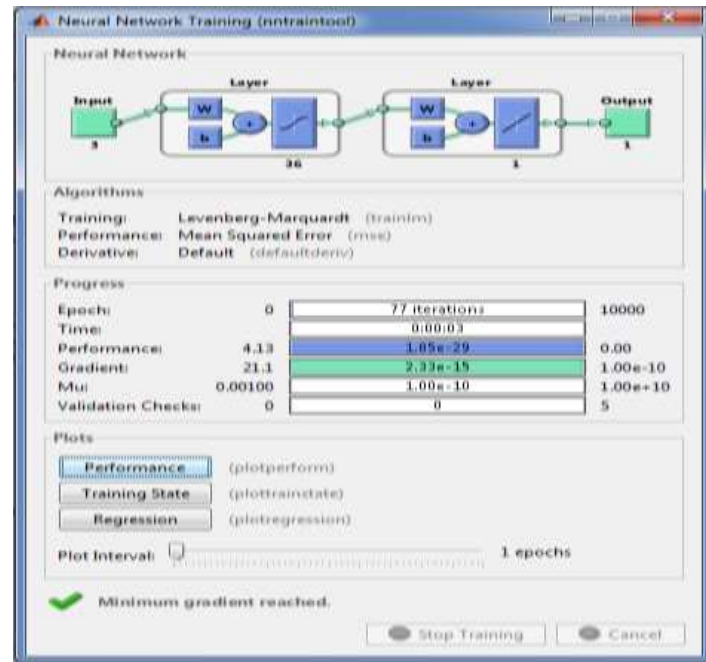


Figure 2. ResultsOfTraining Data WithArchitecture 3-36-1

Figure 2 is a comparison of the architectural model, time velocity, and iteration seen using the Matlab application. The MSE (Mean Squared Error) value and the accuracy of the 5 architectural models were obtained using Microsoft Excel.

Table 4. Conclusion Of Network Training And Testing

| Architecture | Epoch | Training | | Testing | |
|--------------|-------|----------|--------------|------------|----------|
| | | Time | SSE | MSE | Accuracy |
| 3 - 30 - 1 | 96 | 00:03 | 0,0000000012 | 0,01110411 | 77% |
| 3 - 31 - 1 | 146 | 00:04 | 0,0000000014 | 0,18492354 | 69% |
| 3 - 31 - 1 | 19 | 00:01 | 0,0000000013 | 0,38564335 | 77% |
| 3 - 36 - 1 | 77 | 00:03 | 0,0000000013 | 0,01465119 | 85% |
| 3 - 38 - 1 | 147 | 00:05 | 0,0000000013 | 0,02535021 | 77% |

Based on Table 4, it is concluded that the highest level of accuracy is in the 3-36-1 architectural model. Then the best architecture in the Levenberg Marquardt algorithm can be seen in Table 5.

Table 5. Testing Data Accuracy Results Using Model Architecture 3-36-1

| Case Types | Target | Output | Error | SSE | Result |
|---------------------------|---------|---------|-----------|------------|--------|
| Letter Forgery | 0,10797 | 0,09220 | 0,01577 | 0,00024863 | 1 |
| Gambling | 0,13665 | 0,22120 | -0,08455 | 0,00714813 | 1 |
| Insult | 0,11753 | 0,09680 | 0,02073 | 0,00042973 | 0 |
| Persecution | 0,32789 | 0,44050 | -0,11261 | 0,01268136 | 1 |
| Theft | 0,50478 | 0,90280 | -0,39802 | 0,15841922 | 1 |
| Extortion and Threatening | 0,10956 | 0,09850 | 0,01106 | 0,00012236 | 1 |
| Embezzlement. | 0,17649 | 0,21530 | -0,03881 | 0,00150590 | 1 |
| Fraud | 0,20518 | 0,17680 | 0,02838 | 0,00080538 | 0 |
| Destruction | 0,11275 | 0,10830 | 0,00445 | 0,00001979 | 1 |
| Child Protection | 0,15418 | 0,22870 | -0,07452 | 0,00555274 | 1 |
| Domestic violence | 0,14303 | 0,20010 | -0,05707 | 0,00325723 | 1 |
| Unpleasant Deeds | 0,10797 | 0,09330 | 0,01467 | 0,00021515 | 1 |
| Fiduciary | 0,10956 | 0,11730 | -0,00774 | 0,00005988 | 1 |
| | | | Total SSE | 0,19046552 | |
| | | | MSE | 0,01465119 | 85% |

RESULT

The results of the accuracy of the examiners using the 3-36-1 architectural model can be seen in Table V. There are 13 types of criminal cases used in the test. The target value from the 2019 normalization data table, the output value is obtained from the results of training using Matlab software with the formula $[a, Pf, Af, e, Perf] = \text{sim}(\text{net}, PP, [], [], TT)$, error value obtained from target-output, the SSE value is obtained from error^2 (\wedge : rank), the number of SSE is the total SSE value. The MSE value is obtained from: the number of SSE / 13 (many types of cases) and the result 1 (true) is obtained from the formula = IF (error <= 0.02; 1; 0) for data testing. The accuracy value (%) is obtained from: number of correct / 13 * 100.

Estimation Results Using the Levenberg Marquardt Method

In conducting the estimation process in the following year, this study uses the best test data with the 3-36-1 architectural model.

Table 6. Estimation Of Number Of Criminal Results In Pematangsiantar City

| Case Types | 2020 | 2021 | 2022 |
|---------------------------|------|------|------|
| Letter Forgery | 8 | 11 | 13 |
| Gambling | 17 | 14 | 9 |
| Insult | 11 | 12 | 13 |
| Persecution | 77 | 34 | 16 |
| Theft | 132 | 53 | 19 |
| Extortion and Threatening | 9 | 11 | 13 |
| Embezzlement. | 30 | 18 | 14 |
| Fraud | 39 | 21 | 14 |
| Destruction | 10 | 12 | 13 |
| Child Protection | 23 | 16 | 13 |
| Domestic violence | 19 | 15 | 9 |
| Unpleasant Deeds | 8 | 11 | 13 |
| Fiduciary | 9 | 11 | 13 |



In Table 6. The prediction results obtained using the Levenberg Marquardt method with the best architectural model that is 3-36-1 with an accuracy rate of 85% are predictions that can be used as a reference or not. With the results obtained, the Pematangsiantar Police continues to increase security for Pematangsiantar City.

CONCLUSION

Based on the results and analysis of the prediction research on the number of criminals in Pematangsiantar City using Levenberg Marquardt, the following conclusions can be drawn:

1. The results of the prediction of the number of criminals have decreased which is quite stable compared to the number of criminals in the previous year. After training and testing using 5 architectural models, namely 3-30-1, 3-31-1, 3-32-1, 3-36-1 and 3-38-1, we get 1 best architecture with 3-36 models. -1 which has the highest level of accuracy that is 85% and with a learning rate of 0.02, the number of iterations is 77 in 3 seconds and the Mean Squared Error (MSE) value is 0.01465119.
2. Using this architectural model, the level of accuracy in 2020 with the number of criminals is 394 people, in 2021 there are 238 people, in 2022 there are 170 people, When compared to the number of criminals in 2014 to 2019, the number of criminals in 2020 to 2022 has decreased significantly stable.

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