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Electric Vehicle Sales-Prediction Application Using Backpropagation Algorithm Based on Web

Ramadhanti, Hairani Hairani, Muhammad Innuddin
Universitas Bumigora, Mataram, Indonesia

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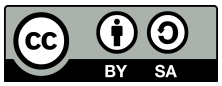
ABSTRACT

The accuracy of predicting future product sales is needed to minimize losses and gain profits. Inventory of goods carried out manually or improper product inventory planning causes the number of goods to accumulate due to the small number of requests, so the goods are damaged. Therefore, a sales prediction system with high accuracy is needed to assist in stocking electric vehicles. This research aimed to predict electric vehicle sales using the web-based backpropagation method. This study uses the backpropagation method to predict electric vehicle sales data from 2015 to 2022. The data is divided into 84 instances as training data and 12 instances as testing data. The result of this study was that the backpropagation method obtained a MAPE error rate of 6.25%. Thus, the backpropagation method can be used for predicting electric vehicle sales because it has a very accurate performance level.



Corresponding Author:

Hairani Hairani,
Universitas Bumigora, Mataram, Indonesia.
Email: Hairani@universitasbumigora.ac.id

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1. INTRODUCTION

Indonesia's population has increased, which has increased the number of motorized vehicles. The increase in the use of motorized vehicles affects the use of fuel oil (BBM). The ever-increasing fuel price causes users to look for alternatives that do not drain their finances to facilitate their daily activities. As a result, users switch to using electric vehicles as daily transportation. The increasing trend of user data switching to electric vehicles in rural and urban areas creates competition between companies to sell electric vehicles.

Every company must have its marketing strategy to increase sales and inventory stock of electric vehicles. An important factor in sales is to predict the demand for consumer orders so that the supply of electric vehicles is not excessive. Electric vehicle companies need to know the number of electric vehicle sales for the next period by analyzing the number of sales based on data from the previous period. The company needs sales forecasting as a basis for decision-making to plan the following steps to increase the sales quantity. The accuracy of predicting future product sales is needed to minimize losses and gain profits. Inventory of goods carried out manually or improper product inventory planning causes the number of goods to accumulate due to low demand and damaged goods. Therefore, a sales prediction system with high accuracy is needed to assist in the in-stock inventory of electric vehicles.

Previous research has done predictions using various approaches, such as research [1] using the neural network backpropagation method for predicting electricity usage with results with an RMSE value level of 0.203424. Research [2] uses the linear regression method for predicting Unilever product sales with a MAPE rate of 7%. Research [3] predicts motor conditions at coal-fired power plants using the Long Short-Term Memory (LSTM) method with an error rate of 3.8%. Research [4] uses the linear regression method for predicting car purchase prices with an MAE value of 2.3%. Research [5] predicts product sales using the LSTM method, with research results 13.76 for RMSE and 12% for MAPE. Research [6] predicts the sales level of electronic products and furniture using the Backpropagation method. Research [7] uses the feedforward neural network method for predicting electricity usage with research results of 0.35 for MSE. Research [8] utilizes a linear regression method for used car price prediction with an accuracy rate of 76%. Research [9] uses the backpropagation artificial neural network method for predicting poverty levels with an accuracy rate of 95.2%. The research [10] used an Artificial Neural Network to forecast product sales with a forecasting accuracy performance of 97%.

Based on previous research, there are differences with this research, namely differences in the use of parameters that will be used. This research focuses on predicting electric vehicle sales based on several parameters such as Murai, Mandalika, Butterfly Trike, Rinjani, and Total Sales (Target). The method used is the backpropagation method, because its performance is particularly good in prediction cases based on several previous studies. Therefore, this research applies the backpropagation method in the case of web application-based electric vehicle sales prediction. Therefore, this research aims to predict electric vehicle sales using a web-based backpropagation method.

2. RESEARCH METHOD

This research has several flows, as shown in Figure 1. The initial stage is the collection of electric bicycle data, followed by data preprocessing, implementation of the backpropagation method, and evaluation of results. The sales data for the types of electric vehicle products used are for four types of best-selling electric bicycle products: Murai, Rinjani, Mandalika, and Butterfly Trike, with a range of 2015 to 2022 and 96 data. The sample data is shown in Table 1.

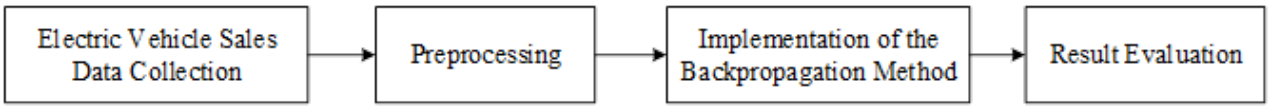

Figure 1. Research Framework

In the preprocessing section, data normalization is carried out into the range of 0 to 1 to minimize the dominance of values with the largest range and adjust the output to the activation function network used, such as the sigmoid (binary) activation function. Data normalization is used as Equation 1. X' is the Normalization Result, x is the i-th data value to be normalized, b is the value with the highest range, and a is the value with the lowest range. The data normalization results are shown in Table 2.

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

Table 1. Electric Vehicle Sales Data for 8 Years

No	Year	Month	Murai	Mandalika	Betterfly Trike	Rinjani	Target
1	2015	1	20	35	20	1	76
2	2015	2	20	45	13	10	88
3	2015	3	20	20	33	20	93
4	2015	4	30	30	17	2	79
5	2015	5	28	19	4	1	52
6	2015	6	39	12	20	2	73
7	2015	7	49	30	20	52	151
8	2015	8	16	20	23	21	80
9	2015	9	20	50	3	1	74
10	2015	10	20	45	2	1	68
11	2015	11	20	30	3	2	55
12	2015	12	29	20	2	35	77
..	...	..	...	...	...	...	...
85	2022	1	40	58	2	17	117
86	2022	2	92	58	1	33	184
87	2022	3	50	74	7	21	152
88	2022	4	130	64	7	13	214
89	2022	5	40	27	2	12	81
90	2022	6	70	33	10	31	144
91	2022	7	70	165	28	40	303
92	2022	8	38	114	13	31	196
93	2022	9	28	89	4	29	150
94	2022	10	102	9	41	2	154
95	2022	11	70	9	31	11	121
96	2022	12	80	9	13	20	122

Table 2. Normalized Data Results

No	Year	Month	Murai	Mandalika	Betterfly Trike	Rinjani	Target
1	2015	1	0,218	0,311	0,218	0,100	0,565
2	2015	2	0,218	0,373	0,174	0,156	0,640
3	2015	3	0,218	0,218	0,298	0,218	0,671
4	2015	4	0,280	0,280	0,199	0,106	0,584
5	2015	5	0,267	0,212	0,119	0,100	0,416
6	2015	6	0,336	0,168	0,218	0,106	0,547
7	2015	7	0,398	0,280	0,218	0,416	1,030
8	2015	8	0,193	0,218	0,236	0,224	0,590
9	2015	9	0,218	0,404	0,112	0,100	0,553
10	2015	10	0,218	0,373	0,106	0,100	0,516
11	2015	11	0,218	0,280	0,112	0,106	0,435
12	2015	12	0,218	0,218	0,106	0,311	0,571
..	...	..	...	...	...	...	...
85	2022	1	0,342	0,453	0,106	0,199	0,819
86	2022	2	0,664	0,453	0,100	0,298	1,235
87	2022	3	0,404	0,553	0,137	0,224	1,036
88	2022	4	0,900	0,491	0,137	0,174	1,421
89	2022	5	0,342	0,261	0,106	0,168	0,596
90	2022	6	0,528	0,298	0,156	0,286	0,987
91	2022	7	0,528	1,117	0,267	0,342	1,973
92	2022	8	0,329	0,801	0,174	0,286	1,309
93	2022	9	0,267	0,646	0,119	0,274	1,024
94	2022	10	0,726	0,150	0,348	0,106	1,049
95	2022	11	0,528	0,150	0,286	0,162	0,844
96	2022	12	0,590	0,150	0,174	0,218	0,850

The next step is implementing the backpropagation method for predicting electric bicycle sales with a division of 84 training data and 12 testing data. In general, there are four stages needed by the backpropagation method to predict data, namely data input,

forward propagation, backward propagation, and weight update. More detailed stages of the backpropagation method process in predicting data can be seen in Figure 2.

The last stage is the evaluation of results or errors. The error rate generated by the Backprogation method is evaluated using Mean Absolute Percentage Error (MAPE). The MAPE value is the average absolute difference between the predicted and actual values. The MAPE value calculation formula uses Equation 2. The range of MAPE accuracy values is a value $< 10\%$ is a highly accurate prediction, a value of 10% to 20% is an accurate prediction, a value of 20% to 50% is a fairly accurate prediction, and a value $> 50\%$ is an inaccurate prediction.

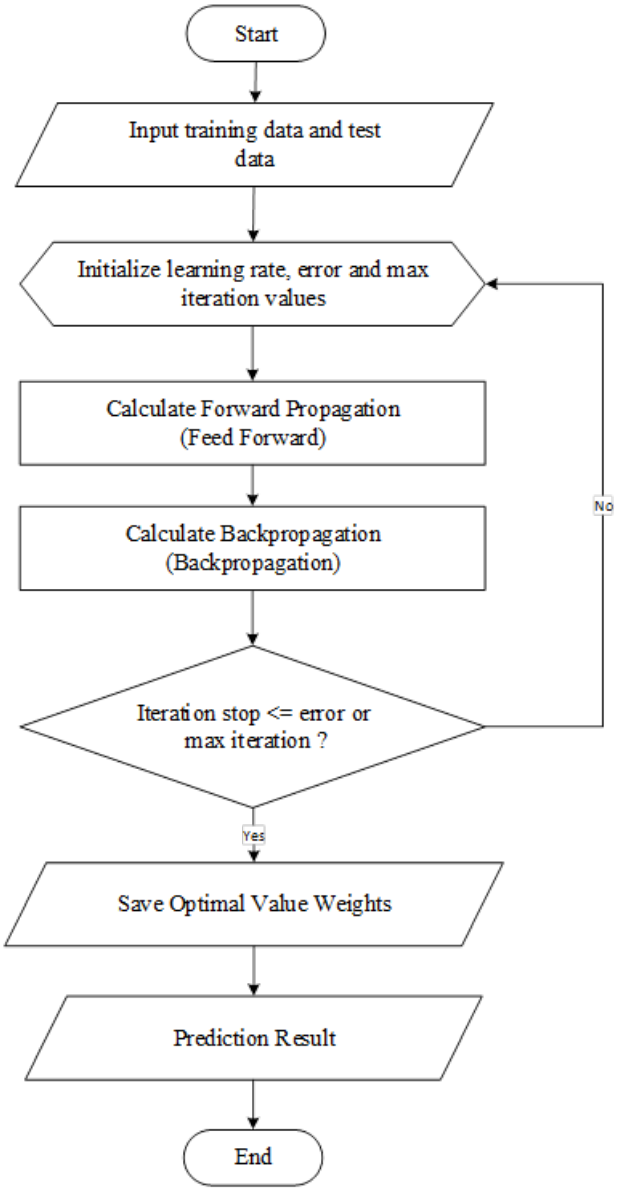

Figure 2. Backpropagation Method Flowchart

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|y_t^{'} - y_t|}{y_t} \quad (2)$$

3. RESULT AND ANALYSIS

This section explains the results of implementing the Backpropagation method on predicting web application-based electric bicycle sales. The application uses the PHP and MySQL programming languages to make predicting future electric bicycle sales easier. The resulting prediction results as a reference in the stock of electric bicycles so that they can minimize losses and get more profit. In the web application developed by applying the backpropagation method for predicting electric bicycle sales, several pages or interfaces can be used, such as the sales data input page, calculation page, and sales prediction page. The sales data page is used as a page to display sales data that has been stored in the system database, as shown in Figure 3. The backpropagation calculation page shows the mathematical calculation process shown in Figure 4. The sales prediction page displays the next sales prediction analysis results, as shown in Figure 5.

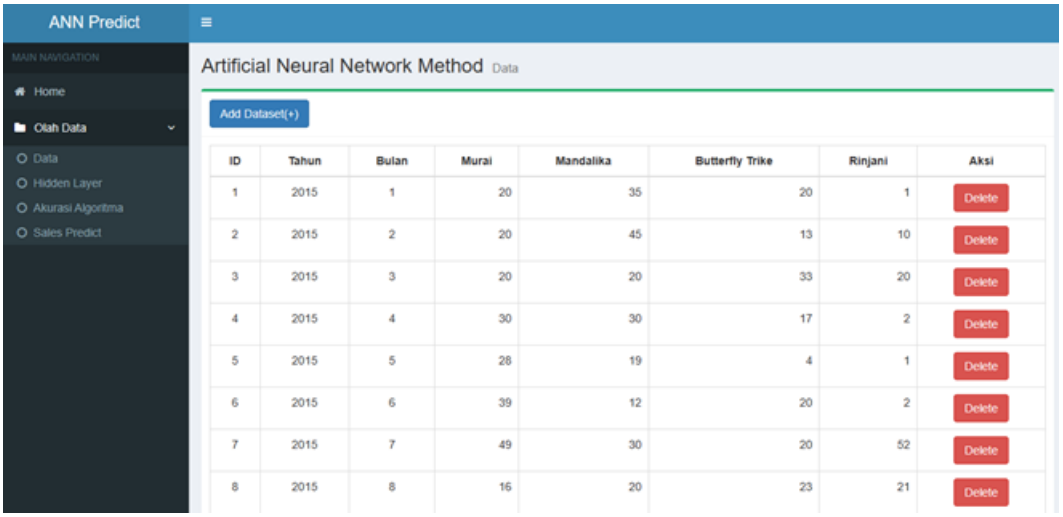

Figure 3. Sales Data Page

In Figure 3, it is used to add electric vehicle sales data with a range of 2015 to 2022 with a total of 84 instances. A delete function can be performed in the data processing menu if there is an input error. In Figure 4, a hidden layer menu is used as an automatic calculation of the backpropagation method in predicting electric vehicle sales in the upcoming period.

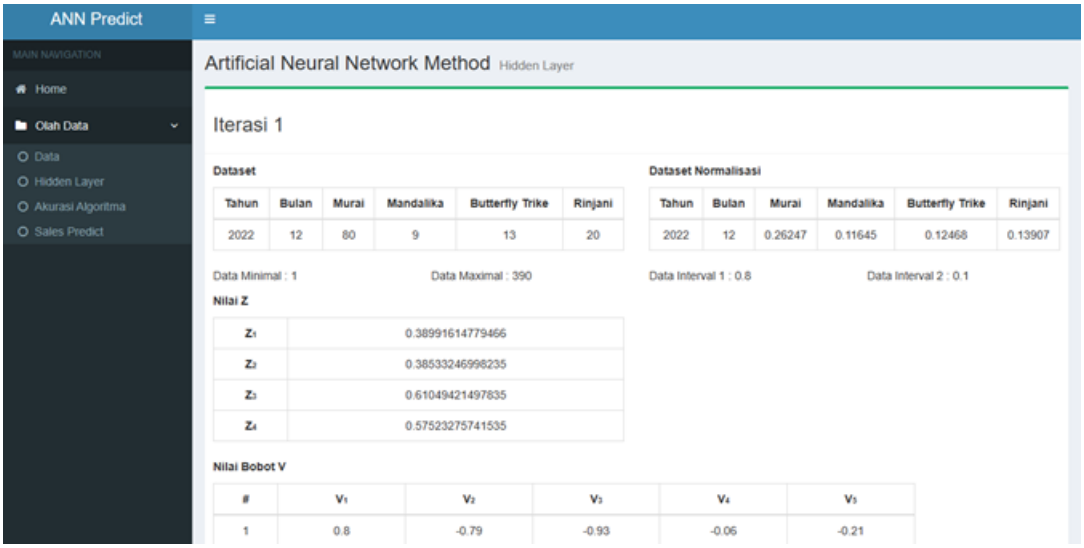

Figure 4. Backpropagation Calculation Page

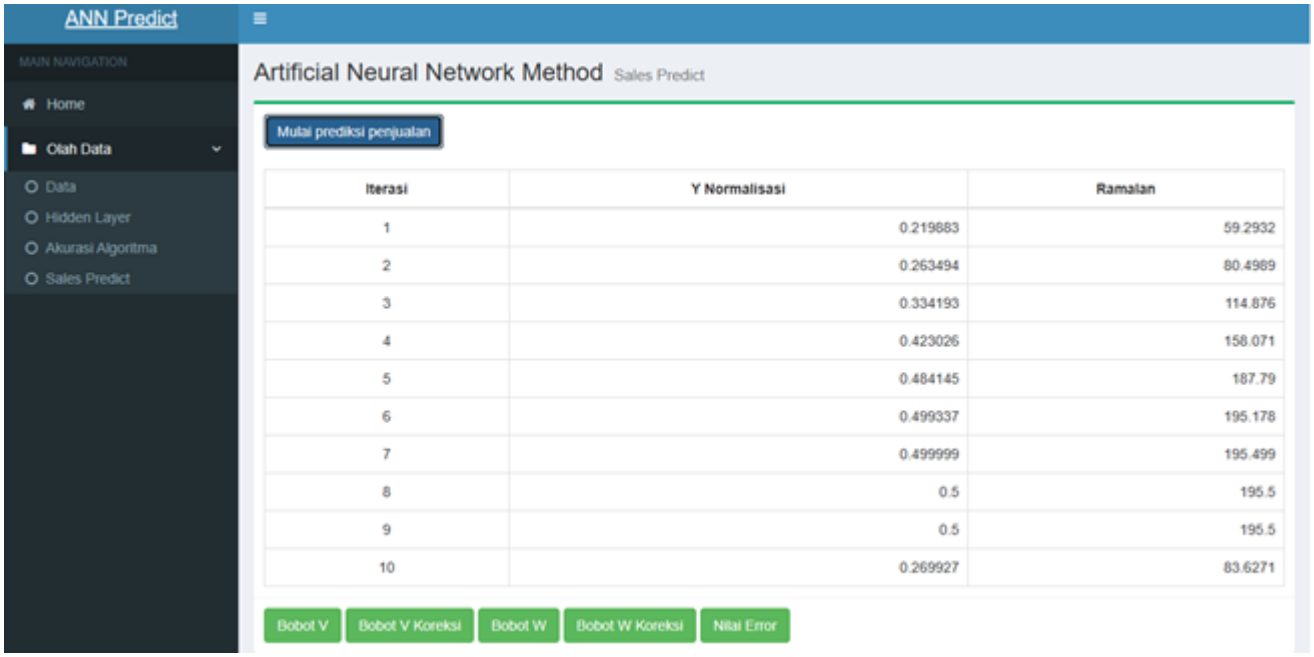

Figure 5. Sales Prediction Page

After calculating with the backpropagation method, Figure 5 uses it to predict electric vehicles with 12 testing data. To see the success rate of the Backpropation method in predicting electric bicycle sales, a test using the MAPE (Mean Absolute Percentage Error) method is necessary. The MAPE method is used to evaluate the results of prediction analysis on testing data based on the stored model of training data learning results. Testing the prediction results in 2019 to 2022 on the model created with training data is close to the actual value of the testing data. This approach shows the error value of the prediction results compared to the actual value. Based on the analysis using Backpropagation based on the 2022 Testing data, the MAPE value can be seen in Table 3. Based on Table 3, the prediction results for 2022, as much as 12 data show the average value of prediction results based on MAPE of 6.25%, which is included in the category of highly accurate prediction results. This is supported by several studies that state that the backpropagation method has a low error rate [11] [12] [13] [14].

Table 3. MAPE Value on Testing Data Prediction Results

No	Year	Month	MAPE	Prediction Category
1	2022	1	5.3	Highly Accurate
2	2022	2	7.10	Highly Accurate
3	2022	3	6.51	Highly Accurate
4	2022	4	7.47	Highly Accurate
5	2022	5	2.89	Highly Accurate
6	2022	6	6.27	Highly Accurate
7	2022	7	8.12	Highly Accurate
8	2022	8	7.33	Highly Accurate
9	2022	9	6.49	Highly Accurate
10	2022	10	6.49	Highly Accurate
11	2022	11	5.46	Highly Accurate
12	2022	12	46	Highly Accurate
Average MAPE Value			**6,25%**	

4. CONCLUSION

The implementation of the backpropagation method in predicting web-based electric bicycle sales has been successfully built. The prediction results generated by the system built obtained the same results as the calculation. The prediction results of the backpropagation method using 12 testing data get a MAPE value of 6.25%, which is included in the highly accurate category. The

suggestion for further research is to use the latest method for predicting electric vehicle sales, such as the LSTM method.

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6. DECLARATIONS

AUTHOR CONTIBUTION

All authors contributed to the writing of this article.

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COMPETING INTEREST

The authors declare no conflict of interest in this article.

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