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Extreme Learning Machine and Multilayer Perceptron Methods for Predicting COVID-19

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Abstract: The number of positive COVID-19 cases in Semarang City has increased over the last year. In anticipating and preparing proper health facilities, the government must predict the number of cases. This research applies Extreme Learning Machine (ELM) and Multilayer Perceptron (MLP) to indicate the number of positive COVID-19 cases. These newly developed methods are part of Artificial Neural Network (ANN). The type of data used in the study is secondary data. Covid-19 patient data was taken from the Semarang City Health Office. The data on the number of positive Covid-19 cases used is data from April 9, 2020 to December 15, 2022. The prediction results of the ELM and MLP methods were then compared to determine which method was more effective in predicting the number of positive Covid-19 cases. The results of the study showed that both methods had an error of less than 10%, meaning that both methods were feasible for predicting the number of positive Covid-19 cases. However, based on the Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) and Root Mean Squared Error (RMSE) values, the MLP method had a smaller error rate than the ELM method. In predicting the number of COVID-19 positive cases, ELM has 93.436331% accuracy, and MLP has 97.055838% accuracy. The best method for predicting the number of COVID-19 positive cases in Semarang City is Multilayer Perceptron (MLP).

Keywords: COVID-19, Prediction, Artificial Neural Network, Extreme Learning Machine, Multilayer Perceptron

INTRODUCTION

World Health Organization (WHO) announced Coronavirus Disease 2019 (COVID-19) as a pandemic disease on March 11, 2020 (Ilham, Idris, & Muttaqin, 2019). Since the first case was identified, COVID-19 has been spreading worldwide and gaining numbers as it is contagious. This virus infects via droplet nuclei (aerosol) that spread through the air from the coughing and sneezing of infected people.

In Indonesia, COVID-19 cases have increased from the first confirmed case on March 2020, to February 2022. Even though the number of confirmed cases has decreased, the virus is still around. Prevention, such as healthy lifestyles, has to be applied. In February 2022, the number reached more than 50,000 a day. The number of confirmed positive COVID-19 cases in Semarang has been increasing daily. There were 2,000 confirmed positive COVID-19 cases a day in July 2021.

The above chart shows that the total number of positive COVID-19 cases fluctuates swiftly. This rapid growth suggests that the government needs to anticipate increasing cases shortly. Health facilities must be prepared properly to increase the recovery percentage of patients. Estimating or predicting the number of positive cases can help the government plan to prevent and control COVID-19.

This study aims to determine the right method for predicting the number of Covid-19 cases. Although the Covid-19 cases have now subsided, the results of this study can be used as a reference and as a form of anticipation for related parties if a similar pandemic occurs. Of course, a pandemic like this is expected not to happen again. However, if something similar happens, the government can use the right method to predict the number of cases that will occur so that the spread of the disease can be overcome and handled properly.

Prediction is an act of predicting or estimating the situation of the future based on the past. There are many prediction methods. Nowadays, artificial intelligence-based prediction methods have been developed, such as Artificial Neural Network (ANN). The ANN method is more accurate to predict than the traditional method (Dhini, Surjandari, Riefqi, & Puspasari, 2015; Holik, Bachtiar, & Setiadevi, 2019; Lesnussa, Mustamu, Lembang, & Talakua, 2018; Lorente-Leyva et al., 2019; Niazkar & Niazkar, 2020; Pangaribuan, 2016; Trifonov, Yoshinov, Pavlova, & Tsochev, 2017).

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There are several training methods in Artificial Neural Network. Extreme Learning Machine (ELM) is one of the methods that developed from feedforward ANN with one hidden layer. This method was developed to solve the learning speed of some ANN's training methods. In ELM, every input and bias in the network is calculated iteratively. Firstly, the input and bias values are determined randomly in ELM. The final value of ELM is estimated using Moore-Penrose Generalized Inverse to accelerate the learning speed of ELM (Alfiyatin, Mahmudy, Ananda, & Anggodo, 2019; Ashar, Cholissodin, & Dewi, 2018; Guang Bin Huang, Zhu, & Siew, 2006; Manoharan, 2021).

ELM training method in Artificial Neural Network (ANN) is more accurate than other ANN training methods (Pratiwi & Harianto, 2019; Tiwari, Adamowski, & Adamowski, 2016; Wang, Lu, Wang, & Zhang, 2022). The ELM has lower error than other ANN methods, thus ELM is more excellent than the other method. ELM is an efficient, accurate, easy-to-implement (Albadr & Tiun, 2017; Gao Huang, Huang, Song, & You, 2015) and good method for prediction (Anam, Chaidir, & Isman, 2021).

Another training method in ANN is backpropagation. Multilayer Perceptron (MLP) is an architectural network model in backpropagation with a random value, three-layer, and back-to-front or feedforward systems (Khoirudin, Nurdiyah, & Wakhidah, 2019; Nuanmeesri, 2022; Rahardiani, Mahmudy, & Indriati, 2018). MLP can determine the most exact value than other methods (Fath, Madanifar, & Abbasi, 2020; Wibawa, Lestari, Utama, Saputra, & Izdihar, 2020). This ability makes MLP's accuracy better for prediction (Mohammed, Arif, & Ali, 2020). If compared with other methods, MLP shows better performance (Bikku, 2020; Brenes, Johannssen, & Chukhrova, 2022; Chai et al., 2021; Hwang, Lee, & Lee, 2021; Isabona et al., 2022; Suradiradja, 2021; Windarti & Prasetyaninrum, 2019). MLP is usually applied for medical research to support diagnostic decisions (Moghaddasi, Ahmadzadeh, Rabiei, & Farahbakhsh, 2017).

ELM and MLP are some of the methods in Artificial Neural Network with feedforward systems for good performance in prediction. This research compares these methods to determine the most effective method in predicting or estimating the number of positive COVID-19 cases.

METHOD

This research uses the data of positive COVID-19 cases from April 9, 2020, to December 15, 2022. The data is obtained from the website of Semarang Public Health Office (Dinas Kesehatan Kota Semarang). The link to the website is *https://siagacorona.semarangkota.go.id/halaman/covid19pertahun/2020*. This data of positive COVID-19 cases in Semarang is time series data. This research explains the prediction of positive COVID-19 cases in Semarang with two methods namely Extreme Learning Machine (ELM) and Multilayer Perceptron (MLP).

The prediction flowchart of the Extreme Learning Machine is shown in Fig. 1.

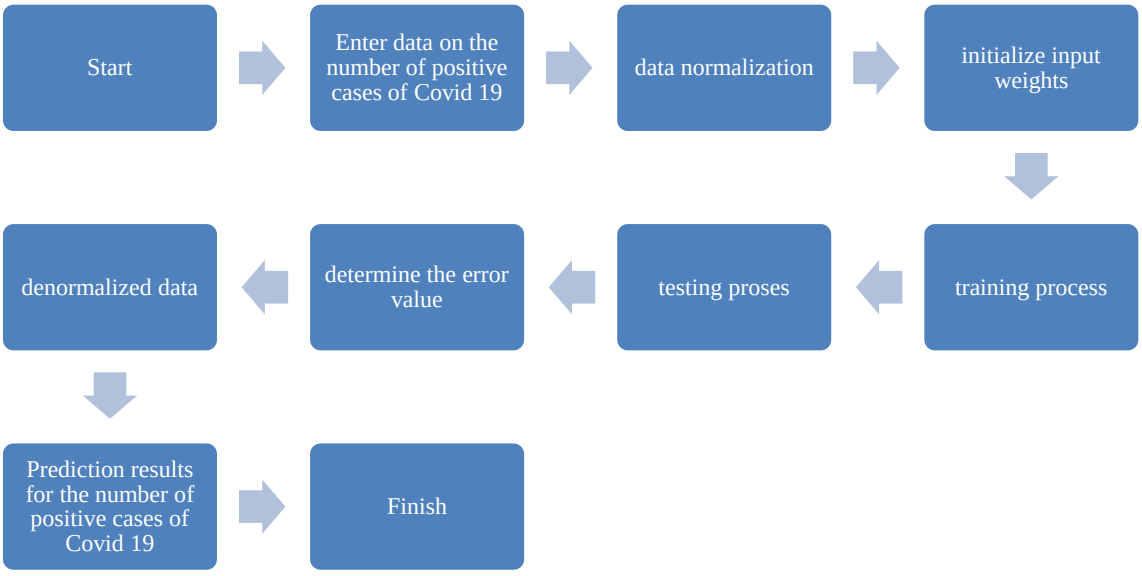

Fig. 1 Prediction flowchart with Extreme Learning Machine

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Prediction flowchart using Multilayer Perceptron as shown in Fig. 2.

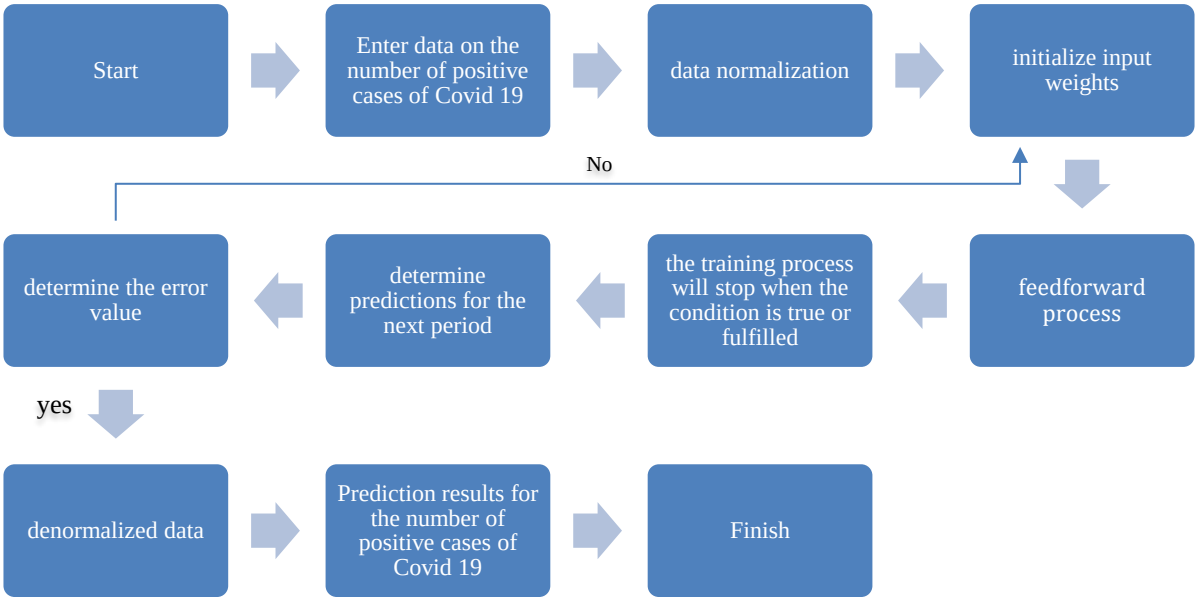

Fig. 2 Prediction flowchart with Multilayer Perceptron

RESULT

The processed data in this research are daily positive COVID-19 cases in Semarang, from April 9, 2020, to December 15, 2022. This data was obtained from the website of Semarang Public Health Office (Dinas Kesehatan Kota Semarang).

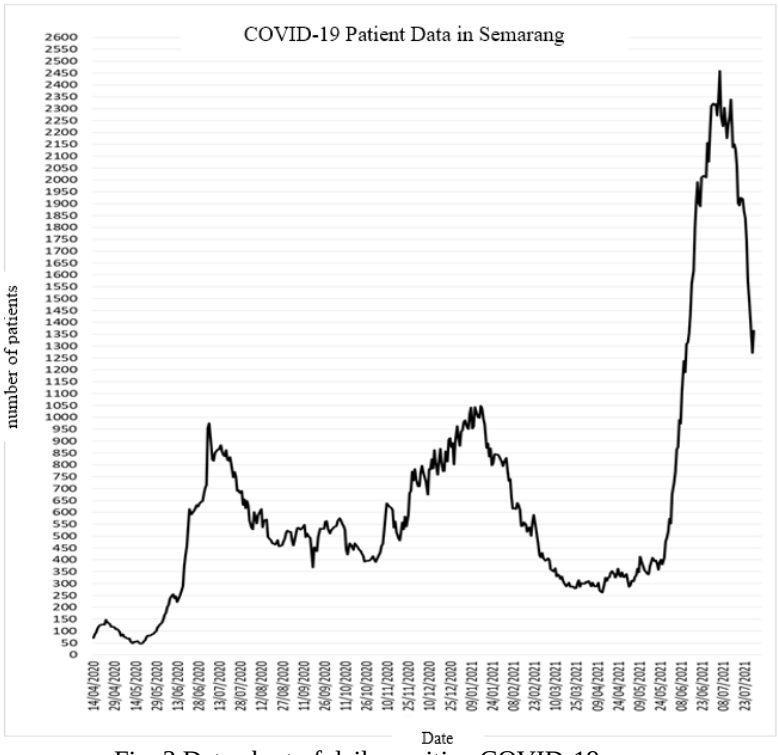

Fig. 3 Data chart of daily positive COVID-19 cases

According to Fig. 3, the lowest number of positive COVID-19 cases was 0 from December 24 to 28, 2021, May 7-9 2022, and May 20-25 2022. The highest positive COVID-19 cases were 2460 cases on July 7, 2021. The average number of positive Covid-19 cases in Semarang City were 447 cases.

The maximum data of positive COVID-19 cases is 2460, making it the maximum number. The minimum data is 0, making it the minimum number. First, the data of positive COVID-19 cases is normalized before initiating

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data training and testing. Data normalizing is conducted to make the process easier for the network. The maximum data of positive COVID-19 cases is 2460, making it the maximum number. The minimum data is 0, making it the minimum number. Table 1 shows the result of positive COVID-19 cases data normalization.

Table 1. Normalized Data of Positive Covid-19 Cases in Semarang

No	Normalization Data
1	0.111707317
2	0.113658537
3	0.114634146
4	0.116260163
5	0.118211382
.	.
.	.
.	.
801	0.132520325

Training and testing data distribution process is conducted to proceed with the prediction process. The data pattern of training and testing process results of positive COVID-19 cases in Semarang is shown in Table 2.

Table 2. Data Pattern Normalization of Positive Covid-19 Cases in Semarang

Pattern	Input Data			
	X_1	X_2	…	X_6
1	0.11171	0.11366	…	0.12016
2	0.11366	0.11463	…	0.12309
3	0.11463	0.11626	…	0.12797
4	0.11626	0.11821	…	0.13024
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
769	0.12504	0.11333	…	0.13252

Five input data are used for the process: X_1, X_2, X_3, X_4, and X_5. The target value of the Extreme Learning Machine training process is X_6. Table 3 shows the percentage result of training and testing data distribution.

Table 3. Distribution Data

Distribution	Percentage	Total
Training Data	80%	641
Testing Data	20%	160
Total	100%	801

DISCUSSIONS

A. Extreme Learning Machine Method

Network architecture must be built in Extreme Learning Machine (ELM). It is an artificial neural network layer with three layers: input, hidden, and output. The result of network architecture building with positive COVID-19 cases in Semarang is 5 neurons in Neuron Input and 1 neuron in Neuron Output. Testing is needed to determine the amount of neurons in the hidden layer. Neuron testing in the Hidden layer shows that the obtained error value is fewer if there are many neurons. In this research, 5 to 10 neurons are tested in hidden layer. Neuron testing aims to determine the optimum neuron based on the smallest Mean Square Error (MSE). Table 4 shows the MSE value of neurons for data testing in the hidden layer.

Table 4. Test The Number of Neurons in Hidden Layer for Data Testing

Amount of Hidden Neuron	MSE
5	0.0001597
6	0.0001446
7	0.0001419

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8	0.0001398
9	0.0001411
10	0.0001364

Table 4 shows the smallest MSE is obtained with 10 neurons with 0.0001364. Thus, the processed neuron in the hidden layer is 10 neurons. Network architecture in this ELM is 5-10-1: 5 neurons in the input layer, 10 neurons in the hidden layer, and 1 neuron in the output layer.

The research proceeds to prediction after network architecture is obtained. Table 5 compares actual data and prediction data in the total number of positive COVID-19 cases on April 9, 2020 – December 15, 2022, for data normalization.

Table 5. Normalized Data Comparison of Actual Data and Prediction Data in The Total Number of Positive Covid-19 Cases

Date	Normalization	
	Actual Data	Prediction Data
09/04/2020	0.1	0.1172439
10/04/2020	0.101980198	0.119289
11/04/2020	0.102970297	0.1219411
12/04/2020	0.104620462	0.126439
13/04/2020	0.10660066	0.1288699
14/04/2020	0.108580858	0.1341401
15/04/2020	0.111551155	0.1370377
.	.	.
.	.	.
.	.	.
27/09/2022	0.607260726	0.5260714
08/12/2022	0.581848185	0.5209076
12/12/2022	0.552805281	0.5246521
13/12/2022	0.507590759	0.5343512
15/12/2022	0.538613861	0.5257687

The result data of prediction in Table 5 is normalized. It needs to be denormalized to obtain the positive COVID-19 case result. This denormalized data is shown in Table 6.

Table 6. Denormalized Data Comparison of Actual Data and Prediction Data in Extreme Learning Machine

Date	Denormalization	
	Actual Data	Prediction Data
09/04/2020	36	88
10/04/2020	42	94
11/04/2020	45	102
12/04/2020	50	116
13/04/2020	56	123
14/04/2020	62	139
15/04/2020	71	148
.	.	.
.	.	.
.	.	.
27/09/2022	1573	1327
08/12/2022	1496	1311
12/12/2022	1408	1323
13/12/2022	1271	1352
15/12/2022	1365	1326

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A comparison plot of actual data and prediction data of positive COVID-19 cases shows denormalized data of ELM according to Fig. 4. Yellow stripe is actual data, while red stripe is prediction data. the *x-axis* shows the daily timeline of positive COVID-19 cases, while the *y-axis* shows the data of positive COVID-19. This plot shows that prediction data is approaching actual data.

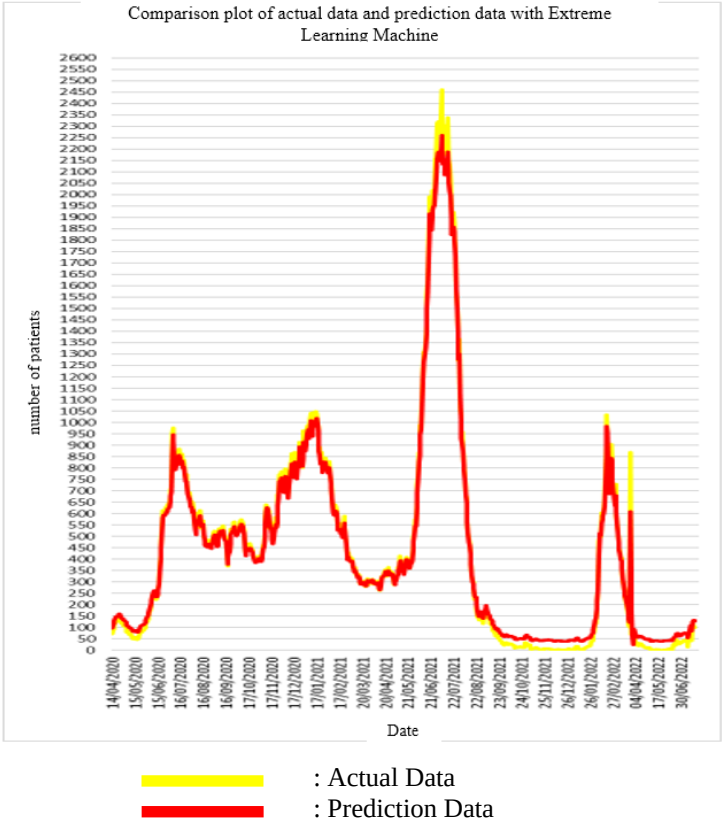

Fig. 4 Comparison plot of actual data and prediction data with Extreme Learning Machine

Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Root Mean Squared Error (RMSE). are used to determine the prediction error of Extreme Learning Machine. The error value of ELM prediction is shown in Table 7. ELM obtains MAPE under 10%, which means this method has good performance in the prediction system. The percentage accuracy of ELM in predicting the number of positive COVID-19 cases is 93.436331%.

Table 7. Error Value of Extreme Learning Machine

Parameter	Value
RMSE	0.02054756
MAE	0.01301334
MAPE	6.563669

The next step in the research is to predict COVID-19 patient amounts for several days based on provided data. Predicted data of positive COVID-19 cases is from December 16, 2022, to January 14, 2023. Table 8 shows the prediction result of positive COVID-19 cases from December 16, 2022, to January 14, 2023. Fig. 5 showcases actual data of positive COVID-19 cases from April 9, 2020, to December 15, 2022. It also shows prediction data of positive COVID-19 cases from December 16, 2022, to January 14, 2023. The *x*-axis shows the daily timeline and the *y-axis* shows the data of positive COVID-19 cases.

Table 8. Prediction Result of Positive Covid-19 Cases in Semarang with Extreme Learning Machine

Date	Denormalization	Date	Denormalization
16/12/2022	128	31/12/2022	261

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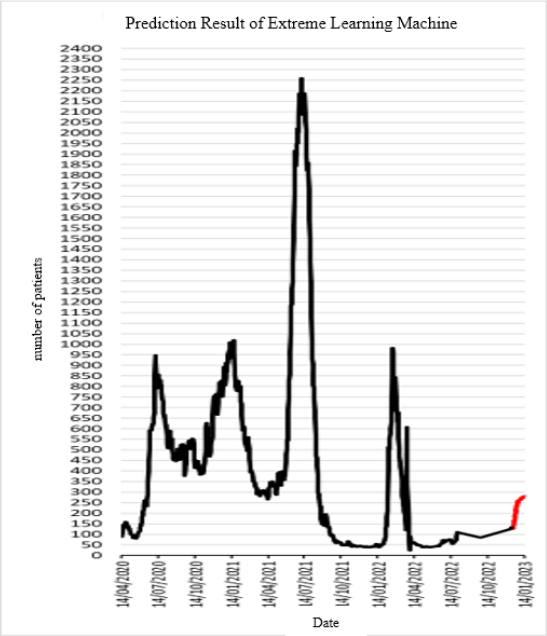
17/12/2022	140	1/1/2023	263
18/12/2022	161	2/1/2023	263
19/12/2022	166	3/1/2023	266
20/12/2022	185	4/1/2023	268
21/12/2022	196	5/1/2023	271
22/12/2022	209	6/1/2023	272
23/12/2022	216	7/1/2023	274
24/12/2022	228	8/1/2023	275
25/12/2022	235	9/1/2023	276
26/12/2022	243	10/1/2023	277
27/12/2022	250	11/1/2023	278
28/12/2022	256	12/1/2023	279
29/12/2022	259	13/1/2023	281
30/12/2022	261	14/1/2023	282



: Actual data from April 14, 2020, to December 15, 2022

: Prediction Data from December 16, 2022 to January 14, 2023

Fig. 5 Prediction Result of Extreme Learning Machine

B. Multilayer Perceptron (MLP)

Network architecture of MLP is 2-10-1, with 2 neurons in the input layer, 10 neurons in the hidden layer, and 1 neuron in the output layer. Prediction of positive COVID-19 cases from April 9, 2020, to December 15, 2022, in Semarang is obtained using network architecture in Multilayer Perceptron (MLP). Comparison results of actual data and prediction data of positive COVID-19 cases in Semarang for data normalization as shown in Table 9.

Table 9. Comparison Result of Normalized Actual Data and Prediction Data of Positive Covid-19 Cases in Semarang

Date	**Normalization**	
	Actual Data	**Prediction Data**
14/04/2020	0.108580858	0.1079714
15/04/2020	0.111551155	0.1100951
16/04/2020	0.11650165	0.1132356

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17/04/2020	0.118811881	0.1182298
18/04/2020	0.124422442	0.1207827
.	.	.
.	.	.
.	.	.
.	.	.
27/09/2022	0.607260726	0.6609221
08/12/2022	0.581848185	0.6042633
12/12/2022	0.552805281	0.5776292
13/12/2022	0.507590759	0.5280937
15/12/2022	0.538613861	0.525371

Normalized data in Table 9 is prediction result data that needs to be denormalized to obtain the number of positive COVID-19 cases. Table 10 shows the denormalization result.

Table 10. Comparison of Denormalized Actual Data and Prediction Data of Positive Covid-19 Cases in Semarang

Date	**Denormalization**	
	Actual Data	**Prediction Data**
14/04/2020	62	60
15/04/2020	71	67
16/04/2020	86	76
17/04/2020	93	91
18/04/2020	110	99
.	.	.
.	.	.
.	.	.
.	.	.
27/09/2022	1573	1736
08/12/2022	1496	1564
12/12/2022	1408	1483
13/12/2022	1271	1333
15/12/2022	1365	1325

The comparison of actual data and prediction data for positive COVID-19 cases in Semarang using MLP is displayed in Fig. 6.

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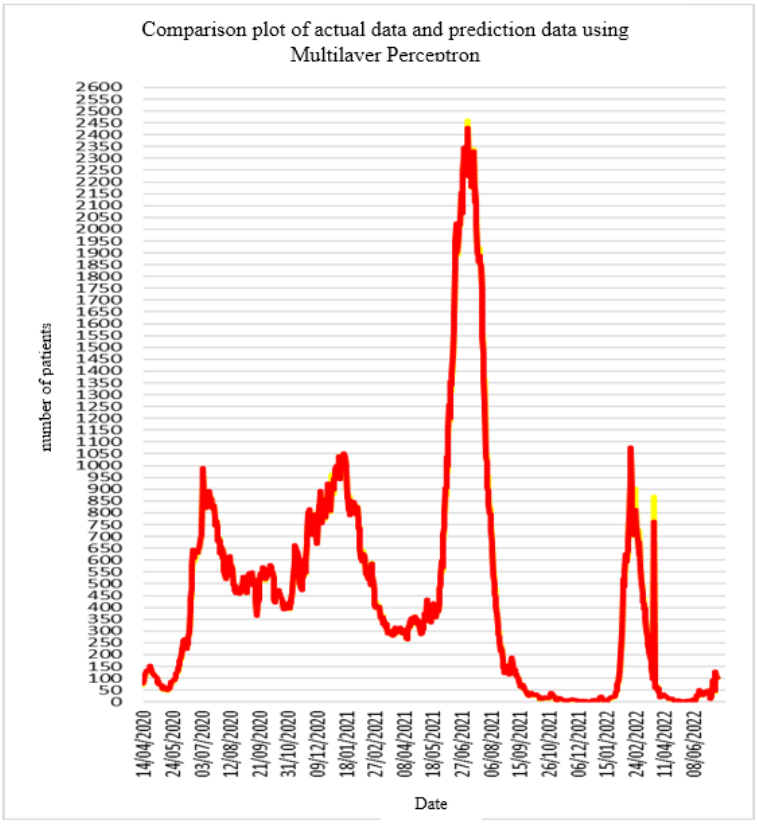

Fig. 6 Comparison plot of actual data and prediction data using Multilayer Perceptron

According to the comparison plot result of actual data and prediction data for positive COVID-19 cases in Semarang from April 9, 2020, to December 15, 2022, the prediction data is approaching actual data. The error value of the prediction is shown in Table 11.

Table 11. Error Value of Multilayer Perceptron

Parameter	Value
RMSE	0.015149
MAE	0.007727037
MAPE	2.944162

The RMSE and MAE error values produced by the MPL method are very small, approaching zero. The obtained value of MAPE is 2.944162%. The prediction accuracy percentage with MPL is 97.055838%.

The prediction result of positive COVID-19 cases from April 9, 2020, to December 15, 2022, is the reference to predict positive COVID-19 cases for upcoming days. The prediction number of positive COVID-19 cases from December 16, 2022, to January 14, 2023, is displayed in Table 12.

Table 12. Prediction Result of Multilayer Perceptron

Date	Denormalization	Date	Denormalization
16/12/2022	112	31/12/2022	197
17/12/2022	124	1/1/2023	203
18/12/2022	123	2/1/2023	208
19/12/2022	128	3/1/2023	213
20/12/2022	136	4/1/2023	219
21/12/2022	143	5/1/2023	224

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22/12/2022	148	6/1/2023	229
23/12/2022	151	7/1/2023	234
24/12/2022	158	8/1/2023	240
25/12/2022	162	9/1/2023	246
26/12/2022	167	10/1/2023	252
27/12/2022	174	11/1/2023	257
28/12/2022	180	12/1/2023	263
29/12/2022	186	13/1/2023	269
30/12/2022	192	14/1/2023	275

Fig. 7 shows the prediction chart of positive COVID-19 cases with MPL from December 16, 2022, to January 14, 2023. The *x-axis* shows the daily timeline and the *y-axis* displays the number of positive COVID-19 cases. The chart in Fig. 7 is divided into 2 parts: black strip and red strip. The black strip shows actual data from April 9, 2020, to December 15, 2022. The red strip shows prediction data from December 16, 2022, to January 14, 2023.

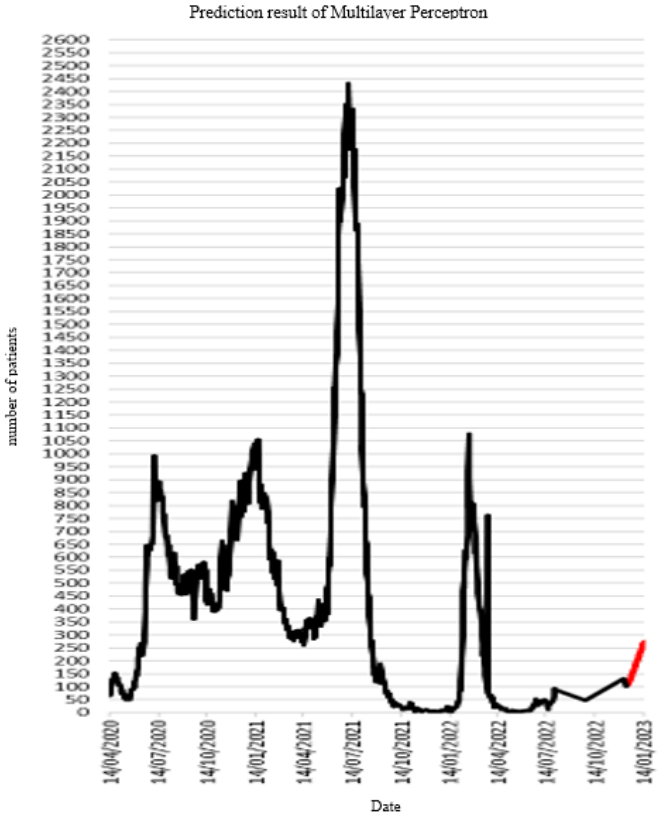

Fig. 7 Prediction result of Multilayer Perceptron

C. Comparison of Extreme Learning Machine (ELM) and Multilayer Perceptron (MLP)

This section compares prediction results from Extreme Learning Machine (ELM) and Multilayer Perceptron (MLP). The comparison of error value uses Mean Absolute Percentage Error (MAPE), Root Mean Square Error (RMSE), and Mean Absolute Error (MAE). This comparison aims to determine the most accurate method for predicting positive COVID-19 cases in Semarang. The best prediction method is the one with the smallest number of errors. Table 13 displays the error value comparison of ELM and MLP.

Table 13. Error Value Comparison of Extreme Learning Machine (ELM) and Multilayer Perceptron (MLP)

Model	**Error Value**		
	MAE	**MAPE**	**RMSE**
ELM	0.01301334	6.563669	0.02054756

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MLP	0.007727037	2.944162	0.015149
Best Model	**MLP**	**MLP**	**MLP**

According to MAE, MAPE, and RMSE values, MLP obtains the smallest error value. The most suitable method to predict positive COVID-19 cases in Semarang is Multilayer Perceptron (MLP).

CONCLUSION

Extreme Learning Machine (ELM) and Multilayer Perceptron (MLP) have the same small error value in predicting positive COVID-19 cases in Semarang. However, the comparison result of ELM and MLP using Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Root Mean Squared Error (RMSE) shows MLP has a lower error than ELM. In predicting the number of positive COVID-19 cases, ELM has 93.436331% accuracy. MLP has 97.055838% accuracy. Thus, MLP is more accurate than ELM to be applied for predicting.

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