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Performance Evaluation of Adaptive Neuro-Fuzzy Inference System (ANFIS) In Predicting New Students (Case Study : UBP Karawang)

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Abstract—The process of admitting new students is an annual routine activity that occurs in a university. This activity is the starting point of the process of searching for prospective new students who meet the criteria expected by the college. One of the colleges that holds new student admissions every year is Buana Perjuangan University, Karawang. There have been several studies that have been conducted on predictions of new students by other researchers, but the results have not been very satisfying, especially problems with the level of accuracy and error. Research on ANFIS studies to predict new students as a solution to the problem of accuracy. This study uses two ANFIS models, namely Backpropagation and Hybrid techniques. The application of the Adaptive Neuro-Fuzzy Inference System (ANFIS) model in the predictions of new students at Buana Perjuangan University, Karawang was successful. Based on the results of training, the Backpropagation technique has an error rate of 0.0394 and the Hybrid technique has an error rate of 0.0662. Based on the predictive accuracy value that has been done, the Backpropagation technique has an accuracy of 4.8 for the value of Mean Absolute Deviation (MAD) and 0.156364623 for the value of Mean Absolute Percentage Error (MAPE). Meanwhile, based on the Mean Absolute Deviation (MAD) value, the Backpropagation technique has a value of 0.5 and 0.09516671 for the Mean Absolute Percentage Error (MAPE) value. So it can be concluded that the Hybrid technique has a better level of accuracy than the Backpropation technique in predicting the number of new students at the University of Buana Perjuangan Karawang

Keywords— ANFIS, Backpropagation, Hybrid, Prediction

Abstract—*Proses penerimaan mahasiswa baru merupakan kegiatan rutin tahunan yang terjadi di sebuah universitas. Kegiatan ini merupakan titik awal dari proses pencarian calon mahasiswa baru yang memenuhi kriteria yang diharapkan oleh perguruan tinggi. Salah satu perguruan tinggi yang menyelenggarakan penerimaan mahasiswa baru setiap tahunnya adalah Universitas Buana Perjuangan Karawang. Ada beberapa penelitian yang telah dilakukan terhadap prediksi mahasiswa baru oleh peneliti lain, namun hasilnya belum terlalu memuaskan, terutama masalah tingkat akurasi dan kesalahan. Penelitian tentang studi ANFIS untuk memprediksi siswa baru sebagai solusi dari masalah akurasi. Penelitian ini menggunakan dua model ANFIS, yaitu teknik Backpropagation dan Hybrid. Penerapan model Adaptive Neuro-Fuzzy Inference System (ANFIS) pada prediksi mahasiswa baru Universitas Buana Perjuangan Karawang berhasil. Berdasarkan hasil pelatihan, teknik Backpropagation memiliki tingkat kesalahan 0,0394 dan teknik Hybrid memiliki tingkat kesalahan 0,0662. Berdasarkan nilai akurasi prediksi yang telah dilakukan, teknik Backpropagation memiliki akurasi sebesar 4,8 untuk nilai Mean Absolute Deviation (MAD) dan 0,156364623 untuk nilai Mean Absolute Percentage Error (MAPE). Sedangkan berdasarkan nilai Mean Absolute Deviation (MAD), teknik Backpropagation memiliki nilai 0,5 dan 0,09516671 untuk nilai Mean Absolute Percentage Error (MAPE). Sehingga dapat disimpulkan bahwa teknik Hybrid memiliki tingkat akurasi yang lebih baik dibandingkan dengan teknik Backpropation dalam memprediksi jumlah mahasiswa baru di Universitas Buana Perjuangan Karawang.*

Kata Kunci— ANFIS, Backpropagation, Hybrid, Prediksi

I. INTRODUCTION

The process of admitting new students is an annual routine activity that occurs in a university. This activity is the starting point of the process of searching for prospective new students who meet the criteria expected by the college. One of the colleges that hold new student admissions every year is Buana Perjuangan University Karawang.

Buana Perjuangan Karawang University is one of the universities in the Karawang area which is developing very rapidly. This is proven by the high interest of new students who register and can be accepted at Buana Perjuangan University, Karawang. This is of course a challenge and a good opportunity for the university. On the other hand, the stability and availability of campus facilities and infrastructure are things that need to be considered by university administrators. The university certainly has to be able to calculate how many new students are accepted at Buana Perjuangan University, this is important for the organizers as a material for decision making, especially those related to campus development, infrastructure, and resources that support the teaching and learning process in the campus environment.

In this study, the authors used the ANFIS model to predict the number of new students at the University of Buana Perjuangan Karawang. Many studies have been conducted, using the Adaptive Neuro-Fuzzy Inference System (ANFIS) model in the prediction system. Among them, the use of Artificial Neuro Fuzzy Inference System (ANFIS) in Determining the Status of Mount Merapi Activities [5]; The Use of Backpropagation Neural Networks for New Student

Admissions in the Computer Engineering Department at Sriwijaya State Polytechnic [1]; Development of Artificial Neural Network Model to Predict the Number of New Students in PTS Surabaya [2]; Adaptive Neuro Fuzzy Inference System (ANFIS) method for prediction of road service levels [11], and other studies. It is expected that the results of this study can provide good accuracy and error rates. In this study, the authors raised the title "Adaptive Neuro-Fuzzy Inference System (ANFIS) Study in Predicting New Student Admissions at Buana Perjuangan University, Karawang.

II. METHOD

A. Types of research

In this research, the type of research used is quantitative. The objective of quantitative research is to develop and use mathematical models, theories and hypotheses related to natural phenomena. Quantitative research is a type of research that basically uses a deductive-inductive approach. This approach departs from a theoretical framework, the ideas of experts, as well as the understanding of researchers based on their experience, then it is developed into problems and their solutions that are proposed to obtain justification (verification) or an assessment in the form of support for empirical data in the field.

B. Data Collection

Data is a unit of information recorded by media that can be distinguished from other data, can be analyzed and is relevant to certain programs. Data collection is a systematic and standard procedure for obtaining the necessary data. To collect research data, the authors used the interview method. To obtain data sources, the authors conducted interviews with the New Student Admissions Committee, which were then validated with the Data Center (Pusdatin) of Buana Perjuangan University.

C. Data Analysis

The data analysis technique used is to divide the data into two, namely training data and testing data. Model training uses training data, while model testing uses testing data. The results of the model trial conclusion will be verified by diagnosis on the testing data. Data analysis in this study aims to determine how accurate the Adaptive Neuro Fuzzy Inferences System (ANFIS) model at Buana Perjuangan University, Karawang. In predicting the number of students using the singular value decomposition method. The stages of ANFIS data analysis can be seen in the following figure.

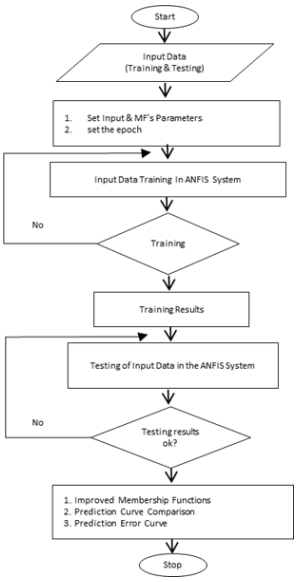

Fig. 1. ANFIS Analysis and Prediction Process

The data used in this research is secondary data, namely data on enrollments from new students obtained from the new student admissions committee, and active students for each study program obtained from the Center for Data and Information (PUSDATIN), University of Buana Perjuangan Karawang.

D. Framework

The problem of admitting new students at a university is a routine problem that occurs every new academic year. So it needs good handlers in its implementation. Information on the number of new students is important data for all campus members. Both leadership, student affairs, academics, infrastructure and others. This is important because the campus must prepare everything due to the teaching and learning process. The prediction system for new students is certainly very helpful for the campus in preparing for needs - a need that must be met by all members of the community in a university. The framework of this prediction system research includes:

1. The number of new students from the 2015/2016 academic year to 2019/2020.
2. The data is obtained from the New Student Admissions Committee and is also equipped from the UBP Data Center.
3. Data preprocessing (initial processing), data cleaning to eliminate data errors and data transformation.
4. The process of training and testing data
5. Make predictions for new students
6. Evaluate the level of accuracy with the MAD and MAPE models

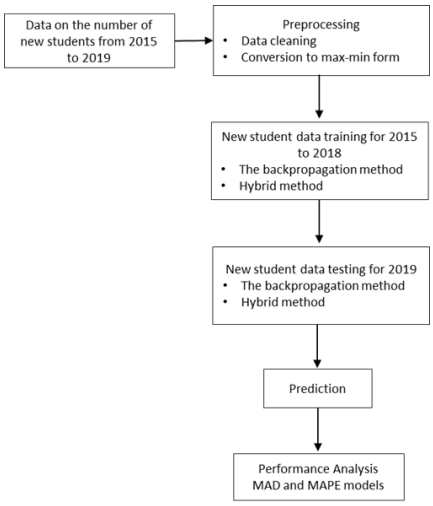

Fig. 2. Framework

E. Research subject

The data source used in this study is data obtained from the Buana Perjuangan Karawang University New Student Admissions Committee which is then validated with the Pusdatin Section. New student data used as the source of data in this study were taken from new students from the 2015/2016 academic year to the 2019/2020 academic year. The new student data can be seen in detail in table 1.

TABLE 1 NEW STUDENTS OF UBP KARAWANG 2015 TO 2019

Year	PKn	PGSD	Law	Psik	Ak	Man	SI	IF	Far	TI
2015/2026	52	152	146	145	155	240	67	187	97	198
2016/2017	54	165	131	150	179	356	56	178	109	243
2017/2018	61	154	142	164	225	536	77	207	143	352
2018/2019	40	139	156	162	190	490	75	231	140	356
2019/2020	42	148	176	250	208	531	74	209	142	324

Source : Pusdatin

The data will then be processed with a preprocessing process (pre-process) by means of data cleaning and normalization, before being used as data analysis in this study. The preprocessing results will then be processed using the Adaptive Neuro Fuzzy Inference System (ANFIS) method as a method for carrying out the prediction process.

III. RESULTS AND DISCUSSION

A. Preprocessing Data

The first step taken in this research data, is to pre-process the data on the number of new students accepted at the University of Buana Perjuangan for the period of the 2015/2016 academic year to 2019/2020. This needs to be done because the data used in the process is not always ideal for processing. Sometimes in this data there are various problems that can interfere with the results of the process itself, such as missing values, redundant data, outliers, or data formats that are not in accordance with the system. The pre-processing of this data includes several stages, including data cleaning and data normalization.

1) Data Cleaning

Data cleaning is performed to eliminate inefficient and error-containing data. In this process, data is cleaned using the Rapidminer application.

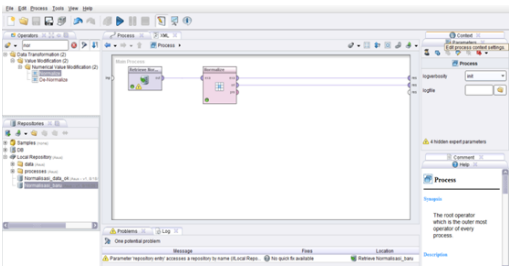

Fig.3. data cleaning process

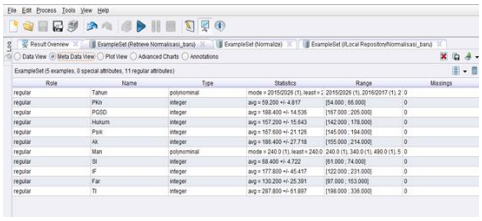

Fig.4. Results of Data Cleaning

From the data cleaning process above, it shows that there are no errors or missing in the data used in this study.

2) Data Normalization

Before input data is entered into the network, the data is transformed into interval data (normalization). These data are normalized so that they are in the range [0,1]. Normalization uses the Min - Max formula (Han, Kamber, and Pei, 2012).

$$(X - Xmin)/(X\max - \min).(Bmax - Bmin) + Bmin \quad (1)$$

X = data input
X_{min} = data X minimum
X_{max} = data X maksimum
B_{max} = upper limit of the interval
B_{min} = lower limit of the interval

The purpose of normalization is to equalize the range of values for each data so that each data has a proportional role in each process. To facilitate the conversion process, the name of the Study Program is changed to the X variable. Namely X_1, X_2, ... X_{10}.

TABLE 2 DATA ON THE NUMBER OF NEW STUDENTS

Year	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
2015/2026	52	152	146	145	155	240	67	187	97	198
2016/2017	54	165	131	150	179	356	56	178	109	243
2017/2018	61	154	142	164	225	536	77	207	143	352
2018/2019	40	139	156	162	190	490	75	231	140	356
2019/2020	42	148	176	250	208	531	74	209	142	324

Become interval data [0, 1]

TABLE 3 CONVERT DATA TO MIN - MAX

r	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
1	0,572	0,5	0,333	0	0	0	0,523	0,169	0	0
2	0,666	1	0	0,047	0,24	0,391	0	0	0,26	0,284
3	1	0,576	0,244	0,18	1	1	1	0,547	1	0,974
4	0	0	0,555	0,161	0,5	0,844	0,904	1	0,934	1
5	0,095	0,346	1	1	0,757	0,983	0,857	0,584	0,978	0,797

B. Hypothesis Test

3) Data Training Process

Data that has been normalized in the form of Min - Max, then used as a source of data for the training process (training) and testing (test data) in the ANFIS analysis process. For the ANFIS analysis process, the data is divided into two parts, namely training data and testing data. New student data from 2015 to 2018 is used as training data, while new student data for 2019 is used as testing data.

TABLE 4 DATA TRAINING

X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
0,572	0,5	0,333	0	0	0	0,523	0,169	0	0
0,666	1	0	0,047	0,24	0,391	0	0	0,26	0,284
1	0,576	0,244	0,18	1	1	1	0,547	1	0,974
0	0	0,555	0,161	0,5	0,844	0,904	1	0,934	1

TABLE 5 DATA TESTING

X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
0,095	0,346	1	1	0,757	0,983	0,857	0,584	0,978	0,797

The training process (training) with the Adaptive Neuro-Fuzzy Inference System (ANFIS) model was carried out using the Matlab R2010 tool. Data analysis for this prediction uses two Adaptive Neuro-Fuzzy Inference System (ANFIS) models, namely Backpropagation and Hybrid techniques. So that the training and testing process is also based on these two techniques

4) Backpropagation Technique Data Training

The data in table 4 shows that new student data is used as training data. The training process consists of 20 epochs (iterations) with an error tolerance of 0.001.

From the results of data training with the Backpropagation technique, the error rate obtained is 0.0394.

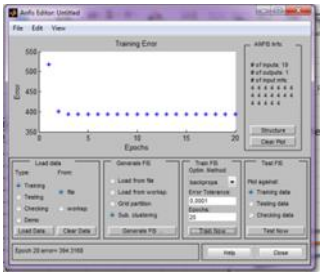

Fig.5. Backpropagation Technique Training Process

From the Backpropagation technique training above, the resulting error rate is 0.0394 with an error tolerance of 0.001 with 20 iterations. From this error value, the rate of increase and decrease in student predictions using the Backpropagation technique is 3.94%.

5) Hybrid Technique Data Training

In the same way, subsequent training is carried out using Hybrid techniques. The training process was carried out 20 times with an error tolerance of 0.001. The training process can be seen in the following image:

Fig. 6. Hybrid Technique Training Process

Based on the results of training with the Hybrid technique, an error rate of 0.0662 was generated. With this error value, the predicted value of increase and decrease in new students with the Hybrid technique is 6.62%.

6) Data Testing Process

The next process is the testing process or data testing. This test is an application of the results of training data to predictions of new students. The data used in this process is the number of new students in 2019, the data can be seen in the following table:

TABLE 6 DATA TESTING

X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
0,095	0,346	1	1	0,757	0,983	0,857	0,584	0,978	0,797
42	148	176	250	208	531	74	209	142	324

From the training process above, the predictive value obtained with the Backpropagation technique is 0.0394 while the Hybrid technique is 0.0662.

7) Backpropagation Data Testing

The test results with the parameters obtained from the data training process with an error rate of 0.0394 for the Backpropagation technique, then the prediction results and errors of new students for 2019 are obtained.

TABLE 7 BACKPROPAGATION TECHNIQUE PREDICTION AND ERROR RESULT

No	Faculty	Data Aktual	Prediction (Backpropagation)	Error
1	PKn	42	42	0
2	PGSD	148	144	4
3	Law	176	162	14
4	Psik	250	168	82
5	Ak	208	197	11
6	Man	531	509	22
7	SI	74	78	4
8	IF	209	240	31
9	Far	142	146	4
10	TI	324	370	46

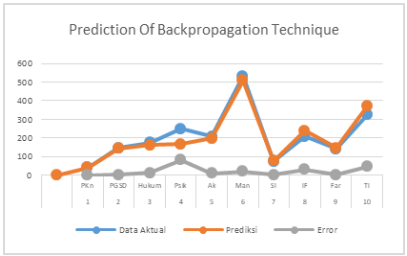

Fig 7. Prediction Of Backpropagation Technique

8) Hybrid Data Testing

Meanwhile, from the data training process with an error rate of 0.0662 for the Hybrid technique, the results of predictions and errors for new students for 2019 are as follows:

TABLE 8 HYBRID TECHNIQUE PREDICTION AND ERROR RESULTS

No	Faculty	Data Aktual	Prediction (Hybrid)	Error
1	PKn	42	43	1
2	PGSD	148	148	0
3	Law	176	166	10
4	Psik	250	173	77
5	Ak	208	203	5
6	Man	531	522	9
7	SI	74	80	6
8	IF	209	246	37
9	Far	142	149	7
10	TI	324	379	55

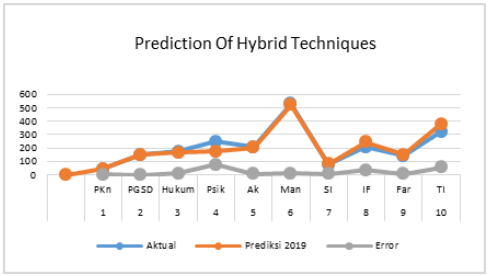

Fig 8. Prediction Of Hybrid Techniques

C. Analysis and Discussion

The model used in this study is the Adaptive Neuro Fuzzy Inference System (ANFIS). Meanwhile, the techniques used in the Fuzzy Inference System (FIS) are Backpropagation and Hybrid Techniques. To measure the level of accuracy of the two techniques, the error rate of each technique must be sought. (Hanke & Wichern, 2005) said that forecasting techniques that use quantitative data often contain data in the form of a certain time series. Which is where there are errors / errors made by forecasting techniques. Therefore a method is needed to measure how much error / error can be generated by forecasting methods to be reconsidered before making a decision. There are also uses of this method of measuring error forecasting are:

- Comparing the accuracy of the 2 (or more) forecasting methods used.
- Measuring the reliability and benefits of the forecasting method used.
- Finding the optimal forecasting method for the organization or company.

To measure the level of accuracy of the Backpropagation and Hybrid techniques, the Mean absolute deviation (MAD) and Mean absolute percentage error (MAPE) methods are used. A good level of accuracy is if the error rate is smaller than the others.

9) Mean Absolute Deviation (MAD)

Mean absolute deviation measures the accuracy of the prediction (forecast) by making an equal of the magnitude of the forecast error, where each prediction has an absolute value for each error.

The formula used to calculate MAD is:

$$MAD = \frac{1}{n}\sum_{t=1}^{n}|Y_t - \hat{Y}_t| \quad (2)$$

Information :

Y = actual value in period t

Y't = forecast value in period t

N = number of data periods

From the measurement results of the accuracy level of the Backpropagation and Hybrid techniques that have been carried out using the Mean Absolute Deviation (MAD) method, the following values are obtained:

TABLE 9 MEAN ABSOLUTE DEVIATION HYBRID

Aktual	Hybrid	$Y_t - \hat{y}_t$
42	42	-1
148	144	0
176	162	10
250	168	77
208	197	5
531	509	9
74	78	-6
209	240	-37
142	146	-7
324	370	-55
	Total Absolute Deviation	5
	MAD	0,5

TABLE 10 MEAN ABSOLUTE DEVIATION (MAD) BACKPROPAGATION

Aktual	Backpropagation	$Y_t - \hat{y}_t$
42	43	0
148	148	4
176	166	14
250	173	82
208	203	11
531	522	22
74	80	-4
209	246	-31
142	149	-4
324	379	-46
	Jumlah Deviasi Absolut	48
	MAD	4,8

From the table above, backpropagation has a Mean Absolute Deviation (MAD) value obtained of 4.8, and for the total deviation of 48. As for the Hybrid technique, the Mean Absolute Deviation (MAD) value obtained is 0.5 and the number of absolute deviations is 5.

10) Mean Absolute Percentage Error (MAPE)

The mean absolute percentage error is calculated by finding the error / absolute error in each period, which is divided by the actual observed value for that period, and an average of the absolute percentage errors is made.

The formula used to calculate MAPE is:

$$\sum^{n}\frac{Yt - \acute{Y}t}{Yt} x\ 100 \quad (3)$$

Information :

n = the number of data periods

Y_t = actual value in period t

Y_t = the forecast value in period t

Based on the results of the calculation of Mean absolute percentage error (MAPE) for the Backpropagation technique, the error value is 1.56365 with a MAPE value of 0.1563647. With a prediction error value of 15.6%.

TABLE 11 MEAN ABSOLUTE PERCENTAGE ERROR BACKPROPAGATION

Aktual	Backpropagation	Y_1-$\hat{y}_t$
42	42	0
148	144	0,02703
176	162	0,07955
250	168	0,328
208	197	0,05288
531	509	0,04143
74	78	-0,05405
209	240	-0,14833
142	146	-0,02817
324	370	-0,14198
	Jumlah Deviasi Absolut	1,56363
	MAPE	0

As for the Hybrid technique, the error value is 0.95167162 with a MAPE value of 0.09516671. With this, the prediction error value with the hybrid technique is 9.52%.

TABLE 12 MEAN ABSOLUTE PERCENTAGE ERROR HYBRID

Aktual	Hybrid	Y_1-$\hat{y}_t$
42	43	-0,023809
148	148	0
176	166	0,056818
250	173	0,308
208	203	0,024038
531	522	0,016949
74	80	-0,081081
209	246	-0,177033
142	149	-0,0492957
324	379	-0,169753
	Jumlah Deviasi Absolut	0,95167162
	MAPE	0,09516671

With the results of this test, it can be concluded that the predictions of new students at the University of Buana Perjuangan Karawang with the Adaptive Neuro-Fuzzy Inference System (ANFIS) model can be used properly. This is evidenced by the results of training (training) Backpropagation technique has an error rate (Error rate) of 0.0394, while the Hybrid technique has an error rate of 0.0662. Then based on the calculation of the value of accuracy in predicting, the Backpropagation technique has an accuracy of 4.8 for the value of Mean Absolute Deviation (MAD) and 0.156364623 for the value of Mean Absolute Percentage Error (MAPE). Meanwhile, based on the Mean Absolute Deviation (MAD) value, the Backpropagation technique has a value of 0.5 and 0.09516671 for the Mean Absolute Percentage Error (MAPE) value. When compared to the accuracy, the Hybrid technique is more accurate than the Backpropagation technique, because it has a smaller error accuracy value.

III. CONCLUSION

From the results of research and testing that have been carried out on the Study of Adaptive Neuro-Fuzzy Inference System (ANFIS) in Predicting New Students at Buana Perjuangan University, Karawang, it can be concluded as follows:

1. The application of the Adaptive Neuro-Fuzzy Inference System (ANFIS) model in the predictions of new students at Buana Perjuangan University, Karawang is successful. Based on the results of training, the Backpropagation technique has an error rate of 0.0394 and the Hybrid technique has an error rate of 0.0662.
2. Based on the predictive accuracy value that has been done, the Backpropagation technique has an accuracy of 4.8 for the value of Mean Absolute Deviation (MAD) and 0.156364623 for the value of Mean Absolute Percentage Error (MAPE). Meanwhile, based on the Mean Absolute Deviation (MAD) value, the Backpropagation technique has a value of 0.5 and 0.09516671 for the Mean Absolute Percentage Error (MAPE) value.
3. Based on the accuracy results, the Hybrid technique is more accurate than the Backpropagation technique, because it has a smaller predictive error accuracy value based on the Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE) values.

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