Jurnal Ilmiah Teknik Elektro Komputer dan Informatika (JITEKI)
Vol. 9, No. 1, March 2023, pp. 1-11
ISSN: 2338-3070, DOI: 10.26555/jiteki.v9i1.25475

Application of the Machine Learning Method for Predicting International Tourists in West Java Indonesia Using the Averege-Based Fuzzy Time Series Model

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ARTICLE INFO

Article history:

Received December 24, 2022
Revised January 10, 2023
Published January 18, 2023

Keywords:

Prediction;
Tourist;
Fuzzy Time Series;
Average-Based Length

ABSTRACT

The purpose of this study is to propose whether an average-based fuzzy time series model is appropriate for use in predicting the number of foreign tourists coming to West Java, Indonesia. Machine learning is a branch of artificial intelligence where machines are designed to learn on their own without human direction. One of the machine learning methods used by data science is for prediction processes, such as predicting the number of tourists. Tourism is one of the economic sectors that has a direct impact on the community's economy. Based on data from the Badan Pusat Statistik (BPS), the number of tourists coming to West Java Indonesia fluctuates, meaning that the number can increase and decrease every month and year. Changes in the number of tourists that fluctuate are one of the problems that have an impact on tourism actors. Therefore, the solution given to answer this problem is that an appropriate model is needed to predict the number of tourists visiting West Java. The contribution of this research is to help related parties in predicting the number of foreign tourists so that it can be used as one to make policies related to tourism preparation and planning efforts in West Java, Indonesia. The method used in this research is a case study approach, where the case study is taken from data on foreign tourists visiting West Java from 2017 to 2020. For the prediction process, the method used is the fuzzy time series method and the average length-based algorithm as the determinant of the interval length. Effective interval length can affect prediction results with a higher level of accuracy. Based on the prediction test results, the Mean Absolute Percentage Error (MAPE) value is 14.71%. These results indicate that the fuzzy time series model based on the average interval length is good for prediction.

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1. INTRODUCTION

Tourism is one of the economic sectors that has received much attention from developing countries. This sector directly touches and involves the community. The tourism sector is important because it contributes significantly to the country's foreign exchange reserves and provides direct and indirect employment opportunities to a large segment of the population [1][2]. West Java as one of the provinces in Indonesia has enormous tourism potential. Tourism potential both natural and culinary tourism can be developed in almost every city and district in West Java [3]. This tourism potential must be able to attract tourists, especially foreign tourists, to visit West Java. Based on BPS West Java data, the number of foreign tourists coming to West Java fluctuates, meaning that it can increase or decrease every month and year. Changes in the number of tourists

that fluctuate affect tourism actors. In addition, it also affects the direction of policies that will be taken by the government, especially the local government, one example is by segmenting tourist destinations [4]–[7]. Machine learning ditujukan untuk pengembangan sistem cerdas atau mesin yang dapat belajar sendiri tanpa harus diprogram oleh manusia secara berulang-ulang [8]. With its intelligence, machine learning is expected to produce more accurate predictions based on input data that has been given before [9]–[12]. The prediction process is a pose to estimate future needs by looking at data from the past, this process can be done using fuzzy logic such as fuzzy mamdani and Tsukamoto [13]–[15]. A new concept for prediction using fuzzy logic is fuzzy time series which is able to provide explanations for vague data and is presented in linguistic values [16][17]. Based on the existing problems, the solution provided is to predict the number of foreign tourists visiting West Java. This research focuses on predicting the number of foreign tourists using fuzzy time series with interval determination based on averages, with the aim of proposing whether the average-based fuzzy time series model is appropriate for use in predicting the number of foreign tourists coming to West Java, Indonesia.

Research on forecasting time series data has been widely carried out. In research [18][19] stated that fuzzy time series forecasting is a field of research that deals with problems related to uncertainty, ambiguity and imprecision. Forecasting using fuzzy time series has an important meaning in decision making in the fields of economics, climatology, the labour sector, agriculture, tourism [20][21]. Research results [18]–[21] state that it shows good performance in prediction and forecasting. Research using fuzzy time series by applying the average-based length algorithm as a determinant of interval length for predicting the development of confirmed positive cases of Covid-19 [22], and produced a MAPE of 10.6% which means the model is good for use in prediction. Research on predicting the number of tourists using Google Trends data and Google Trends data and adopting the Random Forest model suitable for multivariable situations [23], the result of this study is the MAPE of the model used is 6.83%, indicating higher model accuracy. In general, from previous research that the fuzzy time series method can be used as a prediction method for problems related to uncertainty and produces a small error value, it's just that for predicting the number of tourists there is still no one who uses fuzzt time series with an average-length-based algorithm as a determinant of interval length.

The method used in this research is a case study approach, where the case study is taken from data on foreign tourists visiting West Java from 2017 to 2020. For the prediction process, the method used is the fuzzy time series method and the average-length-based algorithm as the interval length determinant. The interval length based on the average is an approach based on the average of the first difference, because the average of the first difference does not necessarily meet the heuristic, the interval length based on the average is set at half the average of the first difference. The data used comes from BPS data from foreign tourists coming to West Java from January 2017 to April 2020. For the accuracy of the forecasting results, the method used is MAPE, namely by taking the smallest value of MAPE. Forecasting accuracy can be seen from the smallest MAPE. The contribution of this research is to assist relevant parties in predicting the number of foreign tourists so that it can be used as one to make policies related to tourism preparation and planning efforts in West Java, Indonesia.

2. METHODS

The method used in this research is a case study approach, where case studies are taken from data on foreign tourists visiting West Java from 2017 to 2020. The process in this research starts from problem analysis, data collection, prediction process, prediction accuracy, and conclusion. The process is shown in Fig. 1.

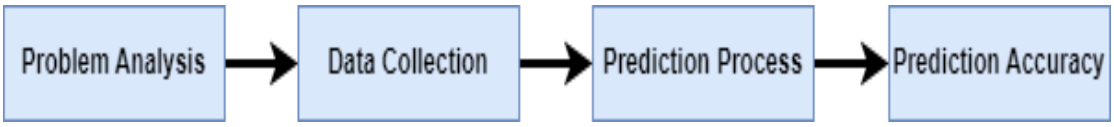


Fig. 1. The stages of the research

2.1. Problem Analysis

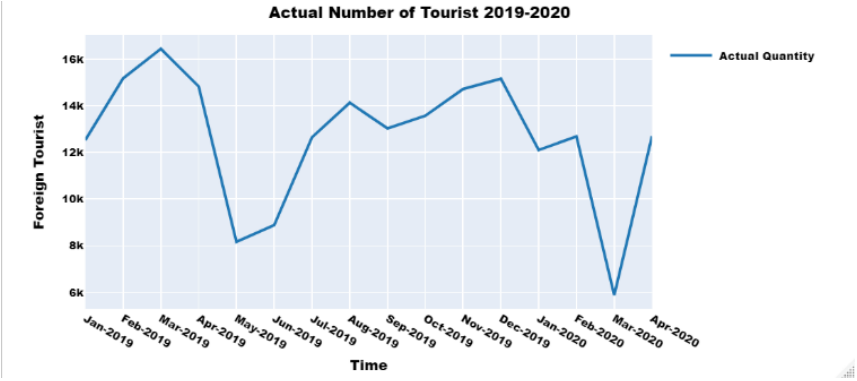
In this section, we analyze problems related to the number of tourist visits in West Java. Based on data obtained from West Java BPS, it is stated that the number of foreign tourist visits to West Java fluctuates every year. The data has an impact on tourism actors, one of which is in making policies in the tourism sector. From previous research related to predicting the number of tourists, the data used was taken from Google Trends [23], this data is certainly doubtful because it is not from a state-owned institution.

2.2. Data Collection

In this study, the data used were secondary data taken directly from the Central Bureau of Statistics (BPS) West Java, Indonesia. The population in this study is all data on the number of tourists who come to West Java, while the sample used in this study is data on the number of foreign tourists for the period January 2017 to April 2020. Meanwhile, as a sample of variation, separation or distribution. The sample was divided into three samples where the first sample was data on the number of foreign tourists from January 2017 to April 2020 as many as 40 data, the second sample was data on the number of foreign tourists from January 2018 to April 2020 as many as 29 data, and the last sample used data on the number of foreign tourists from January 2019 to March 2020 as many as 16 data. The data used for the prediction process can be shown in Fig. 2. Based on Fig. 2, it shows that the number of foreign tourist visits to West Java fluctuates every year.

(a)

(b)



(c)

Fig. 2. Actual Number of Tourist West Java (a) January 2017-April 2020; (b) January 2018-April 2020; (c) January 2019-April 2020

2.3. Prediction Process

The process of predicting the number of foreign tourists coming to West Java using fuzzy time series with length determination using averages based on length. Fuzzy time series is a new concept proposed by Song

and Chissom based on fuzzy set theory and the concept of linguistic variables. The steps in the process are as follows:

a. Determines the universe of discourse U (Universe of Discourse). To determine the universe of discourse using (1).

$$U = [X_{min} - D_1, X_{max} + D_2] \quad (1)$$

Where, X_{min} is minimum data, X_{max} is maximum data, D_1 and D_2 are arbitrary positive numbers determined by researchers to determine the universal set. To get the universal set, first find the minimum data value and maximum data from the data that will be used for predictions [24]. The minimum and maximum values of the data used for predictions can be shown in Table 1.

Table 1. Minimum and Maximum Data Values

Data	X_{min}	X_{max}
January 2017 – April 2020	5800	18031
January 2018 – April 2020	5800	17375
January 2018 – April 2020	58	16440

Based on (2) where the values of $D_1 = 154$ and $D_2 = 215$, the universe of discussion for January 2017 – April 2020 data is $U = 5726{,}1824]$.

b. Determine the effective interval length using the average based method and divide it into several intervals that have the same intervals.
To determine the length of the interval, you must first find the mean of the data used, then determine the length of the interval using (2) [25]. After calculating the length of the interval, then determine the number of intervals (fuzzy numbers) using (3).

$$l = \frac{mean}{2} \quad (2)$$

$$p = \frac{[X_{min} - D_1, X_{max} + D_2]}{2} \quad (3)$$

Table 2 shows the difference in data each month from January 2017 – 2020 data. Based on Table 2, the length of the interval is 1309 and the number of intervals is 10.

Table 2. Difference In Monthly Data In January 2017 – April 2022

No	Month	Foreign tourist Data (Xi)	Difference $\lvert Xi + 1 - Xi \rvert$
1	January 2017	8614	4796
2	Februari 2017	13410	4029
3	Maret 2017	17439	1250
4	April 2017	16189	737
5	Mey 2017	15452	7092
6	June 2017	8360	3657
7	July 2017	12017	3172
…	…		
38	Februari	12686	6806
39	Maret	5880	6806
40	April	12686	-
	Total		**104732**

c. Defining the fuzzy set Ai and fuzzifying the observed data.
Fuzzy sets are mathematical models of vague qualitative or quantitative data, which are often generated through natural language [26][27]. A process for converting an input from a crisp form (crisp) to a fuzzy (linguistic variable) which is usually presented in the form of fuzzy sets with a membership function respectively [28][29]. Suppose A_1, A_2, ..., Ak are fuzzy sets that have a linguistic value from a linguistic variable, then the definition of the fuzzy sets A_1, A_2, ..., Ak in the universe of speech is like in (4).

$$A_1 = 1/u_1 + 0.5/u_2 + 0/u_3 + 0/u_4 + \ldots + 0/u_p \quad (4)$$

$$A_2 = 0.5/u_1 + 1/u_2 + 0.5/u_3 + 0/u_4 + \ldots + 0/u_p$$

$$A_3 = 0/u_1 + 0.5/u_2 + 1/u_3 + 0/u_4 + \ldots + 0/u_p$$

$$\vdots$$

$$A_p = 0/u_1 + 0/u_2 + 0/u_3 + \cdots + 0.5/u_p + 1/n_p$$

where ui $(i = 1, 2, \ldots p)$ is an element of the universal set and the number marked with the symbol "/" denotes the degree of membership of $\mu_{A_i}(u_i)$ to Ai $(i = 1, 2, \ldots, p)$ where the value is 0, 0.5 or 1. The linguistic and fuzzification values of tourist data for January 2017 – April 2022 can be shown in Table 3.

Table 3. Linguistic Values And Fuzzification

Linguistic	Fuzzification
A1	Low
A2	Very Low
A3	Pretty Low
A4	Low
A5	Medium
A6	Tall
A7	A Little High
A8	High Enough
A9	Very High
A10	Highest

The fuzzification stage based on the effective intervals obtained can be determined linguistic values according to the number of intervals formed. The results of fuzzification of tourist data for January 2017 – April 2022 can be shown in Table 4. Perform and create Fuzzy Logical Relationship (FLR) tables based on the data used and form fuzzy logical relationship groups (FLRG). In the forecasting process using fuzzy time series, the fuzzy logical relationship is one of the most critical factors affecting the accuracy of forecasting [30]–[32]. To form FLRG, it is done by grouping fuzzy sets that have the same current state and then grouping them into one group in the next step. The FLR which was formed from January 2017 – April 2020 data pays attention to the $A1$ fuzzy relationship from month to month for $1 \leq i \leq 10$, the FLR from these data can be seen in Table 5. Based on Table 5, the FLRG is obtained from January 2017 – April 2020 data which can be seen in Table 6.

Table 4. Fuzzification

No	Bulan	Foreign Tourist Data	Fuzzification
1	January 2017	8614	A3
2	February 2017	13410	A6
3	March 2017	17439	A9
4	April 2017	16189	A8
5	Mey 2017	15452	A8
6	June 2017	8360	A3
7	July 2017	12017	A5
…	…	…	…
38	February 2020	12686	A6
39	March 2020	5880	A1
40	April 2020	12686	A6

Table 5. Fuzzy Logical Relationship

Time Series	FLR
January 2017 → February 2017	A3 → A6
February 2017 → March 2017	A6 → A9
March 2017 → April 2017	A9 → A8
April 2017 → Mey 2017	A8 → A8
…	…
January 2020 → February 2020	A5 → A6
February 2020 → March 2020	A6 → A1
March 2020 → April 2020	A1 → A6

Table 6. Fuzzy Logical Relationship Group

Group	Fuzzy Logic Relations
1	A1 → A6
2	A2 → A3
3	A3 → A5, A6
4	A4 → A1
5	A5 → A6, A8
6	A6 → A1, A6, A7, A8, A9
7	A7 → A2, A4, A6, A7, A8, A9
8	A8 → A3, A5, A7, A8, A9, A10
9	A9 → A6, A7, A8
10	A10 → A5

d. Defuzzification is the last step in a fuzzy logic system where the goal is to convert every result from the inference engine which is expressed in the form of a fuzzy set to a real number. The result of this conversion is the action taken by the fuzzy logic control system [33]-[36]. The rule for defuzzification using FLRG data is the first rule if the result of fuzzification in year t is Aj and there is a fuzzy set that does not have a fuzzy logic relationship, for example if $Ai \rightarrow \emptyset$, where the maximum value of the membership function of Ai is in the interval ui and the value the middle of ui is mi , then the forecasting result $Ft + 1$ is mi, the second rule if the result of the fuzzification year t is Ai and there is only one FLR in FLRG, for example if $Ai \rightarrow Aj$ where Ai and Aj are fuzzy sets and the maximum value of the membership function from Aj is in the interval uj and the median value of uj is mj , then the forecasting result $Ft + 1$ is m, and the third rule if the result of fuzzification in year t is Aj and Aj has several FLRs in FLRG, for example $Ai \rightarrow Aj_1, Aj_2, \cdots, Ajk$ where Ai , Aj_1, Aj_2, ..., Ajk is a fuzzy set and the maximum value of the membership function of Aj_1,, Aj_2,, ..., Ajp is in the intervals $uj_1, uj_2, .., ujk$ and m_{j1}, m_{j2},, ..., m_{jk}, then the results of forecasting $Ft + 1$ use an (5).

$$F_{t+1} = \frac{m_{j1} + m_{j2} + \cdots + m_{jk}}{k} \quad (5)$$

where k is the number of midpoints and to find the midpoints (mi) in the intervals of the fuzzy set, (6) can be used. Based on the calculations, the FLRG data defuzzification for the period January 2017 – April 2020 can be seen in Table 7.

$$m_i = \frac{Upper\ Limit + Lower\ Limit}{2} \quad (6)$$

Table 7. Result Of FLRG Defuzzification

Predictions of Foreign Tourists
A1 → 12926.33
A2 → 8998.88
A3 → 12271.75
A4 → 6380.58
A5 → 14235.48
A6 → 13118.16
A7 → 12926.33
A8 → 14235.48
A9 → 14235.48
A10 → 11617.18

2.4. Prediction Accuracy

After the forecasting process is carried out, the error value is calculated using MAPE to see the accuracy of the forecasting results that have been carried out. Accuracy is the closeness of the value obtained from the measurement results to the actual value. This accuracy is used as a measure that determines the level of similarity between the measurement results and the actual measured value [36][37][38]. One method that can be used for measurement accuracy is the Mean Absolute Percentage Error (MAPE) method. MAPE is a measure of relative accuracy used to determine the percentage deviation from the estimated results. This approach is useful when the size or magnitude of the forecast variable is important in evaluating the accuracy

of the forecast [39][40], while to find the MAPE value using (7). The results of this accuracy prediction will be used to conclude whether the prediction method used is appropriate for the prediction process.

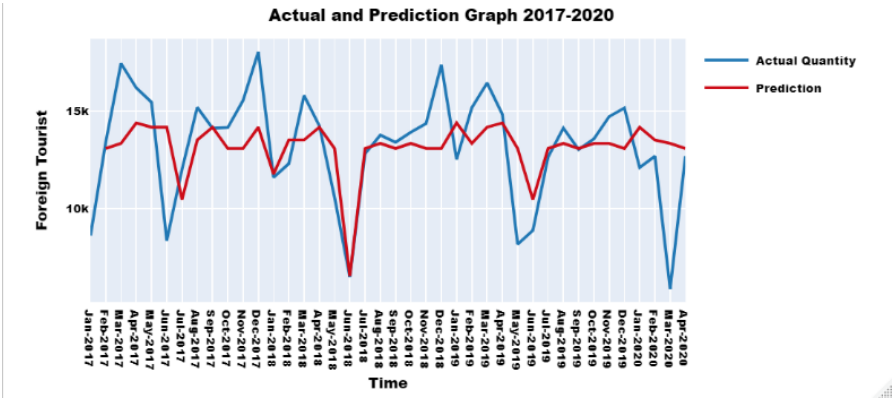
$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\frac{|Y_t - \widetilde{Y_t}|}{Y_t} \quad (7)$$

3. RESULTS AND DISCUSSION

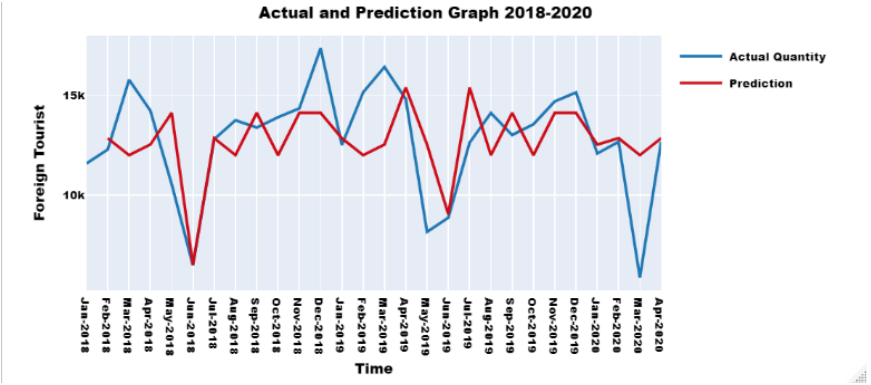
Based on the calculation results that have been carried out, the prediction results for the number of foreign tourists coming to West Java in January 2017 – April 2020 can be seen in Table 8. The results of the prediction calculation can be seen in the form of a graph shown in Fig. 3.

Table 8. Foreign Tourist Prediction Data

Month	Data	Fuzzification	Prediction
January 2017	8614	A3	-
February 2017	13410	A6	12271.75
March 2017	17439	A9	13188.16
April 2017	16189	A8	14235.48
May 2017	15452	A8	14235.48
June 2017	8360	A3	14235.48
July 2017	12017	A5	12271.75
…	…	…	…
February 2020	12686	A6	14235.48
March 2020	5880	A1	13188.16
April 2020	12686	A6	12926.33
May 2020	-	-	**13188.16**



. (a)



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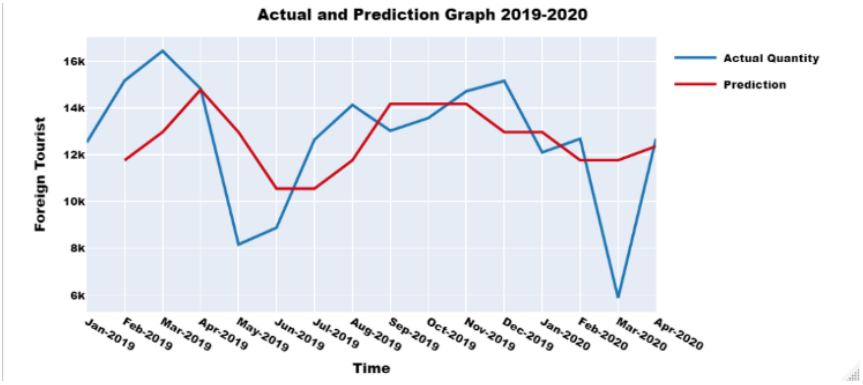

(c)

Fig. 3. Prediction of Tourist West Java (a) January 2017-April 2020; (b) January 2018-April 2020; (c) January 2019-April 2020

Based on Fig. 3, it can be compared to actual data and predictive data of foreign tourists coming to West Java. The plot shape of Fig. 3 (c) shows a much different value between the actual data and the predicted data, whereas in Fig. 3 (a) and Fig. 3(b) the plot shape of the predicted results for each period has a value that is not much different from the actual data. The prediction results for the three samples use the length of the interval, the values D_1 and D_2 are the same as the data samples for January 2017 - April 2020

Based on (6) the calculation of the error value from the prediction results can be seen in Table 9. Based on Table 9, it can be seen that for the prediction of foreign tourists coming to West Java, in this case it is better to use data from January 2018 to April 2020, namely 29 data because it produces an error value which is the smallest compared to data from January 2017 to April 2020 and January 2019 to April 2020. The error value indicates that the average-based fuzzy time series model is good for predictions.

Table 9. Prediction Accuracy

Data	Prediction	MAPE
January 2017 – April 2020 (40 Data)	13188.16	14.74
January 2018 – April 2020 (29 Data)	12707.28	14.71
January 2019 – April 2020 (16 Data)	11762.41	18.95

By comparing previous research which states that fuzzy time series can be used for prediction. one of which is in the tourism sector and produces a small error value [18]–[21]. it turns out that for the case of this research it is also proven that fuzzy time series shows a good model for prediction. one of which is the prediction of the number of foreign tourists coming to West Java. Based on the resulting error value. this study produces a larger error value than research [23]. however the method used in this study still shows that the prediction error value of this method is good for predicting foreign tourists coming to West Java. Indonesia. In addition. the data used in this study when compared to research [23]. has advantages related to the input data used. The research data is taken from official government agencies so that the data is valid.

4. CONCLUSION

A good prediction method is used to predict the number of foreign tourists based on the smallest MAPE value. The length of the interval and the amount of data affect the results of the predictions. Based on the test results. it shows that the average based fuzzy time series model gives a MAPE value of 14.71%. which means that this model is good for the prediction process. With this process. it can be used as a decision support for related parties to make policies related to efforts to prepare and plan tourism in West Java. Indonesia

Acknowledgments

The authors thank the Universitas Komputer Indonesia who have supported in completing this research

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