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Prediction of Crime Cases in 2025 in India Using the Fuzzy Time Series Chen Model Method

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ABSTRACT

India's natural beauty and culture, which attract the attention of international tourists, are less able to increase tourist visits due to high crime cases. Tourists' fear of visiting the country has a direct impact on decreasing economic turnover, so the local economy has become very low. Predictions of criminal cases aim to provide an overview of cases that will occur in the next period, therefore the government can take appropriate policies to reduce crime cases. These predictions enable policymakers to plan strategic and data-based preventive measures. The method used is the Fuzzy Time Series Model Chen, because this method can overcome data uncertainty, and offers simplicity and ease in application. Valid and credible criminal statistics data in India is obtained from the site www.kaggle.com. A trusted platform that provides various quality datasets. This data will be used as a basis for the analysis and prediction of criminal cases in India. The results of this research show that in the range of 60 months from January 2020 to December 2024 using the Fuzzy Time Series Chen Model method to predict the number of criminal cases in India produced predictions in January 2025 with cases of 188.36 cases with a MAPE error ratio of 9.08% which is included in outstanding forecasting category.

INTRODUCTION

Crime can be defined as unlawful actions that harm individuals and society as a whole. Crime covers a wide range of behavior, from theft to actions that endanger human life.

The very high crime cases occurring in India have had a negative impact on local residents and foreign tourists. India's natural beauty and culture, which really attract the attention of international tourists, are actually less likely to increase tourist visits due to the high crime rate. Tourists' fear of visiting the country has a direct impact on reducing economic turnover, so the local economy becomes very low.

Predicting criminal cases is important for the government to take appropriate policies to reduce crime cases. By understanding future crime trends, governments can develop effective policies to create better security in their countries. These predictions enable policymakers to plan strategic and data-based preventive measures.

As stated by Fauziah et al. (2016), predictions can be made using various methods, one of which is the Fuzzy Time Series (FTS) method. FTS is a method used to analyze time series data by utilizing fuzzy logic. This method allows the processing of historical data and uncertain information to produce more accurate predictions in the future. By implementing FTS, research into predicting crime rates in India can be carried out effectively to produce information that is useful for the government in policy-making.

Traditional approaches to predicting crime rates often have limitations, such as dependence on linear data, lack of flexibility in changing patterns, and the inability to handle data that contains elements of uncertainty (Mamat et al., 2018). Traditional methods also tend to be unable to capture the complexity that arises from non-linear relationships between variables in the crime phenomenon. This can result in predictions that are less accurate and ineffective for supporting decision-making.

Based on the description above, a prediction method is needed to assist the government in developing security policies, so that it can minimize the increase in crime rates in the coming period. This research uses the Fuzzy Time Series Chen Model method, because this method has the ability to overcome data uncertainty, and offers simplicity and ease in application.

This research is entitled "Prediction of Crime Rates in 2025 in India Using the Fuzzy Time Series Chen Model Method". With this title, this research focuses on predicting crime rates in 2025 using the Fuzzy Time Series Chen Model method to provide accurate and relevant information for the Indian government in its efforts to create better security policies.

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LITERATURE REVIEW

Research conducted by Ikhsanudin et al. (2022) shows that the Fuzzy Time Series Chen Model method is able to provide accurate predictions for the number of active COVID-19 cases in Indonesia with a MAPE error rate of 3.53%, which is included in the very good category. This shows the potential of this method in handling complex and uncertain time series data, including in the context of criminal data.

Research conducted by Sanly et al. (2022) predicted the crime rate for the city of Ternate, North Maluku province using the Double exponential smoothing method. With the results of forecasting the crime rate for the city of Ternate for October 2022, there were 21.54 cases, in November it rose to 21.66 cases and in December it rose again to 21.78 cases, meaning that from November 2022 to December 2022 crime cases in the city of Ternate has the potential to increase by 5%. This can be a reference for the government in developing policies to maintain security in Ternate City.

Research conducted by Abdul Mazid Gajah et al. (2023) shows that the Fuzzy Time Series Chen Model method is effective in predicting time series data, especially the unemployment rate in Medan City. This method utilizes fuzzy logic to handle historical data with uncertainty and produce accurate predictions. Predicting the unemployment rate for 2022-2024 using this method has a low error rate. The results of the discussions and calculations obtained show that the predicted unemployment rate in 2022 will be 11,998.14, in 2023 it will be 11,791.21, and in 2024 it will be 11,687.75 people.

Research conducted by Ikhsanudin et al. (2022) shows that the Fuzzy Time Series Chen Model method can provide accurate predictions for the number of active COVID-19 cases in Indonesia with a MAPE error rate of 3.53%, which is included in the very good category. This shows the potential of this method in handling complex and uncertain time series data, including in the context of criminal data.

Comparison of the Chen model and the Cheng model in the Fuzzy Time Series algorithm to predict basic commodity prices. The basic commodity price prediction system using the Fuzzy Time Series on the Chen model and the Cheng model can provide chili price prediction results using the Chen model with a MAPE result of 18.25% and the Cheng model with a MAPE result of 10.46%. The results for shallot prices use the Chen model with a MAPE result of 10.52% and the Cheng model with a MAPE result of 6.99%. For rice prices using the Chen model with a MAPE result of 6.30% and the Cheng model with a MAPE result of 2.67% (Fadhillah, Bettiza, & Ritha, 2017).

Research conducted by Normalita Fauziah et al. (2016) in the case of rainfall prediction in Samarinda City for June 2016 used the Fuzzy Time Series Chen method with an average-based approach. Forecasting rainfall for Samarinda City based on data for January 2013 - May 2016, the forecast results for June 2016 were 287.5 mm. For forecasting rainfall for Samarinda City based on data for January 2014-May 2016, the forecast results for June 2016 were 300 mm. From the results of the tests that have been carried out, it was obtained that the best number of samples to be used in the case of Samarinda City rainfall is 29 data, namely for the period January 2014 - May 2016.

METHOD

This research uses the Fuzzy Time Series Chen Model method to predict crime rates in India in 2025. The Fuzzy Time Series (FTS) method is an approach that utilizes fuzzy logic to analyze time series data. The Chen model is a variant of FTS which has the advantage of handling data uncertainty and providing simpler and more accurate prediction results. The following is the general flow of research carried out.

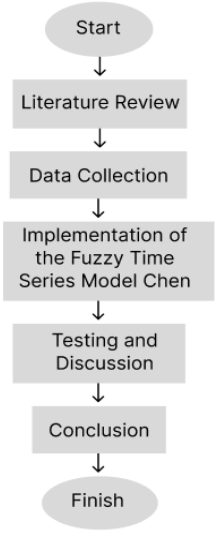

Figure 1. Research Flow

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a. Study literature
The literature study stage is a stage for looking for references that are relevant to the research topic as a basis for a framework of thinking related to research on criminal case prediction and the Chen model of the Fuzzy Time Series method. From this process, an in-depth understanding of the basic concepts, basic theories, and methods that will be applied is obtained. So that research can be carried out in a structured and scientific manner.

b. Data collection
Data collection is a process for collecting information or facts in the field to support research. Valid and credible criminal statistics data in India is obtained from the site www.kaggle.com. A trusted platform that provides various quality datasets. This data will be used as a basis for analysis and prediction of crime rates in India.

c. Implementation of the Fuzzy Time Series Chen Model Method
At this stage, the Fuzzy Time Series Chen Model method is applied to predict crime rates. The process begins by determining the universal set (U) and dividing the fuzzy interval. Historical data is then fuzzified using membership functions to form fuzzy logic rules (Fuzzy Logical Relationships). Predictions are carried out through a defuzzification process, changing the fuzzy results back to numerical form.

d. Testing and Discussion
Forecasting testing is carried out using accuracy measures to ensure optimal prediction results with the smallest possible error rate. The method used to measure forecasting accuracy is the Mean Absolute Percentage Error (MAPE). MAPE calculates the average percentage error between the actual value and the predicted value, thus providing an idea of the accuracy level of the model being applied.

e. Drawing Conclusions and Suggestions
Conclusions are drawn based on test results and analysis of the results obtained. This process aims to summarize the main findings and assess the success of the model in achieving the research objectives. In addition, suggestions are provided as input for further improvement and development in future research, to improve the quality and application of the methods used.

RESULT

The following is a flowchart for implementing the fuzzy time series Chen model in predicting crime rates in India.

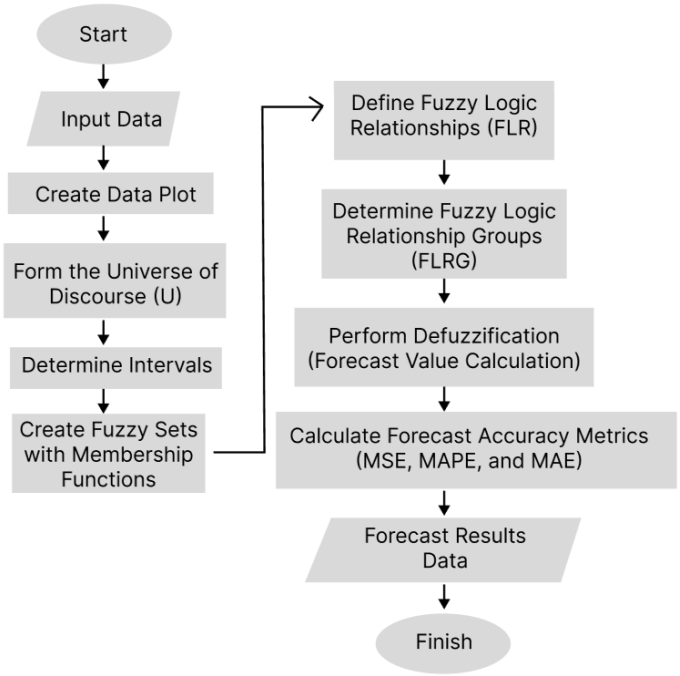

Figure 2. Flowchart Algoritma Fuzzy Time Series Model Chen

Data Collection

The criminal case data used in this research was 60 because it took an average based on the literature review used. The data used starts from January 2020 to December 2024 because it adapts to the latest data at the time this research was

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conducted. The data contained in Kaggel are criminal cases that are reported, but there are still many cases that occur that are not reported.

Table 1. Criminal Cases in India from January 2020 to December 2024

No	Year	Month	Number of cases
1	2020	1	275
2	2020	2	275
3	2020	3	303
4	2020	4	280
5	2020	5	286
6	2020	6	270
7	2020	7	299
8	2020	8	297
9	2020	9	292
10	2020	10	285
11	2020	11	291
12	2020	12	299
13	2021	1	295
14	2021	2	252
15	2021	3	285
16	2021	4	291
17	2021	5	293
18	2021	6	291
19	2021	7	304
20	2021	8	278
21	2021	9	276
22	2021	10	296
23	2021	11	292
24	2021	12	318
25	2022	1	285
26	2022	2	279
27	2022	3	296
28	2022	4	250
29	2022	5	313
30	2022	6	285
31	2022	7	303
32	2022	8	285
33	2022	9	303
34	2022	10	280
35	2022	11	288
36	2022	12	296
37	2023	1	268
38	2023	1	268
39	2023	2	281
40	2023	3	280
41	2023	4	289
42	2023	5	311
43	2023	6	265
44	2023	7	301
45	2023	8	279
46	2023	9	300
47	2023	10	277
48	2023	11	304
49	2023	12	294
50	2024	1	162
50	2024	2	193

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51	2024	3	153
52	2024	4	181
53	2024	5	171
54	2024	6	165
55	2024	7	174
56	2024	8	163
57	2024	9	168
58	2024	10	156
59	2024	11	175
60	2024	12	179

The following is a graph showing the trend in the number of cases by month and year.

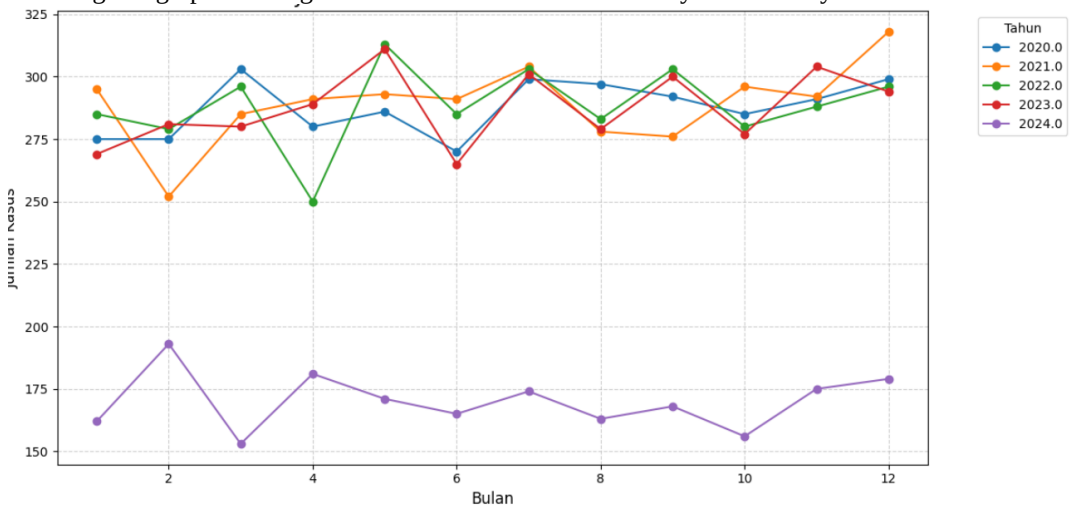

Figure 3. Trends in Number of Cases by Month and Year

Based on the graph above, the highest crime rate occurred in the period 2020 to 2023, which shows a fairly consistent trend in cases over that period. However, criminal cases in 2024 are seen to have decreased significantly compared to previous years. This decline provides a positive indication that the crime control measures implemented are starting to produce results. Prediction of crime rates in 2025 to support more effective policy-making regarding security. With accurate predictions, it is hoped that the government can formulate more targeted policies so that the crime rate in India in 2025 can continue to decline and create a safer environment for society.

Formation of a universal set

In this step the universal set is formed with the symbol U with the definition U= $Dmin$ - $D1$; $Dmax$ + $D2$, where $Dmin$ is the minimum value and $Dmax$ is the maximum value. The values $D1$ and $D2$ are positive values determined by the researcher.

Based on data on criminal cases in India, the maximum data was found to be 318 cases and the minimum value was 153 cases. Then for the values $D1$ and $D2$, the researcher sets each value at 0. So the resulting universe set is:

$$U = [D_{min} - D_1 ; D_{max} + D_2]$$
$$= [153 - 0 ; 318 + 0]$$
$$= [153 ; 318]$$

Interval Formation

To form an interval, first determine the number of interval classes and the interval length. Then intervals can be formed. The number of intervals for each variable is the same because the amount of data for each variable is the same, namely 60 data.

To get the number of classes, use the Stuges formula, namely:

$$K = 1 + 3.322 \log(n)$$

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The following is a calculation of the number of interval classes:

$$\text{Number of intervals} = 1 + 3.322\log(n)$$
$$= 1 + 3.322\ \log(60)$$
$$= 1 + 5.909$$
$$= 6.909 \text{ (rounded to 7)}$$

Next, determine the interval length for criminal cases with minimum data of 153 cases and maximum data of 318 cases, and the number of interval classes is 7.

Following are the calculations.

$$\text{Interval Length} = \frac{D_{max} - D_{min}}{\text{Number of intervals}}$$
$$= \frac{318 - 153}{7}$$
$$= 23{,}57$$

The following is a class calculation table:

Table 2. Class Calculation

D_{min}	=	153 Case
D_{max}	=	318 Case
Range	=	165
Interval Class	=	7
Interval Length	=	23,57

After obtaining the number of interval classes of 7 and the interval length of 23.57, the resulting values $u1$ to $u7$ are intervals from the universal set (U) with a middle value (m) as in the following table.

Table 3. Intervals of the Universal Set (U)

No	Interval			Middle Value		
1	U_1	=	153,00 – 176,57	m_1	=	164,785
2	U_2	=	176,57 – 200,14	m_2	=	188,355
3	U_3	=	200,14 – 223,71	m_3	=	211,925
4	U_4	=	223,71 – 247,29	m_4	=	235,500
5	U_5	=	247,29 – 270,86	m_5	=	259,075
6	U_6	=	270,86 – 294,43	m_6	=	282,642
7	U_7	=	294,43 – 318,00	m_7	=	306,215

Formation of Fuzzy sets

Formation of Fuzzy Sets The fuzzy sets Ai are determined by predetermined intervals, namely 7 interval classes. The fuzzy set membership value Ai is between 0, 0 5, and 1. Where 1< i > 7, and 7 is the number of intervals.

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$$A_1 = \left\{ \frac{1}{U_1} + \frac{0.5}{U_2} + \frac{0}{U_3} + \frac{0}{U_4} + \frac{0}{U_5} + \frac{0}{U_6} + \frac{0}{U_7} \right\}$$

$$A_2 = \left\{ \frac{0.5}{U_1} + \frac{1}{U_2} + \frac{0.5}{U_3} + \frac{0}{U_4} + \frac{0}{U_5} + \frac{0}{U_6} + \frac{0}{U_7} \right\}$$

$$A_3 = \left\{ \frac{0}{U_1} + \frac{0.5}{U_2} + \frac{1}{U_3} + \frac{0.5}{U_4} + \frac{0}{U_5} + \frac{0}{U_6} + \frac{0}{U_7} \right\}$$

$$A_4 = \left\{ \frac{0}{U_1} + \frac{0}{U_2} + \frac{0.5}{U_3} + \frac{1}{U_4} + \frac{0.5}{U_5} + \frac{0}{U_6} + \frac{0}{U_7} \right\}$$

$$A_5 = \left\{ \frac{0}{U_1} + \frac{0}{U_2} + \frac{0}{U_3} + \frac{0.5}{U_4} + \frac{1}{U_5} + \frac{0.5}{U_6} + \frac{0}{U_7} \right\}$$

$$A_6 = \left\{ \frac{0}{U_1} + \frac{0}{U_2} + \frac{0}{U_3} + \frac{0}{U_4} + \frac{0.5}{U_5} + \frac{1}{U_6} + \frac{0.5}{U_7} \right\}$$

$$A_7 = \left\{ \frac{0}{U_1} + \frac{0}{U_2} + \frac{0}{U_3} + \frac{0}{U_4} + \frac{0}{U_5} + \frac{0.5}{U_6} + \frac{1}{U_7} \right\}$$

Based on the definition of each fuzzy set $A1$ above, it can be seen that $A7$ has a definition, namely the membership degree of $u1$,2,$u3$,$u4$ and $u5$ to $A7$ is worth 0, the membership degree of $u6$ to $A7$ is 0.5, and the membership degree of $u7$ to $A7$ value 1.

The next stage is to carry out fuzzification based on the effective intervals obtained, linguistic values can be determined according to the number of intervals formed. The results of fuzzification of data on the number of criminal cases that are notated into linguistic numbers are as follows.

Table 4. Fuzzification of the number of criminal cases

No	Year	Month	Case Count	Fuzzy Set
1	2020	1	275	A6
2	2020	2	275	A6
3	2020	3	303	A7
4	2020	4	280	A6
5	2020	5	286	A6
6	2020	6	270	A5
7	2020	7	299	A7
8	2020	8	297	A7
9	2020	9	292	A6
10	2020	10	285	A6
11	2020	11	291	A6
12	2020	12	299	A7
….	….	….	….	….
49	2024	1	162	A1
50	2024	2	193	A2
51	2024	3	153	A1
52	2024	4	181	A2
53	2024	5	171	A1
54	2024	6	165	A1
55	2024	7	174	A1
56	2024	8	163	A1
57	2024	9	168	A1
58	2024	10	156	A1
59	2024	11	175	A1
60	2024	12	179	A2

Form a Fuzzy Relationship (FLR)

Determine the FLR by considering fuzzy Ai from month to month for $1 < i < 7$. FLR can be written $Ai\ Aj$, where Ai is the set of the left side or previous observations F (t-1) and Aj is the set of the right side or observations after the previous data F (t) on time series data. The following are the FLR results for the number of criminal cases.

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Tabel 5. Fuzzy Logic Relation (FLR)

	Year	Month	Case Count	Fuzifikasi	FLR
1	2020	1	275	A6	A6
2	2020	2	275	A6	A6 -> A6
3	2020	3	303	A6	A6 -> A7
4	2020	4	280	A7	A7 -> A6
5	2020	5	286	A6	A6 -> A6
6	2020	6	270	A6	A6 -> A5
7	2020	7	299	A5	A5 -> A7
8	2020	8	297	A7	A7 -> A7
9	2020	9	292	A7	A7 -> A6
10	2020	10	285	A6	A6 -> A6
11	2020	11	291	A6	A6 -> A6
12	2020	12	299	A6	A6 -> A7
….	….	….	….	….	….
49	2024	1	162	A1	A6 -> A1
50	2024	2	193	A2	A1 -> A2
51	2024	3	153	A1	A2 -> A1
52	2024	4	181	A2	A1 -> A2
53	2024	5	171	A1	A2 -> A1
54	2024	6	165	A1	A1 -> A1
55	2024	7	174	A1	A1 -> A1
56	2024	8	163	A1	A1 -> A1
57	2024	9	168	A1	A1 -> A1
58	2024	10	156	A1	A1 -> A1
59	2024	11	175	A1	A1 -> A1
60	2024	12	179	A2	A1 -> A2

Determine the Fuzzy Logic Relationship Group (FLRG)

Based on the results of Fuzzy Logic Relations (FLR), a Fuzzy Logic Relations Group (FLRG) can be formed by grouping each FLR that has the same left side F (t-1). The following is the grouping or FLRG obtained based on the FLR results.

Table 6. Fuzzy Logic Relations Group (FLRG)

Group	Fuzzy Logic Relations Group (FLRG)
Group A1	A1 -> A2, A1
Group A2	A2 -> A1
Group A5	A5 -> A7, A6
Group A6	A6 -> A6, A7, A5, A1
Group A7	A7 -> A6, A7, A5

Based on Table 6 above, several groups show patterns of relationships between groups in criminal cases. The explanation of each group is as follows:

Group A1 has connections to Group A2 and itself (A1 → A2, A1).

Group A2 only has a connection back to Group A1 (A2 → A1).

Group A5 is connected to Group A7 and Group A6 (A5 → A7, A6).

Group A6 Has more complex connections, including connections back to itself and connections to Groups A7, A5, and A1 (A6 → A6, A7, A5, A1).

Group A7 also shows an interrelated relationship, namely to Group A6, itself, and Group A5 (A7 → A6, A7, A5).

Absence of Groups A3 and A4 In the criminal case data analyzed, Groups A3 and A4 are not included. This is caused by the range of values used to determine the group, namely:

Group A3: Value range 200.14 to 223.71 (mean 211.929).

Group A4: Value range 223.71 to 247.29 (mean 235.5).

This range of values has no case representation in the data, so Groups A3 and A4 are not formed in the analysis.

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Prediction

After the Fuzzy Logic Relations Group (FLRG) is obtained, the defuzzification process is then carried out and the forecasting value is calculated using Fuzzy Time SeriesChen. For example, in Group 3 containing fuzzy relationship group A5, there are A7 and $A6$ so that $A5$ uses the middle value of u7 ($m7$), and $A6$ uses the middle value of $u6$ ($m6$). Then the average of the two middle values is calculated or written as

$$(t) = \frac{m_7 + m_6}{2}$$

In the previous FLRG formation, 5 groups were formed. The results of calculating the forecast values for each group or group along with the calculation formula are as follows.

Table 7. Value of Forecasting Results

Group	Fuzzy Logic Relations Group (FLRG)	Forecasting Formula F(t)	Forecasting Value
Group A1	A1 -> A2, A1	$\frac{m2 + m1}{2}$	176.57
Group A2	A2 -> A1	m1	164.79
Group A5	A5 -> A7, A6	$\frac{m7 + m6}{2}$	294.43
Group A6	A6 -> A6, A7, A5, A1	$\frac{m6+ m7 + m5 + m1}{4}$	253.18
Group A7	A7 -> A6, A7, A5	$\frac{m6+ m7 + m5}{3}$	282.64

Based on the forecasting results above, they can be entered into a table according to the fuzzy logic relations values that represent them, as follows:

Table 8. Forecasting Results with FLRG

No	Year	Month	Case Count	FLR	Forecast
1	2020	1	275	A6	275
2	2020	2	275	A6 -> A6	253.18
3	2020	3	303	A6 -> A7	282.64
4	2020	4	280	A7 -> A6	253.18
5	2020	5	286	A6 -> A6	253.18
6	2020	6	270	A6 -> A5	294.43
7	2020	7	299	A5 -> A7	282.64
8	2020	8	297	A7 -> A7	282.64
9	2020	9	292	A7 -> A6	253.18
10	2020	10	285	A6 -> A6	253.18
11	2020	11	291	A6 -> A6	253.18
12	2020	12	299	A6 -> A7	282.64
….	….	….	….	….	….
49	2024	1	162	A6 -> A1	176.57
50	2024	2	193	A1 -> A2	164.79
51	2024	3	153	A2 -> A1	176.57
52	2024	4	181	A1 -> A2	164.79
53	2024	5	171	A2 -> A1	176.57
54	2024	6	165	A1 -> A1	176.57
55	2024	7	174	A1 -> A1	176.57
56	2024	8	163	A1 -> A1	176.57
57	2024	9	168	A1 -> A1	176.57
58	2024	10	156	A1 -> A1	176.57
59	2024	11	175	A1 -> A1	176.57
60	2024	12	179	A1 -> A2	164.79

Based on the predicted results of the number of criminal cases for the period January 2020 to December 2024, a plot can be created to compare the original data pattern with the predicted data pattern.

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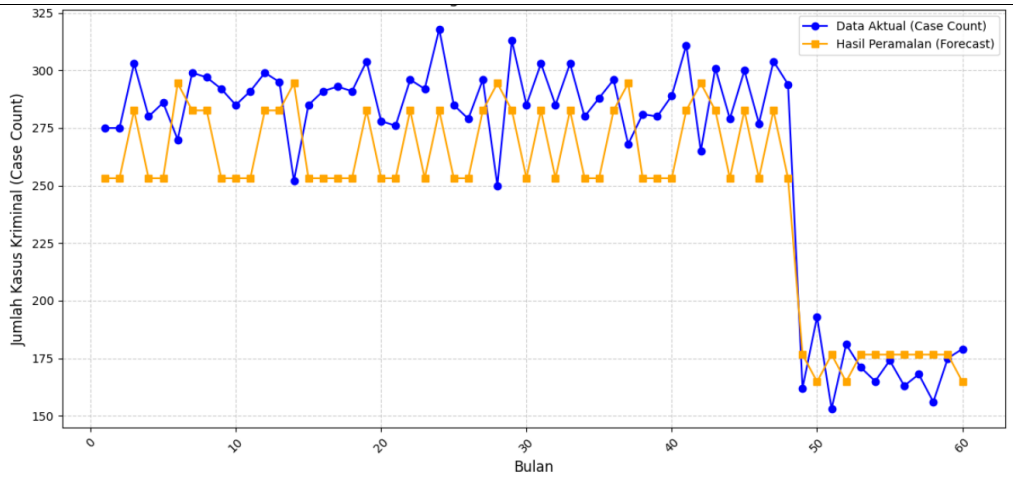

Figure 4. Comparison Chart of Actual Data and Forecast Results

In the image above, it can be seen that the prediction results graph obtained using Chen's Fuzzy Time Series model has the same pattern as the original data plot for the number of cases. The predicted data plot is shown with an orange line and the original data plot for the number of cases is shown with a blue line.

Measure Of Prediction Accuracy

The prediction accuracy measure is used to determine the level of accuracy of the prediction results for 60 criminal case data in India from January 2020 to December 2024..

Following are the results of calculating the values of $error$, and $|PE|$. The value of $error$ is obtained from the difference between the original data and the forecast data or $error\ Xt\ Ft$, where Xt is the original data in period t and Ft is the forecast data in period t. The $|PE|$(Percentage Error) value is obtained by dividing the value of $error$ by the absolute original data and multiplying by 100%.

Table 9. Error Value

No	Year	Month	Case Count	Forecast	Error	PE Absolut
1	2020	1	275		0	0
2	2020	2	275	253.1785	21.8215	7.935090909
3	2020	3	303	282.6426667	20.35733333	6.718591859
4	2020	4	280	253.1785	26.8215	9.579107143
5	2020	5	286	253.1785	32.8215	11.47604895
6	2020	6	270	294.4285	24.4285	9.047592593
7	2020	7	299	282.6426667	16.35733333	5.470680045
8	2020	8	297	282.6426667	14.35733333	4.834118967
9	2020	9	292	253.1785	38.8215	13.29503425
10	2020	10	285	253.1785	31.8215	11.1654386
11	2020	11	291	253.1785	37.8215	12.99707904
12	2020	12	299	282.6426667	16.35733333	5.470680045
….	….	….	….	….	….	….
49	2024	1	162	176.5715	14.5715	8.994753086
50	2024	2	193	164.786	28.214	14.61865285
51	2024	3	153	176.5715	23.5715	15.40620915
52	2024	4	181	164.786	16.214	8.95801105
53	2024	5	171	176.5715	5.5715	3.258187135
54	2024	6	165	176.5715	11.5715	7.013030303
55	2024	7	174	176.5715	2.5715	1.477873563
56	2024	8	163	176.5715	13.5715	8.32607362
57	2024	9	168	176.5715	8.5715	5.102083333
58	2024	10	156	176.5715	20.5715	13.18685897
59	2024	11	175	176.5715	1.5715	0.898
60	2024	12	179	164.786	14.214	7.940782123

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After the values $error$ and $|PE|$ are obtained, then a measure of forecasting accuracy can be sought using the Mean Absolute Percentage Error (MAPE) method. The MAPE value is obtained from the average value of $|PE|$. The following is a calculation of MAPE for the number of criminal cases.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{X_t - F_t}{X_t} \times 100\%\right|$$
$$= \frac{1}{n}\sum_{t=1}^{n}\left|PE_t\right|$$

$$\text{MAPE} = \frac{7.935090909 + 6.718591859 + \ldots.. + 0.898 + 7.940782123}{60}$$
$$= 9.08\%$$

The MAPE value in this test is 9.08%. Based on the interpretation table of MAPE values according to Lewis, the test results of 9.08% indicate that the forecasting results are very accurate (Lewis, 1982).

Table 10. MAPE Value Interpretation Results

MAPE (%)	interpretation
< 10	Highly Accurate Forecasting
10 – 20	Good Forecasting
20 - 50	Forecasting Worthy
>50	Forecasting is less accurate

Source: (Lewis, 1982)

PREDICTION RESULTS

By using the Fuzzy Time Series method, predictions are made for the next period, namely January 2025. To determine the forecast for the next period, it is determined by looking at the FLR formed in the previous period with the far right side. Then match it with the FLRG that has been formed, for example in the December 2024 period FLR $A1$ is formed → $A2$, so that in the January 2025 period the predicted value used is in Group 2 with the relation $A2$ → $A1$. The following is a table of forecasting results.

Table 11. Results of Forecasting the Number of Criminal Cases

Year	Month	Case Count	FLR	Predicted Case Count
2024	12	179	A1 → A2	164.786
2025	1		A2 → A1	188.3571

Results of Forecasting the NuBased on the table above, it can be seen that the predicted value of criminal cases based on 60 historical data from January 2020 to December 2024, then in the next period, namely January 2025, it is 188.3571 rounded up to 188.36 cases which are predicted to occur in the January 2025 period. Member of Criminal Cases.

DISCUSSION

The prediction results indicate that the Chen fuzzy time series model is quite accurate in forecasting crime rate trends. The difference between the predicted values and actual data is relatively small, indicating that the model is effective in capturing historical data patterns.

Several factors can influence the accuracy of the prediction, such as the stability of past data patterns and the quality of the data used. The Chen model relies on logical relationships between fuzzy intervals, making it suitable for time series data that exhibit seasonal patterns or trends.

The strength of this method lies in its simplicity and its ability to accommodate linguistic data. However, its weakness is its sensitivity to the selection of the number and boundaries of fuzzy intervals, which can affect the final results.

Therefore, the findings of this study support the use of the Chen fuzzy time series model as an alternative approach in forecasting crime rates, particularly in regions with relatively stable historical crime data.

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CONCLUSION

Based on research and implementation of Chen's Fuzzy Time Series Model method, it can be concluded that in the range of 60 months from January 2020 to December 2024 it produces predictions in January 2025 with 188.36 criminal cases with a MAPE error ratio of 9.08% which is included in the very forecasting category. Good. The process of creating a forecasting system can be done using the Fuzzy Time Series Chen Model forecasting method. Through the steps of determining the universe set, determining intervals, determining fuzzy sets, determining Fuzzy Logic Relations (FLR) and Fuzzy Logic Relations Group (FLRG), forecasting, and defuzzification.

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