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Applying of F2 (0.004) Forecasting the Number of Tourists in Sanya

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Abstract. F2 (0.004), its prediction formula relies on inverse fuzzy numbers, the difference of historical data and the differential-difference of the historical data. F2 (0.004) is a fuzzy time-series forecasting model. This paper reports the application of F2 (0.004) on forecasting research about the historical data of tourist number in Sanya from 2006 to 2014 and the number of tourist in the unknown year 2015. For the study of time series forecasting problems, F2 (0.004) is an added new methods.

Introduction

It has added a new powerful tool on uncertainty problem research, since Zahde[1] funded the fuzzy set theory. Regarding the time series as fuzzy systems, Song et al.[2-4] brought up the first fuzzy time series forecasting model in 1993 for studying the prediction problem of the registered number in Alabama University from 1971 to 1992 (referred to as the classic case). Later, people constantly put forward various improved forecasting models. In 2012, Saxena et al.[5] proposed a new fuzzy time-series forecasting model based on inverse fuzzy numbers, making the average forecast error rate reach an unprecedented prediction accuracy: for the classic cases, the average forecast error rate: AFER = 0.3406% and the mean square error: MSE = 9169. Wang et al.[6-10] made further improvements for the inverse fuzzy forecasting model, not only greatly simplifying the calculation processes, but improving the prediction accuracy when applied to the classic case. For example, Wang et al.[10] proposed a method to obtain AFER = 0.1705% and MSE = 1121. In this article, the forecasting model in the literature [10] is modified, called F2 (0.004). It makes the prediction formula more streamlined. F2 (0.004) is an element of the collection of forecasting model FTSFM 2 (Fuzzy Time Series Forecasting Model 2). F2 (0.004) is a better fuzzy time-series forecasting model. This model can be utilized to study the predicted values of the historical data about the number of tourists in Sanya from 2006 to 2014 and the predicted values in the unknown year 2015. Therefore, it is worth being recommended.

Collection of Forecast Model FTSFM 2

Forecasting Formula:

$$\xi_i = \frac{\mu+1}{\frac{\mu}{V_{i-1}}+\frac{1}{S_i}}, T_i = U_{i-1}+\xi_i+V_{i-1}, \mu \in (0,1), \quad (1)$$

Where: ξ_i is the inverse fuzzy numbers of the year i, V_i is the difference of historical data of the year i-1, S_i is the differential-difference of the historical data of the year i, T_i is the predicted values of the historical data of the year i, U_{i-1} is the historical data of the year i-1, $\mu \in (0,1)$ is called (V_i's) Membership Degree.

When determining $\mu \in (0,1)$, resulting a formula (1) as the prediction formula of the forecasting model, recording it as F2(μ). The collection of all the forecasting model F2(μ), ($\mu \in (0,1)$,) was recorded as FTSFM 2.

Definition 1: If when forecasting the registered number of Alabama University from 1971 to 1992, resulting that AFER ≤ 0.3406% and MSE ≤ 9169, then the fuzzy time-series forecasting model is known as a better fuzzy time-series forecasting model.

It can prove that the commonly used forecasting model F2 (0.004) is a better fuzzy time-series forecasting model.

Application Process of F2 (0.004)

Step1: Entering historical data; Step 2: Building 3 discourse domains of historical data; Step 3: Building F2 (0.004) prediction formula; Step 4: Applying the F2 (0.004) to predict historical data; Step 5: Applying the F2 (0.004) to predict data of unknown years.

Application of F2 (0.004) to Study the Prediction Problem on Tourist Number in Sangya

The whole application process was showed through the case where using the F2 (0.004) to research the prediction problem which related to the number of the tourist in Sanya between 2006 and 2014.

Entering the Historical Data

Entering the historical data of tourist arrivals in Sanya from 2006 to 2014 and showing in Table 1.

Table 1. Applying of the F2(0.004) Forecasting the Tourist Arrivals in Sanya from 2006 to 2014.

years	Tourist number U_i (10k)	Difference of tourism number V_i	Differential-difference S_i	Predicted values of tourist number T_i (10k)	$(T_i - U_i)^2$	$\lvert T_i - U_i\rvert / U_i$
2006	454.90					
2007	538.43	83.53				
2008	604.15	65.72	-17.81	604.06	0.0081	0.000149
2009	669.05	64.90	-0.82	669.05	0.0000	0.000000
2010	882.65	213.60	148.70	881.98	0.4489	0.000759
2011	1021.07	138.42	-75.18	1020.66	0.1681	0.000402
2012	1102.22	81.15	-57.27	1101.90	0.1024	0.000290
2013	1228.40	126.18	45.03	1228.48	0.0064	0.000065

2014	1352.76	124.36	-1.82	1352.75	0.0001	0.000007
MSE					0.1049	
AFER						0.0239%

Building 3 Discourse Domains

Building discourse domains of the number of tourists in Sanya according to the Table 1:

$$U = \{U_{2006}=454.90, U_{2007}=538.43, \ldots, U_{2013}=1228.40, U_{2014}=1352.76\}.$$

Using the formula $V_i=U_i-U_{i-1}$to calculate and building the every-year difference domain of the tourist number in Sanya:

$$V = \{V_{2007}=83.53, V_{2008}=65.72, \ldots, V_{2013}=126.18, V_{2014}=124.36\}.$$

Using the formula $S_i = V_i - V_{i-1}$ to calculate and building the every-year differential-difference domain of the tourist number in Sanya:

$$S = \{S_{2008}= -17.81, S_{2009}= -0.82, \ldots, S_{2013}=45.03, S_{2014}= -1.82\}.$$

Building F2 (0.004) Prediction Formula

F2 (0.004) is an element of FTSFM 2 (Fuzzy Time Series Forecasting Model 2) and the F2 (0.004) prediction formula was constructed on the basis of the three above-mentioned domains:

$$\xi_i = \frac{0.004+1}{\frac{0.004}{V_{i-1}}+\frac{1}{S_i}}, T_i = U_{i-1}+\xi_i+V_{i-1}, \tag{2}$$

Where: ξ_i is the inverse fuzzy numbers of the year i, V_{i-1} is the difference of tourism number of the year i-1, S_i is the differential-difference of the tourism number of the year i, T_i is the predicted values of the tourist number of the year i, $U_{i-1}$is the tourist number of the year i-1, μ =0.004 is the (Vi's) Membership Degree.

It is obviously to see that the prediction formula is constructed within the framework of the inverse fuzzy numbers.

Applying the F2 (0.004) Forecasting the Tourist Number in Sanya between 2008 and 2014

Applying F2 (0.004) prediction formula (2) calculated the forecasting value of the number of tourists in Sanya from 2008 to 2014 and tested it, then filled in Table 1. It can be seen from Table 1 that the AFER = 0.0339% and the MSE = 0.2221, so the prediction accuracy is higher.

Applying the F1 (0.004) to Forecasting the Tourist Number in Sanya between 2014 and 2015

It is expectant that the tourist number in 2015 can be forecasted from the perspective of the research on data. Because of the lack of the differential-difference of the tourist arrivals in 2015 S_{2015}, the predicted value cannot be directly calculated by using the prediction formula (2). Therefore, it is needed to create F2(0.004) prediction rule on forecasting the unknown year's tourist number in order to fill the missing $S_{2015.}$

F1(3-4-4) Prediction Rule. Set: three years before year i is respectively year i-3, i-2 and i-1, and the differential-difference of each year's historical data is respectively S_{i-3}, S_{i-2} and

S_{i-1}.

Calculate:

$$\delta = \{\max\{S_{i-1}, S_{i-2}, S_{i-3}\} - \min\{S_{i-1}, S_{i-2}, S_{i-3}\}\}/3,$$

Respectively use parameters $V_{\mathbf{i-4}}$ and $S_1 = \min\{S_{i-1}, S_{i-2}, S_{i-3}\}$; $V_{\mathbf{i-3}}$ and $S_2 = \min\{S_{i-1}, S_{i-2}, S_{i-3}\} + \delta$; V_{i-3} and $S_3 = \min\{S_{i-1}, S_{i-2}, S_{i-3}\} + 2\delta$; $V_{\mathbf{i-2}}$ and $S_4 = \max\{S_{i-1}, S_{i-2}, S_{i-3}\}$; and U_{i-1};

Apply F2 (0.004) prediction formula to calculate and the results by ascending order are the small predictive value, smaller predictive value, larger predictive value and large predictive value of the data of the unknown year i. This prediction rule is called F2(3-4-4) prediction rule.

Decision Method for Predicted Value. The first decision method is: the recommend order of small, smaller, larger and large predictive value of the unknown year 2015 is consistent with the ascending order of the prediction error rate between the small, smaller, larger, large predictive value of the historical data in 2014 and the actual value. The second decision method is: the decision-makers select an order relied on their own experience.

Applying the F2(3-4-4) to Calculate the Predicted Value of the Tourist Number in Unknown Year.

Applying the F2(3-4-4) prediction rules to forecast the tourist number in Sanya in the unknown year 2014.

Regarding year 2014 as the unknown year, applying F2(3-4-4) prediction rules forecasted the number of tourist in Sanya in the unknown year 2014. In Table 1, the every-year differential-difference of the historical data between 2011 and 2013 is respectively S_{2011}= -75.18, S_{2012}= -57.27, S_{2013}=45.03.

Table 2. Applying F2(3-4-4) prediction rules to forecast the tourist number in Sanya in 2014.

years	Predicted types	Predicted value in 2014 (10k)	Actual value in 2014 (10k)	$\|T_{2014} - U_{2014}\|/U_{2014}$	Order of the prediction error rate comparing to the actual value
2014	Small predictive value	1331.53	1352.76	1.5694%	4
2014	Smaller predictive value	1354.66	1352.76	0.1405%	1
2014	Larger predictive value	1366.41	1352.76	1.0090%	2
2014	Large predictive value	1371.80	1352.76	1.4075%	3

Calculate

$\delta = \{\max\{S_{2011}, S_{2012}, S_{2013}\} - \min\{S_{2011}, S_{2012}, S_{2013}\}\}/3 = \{45.03 - (-75.18)\}/3 = 40.07$
Respectively use parameters

V_{2010}=213.60 & $S_1 = \min\{S_{2011}, S_{2012}, S_{2013}\}$ = -75.18,
W_{2011}=138.42 & $S_2 = \min\{S_{2011}, S_{2012}, S_{2013}\} + \delta$ = -75.18+40.07= -35.11,
W_{2011}=138.42 & $S_3 = \min\{S_{2011}, S_{2012}, S_{2013}\} + 2\delta$ = -75.18+80.14= 4.96,
W_{2012}=81.15 & $S_4 = \max\{S_{2011}, S_{2012}, S_{2013}\}$ =45.03,

Take U_{2013}=1228.40 and apply F2(0.004) prediction formula (2) to calculate

The values obtained by ascending order are the small, smaller, larger and large predictive value of the number of tourist in the unknown year 2014. As shown in Table 2.

All the calculation and test results of the predicted value of Snaya in the unknown year 2014 were filled in Table 2. According to Table 2, it can be drawn that the prediction error rate between the predicted value and the actual data from small to large is: the first one is the smaller predictive value, the second one is the larger predictive value, the third one is the large predictive value and the last one is the small predictive value. This order is the recommend order of the predicted value in 2015.

Applying F2(3-4-4) Prediction Rules to Predict the Tourist Number of Sanya in the Unknown Year 2015. Regarding year 2015 as the actual unknown year, applying F2(3-4-4) prediction rule forecasted the number of tourist of Sanya in 2015. In Table 1, the every-year differential-difference of the tourist number between 2012 and 2014 is respectively S_{2012}= -57.27, S_{2013}=45.03, S_{2014}= -1.82.

Calculate
$\delta = \{\max\{S_{2012}, S_{2013}, S_{2014}\} - \min\{S_{2012}, S_{2013}, S_{2014}\}\}/3 = \{45.03 - (-57.27)\}/3 = 34.10$
Respectively use parameters

V_{2011}=138.42 & $S_1 = \min\{S_{2012}, S_{2013}, S_{2014}\}$ = -57.27,
V_{2012}=81.15 & $S_2 = \min\{S_{2012}, S_{2013}, S_{2014}\} + \delta$ = -57.27+34.10= -23.17,
V_{2012}=81.15 & $S_3 = \min\{S_{2012}, S_{2013}, S_{2014}\} + 2\delta$ = -57.27+68.20= 10.93,
V_{2013}=126.18 & $S_4 = \max\{S_{2012}, S_{2013}, S_{2014}\}$ =45.03,

Take U_{2014}=1352.76 and apply F2(0.004) prediction formula (2) to calculate

The values obtained by ascending order are the small, smaller, larger and large predictive value of the number of tourist in the unknown year 2015. As shown in Table 3.

Table 3. Applying F2(3-4-4) prediction rules to forecast the tourist number of Sanya in 2015.

Years	Predicted types	Predicted value in 2015 T_{2015}(10k)	Actual value in 2014 U_{2014}(10k)	$\lvert T_{2015} - U_{2014} \rvert / U_{2014}$	Recommend order
2015	Small predictive value	1410.62	1352.76	4.2772%	4
2015	Smaller predictive	1433.59	1352.76	5.9752%	1

2015	value	1444.88	1352.76	6.8089%	2
2015	Larger predictive value Large predictive value	1524.09	1352.76	12.6652%	3

According to the first decision method, the recommend orders can be drawn in the Table 2. The first one is the smaller predictive value at 1433.59 and increase 5.9752% comparing with the value in 2014. The second one is the larger predictive value at 1444.88, growing 6.8089% than that in 2014. The third one is the large predictive value at 1524.09 which rises 12.6652% than that in 2014. The last one is the small predictive value at 1410.62, going up 4.2772% than that in 2014.

As for the second method, the decision-makers need to choose the order on the basis of their own experience.

Conclusion

FTSFM 2 is a collection of fuzzy time-series forecasting model and F2 (0.004) is one of the commonly used forecasting models. F2 (0.004) has historical data for predicting function, but also has forecasting of unknown years capability.

It provides a recommend order for all the predictive value of the unknown year, at the same time, it presents another method which makes the decision-makers do the choice based on their own experience. F2 (0.004) provides a new forecasting model for the study of tourism economic forecasting problems and also the general time series forecasting problems.

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