A Modified Method of Forecasting Enrollments Based on Fuzzy Time Series

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Abstract--- In this essay, we propose a method of forecasting enrollments based on fuzzy time series which is improved by Saxena, Sharma& Easo. Some sections are improved, Such as the setting of universe of discourse, construction of fuzzy set and Inverse fuzzy number, and forecasting formula. We still used the 22 years freshmen's enrollments data of the University of Alabama to illustrate the forecasting process. The result shows that proposed method provide the smallest AFER and MSE.

Keywords-*fuzzy set;fuzzy time series; forecasting; percentage; Inverse fuzzy number*

I. INTRODUCTION

Time series forecasting is widespread used in classical mathematics.Many scholars have acquired great achievements in every field by using Time series forecasting. For example some scholars research Stock Market [3] ~ [5], some research fuzzy data mining for time-series data [6] ~ [8], Li H, Kozma R. who research A dynamic neural network method for time series prediction using the KIII model[9] and so on. Zadeh (1965) publish creativity essay of Fuzzy sets. It may play an important role in research the uncertain fuzzy time series' theory because forecasting problems have some uncertainty. Song and Chissom (1993) propose fuzzy time series and its models and Fuzzy forecasting method have been used to model enrollment data for the University of Alabama[11][12]. Moreover, Song and Chissom(1994) come up with fuzzy time series and its models, Average Forecasting Error Rate (AFER) and Mean Square Error (MSE) to reduce in some extent. Saxena, Sharma and Easo(2012) put forward forecasting formula and used in the same case, as a result, AFER and MSE also reducing. Fuzzy time series forecasting methods are proposed in the literature [14]-[18] and applied to the same case, the results are different. Based on the above work, we propose to modify Saxena, Sharma and Easo's forecasting formula (2012) and gain the new forecasting formula,

applied to the same case, making AFER and MSE become the smallest method in the existing thesis.

II. SOME BASIC KNOWLEDGE

In this paper, we use some basic concepts in literature[1]and literature[14].

III. THE MODIFIED METHOD OF SAXENA, SHARMA AND EASO [1] PROPOSED FORECASTING METHOD BASED ON FUZZY TIME SERIES.

Combined with freshmen's enrollments data of the University of Alabama, proposed the modified method of Saxena, Sharma and Easo [1] come up with forecasting method based on fuzzy time series(A forecasting method of fuzzy time series). Its steps can be drawn as follow:

A. Listed the historical freshmen's enrollments data of university of Alabama

Song and Chissom at first show the historical freshmen's enrollments data of university of Alabama as table1.

B. Calculated the percentage of year by year change rate of historical data

Calculate the percentage of year by year change of freshmen's enrollments data of university of Alabama.This matter is done by Saxena and Sharma and Easo [1], and fill in table1.

C. Established discrete universe of discourse

The percentage of year by year change of freshmen's enrollments data of university of Alabama from 1971 to 1992 as the elements, established discrete universe of discourse. The element in universe of discourse is the percentage of year by year change's historical data from small to large to arrange, established discrete universe of discourse as follow and fill in table1.

$$B = \{b_{1972} = 3.89, b_{1973} = 2.24, b_{1974} = 5.98, b_{1975} = 5.20, b_{1976} = -0.96, b_{1977} = 1.91, \\ b_{1978} = 1.65, b_{1979} = 5.96, b_{1980} = 0.67, b_{1981} = -3.14, b_{1982} = -5.83, b_{1983} = 0.41, \\ b_{1984} = -2.27, b_{1985} = 0.12, b_{1986} = 5.41, b_{1987} = 5.47, b_{1988} = 7.66, b_{1989} = 4.52, \\ b_{1990} = 1.89, b_{1991} = 0.05, b_{1992} = -2.38\}.$$

TABLE 1 THE HISTORICAL ENROLLMENTS' DATA OF UNIVERSITY OF ALABAMA, PERCENTAGE OF YEAR BY YEAR CHANGE, ELEMENT ([1], [10])

year	Enrollments B_i	percentage	element	year	enrollments B_i	percentage	element
1971	13055			1982	15433	-5.83%	-5.83
1972	13563	3.89%	3.89	1983	15497	0.41%	0.41
1973	13867	2.24%	2.24	1984	15145	-2.27%	-2.27
1974	14696	5.98%	5.98	1985	15163	0.12%	0.12
1975	15460	5.20%	5.20	1986	15984	5.41%	5.41
1976	15311	-0.96%	-0.96	1987	16859	5.47%	5.47
1977	15603	1.91%	1.91	1988	18150	7.66%	7.66
1978	15861	1.65%	1.65	1989	18970	4.52%	4.52
1979	16807	5.96%	5.96	1990	19328	1.89%	1.89
1980	16919	0.67%	0.67	1991	19337	0.05%	0.05
1981	16388	-3.14%	-3.14	1992	18876	-2.38%	-2.38

D. Established Inverse fuzzy number of continuous years on discrete universe of discourse B

Here are an inverse fuzzy number of consecutive years of normal distribution as follows:

$$v_i = \begin{cases} \frac{1+0.0002}{\frac{1}{\delta_{1972}} + \frac{0.0002}{\delta_{1973}}}, & i = 1972 \\ \frac{0.0002 + 1 + 0.0002}{\frac{0.0002}{\delta_{i-1}} + \frac{1}{\delta_i} + \frac{0.0002}{\delta_{i+1}}}, & 1973 \leq i \leq 1991, \\ \frac{0.0002 + 1}{\frac{0.0002}{\delta_{1991}} + \frac{1}{\delta_{1992}}}, & i = 1992. \end{cases} \quad (1)$$

E. Established forecasting formula

Applied inverse fuzzy number formula (1) to establish the forecasting formula as follows:

$$F_i = B_{i-1} \times \lambda_i = B_{i-1} \times (1 + v_i \%) \quad (2)$$

F. Forecasting the freshmen's enrollments data of university of Alabama from 1971 to 1992

Applied formula (1) and (2) for freshmen's enrollments data of university of Alabama from 1971 to 1972 to imulate forecasting. It can get the forecasting value of freshmen's enrollments data of university of Alabama from 1971 to 1992 and fill in table2.

TABLE II FORECASTING VALUE OF NEW METHOD

Year	Enrolments B_i	δ_i (%)	$\lambda_i = 1 + \delta_i \%$	Forecasting value F_i	$B_i - F_i$	$(B_i - F_i)^2$	$ B_i - F_i /A_i$
1971	13055						
1972	13563	3.89	1.038894	13563	0	0	0.000000
1973	13867	2.24	1.022422	13867	0	0	0.000000
1974	14696	5.98	1.059779	14696	0	0	0.000000
1975	15460	5.20	1.052068	15461	-1	1	0.000065
1976	15311	-0.96	0.990395	15312	-1	1	0.000065
1977	15603	1.91	1.911082	15604	-1	1	0.000064
1978	15861	1.65	1.016503	15860	1	1	0.000063
1979	16807	5.96	1.059475	16804	3	9	0.000173
1980	16919	0.67	1.006703	16920	-1	1	0.000059
1981	16388	-3.14	0.968561	16387	1	1	0.000061
1982	15433	-5.83	0.941532	15430	3	9	0.000194
1983	15497	0.41	1.004102	15496	1	1	0.000065
1984	15145	-2.27	0.977179	15143	2	4	0.000132
1985	15163	0.12	1.001200	15163	0	0	0.000000
1986	15984	5.14	1.049725	15976	8	64	0.000501
1987	16859	5.47	1.054693	16858	1	1	0.000059
1988	18150	7.66	1.076583	18150	0	0	0.000000
1989	18970	4.52	1.045429	18974	-4	16	0.000211

1990	19328	1.89	1.018784	19326	2	4	0.000103
1991	19337	0.05	1.000501	19338	-1	1	0.000052
1992	18876	-2.38	0.975966	18872	4	16	0.000212
AFER							0.000099
MSE						7	

G. *Testing the forecasting value of freshmen's enrollments data of university of Alabama from 1971 to 1972*

Calculated AFER and MSE, fill in table 2.

IV. A COMPARISON OF DIFFERENT FORECASTING MODELS

Applied this paper's method and different models in

literature[1], [2], [14], [4], [15], [16], [17], We research the forecasting enrollments of University of Alabama . The result shown in table3 (many concepts come from table6 in [1]) ,the better evaluate are Saxena, Sharma & Easo propose the forecasting models in [1] and Stevenson Porter propose forecasting models in[2] & this paper.

TABLE III COMPARISON OF DIFFERENT FORECASTING MODELS [1]

Year	Enroll-ments	This paper's method	Saxena Sharma and Easo[1]	Stevenson Porter[2]	Jilani Burney and Ardil[14]	Chen [15]	Hwang Chen and Lee[16]	Chen [17]	Song and Chssiom[11]
1971	13055	-	-	-	13579	-	-	-	-
1972	13563	13563	13486	13410	13798	-	-	14000	-
1973	13867	13867	13896	13932	13798	-	-	14000	-
1974	14696	14696	14698	14664	14452	14500	-	14000	-
1975	15460	15461	15454	15423	15373	15500	-	15500	14700
1976	15311	15312	15595	15847	15373	15500	16260	16000	14800
1977	15603	15604	15600	15580	15623	15500	15511	16000	15400
1978	15861	15860	15844	15877	15883	15500	16003	16000	15500
1979	16807	16804	16811	16773	17079	16500	16261	16000	15500
1980	16919	16920	16916	16897	17079	16500	17407	16833	16800
1981	16388	16387	16425	16341	16497	16500	17119	16833	16200
1982	15433	15430	15657	15671	15737	15500	16188	16833	16400
1983	15497	15496	15480	15507	15737	15500	14833	16000	16800
1984	15145	15143	15214	15200	15024	15500	15497	16000	16400
1985	15163	15163	15184	15218	15024	15500	14745	16000	15500
1986	15984	15976	15995	16035	15833	15500	15163	16000	15500
1987	16859	16858	16861	16903	17079	16500	16384	16000	15500
1988	18150	18150	17965	17953	17991	18500	17659	16833	16800
1989	18970	18974	18964	18879	18802	18500	19150	19000	19300
1990	19328	19326	19329	19303	18994	19500	19770	19000	17800
1991	19337	19338	19378	19432	18994	19500	19928	19000	19300
1992	18876	18872	18984	18966	18916	18500	15837	19000	19600
AFER		0.0099%	0.34%	0.57%	1.02%	1.52%	2.44%	3.11%	3.11%
MSE		7	9169	21575	41426	86696	226611	321418	407507

V. CONCLUSION

When Song and Chissom proposed the first forecasting model of fuzzy time series in 1993 [11], it is symbol that the theory of fuzzy time series have already been born. Up to now, many literatures and researchers research and develop this theory. Such as literature [1], [2], [3], [11], [12], [13], [14], [15], [16], [17], [18]. This paper modifies the above research and proposed a new forecasting method of fuzzy time series. Thus, this method further reduces AFER and MSE. From the table 3, we can see that this forecasting method's AFER and MSE less than existing method.

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