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A Set of Time Series Prediction Models Based on Difference Method

Xiaoli Lu, Hongxu Wang*, Chengguo Yin and Hao Feng
Hainan Tropical Ocean University, Sanya, Hainan, China, 572022
*Corresponding author

***Abstract*—This paper proposed a set of time series prediction models based on difference method(ASD). For a time series, the computer can automatically find the time series search method to filter out the ideal in ASD prediction model. For example, the forecast number of registered at the University of Alabama in 1971~1992 years, the ideal forecasting model is A_j (0.000003,0.000003), which can make the mean square error MSE=0 and the average prediction error rate AFER=0%, that thoroughly solve the unsatisfactory prediction accuracy of the existing fuzzy time series forecasting model.**

Keywords-differential rate; a set of time series prediction models; ASD's sum of fraction functions K_j (U, V)

I. INTRODUCTION

In year 1993, Song and Chissom[1-4] firstly proposed fuzzy time series prediction model and successfully predicted the number of registered at the University of Alabama in year 1971~1992, based on the fuzzy set theory, but the prediction accuracy is not satisfactory. The registered number is shown in table C, and its distribution map is shown in figure 1, that is actually a time series, which is undulating change radically. method to filter out the ideal in ASD prediction model Aj (0.000003,0.000003), mean square error MSE=0 and the average prediction error rate of AFER=0%, which obtain satisfactory prediction accuracy.

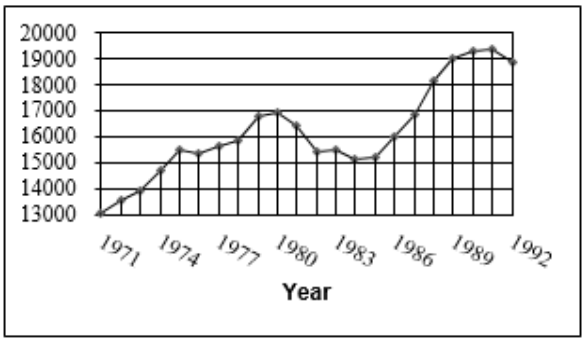

FIGURE I.DISTRIBUTION OF ENROLLMENT NUMBERS OF ALABAMA UNIVERSITY IN 1971~1992

Since then, the fuzzy time series forecasting model are emerging[6-15]. In year 2007, Jilani & Burney & Ardil[4,5] used the concept of de-fuzzification, proposed a fuzzy time series forecasting model, simulated and predicted of the number of registered at the University of Alabama, obtained AFER=1.0242% MSE=41426[5],which forecasting accuracy is the best since 2007, but still unsatisfactory. Affected by this literature, this paper proposed a set of time series prediction models based on ASD's sum of fraction functions K_j (U, V), inverse function H_j (U, V) and prediction function A_j (U, V). This paper also proposed automatic search method and standard time series forecasting model concept. For the registered number of the University of Alabama in year 1971~1992, application of automatic time series search

II. A SET OF TIME SERIES PREDICTION MODELS

Define1: historical data sets W = {W_1, W_2, …, W_n}. The difference of historical data is calculated as $Z_j = W_j - W_{j-1}$, and the difference field of historical data is Z= {Z_2, Z_3, …, Z_n}.

MSE(Mean Square Error): $SME = \frac{1}{n-1}\sum_{j=2}^{n}(W_j - A_j)^2$

AFER (Average Forecasting Error Rate:

$$AFER = \left(\frac{1}{n-1}\sum_{j=2}^{n}\left|W_j - A_j\right| / W_j\right)\times 100\%,$$

A_j is the prediction number in year j.

Define2: For $j \in \{2,3,\ldots,n\}$, and define that($u \in (0,1)$) :

$$K_j(u,v) = \begin{cases} \frac{1}{Z_2} + \frac{v}{Z_3}, & j = 2, \\ \frac{u}{Z_{j-1}} + \frac{1}{Z_j}, & j \in \{3,4,\cdots,n\}. \end{cases} \qquad H_j(u,v) = \begin{cases} \frac{1+v}{\frac{1}{Z_2} + \frac{v}{Z_3}}, & j = 2, \\ \frac{u+1}{\frac{u}{Z_{j-1}} + \frac{1}{Z_j}}, & j \in \{3,4,\cdots,n\}. \end{cases}$$

$$A_j(u,v) = W_{j-1} + H_j(u,v).$$

If u and V are respectively independent variables on specific values within the domain, established a prediction formula of Aj (U, V). which can simulate the historical data to predict the time series.

Define3: If u and V are respectively independent variables on specific values within the domain, many prediction model A_j (U, V) can be obtained, that is a set of time series prediction models based on difference method, abbreviated as ASD.

The general element of ASD is $A_j(u,v)$. $A_j(u,v)$not only represents the prediction formula, but also prediction models.

Define4: If MSE=0 and AFER=0%, which called that the prediction model $A_j(u,v)$ is ideal.

Define5: For a time series, application of computer automatically find the time series standard in ASD prediction model, this method is called automatic searching method. The main steps are: for a time sequence from a decimal as the starting point, programming, search, calculation,... Until the ideal time series prediction model A_j (U, V) is selected out of ASD (AFER=0%, MSE=0)

Example1: Predict registration number of Alabama University in year 1971~1992, from the starting point u=v=0.0003, select u=v=0.0003, u=v=0.00003, u=v=0.000003 successively. By programming, searching, and computing,... Until find the standard ASD model (AFER=0%, MSE=0). When u=v=0.0003, we can get table A, but AFER ≠ 0%, MSE ≠ 0; so continue to search, calculation, get the table B, but AFER ≠ 0%, MSE ≠ 0; continue to search, calculation, get the table C, AFER=0%,MSE=0, terminate the calculation. So A_i (0.000003,0.000003) is an ideal time series forecasting model in ASD when it predicts the number of 1971~1992 registrations at Alabama University.

TABLE I. USING A_J (0.0003,0.0003) TO PREDICT THE NUMBER OF REGISTRATIONS AT ALABAMA UNIVERSITY

Year	Enrollments W_j	Difference Z_j	Forecast A_j	W_j–A_j	$(W_j-A_j)^2$	$\|W_j-A_j\|/W_j$
1971	13055	-	-	-	-	-
1972	13563	508	13563	0	0	0.000000
1973	13867	304	13867	0	0	0.000000
1974	14696	829	14696	0	0	0.000000
1975	15460	764	15460	0	0	0.000000
1976	15311	-149	15311	0	0	0.000000
1977	15603	292	15603	0	0	0.000000
1978	15861	258	15861	0	0	0.000000
1979	16807	946	16806	1	1	0.000059
1980	16919	112	16919	0	0	0.000000
1981	16388	-531	16387	1	1	0.000061
1982	15433	-955	15433	0	0	0.000000
1983	15497	64	15497	0	0	0.000000
1984	15145	-352	15144	1	1	0.000066
1985	15163	18	15163	0	0	0.000000
1986	15984	821	15973	11	121	0.000688
1987	16859	875	16859	0	0	0.000000
1988	18150	1291	18150	0	0	0.000000
1989	18970	820	18970	0	0	0.000000
1990	19328	358	19328	0	0	0.000000
1991	19337	9	19337	0	0	0.000000
1992	18876	-461	18869	7	49	0.000371
AFER						0.0059%
MSE					8.2381	

TABLE II. USING A_J (0.00003,0.00003) TO PREDICT THE NUMBER OF REGISTRATIONS AT ALABAMA UNIVERSITY

ear	Enrollments W_j	Difference Z_j	Forecast A_j	W_j–A_j	$(W_j-A_j)^2$	$\|W_j-A_j\|/W_j$
1971	13055	-	-	-	-	-
1972	13563	508	13563	0	0	0.000000
1973	13867	304	13867	0	0	0.000000
1974	14696	829	14696	0	0	0.000000
1975	15460	764	15460	0	0	0.000000
1976	15311	-149	15311	0	0	0.000000
1977	15603	292	15603	0	0	0.000000
1978	15861	258	15861	0	0	0.000000
1979	16807	946	16807	0	0	0.000000
1980	16919	112	16919	0	0	0.000000
1981	16388	-531	16388	0	0	0.000000
1982	15433	-955	15433	0	0	0.000000
1983	15497	64	15497	0	0	0.000000
1984	15145	-352	15145	0	0	0.000000
1985	15163	18	15163	0	0	0.000000
1986	15984	821	15983	1	1	0.000063
1987	16859	875	16859	0	0	0.000000
1988	18150	1291	18150	0	0	0.000000
1989	18970	820	18970	0	0	0.000000
1990	19328	358	19328	0	0	0.000000
1991	19337	9	19337	0	0	0.000000
1992	18876	-461	18875	1	1	0.000053
AFER						0.0006%
MSE					0.0952	

TABLE III. USING A_J (0.000003,0.000003) TO PREDICT THE NUMBER OF REGISTRATIONS AT ALABAMA UNIVERSITY

Year	Enrollments W_j	Difference Z_j	Forecast A_j	W_j–A_j	$(W_j-A_j)^2$	$\|W_j-A_j\|/W_j$
1971	13055	-	-	-	-	-
1972	13563	508	13563	0	0	0.000000
1973	13867	304	13867	0	0	0.000000
1974	14696	829	14696	0	0	0.000000
1975	15460	764	15460	0	0	0.000000
1976	15311	-149	15311	0	0	0.000000
1977	15603	292	15603	0	0	0.000000
1978	15861	258	15861	0	0	0.000000
1979	16807	946	16807	0	0	0.000000
1980	16919	112	16919	0	0	0.000000
1981	16388	-531	16388	0	0	0.000000
1982	15433	-955	15433	0	0	0.000000
1983	15497	64	15497	0	0	0.000000
1984	15145	-352	15145	0	0	0.000000
1985	15163	18	15163	0	0	0.000000
1986	15984	821	15984	0	0	0.000000
1987	16859	875	16859	0	0	0.000000
1988	18150	1291	18150	0	0	0.000000
1989	18970	820	18970	0	0	0.000000
1990	19328	358	19328	0	0	0.000000
1991	19337	9	19337	0	0	0.000000
1992	18876	-461	18876	0	0	0.000000
AFER						0.0000%
MSE					0	

III. CONCLUSION

For a time series, the application of computer can automatically search ideal prediction model in ASD, in which the MSE=0, AFER=0%. and Table C shows that the A_j (0.000003,0.000003) is the ideal prediction model when predict the registered number at Alabama University in year 1971~1992,which obtain the satisfactory prediction accuracy.

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