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# Forecasting of Rice Production Using Fuzzy Time Series Representation through E-Commerce Website

Mohit Jain[1], Dr. Pankaj Dashore[2]
Computer Science and Engineering, Medicaps Institute of Technology & Management, Indore (MP), India [1, 2]
mohit13_jain@yahoo.com[1], dashorepankaj@gmail.com[2]

***Abstract:*** *Time-Series models are used for predictions in whether forecasting, academic enrollments, rice production etc. The concept of fuzzy time series is introduced by Song & Chissom in 1993. Over the past 24 years, many fuzzy time series methods have been proposed for rice production forecasting, but the forecasting accuracy rate of the existing methods is not good enough. These methods have used actual production, difference of production or percentage change in production as the universe of discourse. And frequency density based partitioning or ratio based partitioning for partition of discourse. This paper, proposed a method based on fuzzy time series, which gives the more accurate result than the existing methods. The proposed method used the actual production as the universe of discourse and mean based partitioning as partition of discourse. To illustrate the forecasting process, the historical data of rice production of University of Agriculture and Technology, India is used.*

***Keywords:*** *fuzzy time series, mean square error, average forecast error rate.*

## I. Introduction

Forecasting plays an important role every day. If there are uncertainties about the future, decision makers need to do forecast. Forecasting is the process for prediction of future outcomes. Decision makers examine the related data and graphs to take the best decisions for the future. The issues of time series forecasting has came into picture for mainly two reasons. First, most of the data existing in business, economic, and financial area are time series. Second, it is very easy to evaluate time series as many technologies are available for evaluation of time series forecast. Various techniques have been developed for time series forecasting in last few decade, but the classical time series technique can not deal with the forecasting issues in which the data of time series are represented by fuzzy sets [1]. To overcome this issue, the concept of fuzzy time series forecasting is given by Song & Chissom in 1993[2]. Fuzzy time series model deals with the both data foam numerical values and fuzzy sets.

Various fuzzy forecasting methods have been developed for different data sets for example enrollment forecasting ([1] - [15]), car fatalities ([16] - [17]), food grain production [18], population forecasting [19] and rice production forecasting [20]. These methods used different values for universe of discourse for example the methods proposed in [3] and [8] used the differences of the enrollments and the method in [10] used the percentage change. And for partition of discourse these models used frequency density petitioning or ratio based partitioning. These fuzzy time series models have also been used to solve different domain problems for example whether forecasting, financial forecasting etc.

The main objective of this paper is to make and implement the fuzzy time series method for rice production forecasting with higher forecast accuracy rate, and comparison of the result with existing forecasting methods.

The basic definitions of fuzzy time series are described in section 2. The new method has developed in section 3 which used the historical data of rice production of University of Agriculture and Technology, India.

Comparison of the result of proposed method with the result of the existing method has done in section 4. Finally the concluding remarks are discussed in section 5.

## II. CONCEPT OF FUZZY TIME SERIES

Definition 1: Fuzzy Set

Fuzzy sets are sets whose elements contain degree of membership.

Let U be the universe of discourse, U= {u1, u2,…, un}, and let A be a fuzzy set in the universe of discourse U defined as follows:

A = fA(u1) / u1 + fA(u2) / u2 +…+ fA(un) / un ,

Where fA is the membership function of A, fA: U → [0, 1], fA(ui) indicates the grade of membership of ui in the fuzzy set A, fA(ui) ϵ [0, 1], and 1≤ i ≤ n, [1].

Definition 2: Time Series

A time series is a collection of sequential data points, measured at successive time span at uniform time intervals.

Definition 3: Fuzzy Time Series

Consecutive sequences of indefinite data are considered as time series with fuzzy data. A time series with fuzzy data is referred to as fuzzy time series. [9]. Let X(t) (t = …, 0, 1, 2, …) be the universe of discourse and be a subset of R, and let fuzzy set fi(t) (i = 1, 2, …) be defined in X(t). Let F(t) be a collection of fi(t) (i=1, 2, …). Then, F(t) is called a fuzzy time series of X(t) (t = …, 0, 1, 2, …)[1].

Definition 4: Time variant and Time-invariant fuzzy time series

Let F(t) be a fuzzy time series and let R(t, t - 1) be a first-order model of F(t). If R(t, t - 1) = R(t - 1, t - 2) for any time t, then F(t) is called a time-invariant fuzzy time series.

If R(t, t - 1) is dependent on time t, that is, R(t, t-1) may be different from R(t - 1, t - 2) for any t , then F(t) is called a time-variant fuzzy time series, [1].

Definition 5: First order model

If F(t) is caused by F(t - 1), denoted by F(t - 1) → F(t), then this relationship can be represented by F(t) = F(t - 1) ₒ R(t, t - 1), where the symbol " ₒ " denotes the Max-Min composition operator; R(t, t – 1) is a fuzzy relation between F(t) and F(t - 1) and is called the first-order model of F(t), [1].

Definition 6: Forecast Error

A forecast error is defined as the difference between the actual value and the forecast value of a time series.

Error = Actual value - forecasted value.

## III. PROPOSED METHOD

This section, proposed a new method for rice production forecasting by using actual production as the universe of discourse and mean based partitioning. The historical data of rice production of University of Agriculture and Technology, India are shown in Table I [20].

The forecasting process follows the following steps:

Step 1: Firstly, define the universe of discourse U and Partition U into equally length intervals.

Step 2: Define fuzzy sets Xi, and apply fuzzification.

Step 3: Apply Forecast and defuzzification on the forecasted output.

**TABLE I.**
THE HISTORICAL DATA OF RICE PRODUCTION [20]

| Year | Production (Kg/hect.) |
|---|---|
| 81-82 | 2730 |
| 82-83 | 2957 |
| 83-84 | 2382 |
| 84-85 | 2572 |
| 85-86 | 2642 |

| | |
|---|---|
| 86-87 | 2700 |
| 87-88 | 2872 |
| 88-89 | 3407 |
| 89-90 | 2238 |
| 90-91 | 2895 |
| 91-92 | 3276 |
| 92-93 | 1431 |
| 93-94 | 2248 |
| 94-95 | 2857 |
| 95-96 | 2318 |
| 96-97 | 2617 |
| 97-98 | 2254 |
| 98-99 | 2910 |
| 99-00 | 3434 |
| 00-01 | 2795 |
| 01-02 | 3000 |

Step 1: Take the historical data of rice production as shown in Table I and define the universe of discourse U for example, assume U=[1400, 3500] and partition it into intervals of equal length. Assume 7 equal intervals shown in Table II. Now find the frequency of each interval.

MEANS OF ORIGINAL DATA AND FREQUENCY OF INTERVALS DATA

| Interval | Number of Data |
|---|---|
| [1400, 1700] | 1 |
| [1700-2000] | 0 |
| [2000-2300] | 3 |
| [2300-2600] | 3 |
| [2600-2900] | 8 |
| [2900-3200] | 3 |
| [3200-3500] | 3 |

Step 2: Split all seven intervals into sub-intervals using mean based partitioning. Define fuzzy set Xi for each sub-interval shown in Table III.

**TABLE II.**
FUZZY INTERVALS USING MEAN BASED PARTITIONING

| Linguistic Variable | Interval |
|---|---|
| $X_1$ | [1400, 1700] |
| $X_2$ | [2000, 2100] |
| $X_3$ | [2100, 2200] |
| $X_4$ | [2200, 2300] |
| $X_5$ | [2300, 2400] |
| $X_6$ | [2400, 2500] |
| $X_7$ | [2500, 2600] |
| $X_8$ | [2600, 2637.5] |
| $X_9$ | [2637.5, 2675] |
| $X_{10}$ | [2675, 2712.5] |
| $X_{11}$ | [2712.5, 2750] |
| $X_{12}$ | [2750, 2787.5] |
| $X_{13}$ | [2787.5, 2825] |
| $X_{14}$ | [2825, 2862.5] |
| $X_{15}$ | [2862.5, 2900] |
| $X_{16}$ | [2900, 3000] |
| $X_{17}$ | [3000, 3100] |
| $X_{18}$ | [3100, 3200] |
| $X_{19}$ | [3200, 3300] |
| $X_{20}$ | [3300, 3400] |
| $X_{21}$ | [3400, 3500] |

Step 3: Apply defuzzification using the Centroid method on the fuzzy sets which are generated in step 2. The defuzzification is shown in Table IV.

## IV. A COMPARISON OF DIFFERENT FORECASTING METHODS

This paper used two parameters to compare result of proposed method with the existing method. First, average forecasting error rate (AFER) and second, mean square error (MSE). The comparison of different forecasting methods shown in Table V:

AFER = (|Ai – Fi | / Ai) / n × 100%

MSE = ( ∑(Ai − Fi) 2 ) / n
i=1 to n

Where Ai denotes the actual population and Fi denotes the forecasting population of year i, respectively. In [20] fuzzy time series method

AFER and MSE comes to 20.83% and 384987.6, respectively, where as for proposed fuzzy time series method has 2.29% and 19198.2381, respectively. Fig1 shows the comparison of different forecasting methods.

**TABLE III.**
FORECASTING RESULT OF THE PROPOSED METHOD

| **Year** | **Production ($A_i$)** | **Fuzzy set** | **Forecast ($F_i$)** | **$A_i$-$F_i$** | **$(A_i-F_i)^2$** | **$\|A_i-F_i\|$ /$A_i$** |
|---|---|---|---|---|---|---|
| 1991 | 2730 | $X_{11}$ | 2450 | 280 | 78400 | 0.1025 |
| 1992 | 2957 | $X_{16}$ | 2950 | 7 | 49 | 0.0023 |
| 1993 | 2382 | $X_5$ | 2350 | 32 | 1024 | 0.0134 |
| 1994 | 2572 | $X_7$ | 2550 | 22 | 484 | 0.0085 |
| 1995 | 2642 | $X_3$ | 2650 | -8 | 64 | 0.0030 |
| 1996 | 2700 | $X_{10}$ | 2690 | 10 | 100 | 0.0037 |
| 1997 | 2872 | $X_{15}$ | 2880 | -8 | 64 | 0.0027 |
| 1998 | 3407 | $X_{21}$ | 3450 | -43 | 1849 | 0.0126 |
| 1999 | 2238 | $X_4$ | 2250 | -12 | 144 | 0.0053 |
| 2000 | 2895 | $X_{15}$ | 2880 | 15 | 225 | 0.0051 |
| 2001 | 3276 | $X_{19}$ | 3250 | 26 | 676 | 0.0079 |
| 2002 | 1431 | $X_1$ | 1550 | -119 | 14161 | 0.0831 |
| 2003 | 2248 | $X_4$ | 2250 | -2 | 4 | 0.0008 |
| 2004 | 2857 | $X_{14}$ | 2840 | 17 | 289 | 0.0059 |
| 2005 | 2318 | $X_5$ | 2350 | -32 | 1024 | 0.0138 |
| 2006 | 2617 | $X_8$ | 2620 | -3 | 9 | 0.0011 |
| 2007 | 2254 | $X_4$ | 2250 | 4 | 16 | 0.0017 |
| 2008 | 2910 | $X_{16}$ | 2950 | -40 | 1600 | 0.0137 |
| 2009 | 3434 | $X_{21}$ | 3450 | -16 | 256 | 0.0046 |
| 2010 | 2795 | $X_{13}$ | 2810 | -15 | 225 | 0.0053 |
| 2011 | 3000 | $X_{16}$ | 2450 | 550 | 302500 | 0.1833 |
| | | | | | MSE = 19198.2381 | AFER = 2.2871% |

**TABLE IV.**
COMPARISON OF DIFFERENT FORECASTING METHODS

| Year | Production | Forecasted Production [32] | Proposed Method |
|---|---|---|---|
| 1991 | 2730 | - | 2450 |
| 1992 | 2957 | 2723 | 2950 |
| 1993 | 2382 | 3011 | 2350 |
| 1994 | 2572 | 2411 | 2550 |
| 1995 | 2642 | 2489 | 2650 |
| 1996 | 2700 | 2711 | 2690 |
| 1997 | 2872 | 2723 | 2880 |
| 1998 | 3407 | 2789 | 3450 |
| 1999 | 2238 | 3250 | 2250 |
| 2000 | 2895 | 2189 | 2880 |
| 2001 | 3276 | 2789 | 3250 |
| 2002 | 1431 | 3217 | 1550 |
| 2003 | 2248 | 1650 | 2250 |
| 2004 | 2857 | 2189 | 2840 |
| 2005 | 2318 | 2789 | 2350 |
| 2006 | 2617 | 2411 | 2620 |
| 2007 | 2254 | 2711 | 2250 |
| 2008 | 2910 | 2146 | 2950 |
| 2009 | 3434 | 3089 | 3450 |
| 2010 | 2795 | 3250 | 2810 |
| 2011 | 3000 | 2789 | 2450 |
| AFER | - | 20.83% | 2.29% |
| MSE | - | 384987.6 | 19198.2381 |

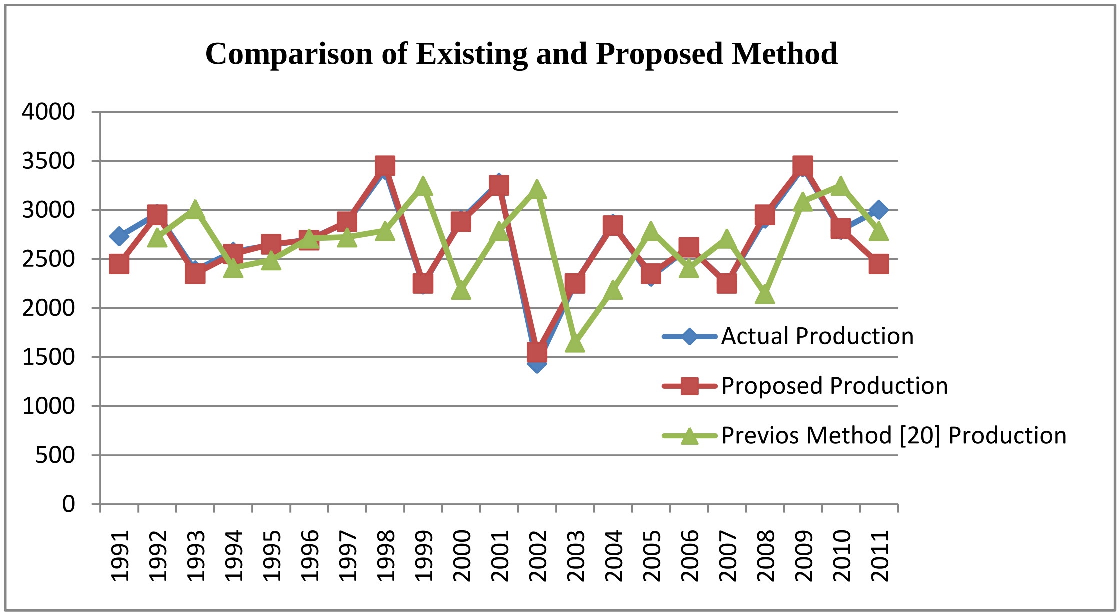


Fig1: Comparison of different forecasting methods


Fig2 :. Representation through E-Commerce Website

## V. CONCLUSION

This paper, proposed a new method with higher forecast accuracy rate. From Table V, it is clear that as the error rate decreases, accuracy rate increases Future work includes the development of new method for different domain with different intervals to get a higher forecasting accuracy.

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