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Forecasting Average Rainfall Model Based on Fuzzy Time Series in Chhattisgarh State

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Abstract

This paper proposes a novel improvement of forecasting approach based on using time invariant fuzzy time series .In recent years many researchers have paid attention to apply fuzzy time series in time series forecasting problems. Songs and chissom (1993) first proposed the seven –step forecasting framework of fuzzy time series which are composed of(1) definition of the universe of discourse, (2) partitioning of universe of discourse,(3) definition of fuzzy sets, (4) fuzzification of crisp time series (5) construction of fuzzy logical relationships from fuzzy time series, (6) forecasting, and (7) defuzzification of its output. On the bases of forecasting results, we can prevent damages to occur or get benefits from the forecasting activities, up to now, many qualitative and quantitative forecasting models were proposed. In the presented paper, we used a new method to forecast the average rainfall of a city of Chhattisgarh state using fuzzy time series approach based on average length of intervals. A visual based programming is used in the implementation of the proposed model. Result obtained demonstrate that the proposed forecasting model can forecast the data effectively and efficiently.

Key Words: Fuzzy time series, forecasting fuzzy sets, Average based length L.

1. Introduction

Forecasting is the process of making statements about event actual outcomes have not yet been observed. A more general term of forecasting is prediction Forecasting plays a notable role in making both crucial and day to day decisions about the future. Weather prediction, stock marketing, production planning and multistage management decision analysis are among distinctive examples of forecasting area where people want to for see, within existing limits ,as closely as possible. It is obvious that forecasting activity play an important role in our daily life. The classical time series method cannot deal with forecasting problem in which values of time series are linguistic terms represented by fuzzy sets. Fuzzy time series allow to overcome this drawback. However the fuzzy time series is limited to linguistic value, and can be used for numerical values too.

Cheng and Hwang (2000) proposed new model to simplify the computational complexity of forecasting process by means of using simple arithmetic operations instead of max-min composition operator on the same set of historical enrollment data. The average forecasting error of Chen's model was 3.23%. Apart from the fact that the result obtained improves a similar figure of Song and Chissom (1994) time variant model, it appear to be more efficient as compared to both time invariant and time variant model of Song and Chissom (1994) in respect to more simple computation.

This paper is devoted to the description of new time –invariant method to deal with forecasting problems. Unlike Songs and Chissom and Chen approaches historical data as fuzzy time series instead of direct usage of raw numeric value.Furthermore, the effect of change in the number of fuzzy sets in the model is investigated.

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2. FUZZY LOGIC

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0). The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s. Fuzzy logic seems closer to the way our brains work. The term fuzzy refers to things which are not clear or are vague. In the real world many times we encounter a situation when we can't determine whether the state is true or false, their fuzzy logic provides a very valuable flexibility for reasoning. In this way, we can consider the inaccuracies and uncertainties of any situation. Fuzzy logic are used in Natural language processing and various intensive applications in Artificial Intelligence. Fuzzy logic are extensively used in modern control systems such as expert systems. Fuzzy Logic is used with Neural Networks as it mimics how a person would make decisions, only much faster. It is done by Aggregation of data and changing into more meaningful data by forming partial truths as Fuzzy sets.

Fuzzy Logic can work with any type of inputs whether it is imprecise, distorted or noisy input information. The construction of Fuzzy Logic Systems given by Zadeh (1975) is easy and understandable. Fuzzy logic comes with mathematical concepts of set theory and the reasoning of that is quite simple. It provides a very efficient solution to complex problems in all fields of life as it resembles human reasoning and decision making. The algorithms can be described with little data, so little memory is required.

3. FUZZY TIME SERIES

In this section briefly summarizes basic fuzzy time series concept The Basic difference between the traditional time series and fuzzy time series is that the observed values of the traditional are real numbers while the observed values of the fuzzy time series are fuzzy sets or linguistic values. In the following, some basic concepts of fuzzy time series are briefly reviewed.

Definition 1: Let $U = \{u_1, u_2, \dots . u_n\}$ be a universe of discourse (universal set); a fuzzy set A of U is defined $A = f_A(u)/u\ f_A(u)/u\ \dots\ f_A(u)/u_n$ where f_A is a membership function of a given set $A, f_A: U \rightarrow [0.1]$.

Definition 2: If there exists a fuzzy relationship $R(t-l,t)$, such that $F(t) = F(t-l) * R(t-l,t)$, where is an arithmetic operator, then $F(t)$ is said to be caused by $F(t-l)$. The relationship between $F(t) and\ F(t-l,t)$ can be denoted by $F(t-l) \rightarrow F(t)$.

Definition 3: Suppose $F(t)$ is calculated by $F(t-l)$ only, and $F(l) = F(t-l), R(t,t-l)$. For any t, if $R(t-1,t)$ is independent of t, then l, then $F(l)$ is considered a time invariant fuzzy time series. Otherwise, $F(t)$is time variant.

Definition 4: Suppose $F(t-l) = Ai\ and\ F(t) = Aj$, a fuzzy logical relationship can be defined as $Ai \rightarrow AjF$ where $Ai\ and\ Aj$are called the left-hand side and the right hand side of the fuzzy logical relationship, respectively.

4. Review of Related words.

Song and chissom (1993) first proposed the seven–step forecasting framework of fuzzy time series. The subsequently forecasting models following songs and chisssom's framework proposed, most of them adopting IF-THEN rules for relationship representation. Li and Kozma (2003) presented a dynamic neural network method for time series prediction using the K III model. su and Li (2003) presented a method for fusing global and local information in predicting time series based on neural networks. sullivan (1994) reviewed the first –order time variant fuzzy time series modeland first –order time invariant fuzzy time series model presented by song and chissom, where their models are compared with eachother and with a time –variant markov model using linguistic labels with probability distributions.However, the forecasting accuracy rates of existing fuzzy time series methods for forecasting enrollments are not good enough. A new method was proposed by Chang and Hwang (2000) to revise song and chissom's method. Average forecasting error is reduced to some extent. The proposed method belongs to the first order and time –variant methods. It can get a higher forecasting accuracy rate.

5. THE PROPOSED FUZZY TIME SERIES ALGORITHM

Algorithm for the fuzzy time series model is as follows

Step 1: Collect the historical data (D_h).

Step 2: Define the universe of discourse Ustarting from variation of the historical enrollment data. Find the maximum D_{max} and the minimum D_{min} among all D_h .Choose two small numbers $D_1\ and\ D_2$ as two proper positive numbers for partition of U . $D_1\ and\ D_2$ forms the lower and upper bounds of U. The universe of discourse U is then defiend by:

$$U = [D_{min} - D_1, D_{max} + D_2] \quad (1)$$

Step 3: Partition U into equally length interval

The length of interval L is computed according to the following steps:

Table 1: Base mapping table

Range	Base
0.1-1.0	0.1
1.1- 10	1
11-100	10
101-1000	100

According to the assigned base, round the length as the appropriate L. Then the number of intervals m is computed according to the assigned base by

$$m = \frac{D_{max} + D_2 - D_{min} + D_1}{l} \quad (2)$$

Then U can be partitioned into equal-length intervals $U = [u_1, u_2, \ldots . u_n]$. Assume that the m intervals are $u_1 = [d_1, d_2] u_2 = [d_2, d_3] \ldots . u_m = [d_m, d_{m+1}]$.

Step 4: Define fuzzy sets from the universe of discourse:

$$A_i = \frac{f_{A1}(u_1)}{u_1} + \frac{f_{A2}(u_2)}{u_2} + \cdots + \frac{f_{Ai}(u_n)}{u_n} \quad (3)$$

Then fuzzify the time series. First determine some linguistic values $A_1, A_2, \ldots A_n$. Second, defined fuzzy sets on U. The fuzzy sets A_i are expressed as follows:

$$A_1 = \frac{1}{u_1} + \frac{0.5}{u_2} + \frac{0}{u_3} + \frac{0.5}{u_4} + \cdots + \frac{0}{u_m}$$

$$A_2 = \frac{0.5}{u_1} + \frac{1}{u_2} + \frac{0.5}{u_3} + \frac{0}{u_4} + \cdots + \frac{0}{u_m}$$

$$A_3 = \frac{0}{u_1} + \frac{0.5}{u_2} + \frac{1}{u_3} + \frac{0.5}{u_4} + \cdots + \frac{0}{u_m}$$

……..

$$A_m = \frac{0}{u_1} + \frac{0}{u_2} + \cdots \frac{0.5}{u_{m-2}} + \frac{1}{u_{m-1}} + \frac{0.5}{u_m}$$

Where $u_1 (i = 1,2, \ldots n)$denote the element and the number mentioned below gives membership of u_i to $A_i (i = 1.2 \ldots \ldots n)$.Degree of the membership of the historical data Y_1 belonging to interval $u_i$can be found by following rules.Expression for the general triangular membership function is given below:

$$A_i \sum_{i=1}^{n} \frac{\mu_{ij}}{u_{ij}} \quad (4)$$

Where u_{ij} is the membership degree of u_i belonging to A_i is given by

$$\mu_{ij} = \begin{cases} 1 & i = j \\ 0.5 & j = i - 1 \; or \; i = 1 \\ 0 & otherwise \end{cases} \quad (5)$$

It is sketched out as follows:

Rule 1: If the historical data Y_i belong to u_v,then membership degree is 1 of u_v is 0.5 of u_2 and otherwise is 0.

Rule 2: If the historical data Y_1belongu_i. $1 < i < n$,Then the membership degree is 1 of u_v is 0.5 of u_{v-12} and u_{1+v}otherwise is 0.

Rule 3: If the historical data Y_1 belong u_i then the membership degree is 1 of u_v is 0.5 of u_{v-12} and otherwise 0.

Step 5: Fuzzify the historical data. If the value of D_h is comes in the range of u_i

Then it takes the fuzzy setsA_i. All D_h must be classified into thecorresponding fuzzy sets.

Step 6. Determine fuzzy logical relationships (FLRs) for all fuzzified data,.

Which shown in Table 1.

Table 1

$A_i \rightarrow A_j$
$A_j \rightarrow A_k$
$A_r \rightarrow A_j$
$A_l \rightarrow A_m$

Step 7. Group fuzzy logical relationship as in step 6 having the same the left-hand sides and the derive fuzzy logical relationships group (FLRG). The fuzzy logical relationship groups are like the following

$$\left.\begin{matrix} A_i A_{j1} \\ A_i A_{j1} \end{matrix}\right\} \Rightarrow A_i \rightarrow A_{j1}, A_{j2}, \ldots \quad (6)$$

Step 8: Calculate the forecasted enrollment which is outlined as follows:

Rule 1: If $F(t) = A_i$ and Group$(A_i) = \emptyset$, then The forecast is m_i the midpoint of u_r and $Forecasting\ value_i = m$.

Rule 2: If the current fuzzy set is A_i and the fuzzy logical relationship group of A_i is one-to-one, i.e, $A_i \rightarrow A_{pl}$, then the forecast is m_{pl}, the midpoint of u_{pl}, and $Forecasting\ value_i = m_{pl}$.

Rule 3: If the current fuzzy set is A_i and the fuzzy logical relationship group of A_i is one-to-many, i.e, $A_i \rightarrow A_{pl}, A_{p2} \ldots . A_{pl}$, then the forecast is equal to the average of $m_{p1}, m_{p2} \ldots m_{p10}$ the midpoint of $u_{p1}, u_{p2} \ldots u_{p10}$ respectively.

$$Forecasting\ value_i = \sum_{x=1}^{k} m_{px} \quad (7)$$

Forecasting Average Rainfall of different cities of a state:-

Table 2 shows that there are 15 observation which is District wise average rain fall in mm for Chhattisgarh state for eight year from 2007-2014.

Table – 2 Historical data of Rainfall

Sl.No.	City	Average Rainfall (mm)
1	Bastar	1338
2	Bilaspur	1177
3	Dantewara	1306
4	Dhamtari	1152
5	Durg	1168
6	Janjgir	1232
7	Jashpur	1223
8	Kanker	1205
9	Korba	1150
10	Koriya	1252
11	Kawardha	904
12	Mahasamund	1250
13	Raigarh	1213
14	Rajnandgaon	1046
15	Surguja	928

Step 1-2 The minimum and maximum of average rainfall are 900 (D min) and 1306 (D max) and $d_1 = 0$ and $d_2 = 44$. The universe of discourse can be defined by $U = [900, 1350], M = 18$, there are M interval, which are

$$u_1 = [900,925], u_2 = [925,950], u_3 = [950,975], u_4 = [975,1000]$$

$$u_5 = [1000,1025], u_6 = [1025,1050], u_7 = [1050,1075], u_8 = [1075,1100]$$

$$u_9 = [1100,1125], u_{10} = [1125,1150], u_{11} = [1150,1175], u_{12} = [1175,1200]$$

$$u_{13} = [1200,1225], u_{14} = [1225,1250], u_{15} = [1250,1275], u_{16} = [1275,1300]$$

$$u_{17} = [1300,1325], u_{18} = [1325,1350],$$

Table -3 The result of Linguistic and Fuzzified Values.

Fuzzified	Linguistic Value
A_1	Very very very very very few
A_2	Very very very very few
A_3	Very very very few
A_4	Very very few
A_5	Very few
A_6	Moderate
A_7	Many
A_8	Many Many
A_9	Many Many Many
A_{10}	Very Many
A_{11}	Too Many
A_{12}	Too Too Many
A_{13}	Too Too Many Many
A_{14}	Too Too Many Many Many
A_{15}	Too Too Too Many Many Many
A_{16}	Too Many Many Many Many
A_{17}	Too Too Many Many Many ManyMany
A_{18}	Too Many Many Many Many Many

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The result of Fuzzy set are:

$$A_1 = \frac{1}{u_1} + \frac{0.5}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7} + \frac{0}{u_8} + \frac{0}{u_9} + \frac{0}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

$$A_2 = \frac{0.5}{u_1} + \frac{1}{u_2} + \frac{0.5}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7} + \frac{0}{u_8} + \frac{0}{u_9} + \frac{0}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

$$A_3 = \frac{0}{u_1} + \frac{0.5}{u_2} + \frac{1}{u_3} + \frac{0.5}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7} + \frac{0}{u_8} + \frac{0}{u_9} + \frac{0}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

$$A_4 = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0.5}{u_3} + \frac{1}{u_4} + \frac{0.5}{u_5} + \frac{0}{u_6} + \frac{0}{u_7} + \frac{0}{u_8} + \frac{0}{u_9} + \frac{0}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

$$A_5 = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0.5}{u_4} + \frac{1}{u_5} + \frac{0.5}{u_6} + \frac{0}{u_7} + \frac{0}{u_8} + \frac{0}{u_9} + \frac{0}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

$$A_6 = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0.5}{u_5} + \frac{1}{u_6} + \frac{0.5}{u_7} + \frac{0}{u_8} + \frac{0}{u_9} + \frac{0}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

$$A_7 = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0.5}{u_6} + \frac{1}{u_7} + \frac{0.5}{u_8} + \frac{0}{u_9} + \frac{0}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

$$A_8 = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0.5}{u_7} + \frac{1}{u_8} + \frac{0.5}{u_9} + \frac{0}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

$$A_9 = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7} + \frac{0.5}{u_8} + \frac{1}{u_9} + \frac{0.5}{u_{10}} + \frac{0}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

$$A_{10} = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7} + \frac{0}{u_8} + \frac{0.5}{u_9} + \frac{1}{u_{10}} + \frac{0.5}{u_{11}} + \frac{0}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

$$A_{11} = \frac{0}{u_1} + \frac{0}{u_2} + \frac{0}{u_3} + \frac{0}{u_4} + \frac{0}{u_5} + \frac{0}{u_6} + \frac{0}{u_7} + \frac{0}{u_8} + \frac{0}{u_9} + \frac{0.5}{u_{10}} + \frac{1}{u_{11}} + \frac{0.5}{u_{12}} + \frac{0}{u_{13}} + \frac{0}{u_{14}} + \frac{0}{u_{15}} + \frac{0}{u_{16}} + \frac{0}{u_{17}} + \frac{0}{u_{18}}$$

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$$A_{12} = \frac{0}{u_1}+\frac{0}{u_2}+\frac{0}{u_3}+\frac{0}{u_4}+\frac{0}{u_5}+\frac{0}{u_6}+\frac{0}{u_7}+\frac{0}{u_8}+\frac{0}{u_9}$$

$$\frac{0}{u_{10}}+\frac{0.5}{u_{11}}+\frac{1}{u_{12}}+\frac{0.5}{u_{13}}+\frac{0}{u_{14}}+\frac{0}{u_{15}}+\frac{0}{u_{16}}+\frac{0}{u_{17}}+\frac{0}{u_{18}}$$

$$A_{13} = \frac{0}{u_1}+\frac{0}{u_2}+\frac{0}{u_3}+\frac{0}{u_4}+\frac{0}{u_5}+\frac{0}{u_6}+\frac{0}{u_7}+\frac{0}{u_8}+\frac{0}{u_9}$$

$$\frac{0}{u_{10}}+\frac{0}{u_{11}}+\frac{0.5}{u_{12}}+\frac{1}{u_{13}}+\frac{0.5}{u_{14}}+\frac{0}{u_{15}}+\frac{0}{u_{16}}+\frac{0}{u_{17}}+\frac{0}{u_{18}}$$

$$A_{14} = \frac{0}{u_1}+\frac{0}{u_2}+\frac{0}{u_3}+\frac{0}{u_4}+\frac{0}{u_5}+\frac{0}{u_6}+\frac{0}{u_7}+\frac{0}{u_8}+\frac{0}{u_9}$$

$$\frac{0}{u_{10}}+\frac{0}{u_{11}}+\frac{0}{u_{12}}+\frac{0.5}{u_{13}}+\frac{1}{u_{14}}+\frac{0.5}{u_{15}}+\frac{0}{u_{16}}+\frac{0}{u_{17}}+\frac{0}{u_{18}}$$

$$A_{15} = \frac{0}{u_1}+\frac{0}{u_2}+\frac{0}{u_3}+\frac{0}{u_4}+\frac{0}{u_5}+\frac{0}{u_6}+\frac{0}{u_7}+\frac{0}{u_8}+\frac{0}{u_9}$$

$$\frac{0}{u_{10}}+\frac{0}{u_{11}}+\frac{0}{u_{12}}+\frac{0}{u_{13}}+\frac{0.5}{u_{14}}+\frac{1}{u_{15}}+\frac{0.5}{u_{16}}+\frac{0}{u_{17}}+\frac{0}{u_{18}}$$

$$A_{16} = \frac{0}{u_1}+\frac{0}{u_2}+\frac{0}{u_3}+\frac{0}{u_4}+\frac{0}{u_5}+\frac{0}{u_6}+\frac{0}{u_7}+\frac{0}{u_8}+\frac{0}{u_9}$$

$$\frac{0}{u_{10}}+\frac{0}{u_{11}}+\frac{0}{u_{12}}+\frac{0}{u_{13}}+\frac{0}{u_{14}}+\frac{0.5}{u_{15}}+\frac{1}{u_{16}}+\frac{0.5}{u_{17}}+\frac{0}{u_{18}}$$

$$A_{17} = \frac{0}{u_1}+\frac{0}{u_2}+\frac{0}{u_3}+\frac{0}{u_4}+\frac{0}{u_5}+\frac{0}{u_6}+\frac{0}{u_7}+\frac{0}{u_8}+\frac{0}{u_9}$$

$$\frac{0}{u_{10}}+\frac{0}{u_{11}}+\frac{0}{u_{12}}+\frac{0}{u_{13}}+\frac{0}{u_{14}}+\frac{0}{u_{15}}+\frac{0.5}{u_{16}}+\frac{1}{u_{17}}+\frac{0.5}{u_{18}}$$

$$A_{18} = \frac{0}{u_1}+\frac{0}{u_2}+\frac{0}{u_3}+\frac{0}{u_4}+\frac{0}{u_5}+\frac{0}{u_6}+\frac{0}{u_7}+\frac{0}{u_8}+\frac{0}{u_9}$$

$$\frac{0}{u_{10}}+\frac{0}{u_{11}}+\frac{0}{u_{12}}+\frac{0}{u_{13}}+\frac{0}{u_{14}}+\frac{0}{u_{15}}+\frac{0}{u_{16}}+\frac{0.5}{u_{17}}+\frac{1}{u_{18}}$$

Step 6-7: Table 4 shows the derived fuzzy relationship and fuzzy logical relationship group are shown in Table 5.

Table 4 Derived Fuzzy Relationship

$A_{18} \rightarrow A_{12}$	$A_{13} \rightarrow A_{10}$
$A_{12} \rightarrow A_{17}$	$A_{10} \rightarrow A_{15}$
$A_{17} \rightarrow A_{11}$	$A_{15} \rightarrow A_{1}$
$A_{11} \rightarrow A_{11}$	$A_{1} \rightarrow A_{14}$
$A_{11} \rightarrow A_{14}$	$A_{14} \rightarrow A_{13}$
$A_{14} \rightarrow A_{13}$	$A_{13} \rightarrow A_{6}$
$A_{13} \rightarrow A_{13}$	$A_{6} \rightarrow A_{2}$

Table 5: Fuzzy Logical Relationship Groups (FLRG)

Group	Fuzzy Logical Relationship
1.	$A_{18} \rightarrow A_{12}$
2.	$A_{12} \rightarrow A_{17}$
3.	$A_{17} \rightarrow A_{11}$
4.	$A_{11} \rightarrow A_{11}, A_{14}$
5.	$A_{14} \rightarrow A_{13}$
6.	$A_{13} \rightarrow A_{13}, A_{10}, A_{6}$
7.	$A_{10} \rightarrow A_{15}$
8.	$A_{15} \rightarrow A_{1}$
9.	$A_{1} \rightarrow A_{14}$
10	$A_{6} \rightarrow A_{2}$

Step 8 All forecasted interval and errors will be calculated as shown in Table 6,

$$Forecasting\ error\ Percentage\ \frac{|Actual - predicted|}{Actual} X100$$

Table 6: Historical, Forecasted and error value

District	**Historical data (y_i)**	**Predicted data ($\hat{y}_i$)**	**Forecasted Error**
Bastar	1338	1187.5	11.28
Bilaspur	1177	1312.5	11.51
Dantewara	1306	1162.5	10.9
Dhamtari	1552	1200	4.16
Durg	1168	1162.5	0.5
Jangir	1232	1212.5	1.5
Jashpur	1223	1145.8	6.30
Kanker	1205	1212.5	0.62
Korba	1150	1262.5	0.09
Koriya	1252	1262.5	0.079
Kawardha	904	912.5	0.9
Mahasamund	1250	1237.5	0.01
Raigarh	1213	1212.5	0.00
Rajnandgaon	1046	937.5	10.37
Surguja	928	937.5	0.00

Average Forecasting Error (AFER)=9.8%.

Mean Absolute Deviation (MAD):-

MAD is the size of overall Forecasting error for a model. The MAD value is calculated by the sum of the absolute value of the forecasting divided by the number of data period.

$$MAD = \frac{\sum|Actual\ value - predicted\ valued|}{n}$$

= 57.33

Root Mean Square Error (RMSE): RMSE is a quadratic scoring rule that also measures the average magnitude of the error it's the square root of the average of square difference between prediction and actual observation.

$$RMSE = \sqrt{\frac{1}{n}\sum_{j=1}^{n}(y_i - \hat{y}_i)^2}$$

= 79.81

From the above results, it is found that all the forecasted values are very close to the actual values and Mean absolute Deviation and Root Mean Square error is also appreciable. This confirms that the model gives good forecasting result which can be further used for forecasting rainfall.

Conclusion

In this paper, we presented a novel similarity measure for fuzzy time series based on average length of intervals. The forecasting ability is better than traditional forecasting methods of chen and Hwang (2000), chen (2002) huarng(2001), hwang chen lee (1998) and Lee hwang chen (1998) in the area of forecasting average rainfall .It has been successfully implemented to the forecasting of the average rainfall of a district of Chhattisgarh state. Result obtained demonstrate the effectiveness of the proposed model compared to previous work in accuracy and simplicity. We see that AFER, MAD and RMSE of the forecasting result of proposed method is smaller than previous existing methods. Future work involves applying proposed method to deal with more complicated problems and extending it to handle problems of multi-dimensional fuzzy Time series.

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