FORECASTING USING NEURAL NETWORK AND FUZZY TIME SERIES: A RELATIVE STUDY USING SUGAR PRODUCTION DATA

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ABSTRACT

This paper reflects a neural network approach together with the methods of fuzzy time series of forecasting sugar production data.On behalf of forecsaters , time series forecasting that have varied variations is an important issue.One of the such process is the agriculture production and its productivity and it is not hold by an stoichastic process because of great non-linear due to great non-linear due to different effective parameters like rainfall, disaster, disease, weather etc. This study comprises of fuzzy set theory and uses various models of fuzzy time series for forecasting the sugar production.From FCI , the sugar production past data have been gathered for investigation of the outcomes.Comparison and examination has been done of the sugar production forecasted data.

Keywords: ANN, DSS, Fuzzy Time Series, Fuzzy Set, Forecasting, High Order Model, Production Linguistic Value.

I. INTRODUCTION

Time Series analysis contribute techniques for examining time series data in order to extricate correct statistics and various characteristics of the data.Time series analysis can be excercised to continuous data , real valued and discrete numeric data that are drawn by different methods like integrated moving average , moving average , regression analysis etc. One of the process is of sugar production, which is not observed by stoicism process due to great invariability because of different perceptual production parameters as cultivation area , diseases , disaster etc. Next to textile industry, second largest is the Indian sugar. Similarly, largest consumer of sugar is India.Bagasse and mollases are some of the other generated sweeting products. The current approach is to relate fuzzy time series model, its implementation, testing and comparison of the outcome of different forecasting models. Zadeh introduced fuzzy logic and fuzzy set theory which gives a method for handling unpredictability and ambiguity of data in linguistic terms. Song and Chissom introduced first model on the basis of fuzzy set theory to deploy techniques for fuzzy time series forecasting and bothered the hindrance of forecasting enrollments on the time series data. The major obstacle in fuzzy time series forecasting is the correctness in forecast with the high order fuzzy time series model . This work is analyzing different models and reflects its applicability in the area of agriculture production . The aim of implementing the forecasting model of fuzzy time series is to identify steps of modelling the divination of crop yield i.e. based on different factors.

II. ARTIFICIAL NEURAL NETWORKS

Neural networks have been related to time-series prognostication since many years from forecasting stock prices and point out tasks for analyzing the expansion of tree rings. In substance all anatomy of time series prediction are conceptually alike. The given data **X**= **X**(τ) it differs as a function of time τ, it is practical to learn the function which maps **X**τ+1=**X**τ. Feed-forward networks can be registered straightly to the issues of this pattern in relation that the data is processed apriori. Assume a single variable *x* it differs with time, a customary commence is to sample *x* at equal time intervals to furnish a series of examination *X*τ-2, *X*τ-1,*X*τ and so on. Thus we can collect such observations and reflect them as the input vector and use examination *X*τ+1 as the targeted value. By moving along the time axis ,considering a single sample at a time we can frame the training set for the issue At once we have trained the network we should then be able to reflect an another vector *X'*τ-2, *X'*τ-1, *X'*τ and assume *X'*τ+1. Thus known as *one step ahead* prediction.

2.1 Neural Network Topologies [13]

(A). Feedforward neural network: The simplest of all the ANN is the feedforward. According to this type of network, there are input nodes then hidden nodes and finally output nodes and thus output is received from output nodes. This is free from loops and cycles. Processing can be extended till hierarchichal units but no reversible connections are there.

(B). Recurrent network: Feedback of connections are contained in recurrency of neural network. Recurrency of neural network are bidirectional model of data flow, unlike feedforward network. The data is processed linearly to output from input in feedforward network but in recurrency of neural network data is processed from later to earlier processing stages.

2.2 Training of Artificial Neural Networks [13]

Configuration of neural network directly or via a relaxation process produce a set of desired outputs. A method to set connection strength is to set weight explicitly using prior knowledge . Another approach to train the neural network is by feeding its teaching pattern and allowing it to change weights as per some learning rule.. Classification of learning situations is follows:

(a).*Supervised learning* or Associative learning in which training of network by providing matching input output patterns. These pairs are provided either by system containing neural network .

(b*).Unsupervised learning* or Self-organization in which an (output) unit is prepared to react to clusters of series within the input. In this area , the system is supposed to determine statistically main characteristics of the input population. Apart of supervised learning area, there is no a priori set of classification into which the series are to be characterized; relatively the system must deploy its individual presentation of the input stimuli.

(c). Reinforcement Learning: In this the learning may be defined as a middle type of the above two classification of learning. In this, the learning machine perform some action on the environment and gets a assessment response from the environment. The learning system rank its action nice (rewarding) or poor (punishable) on the basis of the environmental outcome and relatively adjusts the parameters.

III. FUZZY TIME SERIES

3.1 Fuzzy Set Theory

In the fuzzy set theory, the participation of an individual in a fuzzy set is a concern of degree . A function which allocates to each element a number in the closed unit interval [0, 1] which categorize the degree of membership of the element is called membership function where classical relations define only the presence of association between elements of two sets. Strength of association can be done by fuzzy sets.

3.2 Fuzzy Time Series

Here, the fuzzy relationship will be employed to demonstrate fuzzy time series. Accordingly, the values of fuzzy time series are fuzzy sets .There is also an association between the observations at time t and at previous times. At different times of observations, fuzzy relation is developed in three different scenario, in this forecasting have been done on the basis of time series data for the agricultural production.

3.3 Basics of fuzzy time series

Different properties and definitions of fuzzy time series forecasting seen in various papers and reproduced as follows:

Definition 1. With a continuum of grade of membership, a fuzzy set is a class of objects. Assume U be the universe of discourse , $U= \{u1, u2, u3, . . . un\}$,where ui are linguistic values of U, so a fuzzy set of linguistic variables Ai of U is described by

$Ai = \mu Ai\ (u1)/u1+ \mu Ai\ (u2)/u2+ \mu Ai\ (u3)/u3 + . . . + \mu Ai\ (un)/un$ where μAi is the membership function of the fuzzy set Ai, such that $\mu Ai : U = [0, 1]$. If uj is the member of Ai, then $\mu Ai\ (uj)$ is the degree of belonging of uj to Ai.

Definition 2. Assume $Y(t)$ ($t = . . ., 0, 1, 2, 3, . . .$), as a subset of R, be the universe of discourse on which fuzzy sets $fi(t)$ (i=1, 2, 3, . . .) defined , $F(t)$ is the combination of fi, thus $F(t)$ is defined as fuzzy time series on $Y(t)$.

Definition 3(a). Assume $F(t)$ is because only by $F(t-1)$ and is denoted as $F(t-1)\rightarrow F(t)$; thus there is a fuzzy relationship between $F(t-1)$ and $F(t)$ which can be expressed follows: $F(t) = F(t - 1) * R(t, t - 1)$
where " * " is max–min composition operator.
Moreover, if fuzzy relation $R(t, t-1)$ of $F(t)$ is free of time t, i.e. to say at different times $t1$ and $t2$, $R(t1,t1 -1) = R(t2, t2 -1)$, thus $F(t)$ is known a time invariant fuzzy time series.

Definition 3(b). When $F(t)$ is caused by more fuzzy sets,then $F(t-n)$, $F(t-n + 1)$, . . ., $F(t-1)$, the fuzzy relationship is shown as $Ai1, Ai2, . . . , Ain \rightarrow Aj$
where $F(t-n) = Ai1$, $F(t-n+1) = Ai2$, . . ., $F(t-1) = Ain$. The relationship is known as nth order fuzzy time series model.

Definition 4. Assume $F(t)$ is caused by an $F(t-1)$, $F(t-2)$, . . ., and $F(t-m)$ ($m> 0$) the relations are time variant. The $F(t)$ is known as time variant fuzzy time series and the relation can be represented as the fuzzy relational equation: $F(t) = F(t - 1) * Rw(t, t - 1)$
where $w > 1$ is a time (number of years) parameter by which the forecast $F(t)$ has impact.

IV. SUGAR PRODUCTION FORECASTING

4.1 Computational Steps by Fuzzy Time Series

The simulation of the above mentioned algorithm is on the basis of 22 years (1988-89 to 2009-10) time series production data of FCI.

Step 1. To adapt the time series data describe the universe of discourse. Dmin and Dmax productions are required. So, universe of discourse U is described as [Dmin – D1, Dmax - D2], where D, and D2 are two proper positive numbers. According to the current scenario of production forecasting universe of discourse computed as U = [80 , 290]

Step 2. The universes of discourse is divided into 7 equal length intervals U1, U2,...., U7 as U1 = [80-110], U2=[110-140], U3=[140-170], U4=[170-200], U5= [200-230], U6=[230-250], U7=[260-290].

Step 3. Describe seven fuzzy sets A1, A2, ..., A7 having few linguistic values on the universe of discourse U . Linguistic values are as follows:

A1: bad production,

A2: less than average production

A3: average production

A4: good production

A5: great production

A6: superb production

A7: enormous production

According to different intervals,the fuzzy set in respect of its membership are expressed as follows:

A1 : [1/u1,.5/u2,0 u3,0/u4,0/u5,0/u6,0/u7]

A2 : [.5/u1,.l/u2,.5/u3,0/u4,0/u5,0/u6,0/u7]

A3 : [0/u1,.5/u2,l/u3,.5/u4,0/u5,0/u6,0/u7]

A4 : [0/u1,0/u2,.5/u3,1/u4,.5/u5,0/u6,0/u7]

A5 : [0/u1,0/u2,0/u3,.5/u4,l/u5,.5/u6,0/u7]

A6 : [0/u1,0/u2,0/u3,0/u4,.5/u5,l/u6,.5/u7]

A7 : [0/u1,0/u2,0/u3,0/u4,0/u5,.5/u6, l/u7]

Step 4. According to the fuzzy input for various models the time series data are shown in table 1:

Step 5. For various models ,the logical relations have been gathered.

Fuzzy Relationships

$A_1 \rightarrow A_1$, $A_1 \rightarrow A_2$, $A_1 \rightarrow A_1$, $A_1 \rightarrow A_3$,

$A_2 \rightarrow A_4$,$A_2 \rightarrow A_2$, $A_2 \rightarrow A_2$, $A_2 \rightarrow A_1$, $A_2 \rightarrow A_2$,$A_2 \rightarrow A_3$

A3→ A3, A3→A2, A3→A4, A3→A4

A4→ A4, A4→A4, A4→A5, A4→A6

A5→ A2, A6→A7, A7→A3

Groups are as follows:

A1→ A1A1A2A3

A2→ A1A2A2A2A3A4

A3→ A2A3A4A4

A4→ A4 A4A5 A6

A5→ A2

A6→ A7

A7→ A3

According to chen[1] higher order model,FLR group second order is as follows:

A1A1→ A2

A1A2→ A2

A2A2→ A1

A2A1→ A1

A1A1→ A3

A1A3→ A3

A3A3→ A2

A3A2→ A2

A2A2→ A3

A2A3→ A4

A3A4→ A4

A4A4→ A4

A4A5→ A2

A5A2→ A2

A2A2→ A4

A2A4→ A6

A4A6→ A3

A6A7→A3

A7A3→ A4

According to chen[1] higher order model,FLR group second order is as follows:

#A1A1→A2

A1A1A2→ A2

A1A2A2→ A1

A2A2A1→ A1

A2A1A1→ A3

A1A1A3→ A3

A1A3A3→ A2

A3A3A2→ A2

A3A2A2→ A3

A2A2A3→ A4

A2A3A4→ A4

A2A3A4→A4

A3A4A4→ A4

A4A4A4→ A5

A4A4A5→ A2

A4A5A2→ A2

A5A2A2→ A4

A2A2A4→ A6

A2A4A6→ A7

A4A6A7→ A3

A6A7A3→ A4

A7A3A4→ #

According to chen[1] higher order model,FLR group second order is as follows:

#A1A1A2→ A 2

A1A1A2A1→ A1

A1A2A2A1→ A1

A2A2A1A1→ A3

A2A1A1A3→ A3

A1A1A3A3→ A2

A1A3A3A2→ A2

A3A3A2A2→ A3

A3A2A2A3→ A4

A2A2A3A4→ A4

A2A3A4A4→ A4

A3A4A4A4→ A5

A4A4A4A5→ A2

A4A4A5A2→ A2

A4A5A2A2→ A4

A5A2A2A4→ A6

A2A2A4A6→ A7

A2A4A6A7→ A3

A4A6A7A3→ A4

A6A7A3A4→ #

According to chen[1] higher order model,FLR group second order is as follows:

#A1A1A2A2→ A1

A1A1A2A2A1→ A1

A1A2A2A1A1→ A3

A2A2A1A1A3→ A3

A2A1A1A3A3→ A2

A1A1A3A3A2→ A2

A1A3A3A2A2→ A3

A3A3A2A2A3→ A4

A3A2A2A3A4→ A4

A2A2A3A4A4→ A4

A2A3A4A4A4→ A5

A3A4A4A4A5→ A2

A4A4A4A5A2→ A2

A4A4A5A2A2→ A4

A4A5A2A2A4→ A6

A5A2A2A4A6→ A7

A2A2A4A6A7→ A3

A2A4A6A7A3→ A4

A4A6A7A3A4→ #

Sugar Year	**Sugar production in Lakh Tons**	**Fuzzy Production**
1988-1989	87.52	A1
1989-1990	109.89	A1
1990-1991	120.47	A2
1991-1992	134.11	A2
1992-1993	106.09	A1
1993-1994	98.24	A1
1994-1995	146.43	A3
1995-1996	164.29	A3
1996-1997	129.05	A2
1997-1998	128.44	A2
1998-1999	154.52	A3
1999-2000	181.93	A4
2000-2001	185.1	A4
2001-2002	184.96	A4
2002-2003	201.32	A5
2003-2004	139.58	A2
2004-2005	130	A2
2005-2006	191	A4
2006-2007	257.54	A6
2007-2008	263	A7
2008-2009	147	A3
2009-2010	188	A4

Table 1 Sugar Production Data's Fuzzification

Step 6:-Calculation of fuzzy forecast of the sugar production have been forwarded by the four different models: Chen[2](Model-1) ,Huang[3](Model-2),S.R. Singh[6] (Model-3) and Chen higher order[1] (Model-4) .

Step 7. Defuzzification is the reversal of Fuzzification.In this process , fuzzy output of model is metamorphose to crisp values for receiving the forecasted values.

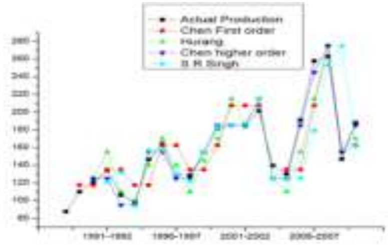

Fig.1 Comparison of Actual and Forecasted Sugar Production by Varios Models

In Fig. 1 we can notice that according to different intervals there are wide ups and downs in sugar production. In cthe scenario of sugar production, same forecast is being reflected by four varius models.We can see in fig 1 that model4 is in close with the actual production while remaining models comprises of large variations.

4.2 Calculative Steps by Artificial Neural Network

Step-by-step for forecasting of neural network:

1. Mention the input instructions (viz. those (Z1, Z2, Z3 …., Zn) ethereal instructions which straightforwardly affect the crop production .
2. Assemble the production data of t years and past years.
3. Tune the production data such that all the value must be in the range of 0 and 1.
4. Form the Artificial Neural Network (ANN) with the remuneration of number of layers.hidden layers and neurons.
5. Choose the most effective training algorithm for ANN.
6. In consideration of the problem describe the transfer function for different layers.
7. Select the number of span and objective for ANN.
8. Choose the procedural tool to note the simulator for the suggested neural network.
9. Then train the ANN in collection with the production data of previous ‘ n’ years for selected instructions (Z1, Z2 , Z3 …., Zn) and actual productions (P(t-1), P(t-2), P(t-3),…….., P(t-m)) .
10. When the ANN is trained for the aim then use the test procdure for the years t + 1, t + 2, t+ 3 ……. t+p .The output of ANN is collected.
11. Perform the relative study with models of fuzzy series forecasting.
12. Perform the error analysis with notified forecasted and actual values to verify the model.

This concept is fine for multi-valued data in which we can notice that what all parameters are affecting the data and what all parameters will help for training,thus this concept is lenghty and not appropriate for a parameter data. Contrary to this, if we have a number of parameter which affects the production thus it will surely reflects great outcomes in comparison to methods of fuzzy time series. In this paper we are explaining steps for the forecasting of sugar production with the help of ANN

V. COMPARITIVE STUDY OF FORECASTING RESULTS

Here, we contrast the results of different forecasting methods on past data of sugar production. A relation of mean square errors (MSE) with various procedures is given in table ,where the mean square error (MSE) is shown below:

MSE=∑ (Actual Production –Forecasted Production)^2/n

Where i=1 to n,

	S.R.Singh[5]	Chen Higher order[1]	Chen [2]	Huarng[3]
MSE	1534.12	63.45	562.78	329.05

Table 2 Relation of MSE

VI. CONCLUSION

The inducement of the application of fuzzy time series in various crop production forecast is to reinforce the expansion of DSS in agricultural production system, one of the actual life issue lies in the group having unpredictability in open and hidden parameters. The previous experiences disclose that the agricultural production system is a multiplex process and tough to model by the statistical formulations, in concern with even all the excellence practices of cropping are inherited; the unpredictability comes in the crop production because of few uncontrolled parameters. Moreover, the sugar production being inflict with the field data, accuracy of data is consistently an impotant issue. The previous time series crop production data used in the current study is gathered from Food Corporation of India. An another scenario was to make a contrast between different techniques of fuzzy time series and neural network method. It is perceived that it gives better results than methods of fuzzy time series As seen in neural network elucidation is done by ANN,thus neural network is considered as objective in comparison to methods of fuzzy time series. It can simply control the imprecision and any degree of intermittent in the data.

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