Consolidation Of Soft Computing Approaches For Predictingthe Wheat Yield In India

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Abstract— this paper prognosticates the production of wheat crop by developing a hybrid model through the combination of soft computing approaches. This material illustrates a brief study on the time series forecasting to predict the future data on the basis of the previous year data. The proposed model has been developed with the combination of Statistical Equations, Artificial Neural Network (ANN) and Genetic Algorithm (GA) to speculate the wheat production and to get more explicit outcomes. This model has been tested on the wheat production data of India from 1980 to 2018. Thereafter, by using statistical error computing techniques like Mean Square Error (MSE), Root Mean Square Error (RMSE) and Average Error, the Prediction Performances have been evaluated. It has been observed that due to the use of our proposed model compared to the Standalone Soft Computing, error prediction decreased.

Keyword —Statistical Equations, Artificial Neural Network (ANN), Genetic Algorithm (GA), Root Mean Square Error (RMSE), Mean Square Error (MSE) and Average Error.

1 INTRODUCTION

After rice, wheat is an important cereal in India. This grain is mainly cultivated in the middle and western part of India. But the productivity of the wheat crop is not enough to feed India's huge population. Latest technology has an increasing effect on the growth of wheat production but still no fruitful results are seen.Like other agricultural products, wheat yield is also sensitive to multiple factors, which often relate to each other, directly and indirectly influence the crop production. Environmental factors, technological factors, plant variety, fertilizer's level are often considered.

By using different types of plant yield models, production performance can be optimized and stimulated. Accordingly, plant yield models may emerge the prognostic tools which can be a significant component of the precision farming and a vital component of Decision Support System (DSS).Recently, the use of Soft Computing analysis in the agricultural sector has increased.This often provides better analytical results compared to the classical statistical methods. Here, we have proposed ahierarchical non-linear regressive framework to determine the relationship between the crop yielding and sowing [7].

According to the above description, it appears necessary to attempt a research in order to get an optimum wheat yield assessment and prediction model through the soft computing assessment techniques which have not been developed yet. Thence, the following pilot study has been attempted to develop such model and to analyze it.The main goal of this paper is to structure a hybrid model byamplifyingthe precisenessof the projectionand extrapolationof the wheatcrop data. This new method is used on secondary time series data of wheatyield in India [3].

The reliabilityand consistencyof this estimationdepends on time series data.In agronomy, latesttechnologies are applied in time series data to analysis and predict the upcomingresults on the basis of past data [1, 2].In Soft Computing, the Artificial Neural Network (ANN) is a frequently used method for forecasting in different fields of finance, education, production and agriculture [4]. The learning algorithm, like back-propagation algorithm, adjusts the network's weights and biases by calculating gradient of the error and then forecasts the error backward by the network to modify the weights and biases [5].Here, Artificial Neural Network is used to determine and to forecastthebuildingcost index for concreting structures on the basis of past records [6]. By using Population, Gross Domestic Product (GDP)and Vehicle-Km,the Genetic Algorithm Transport Energy Demand Estimation model has beenstructured [8]. Genetic algorithm finds the best equation to describethe temporal changes of monsoon in India at all times [9].Another technique for short-term load prediction with a lead time of one day is ANN and GA [10].Theunconstrained building optimization problems that are coupled of energy simulation program are also solvedby using Genetic Algorithm,[11].

The rest of this paperisorganized as: In section 2, Research and Methodologyare discussed. In section 3, Proposed Algorithm is canvassed by flow chart. In section 4, Results of the developed model isexplained. In section 5, Conclusion and the scope of the study is narrated and lastly the reference iselucidated in section 6.

2 RESEARCH AND METHODOLOGY

Soft Computing Methods arefrequently applied to resolve manycritical problemsof thereal-life. In this study, we have used different types of Soft Computing Methodsto forecast and to build a hybrid model to get more accurate outcomes.

2.1 Statistical Equations

Statistical Equation is a crucial part of Soft Computing Analysis. We have employed different types of Statistical Equations like Polynomial, Linear, Gaussian, Fourier, Exponential and Sum of Sine and one of this equation is selected for prediction depends on the minimum error.

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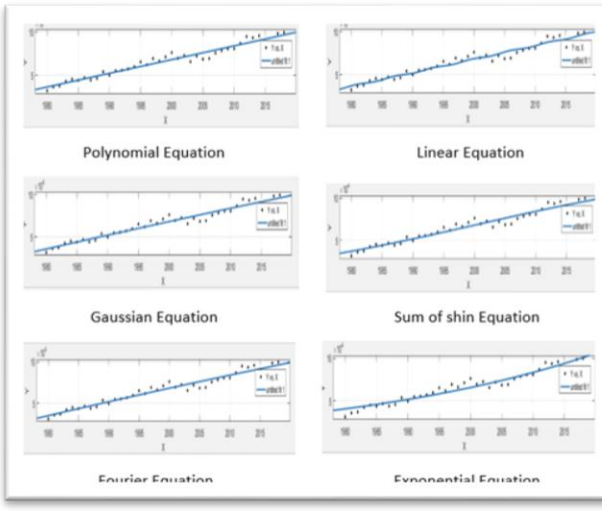


Graph 1. Fitness of statistical equations

Graph 1, it is clearly noticedthat Sum of Sine is the best fitted for wheat crop data set based on the Root Mean Square Error. The constant value, obtains from the Sum of Sine, isused to predict the future data on the basis of the actual data.

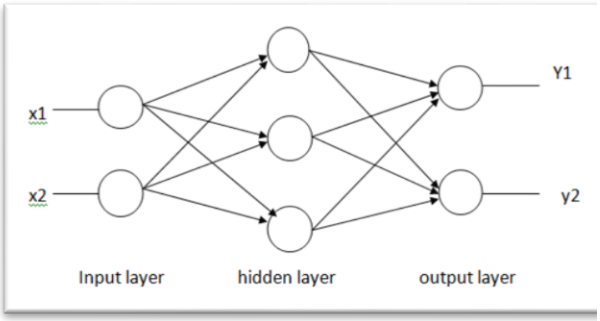
$$\text{Sum of Sine, } f(x) = a_1 * \sin(b_1 * x + c_1) \quad (1)$$

Where, a_1, b_1 and c_1 are constant values.

2.2 Artificial Neural Network

Artificial Neural Network (ANN) is a mathematical model. It simulates the formation and the applicative details of biological neural networks. The construction of Neural Network is similar to the human brain and this network consists of many processing components called neurons. After getting information from the surrounding neurons, neurons execute some calculations and pass the outcomes to the other neurons. Connections of neurons have associated some weights with them. The connection between two neurons can transmit signal from one to another Artificial Neuron. TheArtificial Neuron processes the received signal and then signal additional artificial neurons connected to it. Informationwhichis flowing across the network has an effect on the construction of ANN as neural network changes - or learns, in a sense - based on that input and output [13].

Three main layers of neural network are: Input, hidden and output layer. As represented graph2, two constant values (obtained From Sum of Sine) are adopted in input layer then three neurons are taken up in hidden layers and finally two optimum constant values are gotafter training in output layer. Throughout the training, Weights and bias are balanced in automated manneruntil it providesoptimal results. Constant(Sum of Sine) value provides more accurate predictive data set. Everyiterationshowsthe error ofpredictive data. Neural Network also provides the predictive data set. But still the validity of predictive data is based on the time series data.



Graph 2. Architecture of Artificial Neural Network

2.3 Genetic Algorithm

Genetic algorithm (GA) is a group of evaluation based calculative models. This algorithm encodes a possible solution to a specified problem on an easily understandable data structure like chromosome, and uses recombination operators to this structure as to keep the finical information. GA is usually seen as function optimizer, even though the span of problems to which genetic algorithm has been used is wide-ranging.

The performance of a GA starts with a chromosomes' population (usually random). Then this structure is evaluated and reproductive opportunities are allocated in this way that the better solution given chromosomes of the target problem get more opportunities to 'reproduce' than the poorer solution given chromosomes. On the basis of current population, 'goodness' of the solution is usually defined [14].Generally, Genetic Algorithm uses binary (0, 1) notations. Thus, data have to be encoded into binary notation and this is stated as binary chromosome.

close parenthesis. However, longer lists will be formatted so that:

1. Selection operatorsareapplied to pick up solutions from the present population that isused in formation of the next population of the solutions. Roulette wheel method, which is formulated by Holland,is an elementary strategy of random selection [12].
2. Crossover process is used to mixthe "genetic information" adopted from paired individuals through thecontrol of recombination operator. In the other way, Crossover randomly selectsthe pair of the best solution (Parent Chromosome) and interchanging them to produce a new child.Trial and Error method is used to detect the best result.
3. Mutation is done by using a bit-wise probabilistic method wherethe stated gene value if reversed from 0 to 1, and vice versa. Here, the effects of the mutation probability on search performancesarestudied through applications (trials) [11].
4. The fitness function is not only a function that is closely related to the designer's intentions but it also counts quickly.A fitness function has a specific type of objective function that is summarized as a single figure of merit, determines how close a given design solution is to achieve the set objectives. Therefore, individuals of each generation with minimum differences must be

returned.In this study, Mean Absolute Percentage Error (MAPE) is applied as fitness function.
General equation of MAPE is as follow:

MAPE = 1/n ∑ [(|Actual Value – Forecasted Value|) / Actual Value] * 100. (2)
Where, n is number of fitted point of data set.

3 Error Calculation Technique

We are employingstatistical parameters to examine the accuracy of performances of different Soft Computing Approaches.

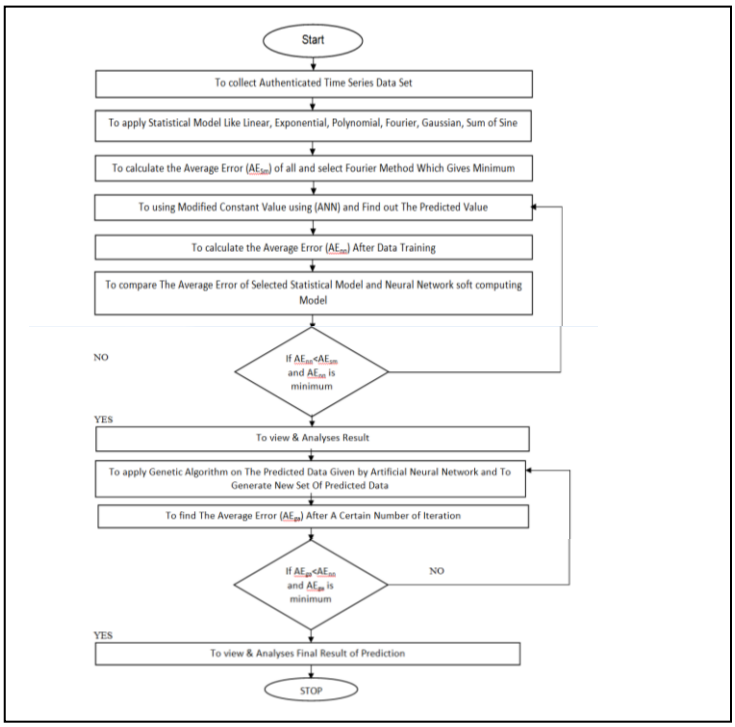
Mean Square Error (MSE) = $\sum^{n}_{i=1}$(Actual Value – Forecast Value)^2/n

Mean Absolute Percentage error = $\sum^{n}_{i=1}$[mod (E_i-F_i)/E_i] *100/n

Where E_i=Actual value and F_i = forecast value.

Residual Analysis –
Absolute Residual = mod [Actual value – Forecast value]
Mean Absolute Residual = mod [Actual value – Forecast value]/Actual value

4 Proposed A Hybrid Model Based on SoftComputing Technique



5 Result and Discussion

5.1 First, we have shown the data prediction using different types of statistical equations in Table 1.

Table 1.

Year	Production	Polynomial	Linear Fitting	Exponential	Fourier	Gaussian	Sum of Sine
1980	31830	36273	56722.8	41127.23	1692.188	37365.4	35918.54
1981	36313	37866	55597.61	42107.27	3379.319	38712.36	37561.71
1982	37452	39459	55243.53	43110.67	5061.394	40085.02	39203.03
1983	42794	41052	55115.76	44137.97	6738.412	41482.7	40842.43
1984	45476	42645	54577.46	45189.76	8410.373	42904.67	42479.82
1985	44069	44238	53485.3	46266.61	10077.28	44350.09	44115.12
1986	47052	45831	52321.19	47369.12	11739.12	45818.08	45748.25
1987	44323	47424	51749.25	48497.9	13395.92	47307.7	47379.13
1988	46169	49017	52005.2	49653.58	15047.65	48817.92	49007.68
1989	54110	50610	52679.66	50836.8	16694.33	50347.65	50633.82
1990	49850	52203	53094.5	52048.21	18335.95	51895.73	52257.47
1991	55134	53796	52926.35	53288.49	19972.51	53460.94	53878.55
1992	55690	55389	52503.87	54558.33	21604.02	55041.97	55496.99
1993	57210	56982	52505.61	55858.43	23230.47	56637.47	57112.69
1994	59840	58575	53336.12	57189.51	24851.86	58246.02	58725.59
1995	65470	60168	54754.05	58552.3	26468.2	59866.13	60335.6
1996	62097	61761	56094.01	59947.58	28079.48	61496.24	61942.64
1997	69350	63354	56878.35	61376.1	29685.7	63134.75	63546.64
1998	66350	64947	57256.29	62838.66	31286.87	64779.98	65147.51
1999	71288	66540	57866.75	64336.07	32882.98	66430.22	66745.18
2000	76369	68133	59250.91	65869.17	34474.03	68083.69	68339.56
2001	69681	69726	61354.67	67438.8	36060.03	69738.55	69930.59
2002	72766	71319	63578.36	69045.83	37640.97	71392.95	71518.18
2003	65761	72912	65328.12	70691.15	39216.85	73044.94	73102.25
2004	72156	74505	66561.85	72375.69	40787.68	74692.59	74682.73
2005	68637	76098	67827.92	74100.36	42353.45	76333.88	76259.54
2006	69355	77691	69761.04	75866.14	43914.16	77966.8	77832.6
2007	75807	79284	72498.66	77673.99	45469.82	79589.27	79401.83
2008	78570	80877	75554.64	79524.92	47020.41	81199.22	80967.15
2009	80679	82470	78266.17	81419.96	48565.96	82794.54	82528.5
2010	80804	84063	80403.18	83360.16	50106.44	84373.1	84085.78
2011	86874	85656	82379.87	85346.59	51641.87	85932.77	85638.94
2012	94882	87249	84873.86	87380.35	53172.24	87471.41	87187.88
2013	93506	88842	88203.23	89462.58	54697.56	88986.87	88732.53
2014	95850	90435	92034.05	91594.43	56217.82	90477.01	90272.83
2015	86530	92028	95687.42	93777.08	57733.02	91939.69	91808.68
2016	87000	93621	98763.62	96011.74	59243.17	93372.79	93340.02
2017	98510	95214	101509.6	98299.65	60748.25	94774.2	94866.77
2018	99700	96807	104592	100642.1	62248.29	96141.83	96388.86

5.2 Determining the accuracy of the predicted data and Error Calculation Technique Using Statistical Equations Statistical

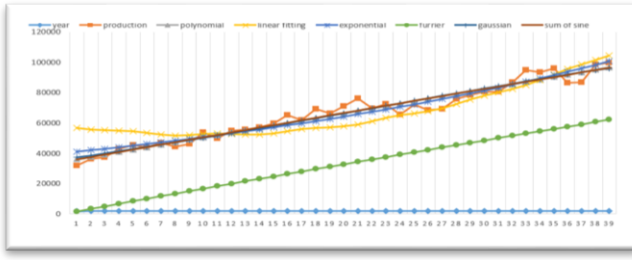
Equations have been used to predict the data set and to find the error by using error calculation techniques. Table 2 shows that Sum of Sine equation gives minimum error. So,Sum of Sine is the most suitable for wheat yield data predictionafter that we have to implementit in Artificial Neural Network.

Table 2. Methodsof Error calculation

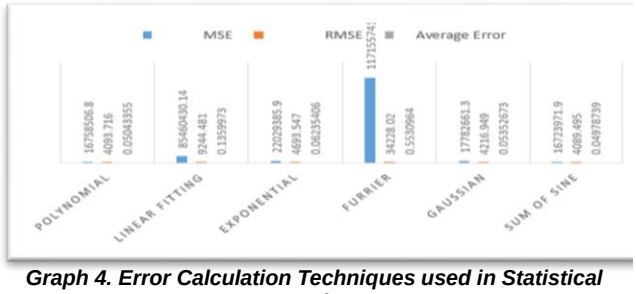
Statistical Equation	MSE	RMSE	Average Error
Polynomial	16758506.8	4093.716	0.05043355
Linear Fitting	85460430.14	9244.481	0.1359973
Exponential	22029385.9	4693.547	0.06235406
Furrier	1171557414	34228.02	0.5530964
Gaussian	17782661.3	4216.949	0.05352673
Sum of Sine	16723971.9	4089.495	0.04978739

5.3 Determining the Accuracy of the Predicted Data Using Statistical Equations

Here, Sum of Sineis indicated bymaroon red and the actual data is indicated by using orange color. Thedata prediction accuracy becomesmore accurate using Sumof Sine than the other statistical equations in Graph 3.Graph4, shows that accuracy of error calculation by using different statistical techniques.



Graph3. Data prediction from Actual Data using Statistical Equations



Graph 4. Error Calculation Techniques used in Statistical Equations

5.4 On the basis of minimum error, we have takenthe Sum of Sine prediction data. Then, the constant value is optimized using Artificial Neural Networkand more accurate prediction data set than the sum of sine data is acquired. Genetic Algorithm (GA), is an optimizing technique of the soft computing approach, brings more accuracy in prediction performance of the proposed hybrid model. All predicated data are shown in Table 3 and Error calculations are shown in Table 4.

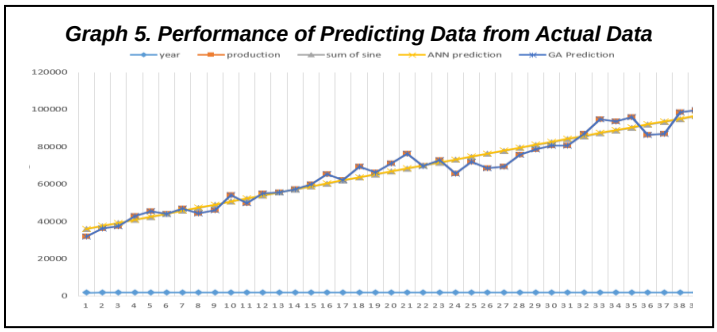
Table 3. Data prediction using Soft Computing Techniques

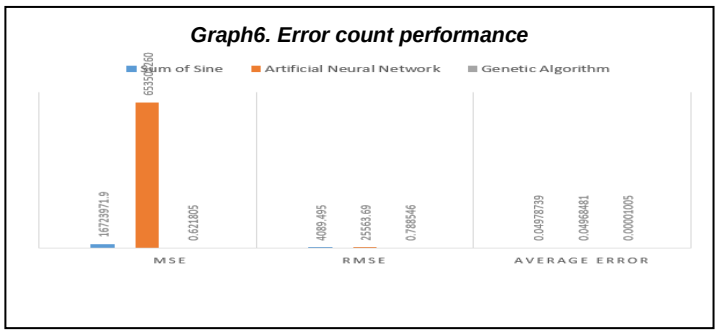
year	production	sum of sine	ANN prediction	GA Prediction
1980	31830	35918.5404	35939.22732	31829.948
1981	36313	37561.71042	37590.60737	36313.677
1982	37452	39203.03362	39240.12066	37451.438
1983	42794	40842.42928	40887.68529	42793.146
1984	45476	42479.8168	42533.21944	45476.292
1985	44069	44115.11568	44176.64139	44069.063
1986	47052	45748.24551	45817.86953	47051.29
1987	44323	47379.12599	47456.82235	44322.646
1988	46169	49007.67694	49093.41846	46169.185
1989	54110	50633.81828	50727.5766	54110.633
1990	49850	52257.47007	52359.2156	49850.122
1991	55134	53878.55245	53988.25445	55134.415
1992	55690	55496.98575	55614.61224	55691.721
1993	57210	57112.69036	57238.2082	57209.545
1994	59840	58725.58687	58858.96172	59839.596
1995	65470	60335.59596	60476.7923	65471.034
1996	62097	61942.63847	62091.6196	62096.939
1997	69350	63546.63539	63703.36344	69350.522
1998	66350	65147.50785	65311.94376	66350.253
1999	71288	66745.17714	66917.28069	71287.154
2000	76369	68339.56471	68519.29451	76368.504
2001	69681	69930.59217	70117.90566	69681.741
2002	72766	71518.18128	71713.03476	72766.74
2003	65761	73102.25399	73304.60259	65759.536
2004	72156	74682.73241	74892.53011	72157.818
2005	68637	76259.53884	76476.73846	68637.847
2006	69355	77832.59574	78057.14898	69356.367
2007	75807	79401.82577	79633.68319	75808.159
2008	78570	80967.15178	81206.26278	78571.591
2009	80679	82528.4968	82774.80967	80679.951
2010	80804	84085.78406	84339.24596	80803.609
2011	86874	85638.937	85899.49397	86873.661
2012	94882	87187.87925	87455.47621	94882.58
2013	93506	88732.53465	89007.1154	93506.303
2014	95850	90272.82725	90554.33451	95850.79
2015	86530	91808.68132	92097.05668	86529.597
2016	87000	93340.02135	93635.20532	87000.438
2017	98510	94866.77205	95168.70403	98509.899
2018	99700	96388.85834	96697.47666	99699.675

Table 4. Error CalculationUsing Different Soft ComputingTechniques

Purposed Method	MSE	RMSE	Average Error
sum of sine	16723971.9	4089.495	0.04978739
Artificial Neural Network (ANN)	653502260	25563.69	0.04968481
Genetic Algorithms (GA)	0.621805	0.788546	0.00001005

5.5 In the Hybrid model, the predicated data of Genetic algorithm and the actual data are overlapped. Actual data ispresented bysaffron color and the predicated data of Genetic algorithm is indicatedby azure blue inGraph 5. The reliabilityof the prediction performance becomes more accurate using Neural Network with Genetic Algorithm. Error counting accuracy is shown in Graph 6.





6 Conclusion

This paper represents an effort tospeculate wheat crop production using the Soft Computing Techniques.The error is further rectified by the ANN on the basis of properly optimized constant value of Sum of Sine. Thus, we get predicted average error is 0.0496848. Finally, Genetic algorithm is applied to obtain more reliable data prediction and the average error of this performance is 0.00001005. It is observed that the efficiency of the proposed hybrid model becomes better in performance. In the future, we will experiment with different soft computing methods to maybe get more accurate results in crop production and weather data.

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