

An Adapted Group Method of Data Handling for Abrupt Data Analysis

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ABSTRACT: — This Research paper shows the experimental study for the Agricultural (Economical) yield prediction output those are based on the past data using Group Method of Data Handling (GMDH) technique. GMDH is very useful concept for solving the real life problem. Because in real life the data is vast, it is dynamic in behavior and complex in nature. The usability of Group Method of Data Handling is to select the useful input from all data set and discard the useless data using external criterion. Useless data not only reduce the performance of the system but also give the inaccurate result.

Keywords: — Artificial Neural Network, Neurons, Back propagation Algorithm, Transfer Function, Network Performance, Mean Square Error.

1. INTRODUCTION

The necessity of modeling is well established since the structural identification of a process is essential in analysis, control and prediction. In the past, limited information on system behavior has driven researchers to introduce modeling techniques with a broad range of assumptions on systems characteristics. [1] Modeling real world systems is a difficult but essential task in control, identification and forecasting applications. Economic, ecological and engineering systems are generally complex with limited information on their underlying physical laws. [2] Mathematical apparatus and assumptions about their features are necessary for their structural identification. The majority of those systems are consisted of subsystems with unclear and unknown inter relationships. [3]

1. Statistical Modeling Methods:

In previous days, due to the limited information on system predictions were based on, the assumptions. The generally failed to fully capture the dynamic characteristics of the complex processes .If data is static then it is predicted by the statistical modeling. But in present scenario data is complex in behavior and statistical modeling is used when object is simple. [4][5]

If object is complex the statistical modeling does not work efficiently. Statistical methods require still a significant amount of a priori information about the model's structure. Statistical method is useful when the problem is static. But in present scenario data is vast and its behavior is dynamic. So due to the problems which we face in Statistical modeling, we introduce other technique also. Statically modeling method is based on the assumptions and if the problem is static then the statistical modeling works efficiently. If the data is dynamic then this method does not work with

METHOD OF DATA MODELING

the dynamic characteristics of data. In present scenario the data is highly volatile in nature [6].

2. Deductive Methods:

Deductive methods have advantages in the cases of rather simple modeling problems, when the theory of the object being modeled is known and therefore it is possible to develop a model from physically based principles employing the user's knowledge of the process. Decision making in process analysis of macro economy, financial forecasting, company solvency analysis and others require tools, which are able to get accurate models on basis of processes forecasting. [7] However, problems due to large amount of variables, very small number of observations and unknown dynamic relation between these variables, such financial objects are complex ill-defined systems.

Problems of complex objects modeling such as analysis and prediction of any field and other cannot be solved by deductive logical-mathematical methods with needed accuracy. In this case knowledge extraction from data, i.e. to derive a model from experimental measurements, has advantages in cases of rather complex objects, being only little a priori knowledge or no definite theory particularly for objects with fuzzy characteristics. This is especially true for objects with fuzzy characteristics. The task of knowledge extraction needs to have a priori information about the structure of the mathematical model. In neural networks the user estimates this structure by choosing the number of layers and the number of Neuron and transfer functions of nodes of a neural network. This requires not only knowledge about the theory of neural networks, but also knowledge of the task (problem), which we want to solve. Besides this the knowledge of task (problem) is not applicable without transformation in neural network world. [1]

2.1 Neural Networks:

Neural Networks have partly improved the modeling procedure. It is very good technique for modeling of data, but the high degree of subjectiveness in the definition of some of their

parameters as well as their demand of long data samples remain significant obstacles. On the other hand, real world systems like financial markets have a high degree of volatility and the utilization of long data samples tends to remove and, in effect, filter the dynamic characteristics of the process. In previous days object is simple and data is limited. [8]

Problems are arises of complex objects modeling (functions approximation and extrapolation, identification, pattern recognition, forecasting) can be solved in general by deductive logical-mathematical or by inductive sorting-out methods. Experts should decide on the quality and quantity of input arguments, the number of hidden layers and neurons as well as the form of their activation function. Such an approach requires not only the knowledge about the theory of neural networks but also the rules for the translation of this knowledge into the language of neural networks. The heuristic approach that follows the determination of network architecture corresponds to a subjective as well as the neural network requires the long data samples. If we want to solve any problem using neural network, experts play a dominant role. The expert has knowledge about the theory of neural network and the knowledge about the task that they want to solve. Neural Networks capture the Dynamic characteristic of data but it require the long data samples, and it tests all available input samples, doesn't matter is useful or useless data. Because the useless data not only increase the time consumption it also gives the inaccurate results. Neural Network is deductive in nature, it gives all type of predictions but first we decide the architecture of neural network means we have knowledge of the theory of neural network as well as knowledge about the task, which we want to perform. [9]

2.1.1 Group Method of Data Handling (GMDH)

The Group Method of Data Handling (GMDH) is self-organizing approach based on sorting-out of gradually complicated models and evaluation of them by external criterion on separate part of data

samples. Computer is found structure of model and measures of influence of parameters on the output variable itself. That model is better that leads to the minimal value of external criterion. A.G. Ivanashko introduces group Method of data handling in 1984. This inductive approach is different from commonly used deductive techniques or neural networks. The GMDH is used for complex systems modeling, prediction, identification and approximation of multivariate processes, decision support, diagnostics, pattern recognition and cauterization of data samples. There are developed methods of mathematical induction for the solution of comparatively simple problems. Group Method of Data Handling can be considered as further propagation of inductive self-organizing methods to the solution of more complex practical problems. It solves the problem of how to handle data samples of observations. The goal is to get mathematical model of the object (the problem of identification and pattern recognition) or to describe the processes, which will take place at object in the future (the problem of process forecasting). Group Method of Data Handling solves, by sorting-out procedure, the multidimensional problem of model optimization [4].

The rapid development of artificial intelligence and neural networks in the last two decades due to the introduction of back propagation learning algorithms increases the significant efforts in modeling tasks. However, neural networks despite the small number of assumptions in comparison to statistical methods require still a significant amount of a priori information about the model's structure. Experts should decide on the quality and quantity of input arguments, the number of hidden layers and neurons as well as the form of their activation function.

Such an approach requires not only the knowledge about the theory of neural networks but also the rules for the translation of this knowledge into the language of neural networks. The heuristic approach that follows the determination of network architecture corresponds to a subjective choice of the final model, which in the majority of

the cases will not approximate the ideal [8]. Comparing the behavior of neural networks in data analysis is to the statistical methods claims that it is not appropriate to be viewed as competitors since there are many overlaps between them. A new approach, which attempts to overcome the subjective ness of neural networks, is an inductive approach, based on principle of self-organization. An inductive approach is similar to neural networks but is unbounded in nature, where the independent variables of the system are shifted in a random way and activated so that the best match to the dependent variables is ultimately selected. In inductive learning algorithms the experts have a limited role. Man communicates with the machine not in the difficult language of details but in a generalized language of integrate signals like selection criteria or objective function [5].

On the other hand in deductive methods the dominant role belongs in the experts with computers being simple large calculators. The inductive approach has a similar concept to that of evolution where a number of solutions is created and an external criterion plays the role of finding the fittest. The objectiveness of GMDH theory in the selection of the optimum model is based on the principle of external complement, according to which when a model's complexity increases then certain criteria, which hold the property of external complement, go through their minimum. Failure to achieve that may be caused by the existence of too noisy data, incomplete information in input arguments and improper choice of reference function. Generally, the modeling procedure may involve either exact or noisy data and the choice of criterion is based on the level of noise within the data. Ivakhnenko points out that their choice will not coincide if the level of noise increases. If we are not using any external criterion it requires supplementary information about the statistical characteristics of the data samples increasing the subjective ness of the choice. They can only choose physical models that can be used explicitly in short range predictions while external criteria are choosing non physical models that are less complex and

more accurate in long range predictions. So we require developing a more robust modeling. In Group Method of data handling is develop an external equation, that will be calculated every time a new equation is added to the system and the extrapolation of the characteristics created by the minimum values of the criterion will indicate the true. Here we describe some features of Group method of data handling.

II.METHODOLOGY

We have used Group Method of Data handling and such types of networks consist of input layer, one or more hidden layers and an output layer. The model was generated in five steps:

- a) Data Collection
- b) Data pre-processing
- c) Neural Network Creation and Training
- d) Network Validation
- e) Using the Network

A. Data Collection

In order to train, validate and test the neural network, data is required and we collected.

B. Data pre-processing

The data must be prepared such that it covers the range of inputs for which the network is going to be used. Since the performance and reliability of the output from the neural network mainly depends on the quality of the data, therefore, the data must be pre-processed before it is fed to a neural network. First of all, we applied attribute relevance analysis on data so as to remove unwanted attributes from data and then the data was normalized in the range -1 to 1 using min-max normalization technique. Since the input is in the normalized form, the output we get is also in the normalized form and hence, it must be demoralized so as to have actual value.

In order to train the network, we divided the data into three subsets [6]: Training Data Set: This data set was used to train the network. The gradient was computed and biases and the weights of the connections between the neurons were adjusted accordingly. Validation Data Set: This data was used to save the weights and biases at the minimum error and to avoid network over fitting data. Testing Data Set: This data set was used to test the performance of the network.

C. Neural Network Creation and Training [10].

In this step neural network was created. Artificial Neural Networks depend on the following parameters [8]:

- Number of layers
- Number of neurons in input layer
- Number of neurons in hidden layer
- Momentum
- Learning rate
- Number of training iterations that are required to obtain the best result
- Transfer function used for hidden and output layer
- Training algorithm used
- Learning function used.

The network was created with some initial values of above mentioned network parameters. Then, these parameters were varied and the results were observed. The network was trained using back propagation algorithm with the aim to improve the network performance i.e. to reduce mean square error (mse). In this algorithm, the network is trained by repeatedly processing the training data set and comparing the network output with the actual output and reducing the error to the minimum possible. If the error between network output and the actual falls below the threshold value, then the training stops otherwise weights of the connections between various neurons are modified so as to reduce mse. The modifications are done in the opposite direction i.e. from output layer through each hidden layer down to the first hidden layer.

Since the modifications in the weights of the connections are done in the backward direction so the name given is back propagation [6]. Transfer functions calculate layers output from its net input. Hyperbolic tangent sigmoid transfer function and Log-sigmoid transfer function can be used for hidden layer and output layer. We have used Log-sigmoid transfer function for hidden layer as well as output layer.

D. Network Validation

After training the network, it was validated using validation data so as to improve the network performance.

E. Using the Network

After validating the network, it was tested using the test data set. The testing was performed on ten

different companies (IT and non IT) and 100 tests were performed for each company. [14][15][16]

III. EXPERIMENTAL RESULTS

The Group Method of Data Handling is very useful concept for solving the real life problem because in real life the data is vast and it is dynamic in behavior and complex in nature. The usability of Group Method of Data Handling is that it select the useful input from all data set and discarded the useless data useless data using external criterion not only reduce the performance of the system but also give the inaccurate result. Previous algorithms are time consuming. In previous work the Group Method of Data Handling are combine with several technique to get more advantage. Polynomial algorithm uses the polynomial basis function. Using these function obtain some Mathematical formula is derived and select the formula that is best one for the prediction. Generally Group Method of Data handling is use for analysis prediction and control the concept of Group Method of Data handling is that it removes the insignificant terms such procedure called optimized. The Problem with the Group Method of Data Handling is that it is suitable for the continuous data. It gives very accurate prediction if data sample is continuous. But if the data is discrete or abrupt it can't work properly. By direct data sampling we take the effective input from the all data using the Group Method of Data Handling [8].Using proposed Algorithm and the data of 33 Year of Wheat Production we are estimated the future production on the basis of previous data. We are taking data and produce the Result [22].

3.1 ALGORITHM

1. (i) Input Data with External Parameters.(Temperature, Humidity, Rainfall)
- (ii) Check for abrupt change.
2. If abrupt Change (Production, Temperature, Humidity)

If $(n1)-n2) \leq 5$

Data transfer in continuous data table. And prediction is done perform the step 2.1 to 2.13.

Else

Data transfer in Increase abrupt data table. And prediction is done perform step 3.12 to 4.2

2.1 GMDH (Group Method of Data Handling) is Based on the Polynomial

Equations:

$Y =$

$$A_0 + A_1 * X_1 + A_2 * X_2 + A_3 * X_3 + A_4 * X_4$$

Here X_1, X_2, X_3, X_4 are the Given Inputs are say Data which are used for Prediction.

A_0, A_1, A_2, A_3, A_4 Are consider as Weight.

2.2 In model Generation If we are using i input data then $i-2$ model will be generated.

In this Algorithm, We are Using 10 input data so 8 model will be generated.

2.3 This is For Only One Input

Put The Value in following Equation.

$$Y_1 \text{ (Today Predicted Value (m))} = A_0 + A_1 * X_1 \text{ (Previous Value (m-1))}$$

Y_1 (Today Predicted Value (m-1)) = $A_0 + A_1 * X_1$ (Previous Value (m-2))

If Using 10 Inputs then 9 Equations Generated.

2.4 Using These Two Equation Find out The Value of A_0 and A_1 by Gauss Elimination method.

For 8 models 8 A_0 & A_1 are found.

For First Model

Put This Values in Equation

$$Y_1 \text{ [Today Value (m)]} = A_0 + A_1 * X_1 \text{ [Previous Value (m-1)]}$$

$$Y_1 \text{ [Today Value (m-1)]} = A_0 + A_1 * X_1 \text{ [Previous Value (m-2)]}$$

$$Y_1 \text{ [Today Value (m-2)]} = A_0 + A_1 * X_1 \text{ [Previous Value (m-2)]}$$

Same, find out 9 predicted values.

2.5 Compare this value by Actual value find out error for all 9 values.

$$\text{Error} = Y_p \text{ (Predicted Value)} - Y_i \text{ (Actual Value)}$$

2.6 Find out The MSE (Mean Square Error)

$$MSE = \sum (Y_p - Y_i)^2 / i - 2$$

$i = 2$ to 10

$$MSE_1 = \text{error}_1 + \text{error}_2 + \text{error}_3 + \dots + \text{error}_9$$

2.7 Stores This MSE and Value of A_0 & A_1 .

We Repeat Above Procedure From (2.3 To 2.7) for All Models With Only One Input.

Find out 9 MSE & 9 A_0 , A_1 .

2.8 Select the Minimum MSE for All Model And Store The Minimum MSE with A_0 A_1 for The Next Phase Discarded All Other MSE With A_0 , A_1 .

2.9 Model Generation for Two

Inputs

The Equation is

$$Y = A_0 + A_1 * X_1 + A_2 * X_2$$

2.10 Make Three Equation

$$Y_1 = A_0 + A_1 * X_1 + A_2 * X_2$$

$$Y_2 = A_0 + A_1 * X_1 + A_2 * X_2$$

$$Y_3 = A_0 + A_1 * X_1 + A_2 * X_2$$

2.11 Find out the Value of A_2 by using Above Procedure

Find out The Minimum MSE from all Models

Store The Minimum MSE with The Value of A_2 .

Model Generation for Three Inputs

Procedure is repeated until the Maximum Inputs.

When All A_0 A_1 , A_2 , A_3 , A_4 Which Are the Model Value (Whose MSE is Minimum) from all The Model Generated.

2.12 Hence Prediction is Done Using Equation

$$Y_1 = A_0 + A_1 * X_1 + A_2 * X_2 + A_3 * X_3 + A_4 * X_4$$

2.13 Find the difference between Actual Value and Predicted Value.

3. for Abrupt Changes

3.1 The Equation is

$$Y = A_0 + A_1 X_1 + A_1 X_1^2 + A_2 X_2^2 + A_3 X_1 X_2 \dots$$

3.2 Repeat step From 2.1 to 2.7

3.3 Store All Models with the Value of A0 A1 & MSE

3.4 Store the Minimum MSE with Value of A0, A1

3.5 For Model 1

$$Y = a_{i0} + a_{i1} * x_1 + a_{i2} * x_2^2 + a_{i3} * x_1 * x_2$$

$$Y = a_{j0} + a_{j1} * x_1 + a_{j2} * x_2^2 + a_{j3} * x_1 * x_2$$

$$Y = a_{k0} + a_{k1} * x_1 + a_{k2} * x_2^2 + a_{k3} * x_1 * x_2$$

$$Y = a_{l0} + a_{l1} * x_1 + a_{l2} * x_2^2 + a_{l3} * x_1 * x_2$$

$$Y = a_{m0} + a_{m1} * x_1 + a_{m2} * x_2^2 + a_{m3} * x_1 * x_2$$

$$Y = a_{n0} + a_{n1} * x_1 + a_{n2} * x_2^2 + a_{n3} * x_1 * x_2$$

$$Y = a_{o0} + a_{o1} * x_1 + a_{o2} * x_2^2 + a_{o3} * x_1 * x_2$$

$$Y = a_{p0} + a_{p1} * x_1 + a_{p2} * x_2^2 + a_{p3} * x_1 * x_2$$

$$A_0 = k_1 * a_{i0} + k_2 * a_{j0} + k_3 * a_{k0} + k_4 * a_{l0} + k_5 * a_{m0} + k_6 * a_{n0} + k_7 * a_{o0} + k_8 * a_{p0}$$

Where $k_1 = \frac{\text{Minimum MSE}}$

MSE of Particular Model

$$A_1 = k_1 * a_{i1} + k_2 * a_{j1} + k_3 * a_{k1} + k_4 * a_{l1} + k_5 * a_{m1} + k_6 * a_{n1} + k_7 * a_{o1} + k_8 * a_{p1}$$

3.6 This Process is Done for all Model

Same Calculate the Value of A2, A3, and A4.

4. Equation is

$$Y = A_0 + A_1 X_1 + A_1 X_1^2 + A_2 X_2^2 + A_3 X_1 X_2 + \dots$$

4.1 Find out the average factor which gives the difference due to external parameter. Multiply this factor in prediction.

$$Y = \text{Average Factor} (A_0 + A_1 X_1 + A_1 X_1^2 + A_2 X_2^2 + A_3 X_1 X_2 + \dots)$$

Find The Difference between Actual and Estimated value.

End.

Then solve the equation and find out the model. If we are taking i data then find (i-1) Equation. If we are taking i data then (i-2) model is generated. In this Example we are Taking 10 Data then nine equations is generated.

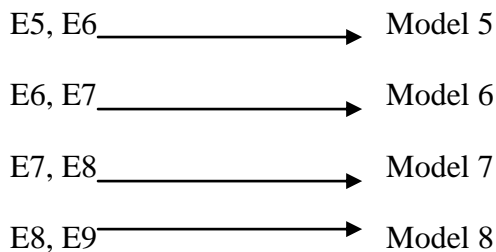
Eight Models Generated.

E1, E2 → Model 1

E2, E3 → Model 2

E3, E4 → Model 3

E4, E5 → Model 4



$$A0 = \frac{Y1X2 - Y2X1}{X2 - X1} \quad A1$$

.... (3.3a)
 (3.3b)

X2-X1

Putting the value of A0, A1 in the 9 equation find the 9 predicted value and then compare the actual value and find the error and find the MSE of the whole model. Store the model No. with the value of A0, A1

MSE (Mean Square Error)

$$MSE = \frac{1}{10} \sum_{i=2}^{10} (Yp - Yi)^2$$

(3.4)

Here we see the Simulation of algorithm only for one input. The Polynomial equation

$$Y = A0 + A1 * X1 + A2 * X2 + A3 * X3 + \dots + An * Xn$$

(3.5)

In this example we have only The Equation.

$$Y1 = A0 + A1 * X1$$

(3.6)

$$Y2 = A0 + A1 * X2$$

(3.7)

Value of A0, A1 are Calculated by using Gauss Elimination Method. Using the Present input. And find Out the Prediction Based on one input.

S. No.	Year to Year	For Year	Actual Production	Estimated Production	Difference
1.	From 1974-1988	1989	71.0	67.1	3.9
3.	From 1990-2003	2004	55.3	56.7	1.4
4.	From 1974-2005	2006	71.3	74	2.7
5.	From 1974-2010	2010	80.2	76	4.2

ACTUAL WHEAT PRODUCTION

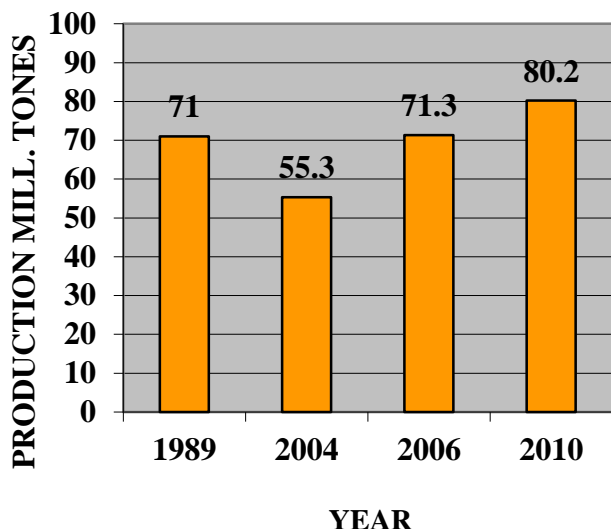


Figure 1.1: This graph shows the actual wheat production of resultant years.

ESTIMATED WHEAT PRODUCTION

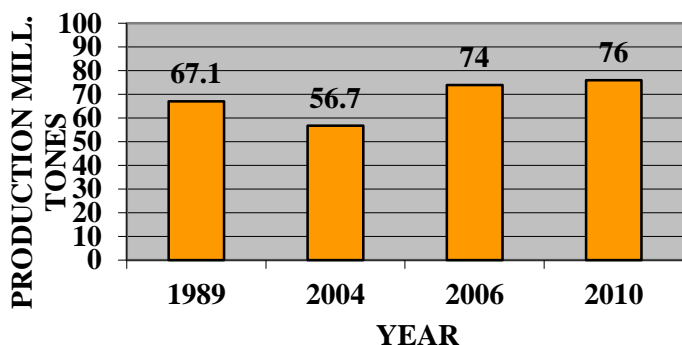


Figure 1.2: This graph shows estimated wheat production of resultant Years.

DIFFERENCE BETWEEN ACTUAL AND ESTIMATED PRODUCTION

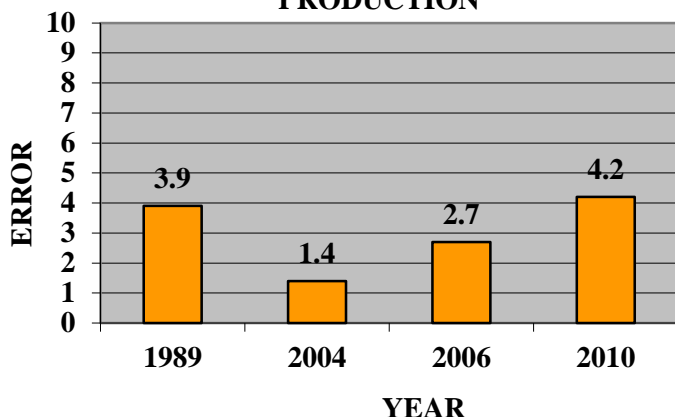


Figure 1.3: This graph shows the difference between Actual and

Estimated production or we can say error in our estimated output.

V. CONCLUSION

This work is presented as to explore the forecasting problem with accuracy. Modeling of data is essential in prediction task. Data is too vast and its behavior is dynamic in nature (nonlinearity). In previous days the statistical methods were used, which was deductive in nature and fail to fully capture the dynamic behavior of the System. Neural network has partially improved the forecasting. The Problem with the neural network is that it demands long data samples. Architecture of neural network is decided based on number of layers, number of neurons in layer, number of hidden layer and the transfer function used. Persons involved in the forecasting require the knowledge of the neural network. Each and every data is tested in neural networks. When data series is too large it increases the computation time and inaccurate result. Group Method of Data Handling Select the useful data and rejects the useless data in each stage. Useless data does not lead to accurate prediction and increases the computation time in addition to producing the inaccurate results. Though GMDH cannot successfully replace neural networks but it has ability to address most of neural networks drawbacks. It has established itself as a successful rival in modeling procedure for real world systems.

The Group Method of Data Handling is based on regression approach. It generates the analytical formula which selects the useful data. The Problem of Group Method of Data Handling is that it is works only in the continuous data. It does not Work with discrete data. Here we are proposing the algorithms which work for the discrete data. We are applying this algorithm in the forecasting of wheat production using Group Method of Data Handling. It gives the accurate results with less computation time. This proposed

technique is more robust and give the accurate prediction with effect of external variable.

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