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Neuro-Fuzzy Based Region Rainfall Forecasting

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Abstract: Monsoon forecasting is the most considerable factor which determines the prosperity and refrain of the agronomics. In the cultivated land India, the heightening of vegetation and the stagnation of seasonal crops and water curtailment are the most viewed topics which have to be look after in a serious way. Rainfall is one of the most entangled processes to be look after for the runoff for foretelling also we have to be vigilant in the usage of water. Water should be used with alert minds so that is no wasted. Also proper management of water is needed. Rainfall prediction acts as a blessing as it gives information about the occurrence of rain and by that knowledge we can predict about the seasonal products. There is needed to be predicting the rainfall. For this we use the Adaptive Neuro-fuzzy inference system approach developed by the integration of fuzzy logic and Artificial Neural Network. After collecting the facts and figures of low rainfall region the proposed technique would be applied and the results are calculated. The outcomes are then compared with the previous data. We get more accurate and precise results for rainfall prediction of low rainfall region.

Keywords: Neuro Fuzzy, Inference Rules, Neural Network, Fuzzy logic, Estimation.

1. INTRODUCTION

Data Mining, is data driven and is also known as knowledge discovery process. It is the process of digging and extraction of the comprehensive, unknown and actionable information from huge sets of data and then analyzing it to extract the hidden relevant pattern to make crucial decisions in time. In short, Data mining automates the detection of relevant patterns in data repositories. With advancement in technology, flood of data is being generated on daily basis in various sectors such as health, metrological, business, education, etc. Data mining provides certain tools that can be used to predict behaviors and upcoming trends which allows taking proactive, knowledge driven decisions. It helped to reduce the time consumed to resolve questions, and helped experts by providing information which they might miss because of flood of data being generated or just because it may lie outside their expectations.

Data Mining automatically senses the patterns within the data which are not always visible by the human eye; moreover the process itself is interactive and repetitive discovery process. With technology great flexibility is achieved and hence the world now seems closer than ever. But having enormous data which is not in an understandable format is a matter of concern, so knowledge discovery process gives aid to this problem by first fetching data from different locations to single, then cleaning to have proper format data which is then analyzed for further use.

a. Prediction:

Predictive analytics is an area of data mining that pact with digging out evidence from data and using it to predict styles and behaviour patterns. Usually the unknown event of concern is in the forthcoming, but predictive analytics can be useful to any type of unfamiliar whether it be in previous or upcoming time.

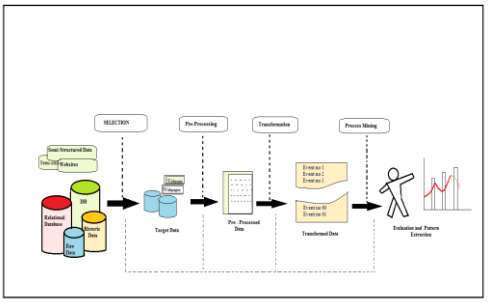

Figure 1: Data Mining Procedure

For case, identifying a criminal's chance of doing a crime based on his past records. The fundamental of predictive analytics count on netting relationships among explanatory variables and the predicted variables from historical happenings, and manipulating them to guess the unidentified outcome. It is vital to note, that the exactness and usability of outcomes will depend prominently on the level of statistics analysis and the value of expectations.

b. Rainfall Prediction:

Weather prediction, application of science and technology is used to forecast the state of the atmosphere for a particular place. The talents of weather forecast originated from initial civilizations by reoccurring astral and meteorological proceedings to aid them monitor the seasonal fluctuations in the climate. Efforts have been made to create predictions based on weather changes and individual experience from old times. Weather estimation is generally done using the facts collected by remote sensor satellites. Weather factors like sea level, humidity, cloud situations, rain, wind, direction of wind are estimated using image taken by weather-related satellites to guess future possibilities.

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Rain is the fundamental agro climatological element and is significant to examine the rainfall for cropping in addition to agriculture predominantly in India. Water intake and farming organization rest on monsoon rainfall as it is a tropical country. It increased vitality for agriculturists, scientists, farmers, disaster management organizations and associated establishments to understand the natural occurrences to design and be ready for the coming scenario.

c. Neural network:

An ANN with moderate number of hidden layer(s) is capable of approximating any smooth function to any anticipated degree of correctness. However, If carelessly used, it can easily learn irrelevant information Artificial neural networks have been extensively used in these days in various aspects of science and engineering because of its ability to model both linear and non-linear systems without the need to make assumptions as are implicit in most traditional statistical approaches. It has been a persistent model over the simple linear regression model. Soft computing deals with approximate models where an approximation answer or result is achieved. Soft computing has three basic components, namely, Fuzzy logic, Artificial Neural Network (ANN) and Genetic Algorithm. Neural network is commonly used by researchers in the field of rainfall prediction. Human brain is a highly complex, nonlinear, and parallel computer (information-processing system).

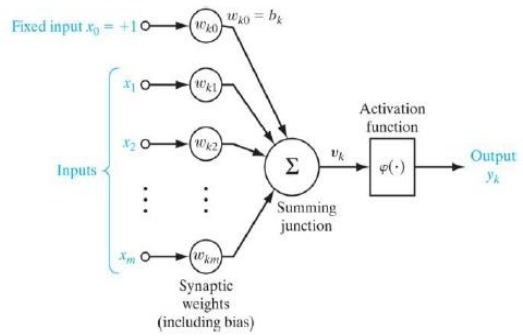

Figure 2: Nonlinear model of ANN

Neural Networks are simplified models of biological neuron system. ANN is a colossally parallel distributed processor made up of simple processing units, which has a natural tendency for keeping experiential knowledge and making it available for use. The fundamental processing element is an artificial neuron, which can receive inputs, and after processing them produces the relevant output just like the natural neuron in human brain. A simple calculated model can be used in explaining a neuron quantitatively. The three basic elements of the neuronal model are: a set of synapses or connecting links, an activation function and an adder. This model also includes an externally applied bias also denoted by bk

d. Adaptive Neuro-fuzzy inference system (ANFIS)

An adaptive Neuro fuzzy inference system or adaptive network-based fuzzy inference system (ANFIS) is a kind of artificial neural network that is based on Takagi–Sugeno fuzzy inference system ANFIS concatenate the fundamentals of Neural Network and the Fuzzy logic. It takes the merits of both the processes i.emodelling ability from FIS and learning capabilties from ANN by being concatenated in a single skeleton. ANFIS gives its benefit in the Rainfall forecasting system and also is well known as universal estimator. It solves the different problems of rainfall prediction. For mere understanding the ANFIS can be seen as an neural network which will behave fuzzily i.e as if an FIS would work.

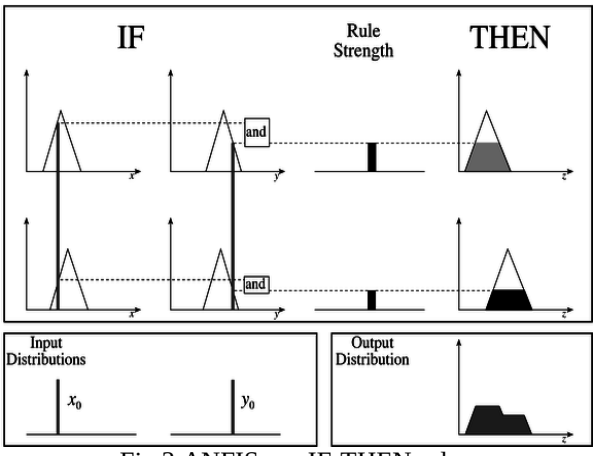

Fig 3 ANFIS use IF-THEN rules

Fuzzy logic

For the rainfall estimation we use the fuzzy logic which uses the if- then rules. Fuzzy mainly consists of some of the specifications which are stated as: corresponding moisture, wind order and its supervision, shallow compression. Fuzzy logic is very beneficial for the compounded systems and for the systems which are unreliable and imperfect. For the methodical applications the fuzzy logic is very constructive. Main phenomenons in operating the fuzzy logic are:

- Fuzzification: this step involves the defining task. In this each variable is properly defined in accordance with the given initials and the coming outcomes.
- Fuzzy rules:In this the rules used for the determination is used for the inference.
- Defuzzification: After applying the rules for inference the outcomes are transfigured back to its raw values.

2. LITERATURE REVIEW

Authors are interested in rainfall events forecast by relating rule-based reasoning and fuzzyLogic. The five parameters: total cloud cover, wind direction, temperature ,relative humidity andsurface pressure are the input variables for model, each has 3 membership functions. The data used is 25 METAR data for Cairo airport station (HECA) [1972–1992]. And 5 years METAR data for MersaMatruh station. Dissimilar models for each station were built depending on the available data sets. Among the overall 243 possibilities we have based our models on 118 fuzzy IF–THEN rules as well as fuzzy reasoning. The output variable which has 4 membership functions, takes values from 0 to 100 corresponding to the % for rainfall

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events given for every hourly data and also used 2 skill scores to verify our results, the Brier score as well as the Friction score. The outcomes are in high pacts with the noted data for the stations with growing in output values towards the real time rain events. Furthermore all implementation are done with MATLAB 7.9 [1].

The arrival of monsoon is keenly awaited in the Indian sub-continent as monsoon has deep impact in the financial and societal domain therefore it has been watched as well as studied in extreme depth. The introduction of satellite imagery made possible to observe the divergent parameters which affect / gets affected by the monsoon on additional worldwide scale. The author has foreseen beginning of monsoon is using two stage parallelized data mining techniques, on features extracted from images taken by satellite.

The objective of this study was to describe a new parallel DM (data mining) technique for the fast forecast of monsoon onset with help of satellite imaging data of earlier years. The system can forecast onset ten to thirty days before hand. There are many of other parameters which get affected or affect the monsoon onset. In future the effectiveness of the method can be enhanced by addition of those features like Outgoing long wave radiation (OLR), (Quantitative Precipitation Estimate) QPE and AP (atmospheric pressure) [2].

Data mining process uses a numerous data assessment method to find patterns and connections in data that are used for exact forecasts. The amount of rainfall may fluctuate from year to year depending on the place. But as Rainfall is major component in monsoon it's planning is at most important for catchment area where assembling of water only on rainfall is carried out for flood/drought/landslide alert techniques. The prevailing system centers on statistical calculations for wide range forecasts of Indian monsoon rainfall have result accurate implementation, for era. Devastating influence on economy of India is caused by small variation in the seasonal rainfall. Component mining method is generally used by climate/water resources researchers to examine high dimensional datasets examples as worldwide sea surface temperature as well as rainfall time to accept the time-based changes of monsoon rainfall in India for experimental purpose [3].

A Web based alert model is that which has customer defined package and gives a specific alert note or warning. Whatever the customer queries or commands that particular request is served by the administrator as a service. Even all bank today conducts alerts to their customers after an amount is credited, withdrawn or a cheque is presented. Weather Guessing is the state of atmosphere by help of science and technology, for a definite area or for fixed time period. Also it summarizes the web based classifications as well as the types of weather forecasting system. Many weather forecasting techniques have been explored but the fundamental intention of the paper is to review the several weather forecasting systems in diverse regions using changed techniques and architecture [4].

Meteorological DM (data mining) is a type of data mining in which finding of concealed patterns inside largely available data in reference to meteorological field is done. Hence the facts retrieved are then changed into expressive knowledge. Weather related data is rich in important knowledge but quality needs to be improved by preprocessing. Agro-cultural sector is predominately depended on rainfall; thereby its forecast becomes a significant matter in agro dominant country India. In this they have used DM (data mining) methods in forecasting Assam's monthly Rainfall, which was carried by using traditional statistical technique –MLR (Multiple Linear Regression). Their dataset includes 6 years period [2007-2012] gathered locally from Regional Meteorological Center of Guwahati. Adjusted R-squared is used to measure their proposed model's performance hence the experiments outcomes shows that the forecasting model based on MLR (multiple linear regressions) shows acceptable accuracy [5].

Over the time, use of GIS has grown intensely in many areas .It consists of computer based tools used to update, capture, store, manipulate, display, print retrieve, analyze large volumes of attribute and geographic data. The author has made effort to understand the fluctuation in rainfall in respect to spatial distribution in Bhilwara District in Rajasthan. Here the practical approach towards classification of data of rainfall over the area of study is represented. To attain this aim work is divided into three sections as pre-processing then data gathering followed by digitization, creation of database geo-referencing, and data refinement is been accomplished. Whereas in the next section connection of spatial and non-spatial data along with creation of map is done. And finally latter section post processing part- the concluding layout with several components is shaped. ArcView is the product of Environmental System Research Institute (ESRI) and is dominant GIS tool when comes to querying, exploring, spatial visualizing and analyzing of spatial data. ArcView 3.2 has new tools which facilitates author's GIS actions as well as strategic updates to prevailing skills [6].

Rainfall plays ansignificant role in the human life. Henceforth, forecast of Rainfall as well as associated parameters are essential to the house hold purpose, agriculture, industries as well as construction of buildings. Any weather prediction is tremendously complicated. This is because related mathematical models are complicate, including many simultaneous nonlinear hydro dynamic equations. In numeroustimes such models do not give accurate predictions. Artificial neural network (ANN) are known to be good at problems where there are no clear cut mathematical models and so ANNs have been tried out to make predictions in our application. Neural networks are now being used in numerous branches of research, with the atmospheric sciences also. The main involvement of the project is the development of ANN to identify the presence of rainfall based on Automatic Weather Station data collected at ISRO weather Research Center, Tirupathi as well aspune [7].

Temperature forecasting is significantas they are used to protect life and property. Temperature predicting is the

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application of science and technology to forecast the state of the temperature for a forthcoming time at a given site. Temperature calculations are made by gathering quantitative data about the present state of the atmosphere. ANN (neural network) can learn multifaceted mappings from inputs to outputs, based exclusively on samples as well as require limited understanding from trainer, which can be guided by heuristics. In this, ANN(neural network)-based algorithm for forecasting the temperature is presented .The ANN (Neural Networks) package supports different kinds of training as well as learning algorithms among which one such is BPN (Back Propagation Neural Network) technique. The chief advantage of the BPN neural network technique is that it can fairly estimated a large class of functions. This is more well-organizedthan numerical differentiation so the simple meaning of this is that the model has potential to arrest the complex relationships between numerous factors that donate to certain temperature. The idea is tested by using the real time weather dataset. The outcomes are compared with applied working of meteorological department as well as these outcomes approve that the models have the potential for fruitful application to temperature foretelling [8].

3. OBJECTIVE

There are lots of problems occur during research process. These problems can be formulated as:

- Collection of the historical data, facts and figures about the rainfall is a difficult process.
- To make the estimate about the rainfall regions, i.e. some having low rainfall, medium rainfall, heavy rainfall. Estimation of these regions is also a very difficult process.
- Choosing the prediction technique is also a matter of concern
- Generating technique of ANFIS is also challenging
- For cleaning the data, pre-processing of the data is also seems like very tough process.
- Performance analysis of different rainfall regions is also difficult

So after analyse the above problems, we have been settled the multiple objectives.

1. To collect real time Rainfall data of Andhra Pradesh region.
2. To pre-processing the data using Data Cleaning technique for predict the accurate result in MATLAB 2010b.
3. To use Intelligent Approach for develop the Fuzzy Inference System with neural Network for rainfall forecasting.
4. To calculate the parameters such as PSNR and Means Squared Error Ratio to identify the accuracy.
5. To Implement the Min-Max Normalization on the Real Data.
6. Generate Results and Compared with actual results.

4. RESEARCH METHODOLOGY

The methodology is the method which has to be followed to complete the research process. The method we are going to explain here is the method for the accurate results of prediction. This section has been explained the steps which have been followed for forecasting accuracy. Initially the input data has been gathered from the available resources and exported to the excel file. Then, the algorithm's step has been mentioned.

1. Study of existing Forecasting Methods/Techniques.
2. Identify and analyze the benefits of forecasting technique.
3. Research on the real time issues of rainfall forecasting.
4. Apply ANFIS Fuzzy Inference Algorithm on real time data in any development tool.
5. Analyze the Accuracy and improvements.
6. Generate Results.

a. Input Data

The input data has been taken for test the proposed algorithm and has been shown as:

	A	B	C	D	E
1	Year	April	May	June	July
2	1835	47.5	205.3	75.7	210.4
3	1836	75.1	115.7	127.9	136.4
4	1837	25.2	133.9	190.5	53.6
5	1838	104.9	79.5	57.2	154
6	1839	30.4	87.1	59.2	182.5
7	1840	63.9	123.8	125.4	30.2
8	1841	97.5	123.9	67.3	112.3
9	1842	29.3	89.7	203.5	81.8
10	1843	59.7	41.8	217.4	334.2
11	1844	5.4	108.3	189.1	282.2
12	1845	21.7	23.7	275.9	220.2
13	1846	26.1	11	127	79.1
14	1847	12.6	85.3	113.7	391.3
15	1848	23.6	17.4	185.5	240.7
16	1849	41.1	67.3	88.1	92.6
17	1850	52.5	54.6	59.5	158.1
18	1851	14.4	95.6	87.1	47
19	1852	3.2	51.9	143.1	71.3
20	1853	2.6	36.6	33.6	31.6
21	1854	6.7	69.4	76.9	34.9
22	1855	25.9	88.9	58.7	76.3
23	1856	43.5	95.6	47	234.8
24	1857	64	11.7	58.1	326.7
25	1858	27.3	63	146.6	117.1

Fig4 Historical Input Data

b. Flow Chart:

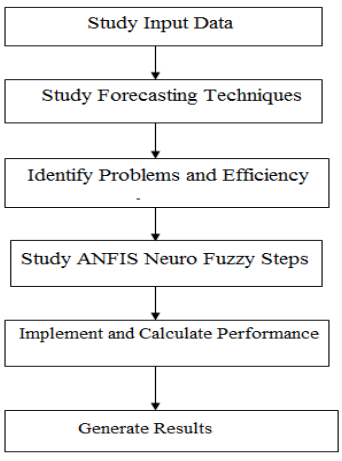

Fig 5: Flow Chart

c. Algorithm

1. Input the Rainfall Data (D) of Particular Region.

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Vol. 4, Issue 7, July 2015

2. Generate a single-output fuzzy inference system (FIS) using a grid partition on the data.
3.Setup Member Functions and input Number of Member Functions,
InMemFuncType = ‘psigmf’;
OutMemFuncType = 'linear';
4. Parameters Adjustment in the Algorithm
5. Move to Next step if Algorithm has been trained, else move to step 4.
6. Perform fuzzy inference calculations.
7. If Successful processed, generate response.
8. If Error Persist, Adjusted Loops, Equations for Actual Prediction and jump to step 5 Else go to Step 10.
9. Results Generated and Identify the Mean Square Errors by Generating Graphs.

5. RESULTS AND PERFORMANCE ANALYSIS

The below graph plots the data according to the enhanced ANFIS algorithm and hence shows the predicted values.

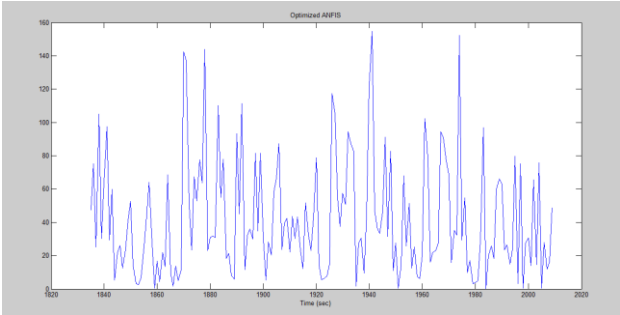

Fig 6 Input Series

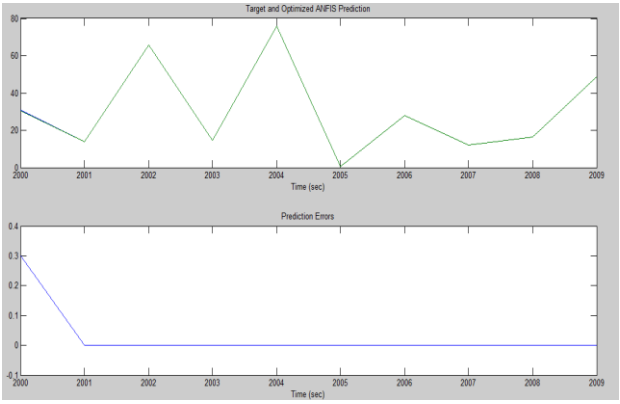

Fig 7Input Series with Predicted Values

For results analysis, the Mean Squared Error has been measured in this context:

MSE Calculation:

n=mean ((OriginalData-anfis_output). ^2);
The outcome for the mean squared error comes out to be 0.0090
Hence calculated MSE =0.0090

6. CONCLUSION AND DISCUSSION

We have used the ANFIS which has been applied for the rainfall forecasting. This provides the proficient, faster and well organised forecasting. We worked on the allocation layer as well as the membership function layer i.e. layer 1&2 simultaneously in order to enhance the proficiency. So we conclude that the overall performance of the forecasting technique has been diverse.
In future, work can be done to enhance the learning algorithm i.e. we can use enhanced hybrid duos of the ANFIS as well as more work could be done in modifying or in fact taking more than one kind of membership functions along with changed values rather than default values of the membership functions.

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