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Prognostication of Climate Using Sliding Window Algorithm

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Abstract

Weather forecasting is the task of determining future state of the atmosphere. To predict the future's weather condition, the variation in the conditions in past years must be utilized. The probability that the weather condition of the day in consideration will match the same day in previous year is very less. But the probability that it will match within the span of adjacent sixty days of previous year is very high. A Sliding window algorithm is emerging as a leading methodology for the application of weather prediction. So, the prediction is made based on sliding window algorithm. So, sixty days are considered for previous year a sliding window is selected of size equivalent to fifteen days. Every thirty days of sliding window is then matched with that of current year's thirty days in consideration. The best matched window is made to participate in the process of predicting weather conditions. The month wise results are being computed for four months to check the accuracy. The experimental results demonstrate that the applied technique gives better predicted weather conditions are quite efficient with an average accuracy of 94.21%.

Keywords: *ANN technique, fuzzy logic, sliding window algorithm, weather prediction*

1. Introduction

Weather is simply refer to the condition of air on earth at a given place and time. Prediction is the statement about future. Weather prediction provide critical information about future weather. There are various approaches available in weather forecasting from relatively simple observation of the sky to highly complex computerized mathematical models. The prediction of weather condition is essential for various applications. Some of them are climate monitoring, drought detection, severe weather prediction, agriculture and production, planning in energy industry, aviation industry, communication, pollution dispersal, marine, and so forth etc., [1]. Accurate prediction of weather conditions is a difficult task due to the dynamic nature of atmosphere. The weather condition at any instance may be represented by some variables like maximum temperature, minimum temperature, rain fall, snow fall, etc. The selection of variables is dependent on the location for which the prediction is to be made. The variables and their range always vary from place to place. The weather condition of any day has some relationship with the weather condition existed in the same tenure of previous year and previous thirty days.

A statistical model is designed [2] that could predict the future weather conditions with the help of past data by making use of time-delayed feed forward neural network. ANNs provide a methodology for solving many types of non-linear problems that are difficult to solve by traditional techniques. Artificial neural network was combined with the genetic algorithm to get the more optimized prediction [3]. An improved technique that uses an

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ensemble of neural networks like multi-layered perceptron network (MLPN), Elman recurrent neural network (ERNN), radial basis function network (RBFN), Hopfield model (HFM) predictive models and regression techniques for prediction [4]. Apart from neural network Fuzzy logic has also been being used in weather prediction models. Also a fuzzy self-regression model was proposed by Lu Feng and Xuxiao Guang [5].Which makes use of the form of self-related sequence number according to observed number. The self-related coefficients were computed by making use of Fuzzy Logic [6]. A combined approach of neural network with Fuzzy Logic is being proposed for the weather prediction system [7]. The work has applied principle component analysis technique to the fuzzy data by making use of Auto associative neural networks.

But the major shortcomings in the techniques proposed above that they utilized the previous weather conditions to predict the ones in future, but the underlying relationship that exists between previous data had not been being mathematically described and analyzed. The techniques using artificial neural networks (ANN) were only concerned with the adjustment of weights in order to get correct output from the given input. But no relationship among the data was mathematically defined. Also the ANN techniques suffered from anomalies like local minima, over fitting, and so forth. Another problem is that it is hard to decide how much training data is sufficient to adjust weights so that optimal accuracy of the predicted weather conditions can be achieved. The number of other techniques for weather forecasting that used regression with machine learning algorithms was proposed in [8,9]. But a mathematical model that could represent the relationship among previous data that could be used for prediction is still desired. A new sliding window approach for the same is being proposed in this text for weather prediction.

2. Proposed Work

2.1. Methodology

There is always a slightly variation in weather conditions which may depend upon the last thirty days or so variation. Here variation refers to difference between previous day parameter and present day's parameter. In this work a methodology is being proposed that could mathematically model these dependency and utilize them to predict the future's weather conditions. To predict the day's weather conditions this work will take into account the conditions prevailing in previous thirty days, that is, in last thirty days which are assumed to be known. Also the weather condition of thirty previous days and thirty upcoming days for previous year is taken into consideration. For instance if the weather condition of 10thOctober, 2013 is to be predicted then we will take into consideration the conditions from 09th September, 2013 to 09th October, 2013 and conditions from 09th September, 2012 to 09th November, 2012 for previous years. Now in order to model the aforesaid dependencies the current year's variation throughout the thirty days is being matched with those of previous years by making use of sliding window. The best-matched window is selected to mark the prediction. The selected window and the current year's thirty days variations are together used to predict the weather condition. The reason for applying sliding window matching is that the weather conditions prevailing in a year may not lie or fall on exactly the same date as they might have existed in previous years. That is why thirty previous days and thirty ongoing days are being considered. Hence a total period of sixty days is checked in previous condition to find the similar one. Sliding window is quite good technique to capture the variation that could match the current year's variation.

2.2. Sliding Window Algorithm

The work proposes to predict a day's weather conditions. For this the previous thirty days weather is taken into consideration along with sixty days weather conditions of past years. Suppose we need to predict weather of 16thNovember, 2014then we will take into consideration the weather conditions of 15th October, 2014 to 15thNovember, 2014 along with the weather conditions prevailing in the span of 15th October, 2013 to 15th December, 2013 in past years. Then the day by day variation in current year is computed. The variation is also being computed from the sixty days data of previous year. In this work the three major weather parameters will be taken into consideration, that is, maximum temperature, minimum temperature and Rainfall. Hence the size of the variation of the current year will be represented by matrix of size 30x3. And similarly for past year the matrix size would be 60x3. Now, the first step is to divide the matrix of size 60x3 into the sliding windows. Hence, 31 sliding windows can be made of size 30 x 3 each. The concept of sliding window is shown in Figure 1.

The below figure 1 represents the sliding window algorithm concept for previous year fortnight consideration. But, in this paper we can implement the sliding window algorithm concept for sixty days.

Now the next step is to compare every window with the current year's variation. The best matched window is selected for making the prediction. The Euclidean distance approach is used for the purpose of matching. The reason for taking Euclidean distance is its power to represent similarity in spite of its simplicity. Following are the parameters used for the weather prediction:

2.2.1. Mean: Mean of day's weather conditions, that is, maximum temperature, minimum temperature, humidity, and rainfall. After adding each separately, and divide by total day's number.
Mean =Sum of parameter/ number of days,

2.2.2. Variation: Calculate day by day variation after taking difference of each parameter. This tells how the next day's Weather is related to previous day's weather.
2.2.3. Euclidean distance: It compares data variation of current year and previous year.

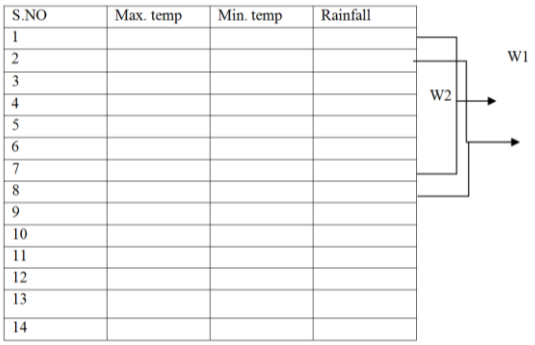

Figure 1. Sliding Window Concept where *W*1 Represents Window Number 1 and *W* 2 represent Window Number 2R

By this we are able to do mathematically model the aforesaid defined dependencies. That the relationship between previous year and previous week data is being defined mathematically can be used to predict the future conditions.

The sliding window used for predicting the "3" number of weather conditions is shown in Algorithm 1.

The sliding window used for predicting the "n" number of weather conditions (WC1, WC2, WC3, ..., WCn) is shown in Algorithm 1.

The main logic behind using sliding window approach is that the weather conditions prevailing at some span of day in the year might not have existed in the same span of days in previous year. For instance, the weather condition of February, 2014 might not have existed in February, in 2013. The similar weather conditions might have prevailed in previous year but not necessarily in same month but in some days. The probability of finding the similar weather conditions are maximum at the considered sixty days spam.

Step 1. Take matrix "CD" of last thirty days for current year's data of size 30 × 3.
Step 2. Take matrix "PD" of sixty days for previous year's data of size 60 × 3.
Step 3. Make 8 sliding windows of size 30 × 3 each from the matrix "PD" as $W1$, W2, $W3$, ..., $W8$.
Step 4. Compute the Euclidean distance of each sliding window with the matrix "CD" as ED1, ED2, ED3, ..., ED8.
Step 5. Select matrix Wi as
Wi= Corresponding Matrix (Min.(EDi))
$\forall i \in [1, 8]$
Step 6. For$k$ = 1 to n
(i) For WC$k$compute the variation vector for the matrix "CD" of size 6×1as "VC".
(ii) For WC$k$compute the variation vector for the matrix "PD" of size 6×1as "VP".
(iii) Mean1 = Mean (VC)
(iv) Mean2 = Mean (VP)
(v) Predicted Variation "V" =(Mean1+ Mean2)/2
(vi) Add "V" to the previous day's weather condition in consideration to get the predicted condition.
Step 7. End

Algorithm 1

3. Results and Discussions

The previous algorithm is being tested against weather data for the years 2014 of the chirala city, Andhra Pradesh. The data has been taken from www.accuweather.com [10]. The algorithm has been executed and tested in Matlab2009b version. Thus, in the algorithm in consideration the previous year's data is being utilized for predicting the weather conditions. Hence, the algorithm is tested to predict weather condition for four months, that is, September, 2014-December, 2014 which is being tested against the available data. Also it can be concluded that learning approach used in the algorithm is supervised. In the test three weather conditions are taken into consideration, that is, minimum temperature, maximum temperature, and rainfall. Temperature, in general, can be measured to a higher degree of accuracy relative to any of the other weather variables. The data of these three factors are taken day wise for the previously mentioned four months. The algorithm is also being tested day wise.

Figure 2 shows the variation of actual and predicted three weather conditions for 4 months in the year 2014.

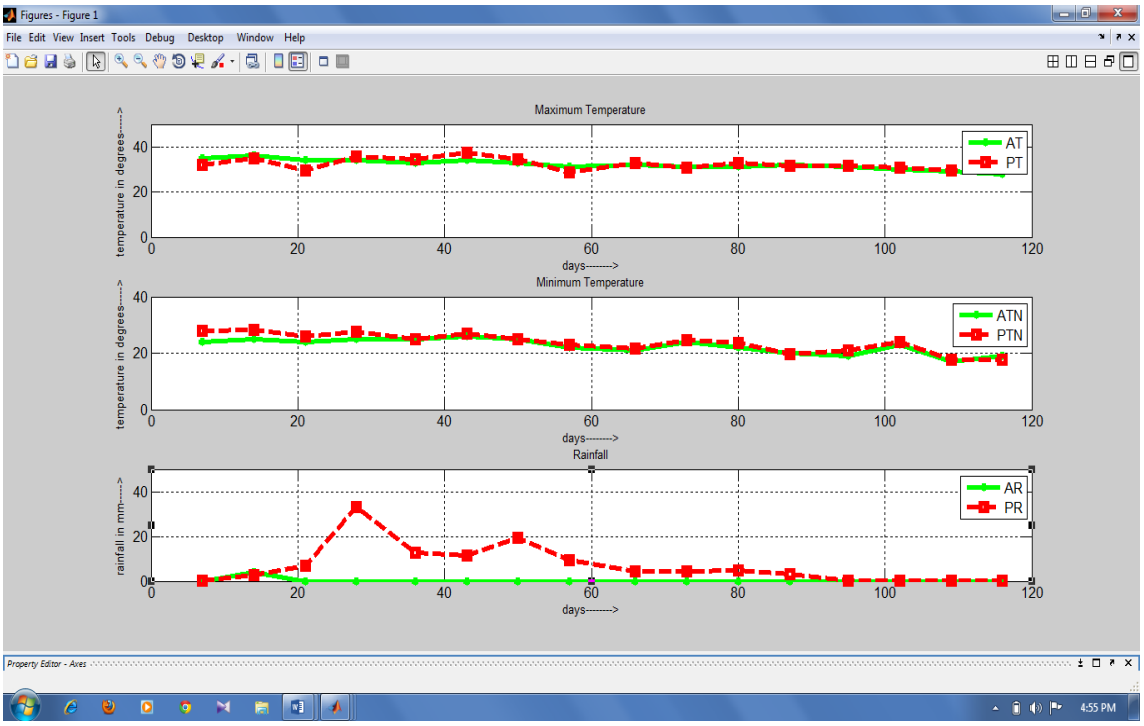

Figure 2. A Graph Representing Predicated Versus Actual Three Parameters are Maximum Temperature, Minimum Temperature, Rainfall for 4 Months in the Year 2014

These graphs are clearly shows least variation among the actual and predicted weather conditions.

Table 1. The Month Wise Accuracy of Predicted Weather Conditions is Being Given in the Below

Month	Accuracy of predicted data
September	90.65
October	93.00
November	96.57
December	96.61

Table 1

The above result of weather conditions have been from an Indian city. India has a typically tropical type of weather, that is, the weather which has all varieties. The chirala city lies in the state of Andhra Pradesh. The month wise accuracy in Table 1 can be understood by the following facts. The month like August, September are considered to be the month when weather changes, that is, a phase of transition from one season to another. In the months like October, November and December are called as winter months.

4. Conclusion and Future Work

The comparison of weather condition variations using sliding window approach has been found to be highly accurate except for the months of seasonal change where conditions are highly unpredictable. Since ANN techniques are very good in mapping

inputs and outputs, the sliding window algorithm if incorporated with ANN could improve the results drastically even for the months of seasonal change.

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