IoT based climate prediction using ANN for green networking

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Abstract

Weather forecasting plays a major role in various fields such as agriculture, transportation etc., It is also essential in prediction of natural disasters like Flood, storm etc., So in order to prevent the damages from such natural disorders, accurate weather prediction is essential. IoT topology is a combination of both hardware and wireless communication network utilized for real-time data analysis. Hence, this proposed topology formulated an IoT based weather monitoring using artificial neural network (ANN) for prediction. The main objective of this designed topology system is monitoring weather parameters such as temperature/humidity/ pressure/ rainfall etc., IoT is organized to collect data from sensors and is communicated through Wi-Fi network. ANN is tailored for weather prediction. The analysis proves that the proposed architecture shows better efficiency in weather prediction than the conventional methods.

Keywords: IoT, ANN, Weather Prediction

1. Introduction

Changes in weather and climate conditions are unavailable one in the world. But observing weather conditions is very essential to predict the changes in the environment. So, traditional weather forecasting is carried out by the government of every country. It is carried out by simulating the atmosphere conditions. However, this system may be unstable under disturbances and also exhibits uncertainty in prediction. Hence, they is need to organize an automated weather station to record the parameters of the atmosphere. Thus by utilizing the developments in technology, the changes in the atmospheric parameters can be easily measured. This kind of weather forecasting will be applicable many kind of fields such as agriculture, transportation etc.,

This accurate atmosphere data measured by the sensors should reach the station fastly and at the same time, it should be accurate so the data can be transmitted by GSM/GPRS etc., Then, the data send to the station should be processed accurately and predict the condition of the weather. Thus, the main motive of this design is to predict the accurate weather condition using ANN. For this, 802.11b/g wireless communication topology is incorporated [10-12]. It updates the data from the remote area. This proposed topology includes rain measurement sensors, temperature sensors and press use sensors. After retrieving data from the remote area, the accumulated data is processed by machine language to predict the accurate weather condition [3,5].
Holmstrom et al (2016) utilized both linear/functional regression methods to predict the weather condition. Piyushkapoor et al (2013) predicted the weather condition using a sliding window algorithm. But the disadvantage of this system is that the change in window size alters the prediction rate. Sathyam Gupta (2016) suggested a weather prediction method using linear regression concept. Qing Yi Feng et al (2016) implemented a weather prediction topology using decision tree algorithm. However, all these methods have accuracy about 80% only so far. Hence, to overcome this problem, this work suggested neural network topology to predict the weather condition. Thus the main objective of this work includes,

- Collection of dataset (such as temperature, rainfall etc) using IoT topology;
- Validation of ANN for weather prediction;
- Comparative analysis of Ann with other machine learning topology.

2. Architecture of Processed Model

In order to carry out the weather prediction topology, data such as temperature, humidity of a particular area is collected using IoT network. For this purpose, the structural diagram shown in Fig.1 is utilized. It comprises sensors and Raspberry pi model.

![Fig.1 Architecture of the proposed topology](image)

The sensors for measuring physical quantities are installed in an area and the required data are measured. Sensors such as DHT-is adopted for humidity measurement and BMP180 is utilized as, a pressure sensor. The measured data are passed via Raspberry pi model to the target area.

2.1 Raspberry pi

It is a Linux based Pc board. The model board of Raspberry pi model utilized in this proposed topology is shown in Fig.2.
It comprises 4 USB ports. 40 pins GPIO Header are in the raspberry pi board to have association with sensors. It has in build MCP3008ADC chip [7]. This Raspberry Pi unit acts like a single IoT node and is interconnected to Wi-Fi network via WLAN technology. This IoT node delivers data to the cloud and the same is depicted in Fig. 3.

Then, collected data in the server are fed as input to the ANN and weather prediction has been made. [8, 9].
2.2 Methodology

This study evaluates the effectiveness of ANN for estimating frequency of occurrence of floods in major cities. Normally, in the present day, Chennai is getting affected by flood during the monsoon season. Hence, in the work, prediction over Chennai is considered as a study case. Once after selecting the area, the next step was to design the factors for prediction of flood occurrence. Hence, the data collected using IoT should include maximum and minimum temperature/ rainfall level and flood occurrence etc., Finally, the data was taken over a period of dataset of flood in Chennai region during 2015. After data collection, two data preprocessing are conducted. They are as follows,

- The missing data are replaced with neighbor one.
- After that, the data should be normalized.

The use of raw original data should be normalized between -1 and 1 before it is processed through ANN. Thus the basic flowchart of designing ANN model is depicted in Fig. 4

![Basic flow for designing ANN model](image)

Then, A three-layer structure shown in Fig.5 was selected with hyperbolic tangent (tanh) transfer function for hidden layer and linear transfer function for output layer. Thus the chosen weather data with 176 samples were divided into 70% as training dataset, 14% for validation and the remaining 16% for testing and the proposed ANN architecture parameters are depicted in Table 1.
Table 1 Parameters of ANN Architecture

| Parameters          | Values |
|---------------------|--------|
| Delay (Input)       | 1:4    |
| Delay (Feedback)    | 1:4    |
| No. of HL           | 9      |
| Learning Rate (LR)  | 0.01   |
| Max. Epochs         | 1000   |

2.2.1 Learning Algorithms

In ANN, the learning algorithms play a major role in the prediction process. Among those, this work utilized two algorithms for prediction.

**Gradient descent (GD):** It provides first-order gradient information about NN (e.g., back propagation and real-time recurrent learning). The only variable which is used for convergence is the step size. If the steps are too small, then it will take long time to converge. Or else if the step size is large, there may overshoot in convergence and it leads to have divergence in results.

**Levenberg-Marquardt (LM):** It is one of the most adapted algorithms in NN with minimized MSE. It is a member of learning algorithms called ‘pseudo second order methods’. It utilizes Gauss-Newton approximation and discards error obtained during second-order derivative. A major advantage of this approach is that it adopts gradient search when the performance deviates from a parabola.

2.4.2 Accuracy Measures

Four quantities are used to calculate the accuracy measures. They are defined as follows:
1. True-Positive (TP)
2. False-Positive (FP)
3. False-Negative (FN)
4. True-Negative (TN)

Based on these parameters, we can calculate Accuracy, Precision, Recall and F1.

\[
\text{Accuracy, } A = \frac{TN+TP}{TN+FN+TP+FN}
\]

\[
\text{Precision, } PV = \frac{TP}{TP+FP}
\]

\[
\text{Recall, } R = \frac{TP}{TP+FN}
\]

\[
F1 = 2 \times \frac{PV \times R}{PV + R}
\]

3. Results and Discussion

3.1 Comparison of Learning Algorithms

The ANN model predicted with different learning algorithms during flood are explored in the following section. Fig. 6 shows the regression analysis of GD.

From the above figure, it is observed that the regression is about 0.7984 which indicates 79% of resemblance between the target and predicted output. Similarly, Fig. 7 illustrates the regression analysis of LM algorithm.
From Fig.7, it is observed that the regression is about 0.9055 which indicates 90% of resemblance between the target and predicted output. Hence, it is concluded that the proposed LM exhibits higher accuracy than GD.

The results of statistical analysis based on MSE, and R to evaluate forecasted flood is shown in Table 2. The results of Table 2 indicated that LM algorithm has less error as compared to GD. From Table 2, it can be clearly shown that all the algorithms are positively correlated. The LM algorithm has the highest R than GD. The results show that LM algorithm is best for flood prediction over Chennai.

| Performance Measures | GD       | LM       |
|----------------------|----------|----------|
| R                    | 0.7984   | 0.9055   |
| MSE (Train)          | 8.9125   | 2.6985   |
| MSE (Validation)     | 9.9521   | 8.2956   |
| MSE (Test)           | 10.6545  | 4.9685   |
| Epochs               | 40       | 20       |

Thus the results of prediction accuracy and other related metrics of GD and LM algorithm are given in Table 3a and 3b.

| Detailed accuracy terms | Value |
|-------------------------|-------|
| Accuracy                | 70.12%|
| Precision               | 0.89  |
| Recall                  | 0.88  |
| F1 Score                | 0.85  |
Table 3b. Metrics of LM algorithm

| Detailed accuracy terms | Value     |
|-------------------------|-----------|
| Accuracy                | 88.12%    |
| Precision               | 0.95      |
| Recall                  | 0.93      |
| F1 Score                | 0.95      |

From the above table, it is clear that higher precision and recall value indicates that predicted results are more accurate for LM algorithm.

Fig. 8 gives the performance accuracy of learning algorithms.

![Fig. 8 Performance accuracy of learning algorithms](image)

The results from Fig. 8 clearly indicated that overall accuracy of LM algorithm is 88.12% whereas GD has accuracy of 70.12%. Hence it is concluded that the ANN model with LM algorithm has the ability to predict weather parameters with reasonable accuracy.

3.2 Comparative analysis

Finally, the accuracy of prediction is high for ANN (88.12%) as compared to other machine learning algorithms. This indicates that this proposed system will give better prediction with an ANN as compared to other machine learning algorithms and the same is depicted in table 4.

Table 4. Comparative analysis with different algorithms

| Algorithm | Accuracy |
|-----------|----------|
| ANN       | 88.12%   |
| SVM       | 85.57%   |
| Bayes     | 87.01%   |
| KNN       | 85.73%   |
Fig. 9 Comparative analysis of algorithms (Accuracy)

Fig. 9 depicts the accuracies of the ANN, Bayes, SVM and KNN algorithms taken over a range of 50 readings each. It can be clearly seen that ANN outperforms the other algorithms with an accuracy of 88.50%. On whole, it is shown that ANN gives the best prediction when compared to other ML algorithms.

Fig. 10 Comparative analysis of algorithms (F1 score)

Fig. 10 shows the F1 score of ANN, Bayes, SVM and KNN algorithms. It can be clearly seen that ANN outperforms the other algorithms with an F1 score about 0.95. On whole, it is shown that ANN gives the best prediction when compared to other ML algorithms.

4. Conclusion

India contributes 1/5th of the deaths due to floods. Hence, more number of works has been carried out for flood prediction using ML algorithms. This work employed ANN for forecasting the occurrence of flood using temperature and rainfall data using LM and GD learning algorithms. From the analysis, it is concluded that the proposed ANN with LM algorithm gives better prediction accuracy. Then on comparing the accuracy of the proposed topology with four different algorithms, the results indicate that the proposed ANN can be efficiently used for flood prediction. Based on this prediction of probability of flood occurrence, an alert can be provided
for migration of humans to save their lives and property. With the advancement of ANN, it can also consider for food prediction in different cities/states of India.

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