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Application of Machine Learning for Weather Forecasting Using Artificial Neural Networks

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Abstract— The weather forecasting has been prepared using the atmosphere condition manually. However, these estimations are unstable and imprecise for long duration. The machine learning is more robust compute the weather forecasting with precise prediction for long duration. This paper has proposed the Artificial Neural Networks (ANN) based model with supervised learning model in weather prediction. This proposed prototype is designed to predict different weather conditions with linear regression. This model is simulated with different dataset using supervised learning machine learning data repository. The proposed model performed better than traditional method in weather prediction. The atmosphere parameters such as temperature, pressure, dew, humidity are exploited to design, train and test a model. The future climate is predicted using machine learning by analyzing the parameters.

Keywords— Weather, Neural Network, Climate, Forecast, Linear Regression, Machine Learning

I. Introduction

The weather prediction is one of the primary environment factor in planting, seedling, harvesting in agriculture applications, etc. In traditional system, weather forecasting has been estimated manually using simulation. The simulation is considered the atmosphere as a fluid to predict the weather. The present atmosphere parameters have been utilized for model references. The forthcoming atmosphere parameters are estimated using thermodynamics and fluid dynamics numerical calculations. However, the differential equations are generated uncertain and unstable prediction in critical situations. It is resulted uncertain output during initial environment condition measurements of the atmosphere. It leads to predict the unreliable results of weather for continuous

15 days' period since misunderstanding the atmospheric processes. The proposed ANN is robust to compute atmospheric disturbances than traditional methods. The ANN is not dependent on the physical laws of atmospheric progressions [13, 14]. The linear regression considers entire features of the dataset and produces results linearly [12]. This linear graph consists the combination of high and low temperatures. It produces the results in numerical data since it is not used for classification data.

II. Related Work

Mark Holmstrom et al have been suggested linear regression and functional regression models that have not been performed well compared with professional weather forecasting approaches since performance is decreased in the longer run. It is inferenced that unable to predicts the results precisely for a longer period of time [1]. PiyushKapoor and Sarabjeet Singh Bedi have described the sliding window technique produced good prediction for varying weather condition. This results are highly precise in few weather conditions except seasonal climate change months. It also could be changed window size for better results i.e window size can be increased from the weeks to months for increasing the accuracy of results [2]. The machine learning approach is made process efficient and effective in recognizing the identity automatically [3].

DivyaChauhan and Jawahar Thakur have been presented that k-mean clustering and decision trees are performing better in data mining to predict upcoming weather conditions. It is suggested that training dataset size influence the accuracy. The huge dataset has produced the high accuracy initially. However, accuracy is decreased gradually after the specific time period [4]. Qing Yi Feng et al have been presented toolbox that is collected climate condition from complex networks [5]. The climate data is collected from the environment through Internet of Things technology using temperature, pressure and moisture sensors [6]. The neural network is capable of process the multivariable data which is collected from the climate condition. This model is designed to predict the weather based on data driven approach. Hence, it is dynamic method. Siddharth et al have been exploited the

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Decision tree data mining technique to classify weather parameters such as minimum temperature, maximum temperature for day, month and year [7]. Sanyam Gupta et al have been recommended and proposed a prototype that predicts the weather forecasting with high precision using normal equations and linear regression model [8]. The normal equation is one of outperforming weather prediction model that considers the temperature, humidity and dew-point entities. This generates the reliable weather forecasting with larger dataset to lead the life with prior decision. Muthulakshmi et al have presented an approach that predicts the rain-falling accurately. It predicts the weather efficiently and reliable to predict rainfall using large dataset [9].

Aditya Grover et al have been proposed a weather prediction model that forecasting the weather using combination of key weather variables and it influences the process. It has been exploited the kernel that showed an interpolation of space, and computed using GPS with such a kernel. It is considered for calculating forecasting such as turbulence. It has shown that deep neural network provides results using temporal analysis based on gradient tree [10]. Williams et al have suggested model using random forest machine learning method to predicts the thunderstorm. The random forest model is identified regimes that improved the processing performance of the application using a forecast logic [11].

III. METHODOLOGY

The proposed neural network is designed with simple neurons that are operating in parallel. This network is connected with numerous neurons which perform a particular operation by adjusting the weight values of the connections among neurons. The neural network is trained with large dataset in which input features leads to a particular target output. The neural network is shown in Fig.1. In supervised learning model, the computed output is compared with target output. If the computed output is not equal to target output, weights of the network is adjusted until the computed output to match with the target output. It is designed to perform complex functions in various domains of applications such as pattern recognition, weather forecasting, face recognition, classification and object identification [13].

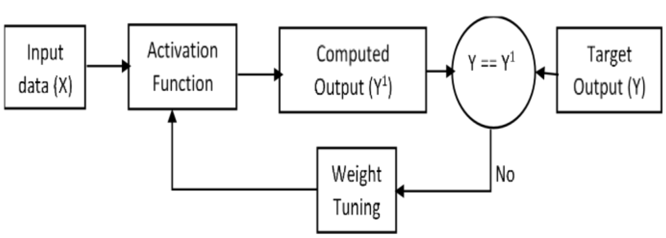

Fig 1. Neural network processing representation

MULTILAYER PERCEPTRON NEURAL NETWORK

Multilayer Perceptron Network is typically called as ANN. It consists complex neural network with four layers such as input layer, two hidden layers and output layer. The input layer consists five neurons, two hidden layers consists seven neurons and output layer consists four neurons []. The input feature variable values ($x_1 ... x_n$) is loaded into the input layer neurons. The input features are standardized in the range of -1 to 1. The input layer neurons are transforming the feature values to every neuron in the first hidden layer. The bias value is multiplied with a corresponding weight and accumulated the value transforming into the neuron. The input variable value of each neuron is multiplied with a weight (w_{ji}). The result is adding weighted values together for value weighted sum (u_j). The sum is transfer to sigmoid function, σ.

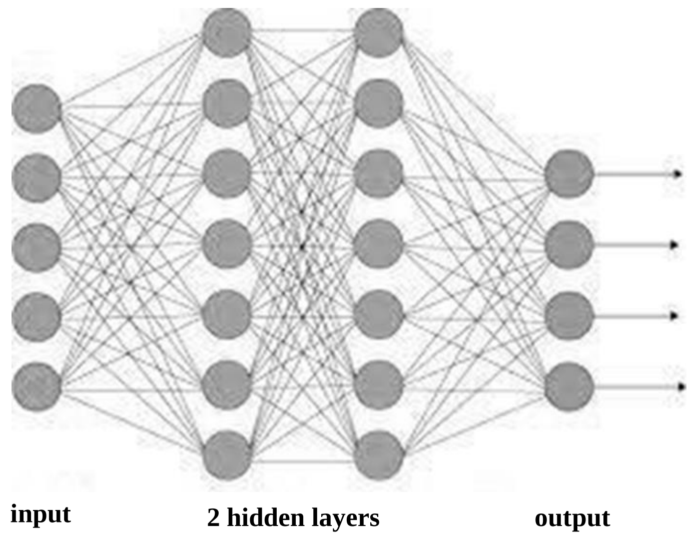

Fig 2. Artificial neural network

The sigmoid function is computed the value h_j which is the output of hidden layer 1. The first hidden layer output value of the predictor variables is distributed to the second layer neurons. The bias value is fed to each neuron of the both hidden layers and output layer. The sum of weighted values of second hidden layer computes sigmoid value that is fed into the output layer. The output value of each second hidden layer neuron is multiplied with a weight (w_{kj}). The computed result is combined weighted values that produces value v_j. The weighted sum (vj) is send to a sigmoid function that computes the output value y_k. The computed values of this network output is y. The Root Mean Square is computes the error of this network. The backpropagation is used for adjusting the weighted values to improve the compute output that should be match with target output.

Algorithm:

1. Train ANN model with input X(i), and weights.
2. X ={ mxT, mnT, mnPr, mxPr, dew, humidity} of past few years
3. Compute and optimize the model with test dataset

4. i. Cross validate the proposed model with unknown dataset
   ii. Minimize the cost function
5. Once model is ready, send the past two days minimum and maximum values as input
6. Predict the minimum and maximum temperature, pressure, humidity, dew for the next day

IV. RESULTS AND DISCUSSION

The proposed ANN model is trained with 80% and tested with 20% of dataset. The data is presented in the Fig 3.

date	meantempm_1	meantempm_2	meantempm_3	meandewptm_1	meandewptm_2	meandewptm_3	meanpressurem_1	meanpressurem_2	meanpres
2015-01-04	-4.0	-6.0	-6.0	-11.0	-9.0	-12.0	1016.0	1022.0	
2015-01-05	-14.0	-4.0	-6.0	-19.0	-11.0	-9.0	1033.0	1016.0	
2015-01-06	-9.0	-14.0	-4.0	-14.0	-19.0	-11.0	1032.0	1033.0	
2015-01-07	-10.0	-9.0	-14.0	-15.0	-14.0	-19.0	1036.0	1032.0	
2015-01-08	-16.0	-10.0	-9.0	-22.0	-15.0	-14.0	1035.0	1036.0	
2015-01-09	-7.0	-16.0	-10.0	-12.0	-22.0	-15.0	1024.0	1035.0	
2015-01-10	-11.0	-7.0	-16.0	-19.0	-12.0	-22.0	1035.0	1024.0	
2015-01-11	-6.0	-11.0	-7.0	-12.0	-19.0	-12.0	1023.0	1035.0	
2015-01-12	-5.0	-6.0	-11.0	-11.0	-12.0	-19.0	1024.0	1023.0	
2015-01-13	-13.0	-5.0	-6.0	-17.0	-11.0	-12.0	1040.0	1024.0	
2015-01-14	-12.0	-13.0	-5.0	-18.0	-17.0	-11.0	1037.0	1040.0	
2015-01-15	-2.0	-12.0	-13.0	-8.0	-18.0	-17.0	1026.0	1037.0	
2015-01-16	1.0	-2.0	-12.0	-6.0	-8.0	-18.0	1023.0	1026.0	
2017-09-14	23.0	22.0	23.0	13.0	14.0	13.0	1008.0	1014.0	
2017-09-15	27.0	23.0	22.0	13.0	13.0	14.0	1005.0	1008.0	
2017-09-16	27.0	27.0	23.0	15.0	13.0	13.0	1006.0	1005.0	
2017-09-17	19.0	27.0	27.0	17.0	15.0	13.0	1012.0	1006.0	
2017-09-18	16.0	19.0	27.0	9.0	17.0	15.0	1021.0	1012.0	
2017-09-19	21.0	16.0	19.0	18.0	9.0	17.0	1014.0	1021.0	
2017-09-20	26.0	21.0	16.0	19.0	18.0	9.0	1005.0	1014.0	
2017-09-21	22.0	26.0	21.0	13.0	19.0	18.0	1007.0	1005.0	
2017-09-22	25.0	22.0	26.0	18.0	13.0	19.0	1008.0	1007.0	
2017-09-23	30.0	25.0	22.0	20.0	18.0	13.0	1008.0	1008.0	
2017-09-24	28.0	30.0	25.0	18.0	20.0	18.0	1011.0	1008.0	
2017-09-25	24.0	28.0	30.0	18.0	18.0	20.0	1012.0	1011.0	
2017-09-26	16.0	24.0	28.0	15.0	18.0	18.0	1014.0	1012.0	
2017-09-27	15.0	16.0	24.0	11.0	15.0	18.0	1019.0	1014.0	

997 rows × 36 columns

Fig 3. ANN presentation of weather dataset

It shows the minimum and maximum temperature, humidity, pressure and dew point. The Fig. 4 shows the computation of average loss of the network. It shows that average loss is minimal.

```
INFO:tensorflow:Restoring parameters from tf_wx_model\model.ckpt-39600
INFO:tensorflow:Finished evaluation at 2018-03-09-12:13:56
INFO:tensorflow:Saving dict for global step 39600: average_loss = 10.4977, global_step = 39600, loss = 1049.77
INFO:tensorflow:Create CheckpointSaverHook.
INFO:tensorflow:Restoring parameters from tf_wx_model\model.ckpt-39600
INFO:tensorflow:Saving checkpoints for 39601 into tf_wx_model\model.ckpt.
INFO:tensorflow:loss = 4735.41, step = 39601
INFO:tensorflow:global_step/sec: 64.9575
INFO:tensorflow:loss = 5452.96, step = 39701 (1.535 sec)
INFO:tensorflow:global_step/sec: 67.1816
INFO:tensorflow:loss = 5073.37, step = 39801 (1.489 sec)
INFO:tensorflow:global_step/sec: 67.5185
INFO:tensorflow:loss = 4967.46, step = 39901 (1.486 sec)
INFO:tensorflow:Saving checkpoints for 40000 into tf_wx_model\model.ckpt.
INFO:tensorflow:Loss for final step: 5024.61.
INFO:tensorflow:Starting evaluation at 2018-03-09-12:14:08
INFO:tensorflow:Restoring parameters from tf_wx_model\model.ckpt-40000
INFO:tensorflow:Finished evaluation at 2018-03-09-12:14:09
INFO:tensorflow:Saving dict for global step 40000: average_loss = 10.4366, global_step = 40000, loss = 1043.66
```

Fig. 4 Average loss representation

Fig 5 shows the loss of network with respect to number of iteration. The curve converges when increasing the number of epochs.

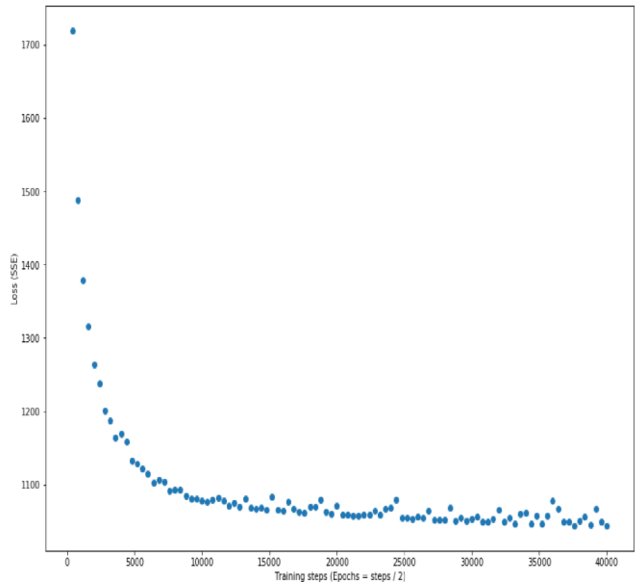

Fig. 5. Epochs versus loss

V. CONCLUSION AND FUTURE SCOPE

This paper has been proposed weather prediction model using machine learning technique ANN. This model is trained with public dataset and tested the results with cross validation. This computes the upcoming period weather based on the past history of weather data. ANN model proves that computes the better results than existing traditional system. The future work could be extended to build a prediction model using images with Convolutional Neural Network.

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