ISSN No:-2456-2165

Artificial Intelligence in Weather Monitoring

MANTU BERA
IT Teacher, JYCSM, Narajole, Paschim Medinipur, West Bengal, India

Abstract:- Weather monitoring and forecasting is generally a analytical measure. We want to develop an smart weather forecasting module as this is a important tool. The tool considers measurements of max. temperature, min. temperature and rainfall for a sampled period of days and then analyzed. An intelligent prediction using available data is carried out with the use of machine learning algorithms or techniques. The study and prediction, on the basis of linear regression that predicts the weather for the next day with good perfection and reliability. Based on the dataset, we got accuracy more than 90%. Recently studies proved that machine learning techniques are obviously better than traditional statistical techniques. The Machine learning techniques is proved to be a powerful method in forecasting as well as investigating a provided data set. This section carries a crucial role in agricultre, industry as well as management sectors, where the weather prediction is a significant criterion.

Keywords:- *Machine Learning, Weather Monitoring, AI, Linear Regression, SVM*

I. INTRODUCTION

We all know weather forecasting is naturally a difficult process. It needs many parameters for forecasting the weather. Weather Monitoring and predicting assists us in several sectors like agriculture, travel, pollution dispersal, communication, disaster management, etc. Hence , the weather forecasting acts a crucial role in everyday aspect and employing the requirements of a ordinary man up the research engineers and scientists. IT implies why weather forecasting is not possible to predict with easier means. Fortunately there are HD-satellite pictures to forecast weather for upcoming or next days with high accuracy, although this process is not simple and not economical. However, the module provides us of prediction of weather with the use of the previous data ,after that analyzing this with good accuracy and also proved as easy one .This section includes the concepts of artificial intelligence as well as machine learning techniques. From Some of the several techniques, we have already preferred linear-regression . Mandatory thing should be carried out by the user have to upgrade weather of the previous day-paramaters or else this system is failed to utilize linear regression for prediction, as each tool associated with machine learning including the continuous update of previous data.

II. ASSOCIATED WORKS

The author carried out the prediction the temperature of atmosphere with the use of Support vector machine(SVM). It make us well understood about the imperfections of Support vector machine (SVM). The forecasting interval by utilizing hydrogeological data that provide us to detect the uncertainty or unreliability has also been talked about (predicted /forecasted amount of the solar energy produced using weather-forecast ,given an example that how to utilize the forecast for our every-day life). Forecasting the max. temperature using SVM, help us in the temperature-prediction- process discussed. The author provide an concepts of different kernels used in SVM. There is also Forecasting by using ANN. From the literature survey we have an instinct of how to implement it further.

III. FUNCTIONS

3.1 HYPOTHESIS:

For analyzing the supervised learning problem, the Output is measured according to the Inputs given. In the hypothesis function, our target is to predict a hypothesis that should be closed to the output.

$$h(x) = h\varphi(x) = \varphi_0 X_0 + \varphi_1 X_1 + \ldots\ldots \varphi_n X_n \quad \ldots\ldots (1)$$

h(x) is the hypothesis function, X is input (in matrix) and Phi(φ) =parameter corresponding to X. Theta is set of values making the mean square error minimum.

3.2 .COST FUNCTION:

Cost function J(φ) is a mathematical function that produce the above hypothesis closed to the output. However, this function reduces the mean square error as minimized. The equation 2, however, defines cost function.

$$J(\varphi) = \{1/(2*m)\} \sum_{i=0}^{m} \{h(x) - y\}^2 \quad \ldots\ldots(2)$$

Note, J(φ) =cost function . And x is known as hypothesis function and m equals numbers of training examples , y= output. This cost function symbolizes the minimum distance between the output curve and the hypothesis curve.

3.4 GRADIENT DESCENT:

Gradient descent can be defined as the differential equation, minimizes value of Phi(φ) for minimizing the cost function((J(φ)) after replicated iterations. In the matlab programming, the bellow function is presented in equation (3), executed for converge the value of the cost function,

J(φ).It may be produced only by minimizing the value of theta in successive steps.

$\varphi_j := \varphi_j - \alpha(d/d\varphi_j)J(\varphi)$ .....(3)

However, φ_j is the value of Phi of a specific value of iteration.

3.5 NORMAL EQUATION**:**

Normal equation provides the finest value of Phi for the hypothesis except any requirement for Iterations , done in the gradient descent.

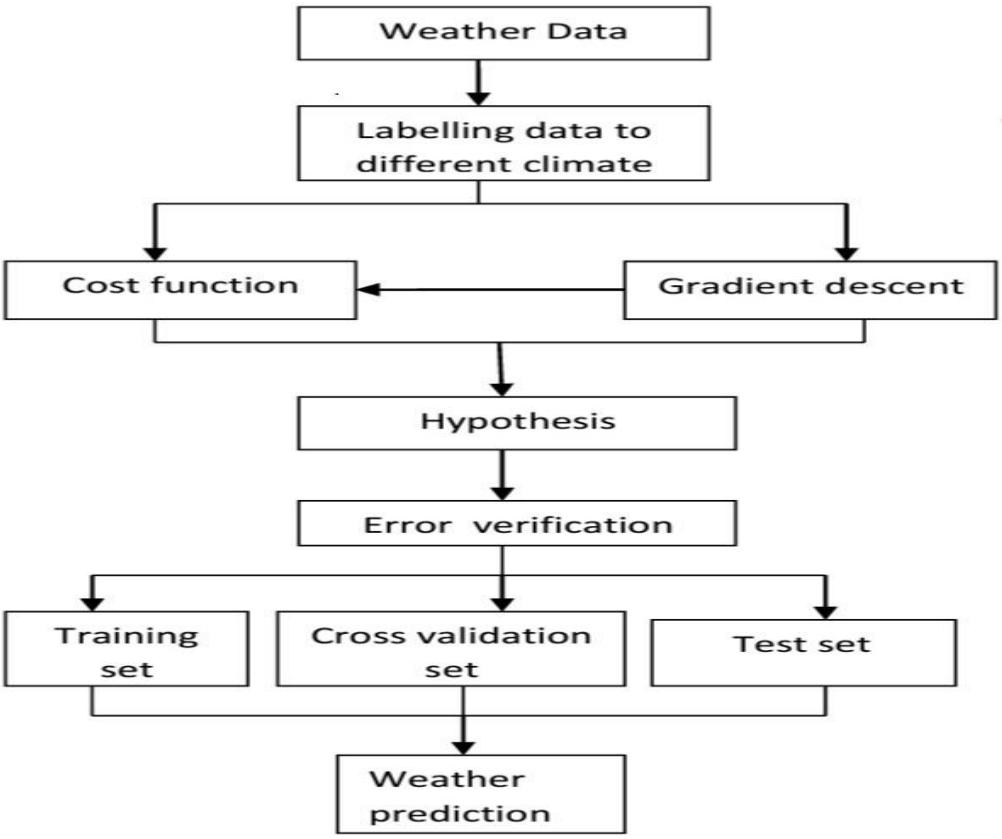
$\varphi=(X^TX)^{-1}X^TY$ .....(4)

The normal equation carries a crucial part for the prediction of the probability for the forecasted day, (i.e.) wheather it was rained or clear-sky or clouded.

3.6 MULTICLASS-CLASSIFICATION:

In case of Multi class classification, classified output-values are actually more than two cases, (more than the usual 1's and 0's). In this occasion, we require to predict one of three classes, rainy or cloudy or sunny. So,we should go for multi-class classification that uses the algorithm of logistic regression, without the fact that this is capable to handle more than 2 classes.

IV. FLOW CHART



V. METHODOLOGY

It is almost impossible to predict the weather with good accuracy. This is a technique to forecast/predict weather with very good accuracy, very small deflection and also to achieve good results. Though, weather forecasting may be deflected more, hence, average accuracy. The complete results has been achieved through MATLAB programming by executing the concept of Vectorization . Initially a 21 days(3 weeks) data of maximum temperature, min. Temp., rainfall amount and the corresponding day is placed in column of a matrix. This matrix is here represented as X. The type of the day we represent as 1for sunny, 2 for cloudy and 3 for rainy .These are placed in a column and the matrix represented as Y. At first, the values of Phi implies zeros, and which produced a result in hypothesis ((h(x)) is zero. The hypothesis and Y is utilized to get the value of cost function .The obtained value(cost-function from the equation 2) sent to the gradient descent (in equation 3)and thus the updated Phi values are obtained . Once Again they are all submitted into the cost function in order to obtain the new cost function. The process is however repeated for many iterations till the accurate value of theta and cost function is gained. This must be the minimum for all the repeated values. The evaluated theta is plotted against the number of days that is the hypothesis curve. The maximum temperature of the predicting day is calculated by obseving the value of y(maximum temperature) in the plot by substituting the value of x(for the particular day) by expanding the hypothesis curve. The same

process is carried out to find min. temperature and rainfall amount. The values of forecasted min, maximum temperatures and rainfall are multiplied with value of theta to obtain a value ranges from 1 to 3 where the sunny-day equals 1 ,cloudy- day mean 2 and rainy-day referred as 3.

In the procedure to find a adequate theta value is the vital task to forecast the day-type. The theta value we got may also be calculated with the use normal equation. To find the value of theta by the normal equation the X and Y matrix are carried out in the equation no.4.The achieved theta-value is multiplied with predicted value of the max-min temperature and also rainfall to obtain what type of the day was.(cloudy or rainy or sunny). The error verification techniques has been described in the error identification and detection -column.

VI. ANALYSIS OF WEATHER CLASSIFIER

The plots in the figures (Fig.1, Fig.2, and Fig.3) display the curves which was achieved by plotting maximum temp. (°C) Vs number of days, minimum temp. (°C) Vs days and the rainfall amount (in mm) Vs days. The curves we got by calculating the cost function with gradient descent. The obtained-Phi , utilized for plotting the curve(for hypothesis).The curved plot is for the polynomial function is utilized to plot the data.

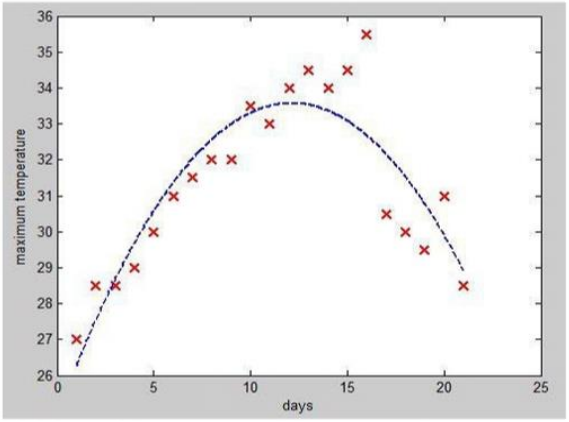


Fig1 Max. Temp. Vs Days

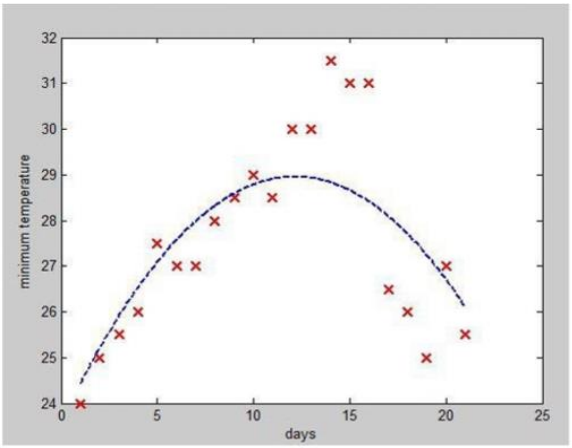


Fig2 Min. Temp. Vs Days

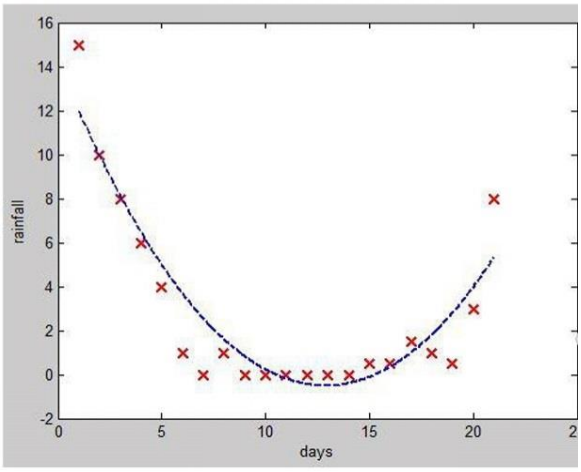


Fig3 Rain vs. Days

Following hypothesis in fig(1,2,3) is curve, that has the minimum distance (perpendicular distance) from itself to the output points. The gradient descent goes through numerous iteration for minimizing the Phi-value that provides the structure of the curve (in hypothesis)

6.1 ERRORS AND THEIR DETECTIONS

The error of training set as well as the cross validation are, however, evaluated to realize the presence of error in the prediction(forecasting). Due to either overfitting (high-variance) or underfitting (hig-bias) for the curves, error presents. A 20% of data is used for the cross validation set and other 20% of data also has been taken for the test set.And Remaining 60% data are calculated for the training set.

The cross validation data set as well as the training set data actually plotted with a number of training examples along the x-axis and error along the y-axis. By performing this, we can conclude if the hypothesis is being suffered from high variance or high bias. Both are subjected in order to increase the error and consequently should be recompensed. You may think if the training set error is very high, then the hypothesis includes high bias. When the cross validation set error is much high, then the hypothesis includes high variance.

The values to plot the curve- error vs no. of training examples for the training set is achieved with 60% of training-set. Every training set data is put into a stack once. The cost function is got by evaluating theta from the data into the stack through the gradient descent. This gained cost function are the values actually plotted in the error curves .As soon as the cost function is gotten , one other data of training set is then loaded in the stack and the process are repeated for the whole data to get the error curves.

In cross validation error the error plot is achieved through cost function values where Phi is utilized in the cost function is gotten with the use of all the values of Cross validation set data by gradient descent though the idea of stack is executed with every cross validation data loaded to find values of the cost function. Remember that the value is calculated using the Phi from our gradient descent ,and the

ISSN No:-2456-2165

whole cross validation set data has been utilized except the concept of stack.

The training as well as cross validation set errors for max. temperature, min. temperature and rainfall are displayed in Fig.4, Fig5 and Fig.6 respectively.

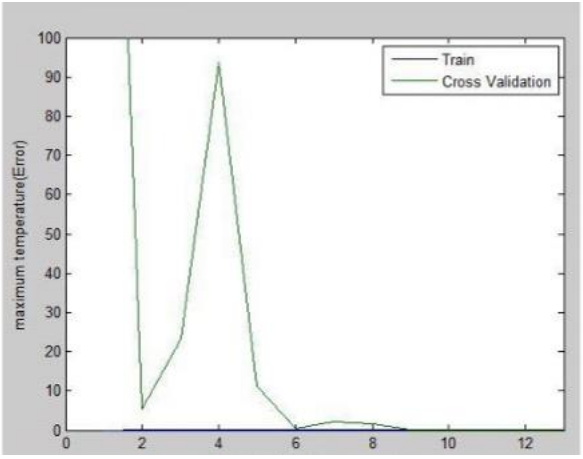


Fig. 4 Error-verification (Max. temperature vs days)

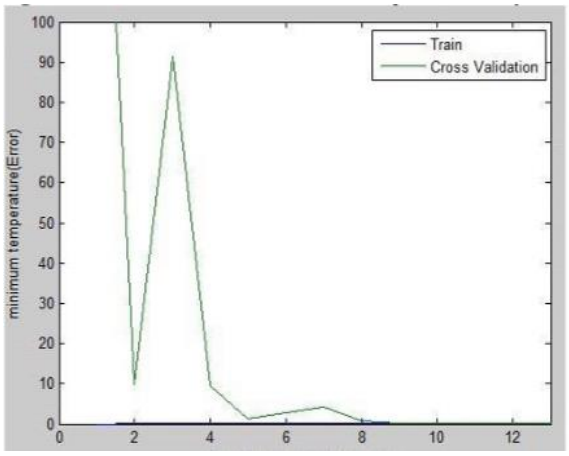


Fig 5. Error -verification (Min. temperature Vs days)

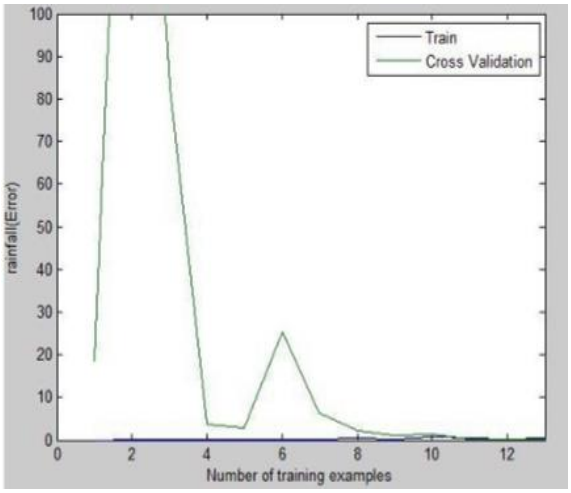


Fig. 6 Error-verification (Rainfall Vs Days)

All the curves in the plot must have tendency toward x-axis of the plot and must have to reach the x- axis while the no. of training examples increased. The length(height) of the curves margin at the ending from x-axis evaluate the error-value which shows in the prediction. Though in the plots it can be observed that this curve touched the x-axis indicating that there actually nothing error in prediction-process.

VII. RESULTS

The forecasting of weather of the next day that following by max. temp, min. temp, rainfall and the nature of the day (if it is sunny or rainy or cloudy) is being forecasted with more accuracy with the use of the plots achieved from fig(1,2,3) via hypothesis by obtaining the value of y-axis from our curve, as substituting the value in the x-axix.

Features or Parameters	Prediction for the 22nd day	Prediction for the 23rd day
Maximum Temperature	27.82	26.59
Minimum Temperature	25.42	24.67
Rainfall amount	6.86	8.57
Day type	Rainy-Day	Rainy-Day

Table.1

That is the next day-date. After getting the forecast(prediction)by using the predicted values of max. temperature, min. temp., and rainfall amount we have the bellow output in two forms:

For 22nd day

Utilizing Normal Equation: Phi has been calculated from the normal equations:

φ_1	φ_2	φ_3	φ_4
11.447	**-0.4578**	**0.1766**	**0.0080**

Table.2

So, the Forecast =2.899957e+00

Utilizing linear Regression using Multiple variables:

Phi actually calculated from the Gradient-descent

φ_1	φ_2	φ_3	φ_4
2.0000	**-0.85844**	**0.18384**	**0.08699**

Table.3

So, The Forcast =2.893346e+00

From the result through out the normal equation as wll as linear regression using multiple variables It may be concluded that the predicted/forecasted weather is set to be a cloudy- day having 89% possibility of rain. But the regression module likely to fit the data effectively and forecasts correct result .A little amount of error we can observe.

ISSN No:-2456-2165

METRICS	REAL VALUE	PREDICTION VALUE)	DEVIATION (in %)
MAXIMUM - TEMPERATURE	34	33.5	1.27%
MINIMUM-TEMPERATURE	30	28.9	3.6%
RAINFALL AMOUNT	0	0	0

Table.4

The error is however predicted by executing the module for those parameters of the past days and making comparison this with the dataset .The error of the 12th day is also shown above.

VIII. CONCLUSION

This results we can also verify using multi class-classification with the use of logistic regression and even using ANN(artificial neural network). Nevertheless, our main problem with Artificial neural network(ANN) and multi class classification are: these provide output for the day but not the approx. value of probability in what manner the day going or the nature of the day. We use Support vector machine for the prediction of the data and traits best while there are many features and classifications exists. But remember redundant traits must be eleminated. The only attempt which should be done by the user is just for updating the data set to represent proper results. This works nice whenever the data set is huge enough to give minimum 1/7 th of the data to be predicted. As an example, if data set is taken for 365 days, the predicted weather tends to be right for first 52 days only. Whenever we have more traits and training examples, the prediction performs best. The module encourage us to monitor and to predict the weather with a very good accuracy-rate , especially in an efficient way.

ACKNOWLEDGEMENT

I hereby wish to express my sincere gratitude and respect to all staff, JYCSM, Narajole, West Bengal. Their valuable co-operation and encouragement have really led me to complete this research work.

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