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Weather Prediction using Stochastic Weight Updation with Reinforced Learning

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Abstract - Humans always want to know what will happen in the next days or future. Now a days, prediction is most important that gives a knowledge about what will happen in the future. Today, weather is variable in nature so its prediction has become an important field of research. Several traditional methods are used for weather prediction. But they have their limitations for handling and predicting accurately. Predicting weather using artificial neural network (ANN) gives better results than the traditional methods. Stochastic weight updation with reinforced learning is used for the learning of neural network. There are several advantages by using this method, its implementation is simple for network topology and it allow better parallelization of the backpropagation algorithm. In stochastic weight update method, weights are selected according to certain threshold for updation instead of updating all weights. Reinforced learning is used for balanced weight updation. Here for attaining an optimized and accurate result it is used along with the stochastic weight updation.

Keywords - *Artificial neural network (ANN), Reinforced learning, stochastic weight updation*

1. Introduction

Weather is the state of the atmosphere, describing the degree to which it is hot or cold, wet or dry, clear or cloudy. Weather phenomena occur in troposphere, the lowest level of the atmosphere which is just below the stratosphere. Weather refers to day-to-day temperature and climate refers the atmospheric conditions over longer periods of time. Weather is controlled by air pressure, temperature and moisture differences between one place and another. The changes in Earth's orbit can affect the distribution of solar energy received by the Earth and this influences the climate change. Surface temperature differences in turn cause pressure differences. Higher altitudes are cooler than lower altitudes, as most atmospheric heating is due to contact with the Earth's surface.

Weather forecasting is the application of science and technology for predicting the state of the atmosphere of a particular location at the future. In the Earth's weather system, small changes to one part of the system will have large effects on the system as a whole. Accurate weather prediction is very important for the day-to-day activities like agriculture, energy supply, operation of hydro power plants and for flood management. Both living and non-living things depends on weather predictions. Weather forecasts are done by collecting quantitative data of the current state of atmosphere and using process it to predict how the atmosphere will evolve ie, based on current weather conditions, forecast models are now used to determine future conditions. Weather warnings are important because they are used to protect life and property. Forecasting weather based on temperature and precipitation are important to agriculture. In some areas, people use forecasts to determine what to wear on a given day. Since outdoor activities are severely affects by heavy rain and snow, forecasts can be used to plan activities and can plan to survive through them.

Meteorologists use satellites to observe cloud patterns, and radar is used to measure precipitation. All of this data is then moved into super computers, which use numerical forecast equations to create weather forecast models of the atmosphere. Traditionally, this has been done by sampling the present state of the atmosphere and the future state is computed by numerically solving the equations of fluid dynamics and thermodynamics. Here, massive computational power is needed to solve the equations. An incomplete understanding of atmospheric processes evolves. Forecasts become less accurate as the range of the forecast (difference in current time and the time for which the forecast is being made) increases. However this system is unstable, significantly unreliable and it restricts the extent of accurate weather forecasting to a limited period. The use of ensembles and models helps to reduce the error. Accurate weather predictions are important for planning our day-to-day activities. It helps us to make more informed daily decisions, and helps to keep us out of danger. Farmers needs weather information to help them for planning the planting and harvesting of their crops.

Machine learning is relatively robust to perturbations and doesn't require a complete understanding of the physical processes that govern the atmosphere. So machine learning may represent an alternative to physical models in weather forecasting. Machine learning is the ability of computer to learn without being explicitly programmed. It allows machines to find hidden patterns. A model is build based on labelled training data in supervised learning. The model is then used for predicting with new examples. So, based on the observed weather patterns from the past, a model can be built and used to predict the future weather. Such models can predict weather conditions faster than traditional meteorological models.

2. Related Works

Sanyam Gupta, Indumathy K, GovindSinghal[1] proposed linear regression model and two optimization techniques, Normal equation method and Gradient descent method to predict the weather on the basis of few parameters. The obtained result was that the normal equation method forecasts the weather with high precision and the gradient descent method forecasts with very little precision. Here they proposes an efficient and accurate weather prediction model using linear regression concepts and normal equation model. The normal equation is a very efficient weather prediction model and using the entities temperature, humidity and dew-point, it can be used to make reliable weather predictions. Linear regression is the most basic and frequently used predictive model for analysis.

Govind Kumar Rahul, Madhu Khurana, A.K.Sinha[2] used soft computing using ANN and Backpropagation algorithm for weather prediction. They predicted maximum temperature, minimum temperature and pressure for the next day. ANN has the capability to extract the relationship between the inputs and outputs, without the physics being explicitly provided. These property of ANN is well suited for weather forecasting. After a detailed study they find that applying soft computing is one of the best alternatives for local and short scale weather forecasting. The results are evaluated based on its ability to produce the minimum error rate or MSE.

Salvetti and Wilamowski[3] introduced the stochastic weight update to improve the speed of convergence of the backpropagation algorithm since it has some limitations in its speed and quality of convergence. They examined another two stochastic modifications called random pattern selection and randomized learning rate. They demonstrated significant improvement in the learning speed especially in the case of using randomized learning rate. This will not only improve the convergence but also it speedup the process.

JurajKoscak and RadolfJaksa[4] evaluated several types of stochastic weight update, among them the stochastic shuffle δ update. They describes the implementation, and present example results on toy-task data with feed-forward neural network topology. They show that stochastic weight update is suitable to replace classical ordered update and gives convergence. The accuracy obtained for stochastic method is greater than the classical ordered update.

RastislavRusnak and RadolfJaksa [5] introduced stochastic weights and neurons selection in neural networks for weather prediction. They used a neural network for the weather prediction with given data and evaluated selected stochastic update methods. They compared the plain backpropagation method with the stochastic method. They proved that by using stochastic weight update method, it gives better result for predicting weather with high accuracy than the plain backpropagation method.

3. ANN for Weather Prediction

Artificial neural networks are computational systems containing many neurons that are linked to each other. ANN bear resemblance to the biological neuron. ANN acquires knowledge through learning. Neural network consist of input layer which receives inputs, a hidden layer which are interconnected with the input and output layer and an output layer which gives output after processing. The internal connections consist of weights that are used for storing the information's. An activation function is applied to the net input for calculating the final output. Neural networks performs in predictive systems, fingerprint analysis, optimization, pattern and design recognition etc. successfully. Neural networks are made of straightforward components that operates in parallel. Several calculations are needed to train a framework. The most popular algorithm for training the neural network is the back propagation algorithm.

The input layer of neural network is the beginning of the ANN. It represents the data's that are fed in to the system. It brings the initial data into the system for processing by other layers of the neural network. The hidden layer is a layer that lies in between input layers and output layers, where the neurons takes a set of weighted inputs and produce an output using an activation function. The Output layer is the last layer of neurons that produces the outputs. The output depends on the activity of the hidden units and the weights.

Artificial neural networks in Machine learning is the perfect area for the future prediction. In case of weather prediction, using ANN gives accurate result for the future weather prediction that is useful to all. One of the noticeable advantage of the neural network is that it is

adaptive, which means they modify themselves as they learned from the training provide more information about the world. The basic thing in the learning process lies on weighting the input streams. That is how the weights are distributed. The inputs that have great influence on the output are weighted higher.

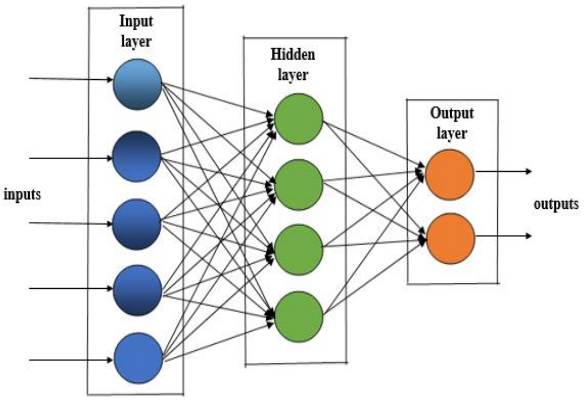

Fig 1. Architecture of Artificial neural network

4. Stochastic Weight Updation

Backpropagation algorithm is a best algorithm used for the training of artificial neural network. But it has some limitation in the speed. Stochastic weight updation is a method that can solve this. When Backpropagation algorithm is used, all weights are updated in the weight updation process. In stochastic weight updation process, all weights are not needed to be updated. It is because all weights do not have equal influence on the learning process. Some of them with higher value has greater influence and those with minimal value has less influence. In this method, weights with less influence is only updated. The speed of training neural network can be increased by using this method. Stochastic weight selection and stochastic neuron selection is other methods used in this way. Weight updation in stochastic process is done based on certain condition. In stochastic weight updation, after computing the error a random number is generated that is in between 0 and 1. Based on this random number the weight is updated. If the random number is greater than 0.5 then the weight is updated otherwise that step is skipped. Here 0.5 means there is 50% chance for the weight updation. By using stochastic weight updation in the weight updation process then the influence of the learning rate can be reduced in the training of the neural network. In weather prediction stochastic weight update method will give an accurate prediction of weather in future.

5. Proposed Weather Prediction Model using Stochastic weight updation with Reinforced Learning

The proposed model uses stochastic weight update with reinforced learning for weather prediction. Neural network can be combined with a reinforced learning. Reinforcement learning can be understood using the concepts of agents, environments, states and actions. When stochastic weight updation is used for the training of neural network, the weights are updated based on certain threshold. This threshold may not be correct. So we want a balanced weight updation. For acquiring that, Reinforced learning is used in the training process. Reinforced learning is a goal oriented program. Our goal is to obtain an optimal weight.

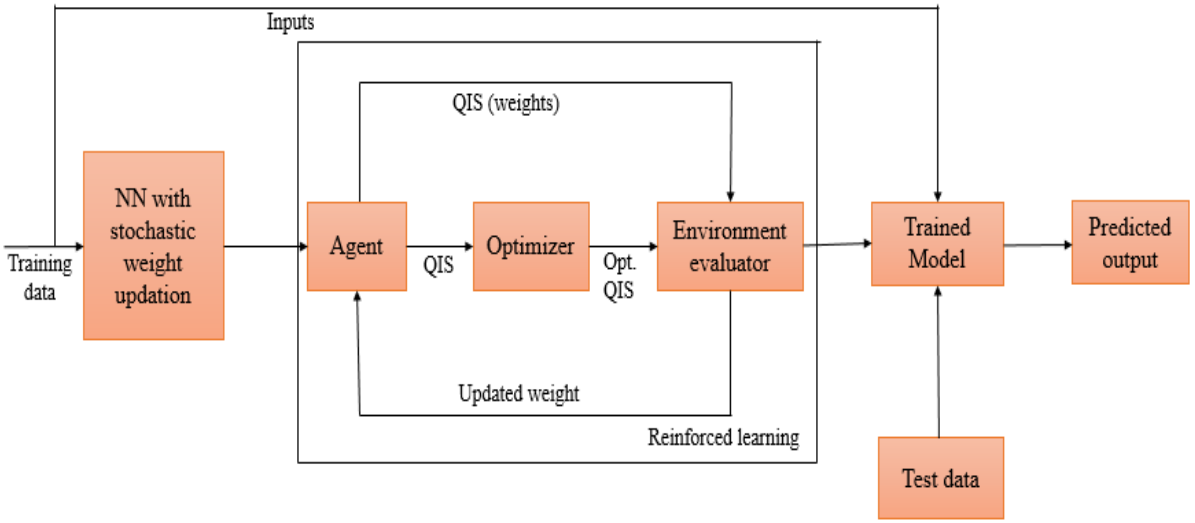

Fig 2. Proposed Architecture using stochastic with reinforced learning

5.1 Dataset

The weather data's for training is taken from the UCI machine learning repository. For training we use data's from past 3 years. The Average rainfall, Pressure, Humidity, Wind Speed, Average Temperature of the past day are taken as the inputs to the model. The maximum and minimum temperature for the next day is predicted as the output.

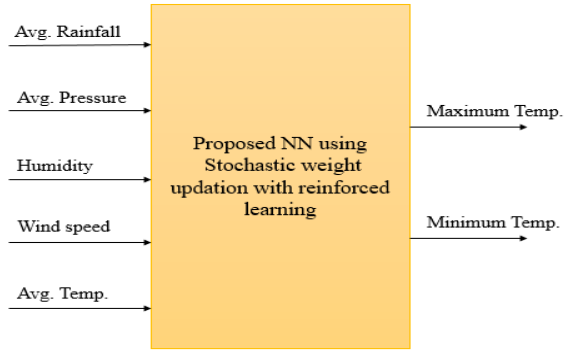

Fig 2. Proposed weather prediction model

5.2 Proposed Architecture

The proposed Architecture is shown in the Fig 2. The data to be trained is passed to the neural network with stochastic weight updation. After training, we will get a fully connected neural network with final updated weights. These weights are needed to be balanced or optimized. For this, the out from the stochastic weight update is passed to the agent in reinforced learning as a distribution. Agent takes an action. Here, each optimal weights are the actions. Agent calculates the QIS or Quantity integrated score. Optimizer optimizes the weights generated by the agent. Environmental evaluator collects optimised weights gives rewards after certain calculations. Probability distribution function is used as an environmental evaluator.

The agent calculates the Quantity integrated score from the following equation:

$$\text{QIS} = w(i) + \mu[target - output]x(i) \quad (1)$$

Where, w(i) are the updated weights from the stochastic updated network. μ is the mean of the distribution. The Quantity Integrated score (QIS) got from (1) is passed to the optimizer for an optimized QIS or an optimized score. It is done using the following equation.

$$_{new}QIS = QIS\sqrt{\frac{b}{BT}} \quad (2)$$

Where, b is the batch size, B is the numbe of data, T is the number of epochs. The environment evaluator calculates the probability score with respect to the optimized QIS and the QIS got from the agent using the following equation.

$$prob(w|QIS) = \frac{\beta}{2}\sum_{n=1}^{N}\{QIS * y(x,w) - T\}^2 \; + \frac{\alpha}{2}\sum_{i=1}^{w} wi^2 \quad (3)$$

Where, ∞ and β are the parameters, y is the prediction, T is the target, w is the weights, w_i is the total sum of the weights. If this probability score decides whether the weight is to be updated or not. If it is to be updated, then updation is done and passed to the agent as a reward. Finally we will get a set of reinforced weights. These weights and the inputs that are given to the stochastic updated neural network s used to build the neural network. This is our trained model. The test data's are given to this trained model and the maximum and minimum temperature of next day is predicted.

6. Performance Analysis

The proposed approach stochastic weight update with reinforced method is used as a perfect model to examine the weather in future. The results are presented in Table 1. We can see that temperature prediction with Stochastic with reinforced learning gives more accurate result than the stochastic weight updation method and backpropagation learning. The proposed model gives 96.82% accuracy.

Table 1: Accuracy of different methods

Methods	Accuracy
Stochastic weight update with reinforced learning	96.82%
Stochastic weight updation	87.37%
Backpropagation learning	73.14%

7. Conclusion

An effective method for the weather prediction is discussed in this paper. The main advantage of this method is the low computational complexity, cheap implementation cost and accurate result. Now, weather prediction has a big challenge of predicting the accurate results. The difficulty of this depends on the complex nature of parameters, variable weather and absence of seasonal change. By using ANN these problems can be avoided. It accepts all complex parameters and generates the intelligent patterns during training and it uses the same patterns to generate the forecasts. Stochastic weight update with reinforced learning shows greater accuracy in prediction and it can be used as a powerful tool for weather prediction.

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