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Comparative Analysis of Numerical Weather Prediction and Deep Learning

Rupali Surve[1] | Dr. Bharti Deshmukh[2]

[1]Assistant Professor, Department of Computer Science, Prerna College of Commerce, Nagpur, MS, India.
[2]Assistant Professor, Department of Computer Application, Prerna College of Commerce, Nagpur, MS, India.

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ABSTRACT

Weather forecasting is used to check the behavior of atmosphere in a specific place by using technology and scientific knowledge to make weather observations. In meteorological department it's a task to predict accurate and timely weather prediction. For weather forecasting currently Numerical Weather Prediction Model (NWP) is used. NWP model guess the meteorological parameters such as wind flow, temperature, humidity. There are numerous challenges in front of NWP such as confused nature of atmosphere, computationally nonlinear equations are expensive, huge amount of observation data etc. Deep Learning is part of machine learning methods based on Artificial Neural Network (ANN). ANN is the powerful data modeling tool. It captures and represent the complex relationship between input and output. It is able to estimate any non-linear function. This paper shows the comparison of NWP and Deep Learning and which one is efficiently.

KEYWORDS:Deep learning, Artificial Neural Network, Numerical Weather Prediction, Weather prediction.

1.INTRODUCTION

Weather admonishing is very important prediction. It is very important factor in our life. Predicting weather is essential for common man, fishery man, farmers, military area,air force and so on. It is science application which predict the behavior of atmosphere for next few days. Currently for predicting weather behavior Numerical Weather Prediction (NWP) is used. It is mathematical model. It is the most familiar form of weather model data. NWP computer models work on current weather observations material to predict future weather. Output of prediction is based on current weather observations, which are merged into the different model's and used to produce predictions for temperature, rain, and hundreds of other meteorological elements.

2. RELATED WORK

XiaoliRena et al in their paper has discussed about different challenges behind Numerical Weather Prediction. Also, it has been pointed out that a minor mistake while collecting weather data makes huge effect on prediction result. [1] focused on whether it is possible to replace all core part of Numerical Weather Prediction with one deep neural Network[2].

3. WEATHER PREDICTION

For decades, weather prediction has been regarded as a physical theory problem, and meteorological scientists have been committed to improving the accuracy of forecasts through the understanding of physical mechanisms, which is a theory-driven

approach. With the explosive growth of multisource, multidimensional and multi scale meteorological data, it has become a typical big Spatiotemporal data. In few years, data scientists have specially focused on data-driven computing paradigms to mine complex spatial and temporal relationships between meteorological data elements, and Deep Learning Weather Prediction has become an interesting research topic and is expected to be able to cope with the data challenges faced by traditional theory-driven approach[1].

4. Tools to collect Data for weather forecasting

Today for predicting weather advanced technologies are used to gather observed weather data, along with the world's most powerful computers. In weather forecasting data collection has been divided into two parts -

i. *Surface Weather Observation*-For surface weather observation some instruments are used such as Stevenson Screen, barometer, SRRG (Rainfall recorder), Anemometer and Wind Vane (Wind Speed and Direction), Sunshine Recorder, Evaporiment.

ii. *Upper Air Weather Observation*- For Upper air weather observation there are some tools are used such as Doppler Radar, Satellite Data, Radiosonds, Automated surface observing system, AWIPS (Advanced Weather Interactive Processing System).

5. Numerical weather prediction

Numerical weather prediction work with mathematical models to predict the weather based on recent weather conditions. Numerical weather prediction model predicts the climatic as temperature, humidity, rain, sunshine, wind velocity, air pressure. For predicting weather conditions first collect the surface weather observations and Upper air weather observation by using different tools which are used for collecting weather data. After that NWP model is applied on that observed data for prediction result. But due to helter - shelter nature of atmosphere there may be small difference in observations make huge impact on weather forecasting result. The initial observations which are collected by tools are imputed to model but data assimilation and incomplete atmospheric physical process may be introduce error. Thereis oversize amount of observational meteorological data are available.

Sensors and autonomous observing platform required PetaBytes of meteorological observation data. But NWP generates Terabytes of data per day. In the observed data collection different type of data and many uncertainties exist in the dataset and Spatio temporal correlation between dataset present unknown challenges to NWP.

Numerical approach to solve the theory based nonlinear equations is computational expensive, which is strongly relies on the capability of super computers [1].

6. Deep learning

A advanced technology Deep learning shows the ability to globalize computational model through hierarchical layers from a large amount of training data with ignorable human interventions. Deep learning allows computational models to learn by collecting knowledge from experience. Complex concepts can be learnt by deep learning approach due to its hierarchical conceptualization [3]. Different types of neural network is used by deep learning to perform specific tasks. Deep learning uses artificial neural networks to perform computations on huge amounts of data. It is a type of machine learning which work on the basis of the structure and function of the human brain [4].

7. Deep Learning Algorithms Working

Neural networks have number of layers of nodes like human brain. Human brain is made up of large number of neurons. Thousand of signals are received by a single neuron. Nodes within separate layers are connected to adjacent layers. In ANN signals move between nodes and assign weights. A heavier weighted node will apply more effect on the next layer of nodes in neural network. The final layer assembles the weighted inputs to build an output. For processing large amount of data, Deep learning systems require powerful hardware and includes several complex mathematical calculations.

For accurate result Deep learning systems require large amounts of data. When system processing the data, ANN are able to classify data with the answers received from a series of binary true or false questions involving highly complex mathematical calculations.

8. Deep learning Algorithms

Deep learning based on time series prediction. There are some algorithms which are based on time series forecasting [5].

- Convolution Neural Network (CNN)
- Long Short-Term Memory Network (LSTMNs)
- Recurrent Neural Network (RNN)
- Radial Basis Function Network (RBFNs)

Deep learning weather forecasting has three components-

i. *Input layer*- The collected observed data is considered as input. The climatic elements such as temperature, wind, rain gauge are used as input data of network layer.

ii. *Hidden Layer*- The observed data is in the image form also which is collected by satellite i.e. Spatio temporal feature. The Convolution Neural Network is used to capture Spatio temporal feature in input data and LSTMNs extract the temporal feature from time series of input data. For capturing complex features, increasing the number of hidden layers in network.

iii. *Output layer*-This layer shows the result of weather observations.

9. FUTURE SCOPE AND CONCLUSION

Weather prediction is a big challenge for meteorological departments. In this paper we have seen that recently used NWP model is facing many problems regarding their accurate results. We can solve these problems by replacing NWP model with Deep learning algorithms. Because of its multiple layers in Deep learning technology, it can show us the accurate result.

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