Accurate Weather Modeling and Forecasting

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Abstract
Precise weather forecasting is very important in today's world as agricultural and industrial sectors are principally dependent on the weather conditions. it is also used to forecast and warn about natural disasters. Weather perdition and forecasting is the application of science and technology to predict the state of the atmosphere for a future time and a given location. Researchers have tried to forecast the weather informally for millennia. Usually, Weather forecasts are made by collecting quantitative data about the current state of the atmosphere and using scientific understanding of atmospheric processes to project how the atmosphere will evolve.

Keywords
Weather Forecasting, Artificial Neural Networks, Weather Models

I. Introduction

Weather is a continuous, data-intensive, dynamic and chaotic process. The parameters required to predict weather are enormously complex such that there is uncertainty in prediction even for a short period .These properties make weather forecasting a formidable challenge.Forecasting is a phenomenon of knowing what may happen to a system in the next coming time periods. Accurate weather forecasting for the future is one of the most important attributes to forecast because agricultural sectors as well as many industries are largely dependent on the weather conditions. It is often used to predict and warn about natural disasters that are caused by abrupt change in climatic conditions.

A. Weather Forecasting Models

Generally, two methods are used to forecast weather (a) the empirical approach and (b) the dynamical approach. The first approach is based uponthe occurrence of analogs and is often referred to by meteorologists as analogforecasting. This approach is useful for predicting local-scale weather if recordedcases are plentiful.

The second approach is based upon equations and forwardsimulations of the atmosphere, and is often referred to as computer modeling or Numerical Weather Prediction that predicts large-scale weather phenomena efficiently. In this technique the atmosphere is considered to be a fluid.

1. Numerical Weather Prediction

Numerical weather prediction uses mathematical models of the atmosphere and oceans to predict the weather based on current weather conditions.Mathematical models based on the same physical principles can be used to generate either short-term weather forecasts or longer-term climate predictions; the latter are widely applied for understanding and projecting climate change.

Manipulating the vast datasets and performing the complex calculations necessary to modern numerical weather prediction requires some of the most powerful supercomputers in the world.

2. Atmospheric Models

An atmospheric model is a mathematical model constructed around the full set of primitive dynamical equations which govern atmospheric motions. It can supplement these equations with parameterizations for turbulent diffusion, radiation, moist processes (clouds and precipitation), heat exchange, soil, vegetation, surface water, the kinematic effects of terrain, and convection. Most atmospheric models are numerical, i.e. they discretize equations of motion.

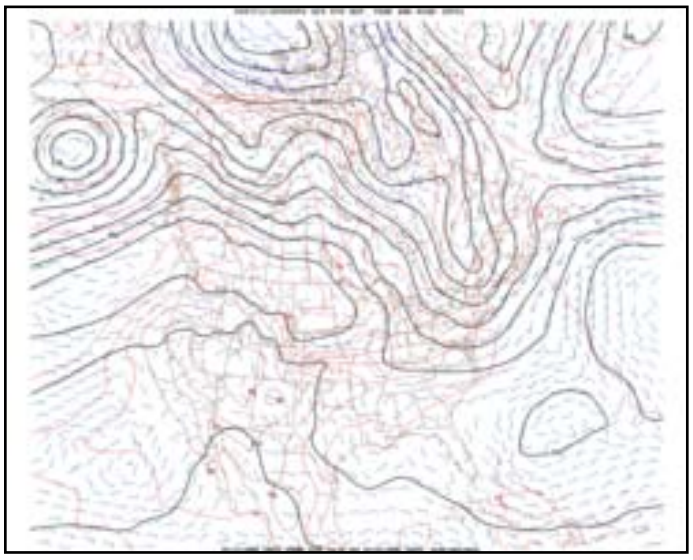

Fig. 1: A 96-Hour Forecast of 850 mbar Geo-Potential Height and Temperature from the Global Forecast System

B. Machine Learning for Climate Modeling

As scientists and philosophers ponder human intelligence, several profound questions arise: what is intelligence and is it measurable, does intelligence even exist, and can it be reproduced in a machine? We immediately go to the best empirical source about what gives humans the capacity to be intelligent, the brain. While trying to classify and understand this vital organ, early researchers attempted to partition the brain into smaller pieces until they arrived at the brain cell and neurons. They found that there existed many neurons in the brain, which were all interconnected and formed a sort of network, a neural network. Artificial neural networks draw much of their inspiration from the biological nervous system.

1. Artificial Neural Networks

The simplest definition of an artificial neural network is provided as: "A computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs". Artificial neural networks are an attempt at modeling the information processing capabilities of nervous systems.Artificial neural networks provide a methodology for solving many types of non-linear problems that are difficult to solve by traditional techniques.

2. Genetic Algorithms

GA differs from conventional non-linear optimizing techniques as by preserving a population of the solutions, they search for better ones. The key feature of such algorithms is characterized by possessing a chromosome. This latter can be coded as a string of characters of given length l. each string represents a

feasible solution to the optimization problem. A chromosome is composed of strings of symbols called bits. Each bit is attached to the position within the string representing the chromosome to which it belongs.

II. Related Work

Baboo et al[1] Temperature warnings are important forecasts because they are used to protect life and property. Temperature forecasting is the application of science and technology to predict the state of the temperature for a future time and a given location. In this paper, a neural network-based algorithm for predicting the temperature is presented. The Neural Networks package supports different types of training or learning algorithms. One such algorithm is Back Propagation Neural Network (BPN) technique. The Author model has potential to capture the complex relationships between many factors that contribute to certain temperature.

In this paper, back propagation neural network is used for predicting the temperature based on the training set provided to the neural network. Through the implementation of this system, it is illustrated, how an intelligent system can be efficiently integrated with a neural network prediction model to predict the temperature. This algorithm improves convergence and damps the oscillations.

Do Hoai et al[2] Downscaling global weather prediction model outputs to individual locations or local scales is a common practice for operational weather forecast in order to correct the model outputs at subgrid scales. This paper presents an empirical-statistical downscaling method for precipitation prediction which uses a feed-forward multilayer perceptron _MLP_ neural network.

This paper has presented an efficient empirical-statistical approach, using the most favorite ANN architecture, the MLP, with error training back-propagation method, to downscale the precipitation from global NWP outputs to a basin-average scale, subsequently, was used for flood-runoff forecast.

Rahul et al[3]Soft computing using ANN is an effective approach to construct a computationally intelligent system that is able to process non-linear weather conditions within a specific domain, and make predictions. The proposed work focus on modeling of such an intelligent system that can forecast with minimum error rate in term of MSE with a better Architecture.

From the above study & discussion they see that applying soft computing approach for weather modeling to forecast Minimum Temperature, Maximum Temperature & MSLP is most feasible rather than any other short term weather forecasting approach. The study also says that MLFFNN with BPA algorithms is the better combination for weather forecasting. The valid & authentic dataset selection, input variable selection, the proper training set and the proper ANN architecture are most vital for the best prediction results.

Foley et al[4] Wind power generation differs from conventional thermal generation due to the stochastic nature of wind. Thus wind power forecasting plays a key role in dealing with the challenges of balancing supply and demand in any electricity system, given the uncertainty associated with the wind farm power output. Accurate wind power forecasting reduces the need for additional balancing energy and reserve power to integrate wind power. This paper presents an in-depth review of the current methods and advances in wind power forecasting and prediction.

Singh et al [5] Temperature prediction is a temporal and time series based process. Accurate forecasting is important in today's world as agricultural and industrial sectors are largely dependent on the temperature. Due to non-linearity in climatic physics, neural networks are suitable to predict these meteorological processes. Back propagation integrated with genetic algorithm is the most important algorithm to train neural networks.

In this paper, in order to show the dependence of temperature on a particular data series, a time series based temperature prediction model using integrated back propagation with genetic algorithm technique is proposed.From the analysis above, it is easy to observe the compensability between time series based BP/GA technique and the back propagation alone. The proposed technique can learn efficiently by combining the strengths of GA with BP. It is good at time series data, global search (not in one direction) and it works with a population of points instead of a single point. Also it blends the merits of both deterministic gradient based algorithm BP and stochastic optimizing algorithm GA.

Devi et al[6] Temperature forecasting is important because they are used to protect life and property. Temperature forecasting i s the application of science and technology to predict the state of the temperature for a future time at a given location. Temperature forecasts are made by collecting quantitative data about the current state of the atmosphere. A neural network can learn complex mappings from inputs to outputs, based solely on samples and require limited understanding from trainer, who can be guided by heuristics.

Aghaei et al[7] The soft computing techniques especially fuzzy logic has been used by many researchers for temperature prediction inrecent years. Artificial neural networks (ANN) have been popular due to their capabilities in handling complex, nonlinear problems in a better way when compared to traditional techniques. In this paper, the theory of ANN with radial basis function (RBF) is presented, and the RBF model is used to predict the daily average temperature for Taipei, Taiwan.

The work presented in this paper was aimed to show the suitability of neural networks to perform predictions. The performance of RBF model was compared with several fuzzy forecasting methods for window basis w = 2 by MATLAB simulation. The experimental results show that the RBF method produces better forecasting results than several existing methods. In summary, neural forecasting was generally more ac-curate than fuzzy forecasting.

Fay, Damien et al [8]Weather information is an important factor in load forecasting models. Typically, load forecasting models are constructed and tested using actual weather readings. However, online operation of load forecasting models requires the use of weather forecasts, with associated weather forecast errors. These weather forecast errors inevitably lead to a degradation in model performance.

This paper examined the effect of weather forecast errors in load forecasting models. The distribution of the weather forecast errors was examined and it was found that a Gaussian distribution was not appropriate in this case. Rather, a structure exists which means that the weather forecast error will have a large effect on any aggregate weather variables.

Sideratos et al[9] A novel methodology for probabilistic wind power forecasting is described. The method is based on artificial intelligence and concentrates on the uncertainty information about the future wind power production predicting a set of quantiles with predefined nominal probabilities. The proposed model uses the point predictions of an existing state-of-art wind power forecasting model and forecasts the prediction uncertainties due to the inaccuracies of the Numerical Weather Predictions (NWP), the weather stability and the deterministic forecasting model.

In this paper, a novel probabilistic wind power prediction model is presented. The model receives as input the point predictions and the uncertainty information of a state-of-art deterministic prediction model based on the use of RBFNNs. Information about the prediction uncertainty of this model is obtained from the hidden layer output of the RBFNNs.

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