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Reviewal perspective of Weather Forecasting using different Deep Learning algorithms based on Time Series Prediction

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ABSTRACT

Weather prediction is the foremost function of science and technology that predicts the future state of weather for a particular location. Weather forecasts are provided by gathering the required data regarding the state of the atmosphere at a particular location. In this paper, various Deep Learning-based algorithms are focused on predicting the weather status. Deep learning supports a variety of algorithms. Of these, CNN, LSTM, RNN, and RBF algorithms are used, which are based on time series prediction. These models have the ability to reflect the intricate interactions among various factors that influence temperature. The extracted results will be compared to the actual working conditions of meteorological department weather data, confirming that this model has the potential to be successfully applied to weather forecasting in the near future. This paper reflects the brief survey of various deep learning algorithms and techniques that are used for weather prediction.

KEYWORDS: Deep learning, Time Series, Convolutional Neural Network, Radial Basis Function Network, Long Short Term Memory networks,Recurrent neural network.

1. INTRODUCTION

Weather forecasting is the prediction of what the atmosphere will be like in a certain location based on weather measurements made with the help of technology and scientific understanding. In other words, it's a way of predicting things like cloud cover, rain, wind speed, and temperature before they happen**1.** Weather conditions are captured by ground observations that include information taken from satellites and several other weather stations followed by aircraft, ships, etc. Because of the chaotic nature of the atmosphere, significant computer power is necessary to solve the equations that describe it, as well as measurement error and an inadequate understanding of atmospheric processes. As the time difference between now and the time for which the forecast is being produced grows, forecasts become less accurate[1].

2. DEEP LEARNING

Advanced technology Deep learning demonstrates the ability to globalize computer models from a huge quantity of training data using hierarchical layers with minimal human interaction. Deep learning allows computational models to learn by accumulating

experience-based knowledge. Because of its hierarchical conception, the deep learning approach can learn complex concepts. Deep learning applies several types of neural networks to accomplish certain objectives. Artificial neural networks are used in deep learning to do computations on large volumes of data [2]. Deep learning provides a novel method of forecasting. Deep learning models, rather than applying explicit physical laws, learn to anticipate weather patterns directly from observable data, and can generate predictions faster than physics-based techniques. These techniques have the potential to increase the frequency, breadth, and accuracy of forecasts. Some of these novel NNs are substantially more efficient than traditional fully connected, feed-forward networks in solving particular ML tasks. [3].

3. TIME SERIES PREDICTION

A time series is a sequence of observations spanning a period of time. Time series forecasts are used to predict the future value or categorization at a specific point in time. Time series forecasting is a method for predicting future occurrences by evaluating previous trends and assuming that future trends will be similar to previous trends. Forecasting is the process of predicting future values by fitting models to historical data. Time series forecasting is a data-driven method of effective and efficient planning that is used to solve prediction problems with a time component.

4. RESEARCH METHODOLOGY

Deep learning has several models. Some of which are based on time series predicted. Time-series predictions have been dominated by the linear method because it is well understood and effective for many simpler forecasting problems. The following algorithms of deep learning are used by several researchers for weather forecasting systems.

- Convolutional Neural Network
- Radial Basis Function Network
- Long Short Term Memory networks
- *Recurrent neural network*

Convolutional Neural Network (CNN)

A CNN deep learning framework is made up of a sequence of cascading layers that perform basic functions such as convolution and sub-sampling, leading to a succession of fully linked layers that work similarly to a traditional ANN. In the fields of computer vision, pattern classification, and image recognition, CNNs have virtually become the de-facto standard method for handling a wide range of issues. They use CNNs to solve the challenge of weather classification. There are several reasons behind their use of this method: CNN is a sort of NN that detects nonlinear mapping between different areas like feature space and label space. Deep CNN has demonstrated its great discriminating power in a number of image description and classification approaches. CNNs are simple and clear-edge convolutional architectures that enable weather categorization without the usage of artificial features. Object detection and recognition is the focus of the majority of CNN research. Forecasting, on the other hand, has nothing to do with these issues. Variables such as illumination, the status of the surroundings, and sunshine will be more important than object-related information such as color and size [4].

The proposed algorithm of convolutional neural network for predicting accurate weather forecasting is as follows.

Step 1: Create a Dataset of weather observations for four parameters i.e. rain, humidity, wind speed, temperature.
Step 2: Choose a dataset to forecast future value.
Step 3: Prepare dataset for training data
Step 4: Create training data
Step 5: Shuffle the Dataset of weather observations
Step 6: Assign Label and Features for weather observation dataset
Step 7: Normalizing X and converting Label to categorical data
Step 8: Split the data into two parts i.e. training set and test set
Step 9: Analysis of accuracy and result of weather

Radial Basis Function Network (RBFN)

Radial Basis Functional Networks (RBFN) are layered non-linear feed forward networks that are utilized as universal approximators. The RBFN is capable of performing arbitrary non-linear input space modifications. Finding a surface in a multidimensional space that best fits the training data is the equivalent of

this learning. These RBFNs are utilized in a variety of applications, but are particularly useful in predicting, such as weather forecasting, modelling, pattern identification, and picture compression. RBF is made up of three layers: input, hidden, and output, with the hidden layer being multidimensional and referred to as radial counters. The hidden unit space to the input space transformation is nonlinear, whereas the hidden unit space to the output space transformation is linear. As a result, RBFN generates a linear combination of non-linear basis functions with the input dimension matching the dimension of each radial centre. Each radial centre and each centre is a hidden unit that represents one or more of the input patterns [5].

The proposed algorithm of Radial Basis Function Network for predicting accurate weather forecasting is as follows

Step 1: Create Dataset for predicting weather nature by using four parameters rain, humidity, wind speed, temperature.
Step 2: Get weather observed data from the file and encode the labels (converting the labels into a numeric form) using LabelEncoder class

Step 3: Split the observed data into training set and testing set.

step 4: Scale the data (apply scale to training data) using StandardScaler class.

Step 5: Calculate Sigma

Step 6: Determine center of the neurons using KMeans

step 7: Determine the value of sigma for K_cent

Step 8: Set matrix A for train set

Step 9: Find weight matrix Wt to train the network.

Step 10: Set matrix A for the test set

step 11: Examine the accuracy of weather prediction on test set

Long Short Term Memory networks (LSTM)

LSTM is type of Recurrent Neural Network. It can handle not only individual data points (such as image) but also complete data series (such as speech or video). Deep Learning uses multi stacked LSTMs to map sequences of weather values of the same length. As there may be lags of undetermined duration between critical occurrences in a time series, LSTM networks are well-suited to categorizing, processing, and making predictions based on time series data. LSTMs were created to solve the problem of vanishing gradients that can occur when training traditional RNN [6].

The proposed algorithm of Long Short Term Memory networks for predicting accurate weather forecasting is as follows.

Step 1: Define the Network for weather prediction with four parameters rain, temperature, wind,
Speed.
Step 2: Compile the Network which is define
Step 3: After compiling Fit the Network
Step 4: Evaluate Network
Step5: Make Predictions for weather observed data

***Recurrent Neural Network* (RNN)**

RNN is a more advanced type of neural network that excels at modeling complicated relationships in time series data. RNNs can take as input multi-variate sequence data, extract temporal features, and generate multi-variate output (predictions). The common neuron layers (and weights) between inputs in a recurrent neural network give it the ability to process prior time-steps. As a result, RNNs are well-suited to modeling sequential data and its related temporal dynamics with greater precision. RNNs architecture makes them suited for weather data. This is especially essential because meteorological data contains non-stationary temporal characteristics including temperature and wind-related factors [7].

2. Literature Review

The proposed algorithm of *Recurrent Neural Network* for predicting accurate weather forecasting is as follows.

Step 1: Create dataset of historical weather observation

Step 2: Load the dataset

Step 3: Apply feature scaling to normalize parameters such as wind, temperature, humidity and rain

Step 4:Create training set
Step 5: Analysis of accuracy and result of weather

Reference Used	Technique used	Achieved Prediction	Research Gap	Duration of used data	Research Area
Amartya Raj Gurung [1]	RBFNN, BPN	With the use of the Neural Network Back Propagation approach, a weather system can be effective. BPN method is more efficient than numerical differentiation.	Numerical differentiation is not more efficient to capture complex relationship between many factors that contribute to certain temperature.	-	-
Mihir Bhawsar et al [2]	Deep Learning Techniques CNN, RNN	A survey of weather forecasting using various techniques	lack of survey available on the present status of exploration and application	-	-
Shahab Wahhab Kareem et al [4]	CNN, ANN	ANN recognizes complex parameters. After comparing the accuracy of CNN and ANN on weather prediction, it conclude that Each of them has unique characteristics and features that set them apart from the others.	Parameter has its own set of value ranges. The complexity of the parameters makes prediction difficult		-
El-Feghi et al [5]	RBFNN ANN	RBF ANN can be trained effectively with smallest number of neurons without compromising the performance. The RBF can achieve good learning performance in very short training time	It was quite difficult for previous methods to train effectively with the smallest number of neurons	-	-
Mohamed Akram Zaytar [6]	RNN, LSTM, Time Series	LSTM based neural networks are competitive with the traditional methods and can be considered a better alternative to forecast general weather conditions	lack of accuracy in traditional methods	2000-2015	Morocco
Jung MinHan et al [7]	RNN (Gated Recurrent Unit (GRU), LSTM, FFNN (Feed-forward neural	The GRU model performed best during model selection and tuning, yielding a low mean square error (MSE) of 2.96 than LSTM and FFNN. RNN generate highly accurate localized weather predictions	local weather stations are located on the rooftop of buildings, with time and cost implications to set-up, and collect target data at a	-	Harvard Center for Green Buildings and Cities

	network)		certain resolution during limited periods		
DavidKreuzer et al [8]	DL, LSTM, SARIMA	The convLSTM model performs best after approximately six hours.	SARIMA model is only capable of using one data input Channel.	-	Germany
Ike Sri Rahayu et al [9]	RNN, LSTM	The findings of this study suggest that RNN and LSTM can be used to predict daily temperatures.	In previous studies some methods are used such as SVR,FTS,EMD LS-SVM	2000-2019	West Java, Indonesia
Tiruvenkadam Santhanam and A.C. Subhajini [10]	MLP, RBFNN, ANN, NWP	According on the findings, the suggested radial basis function neural network outperforms the back propagation neural network.	nonlinear problems are difficult to be solved by traditional techniques	10 YEARS	Kanyakumari, India
XiaoliRen et al [11]	CNN, RNN,LSTM, DNN	Deep learning based weather prediction is expected to be a strong supplement to the conventional method.	Conventional theory driven NWP methods face challenges.	-	China

5. CONCLUSION

The research paper represent the detail review on weather forecasting with different deep learning algorithms which are based on time series prediction. For accurate prediction of weather forecasting minimum ten years of data are required for manipulating the result. After analysis of different research paper it has been found that most of the researchers have used time series based deep learning techniques, such as CNN, RBFNN, LSTM and RNN, for predicting status of the weather. These different techniques are capable of yielding good results and can be considered as an alternative to traditional meteorological approaches. This approach is able to determine the non-linear relationship that exists between the historical data (temperature, Humidity, rainfall, wind) supplied to the system during the training phase and on that basis, it is necessary to forecast what the weather will be like in the future.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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