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Deep Learning Methodologies for Predicting Cyclone Arc Effectively

Mrs. Priya Vijay[1]; Sreehari P[2]; Sriram N[3]; Subramanian C R[4]

[1]Computer Science and Engineering &Rajalakshmi Engineering College, India
[2]Computer Science and Engineering &Rajalakshmi Engineering College, India
[3]Computer Science and Engineering &Rajalakshmi Engineering College, India
[4]Computer Science and Engineering &Rajalakshmi Engineering College, India
[1] priya.vijay@rajalakshmi.edu.in; [2] sh251998@gmail.com; [3] sriramdhoni12345@gmail.com; [4] subbusai2308@gmail.com

Abstract— The most difficult thing in this world is to predict the weather and its effects. Cyclones are one of them which causes heavy damage. An efficient Artificial Intelligence system which can predict and warn about the upcoming cyclones would be a relief to the society. A system using Gated Recurrent Unit which is a newer generation of Recurrent Neural Network (RNN) for predicting the possibilities of upcoming cyclones and the areas that might be affected much ahead of time. Thus, the National Disaster Management Authority will be able to take prior preparation before the disaster so that the property damage and loss of lives can be reduced exponentially.

Keywords— Artificial Intelligence, Machine Learning, Recurrent Neural Network, Gated Recurrent Unit, Cyclone

I. INTRODUCTION

Cyclones are large scale air masses that rotate around a strong center of low pressure [1]. The term Cyclogenesis describes the strength and development of cyclone wave circulation in the atmosphere. The energy released by the progressive feedback formed above the hot marine water raise the concentration of humidity in the atmosphere forms the root cause for tropical hurricanes. These hot cyclones results in abundant damage of properties rate million dollars every year. If we consider cases in India from vardhah cyclone to 2016 intense cyclone of India affects various parts of India even Andaman and Nicobar Islands leaving India in heavy loss of wealth.

But, the impact of these phenomena could have been reduced if we were able to predict their trajectory well in advance. [2] By predicting the occurrence of cyclones well ahead in time, we can save thousands of lives and take appropriate measures to reduce property damage. The development of cyclone forecast methods has advanced over the past decades. Based on National Oceanic and Atmospheric Administration (NOAA), the most commonly used National Hurricane Center (NHC) track and intensity pre-diction models are classified in groups of dynamical, statistical, statistical-dynamical, and ensemble models.

Dynamical model are complex models as they require high computation power for understanding the behavior of the hurricane/cyclone one such model is Geophysical Fluid Dynamics Laboratory(GFDL) Hurricane Prediction by NOAA which is a grid point model that consist of three computational meshes which are nested together with increasingly finer gird point spacing in each mesh which is used to simulate hurricane (Kurihara, Tuleya, and Bender 1998) and the mesh generate the interior structure of the hurricane. Statistical model are light weight model when compared to dynamical model which only use statistical formula to find the behavior of the hurricane using past data. The model predicts the trajectory of the hurricane which based on latitude, longitude, date when the hurricane occurred. On the other hand dynamical model are combined with statistical model which are known as Statistical-Dynamical model which is used to forecasts the large scale circulation by solving equations that describe the changes in atmospheric pressure, wind and moisture and the statistical relations are used to predict the storm future position. Ensemble or Consensus model where forecasts are obtained by combining the forecasts from a collection (“ensemble”) of models. The simplest way to form consensus is the average the output from each ensemble and predict the trajectory.

However, most of the current cyclone trajectory forecast methods also face many challenges in modeling the nonlinearity of hurricane. [3] RNN is a class of artificial neural networks where the modification of weights allows the model to learn dynamic temporal behaviors. A RNN with the capability of efficiently modeling complex nonlinear temporal relationships of a cyclone could increase the accuracy of predicting future cyclone trajectory forecasts.

This paper summarizes the framework of our system under development. After reviewing the related work and background of Gated Recurrent Unit, we describe in detail the elements of our framework.

II. Recurrent Neural Network

A. Introduction to Recurrent Neural Network

Neural network is a universal classifier which classifies both linear and non-linear data extremely well but under certain circumstances where the order in which the data arrive matters such as stock market analysis, weather prediction or next frame in a movie where the sequence matters, the artificial neural network produces less efficiency. [7] Recurrent neural networks play a vital role in the analysis of time series data and provide much more efficiency when compared to the Artificial Neural Network. RNN was designed to take time series of input with no predetermined limit on size. RNN is a dynamic model that is commonly used in machine learning to represent sequential relationships or dynamical relationships between variables. Recurrent neural network is a fully connected network, where connection weights are the training parameters. In RNN we feed the previous time step to back into the network at the next time step.

B. Recurrent Neural Network in Cyclone Prediction

Since Cyclone specific dataset are sequential with RNN's flexible topology and its ability to handle time series data could benefit us to predict of trajectory of the cyclone without much complexity. The difficulty in predicting the trajectory of the cyclone is due the non-linear temporal nature of the cyclone. A RNN with a necessary activation function could even efficiently model the complex nonlinear relationship of cyclone and increase the accuracy of the prediction. By employing Gated Recurrent Unit (GRU) the RNN can even learn better by avoiding the vanishing gradient problem that occurs in sparse recurrent neural network over the time of learning.

III. GATED RECURRENT UNIT

Gated Recurrent Unit is an improved version of Standard Recurrent Neural Networks which aims to solve the vanishing gradient problem. Standard Recurrent Neural Networks suffer from short term memory. If the sequence is long enough it will have hard time carrying the information from earlier time step to next time step and during back propagation recurrent neural networks suffer from vanishing gradient problem. Gradients are the value used to update weight in neural networks. [9]Vanishing gradient problem is when the gradient shrinks as it back propagates through time and if the gradient value is small it doesn't contribute much in learning. To solve this GRU uses update gate and Reset gates which are two vectors which decides what information should be passed to the output. GRU can be trained to keep information from long ago and remove the information which is irrelevant to the prediction. Figure-1 shows a single GRU.

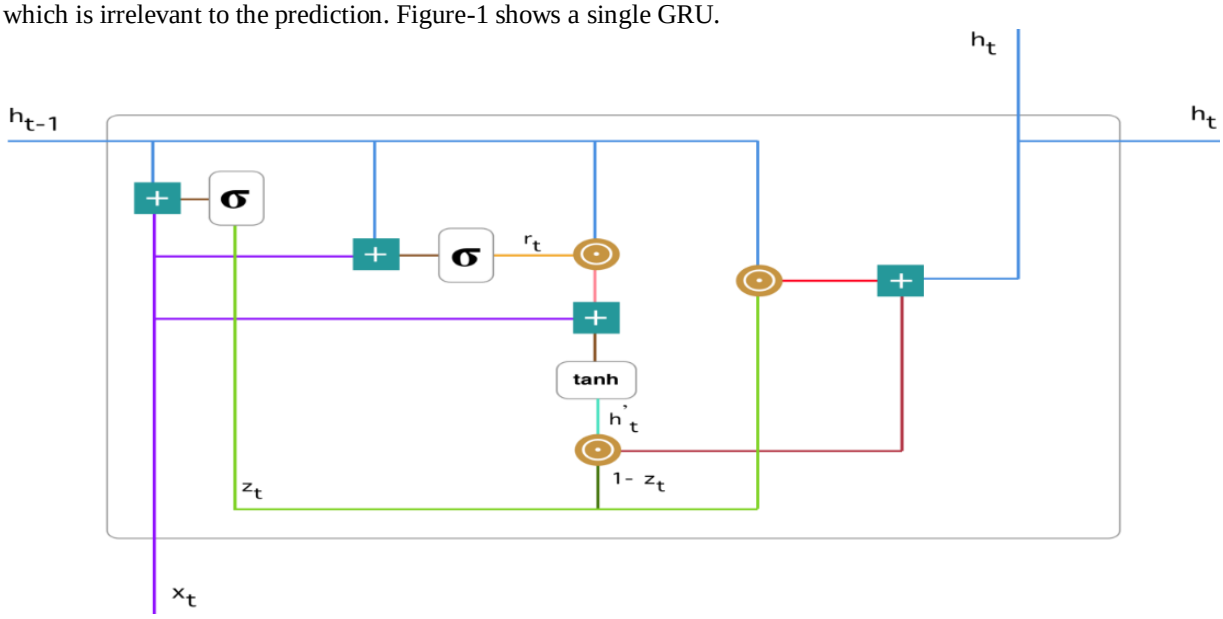

Fig .1 Gated Recurrent Unit

IV. SYSTEM ARCHITECTURE

In this section we present the architecture of the prediction system. The system consists of following modules:

A. Preprocessing

This module is used to clean the dataset that is given as input to the machine learning model. The raw data need to be removed with unwanted data or to remove duplicate data or to fill missing data to make it a data efficient to processing by data preprocessing methods.

B. Model Creation

RNN is a dynamic model that is commonly used in machine learning to represent sequential relationships or dynamical relationships between variables. Recurrent neural network is a fully connected network, where connection weights are the training parameters. In RNN we feed the previous time step to back into the network at the next time step.All the Recurrent Neural Network will be having feedback loops in their recurrent layer. This is very useful in maintaining the information in the "memory" over the time period. For Learning Long-term temporal dependencies, it is difficult to go for the standard RNNs. And the reason behind this is the vanishing gradient problem, which is "exponential decaying of the gradient of the loss function". Thus we go for Gated Recurrent Unit (GRU) networks; it is also a type of RNN which will be having some additional special units. It includes a "memory cell" which will be used to maintain information in the memory over a long period of time. A set of gates will be used to control when the information reaches the memory, when it's output and when it's forgotten.

Gated Recurrent Unit is an improved version of Standard Recurrent Neural Networks which aims to solve the vanishing gradient problem. Standard Recurrent Neural Networks suffer from short term memory. If the sequence is long enough it will have hard time carrying the information from earlier time step to next time step and during back propagation recurrent neural networks suffer from vanishing gradient problem. Gradients are the value used to update weight in neural networks. Vanishing gradient problem is when the gradient shrinks as it back propagates through time and if the gradient value is small it doesn't contribute much in learning. To solve this GRU uses update gate and Reset gates which are two vectors which decides what information should be passed to the output. GRU can be trained to keep information from long ago and remove the information which is irrelevant to the prediction.

C. Prediction

The preprocessed dataset for prediction is given as input to our prediction model which uses gated recurrent unit to predict the trajectory of the cyclone dynamically and saves the output.

D. Trajectory Visualization

The saved prediction data is plotted in the graph and displayed in a webpage. The webpage is created using node-js which reads the result stored by the prediction model and displays it.

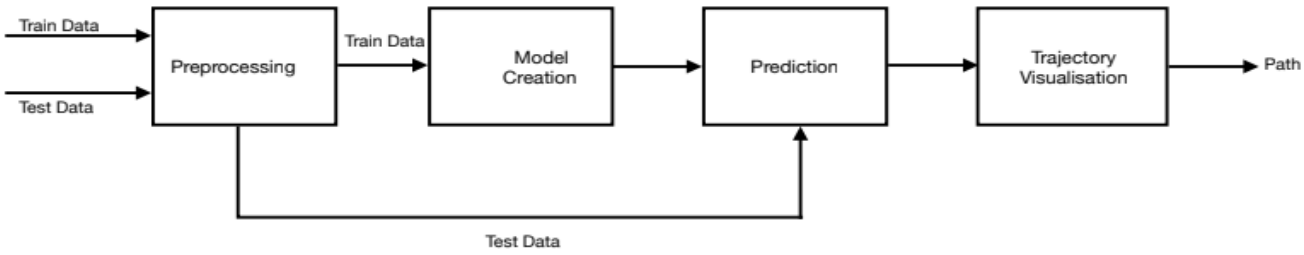

Fig .2 System Architecture

V. Future Scope

The current proposed system gives the information on the trajectory of the cyclone. But being on the dark side of the severity of damage in the different areas of impact by the cyclone is another disadvantage. By predicting the duration of effects of cyclone in an area by taking into account the speed and other terrain factors would be more useful for the National Disaster Management Authority to make efficient use of their resources.

VI. Conclusions

Cyclones are one the most ravaging disasters by the Mother Nature. The above proposed system framework is a relief to unexpected impact by the cyclones. The proposed framework will be more effective than the existing statistical models. The National Disaster Management Authority can be on alert with the help of the system and make efficient use of the resources. With the increase in accuracy of the model the wastage of resources and loss of human lives can be decreased.

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