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RADAR VISION- WEATHER FORECASTING USING CNN-LSTM

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Abstract- Due to the unpredictable swings in climatic and atmospheric conditions, weather forecasting is becoming a more important topic of study. Scientists have been developing novel strategies for training models to achieve accuracy over nonlinear statistical datasets for the past few decades in order to prevent future environmental damage and world disaster. Predicting the climatic condition in advance is easy for farmers to know the favorable climatic conditions for the crops to be grown, which leads to higher yields. Agriculture, which plays a crucial role in the Indian economy, predicts the climatic condition in advance is easy for farmers to know the favorable climatic conditions for the crops to be grown, which leads to higher yields. Artificial intelligence and machine learning have added a new dimension to the area of weather forecasting, requiring only a few perplexing mathematical equations. This study examines a variety of traditional strategies, ranging from classical weather forecasting to modern methodology such as data mining and artificial intelligence. This research also shows a proposed model that predicts with high accuracy and can be used in various time series forecasting applications.

***Keywords-* Weather forecasting, ConvLSTM, AI,NN, Weather Elements, Accuracy.**

I. INTRODUCTION

Weather forecasting is one of the most important applications of Artificial Intelligence and Machine Learning, as it can be used to anticipate atmospheric conditions for a specific location at a specific time. People have struggled to predict the weather informally for millennia, but with the availability of large amounts of data and powerful technologies, it has gotten much easier. Weather forecasts are created utilizing quantitative data collected for a specific location and meteorology to depict the expected change in atmospheric conditions.

The reasons for the inaccuracy seen in weather forecasting ability to predict are a) a large gap between current and forecasting time b) complex mathematical and statistical computations requiring high computational power c) errors made while recording measurements and lack of familiarity with meteorology. Weather forecasting has a number of benefits, including allowing military personnel to organise their strategies properly, assisting farmers in adjusting their farming efforts, and assisting people in evacuating any location before to natural disasters, saving many lives.

This work is divided into eight sections, each of which includes a review of traditional and current weather prediction approaches, as well as a proposal for a new methodology based on the findings.

1.1 Traditional Whether forecasting Methodologies:

Weather forecasting was a random, indeterminate, and unreliable procedure a century ago. The observations made for data gathering were sporadic and irregular. The forecaster employed rough and scattered extrapolation processes, knowledge of local climatology, and estimation based on instinct; theoretical physics concepts played little or no part in practical forecasting. Forecasting seemed to be more of an art than a science. Apart from that, researchers and scientists have made numerous attempts to overcome numerous problems in order to attain precision in weather prediction, which has resulted in the introduction of a variety of novel concepts and approaches. However, the precision obtained by such tactics was insufficient and below expectations.

Following mentioned are descriptions of some of the strategies utilized in forecasting weather.

i. Synoptic weather forecasting: To a meteorologist, a synoptic chart is a weather map that depicts atmospheric conditions at a specific time. A meteorologist creates a synoptic chart based on a number of variables and data collected at numerous locations at a specific time and location. A meteorological centre keeps a record of a succession of synoptic charts to gain an approximate clear image of the changing weather pattern. This set of charts serves as a critical component in weather forecasting. Several rules were deduced from the observation of these synoptic maps over a long period of time, which assisted the analysts in anticipating the amount and pattern of weather change.

ii. Numerical Weather Predictions (NWP): This method makes use of supercomputers' great computational ability to solve exceedingly complicated mathematical equations in order to develop a model that can predict meteorological variables such as wind, temperature, pressure, and rainfall. Because the starting state is not totally understood, the computer's estimate of how the initial state will evolve further is not wholly accurate, which makes it difficult to anticipate how the initial state will evolve further.

iii. Statistical Method: This method corrects the faults of the Numerical method. It is predicated on the premise that past weather events would repeat themselves in the future. A relationship among characteristics can be recognised by finding those aspects of historical weather that operate as good indicators of future forecast, allowing future conditions to be anticipated more correctly. Because only the entire weather may be forecasted, it can be used to project only one feature of the weather at a time.

The weather of a place is the state of the atmospheric condition at a given location for a short period of time with atmospheric phenomena such as wind speed, temperature, precipitation, humidity, cloud cover, and so on. Weather is a natural phenomenon that plays an important part in maintaining atmospheric equilibrium all around the world. The atmospheric condition changes depending on a variety of circumstances, and it can sometimes become intense enough to endanger people's lives and property. This is referred to as severe weather. Future damage can be avoided and prophylactic steps made if the causes that cause these illnesses are known.

Design Descriptions: Some of the deciding factors are explained in brief below:

Reflectivity: Reflectivity images are exactly what they sound like: they use the energy reflected back to the radar to create a picture of the weather. The great majority of radar images you'll see on television are reflectivity images. Base Reflectivity (½° elevation) and Composite Reflectivity are the two types available on the web.

Spectrum Width: Wind shear, turbulence, and/or the quality of the velocity samples all contribute to the variability of the mean radial velocity estimations (movement). Spectrum Width can assist in the decision-making process for severe thunderstorm and tornado warnings. It's used to calculate turbulence at low-level boundaries, thunderstorms, supercell mesocyclones, and mesovortices, among other things.

Wind Velocity: Only motion directed directly at or away from the radar can be detected by the radar. It's called Radial Velocity of Wind because it's the component of the target's motion that moves in the same direction as the radar beam.

II. LITURATURE REVIEW

Artificial intelligence (AI) is a vast field of computer science concerned with creating intelligent machines that can perform activities that would otherwise require human intelligence. Artificial intelligence's ideal feature is its ability to give good reasons for and take actions on any endeavour that has a higher chance of achieving a given goal.

Although AI is a multifaceted science with many techniques, advances in machine learning and deep learning are causing a paradigm shift in nearly every sector of the IT industry. Machine learning is a subset of AI that allows a machine to learn and improve operations without having to be programmed on a regular basis. Deep learning is a subtype of machine learning in which computers process data using artificial neural networks.

2.1 Artificial Neural Network: An artificial neural network (ANN) is a component of a computer system that simulates how the human brain analyses and processes data. An artificial neural network (ANN) is a hardware and/or software system that mimics the way neurons in the brain work. It is the basis of artificial intelligence (AI), which solves issues that are impossible or difficult to address using human or statistical standards. As more data becomes available, ANNs' self-learning abilities enable them to deliver better results.

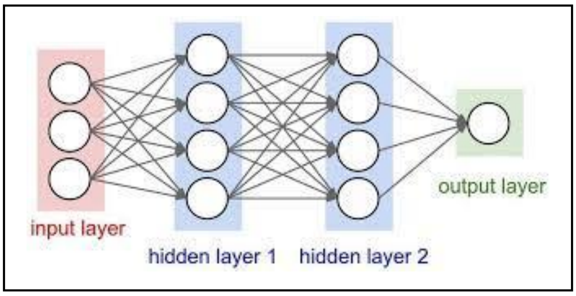
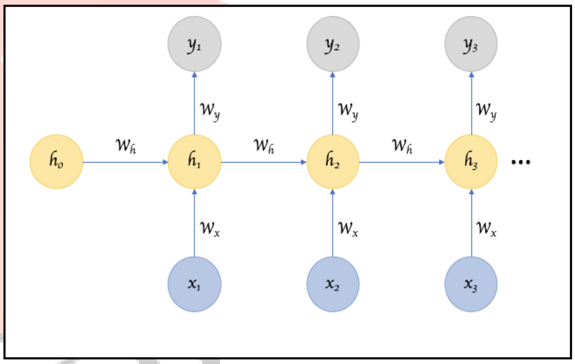


Figure. 2.1: ANN Architecture

2.2 Recurrent Neural Network: - Recurrent neural networks, also known as RNNs, are a class of neural networks that allow previous outputs to be used as inputs while having hidden states. RNN has the ability to remember the past learning and its decisions also depends on the learning in the past. The main difference which we can draw between basic Feed Forward Network and RNNs is that Basic feed forward networks remember things they learnt only during the training while in



addition to that RNN remember things learnt from prior inputs while generating outputs as well. Hence the outputs from RNN are influenced not just by weights applied on inputs, but also by a hidden state vector representing the learning based on past inputs/outputs.

Figure. 2.1: RNN Architecture

2.3 Long Short-Term Memory Unit (LSTM): A recurrent neural network that is trained using Backpropagation Through Time to overcomes the vanishing gradient problem, is called as Long Short-Term Memory Unit or simply LSTM. They work tremendously well on a large variety of problems, and can be used to create large recurrent networks that in turn can be used to address difficult sequence problems in machine learning and achieve up-to-the-minute results.

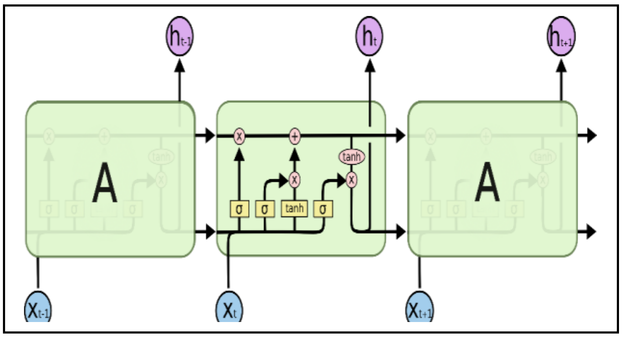


Figure. 2.3: LSTM Architecture

LSTM networks consists of memory blocks connected through layers. Each block operates upon sequence of input and use sigmoid activation functions to determine whether to trigger the block or not, controlling the state and output of the block.

There are three types of gates within a unit:

Forget Gate: conditionally decides what information to throw away from the block.

Input Gate: conditionally decides what new information we're going to store in the cell state.

Output Gate: conditionally decides what to output based on input and the memory of the block.

III. METHODOLOGY

We proposed an approach that overcomes the several limitations faced by the Numerical Weather Prediction Models which is used at most of the weather forecasting agencies till date. By following the proposed approach, the requirement of huge computational power reduced remarkably and the performance become more reliable.

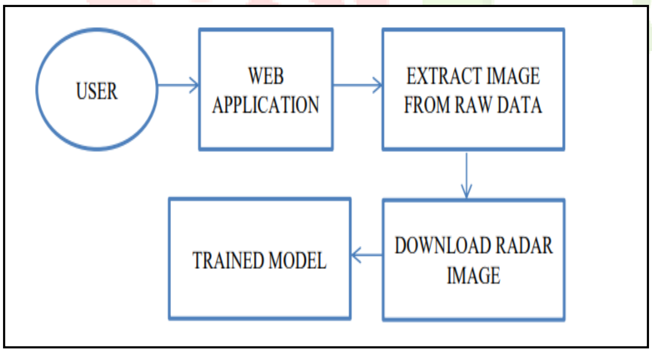


Figure. 3.1: Data flow diagram of proposed system

Above Figure illustrates the Flow of the proposed model. A web application that fetches the current weather conditions and predict the weather for the upcoming fortnight with the help of the trained model was created. Using the web application 'Weather Forecast', the user can view the radar data in the graphical format and can also download the required component of the data. This downloaded radar data is then used as an input by the model to predict the weather condition for the next one hour. The output is also in the form of radar image file.

In the proposed approach, three models were trained instead of training a single model, each for respective three components of radar image, i.e., RED component, BLUE component & GREEN component. This helped to overcome the high requirement of computational power and also increased the accuracy. Following Figure explains the working of the system.

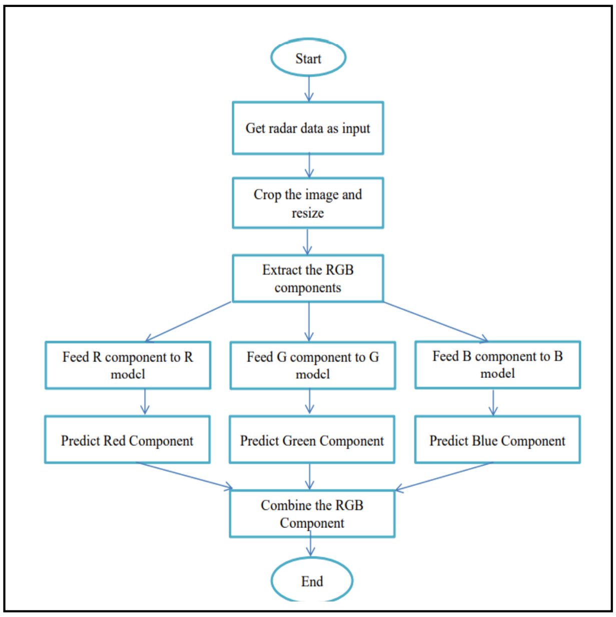
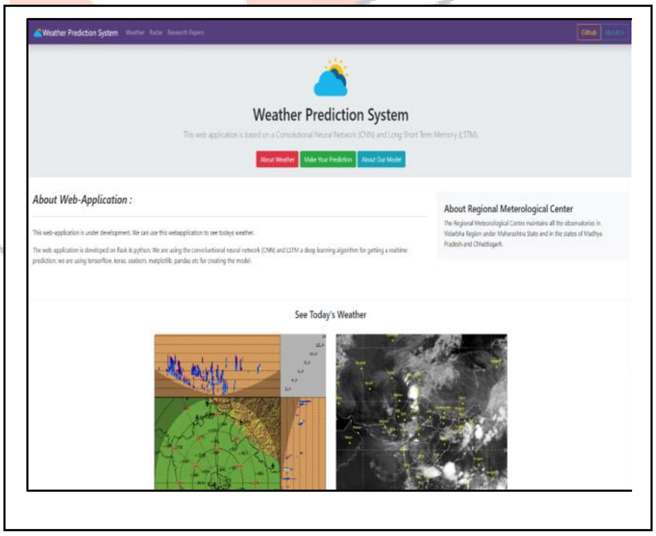


Figure. 3.2: Flow Chart of proposed system

Data Sets used in research Work:

We have used the raw files of a particular day captured by radar at different intervals provided by Reginal Metrological Centre, IMD, Nagpur.The raw files are special type of file format which contains data in multidimensional



array format which we used to plot a graph of a particular field using Py-ART library and further was converted into png images to feed into the model.

Figure. 3.3: Home page

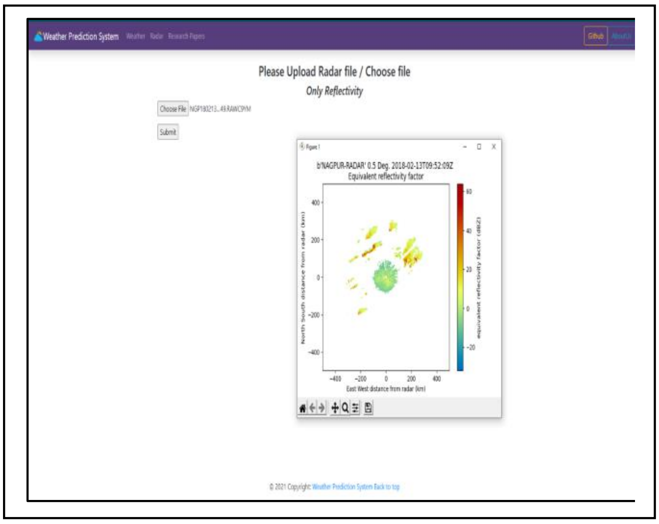


Figure. 3.4: Radar data download page

IV. EXPERIMENTAL RESULTS AND ANALYSIS

The traditional approach is to train a single model, but this require high computational power as the size of input data is large. But in the approach that we followed, the input data was divided into three sets, each representing a particular component namely RED, GREEN and BLUE. These three sets of data were small in size as compared to the original dataset hence required relatively less computational power to train a model.

In the field of time series forecasting acting as a sequential model, the best approach is to use Recurrent Neural Network. Since, weather forecasting is the essence of the analysis of the past historical data, the requirement of the appropriate and long memory units will be of great advantage. Henceforth, the algorithm preferred along with the RNN is Long Short-Term Memory Unit (LSTM model). Following figure shows the graphs being plotted between epochs against validation loss and validation accuracy to analyse the fitness of the model and diagnose it to improvise the model for high accuracy.

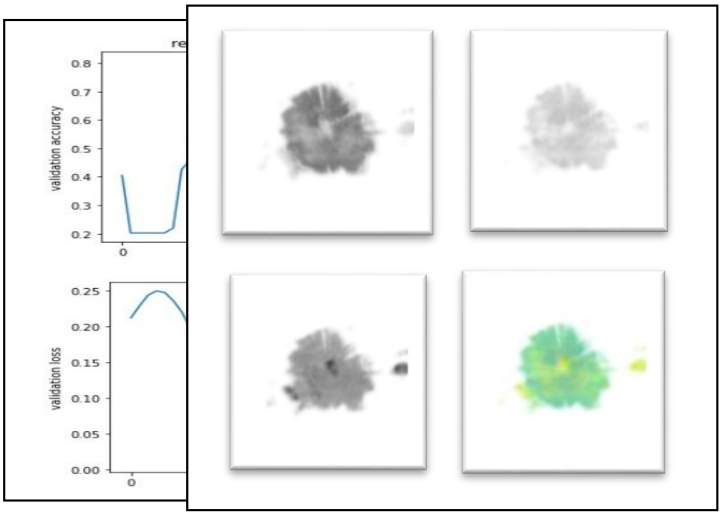
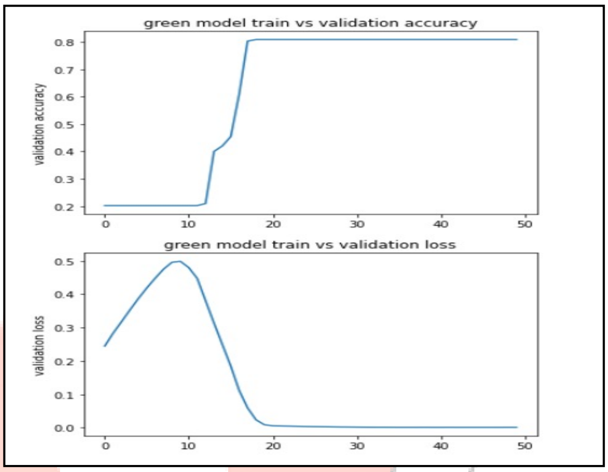


Figure. 4.1: Red



Model train Vs validation accuracy

Figure. 4.2: Green Model train Vs validation accuracy

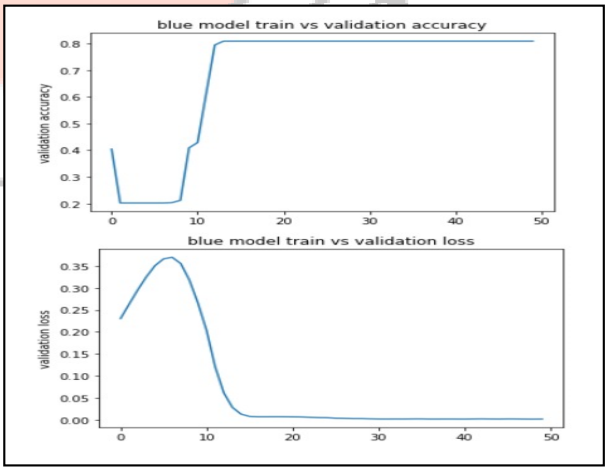


Figure. 4.3: Blue Model train Vs validation accuracy

As in the above graph, the line for validation loss becomes parallel to the X-axis after certain epochs, which states that the loss is constant, inferring there is no scope for improvement.

Following images shows the predicted images which was given as output by the three models and the last image is the final output after merging the 3 components. The accuracy we calculated after merging was nearly around 82%. The accuracy can be further increased by providing more datasets to the proposed model.

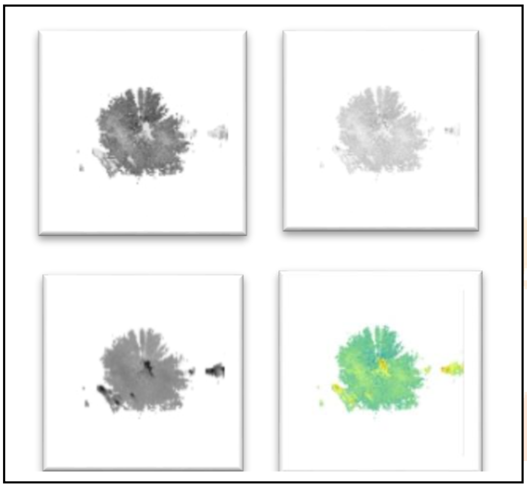
Figure 4.4 Predicted images of red, green, blue, and merged
Figure 4.5 Real images of red, green, blue, and merged

V. CONCLUSION

The two main components of Weather Forecast are as follows: Neural Network (software module) and User Interface. These components together help to create the working of Weather Forecast. As stated in the introduction, the purpose of Weather Forecast is to forecast the weather elements with the maximum accuracy.

Following are the results of the product:

1. The Module is successfully able to forecast next radar image of 1 hour later with 82 % accuracy.
2. Weather is predicted based on the radar data elements like Reflectivity, Wind Velocity and Spectrum Width
3. The User Interface allows the users to view the weather forecast report with the proper representation of dates. Thus, Weather Forecast is a productive as well as inexpensive product in terms of computing that enhances the accuracy of weather predictions in order to predict the unexpected outcomes.



Thus, this work will help in building technique that would increase the accuracy in whether prediction.

VI. ACKNOLEGMENTS

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