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Snowfall Prediction using Long Short Term Memory Model

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Abstract: ***Snowfall can enormously affect the socio-economic development and livelihoods of the indigenous people. It prolongs the longevity of glaciers and there enough water for irrigation, hydro-power generation and drinking. It also boosts tourism and provides biodiversity benefits. It is a blessing but as well as a curse if a timely accurate prediction is not done. The problem lies in the accurate prediction of snowfall as the weather is a random phenomenon and its non-linearity is difficult to understand both in terms of complexity and technology. Deep learning is relatively robust to perturbations and is capable of understanding the non-linearity. In the present investigation, Deep learning algorithm (LONG SHORT TERM MEMORY) has been employed on the dataset taken from three different stations of Jammu and Kashmir. The Experimental results obtained have shown that LSTM was able to predict snowfall for all stations with significant accuracy.***
Keywords: Weather Prediction, Snowfall, LSTM, recurrent neural network.

I. INTRODUCTION

The seasonal Snowfall is an essential part of the earth's climate system. Snow cover is the major single constituent of the cryosphere which is covering an average of about 46 million square kilometers, yearly of earth's surface every year. Snow helps to regulate the temperature of the earth's surface and helps fill rivers and reservoirs in most regions of the world. Snowfall has a significant impact on our society for better and for worse. The accurate forecasting of snowfall has an important contribution to the growth of economy and safety consequences for the entire nation. A timely and accurate prediction of a snowfall event could mean the difference between a manageable snowfall and a city shut down by impassable road conditions. However, an accurate and timely prediction of weather has been one of the most difficult tasks across the globe. This is because of the fact, the weather is a random phenomenon which is non-linear in nature and its prediction has been very difficult both in terms of technology as well as complexity, basically Snowfall prediction remains one of the difficult challenges in weather forecasting for a meteorologist. Reason being that variables such as temperature, atmospheric pressure, humidity, wind which are main meteorological factors are dynamic in nature and generated in a non-linear fashion which affects the accuracy. So a deep learning model (LSTM) is must needed which can understand the non-linearity of the data and increase in the accuracy of the snowfall prediction.

The rest of the paper is organized as: Section 2 throws light upon the literature related to the current study, Section 3 presents the materials and methodology adopted in this work, Section 4 discusses the experimental results and Section 5 explains the conclusion of this study.

II. LITERATURE REVIEW

Snow can hamper flight landings, take-offs, or even a smooth flight journey as well. Huge chunks of snowfall make it really difficult to keep runways clear. Thunder snow storms and blizzards can cause icing, visibility or turbulence issues during landings and flight travels. Therefore predicting snowfall earlier is of utmost importance even in the domain of flight navigation as well.

This was taken up by (Aftab et al.; 2018)[1] in their research study wherein they wanted to have a comparison of visibility forecasting using LSTM and ARIMA models. They selected Hang Nadim Airport of Indonesia for their model for predicting the parameter of visibility as the target variable which was combined with different weather features like humidity, dew-point and temperature. Once the implementation of models was done they compared the RMSE values generated from both the models and concluded that Long Short-term Memory model yielded high accuracy compared to ARIMA in time series analysis in both the cases of values generated.

In, another technical research which was carried by (Geetha and Nasira; 2014b)[2], the author depicted the performance of a decision tree based model for the prediction of weather activities like rainfall, thunderstorm, fog and cyclone. Interestingly, this model resulted with the accuracy of 100% which should not have been considered as the data was highly biased and the author could have relied on sensitivity. Also, in this research random forest proved to be better than Support Vector machine and Decision tree models.

Similar investigation was conducted where a research presented the performance of deep neural network architecture which was implemented on a time-series data for prediction of weather, for this purpose (Zaytar and El; 2016)[3], analysed the performance of a 3 layered LSTM model.

For this research the author used the hourly based data which ranged for the duration of 15 years, and the aim was to implement deep learning model in the city of Morocco for predicting weather parameter for next 24 and 72 hours. The results obtained made it clear that LSTM yielded far better results to the compared traditional neural network approach and proved to be a better alternative to forecast weather conditions. In order to achieve the accuracy of a snowfall prediction model, it is very important to capture the right meteorological factors. According to (Zhang et al.; 2019),[4] relative humidity, temperature, and latitude were identified as the most important factors in predicting snowfall. In order to prevent the disasters created by the floods, an accurate and timely prediction of rainfall is required which can result in minimum possible stochastic error. With this aim in mind,(Chao et al.; 2018)[5] came up with a model (STL) which decomposed the referral time series into trend, season and the residue applications for sensors of MEMS which was able to tackle the problem in real time rainfall prediction in Wuhan. Once the trends were received from the observed series, they were compared with the trends that were generated from the observed authentic dataset. The results suggested that MEMS sensors are believable. Researchers in this study have also used LSTM for predicting real time rainfall which is based on the data observed, it is then compared to a Random Forest, BPNNs, Support Vector Machine, Moving and Auto-regressive Average. Once the results were reported, it was observed that deep learning model (LSTM) showed better results when compared to SVM, RF, and BPNNs in Seasonal time as well real time predictions. It was concluded that LSTM is powerful enough in extracting the changed rules of seasonal rainfall by which we could be optimistic of its performance in the field of snowfall domain as well which can replace the old and expensive traditional approach and can eventually be the optimal benchmark that could be used in snowfall prediction .

III. METHODOLOGY

This study presents the prediction of snowfall based on long short term memory model. The experimental study has been carried out on *Python* platform using *Jupyter Notebook interface.* The primary Snowfall dataset has been collected from Metrological Center Srinagar. In this study, the snowfall data of three different centers have been considered. The collected dataset comprised of a total 20 years of winter data, belonging to 3 different stations of Kashmir valley. The Three stations of Valley comprised of *Srinagar*, *Kupwara*, *Pahalgam*, and each having 20 years of data. The dataset was provided by the Metrological Center Srinagar containing six factors namely maximum temperature, minimum temperature, rainfall, snowfall, relative humidity recorded at two times. The overall collected dataset was divided into two sets in the ratio 80:20 into *Train data Set* and *Test data Set* respectively. The overall methodology for the proposed work is presented in figure 1.

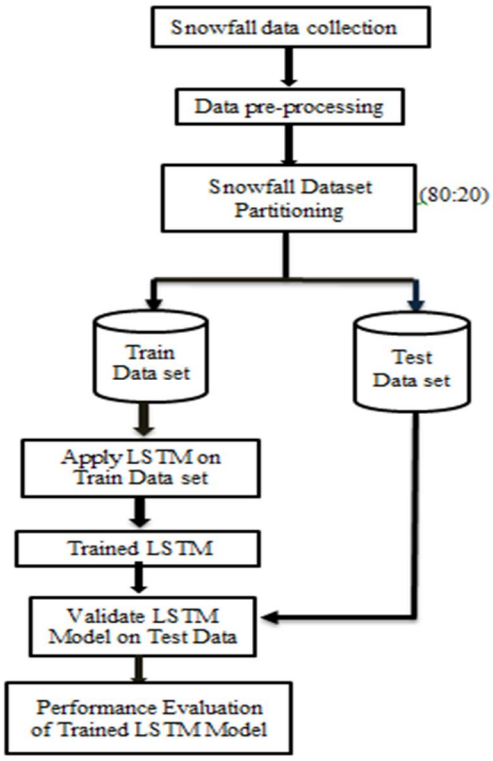

Fig 1: Methodology of current work

To implement a deep learning model, LSTM was used as a classifier. For the development of this model Python 3.8.5 was used as it provides a variety of packages and libraries for LSTM. Keras was used as a platform to implement LSTM. First of all, we imported libraries like NumPy, Matplotlib, and Pandas for calculations, graph plotting and data manipulation respectively. Then the lag was taken up to 3 days for every feature. For feature scaling, MinMaxScaler was used from sklearn metric packages to achieve optimal performance. Data was split to (80 20) ratio for test and train set. Stacked LSTM was implemented for this case of classification where three-dimensional input layer is used for prediction using Dense function. Activation functions were kept to default where sigmoidal was used as activation for inner cells and dropout value set to 0.3 which means 30 percent of the layers were dropped. Finally, model performance was evaluated based on experimental results.

IV. RESULT AND DISCUSSION

The LSTM deep learning model was evaluated using 20 percent test data for all three different stations separately. LSTM predicted snowfall for all the stations with an accuracy of more than 85%. The best prediction results were obtained with dataset from Srinagar station, with the model attaining 94% accuracy. Highest precision score of 97% was also observed which explains the measure of accuracy with which the model predicted snowfall. Table 1 depicts the experimental results achieved by LSTM model for snowfall prediction.

Table 1.Experimental Results of LSTM model

Station	Accuracy	Precision	Recall	F1-Score
Srinagar	94%	97%	53%	0.50
Kupwara	90%	45%	50%	0.47
Pahalgam	86%	58%	38%	0.38

V. CONCLUSION

This paper explores snowfall prediction for three stations of Kashmir valley based on the LSTM model. The model was able to predict with significant accuracy for all three stations. In future work, additional factors responsible for a snowfall event can be included for Snowfall prediction. An extensively large data can be taken for only winter months in order to sufficiently train a deep learning model. Also, the advanced time-series models like GRU and Prophet could be used to for the implementation which has shown success with other time-series domain.

VI. ACKNOWLEDGEMENT

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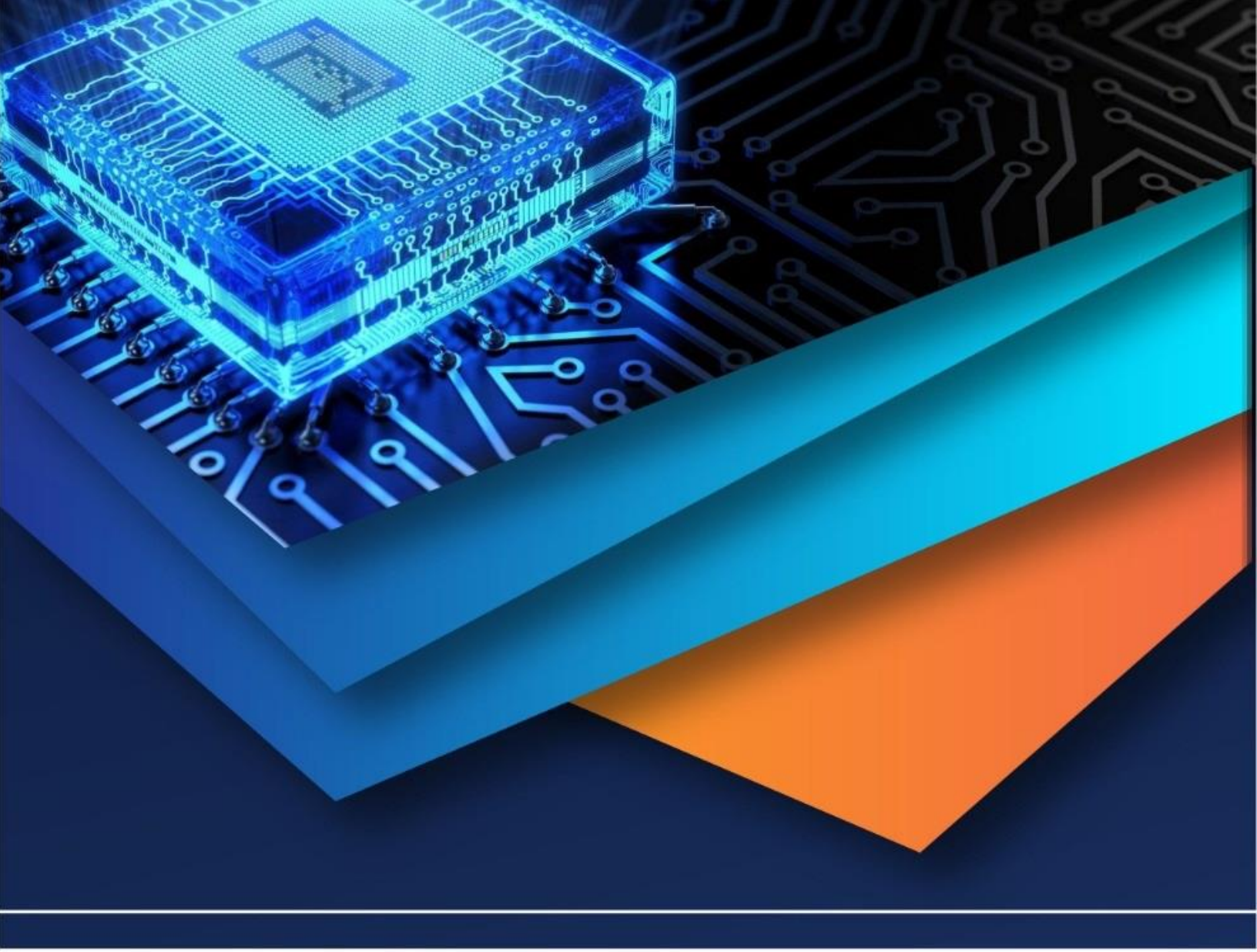

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