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Snowfall Prediction Using Artificial Recurrent Neural Network (RNN)

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ABSTRACT- Prediction of weather is an attempt done by meteorologists to forecast the weather conditions of an area at some time in the future that may be expected. The parameters of the climatic condition are based on the humidity, wind, temperature, rainfall and size of data set. Snowfall has a tremendous effect on the livelihood and the socio-economic development of the native individuals. It extends the permanency of glaciers and thereby providing adequate water for drinking, irrigation and hydro-power generation. Furthermore, it enhances business enterprise and provides diversity advantages. Snowfall is a blessing however if it is not correctly predicted, it can become a curse. The cost of clearing the snow is high both in terms of cost and time. Predicting snowfall for a short-term is effective in scheduling when and how to clear the snow and also necessary to decrease the cost of clearing it. Since the weather is a non-linear phenomenon and its randomness is very difficult to comprehend both in terms of complexity and technology, deep-learning has been applied as it is proficient in understanding the non-linearity and also comparatively robust to perturbations. This paper proposes a deep learning algorithm (LONG SHORT-TERM MEMORY) which is employed on three different datasets obtained from three different locations of Jammu and Kashmir. The results found from this experiment depicted that LSTM was capable of forecasting the snowfall with substantial accuracy.

KEYWORDS- Snowfall Prediction, Weather, Lstm, Recurrent Neural Network, Deep-Learning.

I. INTRODUCTION

One of the vital components of the earth's climate system is the seasonal Snowfall. Individual ice crystals that make up snow develop while hanging in the atmosphere, typically within clouds, before falling and settling on the ground, where they go through additional modifications. It begins with the formation of ice crystals in the atmosphere under favourable conditions, grows to millimetre size, precipitates and accumulates on surfaces, then through a metamorphosis in place, and finally melts, slides, or sublimates away. Snowstorms feed on supplies of atmospheric moisture and cold air to organise and grow. Snowflakes form around airborne particles by drawing supercooled water droplets, which then solidify into crystals with a hexagonal structure. Platelets, needles, columns, and rime are among the basic shapes that snowflakes can take on. Snow may blow into drifts when it builds up into a snowpack. Accumulated snow undergoes changes over time due to sintering, sublimation, and freeze-thaw. A glacier can develop in areas with cold enough winters for year-round accumulation. Otherwise, snow normally melts over the course of a season, causing runoff into streams and rivers and recharging groundwater. The polar regions, the northernmost portion of the Northern Hemisphere, and mountainous places with adequate moisture and chilly temperatures worldwide are among the major snow-prone locales. With the exception of Antarctica, snow is confined to mountainous regions of the Southern Hemisphere. Snow has an impact on a variety of human activities, including transportation, agriculture, warfare, and sports like skiing, snowboarding, and snowmobiling. Transportation is impacted by the requirement to keep windows, wings, and roadways free. Snow also has an impact on ecosystems as well. It provides an insulating layer in the winters under which the plants are able to survive the cold. The cryosphere, which covers an average of around 46 million square kilometres of the earth's surface each year, is primarily composed of snow cover. In most parts of the world, snow helps to fill rivers and reservoirs and regulates the temperature of the earth's surface. Our culture is significantly impacted by snowfall, both positively and negatively. The growth of the economy and safety implications for the entire country are significantly impacted by the correct forecasting of snowfall. The difference between a tolerable snowstorm and a city shut down due to impassable road conditions can be made by timely and accurate snowfall prediction. However, one of the most challenging undertakings worldwide has been making timely and accurate weather predictions. This is due to the fact that the weather is a random occurrence with a non-linear character, making it exceedingly challenging to anticipate in terms of technology and complexity. Specifically, the prediction of snowfall continues to be one of the hardest tasks in weather forecasting for a meteorologist. The primary meteorological parameters including temperature, atmospheric pressure, humidity, and wind are dynamic in nature and produced in a non-linear manner, which influences the accuracy. Therefore, a deep learning model (LSTM) that can comprehend the non-linearity of the data and improve snowfall prediction accuracy is essential. 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 SURVEY

Snow can make it difficult for planes to land, take off, or simply travel without incident. It is extremely challenging to maintain runways clear when there are large snowfalls. Blizzards, snowstorms, and thunder storms can affect visibility, turbulence, and icing during landings and flight travel. As a result, it is crucial to anticipate snowfall even in the field of aviation navigation. This topic was addressed by (Aftab et al.; 2018) [1] in their research paper, which sought to compare visibility predictions using LSTM and ARIMA models. They chose Indonesia's Hang Nadim Airport as the test site for their model to estimate the visibility parameter, which was paired with other weather characteristics like humidity, dew point, and temperature. Following the completion of the models' implementation, they compared the RMSE values produced by the two models and came to the conclusion that, in both situations of values generated, the Long Short-Term Memory model offered higher accuracy than ARIMA in time series analysis. Another technical study by Geetha and Nasira (2014b) [2] revealed the effectiveness of a decision tree-based model for forecasting weather events such precipitation, thunderstorms, fog, and cyclones. The data was heavily biassed, therefore the author might have relied on sensitivity instead of this model's 100% accuracy, which shouldn't have been taken into account. Random forest also outperformed the Support Vector Machine and Decision Tree models in this study. A related study (Zaytar and El; 2016) [3] examined the performance of a three-layered LSTM model with the goal of presenting the performance of deep neural network architecture that was deployed on time-series data for weather prediction.

In order to create a deep learning model in the city of Morocco for forecasting weather parameters for the coming 24 and 72 hours, the author employed hourly-based data that covered a period of 15 years. The outcomes demonstrated that LSTM was a superior alternative for forecasting meteorological conditions, outperforming the standard neural network strategy by a wide margin. It is crucial to include the proper meteorological elements in a snowfall forecast model in order to attain accuracy. Relative humidity, temperature, and latitude were found to be the most crucial variables in predicting snowfall in (Zhang et al.; 2019) [4]. A precise and timely rainfall prediction that can provide the least amount of stochastic error is needed in order to prevent the calamities brought on by floods. In order to achieve this goal, (Chao et al.; 2018) [5] developed a model (STL) that divided the reference time series into trend, season, and residue applications for sensors of MEMS. This model was able to address the issue of real-time rainfall forecast in Wuhan. The trends that were obtained from the observed series and the trends that were produced from the observed authentic dataset were then contrasted. According to the findings, MEMS sensors seem plausible. According to the data collected, researchers in this study have also employed LSTM to forecast real-time rainfall. This method is compared to Random Forest, BPNNs, Support Vector Machines, Moving and Auto-regressive Average. When the findings were made public, it was discovered that the deep learning model (LSTM) outperformed SVM, RF, and BPNNs in both seasonal time and real-time forecasts. As a result, it was determined that LSTM is capable of extracting the modified seasonal rainfall rules, allowing us to be optimistic about its performance in the snowfall domain as well. This means that it can eventually replace the outdated and expensive traditional approach and serve as the best benchmark for snowfall prediction.

Gibson et al. explored weather prediction using parallel genetic algorithms using a cluster of desktop stations running the MPICH MPI distribution [10]. Based on a condensed collection of data, they applied small-scale parallel genetic algorithms and created a straightforward temperature forecast technique.

III. PROPOSED SYSTEM

In this work, snowfall is predicted using a long-short-term memory model. Using the Jupyter Notebook interface and the Python platform, the experimental study was conducted. The Metrological Centre Srinagar provided the main Snowfall dataset. The snowfall data from three separate centres have been taken into account in this study. The collected dataset was made up of 20 years' worth of winter data from three separate Kashmir valley locations. The three Valley stations—Srinagar, Kupwara, and Pahalgam—each had 20 years' worth of data. The information, which included six parameters including maximum temperature, minimum temperature, rainfall, snowfall, and relative humidity recorded twice, was provided by the Metrological Centre Srinagar.

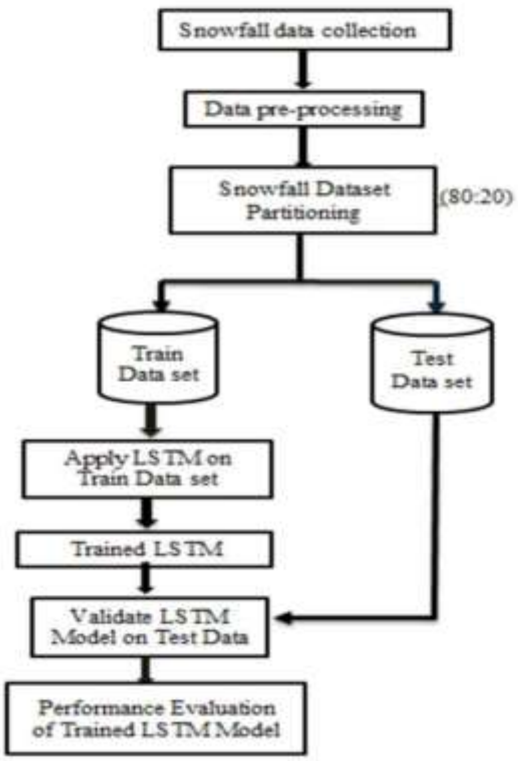

Figure. 1. Proposed System

Before putting any model into use, data pre-processing is a crucial step. In order to get better results from the models, it is essential that irrelevant data from the data be removed. The raw snowfall dataset was collected from the Srinagar metrological department and validated for missing values and NA values. Small outliers and special characters like percentage, brackets, and commas were present in the data but were eliminated. Following the removal of the undesired attribute and renaming of the columns for improved data interpretation, columns were chosen for analysis and data aggregation. Exploratory data analysis followed, which is crucial to understanding the data and moving on to the next phase of the research. The total data that was collected was then split into two datasets namely training data and testing data respectively in the ratio of 80:20. The overall proposed system is depicted in figure 1. LSTM was employed as a classifier in order to implement a deep learning model. To implement LSTM, Keras was used as a platform. For the development of this model Python 3.8.5 was used as it provides a variety of packages and libraries for LSTM. Firstly, for calculations, graph charting, and data manipulation, we imported libraries like NumPy, Matplotlib, and Pandas. Then, the delay for each feature was extended by up to three days. To obtain the best performance, MinMaxScaler from the sklearn metric packages was utilised for feature scaling. In this classification scenario, the three-dimensional input layer is employed for prediction using the Dense function, and stacked LSTM was applied. Inner cells were activated using sigmoidal activation functions, and the dropout value was set to 0.3, which means that 30% of the layers were dropped. Finally, a model's performance was assessed in light of the findings of the experiments.

IV. EXPERIMENTAL RESULTS

It is crucial to include the proper meteorological elements in a snowfall forecast model in order to attain accuracy. Relative humidity, temperature, and latitude were found to be the most crucial variables in predicting snowfall by (Zhang et al.; 2019). As a result, information from the IMD SRINAGAR was gathered in order to perform this research. The dataset consists primarily of 6 meteorological variables, including relative humidity, maximum temperature, minimum temperature, and rainfall. Additionally, it provides readings for the total snowfall. The dataset consists of daily data for 20 years of historical data (2000-2020) from three different stations.

For each of the three stations separately, 20% test data was used to evaluate the LSTM deep learning model. With an accuracy of more than 85%, LSTM foresaw snowfall at all of the stations. The dataset from Srinagar station provided the best prediction results, with the model achieving an accuracy of 94%. This also led to the observation of the highest precision score of 97%, which explains the level of accuracy with which the model projected snowfall. The experimental outcomes of the LSTM model for snowfall prediction are shown in Table 1.

Station	Accuracy	Precision	Recall	F1-Score
Srinagar	94%	97%	53%	0.50
Kupwara	90%	45%	50%	0.47
Pahalgam	87%	80%	64%	0.68

Table 1. Experimental Results of LSTM model

Figure 2, 3 and 4 depicts the above table graphically. Figure 2 shows the metrics for Srinagar station while figure 3 and figure 4 shows metrics for Pahalgam and Kupwara station respectively.

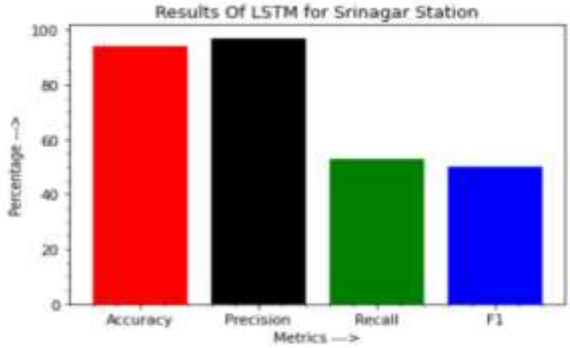

Figure. 2. LSTM results for Srinagar station.

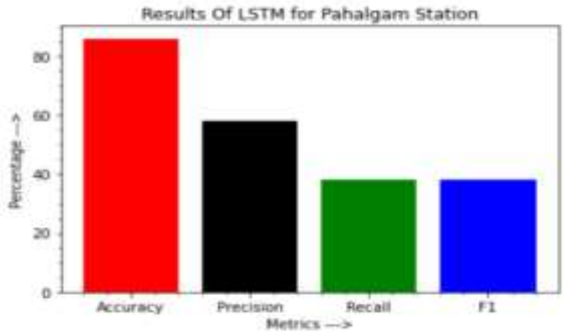

Figure. 3. LSTM results for Pahalgam station.

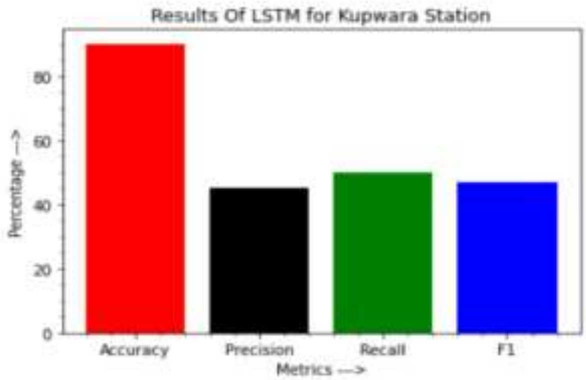

Figure. 4. LSTM results for Kupwara station.

The actual values vs the values predicted by LSTM model is depicted in figure 5, 6 and 7 for Srinagar, Pahalgam and Kupwara station respectively.

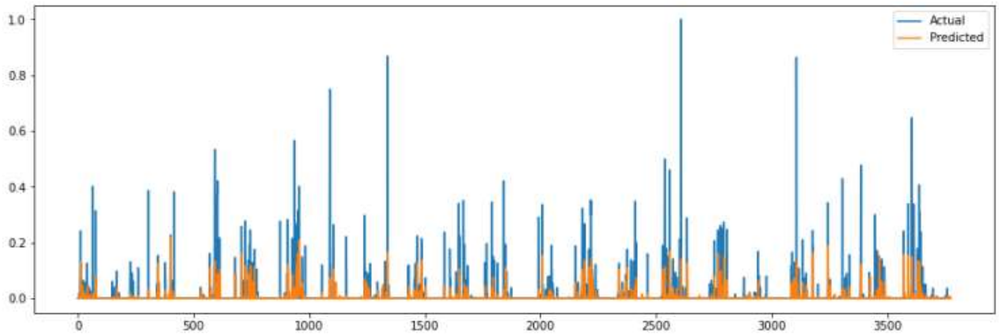

Figure. 5. actual and predicted values for Srinagar station.

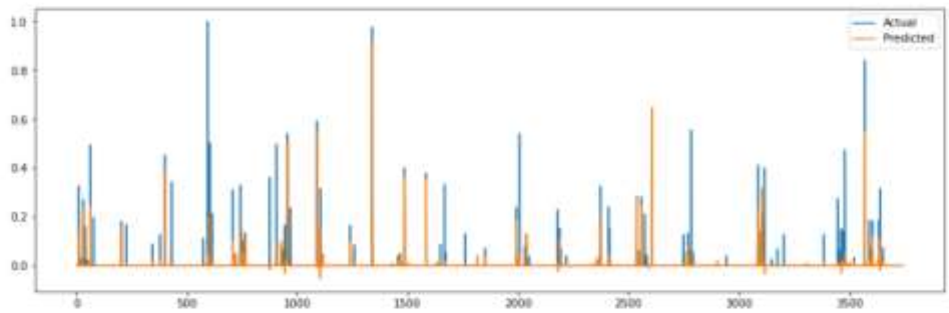

Figure. 6. actual and predicted values for Pahalgam station

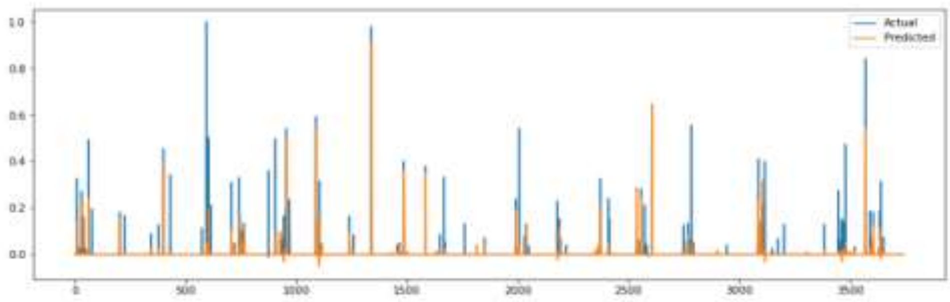

Figure. 4. actual and predicted values for Kupwara station

V. CONCLUSION

For the purpose of predicting snowfall in the Kashmir region for three stations—Srinagar, Kupwara, and Pahalgam—for 20 years of meteorological data, this research analysis proposed the implementation of a deep learning algorithm with long short-term memory. This goal was successfully accomplished by using deep learning technique. The maximum temperature, minimum temperature, rainfall, snowfall, and relative humidity were used to train the model. Additionally, the findings of this study contributed to the body of knowledge in the field of deep learning for snowfall forecasting. The data gathered for this technical report is encouraging. With an accuracy of more than 85%, LSTM foresaw snowfall at all of the stations. The dataset from Srinagar station provided the best prediction results, with the model achieving an accuracy of 94%. This also led to the observation of the highest precision score of 97%, which explains the level of accuracy with which the model projected snowfall. More influencing elements that contribute to an event that results in snowfall can also be taken into account when predicting precipitation.

VI. FUTURE ENHANCEMENTS

Additional causes of a snowfall event may be taken into account in future research for snowfall prediction. Only the winter months' enormous vast data can be used to adequately train a deep learning model. Additionally, the technology that has been successful in one time-series domain may be applied in another. Examples of such advanced time-series models include GRU and Prophet.

REFERENCES

[1] Aftab, S., Ahmad, M., Hameed, N., Bashir, S., Ali, I. and Nawaz, Z. (2018). Rainfall prediction using data mining techniques: A systematic literature review, International Journal of Advanced Computer Science and Applications9.

[2] Geetha, A. and Nasira, G. M. (2014b). Data mining for meteorological applications: Decision trees for modeling rainfall prediction, 2014 IEEE International Conference on

Computational Intelligence and Computing Research, pp. 1–4.

[3] Zaytar, M. A. and El, C. (2016). Sequence to sequence weather forecasting with long short-term memory recurrent neural networks, International Journal of Computer Applications 143: 7–11.

[4] Zhang, X., Li, X., Li, L., Zhang, S. and Qin, Q. (2019). Environmental factorsinfluencing snowfall and snowfall prediction in the tianshan mountains, northwest china,Journal of Arid Land 11: 15–28.

[5] Tang, G., Long, D., Behrangi, A., Wang, C. and Hong, Y. (2018). Exploring deep neural networks to retrieve rain and snow in high latitudes using multisensor and reanalysis data, Water Resources Research 54(10): 8253–8278.

[6] Geetha, A. and Nasira, G. M. (2014a). Data mining for meteorological applications: Decision trees for modeling rainfall prediction, 2014 IEEE International Conference on Computational Intelligence and Computing Research, pp. 1–4.

[7] Mohapatra, S. K., Upadhyay, A. and Gola, C. (2017). Rainfall prediction based on 100 years of meteorological data, 2017 International Conference on Computing and Communication Technologies for Smart Nation (IC3TSN), pp. 162–166.

[8] Roebber, P., R. Butt, M., J. Reinke, S. and J. Grafenauer, T. (2007). Real-time fore- casting of snowfall using a neural network, Weather and Forecasting - WEATHER FORECAST 22.

[9] Chatterjee, S., Datta,B., Sen, S., Dey,N. andC. Debnath, N.(2018). Rainfall prediction using hybrid neural network approach, pp. 67–72.

[10] Parallel Genetic Algorithms: An Exploration of Weather Prediction, through Clustered Computing, Emily Gibson, Jessie Burger, and Deborah Knox, CCSCNE03, Posters Under the Dome, Mar 2003. Presentation to NJ State Legislatures at State Capitol, met with Senator Thomas Kean, Jr. to discuss research at state colleges.