WEATHER PREDICTION USING LSTM

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Abstract

From ages, we are used to check climate every day to prepare our mind and schedule for some daily chores or planning to travel or anything we want to do. This may happen intentionally or unintentionally to check the weather. In the olden days people used to look at the sky and estimate the weather later on started to use instruments to predict the weather in a local place. Then arrived weather forecast in mobile phones. So weather forecast is also being developed and used widely by people every day. Checking everyday weather may help everyone to function their lives without disturbances like heavy rains or cool breezes etc. This is the reason we have chosen this topic to research as it is important for every individual's daily living. In this paper we discussed about types of weather forecasting and different techniques to compute it also our main focus is on the algorithm we chose which is LSTM i.e. Long Short-Term Memory algorithm for an effective computation of weather forecast.

Keywords: *Machine Learning, Long Short-Term Memory, Weather Prediction*

1. Introduction

It is possible to predict the weather by employing technology and scientific understanding to make environmental observations. This process is known as weather forecasting. In other terms, it is a method for anticipating events like cloudiness, rain, snowfall, wind speed, and temperature [3]. Neural networks and artificial neural networks (ANN) are both types of computation techniques. An efficient method for building a computerized system that can process non-linear meteorological conditions inside a particular region and generate forecasts is the use of artificial neural networks [5]. In order to fit an LSTM for a multivariate time series forecast, we employ a weather forecasting model, which is effectively a recurrent neural network using LSTM method [10].

Neural networks are trained using various combinations of meteorological factors, including temperature, humidity, temperature, wind speed, and pressure, in order to anticipate weather conditions utilizing modern technology. The results of the sort of weather by 2 values within a week of training the Inception module using both of these parameters, in addition to the plot on model predictions for the train and test sets and conventional evaluation metrics to assess the model, were presented in this work (good or bad) [8]. It takes into account both the three inputs and what it has learned from

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The facts it has already received before making a judgment. However, RNN have historically been challenging to train.

 Recent, Long-Term, and Short-Term Memory (LSTM) [9].

To accomplish this, weather forecasters employ a wide variety of technologies. We use barometers to monitor air pressure, radar to locate and track clouds, thermometers to measure temperature, and computers to interpret the information these instruments' data provide. A computer program called weather forecasting modeling delivers meteorological data for upcoming times at specified places. Numerical weather prediction, which can be defined as "a system of simplified algorithms used to determine the appropriate atmospheric conditions," is mostly employed in current forecasting models. The process of constructing these equations, determining the boundary conditions, and solving them on incredibly powerful computers is known as numerical modeling [2].

In order to develop a forecast which is based on the present weather, numerical climate model (NWP) takes a significant amount of machine power to solve or compute difficult mathematical equations. In this paper, we investigate cutting-edge deep learning approaches centered on Artificial Neural Networks to introduce Artificial Neural Network which is a compact data-driven weather forecasting model (ANN) [1]. An improved fully convolutional network (RNN) architecture created by humans is used in the deep learning field. The LSTM is built to eliminate long-term dependence and contains feedback links. It can process entire knowledge sequences as well as single data items [4]. For these reasons, we provide a novel Auto ML technology in this study that is based on a cloud platform and is being developed to help scholars in the discipline of artificial intelligence when training models or providing results of metrics for speedy model evaluation [6]. The following supervised learning services are offered by both AWS and Google, and they allow us to train unique models using our own data: Jupiter Notebook, a hosting prototype training and Hyper-parameter optimization service, built-in algorithms to train our models using only data, a model repository and scalable model hosting service for inference, and more [7].

2. Related Study

1.1 Basic Concepts

Machine Learning

Machine Learning is known as a famous technology where it can mimic or enact tasks done by humans, it is a sub category in Artificial Intelligence. These AI that is Artificial Intelligence Systems can be used to perform human tasks which are both and hard. They behave similar to humans.

Long Short – Term Memory

LSTM is a sub category in RNN i.e., Recurrent Neural Networks. In RNN the methodology is like input will be present step, output will be previous step. Separation length is inversely proportional to performance of RNN. LSTM has a feature of auto-save that can be stored for long time. It is employed when forecasting, classifying, and manipulating real - time data.

Weather

The condition of the atmosphere in relation to heat, clouds, moisture, sun, breeze, rainfall, etc. at a specific location and time.

Prediction
To state or make known beforehand. Especially forecast based on experience, observation, or rational scientific justification. The intransitive verb "to forecast".

Weather Prediction
The utilization of data and technology in weather forecasting allows for the prediction of the air quality at a certain area and time. Since the 19th century, climate modeling has been generally completed after being done irregularly for millennia. While numerical methods are used to gather information on the state of the atmosphere, topography, and ocean to produce weather forecasts, barometer is used to forecast how the atmosphere will change at a specific area.

1.2 Purpose of the Study
The purpose of this research is that weather play a vital role in daily chores and travel of an individual. So predicting the weather in advance so that people can prepare themselves mentally and also with necessary things and commodities like food and dressing according to weather and climatic changes.

Not only for individuals but also for someone whose profession is outdoor work or someone who travels frequently or to some people who plans to do some outdoor activity it plays a vital role. Weather details are also useful while someone is planning to shift from one place to another weather their health would support them to live in that weather or not. So using a method or algorithm which makes the job easy that is weather prediction is our motive.

3. Weather Forecast

The process of forecasting the weather involves employing statistical and experimental techniques, together with physics-based principles. In addition to estimations of atmospheric occurrences, weather forecasting also involves the prediction of changes to Earth's surface brought about by weather systems, such as snow and ice blankets, hurricane tides, and rivers. Weather forecasting heavily depends on machine models that take different environmental parameters into account, as opposed compared to earlier manual computations that mainly considered variations in pressure changes, including weather network, and the condition of the heavens or overcast cover.

Choosing the best forecasting model to use as the foundation for the forecast, human input is still necessary. This requires pattern recognition abilities, teleconnections, model performance knowledge, and model bias awareness. Forecasting is inaccurate due to the chaotic nature of the atmosphere, the enormous processing power required to solve the equations describing the environment, ground, and seawater, the sensor inaccuracy related to initial conditions, and a lack of knowledge regarding atmospheric and related industries. Many people regularly check weather forecasts to decide what to dress each day [11]. Forecasts can be used to schedule activities around these conditions as well as to get ready for

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and cope with them since rainstorms, cold, and wind chill significantly restrict outdoor activities.

Weather forecasts are crucial because they protect both property and people's lives. Agricultural forecasts based on the wet and dry seasons are crucial for currency market traders [12]. Utilities utilize temperature forecasts to predict demand for the upcoming days. Let us discuss about some ways in which weather prediction.

Plays a vital role, they are:-

Weather prediction in Travel & Tourism weather prediction in Transportation Weather prediction in Farming

Weather prediction in Planning Weather prediction in Forestry

Dressing according to Weather prediction

Weather prediction in Travel & Tourism

Climate and weather play a significant role in tourist's decision-making and have an impact on how successfully tourism enterprises are run. A location's long- term average of the prevalent conditions is referred to as the climate. In contrast, climate is the result of the climate at a particular location and time. Therefore, even if travelers may anticipate a particular climate when they visit a location, they will actually encounter the weather, which may differ significantly from the expected circumstances. Therefore, weather conditions are likely to have an impact on travelers and tourism enterprises first, even though they may eventually undergo systematic changes as predicted by various climate change scenarios. For instance, it is expected that land and marine temperatures are rising, that rain patterns will alter, making some areas drier and others wetter, and that the frequency of extreme occurrences would rise. Because of this, it will be advantageous for tourist places to comprehend future climate changes in their region and how they can affect their operations.

Weather prediction in Transportation

Although they protect both property and living thing, weather forecasts are very important. Forecasts based on wet and dry seasons are essential for agriculture for speculators in the currency markets. Temperature forecasts are used by utilities to build predictive models for the next days.

Weather forecasts aid in reducing energy consumption, flight times, and delays for air travel, as well as ensuring passenger comfort and safety. The information provided about hazardous weather conditions, such as strong winds, tornadoes, tornadoes, and ice that could threaten an aircraft during departure, arrival, and even during flight is of utmost importance to this industry.

Marine meteorologists create advisory data for ships, which includes details on the location, path, and strength of powerful storms as well as alerts for high winds, mists, and Various dangers, as well as broad prognoses regarding the climate and sea state. As a result, vessels may alter their path to avoid bad weather. As a result, fuel is conserved while also improving ship, cargo, and safety regulation.

The functioning and safety of highways are significantly impacted by weather conditions. They have an impact on risk management and prevention, performance of the vehicle, surface friction, and driver behavior. Weather- related occurrences and the effects they have on roadways can be foreseeable, one-time incidents that have an influence on production, mobility, and safety. This paper demonstrates a multi-model, high-resolution forecast system that is specifically designed for roads and snow conditions transportation issues.

Weather Prediction in Farming

In agriculture activities, the seasons and weather are important factors. The temperature is crucial for the growth of many different fruits, vegetables, and legumes. Thanks to technological advancements and the accessibility of sophisticated weather forecasting systems, farmers may now be able to receive all of their reports on their cellphones. Clear skies are necessary for seeding operations, which must be accompanied by soil moisture storage in the seed zone. Due to crop weather factors, crops and cropping techniques differ between regions during the same season.

Unseasonal temperature changes can have a deleterious influence on plant pathogens and pests, and their consequences are well known. Unseasonably high temperatures may cause plants to produce less and more pests on farms.

Control is required to protect the farms and harvests from flies, parasites, and diseases. In order to prevent crop loss, farmers might utilize weather forecasts to decide when to apply herbicides and insecticides. A multi-sectorial initiative called climate-smart pest management seeks to significantly lower crop losses caused by pests.

Weather Prediction in Planning

Many people have made it a daily ritual since ages to check the weather. From there, decisions about what to wear, how to wear it, as well as other tasks to organize and participate in will be made. The requirement for meteorologists to make comparable studies of environmental conditions in order to create the well-known weather forecasts. Making sound plans is one of the most obvious advantages of weather forecasting. Before travelling or participating in outdoor activities, check the weather forecast online to have a clear idea of what to expect and to prepare.

Weather Prediction in Forestry

For the purpose of putting out and managing wildfires, weather forecasting is essential.

To forecast regions vulnerable to fires brought on by humans or natural causes, a number of indicators, like the Wildfires Climate Forecast as well as the Haines Index, were established. By predicting the path of the weather, it is also possible to predict the growth conditions for insects.

These are some of the areas in which weather forecasting is used effectively.

TYPES OF WEATHER FORECAST
Short-range Long-range Medium range

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Hazardous weather forecasting
Short – range Weather forecast:-

Varied users have different interpretations of the word "short range." We define short range as any horizon that falls within the range of relatively accurate weather forecasts. That may be as soon as the following trading period or as far out as fourteen days. We provide three different tools within this window that work together to help you try and understand whatever market will do in the near future.

Medium – range Weather Forecast:-
A forecast for a time frame that ranges from around three days through seven days ahead of time; the time frame covered by the definition has no strict boundaries. Compare extended forecast and long-range forecast.
During the cold season, medium-range predictions in fast- flow patterns are especially susceptible to inaccuracy. These restrictions on predicting are particularly evident in medium-range forecasting, which typically covers the next three to seven days. Management, operating plan analysis, and sales and production scheduling all require medium- term predictions.

Long – Range Weather Forecast:-
Long-range forecasts offer details on anticipated future atmospheric circulation conditions, averaged across one to three-month time frames. The IFS coupled open sea model generates the long-range forecasts, just like it does for something like the moderate and extended ranges. Long- term forecasts rely on components of Geomorphological variability that are predictable to some extent and have long time spans. The ENSO cycle is the most significant of these. Although the tropical Pacific is the Centre of the coupled ocean-atmosphere phenomenon known as ENSO, its effects can be felt all over the world. The forecast system also includes many more sources of predictability. Every month, long-range forecasts that cover 6 months in the future are made public. Every year, the same system is used to make annual range forecasts.

Hazardous weather forecasting:-
A hazardous weather forecast is a meteorological statement published by the National Weather Report (NWS) that includes information on anticipated severe weather events that could occur over the following seven days. The forecast can mention the likelihood of severe thunderstorms, a lot of rain or flooding, cold weather, or extreme heat.

WEATHER FORECASTING TECHNIQUES
Persistence.
Climatologic forecast
Looking at the sky
Use of barometer

Now casting
Use of forecasting models
Ensemble Forecasting

Persistence
This strategy assumes that the weather will remain as predicted. The persistence approach, for instance, forecasts that it will be bright and 87 temperatures tomorrow if it is warm and 87 degrees today. The persistence approach would forecast two inches of precipitation for tomorrow if 2 inches of rain happened today.

Local forecasters utilize persistence forecasts to estimate the timing of occurrences like the arrival of a rainstorm that is headed their way.
Retention development is not highlighted by projections. This ignores any adjustments to the strength or track of a meteorological storm. Due to these constraints and how quickly wind currents change in most places, persistence forecasts are rendered useless after 12 hours or at most a
day [14].

Climatologic Forecast
Another straightforward method for creating a forecast is the climatology method. In order to forecast using this method, weather data that has been gathered over several years is averaged. The discovery that localized weather on a specific day does not drastically shift with one season over another is the foundation for climatology forecasts. As a result, by using lengthy normal of this same day's or month's weather, it shouldn't be possible to forecast the weather. In this region of the world (Nigeria), the clearest climatology prediction is "Cold in Dec, sunny in July. To make the prediction, one is not required to be a meteorologist.
Climatological statistics are still employed in modern numerical forecasting methods as a "wake-up call." Make sure the simulation tools are not overestimating the climate in any way.

Looking At The Sky
We modern humans are somewhat ignorant of the ability to forecast the weather based on cloud shapes. The majority of us can quickly see a unicorn or frozen yogurt scoop in a cloud, but only a small percentage can do the same for an impending cold front.
Fortunately, it's simpler than one may imagine to forecast the weather. The following details will help you get going. On your next outdoor family outing, it will surely likely amaze, impress, and keep you dry. Four simple categories can be used to classify clouds. High clouds, intermediate clouds, low clouds, and cloud cover with vertical growth are some of these categories.
Along with pressure tendency, one of the more important meteorological factors that may be utilized to anticipate weather in mountainous areas is the condition of the sky.
If the rainfall thickens or even a higher oxygen deck enters, rain is probably going to start falling soon. Morning fog is a sign of good weather since wet conditions are preceded by a

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breeze or cloud cover, which prevents the formation of fog. An approaching cold front may be indicated by a line of thunderstorms. Clear skies indicate pleasant conditions for the near future. The use of plastic background in weather forecasting has led to the development of numerous weather legends over time.

Use of Barometer

Air density, commonly referred to as barometric pressure is measured using a device called a barometer. The atmosphere refers to the outer layer that covers Earth. Everything that comes into contact with that air feels the pressure of gravity pulling it to Earth. Barometers are used to measure this pressure.

Atmospheric pressure is a weather indicator. Variations in the atmosphere, especially modifications in air pressure, have an effect on the weather. Meteorologists utilize barometers to predict rapidly changing weather conditions. A reduced system is approaching if the air pressure is rapidly dropping. Low pressure denotes the absence of sufficient pressure to drive storms or cyclones away. Low- pressure systems are often accompanied by overcast, wet, or windy conditions. The dark and rainy weather is forced out by a sudden rise in atmospheric pressure, clearing the clouds and letting in cold, dry air. In measuring units known as atmospheres or bars, a barometer records atmospheric pressure. A unit of measurement known as an atmosphere is the average atmospheric volume of 15 degrees Celsius at sea level.

Nowcasting

The World Meteorological Society defines nowcasting as weather prediction on quite short to medium-term regional scale period of up to two hours and up to six hours, respectively. This forecast uses methods that account for potential evolution of the air mass to extrapolate known meteorological characteristics across time, including those obtained from remote sensing. As a result, this kind of forecast contains information that can't be resolved by weather prediction (NWP) models that operate over lengthier forecast durations. Now casting techniques quickly combine data from numerous sources using highly automated machines and image processing technologies. To deliver accurate information, trained individuals and/or sophisticated software are needed to interpret the data presented. The importance of nowcasting processes is demonstrated by the rapid forecasting of strong winds and downburst dangers at airports.

Use of Forecasting Models

The complete weather forecast used to be created by human forecasters using the data from available observations. The major portion of human input today is restricted to choosing models according to a variety of criteria, such as the model's shortcomings and efficacy.

Using aggregation members of the various models and a forecast model consensus helps reduce forecast error. No, regardless of how small the proportional deviation goes for any

particular system, however, significant errors within every individual component of direction are still possible on any given model run. The forecast can be improved by humans by including information about local factors that the model might not be able to manage.

Ensemble Forecasting

A technique used in numerical weather forecasting is ensemble forecasting. A collection of predictions is created rather than a singular forecast of the weather that is most likely to occur. The goal of this series of projections is to provide a general idea of the spectrum of potential future atmospheric situations. Monte Carlo analysis is a type of ensemble forecasting. To compensate for the two common sources of error in forecast models, numerous simulations are run. Mistakes brought about through the use of inadequate initial conditions, which are exacerbated by the sheer complexity of the equations governing the evolution of the atmosphere and are repeatedly alluded to as sensitive dependency on initial circumstances, mistakes.

4. Proposed Methodology

Long Short – Term Memory

 LSTM Memory Algorithm is supervised learning and automation using a dcnn usually called Short-Term Storage (LSTM). As opposed to conventional feed forward neural networks, LSTM has feedback connections. Such a recurrent network of neurons (RNN) may analyze whole data sequences in addition to specific data pieces (such as photos) . The application of LSTM includes robotic control, networked, unsegmented handwriting recognition, language processing machine translation, healthcare and computer games. LSTM is the mid-20th century neural network that has been utilized the most. In the naming of the LSTM, "excellent remembrance" and "attention deficits" are analogized to a standard RNN. Similar to how physiological impacts in synapse strengths retain short-term memories, the authenticate mechanisms in the system disturb once per time-step. For each training session, there is a correlation between predispositions and barbells, which works similarly to how synaptic strength-based long-term memory storage is based on metabolic reactions. The LSTM architecture's "extended short-term memory" is designed to provide RNN with a short-term memory that can withstand thousands of time steps.
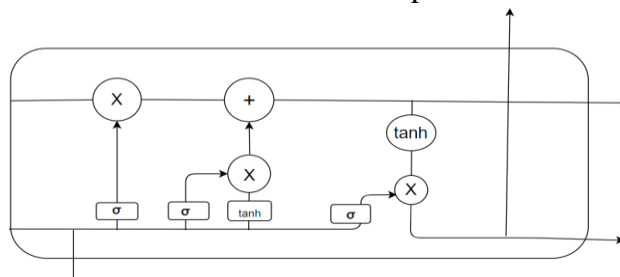

Fig.1. Structure of LSTM

- The LSTM has a value chain.
- Consists of :
  4 Neural Networks
  Memory Blocks

Memory Blocks in LSTM are called "Cells".

LSTM has gates for input, output, and forget. The one values over arbitrary time intervals thanks to the three gates flow of communication both to and from a cell.

Formulation flaws in the model, such as the use of rough mathematical techniques to calculate the equations. The confirmed future atmospheric state should, ideally, be within the projected ensemble spread, and the spread's size should be correlated with forecast uncertainty. This method is generally applicable to probability projections of any stochastic process, not simply weather forecasts [2].

All these are different types of techniques that we studied and researched about weather forecasting.

Knowledge retention and memory remodeling are influenced by both compartments and gates. They are:-

Input Gate:

The input gate adds relevant information to the cell state. In order to control the output using the SoftMax activation function and limit the values that must be remembered in a manner similar to the forget gate, the variables h_{t-1} and x_t are first employed. The tanh function is then used to create a vector with all possible values spanning h_{t-1} and x_t, with an output spanning -1 to +1. The values of the vector and the controllable values are eventually multiplied to obtain the useful information.

Output Gate:

The function of the output gate is to extract relevant information from the prevalent cell state and output it. The cell is initially utilized to construct a vector using the tanh function. The output is then controlled by the sigmoid function after the data is refined more by qualities to be maintained through using input data h_{t-1} and x_t. Finally, the values of the vector and the specified values are multiplied and supplied, respectively, as source and load to the succeeding cell.
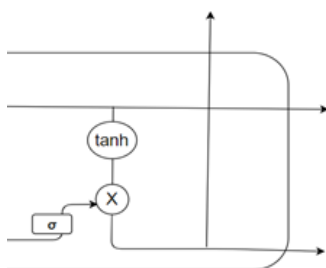

Fig.2. Output Gate structure.

Forget Gate:

Data that is no longer necessary for the cell state is deleted via the forget gate. Prior to bias being applied, the gate's two inputs—x_t (the input at the present time) and h_{t-1} (the output of the prior cell)—are compounded with weight matrices. The outcome is received as the

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activation function's binary output. A material piece is lost if the outcome of a cell state equals 0, but is saved to be utilized in the future if it equals 1.
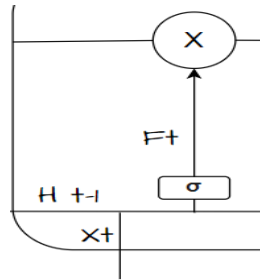

Fig. 3. Forget Gate

LSTM has certain well-known implementations, such as:

    Sentiment analysis

    Automatic Translation Generation of handwriting Video evaluation

  Ask-and-Answer chat bots.
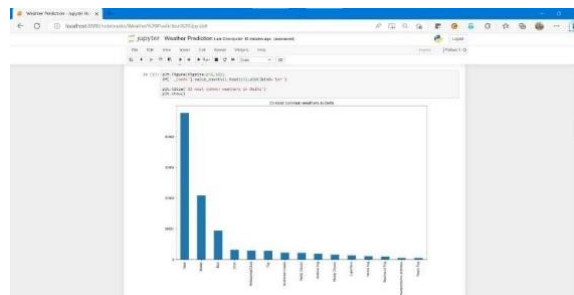
5. Computation

Analysis of the weather data.
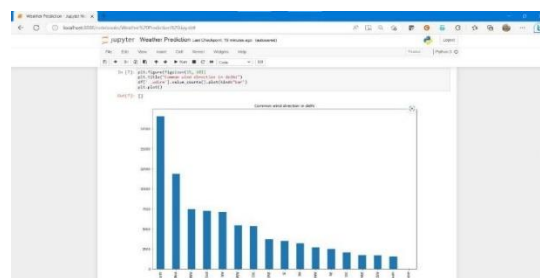

Fig.4.1. Plotting a weather data graph.

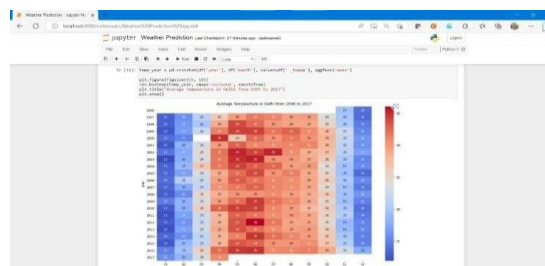**Fig.4.2. Common wind in directions in Delhi.**

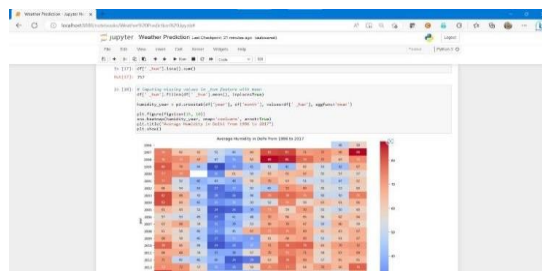**Fig.4.3. Average Temperature in Delhi from 1996 to 2017**

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Fig.4.4. Average Humidity in Delhi from 1996 to 2017.

The analysis of weather data will start by computing the dataset by importing the files needed and reading the dataset file and then plotting a weather data graph that gives a quick analysis of the weather in Delhi. Another graph shows the common wind direction in Delhi where north and west are the most common wind directions in Delhi. The average temperature and humidity in Delhi from 1996 to 2017 will be plotted accordingly.

6. Conclusion

From the research work, we have got to know that even though Weather prediction is being done from age's. Some of the old methodologies are quite slow and time taking and also may cost too much. So doing this thing of predicting in less cost is important. Using of LSTM algorithm for this purpose of weather prediction is most effective and flexible way. Also this algorithm is simple and easy to use. Also costs less. Hence, we conclude that LSTM is the most effective solution.

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