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Predicting Polarity of Tourists Reviews using LSTM Deep Learning Model over Machine Learning Classical Approach to increase the accuracy in Text Classification

[1]Ms. Harsh Arora, Dr. Mamta Bansal[2]

[1]Ph.D Scholar, Shobhit Institute of Engineering & Technology Technology (Deemed-to-be-University), Meerut, India.
[2]Professor, Shobhit Institute of Engineering & Technology Technology (Deemed-to-be-University), Meerut, India.

Abstract

The objective of sentiment analysis is to find positive and negative reviews. Hotel reviews have been analyzed in this research paper using machine learning algorithms and these are compared with most efficient deep learning method based on LSTM. The idea is to use the concept of text classification in the form of customer reviews. Although there are many machine learning techniques available for text classification but here two most important methods of machine learning have been used which are Naïve Bayes algorithm and another is Random Forest algorithm. These techniques are further compared with LSTM based deep learning technique. The goal is to develop a deep learning model that uses the LSTM technique to work on hotel reviews in the context of online tourism and outperforms earlier machine learning techniques. This methodology will aid the tourism industry in growing its business by studying consumer hotel reviews. Sentiment analysis is widely used in business domains to improve products and services by understanding customer opinions about these services and this is the case with hotel reviews analysis using LSTM to obtain efficient and clear results that will undoubtedly help the tourism industry in better understanding the customer opinions so that in the future, the tourism industry can deliver better services to customers.

Keywords: Machine learning, Deep Learning, Hotel Reviews, Online Tourism, LSTM

Introduction

The majority of people in the e-commerce industry use internet resources to obtain items and services provided by various companies or business groups. People utilize the internet to share their thoughts, opinions and experiences by leaving reviews on the items and services they have used. These are sentiments and analyzing them is the major goal of this study, which employs the notion of sentiment analysis of hotel reviews using machine learning and deep learning techniques. These methods will greatly aid in understanding the significance of customer opinions and reviews, which we shall refer to as tourist reviews in the context of hotels and hence as hotel reviews.

Both machine learning and deep learning methods have been examined in the context of sentiment analysis of hotel reviews in this research study. Machine learning is the field in which computers learn without being explicitly programmed, whereas deep learning is based on neural networks and use the LSTM principle. In the context of sentiment analysis, the accuracy and efficiency of several algorithms will be compared. This will lead to the conclusion that deep learning approaches are significantly more effective and efficient than the traditional machine learning methodology for evaluating customer feedback. This characteristic will aid the tourism sector in determining what travelers expect from tourism services, packages, and other products.

When we talk about online access to goods and services, we get a sense of how fierce the competition is these days among various businesses to run their operations online. The tourist sector is a large part of the e-commerce industry, where we see millions of people voice their thoughts or evaluations about the services and goods they use, such as in the case of tourism in this paper, customer hotel services. These views are communicated on social media platforms, in blogs, and on individual websites. Customers are therefore easily influenced by online feedback in the form of concerned company, organization, or industry reviews, on the basis of which they decide whether or not to use these services in the future. There are three types of sentiment analysis models: lexicon-based, machine learning-based, and deep learning-based. Lexicon-based models count the number of sentimental lexicons of each class used in the document to estimate its sentiment. If a document has more positive sentiment lexicons than negative ones, it is classified as positive.

As a result, a sentence lexicon dictionary must be developed prior to classification. Labeled documents are used to train machine-learning models. A label can be a conventional value, such as a rating, or a binary integer (positive or negative). The approaches utilized, label validity, and the volume of labeled documents all influence the model's performance.

For sentiment analysis, the methods Naive Bayes and Support Vector Machine (SVM) are utilized. In recent studies, deep-learning-based sentiment classification algorithms, notably those based on convolution neural networks (CNNs) or recurrent neural networks (RNNs), have outperformed traditional lexicon-based or other machine-learning-based sentiment classification models. Despite the good outcomes of deep-learning-based sentiment classification models, there is no one-size-fits-all structure for diverse domains and datasets, making it difficult for practitioners to choose the correct deep-learning structure for their datasets.

In recent years, a number of studies have presented deep-learning-based sentiment assessments, each with its unique set of features and performance. This study looks at how deep learning models like deep neural networks (DNN), recurrent neural networks (RNN), and convolutional neural networks (CNN) have been used in recent research to solve various sentiment analysis problems (e.g., sentiment polarity and aspect-based sentiment). Deep learning outperforms traditional machine learning algorithms like Navie Bayesian, Random Forest, and SVM in terms of efficiency and accuracy.

Hence, in this paper deep learning and machine learning algorithms have been discussed and analyzed by using hotel reviews dataset to compare the results to show how deep learning model is efficient though complicated rather than machine learning models which are comparatively less efficient though simple to implement [1]. The deep learning model is based on the LSTM principle and all deep learning models such as CNN, RNN, LSTM, and Bidirectional LSTM are explored. Deep learning is a neural network-based model with numerous layers that analyses data as thoroughly as possible. Hence deep neural networks with high precision solve complex binary questions, makes decisions or return numerical responses [2].

With the deep learning LSTM model, the difficult data available in bulk can be resolved, filtered, and evaluated with great clarity. The existing gaps and limitations of not understanding the thoughts of

tourists in terms of ease of accessing services can be bridged with the application of deep learning, which produces highly accurate and efficient results. Customer satisfaction is important in any e-commerce company, and it is also important in the tourism industry. The current tourism industry can be improved if it becomes completely possible to understand millions of reviews and know exactly what customers want using better machine learning methods such as deep learning models and in the case of hotel reviews analysis, if it becomes completely possible to understand millions of reviews and know exactly what customers want. Based on client reviews, the LSTM deep learning technique has been deployed, which is capable of handling the existing gaps and challenges in the tourism business.

Polarity Analysis of Hotel Reviews

Sentiment Analysis is concerned with the management of opinion, sentiment, and subjective type text [3].Sentiments analysis is the study of customer or user emotions or ratings in order to determine whether a product, service, post, document, or other item elicits favorable, neutral, or negative reactions. It considers not only the polarity, but also the intensity of feeling towards a specific service or product. Sentiment classification is widely utilized in a variety of markets. By recognizing user impressions of a product, we can improve it.

Sentiments can be expressed in a number of different ways. Feelings, judgments, vision or insight, or customer's points of view can all be used to portray it. Sentiment analysis can be done in a variety of methods. The level of sentiment analysis is determined by the amount of time available to devote to it and its worth to an ongoing project. Second, the review is at the phrase level. A sentence always has a subject and an object.

After that, the subjective component of the statements is assessed as negative, positive or neutral. Another level is the function level, which considers words and phrases and is the highest standard. With an emotion, it takes a word and determines its meaning. After that, the word is classified as negative, positive, or neutral. As a result, the most deceptive comments can be deleted.

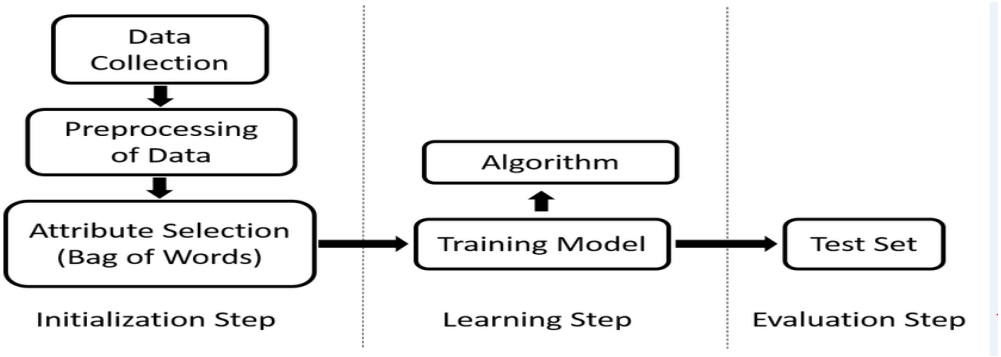

Fig 1: Sentiment Analysis

Polarity analysis is the process of capturing the emotional underpinnings of a text. Client perceptions of a product or service are detected, extracted, and analyzed using natural language processing (NLP) and machine learning. As a result, this type of analysis is also known as opinion mining

or emotional AI. The goal of opinion mining is to determine the polarity of a text, or whether it is positive, negative, or neutral. "We stayed here for five days," for example, is neutral, "I enjoyed staying here" is positive, and "I did not like hotel" is negative. In the above figure 1of sentiment analysis, the process has been depicted where at initial step data is collected that leads to preprocessing of data and data goes under cleaning process. Before we apply any machine learning or deep learning algorithm, data cleaning is required so that machine can be trained easily and further data set has to go through two phases where one comes under training that is learning step and the final where the machine is tested for testing data set called evaluation step.

Sentiment analysis can help with a range of real-world business problems, such as: a. predicting customer behavior for a certain product.

- It can be used to assess a product's adaptability.
- Automates the process of developing customer preference reports.
- It has the potential to quickly automate the process of evaluating a film's performance by analyzing the thoughts conveyed in the film's reviews across many platforms. Every industry today uses sentiment analysis to assess its reputation in the online market. The hospitality industry is following suit with sentiment analysis of hotel reviews.

Sentiments encompass a wide range of highlighted values, such as bi-grams and trigrams, as well as polarities and combinations. Sentiment is assessed from both negative and positive perspective, using various SVMs (support vector machines) and training algorithms. In sentiment analysis, neural networks are used to quantify label belongingness. To aid data extraction at the context level, the conditional dependency between many nodes and edges of an acyclic graph run by a Bayesian network is used.

By optimizing sentences and words, data accuracy and learning could be obtained on a social media network. To generate positive and negative aspects of data, data tokenization is performed at the word root level. Techniques and procedures are utilized to reduce sentiment analysis errors and achieve a higher level of accuracy in social media data [4].

Polarity Analysis Procedure

a. Information Gathering

Data gathering is the initial step in the sentiment analysis process. Data can be gathered from a variety of places,vincluding any website and a variety of online opinion sets and ratings.

b Preprocessing

It is the data cleansing process. Words and symbols that aren't essential are omitted. This is essential in order to streamline subsequent processing. Eliminating hyperlinks, repeated words, emoticons, and special characters is a part of this effort. It also conducts stemming and lemmatization. Finally, it reduces the number of features available and sends them to the classifiers.

C. Classifications

A classifier is the most important component of a sentiment analysis system. Negatives, positives, and neutrals are used to classify the data. Typically, a third of the database is used as training sets for classifiers. The training collection is responsible for a major part of the classifier's precision. The classification can be done using machine learning classifiers such as SVM, Bayesian classifiers, maximum entropy classifiers, and so on.

Machine learning classifiers, on the other hand, do feature extraction before training and testing the classifier, and they can also use deep neural networks to classify the data. These classifications can also be carried out using a deep learning method. Different types of depth methods exist in the context of neural networks, such as Convolutional Neural Networks (CNN), Probabilistic Neural Networks (PNN), Recurrent Neural Networks (RNN), and other neural networks can be used.

d. Display the outcomes

The output is displayed once the data has been processed by the classifier. It depicts the polarity of feelings across the entire dataset, with the level of detail varying depending on the type of classifiers employed.

Machine Learning Approach for Sentiment Analysis

Machine learning is being used to give computers the ability to learn without the need for programming. It comprises statistical and predictive analysis so that the computer can recognize a range of patterns and use that knowledge to derive hidden insights from the data presented. This is accomplished by researching how to incorporate the most recent trend into a fresh design. Unsupervised machine learning algorithms, on the other hand, are generally utilized to group numerous specialized data categories and are used in a number of industries that require data separation [5]. It is impossible to overestimate the relevance of classification in sentiment analysis. A pre-classified sample of the database called a training dataset is utilized in the classifications stage of attitudes analysis to train and create a classifier using machine learning techniques [6]. After learning the pattern, this classifier can categorize the previously unlabeled data. The data utilised for training, on the other hand, often determines the precision of a classifier. As a result, it's clear that supervised machine learning algorithms are preferable for sentiment analysis.

a. Naive Bayes

It is a technique based on the Bayes Theorem's option of prediction independence. The model is also known as the generatic learning model. To put it another way, this classification technique assumes that a characteristic in a class is unrelated to any other feature in the class. Even if all of the traits are interdependent, these attributes contribute to the posterior probability on their own. A name-based classifier is particularly useful for large data sets and is quite simple to construct. As a result, it is used to surpass even the most complex categorization methods. We utilize Bayes Theorem to calculate the likelihood of hypothesis h being true given our previous knowledge d:

P(h/d)=(P(d/h).P(h)/P(d))where
P(h/d)=posterior probability

P(d/h)=likelihood the probability of data D given that the hypothesis is h was true.

P(h)=class prior probability

P(d)=predict or prior probability

b. Random Forest

As the name implies, a random forest is made up of a huge number of individual decision trees that work together as an ensemble. Each tree in the random forest produces a class prediction, and the class with the most votes becomes the prediction of our model.

Random forest is a learning algorithm that is supervised. It creates a "forest" out of an ensemble of decision trees, which are commonly trained using the "bagging" method. The bagging method's basic premise is that combining several learning models improves the overall output.

Random forest is a technique that can be used for both classification and regression. This algorithm works by manipulating decision tree samples and obtaining the output from each tree, as well as the optimal solution, by majority voting. While building a tree during training and generating a class based on the individual tree's predictions. It is superior than a single decision tree because it eliminates the tendency to over fit their training set.

While growing the trees, the random forest adds more randomness to the model. When splitting a node, it looks for the best feature from a random subset of features rather than the most essential feature. As a result, there is a lot of variety, which leads to a better model. As a result, in random forest, the technique for splitting a node only considers a random subset of the features. Instead of searching for the greatest possible thresholds, we may make trees even more random by employing random thresholds for each feature (like a normal decision tree does).

Deep Learning Techniques for Polarity Analysis

Deep learning is a sort of machine learning that is a subset of artificial intelligence. It functions similarly to human brains and some sorts of knowledge. It's an important aspect of data science, together with statistics and predictive modeling. Deep learning techniques are now most effective on large amounts of data collected from numerous websites in order to analyze tourist feedback. Deep learning can be thought of as a means to automate predictive analytics in basic words [7]. Deep learning algorithms are arranged in a hierarchy of high to low complexity and abstraction.

a. Convolution Neural Networks (CNN)

Convolutional Neural Network is a Deep Learning system that can take an input image, assign relevance (learnable weights and biases) to various objects in the image, and distinguish between them. When it is compared to other classification methods, the amount of pre-processing

required by a CNN is significantly less. While basic approaches require hand-engineering of filters, CNN can learn these characteristics with enough training.

The capacity of convolutional neural networks to learn a large number of filters in parallel particular to a training dataset under the restrictions of a certain predictive modeling problem, such as image classification is its unique feature. As a result, extremely precise traits appear on input photographs that can be identified everywhere.

CNN is one of the most fundamental types of neural networks. This is an upgraded version of a traditional neural network, in which each layer has a neuron that corresponds to a neuron in the following layer, and so on. The input layer neurons and the local connections between them to the output are measured using CNN.

CNN then applies filters and, based on the task at hand, learns the filter scale on its own, in this case, the classification of phrases using the filters. CNN is based on a hierarchical paradigm that functions similarly to a funnel. It begins with the creation of a network, which eventually leads to the creation of a fully linked layer, which contains all of the interconnected neurons and is where the output is processed. CNN is commonly used for image identification and classification, computer vision, and picture characteristics or patterns because of its high accuracy [8]. Dynamic CNNs are increasingly utilized to improve the efficiency of traditional CNNs.

b. Recurrent Neural Network (RNN)

RNNs (recurrent neural networks) are deep learning neural networks that are mostly used for textual data classification and are designed to learn data sequences. RNNs, on the other hand, confront the vanishing gradient problem when dealing with large data sequences. The use of LSTM neural networks as a solution to this problem has been demonstrated in a range of real-world applications, including speech recognition, picture captioning, and music composition. Extracting a feeling, on the other hand, is highly dependent on the context of the review [9].

Due to their limited ability to evaluate contextual information, direct feed forward neural networks perform poorly in the ASA task. As a result, the sentiment analysis method employed in this research is a Bidirectional LSTM Network (Bi-LSTM), which is capable of extracting contextual information from feature sequences while dealing with both forward and backward dependencies. Furthermore, our Bi-LSTM allows us to look forward by deploying a forward LSTM that processes the sequence in chronological order and a backward LSTM that processes the sequence in reverse order.

As a result, the output is the concatenation of the forward and backward LSTM states. A Recurrent Neural Network is based on the principle of saving the output of a specific layer and feeding it back to the input in order to predict the layer's output. A recurring neural network is generated by applying the same or familiar set of weights within an environment, and the nodes form a directed graph along a chain. The Hidden state, which remembers certain information over a few sequences, is the most important element of RNN.

The nodes are included in the opinions. This neural system has the advantage of being able to process the sequence of nodes using its internal state store [10].In figure 2 mentioned below, RNN steps have been shown in the form of input layer, hidden layer and output layer. For sentiment analysis, the RNN uses the bottom-top method, which means that after using a composition function and a classifier, the super ordinate vectors and knot vectors' features are determined each time knot vectors are employed.

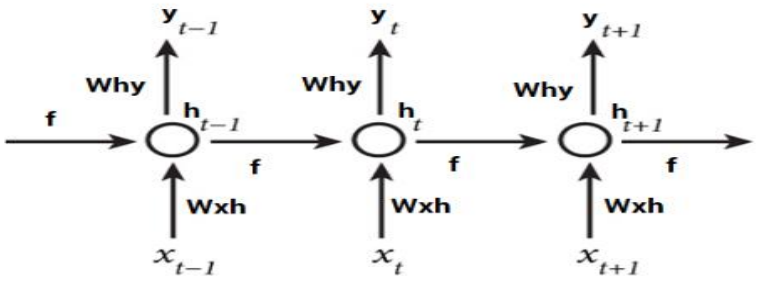

Fig 2: Recurrent Neural Network (RNN)

c. LSTM (Long Short Term Memory): Improvement of RNN

Long Short-Term Memory is a neural network that appears to be quite recurrent. The previous step's output is used as input in the current RNN stage. Its 'internal states memory' is superior at processing sequences. It has the potential to save a state throughout time. By default, LSTM can store knowledge for a lengthy period of time.

It is used to process, predict, and classify time series data according on the concept. This method avoids the disadvantages of recurring neural networks, such as the absence or reduction of the gradient vector over time. The middle layer in LSTM is a hidden doorway. For productive long-term learning, the forgotten gate is utilized to choose which facts should be saved and which should be forgotten. The output layer displays the effect created by the middle layer, which collects data from the input layer.

As we can see from below mentioned figure 3 of LSTM that an LSTM layer is made up of memory blocks, which are recurrently connected blocks. These blocks can be thought of as a differentiable version of a digital computer's memory chips. There are one or more recurrently connected memory cells in each one, as well as three multiplicative units (input, output, and forget gates) that provide continuous analogues of write, read, and reset operations for the cells. As we can see in this figure that there are three gates input gate i_t, forget gate f_i and output gate o_t. Input is shown in form of x_t and output will be o_t.

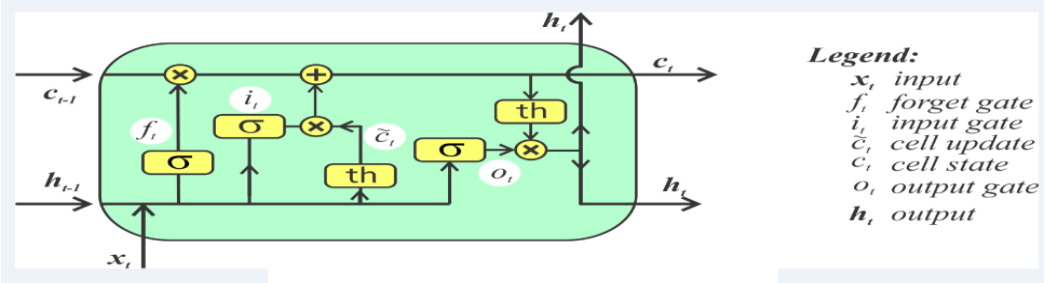

Fig 3: Long Short Term Memory (LSTM)

d. Bidirectional LSTM

Bidirectional LSTMs are a variation on standard LSTMs that improves the model's performance on sequence classification issues [11]. Bi-LSTMs train two LSTMs on the input sequence instead of one LSTM when all time steps of the input sequence are accessible. There are two types of connections: one that travels forward in time and helps us learn from previous representations, and the other that travels backwards in time and helps us learn from future representations [12].

The first is based on the original input sequence, while the second is based on a reversed replica of the original input sequence. This adds more context to the network, resulting in faster outcomes. All available input information in the past and future of a certain time frame can be used to train bidirectional Long Short-Term Memory networks (BLSTM).The following figure 4 is depicting 2 LSTM together hence it is called bidirectional LSTM where one is in the form of forward layer and another is as backward layer. Forward layer learns from previous data or results and backward learns from future results or data.

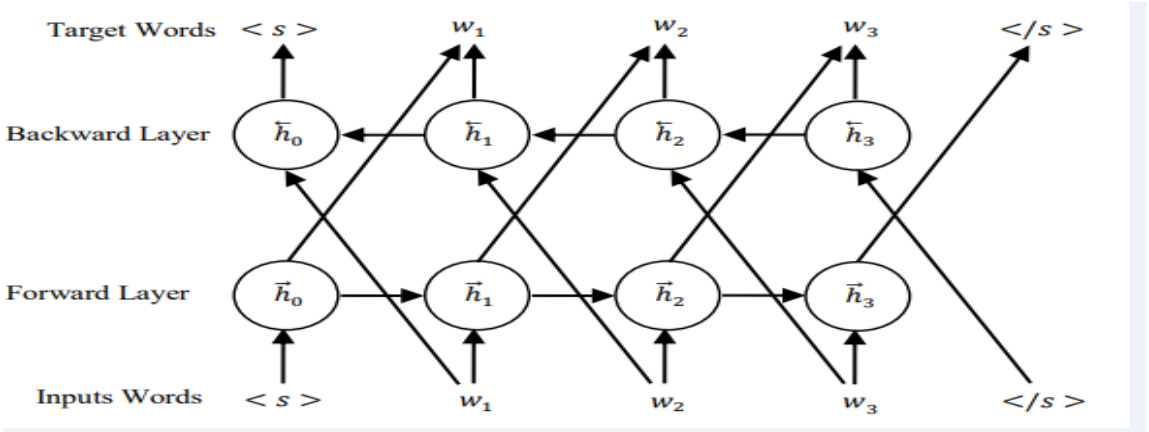

Fig 4: Bi directional LSTM

Lstm And Bi-Lstm Deep Learning Techniques Over Naïve Bayes and Random Forest Machine Learning Techniques

The tourist business must rely on public demand to survive. It's a company that prioritizes its consumers' wishes before their needs. As a result, competitors in this field employ methods and machines to ensure that their consumers receive better service at a lesser cost. Machine learning and deep learning can help with some of these strategies. This challenge can be completed using deep learning.

A computer can easily uncover the relationship between components that cause this seasonal demand by analyzing raw data from the past and precisely estimating the future trend. Hotels strive to provide services at the lowest feasible cost while keeping a profit margin in order to attract as many customers as possible. Machine Learning can aid in this situation. The data can be examined using predictive models based on seasonality, hotel history, local events, local competition, 3rd party promotions, and external real-time events, and then used to produce the best possible pricing for any service and give businesses a competitive advantage. Deep Learning and Machine Learning are paving the way for innovation in all industries. They are being researched and implemented in new fields every day [13]. It's a promising field with a lot of untapped potential and the ability to change the face of the industry.

The demand for sentiment analysis has increased as a result of the requirement to analyze and organize hidden information gathered from social media in the form of unstructured data. Sentiment analysis is implemented using deep learning techniques. Deep learning is made up of a number of well-known and effective models that are used to a variety of problems.

Various studies are covered in this paper in order to provide a full knowledge of how deep learning applications in the field of sentiment analysis have grown to be so successful [14]. Because of the high accuracy of both sentiment analysis and deep learning, many problems have been solved.

Deep learning is booming right now for three reasons: improved chip processing capabilities, much lower hardware costs, and considerable improvements in machine learning algorithms [15].

S.No	LSTM	Naïve Bayes	Random Forest
1	LSTM models are better for text classification because they can capture long-term dependencies between word sequences.	It doesn't necessitate as much data for training. It is capable of dealing with both continuous and discrete data. It can handle a large number of predictors and data points. It is quick and can be used to make predictions in real time.	Both classification and regression tasks are suitable for the Random Forest algorithm. Cross validation ensures a higher level of accuracy. The random forest classifier can deal with missing values and keep a large percentage of data accurate.
2	It is used to solve the vanishing gradient problem and to learn over time.	A variable is distinct from the others.	Random forests are made up of a collection of several decision trees.
3	LSTMs are specifically developed to prevent the problem of long-term dependency. It is not something people struggle to learn, but it is basically their natural nature to remember knowledge for lengthy periods of time.	It can work with a minimal level of training.	By building trees on random subsets, it prevents overfitting.
4	The LSTM cell keeps track of its own state, which can be read and written.	This algorithm does not support categorical al features.	It's impossible to comprehend.
5	Given time lags of uncertain duration, LSTM is well-suited to identify, analyse, and predict time series. LSTM has an advantage over alternative RNNs, hidden Markov models, and other sequence learning approaches due to its relative insensitivity to gap length.	The Naive Bayes classifier is built on prior knowledge of possible event situations. The Bayes Theorem underpins it. There is a high level of independence between the assumed attributes. It calculates ratios between events using categorial data.	Random forest models perform well on huge datasets because all computations can be separated and the model can be executed in parallel. It can handle tens of thousands of input variables without deleting any of them.

Table I: Comparison of LSTM with Naïve Bayes and Random Forest Algorithms

Results and Discussion

For determining the thoughts or sentiments expressed in a text, sentiment analysis is a popular method in Natural Language Processing. As part of customer reviews, customers can use social media to express their opinions on products or services. Dissecting this evaluation has become a vital component of firm analysis because internet business is growing at an exponential rate in today's techno-friendly competitive industry. A large number of algorithms have been discovered in recent studies. One of the most important strategies is deep learning. One of the most important strategies is deep learning. One of the most important strategies is deep learning. The hotel review data was trained in the indicated technique using long short-term memory (LSTM) and bidirectional LSTM, with an accuracy rate of 84% and 85%, respectively, for recognizing customer opinion. The dataset is also investigated for hotel reviews using the Nave Bayes and Random Forest machine learning methods. Naive Bayes has 76% accuracy, while Random Forest has 81% accuracy.

Deep learning is used to improve company performance, as well as to collect consumer feedback and predict consumer opinion. In Naive Bayes, we don't see much of an impact from imbalance datasets, but we do in deep learning models. Use the LSTM impact by imbalance data set to offset the influence of an imbalanced dataset. Our model was less affected by the unbalanced data set when I used the Dropout rate in the LSTM model. We can apply hyper parameter optimization to increase performance.

The LSTM-based deep learning method outperforms and outperforms the Nave Bayes and Random Forest machine learning algorithms in terms of accuracy. For assessing the polarity of visitor opinions indicated in comments or online reviews, this is the most effective deep learning neural network methodology. LSTM based deep learning proposed model has been shown below in the figure 5.As we can see that LSTM layers have been used along with multiple hidden layers that help to retain data for longer period of time in order to provide efficient results with better clarity.

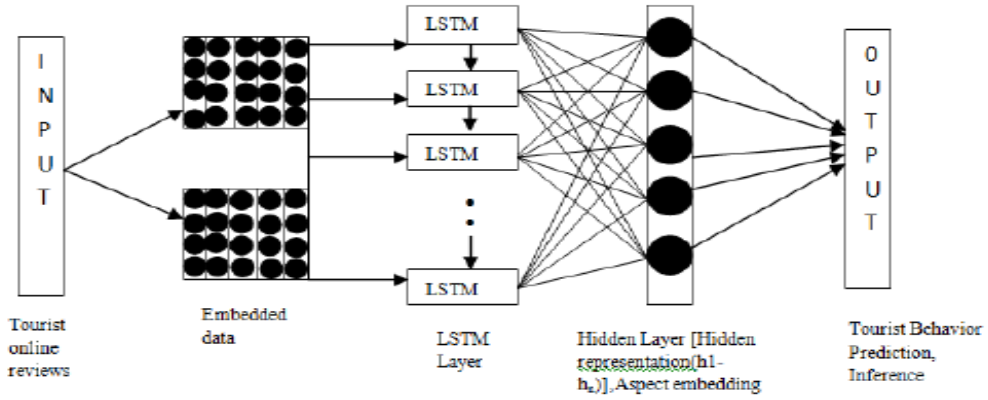

Fig 5: Proposed LSTM Deep Learning Model for Hotel Reviews Analysis

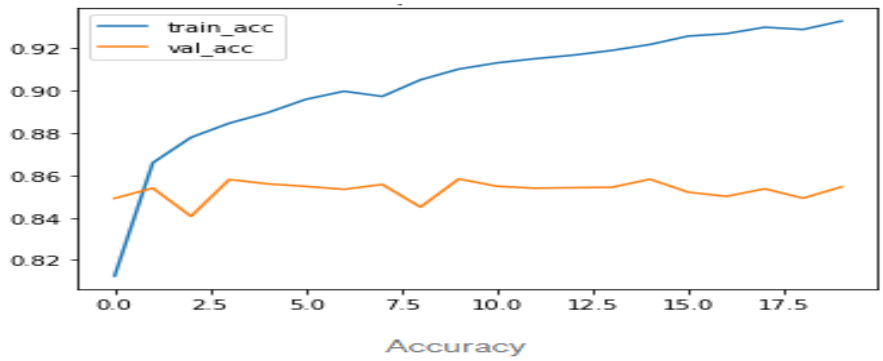

Fig 6: LSTM Model Accuracy Graph

Conclusion and Future Work

In this research, the deep learning algorithms LSTM and Bidirectional LSTM are presented for use on hotel review data. This paper describes the proposed framework for sentiment categorization for hotel reviews, as well as the methodology for doing so, in order to identify positive and negative reviews. Furthermore, traditional and neural network techniques have been contrasted to see which the best future technique is. If tourist opinions are clearer, the strategy will be more effective.

Previous work based on traditional algorithms such as Nave Bayes and Random Forest will outperform the proposed techniques. This study looked at the limitations of existing classical machine learning approaches and better deep learning methodologies were offered to deliver much higher performance accuracy. It has been shown that by combining the LSTM deep learning technology with historical tourism data, LSTM layers of deep learning may produce superior results with greater accuracy. This model's high accuracy and efficiency will undoubtedly aid the hotel or tourism industry in precisely understanding the demands and expectations of tourists, which will benefit both customers and tourism businesses.

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