



Enhancing the Performance Measure of Sentiment Analysis Through Deep Learning Approach

Rajit Nair¹, Vaibhav Jain² and Preeti Sharma Nair³

¹ Assistant Professor, Vellore Institute of Technology, Bhopal, India

² Senior Faculty, In nurture Education Solutions, Bangalore, India

³ Department of Electronics & Communication, Bansal College of Engineering, Mandideep, India

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Abstract: Sentiment analysis is the computational process through which one can categorize the opinions expressed in a form of text, specifically analysis is done to predict the user's perception towards any product, movie, or any particular topic. The prediction can be negative, positive or neutral, even this can categorize to the number of class labels, it depends on the classification task. Already there are many classifiers based on machine learning and they have shown a significant result in this area, but recent years have shown a trend in deep learning due to their high performance. So this paper has also applied deep learning algorithms during the sentiment analysis. The proposed work will show how deep learning-based methods will improve the classification accuracy over machine learning algorithms. The proposed methods are evaluated on the basis of certain datasets like movie reviews, hotel reviews, and political reviews of India. In the initial phase machine learning classifiers like Naïve Bayes, Support Vector Machine, Random Forest, and logistic regression were applied later on deep learning algorithms has been implemented. With the primary focus on deep learning methods, the main contributions of numerous researchers are emphasized. The performance of the algorithm will be evaluated by the parameters like accuracy, precision, recall, and F1 score. The novelty of this work is that other than the combination of RNN and LSTM, we have implemented Deep Chrome Convolutional Neural Network for sentiment analysis and it has achieved the accuracy of 92.76% and 90.76% for a movie review and hotel review dataset respectively that is much higher than other states of the art algorithms. The analysis of sentiments will be more accurate by implementing this proposed work.

Keywords: Convolutional Neural Network, LSTM, Deep belief networks, pooling, dropout

1. INTRODUCTION

The motivation behind this work is that today there are millions of online users are there all around the universe and it is observed that content generated by the online users on the web is increasing rapidly. This content can be of any form like images, video, or any type of textual data. Still, most of the users are using text for expressing their opinions towards any products, movies or any type of services, that's why a huge amount of data is generated in the form of textual reviews and it is very important that we must analyze and predict the reviews otherwise storing this type of data will become useless.

Analyzing and predicting the huge amount of reviews become very difficult by simple algorithms, this problem leads to the occurrence of a machine learning algorithm [1]. Machine learning algorithms are implemented for analyzing and predicting the sentiments

and they have shown significant improvement with high accuracy of analyzing and predicting the data [2]. But now machine learning performance also gets degraded due to large dimensional and huge volumes of data. In this case, if we want to apply a machine learning algorithm then dimensionality reduction becomes very important, dimensionality reduction can be done in the form of feature selection or feature extraction and it depends on the nature of data. Preprocessing steps like feature selection or feature extraction took some time before actual classification, this becomes a time-consuming process.

To overcome these time-consuming problems, there is a development of other algorithms in the area of machine learning which is termed separately as Deep learning. It's a branch of Artificial Intelligence and Machine Learning, which has contributed to new approaches for problem-solving in a variety of fields including computer science, data processing, and biomedical engineering. Deep



learning algorithms are based on artificial neural network models to cascade several nonlinear processing layers, Deep learning transforms data into a cascade of layers, allowing systems to analyze and process complex data sets. Deep learning algorithms extract complex high-level data and process these complex sets to relatively simpler ideas developed in the preceding hierarchical level [3].

Sentiment analysis is a way through which we can analyze the attitude of one's towards anything, it reflects it's likes and dislikes. Artificial intelligence helps us to predict this system efficiently [4], this is the reason deep learning has shown improvised results than traditional machine learning algorithms [5]. There are several areas like the film industry, online shopping market, politics, and many more which get benefited from sentiment analysis. To perform sentiment analysis there are two basic approaches, in the former approach dataset is split into two parts one is a training set and the other one is the testing set, and the classification is done on these sets. The second approach does not require any prior training set, it just performs the classification by identifying a list of words and phrases with their semantic values, It mainly focuses on the unseen data. Some researches work in a hybrid way means a combination of the above two approaches to improve the performance of the classifiers. Deep learning has done significant work in the area of data science [6], the main reasons behind it are chip processing ability [7], the lower expenditure of hardware and enhancement in the machine learning algorithm.

Deep learning architecture consists of many levels of non-linear operations and its capability of modeling artificial intelligence makes it possible to perform in the semi supervise networks. It can achieve better results in the area of Natural Language processing [8], speech recognition [9], and computer vision [10] by its advanced software engineering [11], computing power, training data and enhanced learning procedures. It is inspired by neurons and work in the form of multiple layers. Classifying the sentiments based on words in a text is not an easy task, many times it happens classifiers generate the wrong prediction also and this can lead us to a very disastrous situation. A wrong prediction can generate a huge loss in the business area. Document classification is comparatively difficult than topic-based text classification [12]. Sentiments work in three different levels, which are document level, sentence level, and feature level. In the case of document level, sentiments are analyzed and predicted for a document, sentence-level considered for sentiments, and at last feature level for individual feature analysis and prediction. Let us take a look at some of the used cases of sentiment analysis which are described below.

A. Sentiment Analysis for Brand Monitoring

In today's online world branding of most of the products is done online, through this way products can be branded easily and we get easily capture the opinion of the users related to that particular brand. Even by this approach other users also come to know about the product specification with their positive and negative reviews.

B. Sentiment Analysis for Market Research and Analysis

Sentiment analysis of the product is analyzed and predicted for business purposes [13]. It can be easily predicted that if someone is giving a negative opinion about any product which means that a particular product can give us a big loss to our business. Same way if the product is getting positive reviews in that case business will get more profit from that.

C. Sentiment Analysis for Customer Service

Nowadays customer service reviews are also analyzed and predicted, this is because based on their review's future services will depend. If someone has given his negative opinions concerning any service in that case service providing company can suffer from huge loss. That's why many of the services providing companies are requesting to write a positive opinion about their services [14].

D. Challenges to be faced during sentiment analysis

Sentiment analysis also faces the same challenges as emotion recognition does. The first analysis of sentiment has to be done, like to check whether the sentiment is categorical means can it breaks down into buckets like happy, sad, bored, angry, etc. Another analysis is that whether to check that the sentiment is dimensional and it has to be solved based on the bidirectional spectrum. Another challenge is to predict the correct emotions from the sentence which can have multiple meanings. It is very challenging because there can have multiple layers of meaning for the same sentence generated by humans. Many times humans express their opinion in complex ways like sarcasm, irony, etc, and this can lead us to improper analysis. In these types of cases, it will be better that we must analyze how the full paragraph has started and what is its impact in the upcoming sentences. In section II discussion will be on the literature survey, section III shows the proposed work. Section IV will show the result and in the last section research paper will be concluded with future work discussion.

2. LITERATURE SURVEY

This section will represent the work done in the area of sentiment analysis. Lots of works are done on sentiment analysis using a machine learning algorithm and they have shown a significant accuracy in this area. Due to some limitations of machine learning researchers



have started working on sentiment analysis using deep learning algorithms. It has been observed that when we are dealing with machine learning algorithms many feature selection methods are applied for feature selection [15] and features extraction [16], this has to be done because textual data are considered as high dimensional data [17], so we have to reduce this dimension by using above-said methods [18]. But, in the case of deep learning, these methods are not considered much and we can directly apply the classification method for the sentiment analysis.

Let's discuss the analysis of web content that is in the form of reviews, opinions, emotions, or sentiments through deep learning techniques. Deep learning was developed by G.E. Hinton which is part of machine learning. Deep Learning mainly works in the form of layers. Efforts are already done in the deep learning through implementing CNN (Convolutional Neural Network) [19], RNN (Recurrent Neural Network) [20] and DBN (Deep Belief Networks) [21]. Sometimes we use more than one algorithm and it is termed as a hybrid approach [22]. Deep learning has done an influential task in the area of sentiment analysis. Many researchers have done significant work using deep learning algorithms. Socher has used Recursive Neural Network for the analysis of movie reviews generated from the rottentomatoes.com [23]. Zhao et al. has implemented Dynamic Convolutional Neural Network (DyCNN) which works on pooling operation, i.e. dynamic k-max pooling on linear sequences [24]. Z. Wu et al. has applied ConvNets on characters rather than on the embedded words. The paragraph vector is also proposed for sentiment analysis and it has shown improved results than bag-of-words analysis [25]. Sentence vector-based sentiments are analyzed by Wang et al. [26]. LSTM is also proposed recently for sentiment analysis that can flow on one input direction. Let's discuss some of the methods of machine learning.

A. Convolutional Neural Network

Convolution Neural Network is widely used for image analysis and it has shown a significant result in the case of image recognition. In paper [27] they have proposed a Convolutional Neural Network on the visual content to predict sentiments. It uses transfer learning and hyperparameters approach with a parameter like biases and weights. Its performance gets enhanced by increasing the size and depth of the network. CNN is optimized by activation functions like in neural networks but it consists of more number of layers. The activation function will be like stochastic gradient function [28], Rectified Linear Unit Function (ReLU) [29], etc. Dario et al. [30] has proposed deep learning in the form of CNN on sentiment analysis. They initialize the weight of the parameters of CNN and trained the model accurately without considering newly added features. Refining the

embedded bulky corpus by using Convolutional Neural Network and to initialize the network, previous embedded words and parameters were used. Components used in this work are activation function, matrix pooling, softmax function for the output layer, and convolutional layers. Training of network is done by stochastic gradient descent and non-convex function. Gradients are calculated by backpropagation and optimization algorithms are used. In these work dropout techniques are used for increasing the regularization.

B. Recurrent Neural Network (RNN)

RNN is an algorithm based on back-propagation and lies in supervised learning [31]. It has done influential modeling in sentiment analysis and contains a fixed length that contaminates all history words. The given work [32] has built a Treebank for Chinese sentiments of social data which overcomes the deficiency of labeled and large corpus in given models. Proposed RNN has shown an improved performance than SVM, Naïve Bayes during predicting the label at sentence label that can be positive or negative. In this paper, a Hierarchical bidirectional recurrent neural network (HBRNN) has proposed to extract the reviews of customers of different hotels [33]. Long term sequential information is modeled through HBRNN and the prediction process is done using the same at the review level. It has shown improved results over long short term memory and Bi-directional long short term memory. Bangla text sentiments are also analyzed using RNN which is a big issue because of the Bangla dataset [34]. Another deep recurrent model based on long short term memory was developed to test the dataset by using a two-loss function namely binary and categorical cross-entropy. Data was collected from different websites like Facebook, YouTube, Twitter, and others.

C. Deep Belief Networks

DBN's (Deep belief networks) [35] contain several hidden layers comprised of RBM (restricted Boltzmann machines). Feature representation is done very efficiently by using DBN and has utilized unlabeled data by overcoming the difficulty of labeled analysis issues. Weakly Shared Deep Neural Network is another model based on a recurrent neural network that facilitates two languages to share sentiment labels [36]. The dataset which has been used is Prettenhofer and Stein consists of four languages such as German, English, French, and Japanese. The backpropagation transfer process is used to shorten the overlap among features of both source and target language data.

Another article based on deep belief networks is political detection using word vector in Korean articles [37]. The dataset contains 50,000 articles based on politics from 1 Jan 2014 to 28 Feb 2015. SVM is applied to the dataset for bias calculation, python web crawler to



collect news articles, and five-stage pipelines for the detection of bias. The result has shown improved accuracy of 81.8% by predicting correct labels.

D. Hybrid Neural Networks

A hybrid approach is done to incorporate the features of two or more than two learning algorithms. Thai twitter sentiment is classified by using Convolutional Neural Network and Short Term Memory. Data were collected by analyzing Thai words or Thai tweets from twitter websites [38]. Experiments were conducted to show how deep learning is performing better than other traditional algorithms. Another research study based on a hybrid approach is Probabilistic Neural Network and a two-layered Restricted Boltzmann (RBM). Sentiment analysis is done by using this hybrid approach has achieved improved accuracy [39].

3. PROPOSED WORK

In this work, deep learning methods will be applied to analyze the sentiments of different datasets. The datasets which will be used in this proposed work are based on movie reviews taken from the IMDB dataset, hotel reviews, and reviews based on political parties in India. The implemented deep learning for sentiment analysis is RNN with LSTM [40] and Deep Chrome Convolutional Neural Network (DCCNN) will be applied on the above three datasets and it has shown improved performance than other traditional machine algorithms like SVM, Naïve Bayes, Random Forest, and Logistic Regression.

A. RNN by using LSTM

The steps which are used for sentiment analysis using RNN are usually followed by many classification algorithms. This work will contain the following steps which are as follows:

- Load in and visualize the data – first loading the reviews of the movie, hotel reviews, and political party review.
- Data Processing—Every time we have to process the dataset into a more filtered form to achieve improved accuracy. In the first preprocessing we convert the reviews into lower cases.
- Data Processing—Punctuations are removed
- Data Processing— List of reviews are formed
- Tokenize—Mapping vocab to a dictionary
- Tokenize— Words are encoded
- Tokenize— Labels are encoded
- Removing Outliers—Removing outliers like short and long reviews.
- Review length is computed
- Padding / Truncating the remaining data
- Splitting the dataset into training and testing dataset
- Validating the dataset

- Define the LSTM Network Architecture
- Computing the accuracy, precision, recall, and F1 score.

LSTM works in the form of different layers as shown in Figure 1, before discussing the details of the layer there is one more process that is tokenization, which converts our words into tokens. Now discussions of layers are as follows:

- Embedded layer – Tokens are converted into a specific size.
- LSTM layer – Define the number of hidden and other dimensional layers.
- Fully Connected layer – Mapping is done though this layer from LSTM to the desired output size.
- Activation layer – Sigmoid function is used as an activation function in LSTM which generates output between 0 & 1.
- Output layer- This layer produces the final output.

B. Deep Chrome Convolutional neural Network

Deep Chrome Convolutional Neural Network (DCCNN) based on Convolutional Neural Network with five stages i.e. convolution, rectification, pooling, dropout, and classical feed-forward neural network layers. We consider our dataset with N sample sentiments of the labeled pair of x input sentiments and y as labels of 0 & 1.

1) *Convolution*: In this stage temporal convolution is used with N_{out} filters, each of length k . Filters are used to perform sliding window operation across all positions. Sentiments are divided in the form of bins. Each bin consists of 100 sentiments. Given an input sample X of size $N_f \times b$, the feature map Z , from convolution is computed as follows:

$$Z = f_{conv}(X) \quad (1)$$

2) *Rectification*: A non-linearity functions is added i.e. rectified linear unit (ReLU). The generated value will be lies between 0 & 1.

3) *Pooling*: It is the process through which we select the max value out of the two generated values. Max pooling is applied on an input Z .

4) *Dropout*: The dropout layer is feeded with output. This will regularize the network and prevents overfilling. It is very similar to ensemble techniques like model averaging or bagging.

5) *Classical feed-forward neural network layers*: Multilayer perceptron classifier is introduced to classify the sentiment to class labels. These are fully connected multi-layer perceptron has contained multiple alternating linear and nonlinear layers. Each layer maps its input to hidden feature space and last output layer maps from hidden feature space to class labels i.e. 0 & 1 through softmax function. The whole output can be written as:

$$f(X^{(n)}) = fmlp(fmaxpool(frelu(fconv(X^{(n)})))) \quad (2)$$

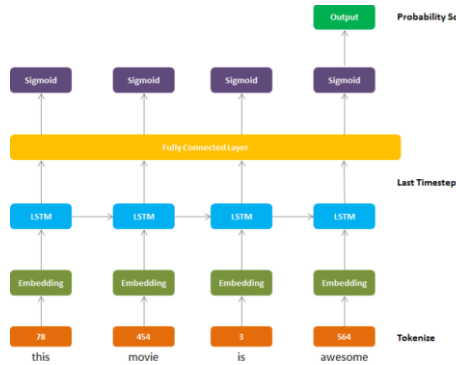


Figure 1. Architecture of LSTM

4. RESULTS AND DISCUSSION

To implement the proposed work we had used Python 3 as a programming tool by using the Anaconda framework. All the results and graphs are shown by using Python libraries [41]. In this work, we have taken three datasets first one is a movie review, the second one is hotel reviews and the third one is review related to a political party in India. The movie reviews dataset IMDb used in this study is downloaded from the website,

<https://www.kaggle.com/nltkdata/moviereview#movie-reviews.zip>, is one of the popular benchmark datasets, which has been exploited by several researchers to analyze the experimental outcomes. The standard movie review dataset consists of overall 2000 reviews where 1000 reviews are tagged as positive and 1000 are negative. Hotel review is taken from the 515,000 customer reviews and scoring of 1493 luxury hotels across Europe. This dataset is downloaded from <https://www.kaggle.com/jiashenliu/515k-hotel-reviews-data-in-Europe> and last review dataset which is based on political parties in India can be downloaded from <https://www.kaggle.com/rajitnitbpl/political-party>.

TABLE I. ANALYSIS PARAMETERS OF MOVIE REVIEW DATASET

| Classifiers | Accuracy (%) | Precision (%) | Recall (%) | F1 score (%) |
|-------------|--------------|---------------|------------|--------------|
| SVM | 90.35 | 89.4 | 86.4 | 87.86 |
| MNB | 87.25 | 86.25 | 83.81 | 84.69 |
| KNN | 85.67 | 84.43 | 81.33 | 82.84 |
| RNN-LSTM | 92.98 | 91.7 | 88.3 | 89.97 |
| DCCNN | 92.76 | 92.1 | 89.1 | 90.58 |

From Table I It is observed that deep learning algorithms have performed better than machine learning algorithms in terms of all the parameters. Accuracy, recall, precision, and F1 score comparison graph is shown in figure 2, figure 3, figure 4, and figure 5 respectively.

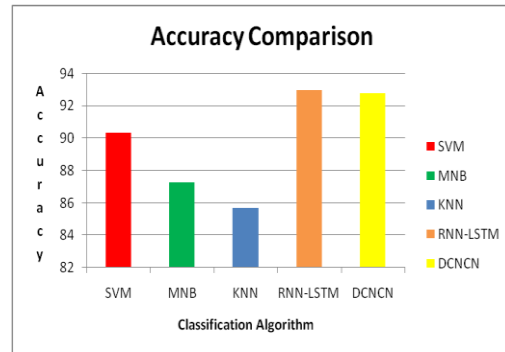


Figure 2. Accuracy comparison of Classifiers

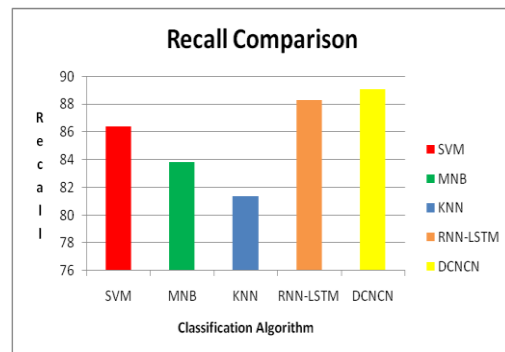


Figure 3. Recall comparison of Classifiers

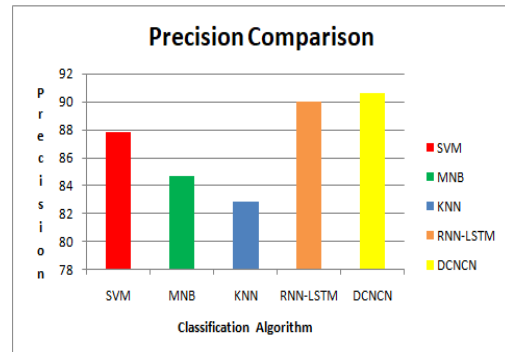


Figure 4. Precision comparison of Classifiers

Figure 2, 3, 4 and 5 shows the accuracy, recall, precision, and F1 score comparison of the existing classifiers with our proposed deep learning models respectively. Graph has shown that the proposed approach DCCNN has outperformed other existing algorithms. Graphs are implemented with the help of python library i.e. matplotlib. Other algorithms taken for comparison are Support Vector Machine (SVM), Naïve Bayes, and K-Nearest Neighbor.

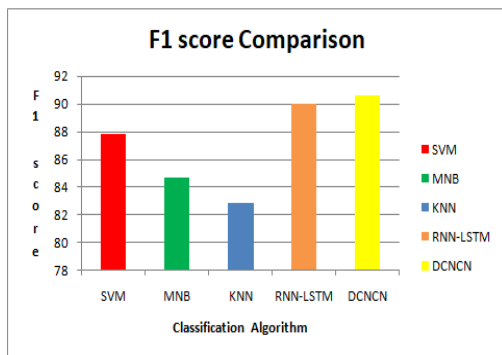


Figure 5. F1 comparison of classifiers

TABLE II. ANALYSIS PARAMETERS OF HOTEL REVIEW DATASET

| Classifiers | Accuracy (%) | Precision (%) | Recall (%) | F1 score (%) |
|-------------|--------------|---------------|------------|--------------|
| SVM | 87.35 | 84.13 | 83.45 | 83.79 |
| MNB | 84.15 | 82.35 | 81.84 | 82.09 |
| KNN | 82.61 | 83.48 | 80.33 | 81.87 |
| RNN-LSTM | 89.98 | 87.76 | 86.35 | 87.04 |
| DCCNN | 90.76 | 88.15 | 87.15 | 87.65 |

Table II shows the analysis of the hotel review dataset and Figure 6 shows the accuracy comparison of the classifier on the hotel review dataset.

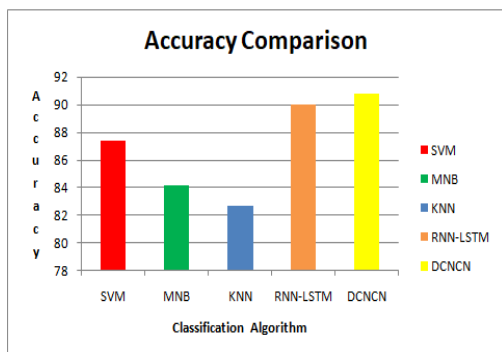


Figure 6. Accuracy comparison of Classifiers on Hotel review dataset

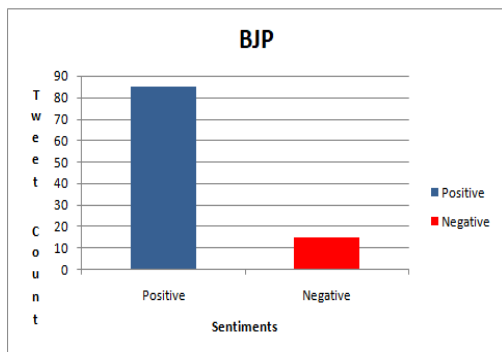


Figure 7. Sentiment Analysis of BJP political party

Our last analysis is done on the twitter sentiments related to political parties in India that are BJP, Congress, and AAP. To perform this sentiment analysis we have

taken 3 separate datasets of reviews related to BJP, Congress and AAP party. The binary classification is performed i.e. positive and negative, which means sentiments are analyzed to observe the mood of the tweets whether it is positive or negative towards the party. Sentiment analysis of the BJP, Congress and AAP party is shown by fig 7, fig 8 and fig 9 respectively and it is indicating that the BJP party has positive reviews as compared to Congress and AAP party.

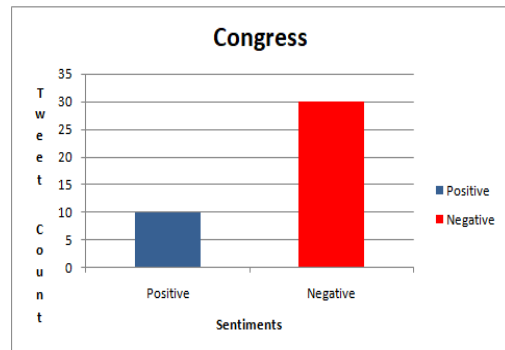


Figure 8. Sentiment Analysis on Congress political party

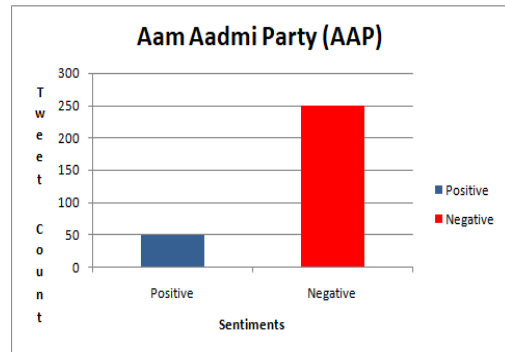


Figure 9. Sentiment Analysis on Aam Aadmi political party

5. CONCLUSION AND FUTURE WORK

Natural language processing is always a challenging area, especially in the case of sentiment analysis. In this work, deep learning methods are applied to perform the analysis of the sentiments and the results have shown better performance than the existing machine learning algorithms. In this work deep learning model is applied on three different types of datasets based on movie reviews, hotel reviews, and political party reviews and this has shown improved performance than the other existing algorithms on the basis of parameters such accuracy, precision, recall, and F1 score. The deep learning models implemented in this work are RNN with LSTM and Deep Chrome Convolutional Neural Network and they have outperformed other states of the art algorithms. One of the major drawbacks in Deep learning approaches is time consumption during processing because of the large number of layers, so in the future, we will consider the time component also and do the analysis. If time consumption factors can be decreased to some extent then



deep learning will always be the better option for performing the prediction and classification.

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Rajit Nair is currently working as an Assistant Professor in Vellore Institute of Technology, Bhopal, India. His area of interest is IoT, Machine Learning, and Blockchain He has published many papers and chapters in various international journals and conferences. He is having more than 13 years of academic experience in the field of Computer Science & Engineering

and also working as a reviewer of reputed International journals.



Vaibhav Jain is working as a Senior Faculty in INurture Educaion solution private limited. Previously he was working as an Assistant Professor & Program Leader in the Department of CSE at School of Engineering & Technology, Jagran Lakecity University, Bhopal (M.P.), India. He has an overall 6 years of Academic and Research Experience. He is currently working in the

research area of Machine Learning, Deep Learning, and the Internet of Things. He is pursuing a Ph.D. in CSE from UIT-RGPV, Bhopal.



Preeti Sharma is working as an Assistant Professor at Bansal College of Engineering which is located in India. She has published many papers and chapters in various international journals and conferences. She is having more than 13 years of academic experience in the field of Computer Science & Electronics & Communication Engineering

and also working as a reviewer of reputed International journals. She also received many awards from various organizations for contribution in the field of academics. Currently, she is working on a different project which is based on IoT and machine learning.