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Analyzing the Sentiments with Neural Network

Niharika* and Sona Malhotra

Dept of C.S.E., UIET, Kurukshetra University, Kurukshetra, India.
niharikadhawan15@gmail.com*, sonamalhotrakuk@gmail.com

Abstract: **In the modern era, ubiquitous means of communications are used. Thus, allowing various platforms where people can exchange their thoughts and opinions. This leads to the situation where the task of sentiment analysis comes into play which is the task of natural language processing. Many approaches such as Maximum Entropy, classifier of Naïve Bayes were used for the purpose of analyzing the sentiments of the users which helps the internet surfers to interpret whether a particular thing is liked or disliked by others. The paper proposes a system with back-propagation neural network (BPNN) which not only analyzes simple reviews but also the opinions that contain emoticons and negation. The neural network was implemented with various datasets and with several different activation functions such as ReLu (Rectified Linear Unit), sigmoid and hyperbolic tangent. The results depict that sigmoid activation function performed better than other.**

Index Terms: **Activation function, Supervised machine learning, sentiment analysis, machine learning, reviews, emoticons, neural network, training and testing**

I. INTRODUCTION

Nowadays, users are great contributors in the creation of the web content which is why they are also referred as the co-creators of the web and their activity is not just limited to be the consumers as each one of us is independent and free to post their opinions and reviews on the web and share it with billions of people on the internet in (Singh et al., 2013). The reviews can be presented on different platforms, whether it, be on a blog, Wikipedia or a forum website. This phenomenon generally leads to information overloading in (Hang et al., 2006). With the emerging trend of sentiment classification these days, this concept is considered as a sub-field of text classification where the polarities are used as the categories which helps the training of the classifiers by applying the methods that are under the approach of supervised and unsupervised machine learning in Chen et al., 2016). But, as the reviews of a particular product or movie grow in number, it becomes difficult for the users to summarize those reviews and state whether the majority of those reviews are negative or positive in (Zhang et al., 2011). With the widespread use of internet and several different web resources, there was a need of effective algorithm for text classification in (Ghiassi et al., 2012). Thus, this problem is addressed through analyzing the sentiments which is also referred as polarity mining. This process uses the concept of presenting the reviews in aggregation and evaluating the reviews in two labels of positive class and negative class in (Bespalov et al., 2011).

Sentiment analysis targets to quantify the polarity of a subject information or review from natural language text and assign a label or a score which will lead to the prediction of the review or opinions that have been expressed by the users in the category of positive, negative or neutral in (Kalchbrenner et al., 2014).

There are several different solutions that have been proposed for the analyzing the sentiments, namely, approach of machine learning, dictionary based, semantic and statistical approach. The first approach includes the techniques like Maximum Entropy, decision tree and Naïve Bayes while the second approach uses a dictionary called sentiment lexicon that has the polarity of words which can be used to obtain a score. The semantic approach then utilizes the semantic relationship between words like antonyms and synonyms to calculate the polarity and the statistical approach uses the statistics to obtain polarity of sentiments based on co-occurrence of words (Sharma and Dey, 2012). Because of the popularity of sentiment classification, machine learning tools have been introduced that deal with finding the feelings of people expressed in review rather than finding the fact in (Moh et al., 2015).

Machine learning also has a sub-field, called as deep learning which has acquired a significant amount of success in analyzing the sentiments of the emotions expressed by the users. The deep learning approach could be implemented in both forms of learning, namely, supervised and unsupervised in (Ouyang et al., 2015). Thus, it is establishing as a powerful tool in analyzing the sentiments of the users in (G. Cai , B. Xia, 2015). Artificial

* Corresponding Author

Neural Networks have witnessed a remarkable rise in the past decades and thus, they are becoming a suitable and most prominent approach in different domains for the problem related to the task of classification and analysis as the deep architecture of the artificial neural networks represent behavior which is intelligent in nature in (G. Vinodhini , R,M, Chandrasekran, 2016).

Artificial Neural Network's work of gathering knowledge is implemented by pattern detection and learning through the experience. Artificial Neural network is composed of several single units called artificial neurons which have weights connected with them in the layered architecture of ANN. The weighted sum of the input makes the activation function of the neuron and it is passed to obtain a single output of the neurons. Then, the process of optimizing the weight is carried out to reduce the error to minimum in the prediction and specific amount of accuracy is achieved. The network is prepared for training and testing in (Rojalina et al., 2010).

The paper proposes a system of ANN for analyzing the thoughts and reviews of the people. The remainder of this paper is organized as follows: Section II elucidates an overview of the formulated problem followed by problem background in Section II. Further, Section IV provides the proposed work which included the ANN model for sentiment analysis. Then, Section V elucidates the implementation of the model followed by the section presenting the results and analysis in the sections VI and VII respectively. Finally, Section VIII gives the conclusion of the research paper along with the discussion of the future scope which could be used further research in the topic.

II. PROBLEM BACKGROUND

Sentiments are referred as opinions, feelings or emotions and thus, there lies a need of the hour to analyze the expressed sentiments and calculate the insights and polarity to explore the business. Machine learning algorithms are proved to be very helpful in analyzing the sentiments. Earlier, the classification of the sentiments was done through the machine learning techniques that came under probabilistic classifiers such as Naïve Bayes (which is an approach for classification that deals with the calculation of prior probability and then using it in the calculation of final probability along with the likelihood) and Maximum Entropy (it always tries to maximize the system's entropy without making any assumptions about the relationship between the features). These two techniques were applied by Pang et al. in (B. Pang, L. Lee, 2008) on the datasets that comprised the movie reviews delivered the accuracy of 81.5% and 81% respectively. Then came the technique of linear classification that included the classifiers such as Support Vector Machine (where two different classes are formed by separating the training set data points) and Artificial Neural Network (that have several properties like fault tolerance, adaptive learning and generalization) under the approach of machine learning.

The results of the later approach were proved to be better as compared to the earlier approach thus, linear classifiers were started to be in use more often for classification of the sentiments as studied by Borele and Borikar in (P. Borele , Dilipkumar , A. Borikar, 2016). Then, between the performance of Artificial Neural Network and Support Vector Machine, ANN performed more accurately in comparison to SVM as witnessed by Vinodhini and Chandrasekaran in (G. Vinodhini, RM. Chandrasekaran, 2012) which has been proved by the performance measures in terms of correctness, efficiency, correctness and effectiveness.

There had been great increase in the implementation of models of different neural networks for the process of analyzing the sentiments like Chen et al. in (L. Chen, 2011) exhibited a model of artificial neural network that included concept of SO indexes followed by training the network and testing the artificial neural network and the evaluated results were proved to be better when compared with the traditional approaches of machine learning.

After that, Sharma and Dey in (A. Sharma , S. Dey, 2012) used the concept of applying back propagation network (BPNN) in 2012 that used the concept of lexicons of the sentiments and Information Gain to train the network and test the ANN which yielded the classification of the opinionated text accurately. Later on, Borele and Borikar (P. Borele , Dilipkumar , A. Borikar, 2016), in 2016, proposed a model that included the steps of preprocessing, weight assignment and classification as the training part followed by testing and evaluating the performance of the model proposed by them.

III. PROBLEM FORMULATION

The problem that is formulated for the study is to analyze the sentiments using artificial neural network which includes the task of evaluating the opinions into the label of either positive or negative. These reviews and opinions could effect the companies and owner of restaurant and product as they could strengthen or destroy the reputation in (Borele et al. , 2016). The approach of ANN (artificial neural network) is chosen for the implementation because the literature study revealed that they yielded better results as a classifier in comparison with other machine learning techniques such as classifier of Naïve Bayes, ME and SVM but few limitations were there in neural networks such as presence of noise and the scope to enhance the efficiency of the artificial neural network.

Moreover, ANNs are also becoming a popular choice to be chosen as classifier model because of their important properties like adaptive learning and generalizations.

The main objective or aim of sentiment analysis is basically to evaluate the opinionated so that it could find the polarity of the opinionated text of the users or the customers. Thus, the approach of ANN (artificial neural networks) is used for classifying sentiments that have been expressed by the user or

the customer so that an algorithm could be implemented for the automatic classification of the reviews/opinions expressed by the users. The reviews and opinions expressed by the users can be easily seen by everyone and also help others users or customers to make their choice about the product, movie or a restaurant.

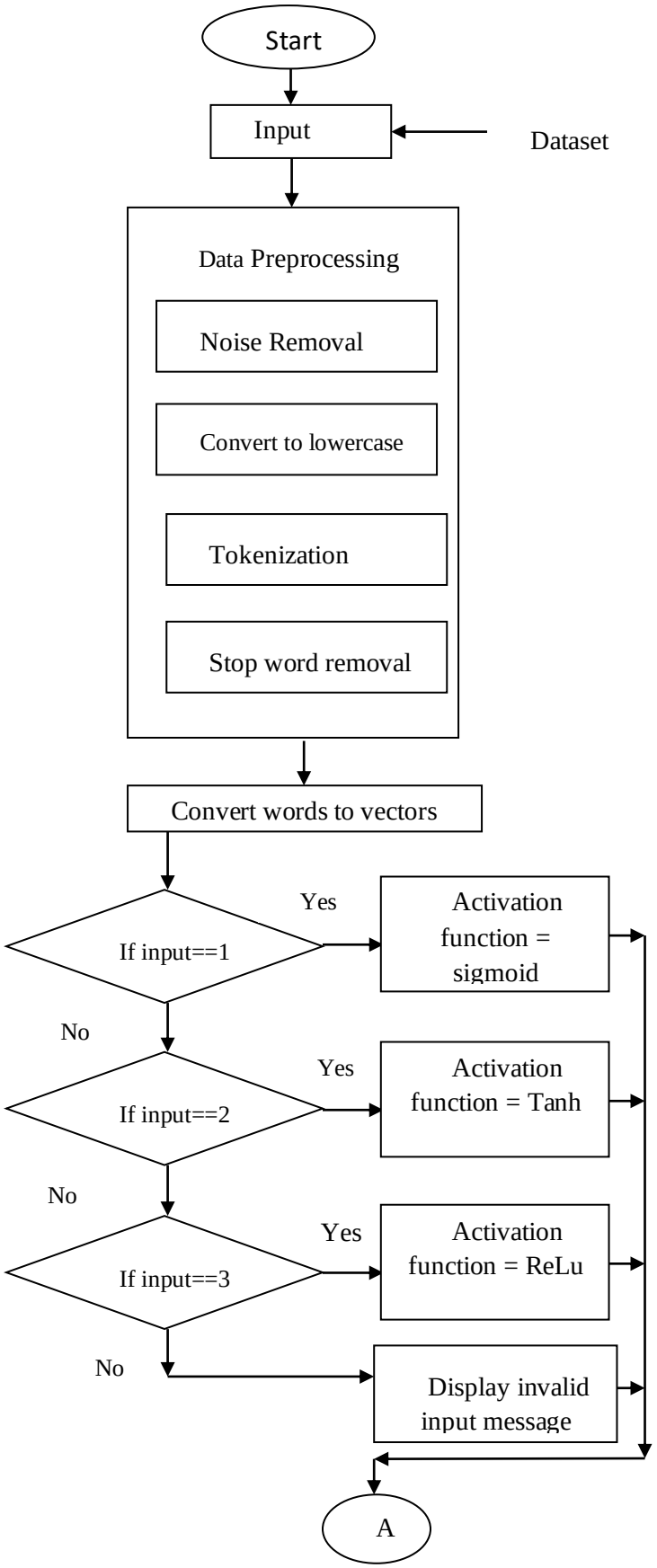
Moreover, the formulated problem of proposing a model of artificial neural network aims not only to classify the opinionated text into the labels of positive and negative, but it also aims to give the analysis of the sentiments that contain emoticons and negations along with the opinionated text as it is witnessed that today's generation are more fond of using the emoticons in order to share their opinions instead of typing a lengthy textual reviews and negation is common linguistic construction by which polarity could get affected in (G. Vinodhini, RM. Chandrasekaran, 2012).

IV. PROPOSED WORK

A back propagation neural network is proposed where the dataset is collected and preprocessed which includes the removal of noise, conversion to lowercase, tokenizing and removal of stop words. The word 'not' is not removed as it contributes to the negation in sentiments such as 'not good'. Then, the words are mapped to vectors followed by the initialization of the neural network and getting input for selecting the activation function to use such as sigmoid, tanh and ReLu. After that, learning phase starts which includes learning of the neural network. Following which evaluation phase starts that includes testing and prediction.

For example, a review "What an absolutely stunning movie, it's too much fun!" is taken from dataset where the initial step of preprocessing is performed that involve noise removal "What an absolutely stunning movie its too much fun" which is then forwarded for lowercase conversion "what an absolutely stunning movie its too much fun". After that tokenization and stop-word removal are performed which results into ['what', 'an', 'absolutely', 'stunning', 'movie', 'its', 'too', 'much', 'fun'] and ['absolutely', 'stunning', 'movie', 'much', 'fun'] respectively. After that the words are indexed as [0,1,2,3,4]. Assume the selection of sigmoid activation function, then in training, assignment of weights is done and forward pass is implemented which lead to output as [[-0.5]]. After that the error is calculated as o/p – desired which results in [[-0.5]]. Then, derivative is calculated as 0.25 from (o/p*(1-o/p)) and delta is calculated as error*derivative which yield -0.125 from (-0.5*0.25). After that backward pass is done where error is [[-0.20304317 0.07646955 0.06602147 0.13412108 -0.10817595 0.28769234 -0.21810147 0.09515086 -0.03987989 0.0311713]]. And finally, weights of output layer are updated to [[1.62434536] [-0.61175641] [-0.52817175] [-1.07296862] [0.86540763] [-2.3015387] [1.74481176] [-0.7612069] [0.3190391] [-0.24937038]] and it is classified as POSITIVE.

The proposed method could be easily illustrated with the flowchart.



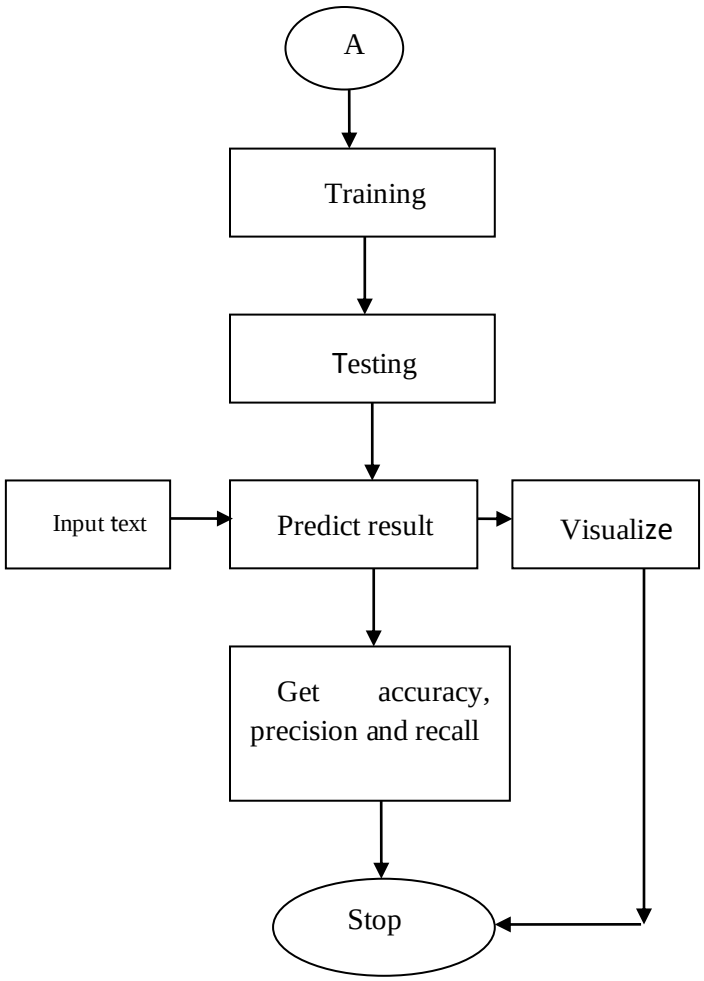


Figure 1: Flowchart of proposed methodology

V. IMPLEMENTATION

1. Datasets:

Two different datasets were considered to train the proposed system followed by testing the network and determining its accuracy.

i) The first dataset contain two files namely, reviews.txt and labels.txt that contain 25K IMDb movie reviews and the second file contain the labels for the corresponding 25K reviews which are used in network's training. It is downloaded from Data Science website at (Babbar, 2018) .

ii) The second dataset contain one file namely, reviews1.txt that contain 50K IMDb movie reviews along with the sentiments for the corresponding 50K reviews which are utilized in the training part of the model. It is downloaded from Kaggle website at (Panth, 2019).

The dataset called ijstable.csv is used to train the system so that it could predict the label, positive class and negative class, for the sentiments that contain emoticons. The dataset is downloaded from Kaggle website at (Prateek, 2018) and contain 11 columns which are:

i) Char : It contains the emoticon
ii) Unicode: It contains the Unicode for the emoticon
iii) Occurrences: It keeps the count of number of times the particular emoticon has appeared
iv) Position: It defines the position of emoticon in range [0,0]
v) Neg: Neg contains the negative score of the emoticon
vi) Neut: It defines the score for the emoticon to be neutral
vii) Pos: It contains the positive score of the emoticon
viii) Sentiment score: Sentiment score defies the overall score for the emoticon
ix) Sentiment bar: Sentiment bar is 100% null
x) Unicode name: It refers to the name of the emoticon
xi) Unicode block: It contains whether the Unicode is emoticon, miscellaneous symbol or pictographs.

2. Activation functions:

The user is asked the choice to select the activation function through user input. The activation function sigmoid, tanh and Smooth ReLu can be selected through user input 1, 2, 3 respectively. The sigmoid activation function spans from 0 to 1 while second one, hyperbolic Tangent (tanH) activation function, ranges from -1 to +1. Smooth ReLu activation ranges between zero and the input value.

3. Precision, Accuracy and Recall:

The three chosen performance metrics are calculated as follows:

Accuracy = No. of correct predictions made/total
Precision = True_Pos / (True_Pos + False_Pos)
Recall = True_Pos / (True_Pos + False_Neg)

Where ,

a) True_Pos are the reviews that are obtained as positive in the prediction and in actual also they are positive.
b) False_Pos are the reviews that are obtained as positive in the prediction but but the actual result is negative.
c) False_Neg are the reviews that are obtained as negative in the prediction but the actual result is positive.
d) True_Neg are the opinions that are obtained as negative in the prediction and in actual also they are negative in (Q. Ye, Z. Zhang, and R. Law, 2009).

VI. RESULT

The datasets aere splitted into training and testing datasets by 80-20 rule where 80% of the dataset was selected as the training dataset while the remaining 20% of the dataset was chosen to be the dataset for testing purpose. Both the datasets were different in sizes, 25K and 50K . The learning rate of the network is set to

be 0.01. The user is asked to select the activation function among the three activation function namely, sigmoid, TanH and Smooth ReLu activation function. The performance measures that were chosen for the evaluation of the neural network were recall, accuracy and precision. The following table shows the results on the basis of size of the dataset and activation function chosen.

Table 1: Evaluation of performance of neural network

Size of Dataset = 25K , Learning Rate of neural network=0.01									
Activation	Sigmoid			TanH			Smooth ReLu		
Dataset 1	Precision	Accuracy	Recall	Precision	Accuracy	Recall	Precision	Accuracy	Recall
Training	83.82%	84%	84.4%	54.59%	52.2%	98.6%	53.41%	56.3%	98.3%
Testing	84.89%	86.8%	89.6%	54.4%	58%	99.8%	55.04%	59.1%	99.6%
Size of Dataset = 50K , Learning Rate of neural network=0.01									
Activation	Sigmoid			TanH			Smooth ReLu		
Dataset 2	Precision	Accuracy	Recall	Precision	Accuracy	Recall	Precision	Accuracy	Recall
Training	83.71%	84.0%	84.4%	55.02%	59%	98%	54.34%	57.9%	98.9%
Testing	88.24%	86.4%	84.24%	57.51%	62.9%	99.8%	59.93%	66.4%	99.34%

Table 2: Output of prediction for user input

Activation function = Sigmoid (input sentence contains negation and emoticons)		
User Inputs	Expected output	Actual Output
The movie is good.	Positive	Positive
The movie is bad.	Negative	Negative
The movie is not good.	Negative	Negative
The movie is not bad.	Positive	Positive
Sad emoticon	Negative	Negative
Smiling emoticon	Positive	Positive
The movie is not bad. Thumbs-up emoticon	Positive	Positive

VII. ANALYSIS

From Table 1, it may be inferred that the most suitable activation for classifying the sentiments or reviews into positive or negative is sigmoid which can also be termed as logistic as the accuracy of training and testing dataset were 84% and 86.8% for the first dataset of 25K and 84.0% and 86.4% for second dataset of size 50K in case where sigmoid activation function is selected while it lies near about 50% for other activation function. Hence, sigmoid activation function is suitable for sentiment analysis while using the back-propagation neural network. The second performance measure precision varies similar to accuracy while recall increases for the testing dataset which is 20% of the original dataset while the user inputs gives suitable predictions that contain both the negation and the emoticons, along with the text, as already seen in Table 2. Another point can also be noticed from the above results is that the volume of the dataset does enhance the accuracy of the neural network. The datasets of large sizes help in increasing some accuracy of the proposed model of artificial neural

network in case of TanH activation function and smooth ReLu activation function. The performance of several other methods, when implemented on movie review dataset, were compared and it led to the conclusion that proposed method had outperformed the performance in comparison to other methods as Naïve Bayes classifier had accuracy of 81.5%, SVM had 82.9% of accuracy and ME had achieved the accuracy of 81%.

CONCLUSION

From the outcome, it could be inferred that the sigmoid activation function, also called logistic activation function, is the best choice for the implementation of proposed system which includes the back-propagation artificial neural network. Also, the outcomes from the implementation of the proposed system on datasets of two different sizes depicted that with increasing the volume of the input data, there is improvement in the accuracy of the proposed artificial neural network in case of TanH activation function and Smooth ReLu activation function. The future scope of the ANN for analyzing the sentiments includes the system to be trained in such a manner so that the system is able to classify the sentiments for those reviews or opinions that are sarcastic in nature and abbreviations. Also, the accuracy can be improved.

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