

A Novel Framework For Sentiment Analysis Using Deep Learning

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Abstract—Large amount of un-structured data is present online in the form of opinions and reviews. The most important task of NLP is to Extract useful information from unstructured data by first converting into structured form. Many customers write down reviews online but do not give rating to them. The main concern of this paper is to perform sentiment analysis by predicting two main types of polarities from reviews available online i.e positive and negative. Neural networks models fail to capture the contextual meaning of words and also fails to save long sequences of words and thus results in reducing performance. To overcome this issue a novel Hybrid model (RNN-LSTM-BiLSTM-CNN) using majority voting, word2vec and pre-trained Glove embedding (100d) is proposed to predict sentiment polarity against each review. Loss function used is Binary cross entropy. The proposed model is tested on different state-of-the-art datasets like SST-1, SST-2 and MR Movie review dataset. Results proved that our proposed model results in improved accuracy.

Keywords— Deep neural network, LSTM, BiLSTM, RNN, CNN, word Embeddings, , Natural language processing (NLP), Sentiment analysis

I. INTRODUCTION

An important task of Sentiment analysis is to find polarity of reviews related to any product, individual or event. Polarity can be either in binary or in labels form as positive, negative or neutral[9]. Sentiment analysis has multidisciplinary tasks involving different techniques such as Natural language and machine learning for identifying the polarity of text under consideration. Deep learning is a special task of ML. A vast research is being performed using conventional text (Reviews, discussion forums and blogs) and using social networks data such as tweets and microblogs[7]. This text provides information related to opinions of customers about product, personality or any topic etc. Deep neural networks include Recurrent neural network(RNN) but it has the limitation that it can only save previous information if the gap is small between the current and previous information and thus has a vanishing gradient problem. LSTMs are advanced form of RNNs that reduces the problem of vanishing gradient but it do not considers future sequences of a hidden unit while calculating output but BiLSTM has two hidden unit to calculate both forward and backward manner output from

sequences and this provides a summary of text that can be used as feature set to classify reviews text according to its polarity[4]. Following equations shows complete process to

$$i_t = \sigma(W_i x_t + U_i h_{t-1} + b_i) \quad (3)$$

$$f_t = \sigma(W_f x_t + U_f h_{t-1} + b_f) \quad (4)$$

$$o_t = \sigma(W_o x_t + U_o h_{t-1} + b_o) \quad (5)$$

$$g_t = \tanh(W_g x_t + U_g h_{t-1} + b_g) \quad (6)$$

$$C_t = i_t * g_t + f_t * C_{t-1} \quad (7)$$

$$h_t = o_t * \tanh(C_t) \quad (8)$$

find output of LSTM hidden unit(ht) having input xt.[1]

Equations 3, 4 and 5 represents input, forget and output gates respectively. Equation 8 represents the hidden state. Compared to RNNs hidden state LSTMs representation is complex. C represents hidden unit internal memory. Sigmoid is a non-linear activation function. Because of this hidden unit LSTM is able to save information for more time[1].

Extraction of features is done by CNN from text and reviews and then these features are provided as input to the model for sentiment analysis. There are many methods of sentiment analysis of reviews and to calculate polarity[8]. The task of SA helps business analysts and companies to know about their customer reviews and needs. They can improve their business and product according to demands of customers and can generate improved revenue.

II. LITERATURE REVIEW

In the paper [2] author used Amazon review dataset scrapped from web to perform task of sentiment analysis by using different algorithms of machine learning including SVM, NB and ME. The results are classified into positive, negative and neutral classes. The results are useful for customers as well as companies to improve their business.

A novel model (CNN-LSTM) for sentiment analysis is proposed in this contribution [3]. In the proposed method not all data is provided to CNN as input but different regions are made of data. Each sentence acts as a region, that divides the

input to multiple regions. It helps in weighing and to extract useful information from text, that ultimately provide better prediction of rating for text of Valence arousal (VA).

Another model is proposed [4] integrating CNN and LSTM that provides advantages of both models in a single model. Local dependencies are captured by the CNN employed filters. While LSTM captures the long-distance relationship. Freezing technique is proposed to avoid overfitting while training.

The author of the paper [5] shows the impact of deep CNN for capturing the semantics of short text as tweets and reviews of movies. Movies datasets includes the famous SSTb and STS datasets. Semantics and context of short sentences is difficult to capture than long text and paragraphs. The proposed architecture also used word, sentence and character level representations for better performance of sentiment analysis. The results are better than state-of-the-art results. Pre-trained word-embeddings are also used to improve results by capturing contextual information.

In this paper [6] author used huge amount of data form Social Network Service (SNS) for the purpose of sentiment analysis. Such a huge amount of data can't be handled easily so, deep learning models are implemented in this study. Using RNNs and CNNs the author proposed a deep learning architecture to predict the polarity of text data available.

III. PROPOSED METHODOLOGY

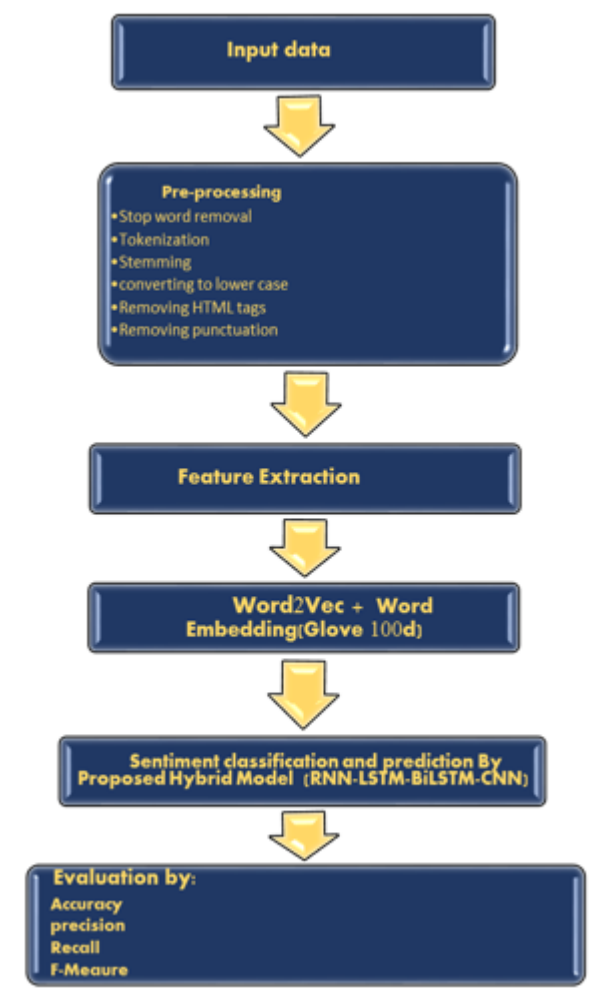


Fig. 1. Proposed Methodology

Natural language processing(NLP) is used for sentiment analysis. Prediction of correct polarity and sentiments of customers about any personality, campaign and product etc. helps business analysts to improve their business and thus gaining profit and customer satisfaction[2]. The proposed framework is used for this purpose.

Python is used for implementing the proposed framework. Different libraries, tools, APIs and packages like Matplotlib, scikit-learn, NLTK and keras are also used for SA. NLTK is a natural language toolkit that deals with natural language tasks. Keras results in fast experimentation and is capable of running on TensorFlow[10].Scikit learn is used in our experimentation for the task of text classification. All models are trained using tensorflow and the proposed model is implemented using GPU.

For the task of sentiment analysis, a novel hybrid model is proposed using word2vec and pre-trained word embeddings (Glove) of 100 dimensions. Pre-trained embeddings result in improved accuracy as these embeddings are trained on large corpuses available online such as Giga words and Wikipedia[11]. Binary cross entropy is used as a loss function.

Following figure shows the proposed hybrid model:

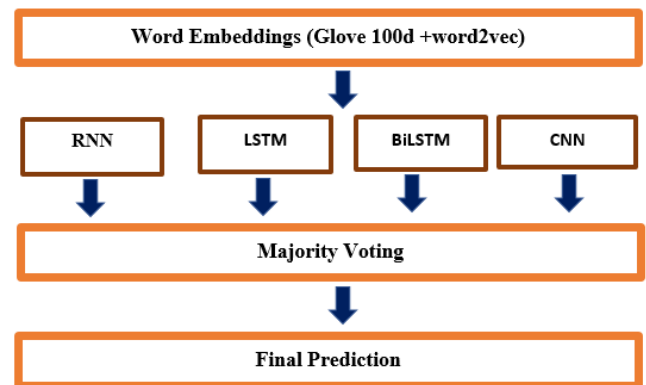


Fig. 2. Proposed Hybrid Model

The proposed framework is a hybrid of different deep learning models namely Recurrent neural network(RNN), Long short Term Memory(LSTM) , Bidirectional LSTM and Convolution neural network(CNN) and word2vec along with pre-trained word embedding. Each model is individually run on input data and then using Majority voting on obtained results, final prediction about polarity of text is produced. Three datasets available online namely SST-1, SST-2 and MR are used for experimental purpose. Following table shows number of classes present in datasets:

TABLE I. DATASETS PROPERTIES

Dataset	Classes	Labels
SST-1	5	positive, very positive, neutral, negative, very negative
SST-2	2	Positive, negative
MR	2	Positive, negative

The data is partitioned into training and testing data in the ratio of 3:1 i.e 75% of data is used for training purpose and 25% is used for testing purpose. Accuracy is calculated based on obtained predictions for text-only reviews. The features like review length, Review text and vector value against each word is fed as input to the hybrid model. Sigmoid function is also used to represent complex input and output of a model as linear models fail to capture such complexity but non-linear models outperform in this task.

IV. RESULTS ANALYSIS

The proposed methodology performed on three datasets results in improved accuracy and more accurate polarity detection (negative, positive) against text-only reviews. We have performed experimentation using different models on same datasets. The extensive results show that the proposed model is more accurate in predicting the labels and accuracy is also improved. Another benefit of the proposed model is that it can be used for other datasets as well and is not only limited to SST-1, SST-2 and MR dataset.

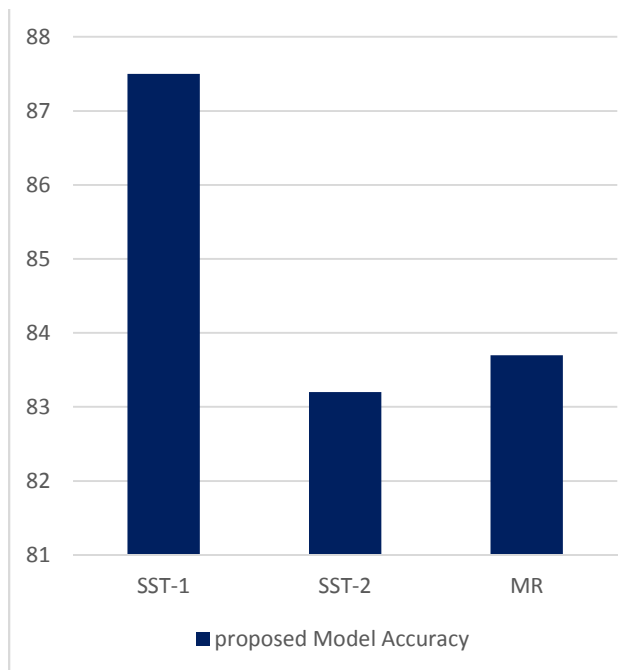


Fig 3. Proposed Model Accuracy

Following comparison shows that our proposed approach results in more accurate results than already proposed models in literature.

TABLE II. COMPARISON OF PROPOSED APPROACH WITH ALREADY PROPOSED MODELS IN LITERATURE

Sr #	Model	Datasets	Accuracy	Reference
1	SVM, NB	Amazon Dataset	81.2%	[2]

2	CNN-LSTM	text of Valence arousal (VA)	84%	[3]
3	CNN-LSTM (freezing technique)	STS, SST, IMDB large movie reviews	86%	[4]
4	CNN-f+LSTM-f	Movie reviews (MR), STS, SST, IMDB	81.59%	[7]
	CNN-f+DVngram	large movie reviews, SenTube	81.11%	
5	GRNN-SR	MR, SST, Amazon Product Reviews	80.6%	[8]
6	Ensemble model	SemEval2013/14, Vader, STS-Gold, Sentiment140, IMDB, PL04	86.49%	[9]
7	CNN-LSTM	Arabic Tweets	65.05%	[10]

8	Proposed Model	MR, SST-1, SST-2	87.5%	-
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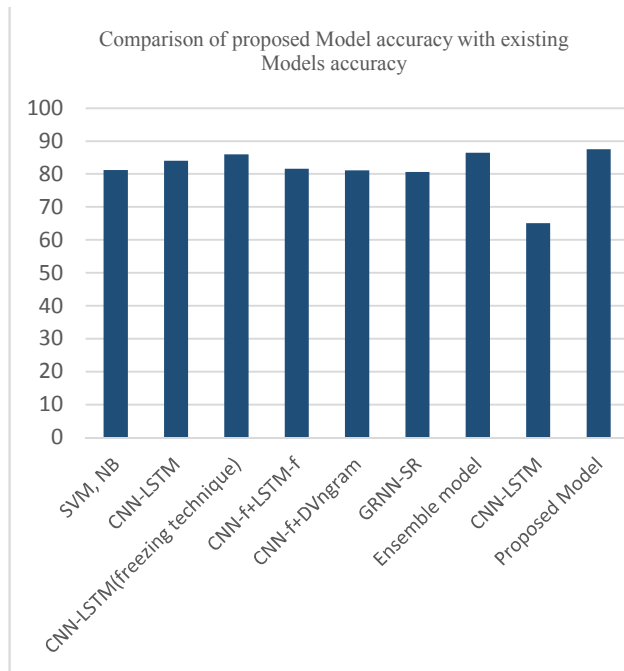


Fig 3. Comparison of proposed Model accuracy with existing Models

V. CONCLUSION AND FUTURE WORK

Different researches have been performed for sentiment analysis using traditional approaches. This paper proposed a novel deep learning based hybrid approach for prediction of polarity against text-only reviews and results in improvement of accuracy and generation of more reliable results that can benefit customers by helping them to know other customers reviews about specific product as well as business analysts to improve their business according to demands of customers analysed from their reviews. Pre-trained embeddings also helps in improving results as they capture the contextual meaning of a word in a sentence.

Future work will focus on implementing the proposed framework on other languages like Persian and also implementing the framework using large datasets like IMDB

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Usman Qamar has over 15 years of experience in data engineering and decision sciences both in academia and industry having spent nearly 10 years in the UK. He has a Masters in Computer Systems Design from University of Manchester Institute of Science and Technology (UMIST), UK. His MPhil in Computer Systems was a joint degree between UMIST and University of Manchester which focused on feature selection in big data. In 2008/09 he was awarded PhD from University of Manchester, UK. His PhD specialization is in Data Engineering, Knowledge Discovery and Decision Science. His Post PhD work at University of Manchester, involved various research projects including hybrid mechanisms for statistical disclosure (feature selection merged with outlier analysis) for Office of National Statistics (ONS), London, UK, churn prediction for Vodafone UK and customer profile analysis for shopping with the University of Ghent, Belgium. He has also done a post-graduation in Medical & Health Research, from University of Oxford, UK, where he worked on evidence-based health care, thematic qualitative data analysis and healthcare innovation and technology.

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Dr. Usman has been able to acquire nearly PKR 100 million in research grants. He has received multiple research awards, including Best Book Award 2017/18 by Higher Education Commission (HEC), Pakistan, Best Researcher of Pakistan 2015/16 by Higher Education Commission (HEC), Pakistan, Best Overall NUST University Researcher Award 2016 and Best College of E&ME researcher award 2016 as well as gold in Research & Development category by Pakistan Software Houses Association (P@SHA) ICT Awards 2013 & 2017 and Silver award in APICTA (Asia Pacific ICT Alliance Awards) 2013 in category of R&D hosted by Hong Kong. He is also recipient of the prestigious Charles Wallace Fellowship 2016/17 as well as British Council Fellowship 2018, visiting research fellow at Centre of Decision Research, University of Leeds, UK and scientific director of Data and Text Mining Lab, Manchester Metropolitan. He is also an expert committee member of engineering & technology for the evaluation/recognition of national research journals for Higher Education

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