SENTIMENT ANALYSIS USING CONVOLUTIONAL NEURAL NETWORK WITH LSTM

A Thesis

Submitted

In Partial Fulfillment of the Requirements

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In

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Submitted by

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August, 2021

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I hereby declare that the thesis titled **"SENTIMENT ANALYSIS USING CONVOLUTIONAL NEURAL NETWORK WITH LSTM"** submitted to Computer Science and Engineering Department, Integral University, Lucknow in partial fulfillment of the requirements for the award of the Master of Technology degree, is an authentic record of the research work carried out by me under the supervision of **Mohammad Suaib,** Assistant Professor, Department of Computer Science & Engineering, Integral University, Lucknow. No part of this thesis has been presented elsewhere for any other degree or diploma earlier.

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Harinam

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ABSTRACT

Sentiment analysis or "opinion mining" or Emotion AI used to extract opinions, thoughts, and emotion from a text. It is a sub-field of Artificial Intelligence. Emotion artificial intelligence is ongoing research in the area of text analysis. With the growth of digital media, datasets are available in both text and images for sentiment analysis. Extension of social media platforms (Weibo, Twitter, and Instagram) people enabled to share their emotion, feelings, and thoughts. Nowadays, mental stress is a concern among the young generation, and they are suffering from stress. Growth in stress shows symptoms of anxiety, unmotivated, irritability, restlessness, sleep disorders and poor diet. Technology advancement, such as digital media, smartphones, blogs, social networks, video conferencing influences researchers to retrieve large data sets for analysis. According to hashtags tweets are being classified, as negative or neutral, which help to detect depression. Globally text messages widely used form of communication. For Emotion Artificial Intelligence, textual data is being used for data analysis and to detect sentiments using various ML techniques. As ML is a vigorous technique emerged to analyse these data. ML uses an advanced statistical and probabilistic technique to build intelligent systems that can automatically learn from the data. Machine Learning is efficient in analyzing big datasets generated from various sources. In the 1950s the term ML theoretically referred to by Allan Turing and named by Arthur Samuel and is being used in several fields including, medical health since the 1990s.

This thesis report uses IMDB movie review dataset to perform text classification for sentiment analysis. This report gives the detail overview of different feature extraction technique named as n-gram, stop words, POS tagging and so on. This thesis report also discusses the existing approaches that are based on deep learning models in detail such as Long Short Term Memory and Covolutional Neural Network.

This thesis report proposed an ensemble approach for text classification that is based on Long Short Term Memory with Convolutional Neural Network. In order to perform sentiment analysis, IMDB movie review dataset is used and word embedding is used to convert the words into vectors for performing the task. This thesis report also provide the data preprocessing techniques such as data cleaning, data formatting and different feature selection methods such as n-grams, stop words and many more. This report gives the summary and result comparison of proposed approach with existing approaches. This report provides the information about implementation work and result comparison of proposed model with existing deep learning models. In order to compare to evaluate the accuracy of model with existing approaches, we found that the proposed hybrid model gives the accuracy 89.75% that may perform better than Long Short Term Memory and Convolutional Neural Network. If we compare the result of proposed model with other existing approaches, then we found the proposed model may perform better than other approaches.

CHAPTER 1

INTRODUCTION

Sentiment Analysis is the most important research field which gains a lot of attention since approximately the year of 2000. The fundamental cause for this is the exponential growth of data on a daily basis. Emotion AI uses sentiment analysis, often known as "opinion mining," to extract views, thoughts, and emotion from a text. It's an Artificial Intelligence subfield. Emotion artificial intelligence is a research project in the field of text analysis that is still in progress. With the growth of digital media, datasets are available in both text and images for sentiment analysis. Extension of social media platforms (Weibo, Twitter, and Instagram) people enabled to share their emotion, feelings, and thoughts. Nowadays, mental stress is a concern among the young generation, and they are suffering from stress. Growth in stress shows symptoms of anxiety, unmotivated, irritability, restlessness, sleep disorders and poor diet. Technology advancement, such as digital media, smartphones, blogs, social networks, video conferencing influences researchers to retrieve large data sets for analysis. According to hashtags tweets are being classified, as negative or neutral, which help to detect depression. Globally text messages widely used form of communication. For Emotion Artificial Intelligence, textual data is being used for data analysis and to detect sentiments using various ML techniques. As ML is a vigorous technique emerged to analyse these data. ML uses an advanced statistical and probabilistic technique to build intelligent systems that can automatically learn from the data. Machine Learning is efficient in analyzing big datasets generated from various sources. In the 1950s the term ML theoretically referred to by Allan Turing and named by Arthur Samuel and is being used in several fields including, medical health since the 1990s. Twitter is one of the largest platforms where people share their daily basis worldwide.

Natural Language Processing (NLP) to analyse the sentiments of tweets and classify them as positive, negative or neutral. NLP applied to subjective tweets rather than objective. It helps to make a faster and more accurate decision. It includes coverage of topics Stemming, Lemmatization, and tokenization. In data pre-processing, URLs, punctuations, stop words, lowercase conversion, POS tagging, TF-IDF, and N-grams are removed. Sentiment analysis is an opinion mining task that can be used to determine a writer's or speaker's feelings (e.g., "love," "angry," "sad," etc.) and attitude (positive, negative, or neutral) toward a certain activity, such as product reviews, movie reviews, or the overall tone of a document.Data is growing at an exponential rate in the digital age. Data is stored in a variety of formats, including structured, semi-structured, and unstructured data. Finding meaningful information through data analysis is a difficult task. (See Figure 1).

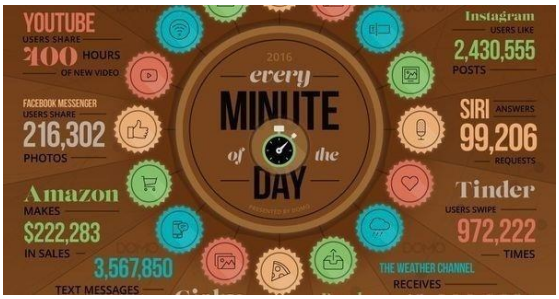

Figure 1: The data in every minute of the day

1.1 RESEARCHBACKGROUND

Everyone has the right to an opinion on whatever they read, watch, listen to, or do. They have the right to express themselves online as well.

-John Scalzi

1.2 PROBLEMSTATEMENT

Sentiment analysis, often known as "opinion mining" or "Emotion AI," is a type of artificial intelligence that extracts views, thoughts, and emotions from text. It's an Artificial Intelligence subfield. In the field of text analysis, research on emotion artificial intelligence is ongoing. With the rise of digital media, datasets for sentiment analysis are now available in both text and visual formats. There are a number of issues in this sector, including text pre-processing by computers, machine understanding of sentences, and so on.

This research work essentially centers on to improve the sentiment classification performance. So as to improve the exhibition of sentiment classification, we considered the issue which is portrayed beneath.

1.2.1 Text pre-processing: Movie Reviews

The movie review data has a lot of noise, which causes the sentiment classification process to produce false results. Stop words, POS tagging, html tags, and hyperlinks are examples of ‘noise' that impact text orientation. Each text is expressed as a vector in order to examine it. Each word in vector space represents one dimension. As a result, the problem becomes more complicated. The goal of this thesis is to look at the classifier in order to improve the classification process.

Movie review data is employed in a computational framework to evaluate the performance of a classification procedure with data pre-processing. The research is based on the IMDB movie review dataset. In this thesis, we used a machine learning-based approach.

1.3 OBJECTIVE

- To handle the text that contains positive and negative oriented opinion.
- Following the Word Embedding method to convert the words into vectors
- To investigate the deep learning-based classifier to the classification process.
- To improve sentiment classification performance using ensemble of LSTM and Convolutional Neural Network.

1.4 THESIS OUTLINE

This includes a brief description on chapters included in this thesis.

Chapter 1: This chapter opens up with focal point of the present proposal and illuminates the sentiment analysis field and, objective.

Chapter 2: The chapter explores the different methods that are used in sentiment analysis. It includes various Natural Language processing techniques. It also discussed the flowchart of the proposed work that contains data collection, data preprocessing and so on. This chapter also includes the fundamentals of deep learning models and gives the overview of different models named LSTM and CNN.

Chapter 3: This chapter includes the literature review part related to text classification field which has been already performed related to Sentiment Analysis.

Chapter 4: This deals with the methodology of proposed work and also discusses experimental work and result. This chapter also gives the detailed architecture of proposed hybrid model. It also gives the processing of implemented work.

It includes the experimental results which demonstrate sentiment analysis accuracies of different deep learning models.

Chapter 5: This includes the conclusion and future scope. This chapter concludes the overall experimental work.

CHAPTER 2

BACKGROUND

2.1 FLOWCHART OF PROPOSED WORK

The following flowchart shows sequential dataflow in proposed work. It contains different steps such as data collection, data preprocessing, feature extraction and estimation of sentiment polarity.

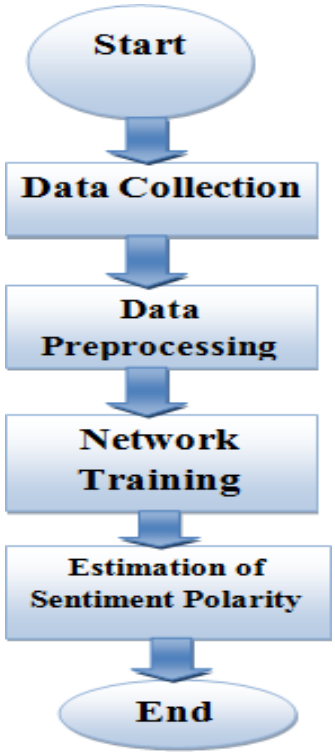

Figure 2.1: Flowchart of Proposed Work

To finish the task, there are usually four steps. In order to perform sentiment analysis, the first and most significant step is to collect data. This thesis report delves deeper into these topics..

2.2 BASICS OF SENTIMENT ANALYSIS

The approaches to sentiment analysis are discussed in this section. It includes several sentiment analysis categorization algorithms and different levels of analysis for performing sentiment analysis.

2.2.1 Sentiment Classification Techniques

The following diagram depicts the various sentiment analysis classification methods. It is broken into multiple subparts and covers both machine learning and lexicon-based techniques.

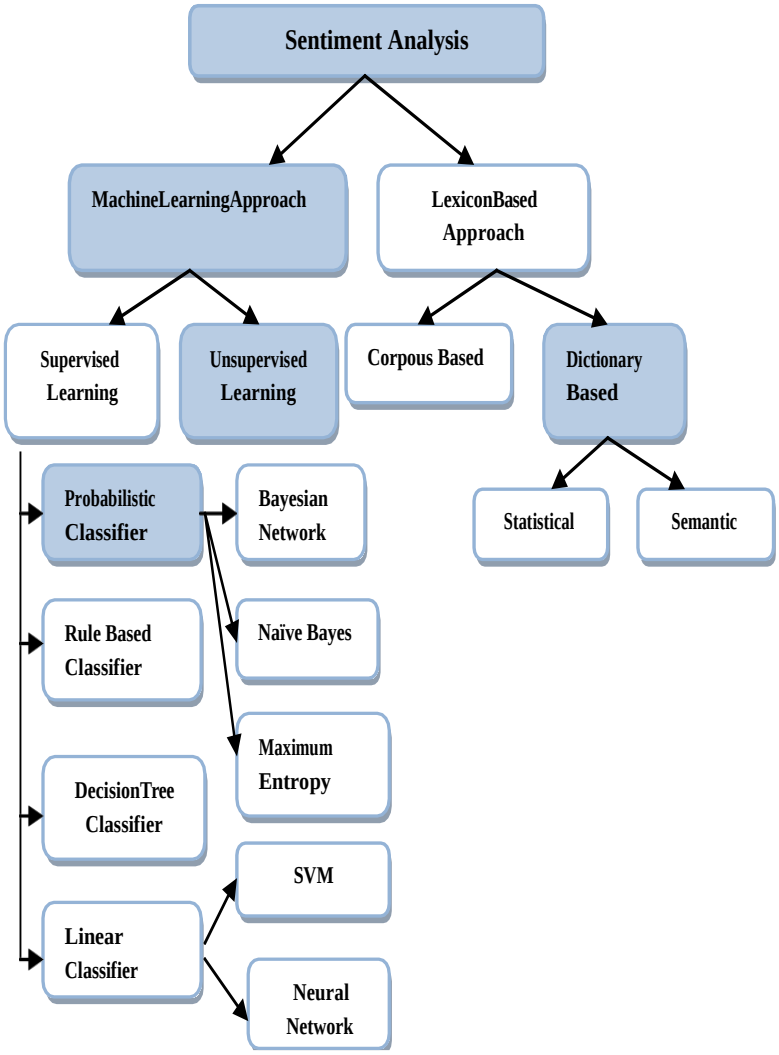

Figure 2.2: Sentiment Classification Techniques

Sentiment analysis can be performed by using classification methods [25]. To build Lexicon, a lexical analysis-based approach is employed to record the track of words. The number of counts for positive or negative terms in a particular text is provided by Lexicon. So that the polarity of a statement can be calculated. It can be divided into two categories: dictionary and corpus-based approaches.

Machine learning based approaches are used for sentiments analysis [26]. It will be accomplished by utilizing the data and text features. This data, along with its textual properties, is referred to as training data. It is divided into two categories: supervised learning and unsupervised learning. Labeled training data is used in the supervised learning approach. Different feature extraction techniques are used to extract the features, and feature selection procedures are used to select the best amount of features. Classifiers based on supervised learning are classified as probabilistic, linear, decision tree, and rule based.

2.3 DEPTH OF ANALYSIS

As per the opinion of Liu [27], there arefour levels of in the sentiments analysis, these are, document level, sentence level, word level and aspect level. These are explained below.

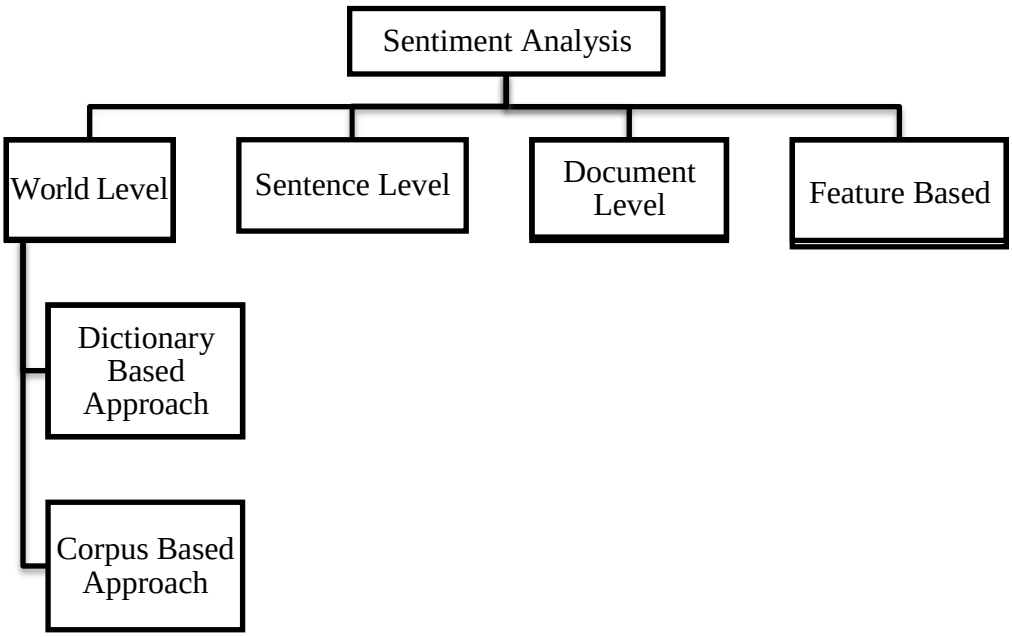

Figure 2.3: Sentiment Analysis Levels

- **Document level:** In this case, the entire document is chosen for sentiment analysis. It provides a single polarity, which can be positive, negative, or objective.
- **Sentence level:** The single opinion, such as positive or negative opinion, is analyzed at the sentence level. It is assumed that each sentence provides a single polarity orientation. [28].
- **Word level:** The word level analysis focuses on adverbs, adjectives, POS, nouns, and verbs. These words convey information about a person's sense of subjectivity and opinion. It is used to construct the sentiment analysis building block in this case.
- **Aspect level:** The polar phrases are included at the aspect level, together with their sentiment [29, 30]. For sentiment analysis, many machine learning-based algorithms have been utilized in the literature [48].

2.4

2.5 SENTIMENT ANALYSIS FOR MOVIEREVIEWS

It is one of the classification problems and uses NLP on many levels. Machine learning-based approaches have dominated most emotion analysis activities over the last two decades. Since feature representation has such a large impact on machine learning efficiency, several researches in the published studies concentrate upon using successful characteristics in conjunction with field knowledge and cautious engineering. Representation learning algorithms, on the other hand, will prevent this by automatically discovering discriminative and explanatory representation of text from input. Deep learning is a class of description learning method in which nonlinear neural networks have been used to learn several levels of representation, including the one that converts the transformation of a reflection from one point to a higher point and represents in more abstract manner. It is possible to portray can be added to identification and classification tasks as a function.

The result of the sentiment classification problem is misleading due to the large amount of noise in the movie reviews data. The term "noise" refers to stop words, POS tagging, html tags, and hyperlinks that have an effect on text orientation. Each text is expressed as a vector in order to be analyzed. As a result, in vector space, each word represents a single dimension.

This thesis focuses in to investigate the classifier to get better the classification performance. In a computational framework, movie review data is used to calculate performance of classification process with data preprocessing. IMDB movie review data are used for performing sentiment analysis [31]. We used machine learning based approach in thesis.

2.6 PRE-PROCESSING OF TEXTUAL DATA

It is a required stage in the categorization process. This document outlines the cleaning procedures and prepares the content for classification. There is a lot of ruckus and uninformative elements in the online information. There are numerous words that do not engage in general orientation and add to the complexity on a word level [32]. It raises difficulty in computational complexity [33]. The whole pre-processing technique includes a few stages:

- Cleaning of text
- Expanding Abbreviation
- Removal of white space
- Handling to Negation
- Feature Extraction and Feature selection
- tokenization
- normalization
- substitution

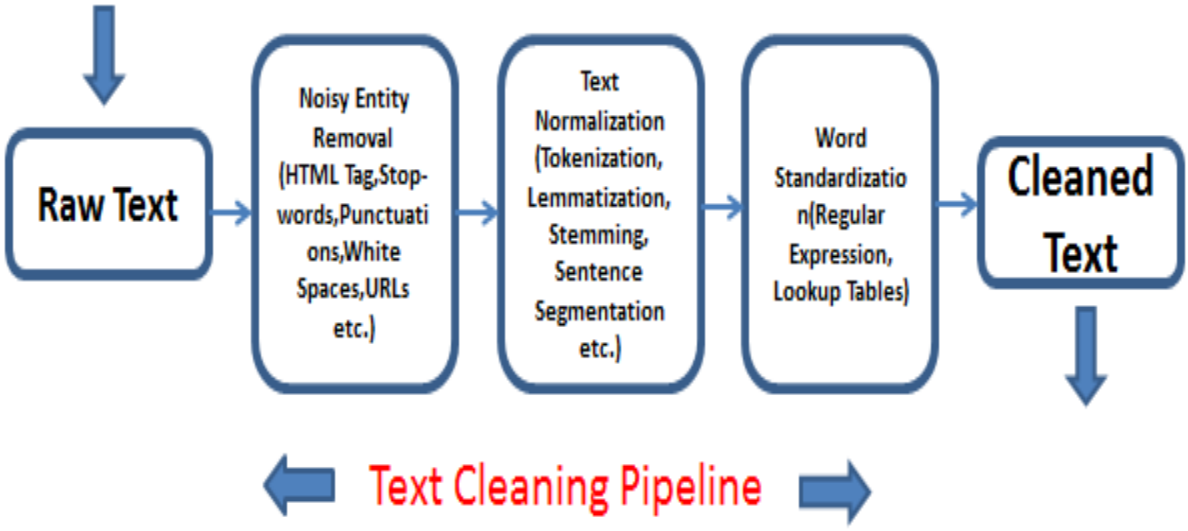

Figure2.4: The textual data preprocessing framework

1. Tokenization

Tokenization is the process of breaking down lengthy text strings into smaller chunks, or tokens. Larger sections of text can be tokenized into sentences, which can then be tokenized into words, and so on. After a piece of text has been suitably tokenized, sentiment analysis can be undertaken. Text segmentation or lexical analysis are other terms for it.

2. Expanding Abbreviation

In the sentiment analysis the abbreviation also creates a noise.So there is a need to expand the abbreviation. Here, they can be written as ‘they are’, hasn’t can be written as has not and so on [34]. So it is necessary to correct frequency of word as well as dimension of manuscript. Here, the negation reverses the meaning of the sentence.

3. Noise removal

Here, in this process the html tags,stop words, punctuation's, white spaces are being removed.There are numerous extra words that add no meaning to the sentence. Stop words are what they're called. As a result, that can be removed prior to the analysis. There are several methods for removing stop words, one of which is known as stoplist. Another method for creating a stop list is based on the frequency of words. Stop words are words that occur frequently. It is usually built from a dictionary[35].

4. Stemming

The Stemming is the process of eliminating affixes such as suffixed, prefixes, infixes and circumfixes from a word in order to obtain a word stem. For example:

$$\text{playing} \rightarrow \text{play.}$$

It helps in decreasing the dimensionality of content [36].Stemming allows the word and all of its derivations to be used as an ace word. In stemming, two algorithms are used: the Porter Stemming algorithm and the Suffix Stripping algorithm [37]. In this thesis stemming is used in classification will be address in chapter[4].

5. Lemmatization and Negation Handling

Lemmatization is the process to convert word to its root form.Lemmatization is a step by step procedure of obtaining the root form of the word. The lemmatization root word is called lemma.

For example:

word	lemma
studying	study
studies	study
beautiful	beauty
beautifully	beauty

Negation handling is the processes of transformation. The sentence contains different type of negation. The direct negation, for example, ‘not nice’ and long distance negation where negation words and negated terminology are separated, for an example “not very interesting, does not have good movie [38].

6. Feature

In the sentiments analysis, a feature might be words, phrases, or keywords that convey a negative or favorable impression. It's used in sentiment analysis to reduce dimensionality. It can be classified into two types, the first of which is explicit and the second of which is implicit. The features are considered to be explicit if it appears in content otherwise as explicit feature. It can be considered in the form of unigram, bigram or n- grams subject to necessities. We achieve better polarity classification [39].

Term Frequency-Inverse Document Frequency (TF-IDF)

By multiplying the TF and IDF scores, the Term Frequency-Inverse Document Frequency (TF-IDF) value is achieved.

Term Frequency (TF):

The term frequency of a word refers to the number of times the word appears in the document. The term frequency is divided by the document length for normalization.

$$TF(t) = \frac{Number\ of\ times\ term\ t\ appears\ in\ a\ document}{Total\ number\ of\ term\ in\ the\ document}$$

Inverse Document Frequency (IDF)

The Inverse Document Frequency (IDF) score indicates how uncommon a word is across documents. It reflects the importance of a word in a written text documents.

$$IDF(t) = \ln(\frac{Total\ number\ of\ documents}{Number\ of\ documents\ with\ term\ t\ in\ it})$$

$$TF - IDF\ score = TF * IDF$$

2.7 DOCUMENT SENTIMENT CLASSIFICATION

The emotion towards content or an opinion is taken as the classification problem. There are two classes named as positive and negative. There is another method for classification which depends on ranking factor named as star based ranking. Therefore problem is known as multi-class categorization task [41].

There are huge number of classification algorithms that is worn in text mining and Machine learning, for example SVM, Word Count Classifier etc. Language dependent classification can be defined as the linguistic characteristic of text.

2.8 PERFORMANCE EVALUATION

In text classification, the evaluation is usually based on the classifier's effectiveness rather than its efficiency. There are several methods for evaluating performance measures, such as precision, recall, accuracy, f-measure, and so on [42,43,44]. They are typically evaluated using a confusion matrix table, which displays the correctly and incorrectly classified cases. The error matrix Table 2.7 is as follows:

Table 2.7: Confusion Matrix

	Label 1 (Predicted)	**Label 2 (Predicted)**
Label 1(Actual)	Tn	Fp
Label 2 (Actual)	Fn	Tp

The classification results are shown in the table above, with TN denoting ‘true negative,' FP denoting ‘false positive,' FN denoting ‘false negative,' and TP denoting ‘true positive.' That is the number of positively predicted classes that are correctly predicted. We calculate accuracy, recall, specificity, and other metrics using these parameters.

- **Accuracy**: It's used to assess the performance of models through binary classification. The confusion matrix is used to calculate it.

$$\textbf{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \qquad \textbf{(2.3)}$$

2.9 FUNDAMENTAL CONCEPTS OF MACHINE LEARNING

This section contains fundamental concepts of machine learning. It provides detailed information about deep learning based approaches likewise Recurrent Neural Network, CNN, Gated Recurrent Unit and so on.

2.9.1 Artificial intelligence

Alan Turing pioneered artificial intelligence in the 1950s. “Artificial Intelligence is the technique that allows computers to mimic human behaviour” [18]. AI is defined as “the simulation of human intelligence processes by machines, particularly computer systems; these processes include learning, reasoning, and self-correction” [19].

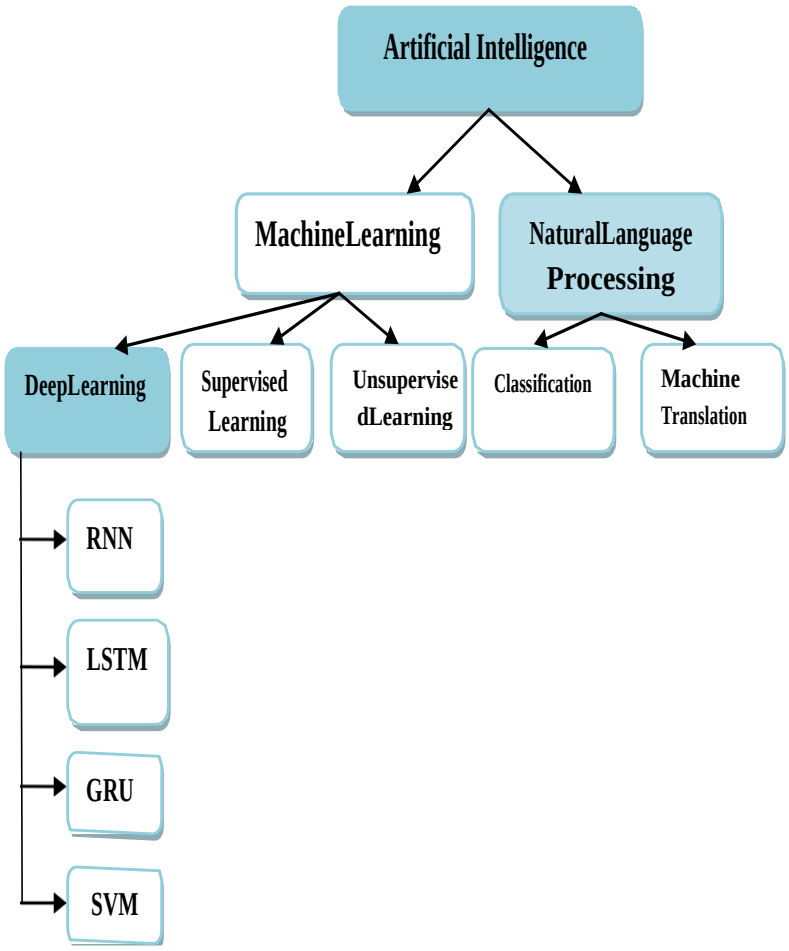

Figure 2.5: Artificial Intelligence

2.9.2 Machine Learning

Machine Learning is the application of AI that makes systems able to learn automatically. In the ML the system can learn from historicaldata, examples, and experiences,to make decisions.

2.9.3 Deep Learning

Deep learning is based on learning many layers of representations with the help of artificial neural networks, and is a part of machine learning. Deep learning has its applications in variety of fields like Computer vision, recognition of speech, natural language processing etc.

2.9.4 Natural Language Processing

Natural language processing (NLP) refers to a group of techniques for dealing with natural languages. It has to do with natural language interaction between computers and humans. NLP approaches are used in a variety of ways, including voice assistants, text filtering, and machine translation.One of the uses of Natural Language Processing is sentiment analysis. It is the process of extracting emotions, thoughts, feelings, and sentiments about a specific task. In this thesis, we perform sentiment analysis on IMDB movie review dataset by using classification process.

2.9.5 Deep Learning Models

It's a subset of Machine Learning in which the number of layers (multilayers) used to produce better outcomes is raised. It's a term for a big neural network. Data is passed through interconnected layers of nodes in a neural network. Deep learning models have dozens or hundreds, of hidden layers that allow them to learn and improve over time. This thesis presents the various deep learning-based models used for sentiments analysis.

2.9.5.1 Recurrent Neural Network

One of the deep learning algorithms for sentiment analysis that is based on sequential data is the recurrent neural network. It uses sequential information to produce the output based on earlier computations. The re- current neural network (RNN) in the neural setting is used to solve these dependency- based functions, with considerable results. A typical RNN evaluates the output secret vectors in a timely order manner.The RNN is considered to be a framework in deep learning as it has basic network architectures that can be used for the design of the other deep

learning architecture. The recurrent network might have a connection that feedback to last layers despite full feed forward (or into the same layer) this differentiates it from the traditional multilayer network. The feedback system enables the RNNs can keep track of the recently acquired inputs and loop hole in the model in run time environment

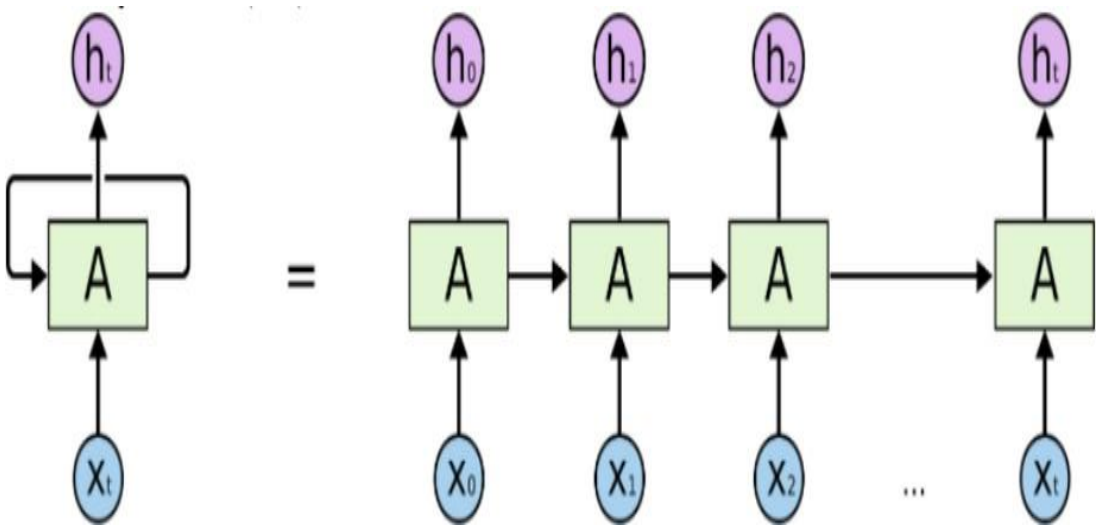

Figure 2.6: Recurrent Neural Network Structure

The number of input sequences is denoted by Xt, and the number of output sequences is denoted by ht in the diagram above. RNNs often do analysis using short-term memory. It can learn more recent words than older words, which causes the vanishing gradient problem. To overcome the vanishing gradient problem, a recurrent neural network employs Long Short Term Memory.

2.9.5.2 Long Short Term Memory

Long Short Term Memory is another model which is used for sequential information and presented by the Sepp Hochreiter and Juergen Schmidhuber [20]. Sepp Hochreiter and Juergen Schmidhuber presented another model for sequential information called long short term memory. LSTM networks are a form of RNN that may learn order dependence in the situations of sequence prediction. The LSTM architecture is an RNN that remember information at regular periods. It is employed in the solution of the vanishing gradient problem. It has the ability to learn long-term dependence. At observation time, RNN has only two gates: an input gate as well as an output gate from the last hidden state and there is no knowledge about the past to remember. RNNs can remember their inputs for a long time due to LSTMs. That is why long short term memory uses their memory to accumulate the information over a long period of time. This memory cell is known as a gated cell, because it represents whether or not to store or delete information dependent on the relevance of the information. LSTM is made up of three gates. The input gate is used for new data input, the forget gate is used to determine whether or not the data should be deleted, and the output gate is used to determine the output at the current time step.

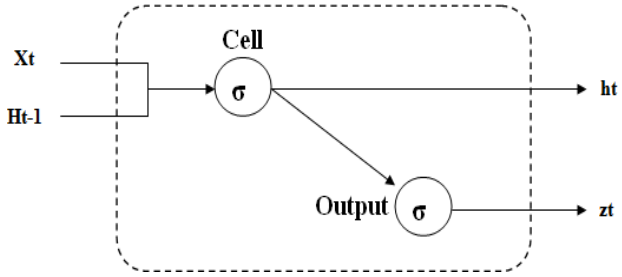

Figure 2.7: Recurrent Neural Network Cell

RNNs can remember their inputs for a long time due to LSTMs. Long Short Term Memory does this by storing information in their memory over a long period of time. This memory cell is referred to as a gated cell because it represents whether or not to store or delete information based on its relevance (by weights).The LSTM is composed of three gates. The input gate receives new data, the forget gate determines whether the data should be deleted, and the output gate determines the output at the current time step. The diagram depicts the LSTM gate structure.

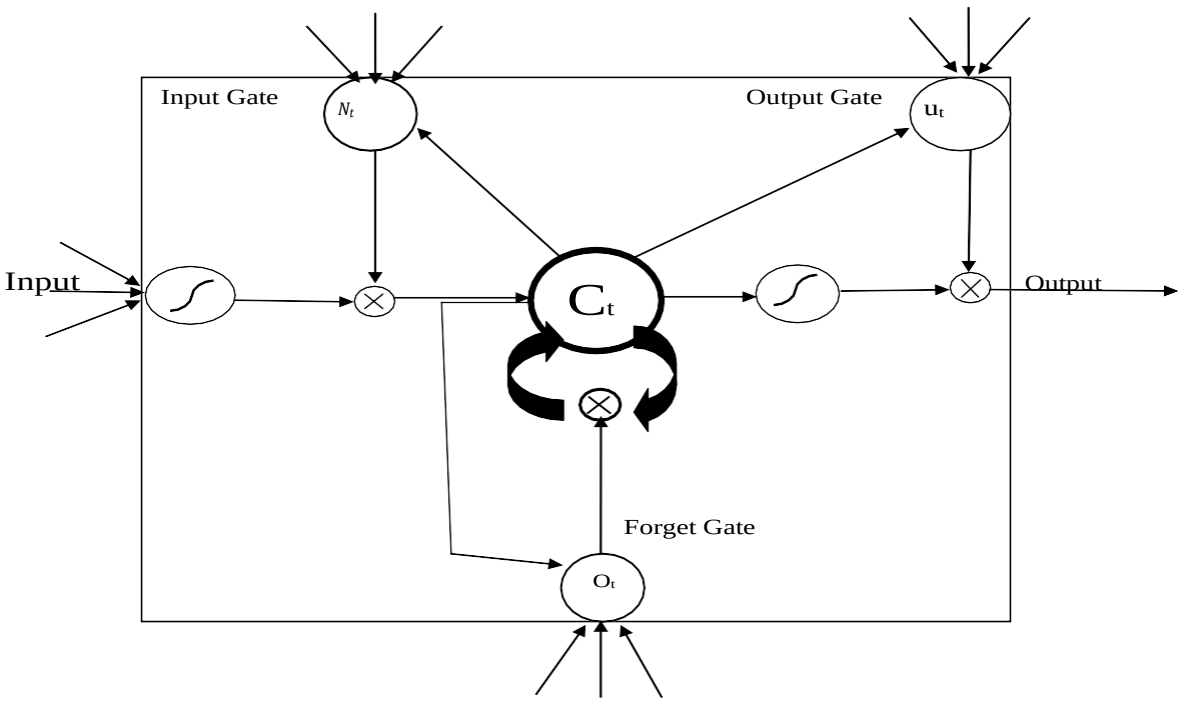

Figure 2.8: Long Short Term Memory Gate Structure

2.9.5.3 Convolutional Neural Network

Convolutional Neural Network was initially developed in the neural network image processing community. A CNN involves basically two operations named as convolution and pooling as feature extractors. The output of this sequence of operations are connected to fully connected layer same as Multi-layer perceptron. There are basically two kind of pooling used such as max-pooling and average-pooling. The neural network image processing group was the first to create the convolutional neural network. ConvNets are developed to accommodate data in the form of several arrays, such as a colour image made up of three 2D arrays representing pixel elevations in each of the colour channels. As attribute extractors, a CNN uses two operations such as convolution and pooling. As in a multi-layer perceptron, the output of this series of operations is bound to a completely connected layer. Convolutional neural networks are often used on text in Natural Language Processing. There are two types of pooling used: max-pooling and average-pooling. When we use CNN for text instead of images, we display the text with a 1-Dimensional string. CNN is mostly used in sentence classification in NLP tasks.

CNN is also used in Natural Language Processing. When we use CNN to represent text rather than images, we use a 1-Dimensional array. CNN is commonly used in the classification process in NLP tasks. Each sentence or document is represented as a matrix in order to perform text classification.Each row of the matrix displays a single token, which is typically a word. We can say that each row is a vector that represents a word. These vectors are typically word embeddings such as word2vec and Glove. Word embeddings are low dimensional representations of vectors, but they could also be one-hot vectors that index the

word into vocabulary.

In NLP task, we use filters over full rows of the matrix so the width of filters and the width of input matrix are same. CNN model has given beneath:

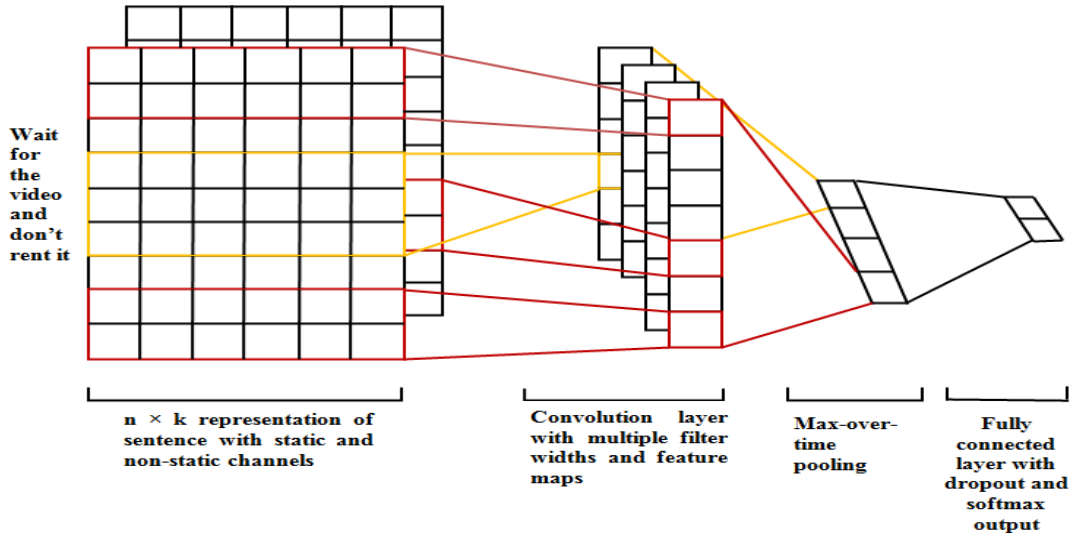

Figure 2.9: Convolutional Neural Network Model

The earliest layers of the model incorporate words into low-dimensional vectors, as seen in the diagram above. Convolutions are applied to the embedded word in the next layer.The convolutional layer's result is then max-pooled, dropout regularization is applied, and the result is classified using a softmax layer. [22]. In this thesis, we use CNN for text classification to perform emotion analysis on IMDB movie review data.

CHAPTER 3

RELATED WORK

For the accurate classification of sentiments, numerous analysts have tried endeavors to consolidate machine learning and deep learning ideas concept in ongoing years. This section quickly portrays the various investigations, related to sentiment analysis of web contents about user's sentiments, emotions, opinion toward various matters like motion pictures and products using machine learning techniques.

The authors have been presented the hybrid model for text classification that gives the better accuracy than traditional models. In this paper, they combined two traditional neural network model named as CNN and LSTM. The experimental result showed the improved accuracy of text classification. They evaluate 87.31% accuracy [1]. An efficient model is proposed by authors for sentiment classification which calculates the accuracy 82.53% on Bengali text. In order to evaluate, they used two deep neural network models such as deep RNN with BiLSTM [2]. It has achieved significant results in field of text classification. The authors have been presented an innovative approach for target- based emotion analysis that reduces training time of proposed model through regional Long Short Term Memory [3].

Deep learning models are frequently used in Natural Language Processing applications. An efficient approach has been proposed for multi-domain system that is based on word embedding. The tool named NeuroSent gives the accuracy 85.15% by using amazon web site dataset for multi-domain [4]. Some of the machine learning models are based on content classification in NLP. An ensemble method proposed for Vietnamese text for sentiment analysis by some researchers. In this approach they combine traditional method with deep learning algorithm. This proposed approach gives the accuracy 89.19% by using

vote rule [5]. The author has been presented a paper on deep learning approach for text classification[6].

A novel approach has been proposed for IMDB movie review sentiment analysis by using Deep CNN-LSTM model that gives the accuracy 89% [7]. Some authors give survey on various models for analysis. A comparative study is given by using deep learning models and classifiers [8]. Researchers have been proposed an approach for analysis [9]. The ensemble approach has been performed better than traditional models in the field of text classification. The authors have been presented a machine learning method for performing analysis. They used Long Short Term Memory, Naïve Bayes and SVM for analysis by using reviews on Google Play in Chinese[10].

The authors have been proposed a model named SentiWordNet that is depend on Word2Vec to perform sentiment analysis [11]. A novel approach proposed by researchers named ECNN that is to identify opinion, polarity and emotions in microblogs [12]. In order to perform sentiment analysis, the authors have been presented the model related to text classification. They used word embedding at word level and sentence level by using skim gram model [13]. The authors have been proposed a model for text analysis base on CNN and SVM [14]. The authors have been proposed an efficient method to perform sentiment analysis on IMDB review dataset. They found that deep learning model RNN is effective in terms of words semantic and evaluate the accuracy 89.8% [15].

The author has been build a model that is based on heterogeneous feature [16]. The authors have been used word embedding for sentiment analysis. An efficient approach has been proposed for sentiment analysis by using word embedding [17]. Some of the authors have been presented the overview of sentiment analysis. This paper presents the different

feature selection methods and machine learning algorithms [23]. A joint framework has been proposed for sentence classification that is based on CNN and RNN. The proposed framework gives the accuracy 93.3% on movie review dataset [24].The authors have been proposed an approach for analysis. This paper presents the ConvLstm accuracy 88.3% for fine-Grained [25].

The authors have been presented an approach for analysis. Patel Alpna and tiwari AK [45] is calculated the accuracy 87.42% by using RNN. The authors have been presented a method for feature extraction by using deep CNN [46]. Patrawut Ruangkanokmas *et. al.* have been proposed a model named Deep Belief Network. They have used semi-supervised method known Deep Belief Network with Feature Selection Method [47]. The authors have been proposed a framework for users interests classification that is based CNN and Word2Vec. The proposed framework is based on deep learning and they used CBOW as feature extraction algorithm and SVM for classification that give the accuracy 96% on IMDB movie review dataset [48].

Changliang Li *et. al.* [49] builds the Chinese Sentiment Treebank over social data and further introduces an approach named Recursive Neural deep model for analysis process. The authors have been used word vectorization to extract corpus feature and PCA to reduce dimension [50]. Kumar Ravi *et. al.* [51] performed sentiment analysis on article citation sentences and they have been proposed an ensemble method for deep learning. The

authors have been performed sentiment analysis by using word embeddings techniques like word2vec and Glove as pre-trained vector [52]. The following Table 3.1 shows the summary of different machine learning approaches by authors to performs text analysis:

Table 3.1: Summary of the Machine Learning Approaches for Sentiment Analysis

Reference No.	Author's Name & Year	Proposed Approach	Result
[1]	Jiarui Zhang, Yingxiang Li， Juan Tian and Tongyan Li [2018]	CNN-LSTM	87.31%
[2]	Abdullah Aziz Sharfuddin, Md. Nafis Tihami and Md. Saiful Islam [2018]	BiLSTM	85.67%
[3]	Siyuan Chen, Chao Peng, Linsen Cai and Lanying Guo [2018]	CNN-RLSTM	94.35%
[4]	Mauro Dragoni and Fondazione Bruno Kessler [2017]	NeuroSent	84.60%
[5]	Hoang-Quan Nguyen and Quang-Uy Nguyen [2018]	Vote-rule	92.80%
[6]	Ali Alwehaibi and Kaushik Roy [2018]	AraFT	93.5%
[7]	Alec Yenter and Abhishek Verma [2017]	Base-Model	84.98%
[8]	Min-Yuh Day and Yue-Da Lin [2017]	Deep Learning with Bi-LSTM	94.00%
[9]	Abdalraouf Hassan and Ausif Mahmood	Convlstm	88.3%

	[2017]		
[10]	Benwang Sun, Fang Tian and Li Liang [2018]	CNN-LSTM	86.21%
[11]	Eissa M.Alshari, Azreen Azman, Shyamala Doraisamy, Norwati Mustapha and Mostafa Alkeshr [2018]	Senti2vec	85.4%
[12]	Guang Yang , Haibo He , Fellow, IEEE, and Qian Chen [2019]	ECNN	72.55%
[13]	Zhihua Zhang and Man Lan [2015]	MS-skip, CS-skip	87.89%, 89.62%
[14]	Jingjing Cai, Jianping Li, Wei Li And Ji Wang [2018]	TextRNN+ Attention	84.56% (precision)
[15]	Arman S. Zharmagambetov and Alexandr A. Pak [2015]	Deep Learning	89.8%
[16]	Rachana Bandana [2018]	Naïve Bayes, Linear SVM	84%, 79%
[17]	Oscar B. Deho, William A. Agangiba, Felix L. Aryeh and Jeffery A. Ansah [2018]	Word2Vec	81%
[23]	Yelena Mejova [2009]	-	-
[24]	Abdalraouf Hassan , (Member, Ieee), and	Deep learning	93.2%

	Ausif Mahmood, (Senior Member, Ieee) [2018]		
[25]	Abdalraouf Hassan and AusifMahmood	ConvLstm	88.3%
[45]	Alpna Patel and Arvind Kumar Tiwari [2019]	RNN	87.42%
[46]	Soujanya Poria, Iti Chaturvedi, Erik Cambria and Amir Hussain [2017]	Multimodel	96.55%
[47]	Patrawut Ruangkanokmas, Tiranee Achalakul, and Khajonpong Akkarajitsakul [2017]	DBNFS	72.2%
[48]	Abubakr H. Ombabi, Onsa Lazzez, Wael Ouarda, Adel M. Alimi [[2017]	CBOW	96%
[49]	Xingtong Ge and Xiaofang Jin, Bo Miao, Chenming Liu and Xinyi Wu [2018]	Random Forest Classifier	94%
[50]	Changliang Li, Bo Xu, Gaowei Wu, Saike He, Guanhua Tian and Hongwei Hao [2014]	RNDM	95%
[51]	Ravi kumar, Vadlamani Ravi, Srirangaraj Setlur and Venu Goovindaraju [2018]	wvCNN-non-static	44.4%(Mac F1)
[52]	Liang-Chih Yu, Jin Wang K. Robert Lai and Xuejie Zhang [2017]	DAN, CNN, Bi-LSTM, Tree-LSTM	87.3%, 87.9%, 88.6%, 90.3% (Binary)

This chapter provides the overview of related work to this field and discusses the different work done by different researchers in the field of text classification that is very helpful to this research work.

CHAPTER 4

IMPLEMENTATION WORK AND RESULT ANALYSIS

In this chapter, we proposed an efficient ensemble approach that is depends on Long Short-Term Memory and Convolutional Neural Network with max-pooling layer. The given step is followed by proposed model.

- Word Embedding is used to convert the words into vectors in given text.
- Hybrid model used two deep learning models named as LSTM and CNN for feature extraction.
- Text classification by using Soft Max function.

4.1 Introduction

Sentiment Analysis is the most important research field that has received a lot of attention since around the year 2000. The primary reason for this is the explicit growth of data on a daily basis. There are numerous data generation methods, such as social media sites (twitter, facebook, linkedIn, and so on), RSS news feeds, blogging sites, e-commerce sites, and so on [23]. These are the places where people express their emotions, ideas, and attitudes (positive, negative, or neutral) toward a specific task. Various for-profit and non-profit organisations use sentiment analysis for decision making and eagerly want to know what customers think about the products and services they offer.

In a sense, sentiment analysis began as a research topic in Natural Language Processing around the world. The most important application of NLP, computational linguistics, and text processing is sentiment analysis.Sentiment analysis is an opinion mining task used to determine a writer's or speaker's feelings (e.g., "love," "angry," "sad," etc.) and attitude (positive, negative, or neutral) toward a specific activity, such as product reviews, movie

reviews, or the overall tone of a document. Data is growing at a rapid rate in the digital age.Data is stored in a variety of formats, including structured, semi-structured, and unstructured data. Finding meaningful information through data analysis is a difficult task.

4.2. Related Work

For the accurate classification of sentiments, numerous analysts have tried endeavors to consolidate machine learning and deep learning ideas concept in ongoing years. This section quickly portrays the various investigations, related to sentiment analysis of web contents about user's sentiments, emotions, opinion toward various matters like motion pictures and products using machine learning techniques.

The authors have proposed an efficient deep learning classifier for sentiment classification which calculates the accuracy of 82.53% on Bengali text. In order to evaluate the performance, they used two deep neural network models such as deep RNN with BiLSTM [1]. Deep learning techniques achieved significant results in text analysis. Chen S et. al. [2] has been proposed an innovative method for target-based sentiment analysis which reduces the training time of the proposed model through regional LSTM. Deep learning models are frequently used in NLP applications. An efficient approach has been proposed for the multi-domain system that is based on word embedding. The tool named NeuroSent gives an accuracy of 85.15% by using the Amazon web site dataset for multi-domain [3]. Some of the deep learning models are based on sentence classification in Natural Language Processing and some of them are based on traditional models like SVM, RNN, LSTM and much more. In this literature survey, we basically study the ensemble approaches to improve the performance. Some authors proposed an ensemble method for text classification by using Vietnamese text. In this technique, they have merged the

traditional models with deep learning models and achieved the remarkable result that is 89.19% [4]. Some authors have done their research study in artificial intelligence on deep learning models. The review basically focuses on text classification by using different datasets [5]. A novel approach has been proposed by authors that are based on an ensemble of two models and achieves the accuracy 89%. They have used the IMDB movie review dataset for the analysis process [6]. The ensemble approach gives outstanding results over traditional models in text analysis. We noticed that the ensemble approaches performed much better than traditional models. Some authors have proposed a machine learning-based approach for improving the performance of sentiment analysis. They have used LSTM, Naïve Bayes and SVM for analysis process [7]. Some authors have gained remarkable results in the field of Natural Language Processing by using deep learning techniques for text classification [8]. In order to do classification, the authors have used Tibetan microblogs and achieved the result up to the mark [9].

The deep learning-based models improve the result in the field of NLP over the years. The authors have proposed a model named SentiWordNet and achieved better results. The model used word2Vec to perform analysis [10]. A novel approach ECNN has proposed that is used to identify opinion, polarity, and emotions in microblogs [11]. Numerous researchers have proposed a model related to sentiment classification. They have used word embedding methods of learning at the word level and sentence level [12]. In this field of research, we can achieve better results by using deep learning-based approaches. The authors have proposed an ensemble approach that is the result of two machine learning models CNN, SVM for text sentiment analysis [13]. Many researchers have proposed an efficient method to perform classification processes on the IMDB review dataset and they found that RNN performs effectively in terms of words semantic and they achieved an

accuracy of 89.8% [14]. In order to perform analysis, there are different parameters used such as feature extraction, opinion mining, applying different kinds of machine learning algorithms. An approach has been proposed that is based on a machine learning and Lexicon based features to perform sentiment analysis on the movie review dataset [15]. Word embedding is a technique that is used to convert the words into vectors. The researchers have been using the word embedding method for sentiment analysis. An efficient approach has been proposed for sentiment analysis by using word embedding [16].

4.3 Materials and Methods

This section presents the detailed overview of the proposed model to classify sentiments in movie domain.

4.3.1 Data set Description

In order to evaluate the performance, we have used the IMDB dataset. It includes 25000 numbers of data on movie reviews from the Kaggle website that contain binary values named positive and negative sentiment. This paper uses the IMDB movie review dataset for the purpose of experimental work, the dataset contains 25000 numbers of data in which a 75% number of data for the training set and 25% number of data for the validation set. After the split the dataset, further we perform dataset preprocessing tasks to clean the raw data and break the sentences into words and words into text.

4.3.2 Sentiment Analysis using Convolutional Neural Network with LSTM

The proposed approach uses two classifier of deep learning i.e Long Short Term Memory and Convolutional Neural Network. It uses word embeddings as input and takes them to LSTM for feature extraction and further output is given to CNN and followed by

classification layer. The following step is followed by a proposed approach:

Word Embedding method is used to convert the word into featured vectors in the given text. The hybrid model takes the advantages of two deep learning approaches such as LSTM and CNN for feature extraction. The classification layer uses the Softmax activation function to compute the predictive probability.

4.3.2.1 Long Short Term Memory

Sepp Hochreiter and Juergen Schmidhuber presented another model for sequential information called long short term memory. LSTM networks are a form of RNN that may learn order dependence in the situations of sequence prediction. The LSTM architecture is an RNN that remember information at regular periods. It is employed in the solution of the vanishing gradient problem. It has the ability to learn long-term dependence. At observation time, RNN has only two gates: an input gate as well as an output gate from the last hidden state and there is no knowledge about the past to remember. RNNs can remember their inputs for a long time due to LSTMs. That is why long short term memory uses their memory to accumulate the information over a long period of time. This memory cell is known as a gated cell, because it represents whether or not to store or delete information dependent on the relevance of the information. LSTM is made up of three gates. The input gate is used for new data input, the forget gate is used to determine whether or not the data should be deleted, and the output gate is used to determine the output at the current time step.

4.3.2.2 Convolutional Neural Network

The neural network image processing group was the first to create the convolutional

neural network. ConvNets are developed to accommodate data in the form of several arrays, such as a colour image made up of three 2D arrays representing pixel elevations in each of the colour channels. As attribute extractors, a CNN uses two operations such as convolution and pooling. As in a multi-layer perceptron, the output of this series of operations is bound to a completely connected layer. Convolutional neural networks are often used on text in Natural Language Processing. There are two types of pooling used: max-pooling and average-pooling. When we use CNN for text instead of images, we display the text with a 1-Dimensional string. CNN is mostly used in sentence classification in NLP tasks.

4.3.2.3 The Proposed Approach

The proposed approach ensemble the advantages of two deep learning classifiers i.e LSTM and CNN.. In this approach, the convolutional layer uses Max-pooling. The ensemble approach uses the embedding layer to take the input in the form of words and pass it to the multi-layer LSTM model. The multilayer LSTM generates the output and it is further passed to the convolutional layer as an input for further process. After the output of the convolutional layer passed to the classification layer for the classification process. The convolutional layer extracts the features of text sequences.

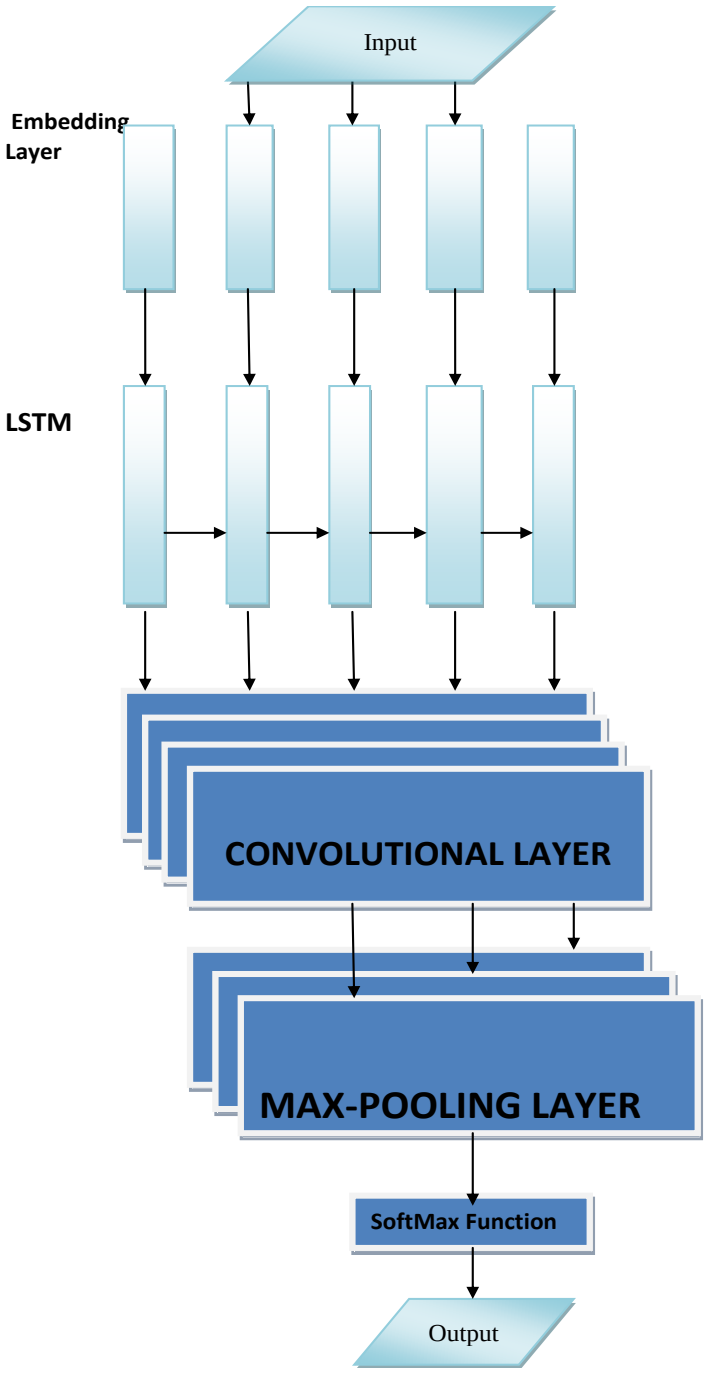

Figure 4.1: Framework of the Proposed Model

4.4 RESULT AND DISCUSSION

This section briefly discusses the experimental setup and measures the result of the approach. The performance was evaluated by using different parameters.

4.4.1 Performance Measure

$$\text{Accuracy}=\frac{tp+tn}{tp+tn+fp+fn}X\ 100\%$$

The parameter accuracy is used to validate the proposed hybrid model by using the test set and validate set.

Table 4.1 : ACCURACY COMPARISON OF ENSEMBLE APPROACH WITH DEEP NEURAL NETWORK MODEL FOR SENTIMENT ANALYSIS

Deep Learning Models	Valid Accuracy
LSTM	84%
CNN (max- pooling)	88.96%
Proposed model	**89.75%**

Here, we compare the outcome of proposed approach over traditional approaches. Here The LSTM provides accuracy 84%, CNN provides an accuracy 88.96%. and proposed model provides an accuracy 89.75%. We can see that the proposed approach gives the outstanding result over other deep learning approaches.

4.5 CONCLUSION

Sentiment classification is the method of extracting a user's view as positive or negative for a specific task. We have introduced an efficient approach for sentiment analysis that ensemble the advantages of two deep learning models name as Long Short-Term Memory and Convolutional Neural Network. LSTM overcomes the vanishing gradient problem and preserves historical information of long-term text dependencies. Further, CNN extracts the feature of context. In this paper, the proposed ensemble approach efficiently improves the accuracy of sentiment classification. The proposed ensemble approach gives an accuracy of 89.75% on IMDB movie review data. It is found that the proposed approach performs better than other deep learning approaches

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

Natural Language Processing (NLP) is a branch of computer science that studies how humans and computers interact. One of the most essential uses of NLP is sentiment analysis. This is a method of obtaining a writer's point of view, whether good or negative, for a specific goal. Email categorization, online search, spam screening, and information retrieval are all included. This thesis discussed several data preprocessing techniques and feature extraction methods such as tokenization, stemming, and n-grams, among others. The thesis also discusses different classification techniques such as Lexicon and machine learning based approach and also provides detailed overview of deep learning models.

The learning process in a machine learning-based approach is divided into two types of algorithms: supervised learning and unsupervised learning. For content categorization, the first learning phase employs a variety of algorithms, including SVM, Nave Bayes, maximum entropy, and regression. Unsupervised learning method uses word embedding for large unlabeled data. This report discussed the different deep learning models such as LSTM and CNN.

This report discussed about the hybrid model that gives the accuracy 89.75% on IMDB movie review data that is better accuracy than other existing approaches such LSTM, CNN. If we focused on the implementation part, we found that the proposed model evaluate the accuracy 89.75% that is much better the other one for text mining. This paper concludes that the proposed hybrid model performs better than other models and concludes that the deep learning model is better than traditional models in respect to complexity.

5.2 FUTURE SCOPE

This field has been popular because of several challenging research-oriented problems in recent years. It includes various issues in the area of content classification likewise stock market price prediction, business analysis, decision making and so on. This thesis report presents the hybrid model which gives the better accuracy. Similarly, one could merge two different deep learning models to improve the accuracy in classification. This hybrid model gives improved accuracy compare to individual one. This thesis dealt with English language but other could use different language for sentiment analysis, for example Roman text, Bengali Text and many more.

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Dissertation

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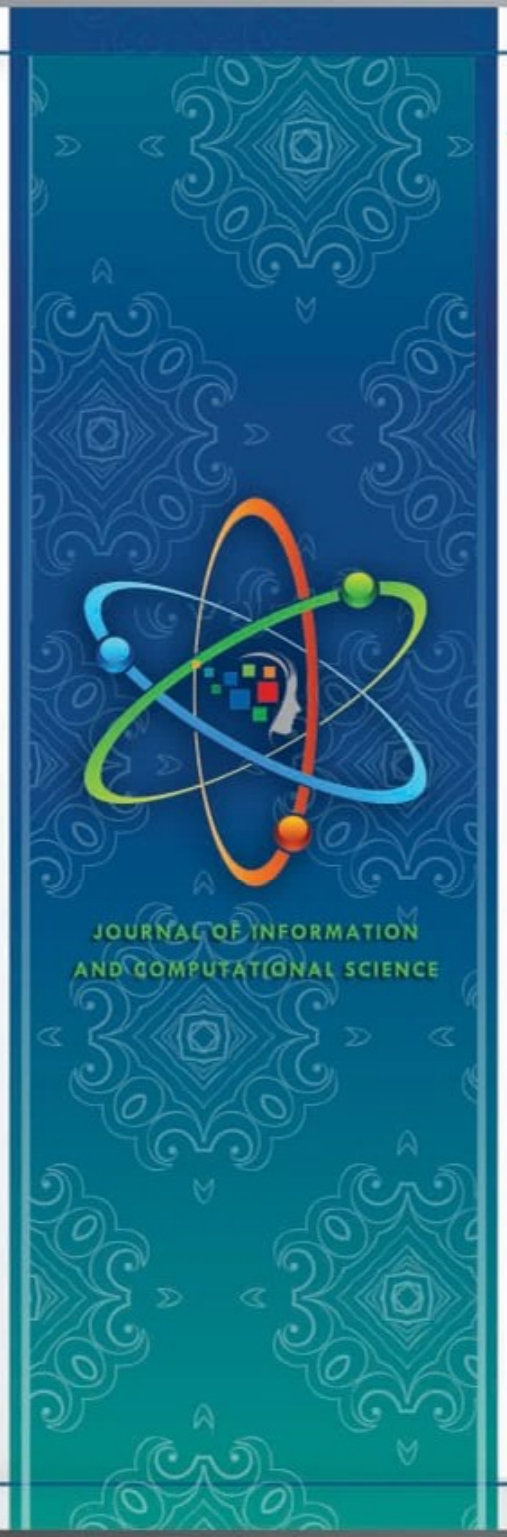

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Sentiment Analysis using Convolutional Neural Network with LSTM

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Abstract: *Sentiment classification has become the most effective research area in NLP due to an increase in public interest in movies, outlooks, and elections. It aims to identify opinions, emotions, and attitudes towards specific tasks like movies, events, elections and many more. In this paper the IMDB movie review dataset and Long Short Term Memory and Convolutional Neural Network are to analyze the experimental result. The proposed hybrid model achieved the accuracy 89.75% that better in comparison with Long Short Term Memory and Convolutional Neural Network..*

Keywords:Natural Language Processing; Sentiment Analysis; Deep Learning Classifiers; LSTM; CNN

1. Introduction

Sentiment Analysis is the most important research field which gains a lot of attention since approximately the year of 2000. The main reason behind this is, the explicitly growth if data day by day. There are various methods of data generation likewise social media sites (twitter, facebook, linkedIn etc.), RSS news feeds, blogging sites, e-commerce sites and many more [23]. These are the sources where people share their feelings, ideas and attitude (positive, negative or neutral) towards the particular task. The various profit and non- profit organizations use sentiment analysis for decision making and willingly to know the customer reviews and feel about products and services they provide.

In a way, sentiment analysis started as a research topic in Natural Language Processing across the world. Sentiment analysis is the most important application of NLP, computational linguistics and text processing. Sentiment analysis is the opinion mining task that can be used to obtain the writer's or speaker's feelings ("love", "anger", "sad" etc.), attitude (Positive, negative or neutral) towards particular task such as product reviews, movie reviews or overall tonality of document. In the era of digitalization, the data increases day by day. Data stores in different format such as structured

data, semi- structured data and unstructured data. The challenging task is to find out useful information through analysis of data..

2. Related Work

For the accurate classification of sentiments, numerous analysts have tried endeavors to consolidate machine learning and deep learning ideas concept in ongoing years. This section quickly portrays the various investigations, related to sentiment analysis of web contents about user's sentiments, emotions, opinion toward various matters like motion pictures and products using machine learning techniques.

The authors have proposed an efficient deep learning classifier for sentiment classification which calculates the accuracy of 82.53% on Bengali text. In order to evaluate the performance, they used two deep neural network models such as deep RNN withBiLSTM [1]. Deep learningtechniques achieved significant results in textanalysis. Chen S *et. al.* [2] has been proposed an innovative method for target-based sentiment analysis which reduces the training time of the proposed model through regional LSTM. Deep learning models are frequently used in NLP applications. An efficient approach has been proposed for the multi-domain system that is based on word embedding. The tool named NeuroSent gives an accuracy of 85.15% by using the Amazon web site dataset for multi-domain [3]. Some of the deep learning models are based on sentence classification in Natural Language Processing and some of them are based on traditional models like SVM, RNN, LSTM and much more. In this literature survey, we basically study the ensemble approaches to improve the performance. Some authors proposed an ensemble method for text classification by using Vietnamese text. In this technique, they have merged the traditional modelswith deep learning models and achieved the remarkable result that is 89.19% [4]. Some authors havedone their research study in artificial intelligence on deep learning models. The review basically focuses on text classification by using different datasets[5]. A novel approach has been proposed by authors that are based on an ensemble of two models and achieves the accuracy 89%. They have used the IMDB movie review datasetfor the analysis process [6]. The ensemble approach gives outstanding results over traditional models in text analysis. We noticed that the ensemble approaches performed much better than traditional models. Some authors have proposed a machinelearning-based approach for improving the performance of sentiment analysis. They have used LSTM, Naïve Bayes and SVM for analysis process[7]. Some authors have gained remarkable results in the field of Natural Language Processing by using deep learning techniques for text classification [8]. In order to do classification, the authors have used Tibetan microblogs and achieved the result up to the mark [9].

The deep learning-based models improve the result in the field of NLP over the years. The authors have proposed a model named SentiWordNet and achieved better results. The model used word2Vec to perform analysis [10]. A novel approach ECNN has proposed that is used to identify opinion, polarity, and emotions in microblogs [11]. Numerous researchers have

proposed a model related to sentiment classification. They have used word embedding methods of learning at the word level and sentence level [12]. In this field of research, we can achieve better results by using deep learning-based approaches. The authors have proposed an ensemble approach that is the result of two machine learning models CNN, SVM for text sentiment analysis [13]. Many researchers have proposed an efficient method to perform classification processes on the IMDB review dataset and they found that RNN performs effectively in terms of words semantic and they achieved an accuracy of 89.8% [14]. In order to perform analysis, there are different parameters used such as feature extraction, opinion mining, applying different kinds of machine learning algorithms. An approach has been proposed that is based on a machine learning and Lexicon based features to perform sentiment analysis on the movie review dataset [15]. Word embedding is a technique that is used to convert the words into vectors. The researchers have been using the word embedding method for sentiment analysis. An efficient approach has been proposed for sentiment analysis by using word embedding [16].

3. Materials and Methods

This section presents the detailed overview of the proposed model to classify sentiments in movie domain.

3.1 Data set Description

In order to evaluate the performance, we have used the IMDB dataset. It includes 25000 numbers of data on movie reviews from the Kaggle website that contain binary values named positive and negative sentiment. This paper uses the IMDB movie review dataset for the purpose of experimental work, the dataset contains 25000 numbers of data in which a 75% number of data for the training set and 25% number of data for the validation set. After the split the dataset, further we perform dataset preprocessing tasks to clean the raw data and break the sentences into words and words into text.

3.2 Sentiment Analysis using Convolutional Neural Network with LSTM

The proposed approach uses two classifier of deep learning i.e Long Short Term Memory and Convolutional Neural Network. It uses word embeddings as input and takes them to LSTM for feature extraction and further output is given to CNN and followed by classification layer. The following step is followed by a proposed approach:

- Word Embedding method is used to convert the word into featured vectors in the given text.
- The hybrid model takes the advantages of two deep learning approaches such as LSTM and CNN for feature extraction.

- The classification layer uses the Softmax activation function to compute the predictive probability.

3.2.1 *Long Short Term Memory*

SeppHochreiter and JuergenSchmidhuber presented another model for sequential information called long short term memory. LSTM networks are a form of RNN that may learn order dependence in the situations of sequence prediction. The LSTM architecture is an RNN that remember information at regular periods. It is employed in the solution of the vanishing gradient problem. It has the ability to learn long-term dependence. At observation time, RNN has only two gates: an input gate as well as an output gate from the last hidden state and there is no knowledge about the past to remember. RNNs can remember their inputs for a long time due to LSTMs. That is why long short term memory uses their memory to accumulate the information over a long period of time. This memory cell is known as a gated cell, because it represents whether or not to store or delete information dependent on the relevance of the information. LSTM is made up of three gates. The input gate is used for new data input, the forget gate is used to determine whether or not the data should be deleted, and the output gate is used to determine the output at the current time step.

3.2.2 Convolutional Neural Network Architecture

The neural network image processing group was the first to create the convolutional neural network. ConvNets are developed to accommodate data in the form of several arrays, such as a colour image made up of three 2D arrays representing pixel elevations in each of the colour channels. As attribute extractors, a CNN uses two operations such as convolution and pooling. As in a multi-layer perceptron, the output of this series of operations is bound to a completely connected layer. Convolutional neural networks are often used on text in Natural Language Processing. There are two types of pooling used: max-pooling and average-pooling. When we use CNN for text instead of images, we display the text with a 1-Dimensional string. CNN is mostly used in sentence classification in NLP tasks.

3.2.3 *The Proposed Approach*

The proposed approach ensemble the advantages of two deep learning classifiersi.e LSTM and CNN.. In this approach, the convolutional layer uses Max-pooling. The ensemble approach uses the embedding layer to take the input in the form of words and pass it to the multi-layer LSTM model. The multilayer LSTM generates the output and it is further passed to the convolutional layer as an input for further process. After the output of the convolutional layer passed to the classification layer for the classification process.The convolutional layer extracts the features of text sequences.

4. RESULT AND DISCUSSION

This section briefly discusses the experimental setup and measures the result of the approach. The performance was evaluated by using different parameters.

4.1 Performance Measure

$$\textbf{Accuracy}=\frac{tp+tn}{tp+tn+fp+fn}\text{X } 100\%$$

The parameter accuracy is used to validate the proposed hybrid model by using the test set and validate set.

Table I: ACCURACY COMPARISON OF ENSEMBLE APPROACH WITH DEEP NEURAL NETWORK MODEL FORSENTIMENT ANALYSIS

Deep Learning Models	**Valid Accuracy**
LSTM	84%
CNN (max- pooling)	88.96%
Proposed model	**89.75%**

Here, we compare the outcome of proposed approach over traditional approaches. Here The LSTM provides accuracy 84%, CNN provides an accuracy 88.96%. and proposed model provides an accuracy 89.75%. We can see that the proposed approach gives the outstanding result over other deep learning approaches.

5. CONCLUSION

Sentiment classification is the method of extracting a user'sview as positive or negative for a specific task. We have introduced an efficient approach for sentiment analysis that ensemble the advantages of two deep learning models name as Long Short Term Memory and Convolutional Neural Network. LSTM overcomes the vanishing gradient problem and preserves historical information of long term text dependencies. Further, CNN extracts the feature of context. In this paper, the proposed ensemble approach efficiently improves the accuracy of sentiment classification. The proposed ensemble approach gives an accuracy of 85.78% on IMDB movie review data. It is found that the proposed approach performs better than other deep learning approaches.

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A Survey on Deep Learning Techniques for Sentiment Analysis

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Abstract: *Social media is a rich source of information nowadays. If we look into social media, sentiment analysis is one of the challenging problems. Sentiment analysis is a substantial area of research in the field of Natural Language Processing. This survey paper reviews and provides the comparative study of deep learning approaches CNN, RNN, LSTM and ensemble-based methods.*

Keywords: Natural Language Processing; Sentiment Analysis; Deep Learning Classifiers; LSTM; CNN

1. Introduction

SA is a branch of psychology that analyses people's thoughts, feelings, and emotions derived through customer script automatically. Sentiment analysis is a hot topic in natural language processing, and it's still getting much attention in data mining because emotions are powerful drivers of social behaviour. In a way, sentiment analysis started as a research topic in Natural Language Processing across the world. The most important application of NLP, computational linguistics, and text processing is sentiment analysis. Sentiment analysis is an opinion mining task that can be used to ascertain the writer's or speaker's emotions, attitude toward a specific task, such as product reviews, film reviews, or the overall tone of the document. The era of digitalization has resulted in the exponential growth of data. Data is stored in a variety of formats, including structured, semi-structured, and unstructured. The difficult task is to discover useful information through data analysis.

2. Deep Learning Models

It is a subset of Machine Learning in which the number of layers (multilayers) used to achieve the desired results is increased. It is a term used to refer to an extensive neural network. Nodes in a neural network communicate with one another via interconnected layers of nodes. Deep learning models incorporate dozens, if not hundreds, of hidden layers to create complex models that continuously learn and improve. This article discusses the various deep learning-based models that have been used to analyze sentiments.

2.1 Recurrent Neural Network

The Recurrent Neural Network is a deep learning technique used for sentiment analysis and is based on sequential data. It generates the output using sequential information based on previous computations. It can accept multiple input vectors and output multiple vectors. Traditionally, neural networks have relied on independent inputs, making them unsuitable for specific tasks in Natural Language Processing. Consider the following example: word prediction within a given sentence. The RNN model is a highly efficient model for sentiment analysis. RNNs make use of memory cells that are capable of storing data about lengthy sequences. To begin, we must comprehend sequential information. Sequential data is data that is ordered in such a way that similar items follow one another.

2.2 Long Short-Term Memory

SeppHochreiter and JuergenSchmidhuber presented another model for sequential information called long short-term memory. LSTM networks are a form of RNN that may learn order dependence in situations of sequence prediction. The LSTM architecture is an RNN that remember the information at regular periods. It is employed in the solution of the vanishing gradient problem. It can learn long-term dependence. At observation time, RNN has only two gates: an input gate and an output gate from the last hidden state, and there is no knowledge about the past to remember. RNNs can remember their inputs for a long time due to LSTMs. That is why long short-term memory uses its memory to accumulate information over a long period. This memory cell is known as a gated cell because it represents whether or not to store or delete information dependent on the relevance of the information. LSTM is made up of three gates. The input gate is used for new data input, the forget gate is used to determine whether or not the data should be deleted, and the output gate is used to determine the output at the current time step.

2.3 Convolutional Neural Network

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networks are often used on text in Natural Language Processing. There are two types of pooling used: max-pooling and average-pooling. When we use CNN for text instead of images, we display the text with a 1-Dimensional string. CNN is mostly used in sentence classification in NLP tasks.

3. Related Work

Numerous analysts have tried to consolidate machine learning and deep learning ideas concept in ongoing years for the accurate classification of sentiments. This section quickly portrays the various investigations related to sentiment analysis of web contents about user's sentiments, emotions, opinion toward various matters like motion pictures and products using machine learning techniques. The authors have been presented the hybrid model for text classification that gives better accuracy than traditional models. They combined two well-known neural network models, CNN and LSTM, in this paper. The experimental result demonstrated an increase in text classification accuracy. They evaluate with an accuracy of 87.31 per cent [1]. The authors propose an efficient model for sentiment classification, which calculates the accuracy of 82.53% on Bengali text. They used two deep neural network models, such as deep RNN with BiLSTM [2], to evaluate. It has achieved significant results in the field of text classification. The authors have been presented an innovative approach for target-based emotion analysis that reduces training time of the proposed model through regional Long Short-Term Memory [3].

Deep learning models are frequently used in Natural Language Processing applications. An efficient approach has been proposed for a multi-domain system that is based on word embedding. The tool named NeuroSent gives the accuracy 85.15% by using the amazon website dataset for multi-domain [4]. Some of the machine learning models are based on the content classification in NLP. An ensemble method proposed for Vietnamese text for sentiment analysis by some researchers. In this approach, they combine the traditional method with a deep learning algorithm. This proposed approach gives an accuracy of 89.19% by using the voting rule [5]. The author has been presented a paper on the deep learning approach for text classification [6]. A novel approach has been proposed for IMDB movie review sentiment analysis using the Deep CNN-LSTM model that gives the accuracy 89% [7]. Some authors give a survey on various models for analysis. A comparative study is given by using deep learning models and classifiers [8]. Researchers have been proposed an approach for analysis [9]. The ensemble approach has been performed better than traditional models in the field of text classification. The authors have been presented a machine learning method for performing analysis. They used Long Short-Term Memory, Naïve Bayes and SVM for analysis using reviews on Google Play in Chinese [10].

The authors have been proposed a model named Sent WordNet that is dependent on Word2Vec to perform sentiment analysis [11]. A novel approach proposed by researchers named ECNN is to identify opinion, polarity and emotions in microblogs [12]. To perform sentiment analysis, the authors have been presented the model related to text classification. They used word embedding at word level and sentence level using the skim gram model [13]. The authors have been proposed a model for text analysis base on CNN and SVM [14]. The authors have been proposed an efficient method to perform sentiment analysis on the IMDB review dataset. They found that the deep learning model RNN is effective in terms of words semantic and evaluate the accuracy of 89.8% [15]. The author has been building a model that is based on heterogeneous feature [16]. The authors have been used word embedding for sentiment analysis. An efficient approach has been proposed for sentiment analysis by using word embedding. The author has suggested providing human behavioural and trust security by using blockchain and verifying sentiment analysis [17]. Some of the authors have been presented an overview of sentiment analysis. This paper presents the different feature selection methods and machine learning algorithms [23]. A combined framework for sentence classification has been proposed that is based on CNN and RNN. On a movie review dataset, the proposed framework achieves an accuracy of 93.3 per cent [24]. The authors have proposed an analysis strategy. This article discusses the accuracy of the ConvLstm at 88.3 per cent for fine-grained data [25]. This approach is certain to succeed because both operate under distinct conditions: one between users and the data centre and another between memory in the data centre [26].

Table 3.1: Summary of the Machine Learning Approaches for Sentiment Analysis

Ref. No.	Methodology	Deep Learning Models	Results
[1]	Text Classification, Nature Language Processing, LSTM, Long Text Sequences, CNN	CNN-LSTM	87.31%
[2]	Bengali text, Deep learning, Sentiment Classification, RNN, LSTM, BiLSTM, Facebook, NLP	BiLSTM	85.67%
[3]	Deep Learning, Sentiment analysis, Target-based sentiment analysis, Convolutional neural network, Long short term memory network, Deep neural network model	CNN-RLSTM	94.35%
[4]	Sentiment Analysis, Natural Language Processing, Neural Networks, Multi-domain	NeuroSent	84.60%

	Sentiment Analysis, Deep Learning		
[5]	Sentiment analysis, deep learning, ensemble Learning	Vote-rule	92.80%
[6]	sentiment analysis, natural language processing, deep Learning, long- short term memory	AraFT	93.5%
[7]	IMDb, sentiment analysis, text classification, neural network, CNN, LSTM	Base-Model	84.98%
[8]	Deep Learning, Sentiment Analysis, Consumer Review, Recurrent Neural Network (RNN), Long Short Term Memory (LSTM)	Deep Learning with Bi-LSTM	94.00%
[9]	Convolutional neural network, long short- term memory, recurrent neural network	Convlstm	88.3%
[10]	Deep Learning, Tibetan Microblog, Word vector, Sentiment Analysis	CNN-LSTM	86.21%
[11]	Sentiment analysis, Word2Vec, Word embeddings, SentiWordNet	Senti2vec	85.4%
[12]	Natural language processing, sentiment analysis, deep learning, convolution neural network, emoticons.	ECNN	72.55%
[13]	Word Embedding	MS-skip, CS-skip	87.89%, 89.62%
[14]	Deep learning model, Text classification, Natural Language Processing, CNN, RNN	TextRNN+ Attention	84.56% (precision)
[15]	NLP, sentiment analysis, deep learning, machine learning, text classification	Deep Learning	89.8%
[16]	NLP, Text Mining, Data Mining, Big Data, Sentiment Analysis,	Naïve Bayes, Linear SVM	84%, 79%
	Opinion Mining, Machine Learning, Deep Learning, SentiWordNet (SWN)		
[17]	Word embedding, Word2Vec, Machine Learning, Bag-of-words.	Word2Vec	81%
[23]	Sentiment Analysis, Machine Learning	-	-
[24]	Convolutional neural network, recurrent neural network, natural language processing, deep Learning, sentiment analysis, long-term dependencies.	Deep Learning	93.2%
[25]	convolutional neural network; long short- term memory; recurrent neural network	ConvLstm	88.3%

4. CONCLUSION

Sentiment classification is the method of extracting a user's view as positive or negative for a specific task. Social media is a rich source of information nowadays. If we look into social media, sentiment analyses are one of the challenging problems. Sentiment analysis is a substantial area of research in the field of Natural Language Processing. This survey paper reviewed and provided the comparative study of well-known deep Learning approaches CNN, RNN, LSTM and ensemble.

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