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Research Article

Comparative Study on Performance of Machine Learning Algorithm and Deep Learning Algorithms for Sarcasm Detection

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ABSTRACT

Sarcasm is irony, to mock or deliver contempt. It is delivered in comic and sometimes in terrible tone which is often not taken in positive sense. This sarcasm has become a trend to mock or discourage people. Hence it is necessary to detect sarcasm in text which is mostly observed in social media platforms like Facebook, twitter, Instagram etc. Machine learning has become an aid in analyzing textual information for sentiment analysis and sarcasm detection. Recent research mainly focuses on deep learning approaches due to its promising results. This paper presents a comparison of various machine learning and deep learning approaches relevant to sarcasm detection. Further, results of these approaches and their evaluation are presented and future directions are mentioned. In this paper, we have used five methods of machine learning to detect sarcasm. Deep learning methods are also being used with machine learning methods and compared.

Keywords: Sarcasm detection, machine learning, deep learning, linguistic data, natural language processing (NLP).

I. INTRODUCTION

Social media platforms Similar as Twitter and Facebook have come popular channels for people to record and express their passions, opinions, and feedback in the last decades. With proper birth ways similar as sentiment analysis, this information is useful in numerous aspects, including product marketing, behavior analysis, and epidemic operation. There are numerous ways for someone to express their passions and feelings. These sentiments are occasionally accompanied by affront, especially when conveying violent emotion. Affront is defined as a positive judgment with underpinning negative intention [1]. Companies, associations, and exploration centers have been examining this kind of data for numerous reasons due to the Internet's stoner- generated content's explosive expansion. A part of this exploration has concentrated on how Internet druggies engage with one another, the kinds of information they partake, and indeed the kinds of connections they produce. Still, utmost of the interest has targeted the content of the data they partake, for it being the richest in terms of information bedded. Several studies have been conducted on the content of the stoner generated data [2].

Some users express their emotions and opinion with the help of sarcasm. Sarcasm is the positive sentence with underlying negative intentions. Sarcasm has been used by normal users as well as public figures in online debates or when addressing a public event or hot and controversial topics. Depends on the media on which the data is being shared the detection of sarcasm is also different. If any opinion is video then by analyzing the user's expression and gestures it can be determined that person is expressing sarcastic or not. Similarly, in case of audio, from the change in tone one can determine the person is talking in sarcastic way or not. But it is very difficult to determine the textual data is sarcastic or not [3].

Various machine learning algorithms are implemented for automatic sarcasm detection on social media data like Twitter or Reddit. These algorithms works on patterns that are associated with sarcasm. Also, in recent years various deep learning algorithms are implemented for sarcasm detection like CNN (Convolutional Neural Network), Bi-LSTM (Bidirectional Long Short Term Memory Network) and BERT (Bidirectional Encoder Representation from Transformer). The objective of this paper is to understand the concept of sarcasm and analyze the various machine learning methods and deep learning methods. This paper compares the performance of both the methods for sarcasm detection.

II. LITERATURE REVIEW

Sarcasm refers to the words that are used in order to insult someone, to show your aggression or irritation or to make things funny. It is a form to convey your negative feelings in positive or funny words. In recent times, Twitter is one of the largest social platforms where people convey their thoughts, feelings or actions in the form of tweets, which sometimes can be sarcastic. To detect the statement is sarcastic or not various machine learning algorithms are implemented by various authors. The following sections discusses the machine learning algorithms and deep learning algorithms along with their results.

A. Sarcasm Detection using Machine Learning Algorithm

When using standard machine learning models, feature extraction plays an important role. To extract more context from the data, a set of features should be defined. In a study by [4], a set of features to determine if a review is ironic or not was created. Some of these features are imbalance, hyperbole and punctuation. They marked a review imbalanced if the given star rating was high, but most words in the text had negative sentiment, and vice versa. The review was marked hyperbolic if there were three or more positive or negative words in a row. The punctuation feature marks the presence of multiple questions or exclamation marks [5].

Reference [6] used the Arabic sarcasm Twitter dataset and used ML classifiers as well as DL classifiers with a swarm optimization algorithm to detect sarcasm. They tried to reduce the features and got an accuracy of 86.85% on the dataset.

Conventional machine learning methods necessitate the human extraction of features from the data [7]. This method gives the researcher greater flexibility, but selecting the appropriate, valuable characteristics is typically just as challenging as selecting the appropriate machine learning model.

Sentiment-related, punctuation-related, syntax-related, and pattern-related characteristics were the categories into which features were separated in a research conducted by [8]. In machine learning classification models, this thorough feature selection worked well.

Reference [6] experimented with many techniques to choose the appropriate features from all of the features offered. Sarcasm was identified with the use of ML classifiers. They recommended combining ML classifiers with clustering. In paper [26] author combined an LSTM model with the GLOVE model's embedding's with a variety of ML classifiers. A 95% accuracy rate was attained.

ML methods were employed by Reference [9] to identify sarcasm. With Bengaluru city traffic, they used the Twitter API to extract 20500 tweets. To transform text data into vectors, they employed the Term Frequency-Inverse Document Frequency method. Out of all the classifiers used, the Support Vector classifier produced the greatest accuracy, at 80.98%.

B. Sarcasm Detection using Deep Learning Algorithm

Because deep learning algorithms can automatically learn complicated patterns and representations from raw text data, they have also been used to the task of sarcasm detection. The challenging aspect of deep learning models is model selection [10]. Transformer models are a relatively new advancement in deep learning that have shown to be quite successful in a variety of natural language processing applications.

The models' application was expanded to include data from social media platforms by [11]. They looked into the application of bidirectional long short-term memory (BiLSTM) models for news headline sarcasm detection.

Paper [12] proposed an ensemble model to detect sarcasm. They used GloVe embedding's and Word2Vec embedding's to convert text into vectors and then used the LSTM technique. They worked on the Twitter dataset

and Headlines dataset because Twitter has short phrases while Headlines are generally longer. The LSTM technique used dense layers and the context of the previous sentence was used to determine if the current sentence was sarcastic or not. They achieved an accuracy score of 88.9% on the Twitter dataset and 81.4

III. METHODOLOGY

The methodology of this research consist of various components from data collection to result evaluation using both machine learning and deep learning algorithms on news headlines dataset and Reddit dataset. The phases of sarcasm detection is given in following figure.

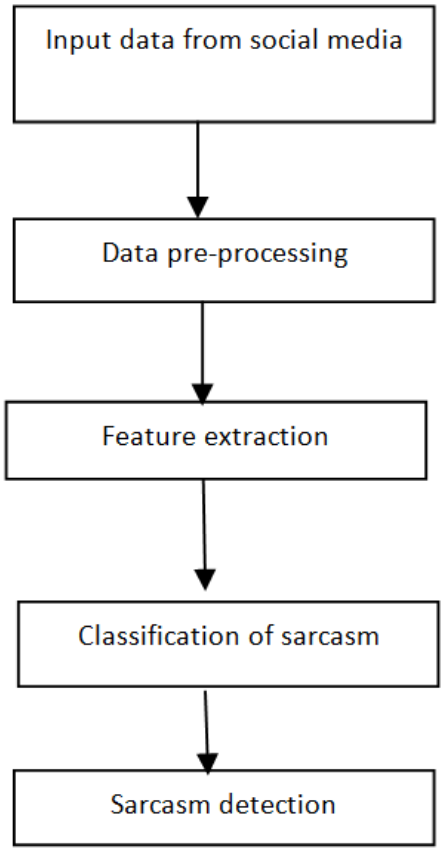

Figure 1. Phases of sarcasm detection

A. Data Collection

Two datasets are considered that are Reddit and News Headline dataset. Reddit works as a "is a network of communities based on people's interests" [13]. Reddit has grown in popularity as a resource for knowledge for people with a variety of interest enabling users to rate and discuss any subject including prominent figures, goods and services. Many of other datasets used by researchers are annotated by themselves, so this is one of the difficult challenge for new researchers to get standardized datasets.

B. Data Pre-processing

Data collected from various sources are in raw format so it needs to convert in structured format using various tools of data pre-processing such as Stop word removal, Tokenization, Stemming and Lemmatization. After pre-processing these unstructured data is converted into usable and comprehensible format which is then passed for feature extraction.

C. Feature Extraction

Feature extraction refers to the process of transmuting pre-processed data into numerical vectors. Several algorithms and techniques are available to extract features from textual datasets. Some examples of techniques are Bag of Words, N-Grams, word2vec and Term Frequency-Inverse Document Frequency (TF-IDF). In this paper, TF-

IDF is used for feature extraction which then used to train the model that classify text as sarcastic or not using machine learning and deep learning approaches.

D. Sarcasm Detection Techniques

The process of sarcasm detection is essentially a binary classification problem, with the two labels being "sarcastic" and "non-sarcastic". Various machine learning algorithms are reviewed and their performances are explored. Machine learning algorithms such as Gradient Naïve-Bayes, Random Forest, K-nearest Neighbor (KNN), Logistic Regression and Support vector machine (SVM) are implemented on datasets. Author in [14] implemented different methods to select appropriate features and machine learning classifiers are implemented on selected features to detect sarcasm. [6] Uses combination of machine learning classifiers with LSTM model which achieves 95% accuracy. Paper [15] uses Support vector machine (SVM) method to classify text as sarcastic from tweets extracted from Twitter API. SVM gives 80.98 % accuracy. Paper [16] works on Hindi language. TF-IDF is used to convert features of text into vectors and SVM is implemented on that vector to detect sarcasm. Maltare et al., (2023) explored the rainfall pattern and groundwater level and predicted a rise in the groundwater level using SARIMA, multi-variable regression, ridge regression, and KNN regression.

Deep learning techniques like CNN, RNN and Bidirectional Encoder Representations from Transformer (BERT) are also used in this paper. The use of these models was expanded to include data from social media by [17]. Bidirectional long short-term memory (BiLSTM) models were examined for their potential to identify sarcasm in news headlines. [18] With the rise of deep learning models, BERT's release represented a major advancement. In order to identify sarcasm in tweets, [19] combined BERT and GloVe embedding's. Though sarcasm is very context-dependent, deep learning models may be a suitable fit for the task of sarcasm identification [20]. In paper [21] the model is developed with the help of BERT and LSTM methods of deep learning on Tweeter and Reddit dataset. The model gives F-score value for BERT is 0.743 on Twitter dataset, and 0.658 for Reddit dataset. The paper [22] uses CNN algorithm to implement a model for sarcasm detection which gives 96.12% of accuracy. In paper [23], author has implemented model using BERT for embedding and LSTM for autoencoder. Embedding's is then passed to softMax activation function for final classification. The model is trained and tested on Reddit and News headlines and gives accuracy of 83.92% and 90.8% respectively.

IV. RESULTS AND DISCUSSION

After the analysis of various machine learning methods and deep learning methods, in this section of work results of various methods are discussed. The performance of each model is measured by using different performance measures such as Accuracy, Precision, Recall and F1 score.

A. Accuracy (A) - It is one of the most fundamental measures used to judge the performance of a model which focuses on the predictions which are correctly done for both positive and negative classes. Accuracy is calculated by the formula:

Accuracy= (TP + TN)/ (P + N) where, P and N are total positive and negative classes.

B. Precision (P) - It focuses on the correctly classified positive class samples in relation to the positive class samples. It is calculated by the formula:

Precision= TP/ (TP + FP)

C. Recall (R) - It focuses on the correctly classified positive samples in relation to the rightly marked positive samples and incorrectly marked negative samples. Recall is calculated as-

Recall= TP/ (TP+FN)

D. F1-score (F) - It is one of the best performance measures that uses the average of P and R. For balanced as well as imbalanced datasets, this performance measure works well.

F1 Score = 2 x ((Precision*Recall) / (Precision + Recall))

The various machine learning methods are implemented on News Headline dataset and their performances are depicted in the following table.

TABLE 1. SARCASM DETECTION USING MACHINE LEARNING

Algorithm	Accuracy	Precision	Recall	F1-Score
Gradient Naïve-Bayes	82.81	83.69	82.8	81.8
K-nearest Neighbor	85.81	88.70	85.31	85.62
Logistic Regression	81.82	82.69	82.81	82.80
Random Forest	91.68	92.70	91.68	91.08
Support Vector Machine	94.06	95.10	94.06	94.06

From the table it is being concluded that SVMs gives the best performance over the other methods. It gives accuracy of 94.06 and precision of 95.10%.

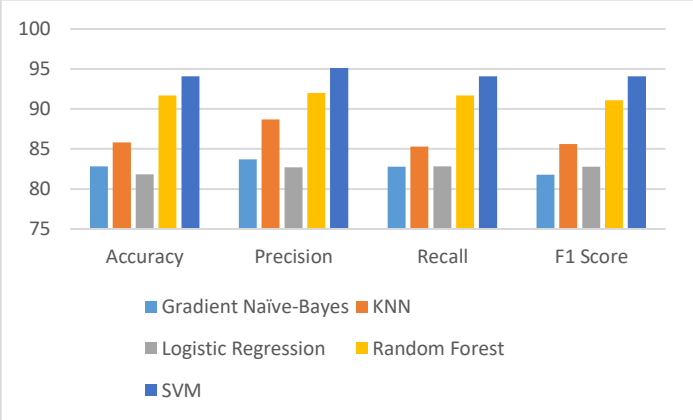

Figure 2. Results of ML models

Similarly, various deep learning models like CNN, LSTM, Bi-LSTM and FCNET are implemented Headline dataset and their performances are given in the table2.

TABLE 2. SARCASM DETECTION USING DEEP LEARNING

Algorithm	Accuracy	Precision	Recall	F-Score
CNN	69.50	69.50	69.50	69.50
FCNET	83.51	83.51	83.51	83.51
LSTM	50.97	25.98	50.97	34.42
BILSTM	49.06	24.04	49.03	32.26

From the above table it is concluded that the results obtained by Fully Connected Neural Network (FCNet) model gives best performance over the other models. The results can be shown graphically as follows-

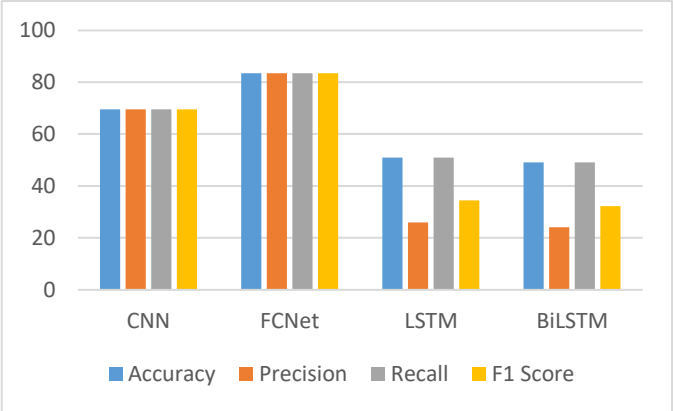

Figure 3. Results of DL Models

V. CONCLUSION

In this study we have discussed the role of opinion mining and sentiment analysis for social media data and for business related frameworks. Sarcasm is also necessary to express the emotions on various subjects on social media. For this purpose sarcasm detection is challenging for textual data. Using very diverse and publically accessible dataset of News Headline and Reddit, we have implemented all the models of machine learning and deep learning along with all phases like preprocessing, vectorization and classification for sarcasm detection. It is observed that News headline dataset performs better than Reddit dataset because News contains more contextual text which helps to detect sarcasm in effective manner while Reddit contains less contextual text and review comments are more. Total five algorithms we have implemented on the mentioned dataset and it is concluded that Support Vector Machine (SVM) is better in performance in terms of Accuracy, Precision, Recall and f-Score parameters. We have also implemented four deep learning methods, from these FCNET performs better than other algorithms.

We have identified some of the research gaps as-

1) More diverse and contextual dataset is required for fine-tuned and accurate sarcasm detection.

2) More research is needed for real time data on social networking sites.

3) For better results in vectorization new and evolutionary word embedding techniques are required.

Based on the above observation the future scope for this research is to find appropriate and more accurate method that can identify sarcasm from real time data in very less amount of time. In future we would like to identify method that gives accurate results with less processing speed.

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