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Depression Detection on Twitter using Sentiment Analysis: A Machine Learning Approach

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Abstract - *More than three hundred million folks are littered with depression everywhere in the globe. Mental illness detection in social media can be considered a difficult task, mainly due to the complicated nature of mental disorders. In recent years, this research area has started to evolve with the continuous increase in popularity of social media platforms such as Instagram, Twitter, and Facebook, etc that became an integral part of people's life. This close relationship between social media platforms and their users has made these platforms reflect the users' personal life with different limitations. Social networks have been developed as a great platform for its users to communicate with their friends and share their opinions, photos, and videos reflecting their moods, feelings, and sentiments. This creates an opportunity to analyze social network data for user's feelings and sentiments to investigate their moods and attitudes when they are communicating via these platforms. In this paper, we have proposed a depression analysis and detection system. The present study aims to exploit natural language processing and machine learning techniques for analyzing and detecting of depression level of the Twitter user. For this purpose, we used NLP techniques on to the textual data extracted from Twitter to analyze and identify the emotions in the data. We used machine learning classifiers and trained and tested classifiers to analyze the extracted tweets from Twitter and evaluate the tweets to classify whether the user is going through depression or not. All this are done using the Predictive approach for early detection of depression or other mental illnesses.*

Key Words: **Natural language Processing, Sentiment Analysis, Twitter API, Machine Learning, Twitter, Naïve Bayes**

1. INTRODUCTION

Human beings are social creatures. The strength of our connections encompasses a Brobdingnagian impact on our psychological state and happiness. At this time of social distancing and isolation, social media are a great tool for keeping you in-tuned with friends, loved ones, and thus the wider world. Whereas many individuals get pleasure from staying connected on social media, excessive use will fuel feelings of tension, depression, isolation, and FOMO.

Depression is classed as a mood disorder. It ought to be painted as feelings of unhappiness, loss, or anger that interfere with a person's everyday activities. Humans being experience depression in varied ways. It may be going to interfere in conjunction with your daily work, resulting in lost time and lower productivity. It may be going to influence relationships and some chronic health conditions.

For healthy growth and development, youth should have the simplest way of happiness, love, action, and independence and to have a purpose in life. Throughout this process stage, several styles of behavior unit developed which might cause either normalcy or standing malady. Depression can cause the affected person to suffer greatly and perform poorly at work, at college, and in social events. Social media is a big part of many youth's lives. A Pew Research Center survey of nearly 750 13- to 17-year-olds found that 45% are online almost constantly and 97% use a social media platform, such as YouTube, Facebook, Instagram, and Twitter.

Depression becomes a great contributor to the overall global burden of diseases. Normally, doctors diagnose depression face to face via referring to clinical depression criteria. However, more than 75% of the patients would not consult doctors at the early stages of depression, which leads to further deterioration of their conditions. Meanwhile, people are increasingly relying on social media platforms to disclose emotions and sharing their daily lives, thus social media have successfully been leveraged for helping detect physical and mental diseases. Therefore, our work aims to make depression detection via analyzing social media data. We analyze well-labeled depression and non-depression datasets on Twitter but also online behaviors on social media.

In this study, depressive and non-depressive behaviors are analyzed with the help of the Machine learning model and Natural language processing. Finally, we tend to analyze a large-scale dataset on Twitter to reveal the underlying on-line behaviors between depressed and non-depressed users.

It might greatly help the user to identify his mental status. Nowadays, mental status is the most important thing. As humans are going through Covid it reflects on his routine life very badly. From little ones to elders everyone has to changes his daily things. People start turning towards social platforms more and spend more time on various social platforms such as Instagram, Twitter, WhatsApp, and Telegram. People disclose their feelings on social

media via posts and stories. Sometimes it is difficult for a person to disclose depressive thoughts to anyone and ask for help and this study gives affirmed statement to the person who might need clinical help and also let know his family and friends.

2. LITERATURE SURVEY

Primarily data is to be collected, by various means of social media platforms such as Facebook, Twitter, Instagram and Tumblr and then pre-processed and finally analyzed to predict various suicidal attempts. Data analysis extracts the sentiments of the person who want to die through their tweets. As sentiments are the main reason to attempt suicide and this is discussed by various researchers. There are various data Analysis techniques i.e., text mining, sentiment analysis, network analysis, quantitative data analysis. This paper predicts and presents a review of these techniques and challenges of the above-mentioned problem.

In the paper [1], authors have discussed steps involved in classification process with detailed. Moreover, have performed the comparison of different classifiers with respect to their methodologies and attained results of state-of-the art approaches are presented effectively.

In the paper [2], author presents how to find the depression level of a person by observing and extracting emotions from the text, using emotion theories, machine learning techniques, and natural language processing techniques on different social media platforms.

In this paper [3], acoustic features are used to train a classification model to categorize a human as Depressed or not-Depressed. DIAC-WOZ database is considered for training the classifiers and 93% accuracy is obtained with the SVM algorithm resulting in Depression Classification Model (DCM).

The research in paper [4] employs Natural Language Processing (NLP) techniques to develop a depression detection algorithm for the Thai language on Facebook where people use it as a tool for sharing opinions, feelings, and life events. Results from 35 Facebook users indicated that Facebook behaviors could predict depression level.

The paper [5], aims to apply natural language processing on Twitter feeds for conducting emotion analysis focusing on depression. Individual tweets are classified as neutral or negative, based on a curetted word-list to detect depression tendencies. In the process of class prediction, support vector machine and Naïve Bayes classifier have been used. The results have been presented using the primary classification metrics including F1-score, accuracy and confusion matrix.

The objective of this paper [6] is to propose a data-analytic based model to detect depression of any human being. In this proposed model data is collected from the users' posts of two popular social media websites: twitter and Facebook. Depression level of a user has been detected based on his posts in social media. In this research, machine learning is used to process the scrapped data collected from SNS users. Natural Language Processing (NLP), classified using Support Vector Machine (SVM) and Naïve Bayes algorithm to detect depression potentially in a more convenient and efficient way.

The motivation of this paper [7] is to provide general review about the prognostics of suicide attempts on social media.

The paper [8], tries to analyze health tweets for Depression, Anxiety from the mixed tweets by using Multinomial Naive Bayes and Support Vector Regression (SVR) Algorithm as a classifier.

This paper [9], have proposed a depression analysis and suicidal ideation detection system, for predicting the suicidal acts based on the level of depression. The authors have collected real time data from students and parents by making them fill questionnaires and processed it into meaningful data with related features. Then, classification machine algorithms are used to train and classify it in five stages of depression depending on severity. Maximum accuracy i.e., 83.87 % was achieved by using XGBoost classifier in this dataset.

In this paper [10], authors have proposed a depression analysis system, for predicting the suicidal acts supported the extent of depression. The present study aims to exploit machine learning techniques for detecting a probable depressed Twitter user his/her tweets. For this purpose, we trained and tested classifiers to differentiate whether a user is depressed or not using features extracted from his/her activities within the tweets. Classification machine algorithms are used to train and classify it in different stages of depression on scale of 0-100%. This study's main contribution is that the exploration a neighborhood of the features and its impact on detecting Depression level.

3. PROPOSED METHODOLOGY

Nowadays, Social media networking sites are the new knowledge gateway for all age groups. Language in social media activities is thought to represent this state of writers as well as their psychological state. Tens of us annually suffer from depression and solely a fraction receives adequate treatment. We tend to explore the potential to use social media to find and diagnose the key clinical depression in people.

The approach being taken up in this paper is modular in it's' organization. Individual component of the workflow has been segregated into stand-alone steps, to improve the quality of implementation. In this paper, a structural model is represented that identifies users' depression levels from their Twitter account posts. The system includes two techniques: Natural Language Processing and Machine Learning.

The workflow starts with the data collection step, which utilizes Twitter API for the generation of the dataset. The linguistic communication process facilitates far better than average classification for sentimental analysis done by the human. After the creation of the dataset, the data preprocessing module which systematically churns the data through tokenization, stemming, and stop words removal.

3.1 Dataset

We have used a large-scale publicly available depression dataset proposed by Shen et al. The tweets were crawled and labeled by the authors.

The dataset contains three components: Depressed dataset D1, which comprises of 1.3millions samples labeled as Positive tweets Non-depressed dataset D2, which comprises of 1.3millions labeled non-depressed that is Negative tweets. In our experiments, we used the labeled dataset: D1 and D2. We preprocess the dataset and perform NLP operation over the dataset. For evaluation purpose, we split the data set into Training (80%) and Testing (20%) sets. However, to assess the overall performance of the proposed model we also report the accuracy.

3.2 System Architecture

A quantitative study is conducted to train and test various machine learning classifiers to determine whether a twitter account user is depressed, from tweets initiated by the user or his/her activities on Twitter.

Following figure illustrates the workflow of depression detection model.

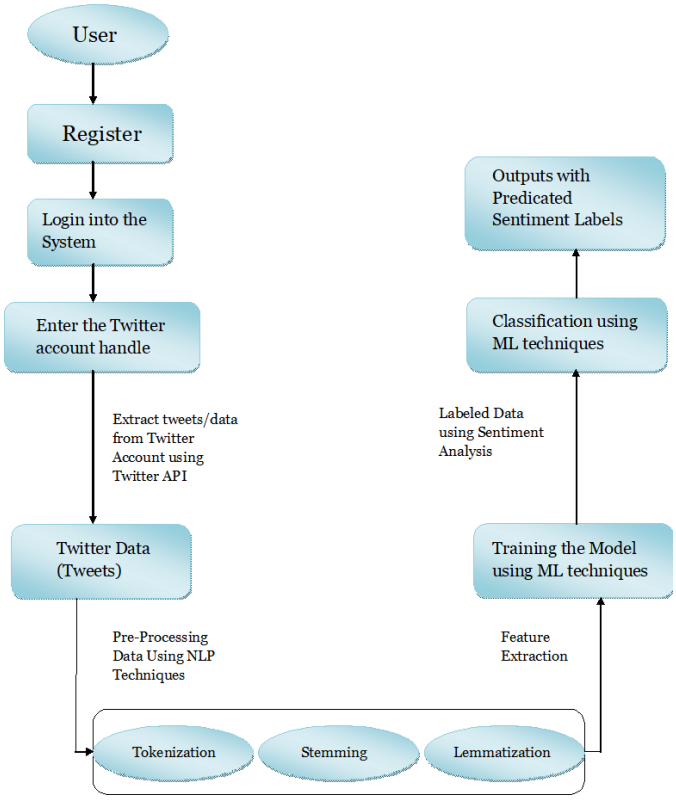


Fig.1: Dataflow Diagram

3.2.1 Twitter API

We can use the Twitter API to investigate, learn from, and move with Tweets, Direct Messages, and users. We can scale our access to grow, experiment, and innovate.

We are using the Twitter API platform to gain broad access to the public Twitter data that the users have chosen to share with the world. The Twitter API allows the user to read and write Twitter data.

In the model, the Twitter API is used to gather the data for the Sentiment Analysis of the tweets generated by the Twitter account holder. We have used the Twitter API for accessing the tweets from users' Twitter account.

Gaining the access to the API using the developer account it was easy for us to gather all the required information from the user profile and perform operations on that data.

Thus, we have used it to compose tweets, read profiles, and access the followers' data and a high volume of tweets on particular subjects in specific locations.

3.2.2 Natural Language Processing

Natural Language process (NLP) may be a field of computing (AI) that creates human language intelligible to machines. Natural Language Processing combines the ability of linguistics and computing to check the foundations and structure of language, and build intelligent systems (run on machine learning and natural language processing algorithms) capable of understanding, analyzing, and extracting which means from text and speech.

NLP is employed to know the structure and which means of human language by analyzing totally different aspects like syntax, semantics, pragmatics, and morphology. Then, technology transforms this linguistic data into rule-based, machine learning algorithms that may solve specific issues and perform desired tasks.

A. Data Pre-Processing

For the pre-processing of the tweets, the NLTK (Natural language processing toolkit) is most important. We use the Natural Language Processing tools to pre-process the dataset gathered from Twitter before it is preceded to the feature extraction, training, and testing stages. In the starting, we converted all the extracted data to the string format. The entire test converted into lowercase so that the algorithm does not treat the same words in different cases as different. We then removed all the hyperlinks included in the data. After the hyperlink removal phase, the punctuations are removed from the strings. Next, the stop words in the strings are removed which could lead to erratic results if stay ignored. Stemming and Lemmatization are the important steps in NLP to reduce the number of words, which then performed on the data. Tokenization is done to divide the posts into individual tokens.

The CSV file is read and several data preprocessing steps are performed on it. NLP has been utilized for preprocessing methods applied on the extracted data:

(1)Stop Word Removal:

Stop words are the foremost common words in any linguistic communication. For the purpose of analyzing text data and building NLP models, these stop words might not add much value to the meaning of the document. In computing, stop words are words, which are filtered out prior to, or after, processing of natural language data (text). The frequently used words, referred to as stop words have to be compelled to take away since they're of no use within the training section and will conjointly cause erratic results if not neglected. NLTK library has a set of stop-words that can be used as a reference to remove stop-words from the tweet.

(2)Tokenization:

Tokenization is breaking the raw text into tiny chunks. Tokenization breaks the raw text into words, sentences referred to as tokens. These tokens facilitate understanding the context or developing the model for informatics. The tokenization helps in decoding which means of the text by analyzing the sequence of the words. During this case, the column of the CSV file containing the tweet is extracted and is reborn into individual tokens. We have used the method word_tokenize() to split a sentence into words. The output of the word tokenization method is then converted to Data Frame for better text classification in the machine learning model.

['Let', "'s", 'see', 'how', 'it', "'s", 'working', '.']

(3)Stemming:

Stemming is that the method of reducing a word to its word stem that affixes to suffixes and prefixes or to the roots of words called a lemma. Stemming is important in natural language understanding (NLU) and natural language processing (NLP).

Stemming involves reducing the words to their root form. This would help us to group similar words together.
Sentiment analyzer analyzes the positive and negative sentiment of words in a given document, for example, wonderful express a positive sentiment orientation. This would help us to group similar words together.

(4)Lemmatization:

Lemmatization sometimes refers to doing things properly with the employment of a vocabulary and morphological analysis of words, ordinarily reaching to take away inflectional endings solely and to come the bottom or lexicon variety of a word, that is called as the lemma. Lemmatization is one of the most common text pre-processing techniques used in Natural Language Processing (NLP) and machine learning in general. The aim is to take away inflectional suffixes and prefixes to bring out the word's dictionary form.

3.2.3 Training

The classifier mainly requires two parameters: training set and label of the text. The training set in this case is the set of tweets which needs to be further processed in order to feed into a classifier. The set of tweets need to convert into vector format for further processing. The set of labels corresponding to each tweet is also fed into the classifier in the form a vector.

A. Machine Learning Classification

(1) Naïve Bayes:

Naive Bayes is a machine learning model which can be used for both classification and regression challenges. Naive mathematician classifiers are a set of classification algorithms supported by Bayes' Theorem. It is not one rule however a family of algorithms wherever all of them share a standard principle, i.e. each feature in the dataset that is being classified is independent of one another. Naive Thomas Bayes may be a straightforward supervised machine learning rule that uses the Bayes' theorem with sturdy independence assumptions between the options to obtain results; meaning that the rule simply assumes that every input variable is independent. It is in fact naive assumption to create concerning real-world knowledge.

Bayes Theorem provides a high principled means for conditional probability, though in follow needs a vast variety of samples (very large-sizes dataset) and is computationally high-priced. The simplification of Bayes Theorem is very common and widely used for the classification of predictive modeling problems and is generally known as Naïve Bayes.

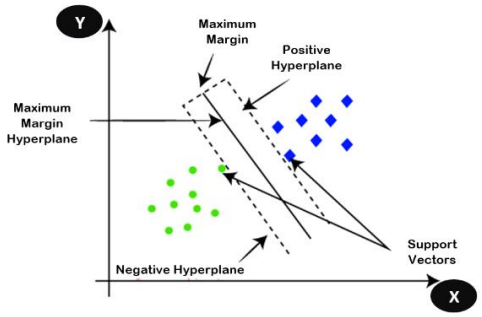
In our model, for example, if you use Naive Bayes for sentiment analysis, given the sentence 'I like Harry Potter', the algorithm will look at the individual words and not the full sentence. In a sentence, words that are placed next to each other influence the meaning of each other, and the position of words in the text is also very important. Nevertheless, for the algorithm, expressions like 'I like Harry Potter', Harry Potter-like I', and 'Potter I like Harry' are the same.

In this algorithmic rule, we have a tendency to plot every knowledge item to some extent in an n-dimensional house with the worth of every feature being the worth of every coordinate, wherever n is the number of features we have,

$$P(A \mid B) = \frac{P(B \mid A)\, P(A)}{P(B)}$$

(2) Support Vector Machine (SVM):

SVM is known as the supervised machine learning algorithm (feed-me) that we can use for both classification and regression problems. Classification is predicting a label or group and Regression is predicting a continual worth. SVM performs classification by finding the hyper-plane that differentiates the classes we plotted in n-dimensional space (where n is the varying of choices you have). We tend to perform classification by finding the hyper-plane that differentiates the 2 categories fine (look at the below diagram).



SVM attracts that hyper-plane by reworking our knowledge with the assistance of mathematical functions primarily known as Kernels. The different types of Kernels are unit linear, sigmoid, RBF, non-linear, polynomial, etc.

The standardization parameter RBF kernel is for non-linear issues and it's conjointly a general kernel used once there's no previous information regarding the information. Linear Kernel is for linear divisible issues. Since our model is linear (just positive and negative) here, we'll choose "linear SVM".

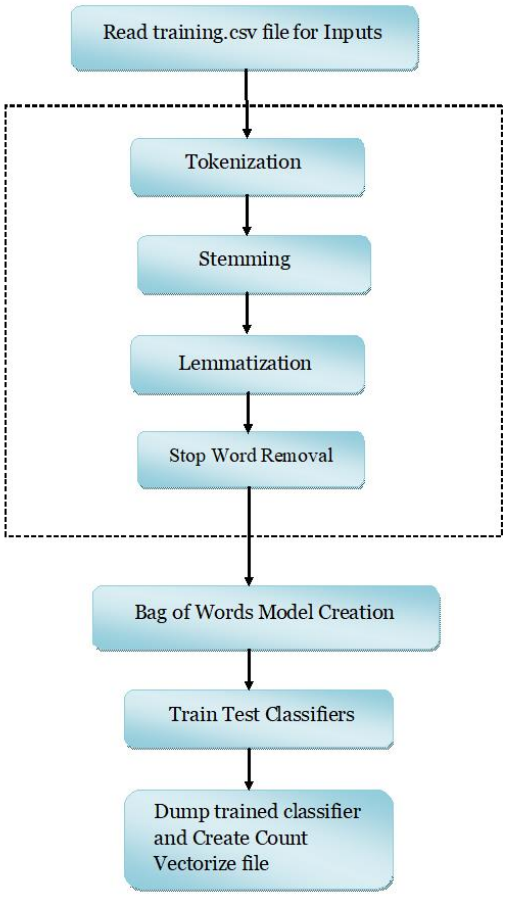


Fig.2: Training Phase

We have presented machine learning techniques to analyze the sentiment of the tweets in our model and using both classifiers we made a comparison between the two classifiers that is, Support Vector Machine (SVM) and, Naïve Bayes (NB) and, maximum accuracy of the classifier for calculating the sentiment regarding the topic. We observed that Naïve Bayes shows superior results than SVM.

3.2.4 Testing:

Testing the classifier involves the following steps:

Loading saved models: The trained classification models are loaded from the file created in the training phase, which to is used for prediction on the test dataset.

Data Preprocessing: The test dataset is pre-processed using NLP techniques in the same way as the training dataset.

Class Prediction on Test Tweets: After the pre-processing, each tweet or text is classified into a depressed or neutral class.

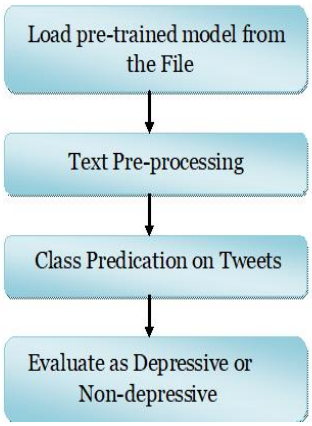


Fig.3: Testing Phase

4. OBSERVATION

At first, it takes one string as an input, which goes through all the steps of pre-processing such as removing slangs, emoji, hash tags etc. After that in feature extraction tweets are analyzed from various sentiment analyzers textBlob and SentiWordNet (in python script). TextBlob is used to extract the polarity and subjectivity of the sentence. SentiWordNet dictionary is also used to calculate the positivity and negativity of the sentence. Sentiment scores are calculated using textblob and SentiWordNet dictionary, POS tags-POS vector, POS score and n-grams. Tweets are validated according to positive, neutral and negative score of sentence with the aim of determining the accuracy of these analyzers. Multinomial Naive Bayes (MNB) and Support Vector Regression SVR) classifiers are implemented to give a comparison of their accuracies.

Proposed Classifiers	**Multinomial Naïve Bayes**	**Support Vector Regression**
Accuracy	82.22%	78.34%

5. CONCLUSIONS

Sentiment analysis using Machine Learning has successfully been applied to the task of depression detection using Twitter data. Supervised learning classification has a limitation and cannot grant a human level of accuracy in the prediction of depression through text data. Moreover, there is significant noise in the Tweets collected before pre-processing, which eliminates about a third of the data. In this paper, we have made a comparison among SVM, and, Naive Bayes classifiers regarding sentence-level sentiment analysis for depression measurement. Our model indicates that NB shows the higher result as compare to SVM and has maximum accuracy.

6. FUTURE SCOPE

For future work, a system can be developed that can work efficiently and more accurately than the current system, and also the project can be expanded by including additional features of online user's behavior. For example time of tweets or interaction with others. The system can also be expanded for more than one language, such as Hindi, Marathi, Telugu, Tamil, Kannada, Urdu, Japanese, German, and many more. Also, expansion of the model will lead to deal with more health-related issues, to make our surroundings better. In our current work, we have used two class labels such as positive and negative. To be more specific, two-class labels can be extended to five-class labels. They are: very positive, positive, neutral, very negative, and negative. We have applied a Multinomial Naive Bayes classifier in the current work for sentimental analysis and found this process to be successful. In the future, more classifiers can be tried with advanced machine learning approaches like deep learning.

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