Depression Detection and Management Using Naïve Bayes and NLP

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***Abstract*— Depression is a common mental disorder with approximately 280 million people in the world suffering from it [8]. With the stress and the increased societal burden to achieve success that students go through, it has been found that up to 44% of college students reported having symptoms of depression and anxiety, and that suicide is the third leading reason of death among college students[9]. Emotional artificial intelligence is a continuing research field in emotion detection that focuses on the extraction and analysis of emotions. This paper aims to employ natural language processing and machine learning to create a chatbot for making emotion analysis of the user's chat data and identify the user's mental health status by feeding the data into a classifier which is Naïve Bayes and then analyzes whether the user is depressed or not based on his input.**

Keywords— Artificial Intelligence, Depression Detection, Machine learning, Natural Language Processing, Chatbot, Naïve Bayes Classifier.

I. INTRODUCTION

Chatbots are becoming commonly used recently in various applications and different fields where they can converse with humans using AI in messages platforms. Once a chatbot receives an input message, it stores this input then responses to the user with an appropriate reply. The more inputs it gets, the more precise it becomes. Apple's Siri, Microsoft's Cortana, and Elomia are some of the presently available chatbots that use Natural Language Processing (NLP) to facilitate the communication between the machine and the user using human natural language.

Depression is a widespread and serious mental illness. It negatively affects your emotions and how you feel, the way you think and your daily actions. It can cause feelings such as sadness or numbness and a loss of interest in activities a person once enjoyed. It can also be the reason for a variety of emotional and physical problems and can affect the ability to perform daily tasks whether it was for work or for the person's personal life. Nowadays stress keeps increasing especially among students, and that can be overwhelming for many and might lead to serious issues such as depression. However, most students dealing with depression, or any other mental illness are often unwilling to communicate their true feelings and share their thoughts with other people, and it is even more unlikely that they will willingly seek the help of a psychologist to learn how to cope and deal with their negative emotions.

The limitation of the model is that people may write words that is not in the standard format in their tweets, which will result in some confusion to the classifier, thus, the results will be affected, and it may be harder to achieve significant results without improving the model.

In this paper, we proposed an intelligent chatbot to detect and manage the mental illness depression, especially for students. To detect the mental illness, the user needs to chat with the proposed chatbot. In this process, based on the chat data provided by the user, the bot will identify emotions of the user by calculating the percentage of negativity in chat. Further, with the help of negative content in the chat, the bot will categorize the level of mental status of the user as either normal, or depressed. To extract the emotion from the user's chat data, we deployed the machine learning algorithm Naïve Bayes. The rest of this paper is organized as follows: Section 2 describes the related work. Section 3 presents the dataset and methodology. Section 4 shows the summarized results. Section 5 gives a brief conclusion and future work for the paper.

II. RELATED WORK

In the [1] paper, an intelligent social therapeutic chatbot was designed, this chatbot provided mental relief to students who suffer from various levels of stress. To triumph

over the mental illness, the user must chat with the chatbot, while doing this the chatbot will ask the user a few questions to identify the problem, the chatbot takes the chat entered by the user as input and processes it into several emotion labels namely, Happy, Joy, Shame, Anger, Disgust, Sadness, Guilt, and Fear. Moreover, depending on the chat data, the chatbot will detect emotions of the user to calculate the positivity and negativity percentage of each chat text, using the negative content in the chat data the chatbot will classify the level of mental status for the user as normal, stressed, or depressed, and gives a suitable advice depending on the user's mental health state. Further, the emotion detection from the user's chat data was done by deploying three common deep learning classifiers, Convolutional Neural Network (CNN), Recurrent Neural Network (CNN), and Hierarchical Attention Network (HAN).

The main objective of paper [2] is to create a therapy Chatbot, which is able to cater the needs of a user. Moreover, the paper focuses on using technology to help individuals suffering with depression and its consequences. Also, it aims to detect the level of depression in an individual and then offers some suggestions of advices/solutions for helping to lower the level of depression. One of the most important advantages of a therapy Chatbot comparing to a psychotherapist is that it is more flexible, having a therapy Chatbot on a mobile phone available for 24/7 without the need of any appointments reduces the delay that might happen, and guarantee that an individual therapy course will not be affected in a bad way. Python is used as the base language for creating the Chatbot, which is designed as Digitally Advanced Depression Relieving Machine (D.A.D.R.M). That design can be achieved by using multiple methodologies, such as: (1) machine learning, (2) text-based cognitive behavioral approach (NLP), and (3) storing a user's data in a database.

Study [3] conducted to assess the usability of a chatbot for mental health care in the workplace using a questionnaire developed by Chatbot test and the System Usability Scale. The chatbot provided guided self-assessment on several mental health issues such as stress, anxiety, depression, sleep and self-esteem. Initially, the user is asked to complete a self-assessment instrument based on Perceived Stress Scale in order to assess perceived stress levels. Thereafter, a piece of advice in addition to evidence-based recommendations are presented to the user based on the self-assessment survey results. This chatbot was implemented using Microsoft Bot Framework with NodeJS and was connected to a MySQL database contains coping strategies and questionnaire scores. The study concluded that the chatbot performed well on many areas and the participants enjoyed interacting with the chatbot and found it easy to use.

Paper [4] developed a chatbot for students to promote their mental health status through emotion recognition. This kind of chatbot can help in reducing the number of suicides attempts related to depression and stress. The proposed chatbot namely Maxx will facilitate by helping students either solve existing mental health caused by their daily life stress and issues or prevent them from accruing. Maxx works by first having a conversation with the user, in which it understands the user's current emotional state and if it's related to any mental health issue. Then identifies the source of that mental health issue and provides the right advise and guidance. Maxx was developed using DialogFlow which is a Natural Language Understanding (NLU) platform created by Google that aids in constructing chatbots for Natural Language Processing (NLP) in an effective and powerful way through using several Machine Learning (ML) algorithms, Flutter the app development, and Google Cloud Platform (GCP) for data storage and security.

Paper [5] proposed a chatbot directed to students that will provide the necessary support and guidance that is somewhat like a counsellor or a therapist. It aims to relive the stress that students face and deal with their mental health issues if any. The user will be asked to fill questionnaires such as PHQ-9 and WHO-5, both are questionnaires recognized by the world health organization (WHO) for determining the severity of initial symptoms of depression. Afterwards the bot will ask the user about the issues that they believe are facing. Eventually, the user will be suggested with minor tasks to tackle their issues. The method for developing the chatbot includes Surveys, Questionnaires, Data Analysis, and Natural Language Processing (NLP), The Transformer Model architecture was carefully chosen to train the chatbot and works completely on the principle of Self- Attention.

Aside from the current field limitation mentioned in section 1, due the lack of time the proposed work is considered a simple detector that only receives one sentence as an input and then does the analysis accordingly. To implement a complete and powerful chatbot application, the concept of Natural Language Understanding (NLU) also is better to be introduced. In addition, the GUI is implemented to simulate the chatbot form using the standard Tkinter toolkit to be designed for a special purpose, unlike the predefined Chatterbot library which is designed to provide general automated responses.

III. DATASET

In this work, we have used the depression_data dataset for emotion detection in text. The dataset consists of 3 columns (Unnamed, message, label) and 10314 rows, each message is a tweet. It is categorized into two labels positive (0) and depressed (1).

	Unnamed: 0	message	label
0	106	just had a real good moment. i missssssssss hi...	0
1	217	is reading manga http://plurk.com/p/mzp1e	0
2	220	@comeagainjen http://twitpic.com/2y2lx - http:...	0
3	288	@lapcat Need to send 'em to my accountant tomo...	0
4	540	ADD ME ON MYSPACE!!! myspace.com/LookThunder	0

Figure 1: Example of the Dataset

IV. METHODOLOGY

To distinguish the emotion from text, Naïve Bayes model is deployed for training and testing.

A. Preprocessing stage

The design workflow, as illustrated in figure 1, starts with data collections followed by the preprocessing of the collected dataset. At this point, any words or punctuations that do not contribute to the sentiment classification and only increase the redundancy will be removed. By focusing on the important keywords, the work easier and more efficient.

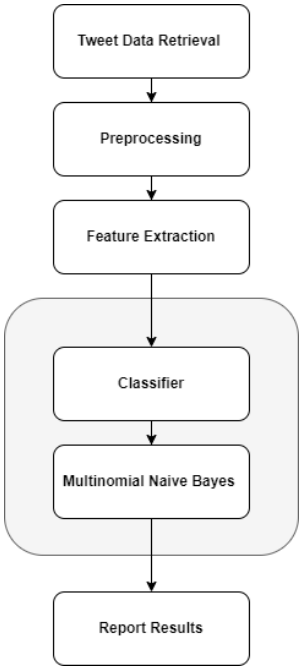

Figure 2: Workflow of the Proposed Work

Moreover, NLP is used on the extracted data for preprocessing:

- Lowercasing all words in the dataset.
- Removing punctuation and digits.
- Removing hashtags, special symbols and extra blank spaces.
- Removing stop-words that do not add meaningful content, e.g., conjunctions.

Feature Extraction stage includes:

- Tokenization, where the string is divided into meaningful substring, i.e., tokens. In this case, the *message* column containing the tweet is extracted and converted into separated tokens where they can be used as features.
- Stemming, where the words are reduced to their root form, e.g., *lives* is converted to *life*
- Gram features, where the sentence is calculated and mapped into key and value.
- Sentiment Extractions, where the polarity and subjectivity are determined.

B. Splitting methodology

A ratio of 70:30 has been adopted for splitting the dataset into training set and testing set.

C. The proposed method

The chosen machine learning algorithm to implement the model is Naïve Bayes. Naïve Bayes Classifier utilizes Bayes theorem with independent feature model. Basically, the Bayes Theorem finds the probability of an event given some other event that has already occurred, i.e., conditional probability. The classifier predicts the most likely class of an instance by finding the conditional probability of the class based on a set of evidence. This classifier is very popular technique whose equation is defined as follows:

$$P(H|M) = \frac{P(E_1|H) * P(E_2|H) * P(E_n|H) * P(H)}{P(M)}$$

Where H is the probability of a classification, E_1 to E_n are the evidence variables and M is the set of all evidence.

The Naïve Bayes Classifier is divided into three types:

1. Gaussian Naïve Bayes
2. Multinomial Naïve Bayes
3. Bernoulli Naïve Bayes.

The second type, which is Multinomial Naïve Bayes, is chosen as a classifier since it is widely used in text classification because it works well with multinomially distributed data.

A. Training

The training set is converted into vector format along with the corresponding labels for further processing. Since the model needs to be trained once, it needs to be loaded and saved as a pickle file. The same is applied to the Count Vectorizer Object.

B. *Testing*

The testing step involves the following:

1. Loading saved models: the trained model are retrieved from the pickle file.
2. Data Preprocessing: the testing set is preprocessing in a similar manner as the training set.
3. Class Prediction on Test dataset: each text is classified into 0 or 1.
4. Computation the Performance: to evaluate the performance of the classifier, some chosen metrics are computed.

V. RESULT AND DISCUSSION

In this section we will discuss classification measures after applying the Naïve Bayes model to a dataset containing 10314 tweets which shows whether a person is depressed or not. For the performance evaluation, we used well-known evaluation metrices such as accuracy, precision, recall and f1. The current results show that the performance matrices all have a score of 95% on the dataset.

Table 1: Result

Comparison of Performance Metrics				
Model	Precision	Recall	F1 score	Accuracy
Multinominal Naïve Bayes	0.95	0.95	0.95	95%

Figure 3 and 4 shows the output after testing the chatbot.

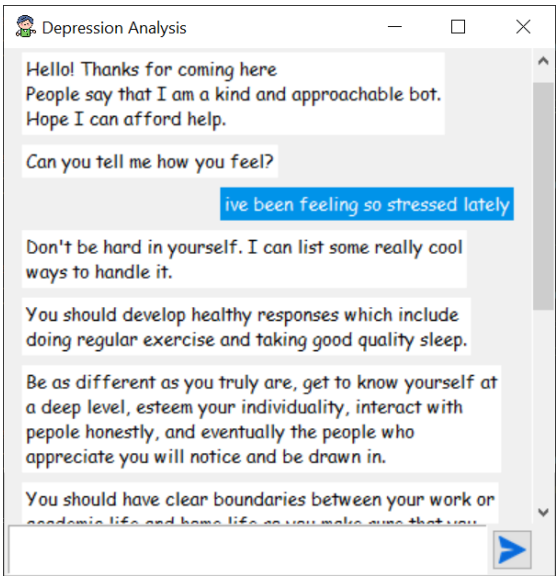

Figure 3: Screenshot 1 after Interaction with the Chatbot

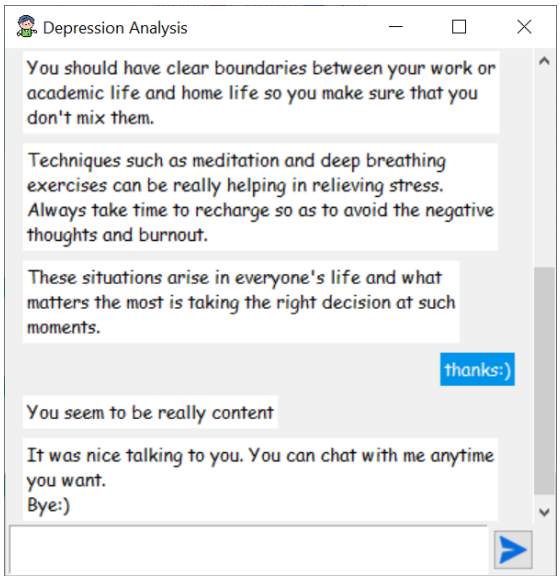

Figure 4: Screenshot 2 after Interaction with the Chatbot

VI. CONCLUSION AND FUTURE WORK.

This paper emphasized the importance of therapeutic chatbot specifically for students considering their young age and the stress they deal with. In this work, we proposed an intelligent chatbot for the recognition of depression and the providing the necessary remedy for it. For the extraction of emotions from the user's chat data, we deployed the well-known machine learning algorithm Naïve Bayes. In the future, we will further improve the chatbot to detect the level of depression the user has, and accordingly give an appropriate advice to help the user overcome this disease.

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