

Analyzing Depression on Social Media Utilizing Machine Learning and Deep Learning Methods

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Abstract

Depression is a psychological phenomenon that affects the mental health of people. At the maximum level of depression, one may commit suicide. Besides, it hampers the family and social activities. As a result, identifying depressed persons is crucial before proceeding with physiological treatment. Social media has become the most powerful platform for expressing feelings of individuals and also became a potential source of depressive data. Some handy research works are available for English data while it is poor for Bengali data. We have created a noble dataset in Bengali and applied different machine learning and deep learning methods for performance evaluation. A combined method of CNN and GRU gives us the highest accuracy of 87.11%. Our research finds that the performance of CNN+GRU is better compared to other previous research works.

Keywords: Depression analysis; machine learning; deep learning; Bengali depression dataset.

1. Introduction

In this era of technological advancement, an enormous number of micro blogging sites have been emerged since the last decade. Different social media platforms are gaining popularity day by day. The main reason behind becoming so popular social media platforms facilitates user interactions on it. People are now sharing their emotions on social media freely without any hesitation. A huge amount of data is generated on social media every moment because people are interacting on it. On social media, people are talking about their emotions, feelings over others, opinions on political views and other different types of thoughts. These data of different persons can be used for analyzing their psychological behavior because they are sharing their personal thoughts and observations about the surroundings without knowing their emotions can get viral on social media platforms. Different people have different opinions on same event as their personal views are different.

At present, suicidal tendency among young generation has become an alarming issue. Recently, teenagers as well as youngsters commit suicide writing a suicide note on social media. Among the youngsters, depression has become an acute problem in recent times. About 5% adults around the globe, suffer from depression [1]. WHO reports, depression is so acute that can lead to suicide. Due to the easily available social media access, people are expressing depression on social media through their posts, comments etc. Psychological behaviors of people were analyzed through questionnaires and interviews before the social media revolution [2]. To analyze

psychological behavior, sentiment analysis is a powerful technique. It is used to classify sentiments from opinion dataset of different events expressed by humans [3].

Social media users in Bangladesh are increasing day by day. Therefore, a potential source of depression data can be found from Bangladeshi social media handles. The people posts depressive emotions on social media daily which may lead them to extreme activities like suicide. Bangla natural language processing can be used for detecting depression on social media for Bengali dataset. We are aiming to design a deep learning based model that can be used for detecting depression on Bengali language. Although there are many useful models for sentiment analysis, there is little work for emotion detection like depression on Bengali language. When the depression level gets high, people may commit suicide. It may save lives if we can detect depression level at an early stage. In our work we will try to answer the following research questions.

RQ-1: Can we detect depression on Bengali language using posts/comments from micro blogging sites like Facebook, Twitter etc.?

RQ-2: How can we apply social media platform's data for analyzing specific emotions like depression?

RQ-3: How machine learning and deep learning can be useful for detecting depression on social media?

Social media platforms have become mass communication platform across the world. People can easily express their internal feelings on social media frequently. However, depressed people are using these more frequently than others because they are usually unwilling to talk about their depression face to face. This is extremely vulnerable for them because they can commit suicide out of depression. If we can detect their depression by analyzing their social media interactions, we can take steps to prevent suicidal tendency among them. Technically saying, there are few details of analyzing depression on textual data in English as well as other languages like Bengali. The main motivation for our work is that if we can detect depressed people early, we can save many depressed people's life by preventing them from taking extreme steps like committing suicide.

The key contributions on this research are as follows:

- (1) Build dataset by crawling Bengali data like posts or comments from different social media platforms like Facebook, Twitter etc. to adjust RQ-1.
- (2) Apply machine learning and deep learning models on our noble dataset to show how these models perform on the dataset to answer RQ-2.
- (3) Present a comparative analysis among different machine learning and deep learning techniques for the detection of depression on social media to answer RQ-3.

The rest of the paper constitutes as following, section 2 describes some previous works done in this field. Section 3 and 4 describes our methodologies and result analysis respectively. Finally, section 5 concludes our research providing some future directions.

2. Related Works

Though psychological disorder related events are occurring frequently, there are not much works available on that topic. However, modern technology has made the way to work on that in recent times. Different machine Learning based approaches can be found in analyzing depressive emotions on social media.

A depression analysis research has been done in Chinese language using machine learning in [4]. They have used Sina micro blog which is the most used micro blogging site in China. Collectively 10 features were used on that research from three different dimensions which means the dataset contains the contents, interactions and behaviors. They have used different machine learning classifier algorithms for their proposed model where they have used 90 depressed and 90 non-depressed user's data. In [5], the authors have described a system which can analyze emotions on twitter data. The basic emotions of a human being like happiness, sadness, surprise, disgust etc. were used for classification in their work. A collection of 4232 tweets were used which were mostly manually labeled. They have applied their own way of data preprocessing that includes expanded abbreviations, removing hash tags, usernames, urls etc. a bag of words model were used for training purpose with unigram feature. For the classification work, Multinomial Naïve Bayes algorithm was used. They have avoided zero probability by using Laplacian add-1 smoothing technique. They have achieved an average of 81% accuracy while applied unigram model.

The authors of [6] have used textual dataset which contains Bangla and Romanized Bangla textual data for sentiment analysis. They have applied LSTM model with the dataset. The dataset consists of 9337 textual data. They have found 78% accuracy for Bangla data and about 55% accuracy for Romanized Bangla data. In [7], the authors have used Facebook posts data for emotion classification. They have used some ML tools for the detection of depression in Facebook. Machine Learning algorithms like KNN, SVM were used for classification.

They have found that about 54.77% depressive users use Facebook between midnight and midday while it is 45.22% in midday to midnight.

In [8], the authors have applied different machine algorithms using volumetric features of the brain to detect depression among people. SVM, J48, Random Forest, Decision Tree and some other algorithms were used in WEKA to find the accuracy for the classification of detecting depression. The authors in [9] used Facebook data for detecting major symptoms of depression among users. They have used four different factors to train their model. They have achieved a satisfactory result in their observations. In [10] the authors suggested a model which can capture messages to detect sentiments. Different NLP techniques were used for preprocessing and multinomial Naïve Bayes algorithm was used for classification. They have achieved 74% accuracy for depressive user detection.

The authors of [11] created a 4-class classification system where depression related texts were classified into 4 classes after preprocessing the texts. They have used different ML and DL methods for classification. Transformer based models were also used where xlm-roberta-base model gave the highest 60.89% of accuracy. However, they have found 54.45% accuracy for SVM and 58.87% accuracy for BiLSTM. In [12] the authors have analyzed social media depression related posts for a binary classification system. The preprocessing steps consisted of removing punctuations and stopwords and created a balanced dataset. After applying a modified feature selection technique, they have used six different ensemble classifiers for performance evaluation. Throughout their investigation, they have found the highest of 92.80% accuracy for XG Boost algorithm. The authors of [13] have used a binary classification model for analyzing depressive data. In that research 5053 depressive and 2110 non-depressive texts were used. They have processed their data by removing punctuations, emoticons, stopwords etc. They have found 81.49% of accuracy for Logistic Regression when used TF-IDF feature extraction technique. In [14], the authors have utilized machine learning methods to analyze sentiments from depression related posts or comments. They have extracted linguistic features from social media data for better performance of the classifiers and got the highest 60.54% accuracy from Random Forest classifier.

3. Methodology

In this section, we demonstrate our research workflow to detect depression on Bengali dataset. Fig. 1 shows the detailed workflow of our research.

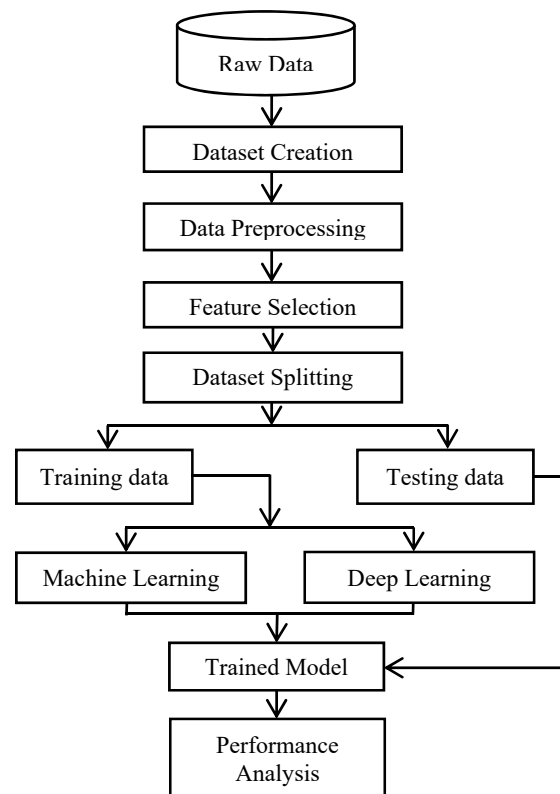


Fig. 1. Work flow of our research methodology.

3.1. Data Collection

We have collected our raw data from different online sources and social media platforms mostly from Facebook posts and comments, YouTube comments, tweets etc. About 5000 data were collected from where we have created a balanced dataset consisting of 1592 depressive and 1592 non-depressive texts. A sample of our dataset is shown in Table 1.

Table 1. A sample list of depressive and non-depressive texts

	Content	Label
01.	একদিন সব কিছু ছেড়ে চলে যাবো তখন আর কারো বরক্তির কারন হবো না।	Depressive (1)
02.	কখন যে কেঁদে ফেলেছি বুঝতে পারিনি, এক কথায় অসাধারণ।	Non-depressive (0)
03.	একটি শূন্য পেট এবং শূন্য পকেট যা শিক্ষা দিতে পারে তা দুনিয়ার কোন শিক্ষক দিতে পারে না।	Depressive (1)
04.	খুবই ভাল লাগছে, ছেলেটি তার আপন জনকে খুঁজে পাওয়ায়।	Non-depressive (0)

3.2. Preprocessing

In this step, we have eliminated the duplicate and unwanted rows first. After that, we have removed punctuation marks, URLs, special characters etc. We have used a modified Bengali stop-word list to remove unnecessary stop-words from the dataset. We have performed tokenization on the dataset.

3.3. Feature Selection

Generally texts are unstructured and to use them for mathematical modeling of classifiers we must convert them into structured feature space. Since social media texts are collected in our dataset, BoW feature extraction technique is used. BoW is mostly used for creating vocabulary of words decomposed from the dataset.

3.4. Model Classifier

In this experiment, we have used different classical ML algorithms like MNB, LR, RF, DT, SVM, SGD, KNN, AdaBoost to detect depression on social media data. We have also applied deep learning classifiers like CNN, GRU, LSTM, BiLSTM in our experiment. A combination of CNN and GRU is also used in our research to classify depression related texts. For the deep learning classifier, the experimental setup is given Table 2.

Table 2. Experimental setup of hyper-parameters for deep learning classifiers

Hyper-parameters	Value
Hidden units	128
Batch size	64
Epoch	10
Loss function	binary_crossentropy
Activation function	softmax
Learning rate	0.001
Dropout	0.2

4. Experimental Results

For the experimental classifiers, we have performed different ML and DL algorithms against four parameters like accuracy, precision, recall, and f1-score. At the testing phase each algorithm generates a confusion matrix from where we can calculate all these measurement parameters.

Table 3. Confusion matrix

		Actual Values	
		Positive (1)	Negative (0)
Predicted	Positive (1)	TP	FP
	Negative (0)	FN	TN

The corresponding formulas for calculating the measurement parameters are stated on the below equations.

$$accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (1)$$

$$precision = \frac{TP}{TP+FP} \quad (2)$$

$$recall = \frac{TP}{TP+FN} \quad (3)$$

$$f1 - score = \frac{2 \times precision \times recall}{precision + recall} \quad (4)$$

About 80% of our data is used for training purpose and the rest 20% are used for testing purpose. The performance of machine learning models applying on our dataset can be shown in Table 4. Logistic Regression gives the highest accuracy of 77.39% for this classification problem while KNN performs poorly in terms of accuracy.

Table 4. Performance evaluation of machine learning classifiers

Algorithm	Accuracy	Precision	Recall	F1-Score
Random Forest	76.63	74.2	81.66	77.75
Logistic Regression	77.39	77.25	77.64	77.44
Multinomial NB	75.38	72.05	82.91	77.10
Linear SVC	75.38	75.12	75.88	75.50
SGD	75.13	75.91	73.62	74.74
Decision Tree	68.34	67.14	71.86	69.42
Ada Boost	66.58	68.13	62.31	65.09
KNN	62.31	61.40	66.33	63.77

For the deep learning classification we have used CNN, LSTM, GRU, BiLSTM, and CNN+GRU. The performance of these algorithms is given in Table 5. Here the combination of CNN and GRU outperformed all other algorithms in terms of all performance parameters. It gives the highest accuracy of 87.11% along with 92.65% of precision, recall and f1-score.

Table 5. Performance evaluation of deep learning classifiers

Algorithm	Accuracy	Precision	Recall	F1-Score
CNN	81.65	81.65	81.65	81.65
GRU	75.10	78.52	78.52	78.52
LSTM	74.62	74.72	74.76	74.74
BiLSTM	76.26	76.25	76.27	76.26
CNN+GRU	87.11	92.65	92.65	92.65

The training and testing accuracy graph in respect to epoch for CNN+GRU is shown in Fig. 2. It shows that the

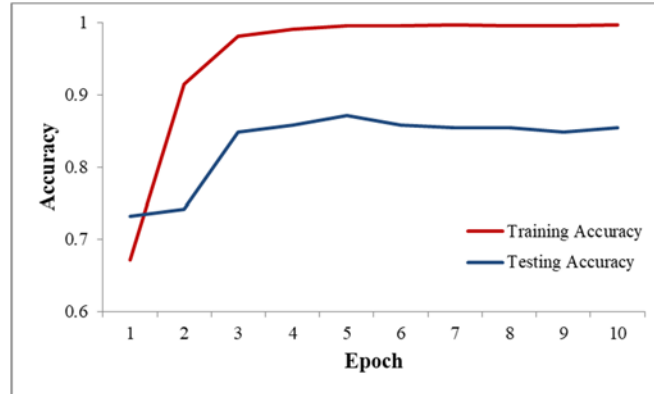


Fig. 2. Training and testing accuracy curve of CNN+GRU.

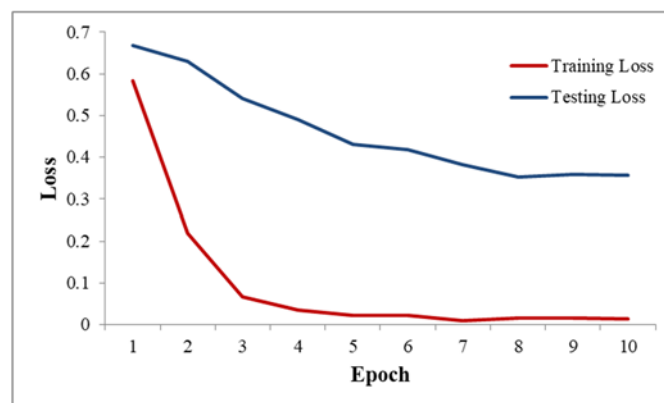


Fig. 3. Loss graph for CNN+GRU.

training accuracy is much higher than testing accuracy and very close to 100%. The loss graph for training and testing is given in Fig. 3. The training and testing loss gradually decreases when the number of epoch increases and training loss goes close to the zero.

A few number of research works are available for depression analysis in Bengali language. Some of the recent works are compared with our results in Table 6.

Table 6. Performance comparison with previous works

Research	Dataset size	Used methods	Best Accuracy
M. N. Hoque et al. (2023)	2598	SVM, MNB, RF, LR, LSTM, BiLSTM, BERT, XLM-Roberta	60.89% for XLM-Roberta
T. F. Mumu et al. (2021)	7163	CNN, LSTM, LR	81.49% for LR
N. A. Asad et al. (2019)	-	MNB	74%
M. R. Islam et al. (2018)	7145	DT, SVM, KNN, Ensemble	72% for DT
Our research	3184	RF, LR, MNB, SVM, SGD, DT, AdaBoost, KNN, CNN, GRU, LSTM, BiLSTM, CNN+GRU	87.11% for CNN+GRU

5. Conclusion

Depression has become a serious problem among the new generation youngsters which is frequently leading to extreme activities. The early detection of depressive symptoms on social media has become necessary for the authority to prevent unusual casualties. In our research, a systematic way of depression analysis on social media data is given. NLP advancement in Bengali language paved the way to do so. Among the applied machine learning and deep learning methods on our dataset, CNN+GRU gives us the best performance in terms of accuracy, precision, recall, and f1-score. CNN and GRU jointly performed better than some previous works having the accuracy of 87.11%. In future, we will analyze transformer based models along with increasing the size of dataset as rich as possible.

Conflict of interest

The authors have no conflicts of interest to declare.

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