

Cyberbullying Detection Based on Hybrid Ensemble Method using Deep Learning Technique in Bangla Dataset

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Abstract—Globalization is certainly a blessing for us. Still, this term also brought such things that are constantly not only creating social insecurities but also diminishing our mental health, and one of them is Cyberbullying. Cyberbullying is not only a misuse of technology but also encourages social harassment among people. Research on Cyberbullying detection has gained increasing attention nowadays in many languages, including Bengali. However, the amount of work on the Bengali language compared to others is insignificant. Here we introduce a Hybrid ensemble method using a voting classifier in Bangla Cyberbullying detection and compare this with traditional Machine Learning and Deep Learning Classifiers. Before implementation, Exploratory Data Analysis was performed on the dataset to gather better insight. There are lots of papers that have already been published in other languages where it is seen that the hybrid approach provides better outcomes compared to traditional methods. Thus, we propose a highly well-driven method for Cyberbullying detection on the Bangla dataset using the hybrid ensemble method by voting classifier. The overall deployment consists of three Machine Learning classifiers, three Deep Learning classifiers, and a Hybrid approach using the voting classifier. Finally, the Hybrid ensemble method yields the best performance with an accuracy of 85%, compared with other Machine and Deep Learning methods.

Keywords—Bangla dataset; cyberbullying; exploratory data analysis; machine learning; deep learning; hybrid ensemble method

I. INTRODUCTION

Globalization impacted Bangladesh immensely a long time ago, and we're moving forward with this new era and keeping ourselves up-to-date with technology, which is a blessing and positive news for us. But now the major concern is cyberbullying, which is also spreading drastically in the Bengali language. People got so aggressive while bullying others, and it is high time we should be concerned and do more research [1] on our language to prevent and detect those nonsocial texts. Research says, this type of behavior recurrently arose on YouTube, Facebook, and Twitter sites (Eric Rice, Cyberbullying perpetration and victimization among middle-school students., 2015). There are about 126.21 million internet consumers in Bangladesh [2], and the majority of active internet consumers are young. Also, Bengali is in the 6th rank as the most spoken language around the globe [3],

which accelerates the use of Bangla over social media. Which also increases the devastating amount of bullying on the internet. The expression "cyberbullying" can refer to a variety of behaviors, including hostile material, harassment, toxic commenting (such as gibe, triggered, sexual, or religious), and so on. And these sorts of aggressive behavior most lead to terrible mental health issues, such as self-harm anxiety, depression, social and emotional perplexity even suicidal thoughts or attempted suicide [4]. In Bangladesh, a survey stated, about 85 percent of youths believe that online bullying is an unadorned problem and 8 percent of youths have faced online bullying, at least one time a week or more since the pandemic [5].

Therefore, to mitigate such heinous acts of cyberbullying, many global preventive and intervention approaches have been introduced to improve the safety of internet users all around the world, and we should also be concerned about our Bangla language. Thus, we are approaching a new method to prevent this vile activity. Due to the numerous benefits the hybrid approach has over traditional machine learning algorithms, researchers are moving away from traditional machine learning techniques and toward them in the detection of cyberbullying. That's why, focusing on detecting bully on Bengali Language using a Hybrid Ensemble approach. The following are main highlights of this paper:

1) Introducing and proposing a hybrid ensemble approach that combines all the traditional approaches utilized in this study and uses a voting classifier to detect cyberbullying in the Bangla dataset.

2) The proposed method outperforms the currently used worldwide for classification and analysis, including Dense Architectural, LSTM, Bi-LSTM, KNN, Logistic Regression, and Decision Tree.

3) Performed exploratory data analysis (EDA) to get the appropriate insights and visuals for the desired cyberbullying model in the Bangla dataset.

4) Performed visualization and comparative analysis on the classification performance of three traditional machine learning and deep learning algorithms.

5) Evaluated various feature extraction methods to identify the optimal strategies for feature extraction and text

embedding for both conventional machine learning and neural network-based techniques.

Our whole work is divided into two parts:

- Performing Exploratory Data Analysis (EDA) to get insight from the dataset.
- And then introducing a hybrid ensemble method to detect cyberbullying in the Bangla dataset.

II. RELATED WORKS

Cyberbullying is indeed like a parasite in our modern tech world. There are so many works and activities being practiced preventing this. Recently, the amount of work has increased in the field of Cyberbullying detection in the Bangla dataset. But the progress is not comprehensive; we should enrich our research by doing more work to prevent this aggressive vulnerability on social media.

For English language, tons of work already been done in text categorization or Cyberbullying detection using text mining by classifying posts or conversations. Yin et al. text classification by using supervised learning [6]. In [7], they proposed unsupervised method for bully detection. Haidar et al. detect Cyberbullying by proposing a multilingual system in the Arabic language by using Machine Learning [8]. Dadvar et al. they proposed a Hybrid approach to detect Cyberbullying, where they show that the hybrid approach provides better performance than the expert systems [9]. Zhao et al. proposed an automatic Cyberbullying detection using bullying features on social media [10]. Mohammed Ali Al-garadi et al. proposed a model that provides a practical explanation for Cyberbullying detection in social media. This is an offensive language detection approach equipped with a lexical syntactic feature only [11]. Dalvi et al. they introduced a method to recognize and stop Cyberbullying on Twitter using machine learning [12]. Muneer et al. proposed an automatic bully detection system where they used more than 35,000 distinctive tweets as a dataset [13]. Herath et al. presented an automated bully detection system against immigrants, women, and cross-domain adaptability [14]. Robin M. Kowalski et al. came out social media bullying between Middle School Students, their results disclosed that about 84% of school students have experienced bullying in this study [15]. In a previous study conducted by Prathyusha et al. [16], a novel approach was proposed that integrates the Multiple Correlation Coefficient and the Support Vector Machine. In Bengali language, some noteworthy works been seen for Cyberbullying detection. Mahmud et al. [17] Utilizing the Bangla dataset, we were able to come up with a visualization method work on the Bangla corpus is specifically used for sentiment analysis [18]. In [19], Shahin Akhter et al. performed Cross-validation using ML classification models with 2400 data labeled as bullied and non-bullied and achieves superior performance on Bangla text with a detection accuracy of 97%. This study shows a very insignificant amount of data, that's why it's over fitted. In [20], Ahmed et al. used 44,001 users' comments from popular public Facebook pages and came out with a binary classification model of 87.91% accuracy. They proposed binary classification model which isn't well suited for text classification. In [21], Chakraborty et al. used several ML and

DL approach to analyze Bangla texts. In [22], Ahammed et al. proposed a Machine Learning approach with an accuracy of 72%. Again in [23] [24], Ahmed et al. used Bangla, Romanized Bangla and Meme Detection [25] text for Cyberbullying detection using traditional ML, and DL Classifiers.

In terms of bullying detection, the above approaches are all good, but they got a few lacking like, using insignificant amount of dataset, implementing traditional approach for bully detection, and the approach that doesn't help to classify text accordingly. Hence, we're introducing a new approach for Cyberbullying detection on the Bangla dataset: Hybrid Ensemble Method using the voting classifier. The detailed methodology is discussed in Section III. Section IV presents the Results analysis and the conclusion is given in Section V.

III. RESEARCH METHODOLOGY

This research mainly focuses on introducing a new approach for Cyberbullying detection in the Bangla dataset.

A. Dataset

There is total number of 10,512 data on our dataset and the dataset consists of three columns - comments, class, and gender. The class column categorized into- Gibe, Triggered, Sexual, Religious, and not bully. And the Class and Gender section is specifically used to perform Exploratory Data Analysis to get insight from the Bangla dataset. Fig. 1, a complete portrait of how the bully is differing from gender to gender.

Gender	Class				
	Gibe	Not bully	Religious	Sexual	Triggered
Female	1,321	1,101	286	251	873
Male	1,824	3,174	439	242	1,021

Fig. 1. Different types of bullies among gender.

B. Model Procedure

In the proposed work, introducing Hybrid Ensemble approach for bully detection in the Bangla dataset. The overall reasearch is divided into four parts or sections:

- Exploratory Data Analysis to get proper insight from the dataset,
- Machine Learning deployment,
- Deep Learning deployment, and
- Hybrid Ensemble approach deployment.

To get an accurate and precise model, one need to know the dataset precisely that's why exploratory data analysis is must to do part before any model implementation. In our work, we use the table for our data visualization and find out proper insight through this visualization. The Bangla comments are collected from social media platform. Since

dataset is in raw format, contain noisy elements, unwanted data, null value which could degrade our model evaluation. So, lots of data preprocessing method been applied to sort out the dataset and remove those unwanted part from the Bangla dataset. A classifier is a function that uses an example's values as predictor variables or independent variables to determine the class to which the example belongs (the dependent variable). A computational software called machine learning is able to learn without being told where to look. In our work, Machine Learning Classifier perform one part which helps to understand further classification. New and robust deep learning (DL) algorithms have been developed as a result of advancements in computing technology, and they have shown promising outcomes in a variety of applications. Further implemented a few Deep Learning model in order to get overview from the dataset.

Finally introduced a Hybrid Ensemble method and compare between these three methods, to find out best performance. Illustrating overall workflow in below Fig. 2. Based on split data, the program then trains each classifier to develop a method of classifying. Three columns from dataset is taken for further analysis. They are- comments, Gender, and class. The class column divided comments into five categories:

Comments can be in different formats, like:

- Not bully,
- Triggered,
- Gibe,
- Sexual,
- Religious, etc.

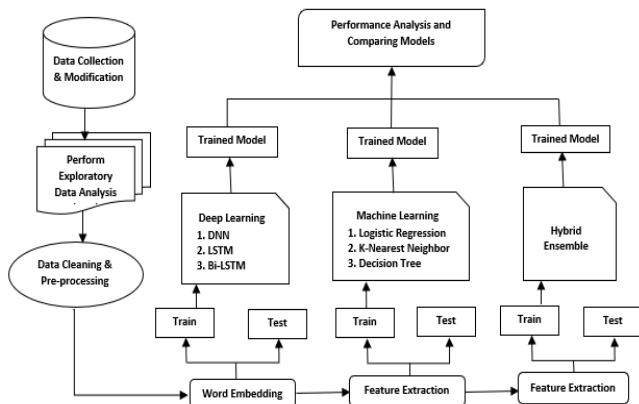


Fig. 2. Diagram of the proposed workflow for the research.

So, Not Bully are the type of comments which are in general comments on a post or write as well wishing. Then others four types of comments are basic criteria of bully comment or language. For better clarification triggered comments are like make some pointing negatively publicly, gibe means spreading some rumors about other user, sexual mean abuse someone or eve teasing female through social media and the religious bullies are like contradicting with religious and conflict with each other and so on.

For further implementation and evaluation, we used three ML classifiers and three DL classifiers and Hybrid Ensemble approach using voting classifier. The accuracy, precision, recall, f1 score, validation loss, and accuracy of each of the classifiers used in these models have been evaluated in order to choose the optimal model for implementing the Cyberbullying detection on the Bangla dataset. The model procedure is detailed below.

1) *Exploratory data analysis:* The Exploratory Data Analysis (EDA) is performed on Tableau and came out with some important points and insights from our dataset. Dashboard of the overall Exploratory Data Analysis is shown in Fig. 3. Which is a collection or assembly of multiple worksheets. Worksheet are made by importing Class and Gender columns in Tableau.

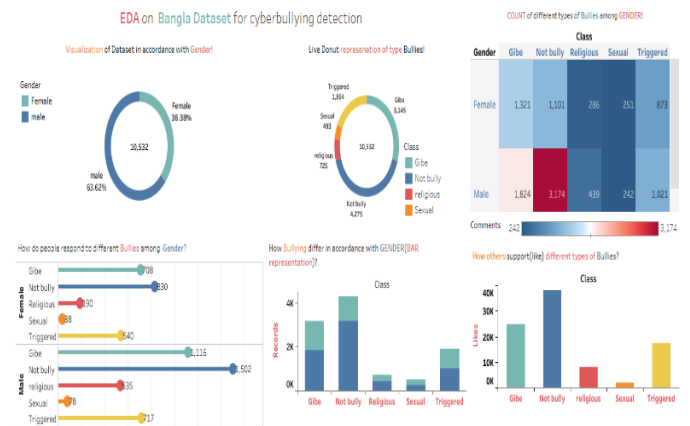


Fig. 3. Exploratory data analysis (EDA) on the Bangla dataset, and dashboard using tableau.

2) *Data analyzing and preprocessing:* For analysis, first dropped all the unwanted columns from the dataset. Before implementation, data analysis is mandatory for getting a clean and accurate model. The BNL corpus is used to remove Bangla stop-words, letters, and digits from the Bangla comments. The dataset was also cleaned of any duplicate information, links, or URLs, as well as numerals, punctuation marks, and emojis. The next step is to clean, instance selection, remove noisy data, unwanted value, feature extraction, and selection are among the steps that are involved.

3) *Feature extraction:* Machine Learning and Hybrid Ensemble approach feature extraction, we used Term Frequency & Inverse Document. It is stated that, in Machine Learning strings is converted into number by using TF-IDF and then provide a numerical format for the Machine Learning models. Using the text vectorizer term frequency-inverse document frequency, text is transformed into a vector format. The concepts of Term Frequency (TF) and Document Frequency are integrated (IDF).

4) *Split processed dataset:* The dataset was divided into training and testing data using the sklearn model selection module for subsequent implementation. A total number of 10,512 data is in the dataset and split them for further training and testing using several approaches.

C. Machine Learning Classifiers

Here three Machine Learning classification models been used for the bully detection purpose and they are: Logistic Regression (LR), K-Nearest Neighbor (KNN), and Decision Tree (DT).

1) *Logistic regression (LR)*: Logistic Regression (LR) been widely used for classification algorithm (two-class classification). Logistic Regression estimates the probability of an event occurring by using the sigmoid function which maps any real value into another value between probability 0 and 1. The sigmoid function is written in Eq. (1).

$$\text{Logit}(x) = 1/(1 + \exp(-x)) \quad (1)$$

2) *K-Nearest neighbor (KNN)*: The k-nearest neighbors' algorithm (KNN) is a supervised learning and a non-parametric classifier, which uses propinquity where they group distinct data point to make prediction. Although it can be applied to classification or regression problems, it is commonly employed as a classification algorithm because it assumes that comparable points are located close to one another.

3) *Decision tree (DT)*: Decision Tree is also a supervised learning classifier. When it comes to classification issues, decision tree is often used. In DT, internal nodes outline dataset appearances, branches signify decision rules, and each leaf node denotes the result.

D. Deep Learning Classifiers

For our research purpose, we used three Deep Learning approaches, like- Dense architecture model, LSTM, and Bi-LSTM.

1) *Dense architecture model*: The proposed approaches run 30 epochs to find out the upmost accurate performance for Dense Architectural model. It can be observed that, by the time each cycle or epoch running the performance of the model also enhances, which means decreasing validation loss of model and increasing validation accuracy of the model. The model summary provides the layer, shape, and number of parameters used in each layer. Fig. 4 below demonstrating, overall Dense Architectural Model summary, which includes that the model is running sequentially, the embedding layer got total 8000 parameters, dense layer got 408 parameters, there is no dropout in the dense layer. It also indicates that the total parameters are 8433 and all of them are trainable.

2) *Long short-term memory (LSTM)*: Long short-term memory (LSTM) is a type of recurrent neural network that was created specifically to stop the neural network output for a particular input from expanding up as it rotates with the feedback loops. Recurrent networks were able to outperform other neural networks at pattern identification thanks to these feedback loops. Another popular advanced recurrent neural network (RNN) structure that was created with long-range dependencies and temporal sequences in mind is known as Long Short-Term Memory. Fig. 5, Number of epochs and validation accuracy and loss scores in our LSTM model.

```
Model: "sequential"
-----
Layer (type)                Output Shape              Param #
-----
embedding (Embedding)      (None, 50, 16)           8000
global_average_pooling1d (Gl (None, 16)                 0
dense (Dense)               (None, 24)               408
dropout (Dropout)          (None, 24)               0
dense_1 (Dense)             (None, 1)                25
-----
Total params: 8,433
Trainable params: 8,433
Non-trainable params: 0
```

Fig. 4. Proposed dense architectural model.

```
Epoch 1/30
263/263 - 37s - loss: 0.6382 - accuracy: 0.6522 - val_loss: 0.5797 - val_accuracy: 0.7291
Epoch 2/30
263/263 - 16s - loss: 0.5639 - accuracy: 0.7448 - val_loss: 0.5576 - val_accuracy: 0.7457
Epoch 3/30
263/263 - 13s - loss: 0.5613 - accuracy: 0.7405 - val_loss: 0.5762 - val_accuracy: 0.7316
Epoch 4/30
263/263 - 14s - loss: 0.5440 - accuracy: 0.7563 - val_loss: 0.5551 - val_accuracy: 0.7489
Epoch 5/30
263/263 - 13s - loss: 0.5212 - accuracy: 0.7702 - val_loss: 0.5408 - val_accuracy: 0.7468
Epoch 6/30
```

Fig. 5. Validation accuracy and loss scores of LSTM model, and number of epochs.

3) *Bi-LSTM*: Bidirectional recurrent neural networks are the combination of two independent RNNs together for further implementation. With the help of this Bi-LSTM structure, the networks can vividly have both forward and backward information at every stage of the process. Using a bidirectional will run inputs in two ways: one from the past to future and another one from the future to past and where LSTM that only runs backward (unidirectional). Fig. 6 illustrates the number of epochs and validation accuracy and loss scores in our Bi-LSTM model.

```
Epoch 1/30
263/263 - 43s - loss: 0.6297 - accuracy: 0.6539 - val_loss: 0.5504 - val_accuracy: 0.7380
Epoch 2/30
263/263 - 22s - loss: 0.5224 - accuracy: 0.7536 - val_loss: 0.5296 - val_accuracy: 0.7456
Epoch 3/30
263/263 - 19s - loss: 0.5074 - accuracy: 0.7576 - val_loss: 0.5211 - val_accuracy: 0.7446
Epoch 4/30
263/263 - 18s - loss: 0.4950 - accuracy: 0.7658 - val_loss: 0.5271 - val_accuracy: 0.7476
Epoch 5/30
263/263 - 17s - loss: 0.5002 - accuracy: 0.7636 - val_loss: 0.5927 - val_accuracy: 0.6981
```

Fig. 6. Validation of the correctness of the Bi-LSTM model in terms of loss as well as the number of epochs.

E. Hybrid Ensemble Method

Hybrid Ensemble Method is one of the popular methods used nowadays for better predicted outcome. It's also called the heterogeneous assembly of weak learners. Lots of Machine Learning classifiers are combined in this task to come up with a classification problem. Ensemble learning techniques got a long record and history of showing handsome performance comparing with any other traditional

ML approaches. The domains of these applications include classification and regression problems. Fig. 7 shows how the hybrid ensemble method works in a simple way.

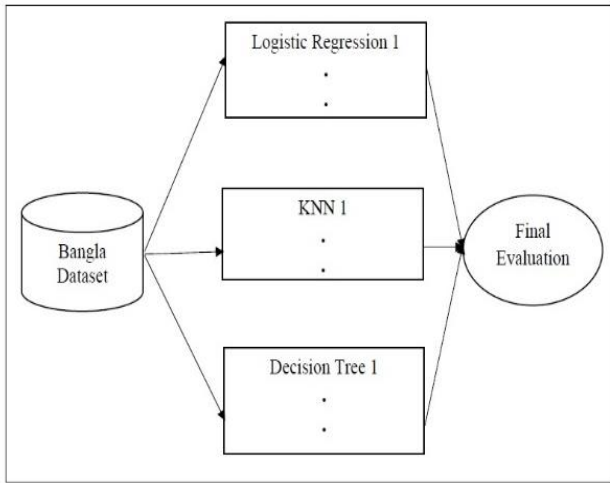


Fig. 7. Basic working procedure of hybrid ensemble method.

IV. RESULT ANALYSIS

A. ML Models Result Analysis

The performance of the Machine Learning models was further examined through the utilisation of Receiver Operating Characteristic (ROC) curves and the Area Under the ROC Curve (AUROC). In Fig. 8, the receiver operating characteristic (ROC) curve and the area under the ROC curve (AUROC) are depicted for our machine learning classifiers. It is observed that the logistic regression (LR) model achieved the highest AUROC score of 88%. It has been noticed that Logistic Regression achieved the greatest AUROC score. It's stated that, highest AUROC means better classifier. Summary of ROC curve with AUROC score: Logistic Regression AUROC score is 0.88, K-Nearest Neighbor AUROC score is 0.832, and Decision Tree score is 0.551. According to the measurements of AUROC, Logistic Regression is the best classifier amongst the three ML classifiers.

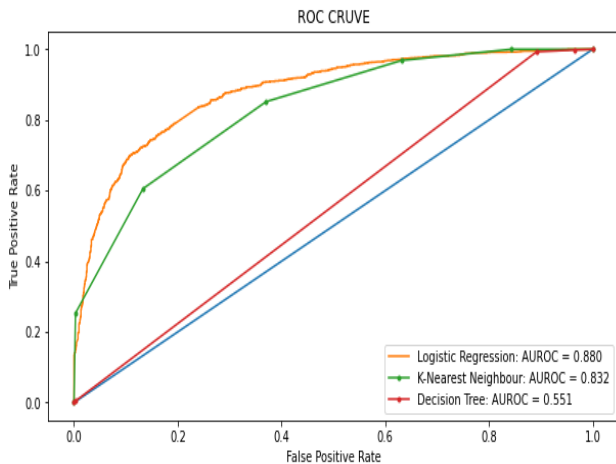


Fig. 8. Receiver operating characteristic, and area under-ROC curve and scores of ML classifiers.

B. DL Models Result Analysis

For Deep Learning models, the visualization shown below is the result in validation loss and accuracy curve for comparison. Both Validation loss and Validation accuracy of Dense Architectural Model are illustrating in Fig. 9. For Dense Architectural Model with increasing number of epochs validation loss also decreasing and in mean-time validation accuracy increased. For the Dense Architectural Models Training and Validation evaluation, where employed a total number of 12 epochs. In below graph, validation accuracy versus the number of epochs provides a visual. Where blue line represents as Training accuracy score and yellow line representing Validation Accuracy score. This is time series analysis of visualizing how accuracy scores of Dense Architecture model increasing with number of epochs. Highest accuracy for both training and validation is highlighting in epoch number 12, where Training accuracy score around 0.775 and Validation accuracy score is around 0.770.

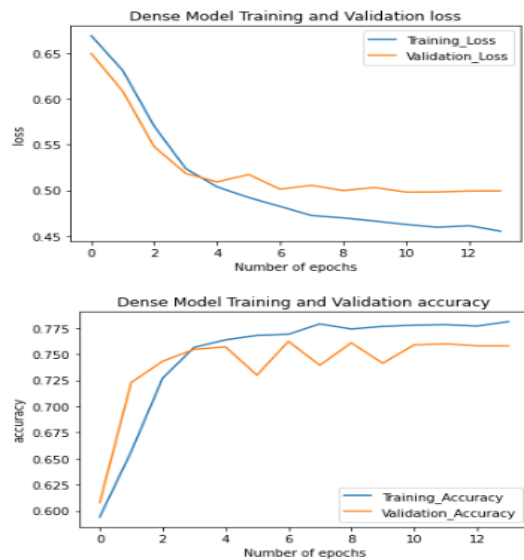


Fig. 9. Time series representation Dense Architectural model (Validation loss and accuracy scores with respect to number of epochs).

LSTM model Validation loss and accuracy in below Fig. 10 Validation accuracy as a function of the total number of epochs. Where blue line represents as Training accuracy score and yellow line represents Validation Accuracy score. This is a time series analysis of visualizing how accuracy scores of LSTMs (Long Short-Term Memory) model increasing with number of epochs. Highest accuracy for both training and validation is highlighted in epoch number 5, where Training accuracy score around 0.78 and Validation accuracy score is around 0.76 in the 4th epoch.

Bi-LSTM model Validation loss and accuracy in the Fig. 11. Where blue line represents as Training accuracy score and yellow line represents Validation Accuracy score. This is a time series analysis of visualizing how accuracy scores of Bi-LSTM (Bidirectional) model increase with number of epochs. Highest accuracy for both training and testing is highlighted in epoch number 7, where Training accuracy score around 0.78 and Validation accuracy score is around 0.7 at the 7th epoch.

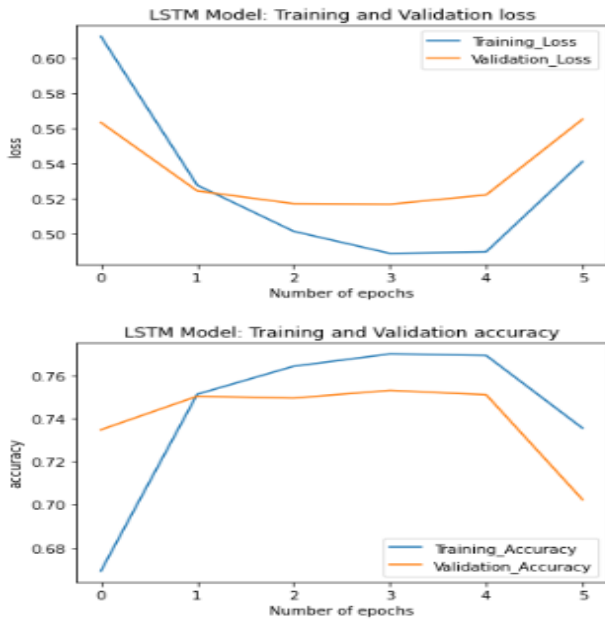


Fig. 10. Time series chart of LSTM model (Validation loss and accuracy scores with respect to number of epochs).

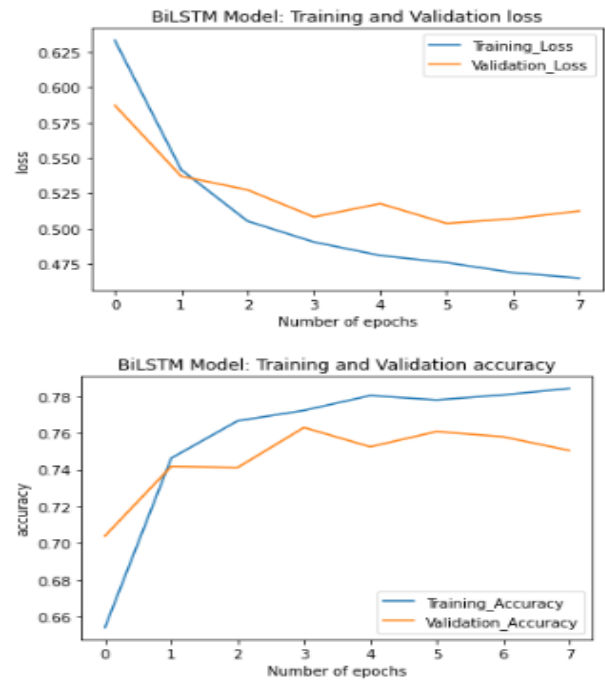


Fig. 11. Time series representation Bi-LSTM model (Validation loss and accuracy scores with respect to number of epochs).

C. Hybrid Ensemble Models Result Analysis

Now finally comparing and analyzing the proposed Hybrid ensemble model with ML and DL Models result. In Fig. 12, a bar chart representation to compare performance measurement scores of Machine learning classifiers and the proposed Hybrid Ensemble model is shown. Where it reflects that Hybrid Ensemble model performs better than Machine Learning classifier.

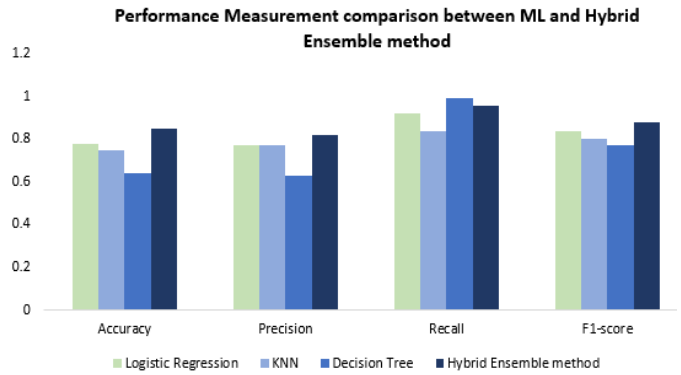


Fig. 12. Comparing our proposed hybrid ensemble approach with machine learning models.

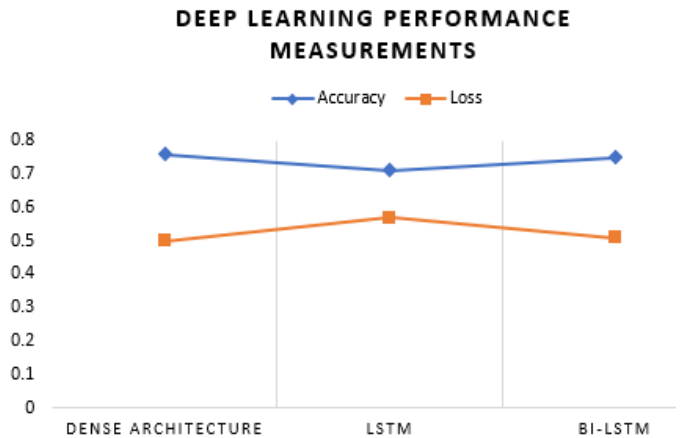


Fig. 13. Time series chart of deep learning models.

Fig. 13 illustrates a short time series chart comparing Deep Learning models with our approached Hybrid Ensemble method. Where blue line representing accuracy scores and yellow line representing loss performance scores of the deep learning models.

V. CONCLUSION

The primary objective of this study is to priorities efforts towards the identification of Cyberbullying using the Bangla dataset, while also emphasizing the importance of raising awareness using visualization techniques. This research presents a novel methodology for identifying instances of bullying in the Bengali language. The Hybrid Ensemble approach was presented, which use a voting classifier and achieves an accuracy rate of 85%. In addition, conventional machine learning classifiers and deep learning classifiers were utilized for comparison with the proposed methodology. Ultimately, after doing a comparative analysis of the three ways, it has been determined that the Hybrid Ensemble approach exhibits superior performance. The primary objective and approach of this study are to foster increased participation among researchers in their respective native languages and mitigate societal obstacles such as Cyberbullying. In subsequent investigations, there is potential for the expansion of research through the utilization of Unsupervised or Reinforcement Learning methodologies. This

approach might be employed to further boost the efficacy of the bully detection model by using a Bangla dataset.

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