Sentiment Analysis on Bangla Text Using LSTM, GRU and RNN Neural Networks

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***Abstract*—Sentiment analysis, also known as opinion mining, is a branch of natural language processing (NLP) that involves determining the sentiment or emotional tone behind a body of text. It is used to identify and categorize opinions expressed in text to determine whether the writer's attitude towards a particular topic, product, or service is positive or negative. This paper explores the application of advanced neural network architectures, specifically Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU), and Recurrent Neural Networks (RNN), for sentiment analysis on Bangla text. Our experimental results demonstrate that LSTM and GRU models outperform traditional RNNs in capturing the complex dependencies and contextual nuances of Bangla sentences. The findings underscore the potential of using these advanced neural architectures to enhance sentiment analysis accuracy for Bangla text, providing valuable insights for businesses and researchers focusing on Bangla-speaking demographics.**

***Index Terms*—Natural Language Processing, NLP, Sentimemt Analysis, LSTM, GRU, RNN**

I. Motivation

Sentiment analysis has become an indispensable tool for businesses, governments, and researchers aiming to understand public sentiment and make data-driven decisions. The complexity and rich morphology of the Bangla language present unique challenges that are not adequately addressed by traditional sentiment analysis methods. Advanced neural network architectures like Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU), and Recurrent Neural Networks (RNN) offer promising solutions due to their ability to capture long-term dependencies and contextual nuances in text.

II. Literature Review

[1] This paper investigates the use of a character-level recurrent neural network (RNN) for sentiment extraction from Bangla text. Addressing the challenge of limited resources and complex grammar in Bangla, the authors show that their model achieves an accuracy of 80 percent, outperforming a word-level baseline. This study highlights the potential of character-level RNNs for sentiment analysis in Bangla, offering a promising approach for handling unseen words and complex grammatical structures in real-world data.

[2] This paper examines sentiment analysis on Bangla text using deep learning algorithms. The authors compare the effectiveness of various deep learning models, including CNN, LSTM, GRU, attention-based networks, and capsule networks. Their findings suggest that hybrid models combining LSTM with attention or capsule networks achieve superior performance compared to traditional deep learning approaches. The study highlights the potential for deep learning to advance sentiment analysis in low-resource languages like Bangla.

[3] This article presents a novel approach to Bangla hate speech detection using an attention-based recurrent neural network (RNN). The authors address the growing concern of hate speech in Bangla social media, particularly on Facebook. The authors propose an encoder-decoder architecture, employing convolutional layers for feature extraction and attention-based LSTM and GRU decoders for prediction. The attention mechanism significantly improves accuracy, achieving 77 percent compared to 74 percent for LSTM and GRU-based decoders. This work contributes to the limited research on Bangla hate speech detection, demonstrating the potential of attention-based RNNs for effectively classifying hateful content in this language.

[4] This research explores the application of deep learning models for Bengali newspaper headline classification. The authors compare the performance of LSTM, Bi-LSTM, and Bi-GRU models on a dataset comprising primary and secondary Bengali news headlines, finding that Bi-LSTM outperforms the other models in terms of accuracy, precision, and recall. The study highlights the need for larger, more diverse datasets to further enhance the performance of these models and contribute to the development of more robust and accurate news classification systems.

[5] The field of cyberbullying detection has seen significant advancements with the application of deep learning (DL) models. Recent studies have explored various DL architectures like CNN, RNN, LSTM, and BERT, with notable successes in identifying cyberbullying across different social media platforms. However, challenges remain, including the need for large datasets, the interpretability of DL models, and the adaptation of these models to dynamic data. Future research is focusing on addressing these challenges by exploring multilingual and multimedia content.

III. Methodology

Our approach to sentiment analysis on Bangla text involves a systematic process that includes data preprocessing, tokenization, word embedding, and the application of

advanced neural network models. The following steps outline the methodology adopted for this study:

A. Data Preprocessing

- Punctuation Removal: The first step involved cleaning the dataset by removing all punctuation marks. This is essential to eliminate noise and ensure that the text data is standardized.
- Stopwords Removal: We removed common Bangla stopwords that do not contribute to the sentiment of the text.

B. Tokenization

After cleaning the text, we tokenized the data. Tokenization involves splitting the text into individual words or tokens. This step is crucial for converting the raw text into a format that can be used for further processing and analysis.

C. Word Embedding

We used the BengaliWord2Vec model to obtain word embeddings. Word2Vec is a popular technique for representing words in continuous vector space, where semantically similar words have similar vectors. The BengaliWord2Vec model, specifically trained on Bangla text, enabled us to capture the semantic and syntactic nuances of Bangla words. This step resulted in a high-dimensional vector representation for each word in our dataset.

D. Neural Network Models

- Recurrent Neural Networks (RNN): RNNs are a class of neural networks well-suited for sequential data. We implemented a standard RNN model to capture the temporal dependencies in the Bangla text data. Despite their effectiveness in handling sequences, RNNs can struggle with long-term dependencies due to vanishing gradient problems.
- Long Short-Term Memory (LSTM): To address the limitations of RNNs, we employed LSTM networks, which are designed to overcome the vanishing gradient issue by using memory cells and gating mechanisms. LSTMs are particularly effective at capturing long-term dependencies in the text, making them suitable for sentiment analysis.
- Gated Recurrent Unit (GRU): GRUs are a variant of LSTM networks that combine the forget and input gates into a single update gate. GRUs are computationally more efficient and have been shown to perform well on various sequence modeling tasks.

E. Model Training and Evaluation

The preprocessed and tokenized data, represented as word embeddings, were fed into the RNN, LSTM, and GRU models. We trained each model using labeled Bangla text data, optimizing for classification accuracy. We evaluated the performance of each model using standard metrics such as accuracy, precision, recall, and F1-score. The results were analyzed to determine which model best captures the sentiment in Bangla text.

IV. Result Analysis

These results were achieved after fine-tuning the parameters of the models. The Training loss curve is shown in figure 1.

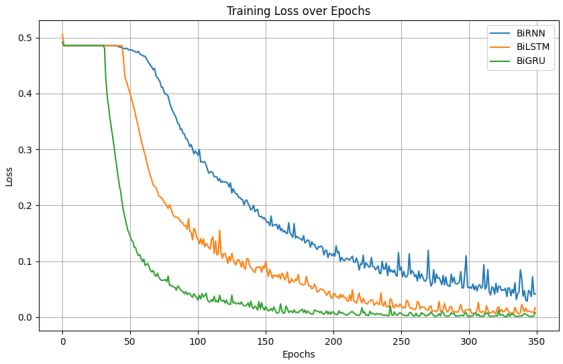

Fig. 1. Training Loss of DL models

The accuracy, precision, recall and f1 scores of these deep learning models are shown in table I.

TABLE I
Performance of Different DL Models

Model	Accuracy	Precision	Recall	F1 Score
BiRNN	0.8016	0.4008	0.5000	0.4449
BiGRU	0.8611	0.7961	0.7351	0.7561
BiLSTM	0.8623	0.7865	0.7123	0.7394

The results achieved show that LSTM and GRU Perform significanlty better than RNN. The accuracy, precision, recall and f1 scores of these models in shown in table I.

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