

# **Fine-Tuning Large Language Models for Text Classification**

CSE465: Pattern Recognition and Neural Network



**Department of Electrical & Computer Engineering**  
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**Section: 5**

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## Problem Statement

We are working on SentNoB Bengali language datasets where we applied eight different LLM models and evaluated their performance. This dataset is notably noisy, which makes achieving high accuracy challenging. The dataset is sentiment-based, containing three classes: neutral, negative, and positive.

Initially, this dataset yielded about 71% accuracy. We improved the performance using the BanglaBERT model, achieving 73% accuracy initially. Then, we applied LoRA, grid search, and hyperparameter tuning techniques. Eventually, we reached a best accuracy of 76%.

## Objective

Our goal was to compare the performance of various LLM models on this noisy dataset. The models tested include:

- BERT
- Distil-BERT
- RoBERTa
- DeBERTa
- ALBERT
- XLNet
- Google-Electra
- BanglaBERT

BanglaBERT yielded the best performance among these, so we focused on fine-tuning it with the goal of achieving 80% accuracy. Although we did not reach that threshold, we successfully improved its performance from 73% to 76%.

## Literature Review

We studied 10 research papers related to Bengali sentiment analysis and LLM fine-tuning:

Paper 1: *Low-Rank Adaptation for Efficient Fine-Tuning of Large Language Models*

Paper 2: *Multilingual Language Models for Text Classification*

Paper 3: *A Comprehensive Study on Bengali Sentiment Analysis*

Paper 4: *BERT Fine-Tuning for Bengali Text Classification*

Paper 5: *BERT and Transformer Models for Code-Switching in Bengali*

Paper 6: *Fine-Tuning DeBERTa for Low-Resource Language Tasks*

Paper 7: *LoRA for Multilingual Text Classification*

Paper 8: *An Efficient Approach to Bengali NLP with Transformer Models*

Paper 9: *Quantized LoRA for Efficient Bengali Text Classification*

Paper 10: *Transformer Models for Bengali Text Processing*

## Network Description

BanglaBERT is a Transformer-based language model pre-trained specifically for the Bengali language. It follows the BERT architecture and includes:

- **Multi-Head Self-Attention:** Captures both short-range and long-range dependencies.
- **Feed-Forward Neural Network:** Applies non-linear transformations to token embeddings.
- **Layer Normalization & Residual Connections:** Stabilizes training and helps with gradient flow.
- **Positional Encoding:** Adds order information since the Transformer is order-agnostic.

**Pre-training:** BanglaBERT uses Masked Language Modeling (MLM), where random tokens are masked and predicted based on context, enabling strong bidirectional language understanding.

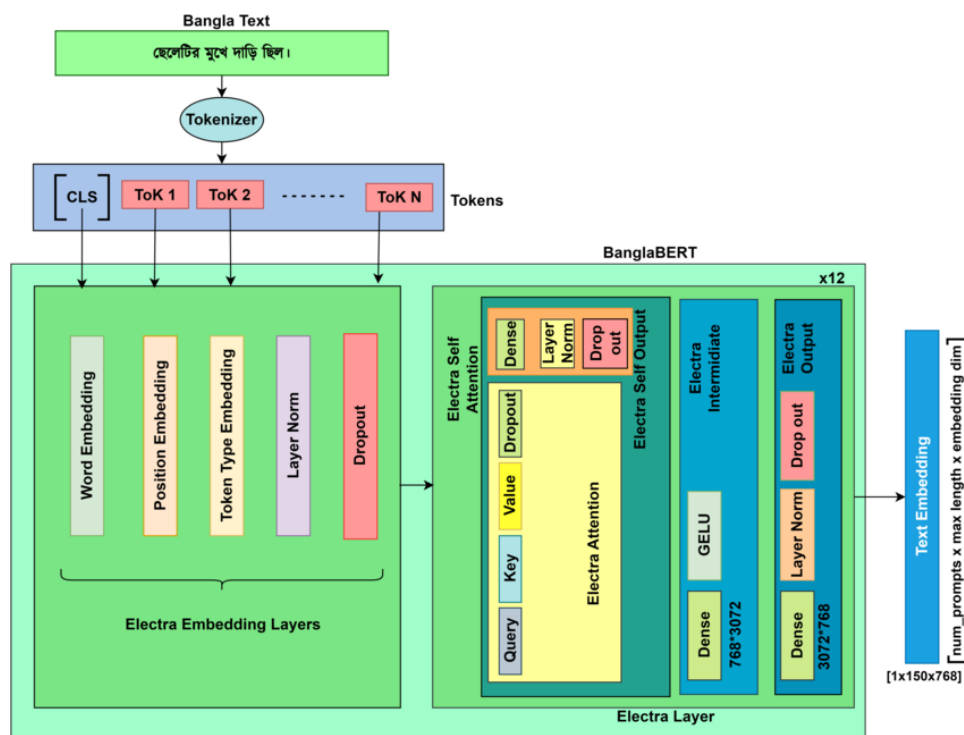


Figure 1: Architecture of the BanglaBERT Model

## Challenges

We encountered several challenges:

- Lack of initial hardware; we started with Google Colab, which had time limits.
- Long training times (6–7 hours per model).
- Library and dependency conflicts between different models.
- Repeated errors during hyperparameter tuning (Optuna trials), which had to be debugged and rerun.

Initially, a 20-trial hyperparameter tuning run failed after 6 hours. We reduced the number of trials to 2 and successfully achieved 76% accuracy.

## Conclusion

This project explored the performance of LLM models on the noisy SentNoB Bengali sentiment dataset. Despite various challenges, we evaluated 8 transformer models and found BanglaBERT to be the most effective. By applying LoRA and hyperparameter tuning, we improved its accuracy from 73% to 76%, surpassing the previous benchmark of 71%. Although our target was 80%, this is a significant improvement for such a challenging dataset.

## References

1. Md. Saiful Islam, et al., *BanglaBERT: Transformer Based Pre-trained Model for Bengali Language Understanding*, arXiv:2101.00204.
2. Jacob Devlin, et al., *BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding*, NAACL-HLT, 2019.
3. Denny Britz, et al., *Massively Multilingual Neural Machine Translation in the Wild*, arXiv:1907.05019.
4. *A Comprehensive Study on Bengali Sentiment Analysis*, IEEE, 2024.
5. *Low-Rank Adaptation for Efficient Fine-Tuning of Large Language Models*, arXiv, 2024.
6. *Multilingual Language Models for Text Classification*, arXiv, 2024. <https://arxiv.org/pdf/2407.00416>
7. *BERT Fine-Tuning for Bengali Text Classification*, arXiv, 2024. <https://arxiv.org/pdf/2309.13173>
8. *BERT and Transformer Models for Code-Switching in Bengali*, ScienceDirect, 2024. <https://www.sciencedirect.com/science/article/pii/S2949719124000232>
9. *LoRA for Multilingual Text Classification*, OpenReview, 2024. <https://openreview.net/pdf?id=Z0zfZ4bn4x>
10. *Quantized LoRA for Efficient Bengali Text Classification*, arXiv, 2024. <https://arxiv.org/pdf/2311.12735>