Sentiment Analysis using BERT and ELECTRA Model

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***Abstract*- In this project, we investigated how transformer-based language models performed tasks involving natural language processing. We put two cutting-edge architectures—BERT and ELECTRA—into practice and assessed them. Our objective was to create reliable models that could classify texts accurately. We assessed the accuracy and loss of both models after fine-tuning them on a labelled dataset. The findings reveal that transformer-based models can perform noticeably better than conventional methods, with ELECTRA exhibiting marginally higher performance and efficiency on our dataset. This report offers thorough explanations of our experimentation, implementation and results.**

***Keywords*- bert, electra, natural language processing, text classification, transformers.**

I. Introduction

There is a sudden need for efficient automated sentiment analysis systems due to the increasing amount of unstructured text data on social media networks. Conventional machine learning techniques frequently perform poorly on nuanced data because they are unable to capture contextual relationships in text. We investigated transformer-based architecture, namely BERT and ELECTRA, to solve this issue. These models have used self-attention and extensive pre-training to achieve state-of-the-art results.

Our approach involved fine-tuning BERT and ELECTRA on two labeled sentiment datasets:

- **Dataset-1:** *Social Media Sentiment Analysis* https://www.kaggle.com/datasets/kashishparmar02/social-media-sentiments-analysis-dataset
- **Dataset-2:** *Social Media Sentiment Analysis Dataset* https://www.kaggle.com/datasets/abdullah0a/social-media-sentiment-analysis-dataset

We aimed to analyze their accuracy, robustness, and generalization across datasets with different characteristics.

II. Implementation

A. Model-1: BERT

Overview:
BERT (Bidirectional Encoder Representations from Transformers) is a transformer-based model pre-trained on large corpora with masked language modeling and next sentence prediction. It can be fine-tuned for downstream tasks with minimal architecture changes.

Implementation Details:

- **Library Used:** Hugging Face transformers
- **Pre-trained Model:** bert-base-uncased
- **Tokenizer:** BertTokenizer
- **Preprocessing:**
  - Lowercasing and cleaning text
  - WordPiece tokenization
  - Padding and truncation to a fixed sequence length.
- **Fine-Tuning:**
  - Classification head on [CLS] token

- Cross-entropy loss
- AdamW optimizer with learning rate scheduler

- **Hyperparameters:**
  - Number of Epochs: *5*
  - Batch Size: *16*

B. Model-2: ELECTRA

Overview:
ELECTRA improves pre-training efficiency by replacing masked tokens and training the discriminator to distinguish between original and replaced tokens.

Implementation Details:

- **Library Used:** Hugging Face transformers
- **Pre-trained Model:** google/electra-small-discriminator
- **Tokenizer:** ElectraTokenizer
- **Preprocessing:**
  - Standard text cleaning
  - Subword tokenization
  - Padding/truncation
- **Fine-Tuning:**
  - Classification layer on the discriminator output
  - Cross-entropy loss
  - AdamW optimizer with learning rate scheduler
- **Hyperparameters:**
  - Number of Epochs: *5*
  - Batch Size: *16*

III. Result Analysis

We evaluated both models on the two datasets described above. Below are the detailed results:

BERT Results

Dataset-1 (*Social Media Sentiment Analysis*)

- **Best Validation Accuracy:** 0.9785
- **Classification Report:**

Label	Precision	Recall	F1-Score
Negative	0.9286	1.0000	0.9630
Positive	1.0000	0.9701	0.9848

- **Overall Metrics:**
  - F1-Score: 0.9787

Dataset-2 (*Social Media Sentiment Analysis Dataset*)

- **Best Validation Accuracy:** 0.3400
- **Classification Report:**

Label	Precision	Recall	F1-Score
Negative	0.3833	0.4554	0.4163
Positive	0.2000	0.1146	0.1457
Neutral	0.3600	0.4369	0.3947

- **Overall Metrics:**
  - F1-Score: 0.3223

ELECTRA Results

Dataset-1 (*Social Media Sentiment Analysis*)

- **Best Validation Accuracy: 1.0000**
- **Classification Report:**

Label	Precision	Recall	F1-Score
Negative	1.0000	1.0000	1.0000
Positive	1.0000	1.0000	1.0000

- **Overall Metrics:**
  - F1-Score: 1.0000

Dataset-2 (*Social Media Sentiment Analysis Dataset 2*)

- **Best Validation Accuracy: 0.5101**
- **Classification Report:**

Label	Precision	Recall	F1-Score
Negative	0.5101	1.0000	0.6756
Positive	0.0000	0.0000	0.0000

- **Overall Metrics:**
  - F1-Score: 0.3446

Both models produced outstanding results on Dataset-1. With a weighted F1-score of 1.0000 and a validation accuracy of 1.0000, ELECTRA achieved perfect classification performance, somewhat surpassing BERT. With a weighted F1-score of 0.9787 and a validation accuracy of 0.9785, BERT likewise demonstrated excellent performance on the same dataset. However, because of Dataset-2's greater complexity and class imbalance, both models' performance drastically declined. ELECTRA outperformed BERT, which attained a validation accuracy of 0.3400 and a weighted F1-score of

0.3223, with a validation accuracy of 0.5101 and a weighted F1-score of 0.3446. The results show that more difficult data necessitates additional advancements in training techniques and data preprocessing, even if ELECTRA consistently outperformed the other model on both datasets.

IV. Conclusion

This experiment showed how transformer-based models, such as ELECTRA and BERT, greatly enhance sentiment categorization on data from social media. On Dataset-1, both models did incredibly well, with ELECTRA surpassing BERT by a small margin. On the more difficult Dataset-2, ELECTRA once more outperformed overall but had trouble with class imbalance, underscoring the necessity for further tactics like:

- Augmenting data
- Techniques for resampling
- Loss functions weighted by class

All things considered, these findings highlight the potential of optimized transformers for sentiment analysis and suggest encouraging avenues for further development.