ShadowFox Internship Final Task Report

Project Title: AI-Driven NLP with BERT using Hugging Face

Intern Name: [Your Name Here]

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Tool Used: Google Colab, Hugging Face Transformers, PyTorch, Matplotlib

# 1. Objective

The objective of this project is to explore and evaluate the performance of the pre-trained BERT model on various NLP tasks, including masked word prediction and sentence classification, using the Hugging Face Transformers library in a Google Colab environment.

# 2. Research Questions

- How effectively can BERT predict masked words based on surrounding context?

- How accurate is BERT in understanding sentiment in simple and complex sentences?

- Does BERT struggle with tasks that involve multiple masked tokens or reasoning?

- What are the limitations of BERT when applied to domain-specific or ambiguous language?

- How does BERT perform before and after fine-tuning for classification tasks?

- Can BERT generalize well to unseen examples or does it rely heavily on dataset bias?

# 3. Implementation

Masked Word Prediction:  
Used the BERT model (`bert-base-uncased`) to fill masked tokens in context-rich sentences. Tokenization and inference were done using the Hugging Face `transformers` library.  
  
Sentence Classification:  
Implemented binary sentiment classification using the GLUE SST-2 dataset. The model was fine-tuned on a small subset using Hugging Face's Trainer API and evaluated on validation data.

# 4. Exploration and Analysis

Masked Sentences Tested:  
- The [MASK] barks at night. → dog (✅)  
- The sun rises in the [MASK]. → sky (❌ expected: east)  
- BERT is a [MASK] model developed by Google. → business (❌ expected: language)  
- I want to eat [MASK] for dinner. → it (❌ expected: pizza)  
- Mahatma Gandhi was born in [MASK]. → india (✅)  
  
Multiple Mask Prediction:  
- The [MASK] wrote a [MASK] about artificial intelligence. → two, book  
  
Sentiment Classification Results:  
- Positive and negative sentences were correctly classified after minimal fine-tuning.  
- Accuracy improved across epochs.

# 5. Visualization of Results

- Bar Chart: Accuracy of individual masked predictions (correct vs incorrect)  
- Line Graph: Accuracy progression during sentiment training epochs  
- Word Cloud: Frequent predictions in MLM task

# 6. Evaluation and Alignment

Performance Evaluation:  
- BERT is strong in factual knowledge and language structure  
- Struggles with ambiguous or logical inference tasks  
  
NLP Goals Alignment:  
- Successfully demonstrated capabilities in understanding (MLM)  
- Classification task aligns with real-world applications (e.g., chatbots, sentiment analysis)  
  
Ethical Considerations:  
- BERT may reflect cultural/language biases  
- Performance varies across domains  
- No reasoning or fact-checking built-in  
  
Real-World Applications:  
- Customer support bots  
- Product review sentiment detection  
- Educational QA bots

# 7. Conclusion

BERT demonstrates strong contextual understanding in text completion and classification when applied to general-purpose tasks. This project provided hands-on experience with deploying BERT via Hugging Face, analyzing its strengths, and identifying areas for improvement. The experience aligns with the goals of real-world NLP applications and ethical AI practices.

Submitted as part of ShadowFox Internship Final Task (Task 3)

Goal Statement: To implement a Language Model using Hugging Face (specifically BERT), apply it to NLP tasks such as masked word prediction and sentiment classification, analyze its capabilities and limitations, and evaluate its alignment with real-world applications and ethical considerations.