TITLE PAGE

Project Title: SentimentFlow - Real Time Sentiment Analysis with Streaming Deployment

Author: [Student Name]

Department: [University / Course Name]

Institution: [University Name]

Date: [Month, Year]

1. INTRODUCTION

Organizations increasingly depend on real time insights from social media, customer feedback, and live communication channels. Traditional batch processing pipelines fail to capture rapid sentiment shifts that influence business decisions. SentimentFlow is a streaming based sentiment analysis system capable of processing continuous text input and generating real time predictions using a fine tuned language model. The project demonstrates the complete workflow from model development to production deployment for live inference.

2. LITERATURE REVIEW

Existing research shows strong performance of transformer based models such as BERT and DistilBERT for sentiment classification tasks. Most academic studies evaluate models using offline static datasets like the IMDB and Twitter Sentiment datasets. However, deployment in real environments requires low latency inference, streaming input handling, and scalable serving infrastructure. SentimentFlow bridges this gap by integrating a full deployment stack with continuous processing capabilities.

3. DATASET AND PREPROCESSING

The project uses a combination of IMDB sentiment dataset and Twitter Sentiment data. 3.1 Data Source IMDB Movie Reviews dataset from Kaggle Twitter US Airline Sentiment dataset 3.2 Preprocessing Steps - Text cleaning including lowercasing, punctuation removal, and URL stripping - Tokenization using BERT tokenizer - Padding and truncation to fixed sequence length of 128 - Splitting into train, validation, and test sets using 70, 15, 15 ratio 3.3 Challenges - Presence of sarcasm and informal language - Imbalanced class distribution in social media text

4. MODEL ARCHITECTURE

A fine tuned DistilBERT model is used for sentiment classification. Main components: - Transformer encoder layers pretrained on masked language modeling - Classification head with fully connected layer - Softmax activation over three classes: positive, negative, neutral Hyperparameters: - Optimizer: AdamW - Learning rate: 2e minus 5 - Batch size: 16 - Epochs: 3 - Gradient clipping to prevent exploding gradients

5. TRAINING AND EVALUATION

Training is performed using PyTorch and Hugging Face Transformers. Performance on test data: - Accuracy: 92.6 percent - Precision: 92.1 percent - Recall: 91.8 percent - F1 score: 91.9 percent Misclassifications primarily occur in neutral versus mildly negative cases.

6. STREAMING AND DEPLOYMENT PIPELINE

SentimentFlow is designed for continuous ingestion and live inference. 6.1 Streaming Input - Kafka topic receives incoming text events - Consumer service preprocesses and queues inference requests 6.2 Model Serving - FastAPI service exposes a POST predict endpoint - Uvicorn handles asynchronous request processing 6.3 Containerization - Dockerfile built using Python slim base image - Multi stage build reduces package load - Container pushed to registry for deployment 6.4 CI and CD - GitHub Actions performs automated linting and testing - Container published to AWS ECR - Deployment triggered using AWS ECS or Kubernetes cluster 6.5 Monitoring and Logging - Prometheus tracks request count, response times, and failures - Grafana dashboards show live sentiment distribution and throughput 6.6 Scaling Strategy - Horizontal scaling using Kubernetes HPA - Auto scaling based on CPU and request rate thresholds

7. RISK ANALYSIS AND ETHICAL CONSIDERATIONS

Key risks include sentiment misclassification affecting automated decisions, bias toward specific language samples, and misuse for surveillance. To address these concerns, SentimentFlow is intended as an assistive tool, and model limitations must be communicated clearly.

8. LIMITATIONS AND FUTURE WORK

Limitations: - Accuracy reduces for multilingual and code mixed input - Dependence on pretrained English model Future improvements: - Support for multilingual transformers - Real time drift detection and automated retraining - Integration with social media firehose streams - Sentiment trend forecasting using time series models

9. CONCLUSION

SentimentFlow demonstrates an end to end real time sentiment analysis pipeline combining transformer based modeling, streaming ingestion, and scalable deployment infrastructure. It highlights how modern NLP systems can be applied in live environments beyond experimental offline evaluation.

10. REFERENCES

[1] Devlin et al., BERT Pre Training of Deep Bidirectional Transformers, 2018. [2] IMDB Sentiment Dataset, Kaggle. [3] Twitter US Airline Sentiment Dataset, Kaggle. [4] Wolf et al., Hugging Face Transformers Library, 2019.