

Universidad Panamericana
Master's in Data Sciences
Natural Language Processing

Final Project: *Sentiment Analysis of FIFA World Cup Tweets*

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Contents

1	Introduction	2
2	Related Work	2
3	Methodology	3
3.1	Dataset Description	3
3.2	Preprocessing & Balancing	3
3.3	Feature Extraction	4
3.4	Modeling	5
3.4.1	Traditional Machine Learning Models	5
3.4.2	Deep Learning Models	5
4	Experiments and Results	6
4.1	Evaluation Metrics	6
4.2	Results Comparison	6
5	Discussion	11
5.1	Analysis of Results	11
5.2	Strengths and Weaknesses	12
5.3	Limitations	12
5.4	Future Work	12
5.5	Concluding Remarks	12
6	Appendix	13
6.1	GitHub Repository	13

Abstract

This project aimed to perform sentiment analysis on tweets related to the FIFA World Cup 2022 using both traditional machine learning and deep learning models. The dataset contains $\approx 25,000$ tweets collected on the first day of the tournament using the `Snsrape` library and pre-labeled with the `cardiffnlp/twitter-roberta-base-sentiment-latest` model from Hugging Face. Classical approaches (e.g., Logistic Regression, SVM) using TF-Df features are compared against neural architectures such as LSTM, CNN, and Transformer-based models. Evaluation metrics include Accuracy, Precision, Recall, and F1-score. The results highlight how deep learning models outperform traditional ones in handling contextual nuances of tweets.

1 Introduction

The FIFA World Cup is one of the largest and most influential sporting events worldwide, attracting billions of viewers and generating massive engagement across digital platforms. During the 2022 edition in Qatar, social media—especially Twitter—became a real-time forum for fans to express opinions, emotions, and reactions to matches, players, and events. This global activity creates a rich source of textual data that can be leveraged to analyze public sentiment and collective emotional dynamics surrounding major sports events.

Understanding the sentiment behind these tweets are important for several reasons. First, it provides valuable insights into fan behavior, public perception of teams and players, and the emotional impact of sporting events on different audiences. Second, sentiment analysis can assist broadcasters, sponsors, and organizations such as FIFA in gauging audience engagement and reputation trends. Finally, from a data science perspective, it represents a challenging Natural Language Processing (NLP) problem due to the informal, multilingual, and often sarcastic nature of social media text [1, 2, 3].

Sentiment analysis, or opinion mining, aims to classify text into categories such as positive, negative, or neutral, based on the emotional tone conveyed by users. Previous research has explored a range of approaches—from traditional machine learning models such as Logistic Regression, Support Vector Machines (SVM), and Random Forests [1] to deep learning architectures like Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks [2]. More recently, transformer-based models such as BERT and RoBERTa have achieved state-of-the-art results in sentiment classification tasks on Twitter data [3, 4].

Building upon this body of work, this project focuses on the sentiment analysis of tweets related to the 2022 FIFA World Cup. Tweets are categorized into three sentiment classes—positive, neutral, and negative—using both traditional machine learning and modern deep learning models. The goal is to evaluate how different text representations and architectures perform in understanding contextual nuances, emotion, and sarcasm in sports-related tweets. Through this comparison, the study contributes to the broader understanding of how NLP techniques can extract meaningful insights from real-world social media discourse.

2 Related Work

Previous research on sentiment analysis of sports-related tweets has evolved significantly over the past decade, progressing from traditional machine learning approaches to deep neural and transformer-based architectures.

Early works (2016–2018) commonly employed statistical text representations such as Bag-of-Words and TF-Df combined with models like Logistic Regression, Linear SVC, Random Forest and Bayesian Logistic Regression. For instance, Barnaghi et al. [1] analyzed FIFA World Cup 2014 tweets using TF-Df with Bayesian Logistic Regression, achieving competitive accuracy but later works noted limitations in capturing sarcasm and emoji-driven sentiment.

From 2018 onward, deep learning architectures such as CNN and LSTM began outperforming traditional classifiers in sentiment analysis tasks. Venkatesh et al. [2] proposed a CNN-LSTM hybrid for classifying sports tweets, demonstrating that combining convolutional and recurrent layers improved contextual understanding.

The next major shift came with transformer-based models like BERT and RoBERTa, which leverage self-attention mechanisms and large-scale pretraining. Barbieri et al. [3] introduced the TweetEval benchmark,

fine-tuning RoBERTa for multiple Twitter NLP tasks and achieving state-of-the-art sentiment accuracy. More recent studies (2021–2025) fine-tuned RoBERTa specifically on sports tweets [4], reporting superior F1-scores and robustness compared to CNN and LSTM models.

This project builds upon these advancements by directly comparing traditional machine learning models (Logistic Regression, Linear SVC, Random Forest) with deep learning architectures (LSTM, CNN) and transformer-based methods (RoBERTa as both feature extractor and fine-tuned model) on FIFA World Cup 2022 tweets. By systematically evaluating across these paradigms, this work highlights the evolution of sentiment analysis methods and quantifies the contextual advantages of transformer-based approaches for real-world, event-driven social media data.

3 Methodology

3.1 Dataset Description

The dataset used in this project is titled **"FIFA World Cup 2022 Tweets"**, consisting of approximately **25,000 tweets** collected during the first day of the tournament in Qatar 2022.

Data was obtained using the **Snsrape** library for scraping and labeled automatically with the pre-trained RoBERTa-based sentiment model `cardiffnlp/twitter-roberta-base-sentiment-latest` from Hugging Face. The dataset is stored as a CSV file named `fifa_world_cup_2022_tweets.csv` and contains the following columns:

- **Date Created:** Timestamp of tweet publication.
- **Number of Likes:** Engagement measure.
- **Source of Tweet:** Platform or device used to post.
- **Tweet:** Raw text content of the tweet.
- **Sentiment:** Pre-assigned label (Positive, Neutral, or Negative).

The dataset is publicly available under the **CC0 1.0 Universal (Public Domain)** license, allowing unrestricted reuse and modification.

3.2 Preprocessing & Balancing

Preprocessing. The preprocessing pipeline was implemented in Python using regular expressions to robustly clean and normalize tweet text while preserving sentiment cues. All text is first converted to lowercase. Mentions (e.g., @usernames) are replaced with the token `USR`, and URLs with `URL`. Hashtags are preserved as semantic tokens by replacing the symbol `#` with the prefix `hash_`. Additionally, a curated list of emoticons (e.g., :-), XD) and emojis (e.g., 😊, 🙌, 🏆) is kept intact to retain emotional context. A whitelist of characters ensures that only meaningful alphanumeric and sentiment-relevant symbols (e.g., ! ? () : -) are preserved, avoiding the loss of informal markers common in social media text. Finally, redundant spaces are removed, resulting in clean and normalized text ready for tokenization and embedding generation.

Balancing. Re-balancing techniques were not applied because the class distribution was moderately balanced: *Positive* $n = 8,489$ (37.7%), *Neutral* $n = 8,251$ (36.6%), and *Negative* $n = 5,784$ (25.7%), for a total of $N = 22,524$. The imbalance ratio $IR = \frac{\max_c n_c}{\min_c n_c} = 1.47$ stayed below the predefined threshold ($IR < 1.5$), so models were trained without resampling and simply monitored per-class metrics.

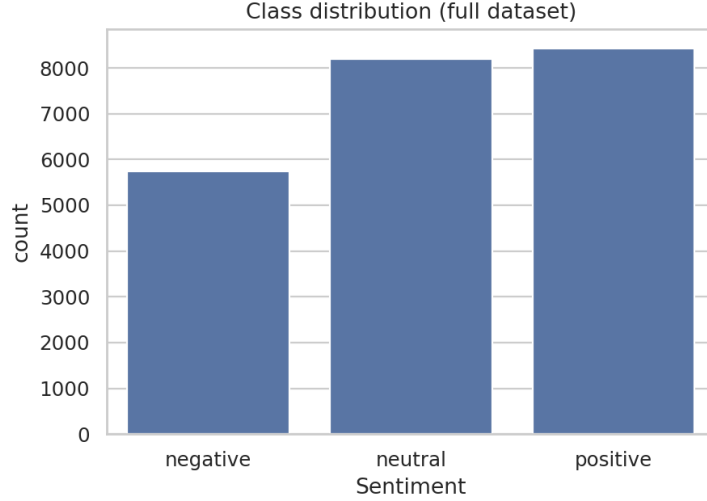


Figure 1: Class distribution in the full dataset: *Positive* 8,489; *Neutral* 8,251; *Negative* 5,784.

3.3 Feature Extraction

After preprocessing, the data was split with a stratified 80-20 train-test partition (`random_state=42`).

Protocol (no leakage & reproducibility). All vectorizers/tokenizers were **fit exclusively on the training split** and then reused to transform validation/test without refitting or peeking at test labels. Random seeds were fixed for reproducibility (Python `random`, NumPy, TensorFlow, and PyTorch) and used the same stratified splits across all models.

Statistical representations. For traditional ML models, a TF-IDF vectorizer was used with `max_features = 50,000`, `n-grams (1,3)`, `min_df = 2`, and English stopwords. The resulting sparse matrix feeds Logistic Regression, Linear SVM, and Random Forest. *Leakage control:* the TF-IDF vectorizer was fit on the **training texts only** and then applied unchanged to validation/test.

Semantic representations (word embeddings). For sequence models, **GloVe-Twitter-200** (via `gensim`) was used. A Keras `Tokenizer` (`num_words = 50,000`, explicit `<OOV>`) builds the vocabulary; sequences are padded/truncated to $L = 180$. The embedding matrix is aligned to this vocab, with zero vector at the padding index and the `<OOV>` vector set to the mean of known embeddings. *Vocabulary policy:* the Keras `Tokenizer` was fit on the **training split only**; the learned vocabulary and index mapping were reused as-is for validation/test.

Transformer representations. `cardiffnlp/twitter-roberta-base-sentiment-latest` was used in two modes: `Tokenizer/splits`: the Hugging Face tokenizer is pre-trained and not fitted; fine-tuning uses only the training split.

1. **Feature extractor:** backbone was frozen and compute sentence embeddings with masked mean-pooling over the last hidden states (max length 96 tokens, batch size 64, `no_grad`). Train/test embeddings are cached to `.npy`.
2. **Fine-tuning:** tokenization to 128 tokens and train a classification head end-to-end using `Trainer`.

3.4 Modeling

3.4.1 Traditional Machine Learning Models

Logistic Regression (TF-IDF). Multinomial Logistic Regression with `max_iter= 2000`, `C= 1.0`, and `class_weight=balanced`.

Linear SVM (TF-IDF). LinearSVC with `C= 1.0` (hinge loss).

Random Forest (TF-IDF). `n_estimators= 400`, `max_depth=None`, `min_samples_split= 2`, `class_weight=balanced_subsample`, `n_jobs= -1`.

All models are trained on the TF-IDF features and evaluated with macro-averaged accuracy, precision, recall, and F1.

3.4.2 Deep Learning Models

CNN with Squeeze-and-Excitation and attention. TextCNN_TwitterSE_Attn architecture:

- **Input:** token indices ($L = 180$) with `SpatialDropout1D(0.2)`.
- **Embedding:** GloVe-Twitter-200 matrix (frozen in Stage 1; unfrozen in Stage 2).
- **Trunk:** five Conv1D branches (128 filters; kernel sizes $\{2, 3, 4, 5, 7\}$), each followed by `BatchNorm` and `ReLU`.
- **SE-block:** channel-wise recalibration with reduction ratio $r = 8$.
- **Attention pooling:** per branch, concatenating global max-pooling, global average-pooling, and a softmax-weighted sum across time.
- **Head:** concatenation \rightarrow `Dropout(0.4)` \rightarrow `Dense(192, ReLU, L2= 10^{-4})` \rightarrow `Dropout(0.4)` \rightarrow `Dense(#classes, softmax)`.
- **Training:** `sparse_categorical_crossentropy`, Adam. *Stage 1:* `lr= 10^{-3}` , batch 128, val split 0.1, `EarlyStopping(patience=3)` + `ReduceLROnPlateau(factor 0.5, patience 2, min_lr= 10^{-5})`. *Stage 2:* unfreeze embeddings and add class weights, `lr= 10^{-4}` , `clipnorm= 1.0`. *Stage 3:* `CosineDecayRestarts` with initial `lr= 5×10^{-5}` , batch 64; `EarlyStopping` only.

BiLSTM with attention. BiLSTM_Attn architecture:

- **Input/Embedding:** same as CNN (GloVe embeddings, $L = 180$, `mask_zero`).
- **Trunk:** `SpatialDropout1D(0.2)` \rightarrow `BiLSTM(96, return_sequences)` \rightarrow `BiLSTM(64, return_sequences)`; no recurrent dropout in the runs.
- **Attention pooling:** `tanh` projection \rightarrow 1D score \rightarrow temporal softmax; concatenating attention-weighted sum with global max/avg pooling.
- **Head:** `Dropout(0.4)` \rightarrow `Dense(128, ReLU, L2= 10^{-4})` \rightarrow `Dropout(0.4)` \rightarrow `Dense(#classes, softmax)`.
- **Training:** three stages mirroring the CNN: Stage 1 Adam (`lr= 10^{-3}`); Stage 2 unfreezes embeddings and adds class weights with Adam (`lr= 10^{-4}` , `clipnorm= 1.0`); Stage 3 uses `CosineDecayRestarts` (`lr= 5×10^{-5}`).

Transformers (RoBERTa).

- **Feature extractor + heads:** with the backbone frozen, mean-pooled embeddings computation was performed (96 tokens). On top, (i) Logistic Regression (`max_iter= 2000`, `C= 1.0`) and (ii) LinearSVC (`C= 1.0`) were trained.
- **Fine-tuning:** `AutoModelForSequenceClassification` with explicit `id2label/label2id`; tokenization to 128 tokens. `TrainingArguments:` `learning_rate= $2 \cdot 10^{-5}$` , `per_device_train_batch_size= 16`, `per_device_eval_batch_size= 32`, `num_train_epochs= 3`, `weight_decay= 0.01`, `save_total_limit= 1`, `report_to=none`. In this report, macro accuracy, precision, recall, and F1 are reported.

Ensemble. Per-example predictions were aggregated using two strategies: (i) **weighted voting** with fixed weights $\{w_{\text{RoBERTa}} = 0.90, w_{\text{BiLSTM}} = 0.76, w_{\text{CNN}} = 0.75\}$ and a tie-breaker that favors RoBERTa; and (ii) **majority voting** (three equal votes with the same tie-break rule). Both were reported and the one with the best macro F1 was retained.

4 Experiments and Results

4.1 Evaluation Metrics

Models were evaluated with *accuracy*, *precision*, *recall*, and *F1-score*. Let $\{(x_i, y_i)\}_{i=1}^N$ be labeled examples with $y_i \in \mathcal{C} = \{\text{negative}, \text{neutral}, \text{positive}\}$ and predictions \hat{y}_i .

Accuracy.

$$\text{Acc} = \frac{1}{N} \sum_{i=1}^N \mathbf{1}\{y_i = \hat{y}_i\}.$$

Per-class precision/recall/F1. For each class $c \in \mathcal{C}$, define true positives TP_c , false positives FP_c , and false negatives FN_c . Then

$$\text{Prec}_c = \frac{\text{TP}_c}{\text{TP}_c + \text{FP}_c}, \quad \text{Rec}_c = \frac{\text{TP}_c}{\text{TP}_c + \text{FN}_c}, \quad \text{F1}_c = \frac{2\text{Prec}_c\text{Rec}_c}{\text{Prec}_c + \text{Rec}_c}.$$

Macro-averaging. To avoid dominance by frequent classes, *macro* metrics were used:

$$\text{Prec}_{\text{macro}} = \frac{1}{|\mathcal{C}|} \sum_{c \in \mathcal{C}} \text{Prec}_c, \quad \text{Rec}_{\text{macro}} = \frac{1}{|\mathcal{C}|} \sum_{c \in \mathcal{C}} \text{Rec}_c, \quad \text{F1}_{\text{macro}} = \frac{1}{|\mathcal{C}|} \sum_{c \in \mathcal{C}} \text{F1}_c.$$

All metrics are computed with `scikit-learn` using the label order `[negative, neutral, positive]` and `zero_division=0`. Confusion matrices follow the same class order.

4.2 Results Comparison

Model leaderboard. Traditional, deep, and transformer-based models on the test split were compared. Table 1 summarizes macro metrics; Figure 2 visualizes macro-F1 across models.

Table 1: Model comparison on the test set. Macro-averaged metrics; higher is better.

Model	Accuracy	Precision	Recall	F1
RoBERTa fine-tuned (twitter-roberta-base-sentiment-latest)	0.897800	0.897500	0.901100	0.899000
RoBERTa feature extractor (LogReg head)	0.886900	0.889200	0.889000	0.889100
RoBERTa feature extractor (LinearSVC head)	0.884200	0.886700	0.886100	0.886300
Ensemble (Weighted Voting)	0.814200	0.811800	0.818900	0.814400
Ensemble (Majority Voting)	0.814200	0.811800	0.818900	0.814400
CNN (Twitter SE+Attn)	0.767900	0.766500	0.772300	0.768400
BiLSTM+Attention (GloVe-Twitter)	0.767000	0.764900	0.772500	0.767300
Logistic Regression (TF-IDF)	0.706800	0.705000	0.711900	0.707800
LinearSVC (TF-IDF)	0.698600	0.700100	0.699000	0.699400
RandomForest (TF-IDF)	0.677300	0.686900	0.671900	0.677400

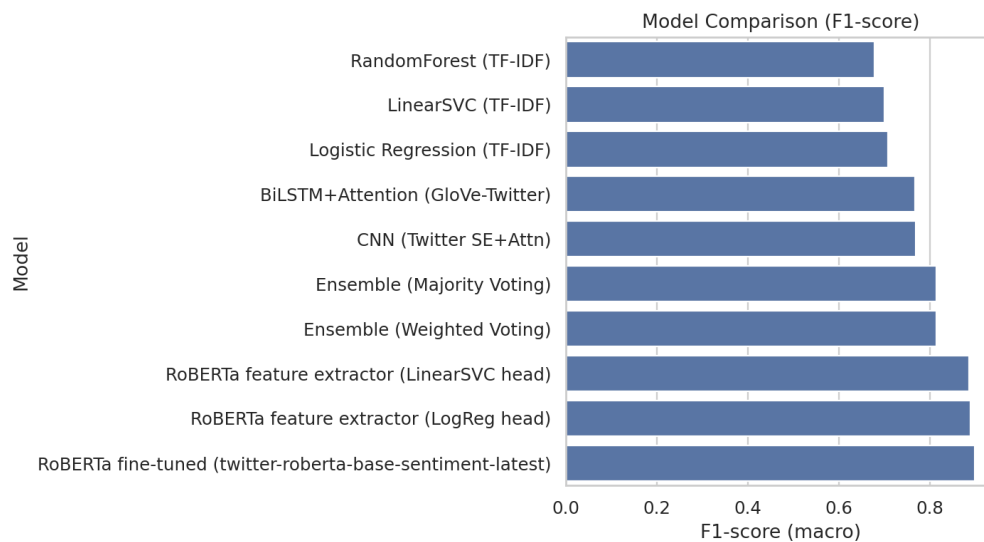


Figure 2: Macro-F1 across all models.

Per-class analysis. For the best model (top row in Table 1), its confusion matrix and per-class metrics are reported here:

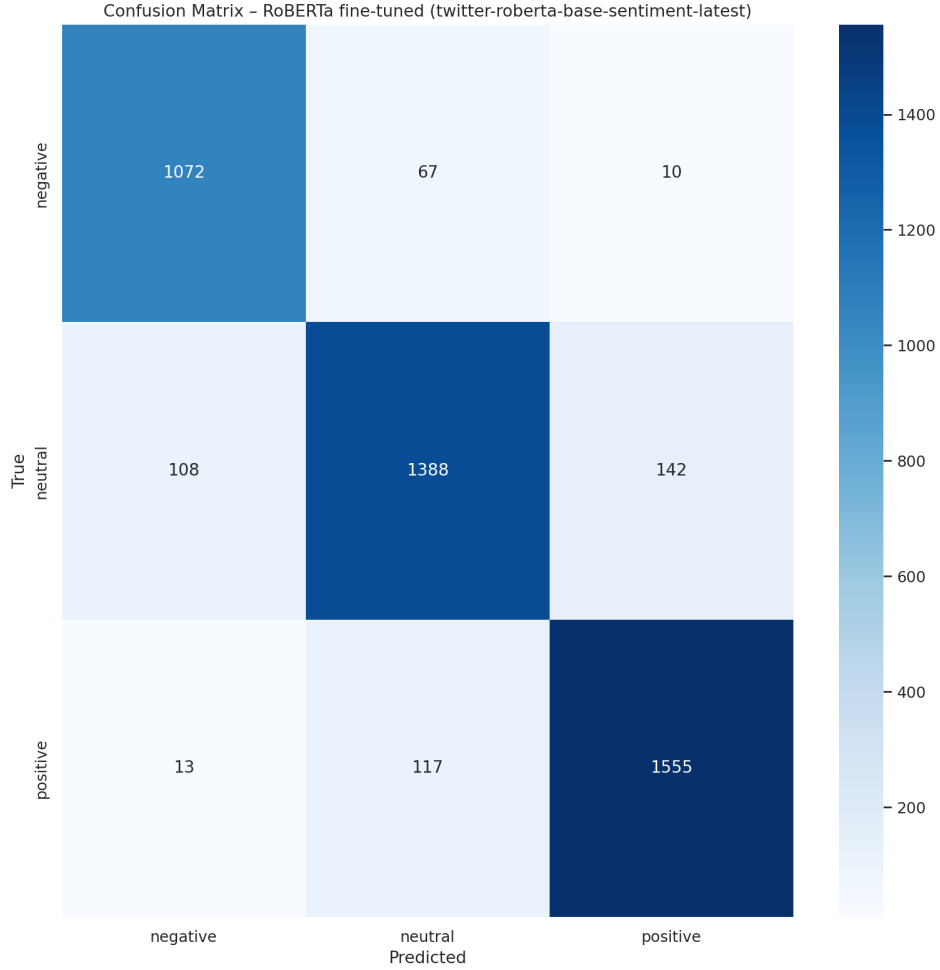


Figure 3: Confusion matrix for the best model (label order: negative, neutral, positive).

Table 2: Per-class report of the best model (precision, recall, F1, and support).

class	negative	neutral	positive	accuracy	macro avg	weighted avg
precision	0.898575	0.882952	0.910955	0.897809	0.897494	0.897517
recall	0.932985	0.847375	0.922849	0.897809	0.901070	0.897809
f1-score	0.915457	0.864798	0.916863	0.897809	0.899039	0.897431
support	1149.000000	1638.000000	1685.000000	0.897809	4472.000000	4472.000000

Probability-based curves. For models that output class probabilities (e.g., Logistic Regression, Random Forest, CNN, BiLSTM, RoBERTa heads and fine-tuned), plot reporting macro ROC and macro PR curves are available in the Repository.

The figure below shows the macro ROC curve for the fine-tuned RoBERTa model.

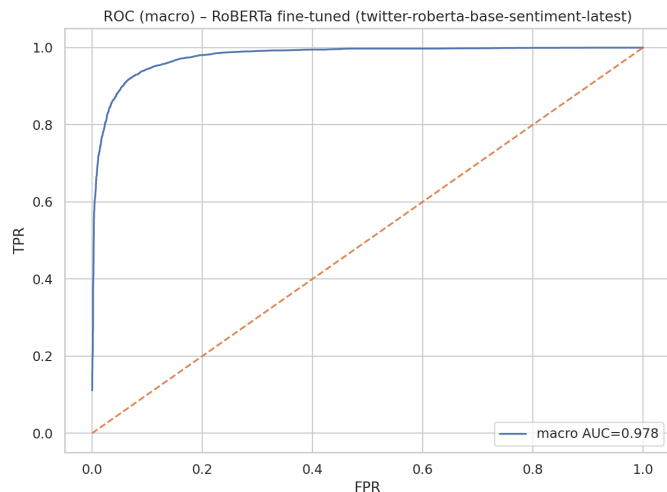


Figure 4: Macro ROC for a probability-capable model (example: fine-tuned RoBERTa).

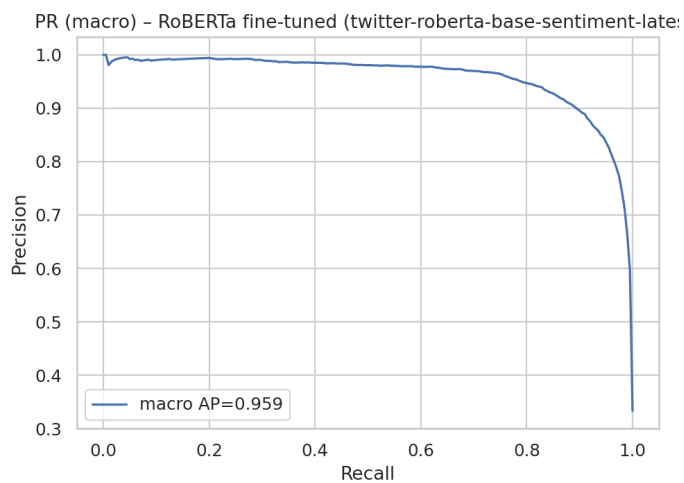


Figure 5: Macro PR for the same model as Figure 4.

The macro ROC curve hugs the top-left corner ($\text{AUC} \approx 0.98$), reflecting strong class-averaged discrimination. Across reasonable thresholds, the model attains high true-positive rates at low false-positive rates for most classes.

Training dynamics. Training/validation curves for neural models were reported to show convergence and regularization behavior:

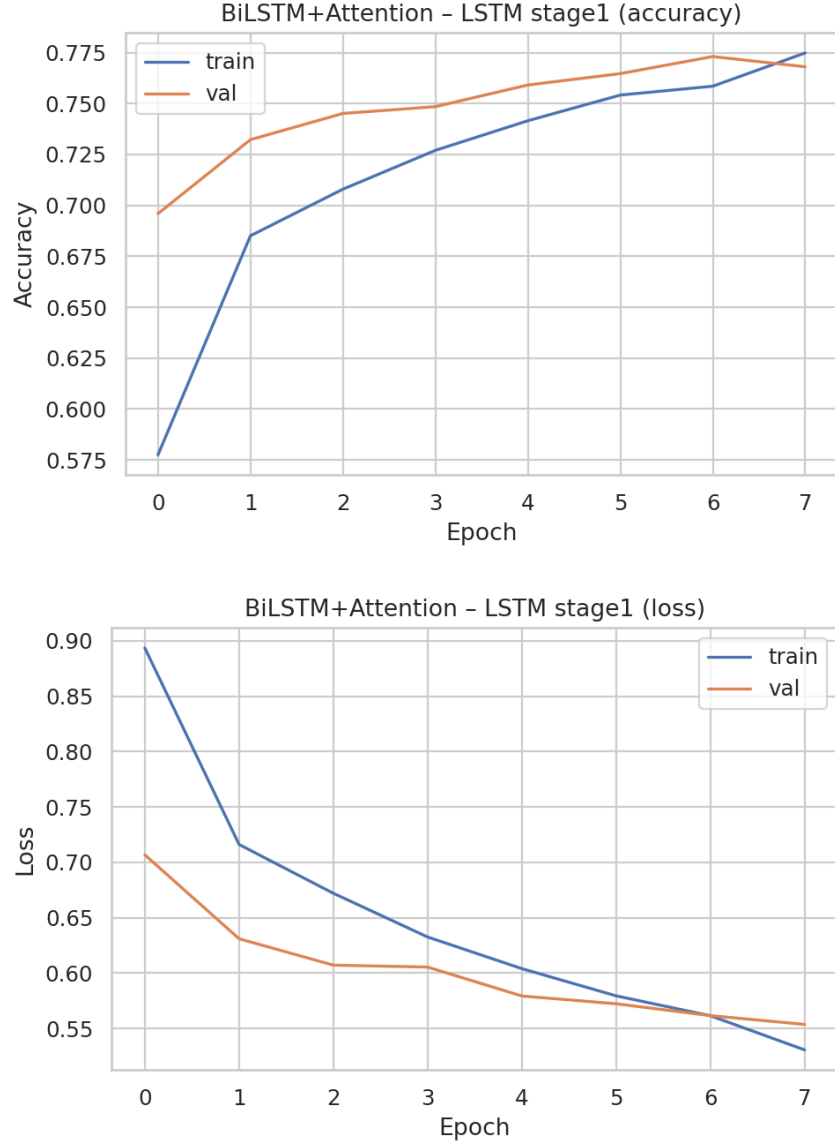


Figure 6: Example training curves (BiLSTM+Attention). Additional stages/architectures are in the Repository.

Stage-1 learning curves exhibit steady convergence: validation accuracy rises and validation loss falls over epochs. The train-val gap stays small, indicating regularization (dropout/L2) plus early stopping effectively limit overfitting.

Representation analysis When using RoBERTa as a frozen feature extractor, visualization of test-set embeddings with UMAP was used to inspect class separability:

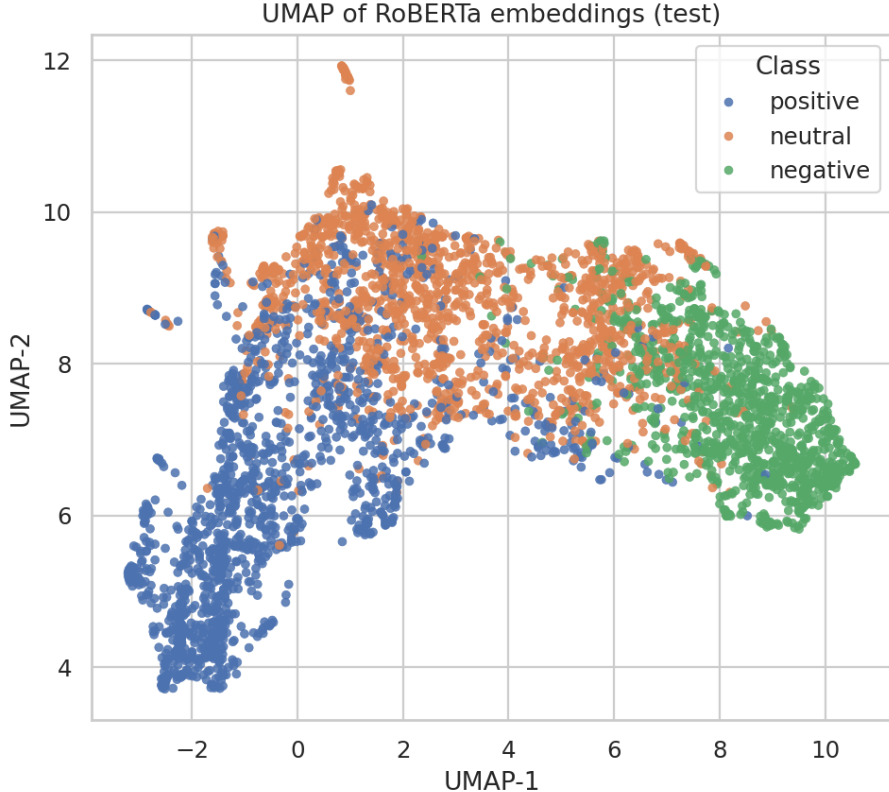


Figure 7: UMAP of mean-pooled RoBERTa embeddings (test split).

The UMAP of mean-pooled RoBERTa embeddings on the test set shows well-separated clusters for positive and negative, while neutral occupies a transitional region with more overlap. This suggests the transformer captures polarity clearly, with remaining ambiguity concentrated around the neutral boundary.

Traditional vs. deep vs. transformers. At a glance (Table 1), TF-IDF baselines are lowest (macro-F1 0.677–0.708), GloVe-based neural models close part of the gap (0.759–0.764), and transformer variants lead (0.889 with frozen RoBERTa + LR; 0.899 with fine-tuning). Simple voting ensembles (0.809) did not outperform the best single model. Interpretation of these results is deferred to Section 5.

5 Discussion

5.1 Analysis of Results

Fine-tuned **RoBERTa** achieved the highest test performance (macro-F1 = 0.899; Accuracy 0.898, Precision 0.898, Recall 0.901), while using RoBERTa as a frozen feature extractor with a Logistic Regression head was a close second (macro-F1 = 0.889). The $\approx +1.0$ pp macro-F1 and $+1.2$ pp macro-Recall gains from end-to-end fine-tuning suggest that task-specific adaptation mainly reduces errors on boundary (often *neutral*) tweets. Non-transformer neural models (BiLSTM+Attention 0.764, CNN with SE+Attn 0.759) clearly outperform TF-IDF baselines (Logistic Regression 0.708, LinearSVC 0.699, Random Forest 0.677) but still trail transformers, consistent with the limits of static word embeddings and shallower context modeling. Confusion matrices (Fig. 3) and the UMAP projection (Fig. 7) indicate that residual confusion is concentrated around the *neutral* region. Both ensemble variants (weighted and majority voting) reached macro-F1 = 0.809, below the best single transformer. Operationally, the frozen RoBERTa + LR head offers a strong accuracy–latency trade-off, whereas fine-tuning yields a small but reliable boost at higher compute cost.

5.2 Strengths and Weaknesses

Strengths. (i) A Twitter-aware preprocessing pipeline preserves emojis/emoticons and hashtag semantics; (ii) the study spans three modeling families (TF-IDF, GloVe-based neural, transformers) for a fair comparison; (iii) careful training (class weights, staged unfreezing, cosine restarts) stabilize neural models; (iv) full reproducibility: seeds, cached embeddings, and exported artifacts (tables/figures).

Weaknesses. (i) The naive voting ensembles (fixed weights/majority) underperformed the best single transformer, indicating limited error complementarity or poor weighting; (ii) compute cost: transformer fine-tuning is heavier than TF-IDF/Glove baselines.

5.3 Limitations

This study has several limitations. First, labels are derived from `cardiffnlp/twitter-roberta-base-sentiment-latest`, which was also used as a backbone; this “teacher-student” setup can bias evaluation toward transformer variants that approximate the teacher’s decision boundary. Second, the dataset covers only the first day of the tournament, limiting topical and temporal diversity. Third, global tweets are likely multilingual, while this study focused on English tweets, the approach may not generalize equally well to other languages.

Compute constraints. Training was under limited GPU memory and time on a single device, which constrained batch sizes, sequence lengths, and training schedules. Consequently, it was not possible to run extensive hyperparameter sweeps or multi-seed cross-validation, nor explore larger backbones (e.g., RoBERTa-large, DeBERTa-v3-large, XLM-Roberta large), longer-context inputs, or calibration-aware/stacked ensembles. These restrictions likely cap absolute performance and stability, so the reported scores should be viewed as conservative lower bounds.

5.4 Future Work

(i) Evaluate cross-domain generalization (other tournament days, clubs, other sports) and cross-lingual robustness (e.g., XLM-T, mDeBERTa, or multilingual RoBERTa); (iii) replace naive voting with calibrated stacking: temperature scaling/Platt scaling per model, then a meta-learner on per-class probabilities; (iv) ablations on preprocessing (emoji/hashtag handling), sequence length, and embedding choices; (v) explore larger or instruction-tuned transformers and prompt-based zero-/few-shot setups; (vi) address *neutral* with margin-aware losses or focal loss and targeted augmentation for borderline cases.

5.5 Concluding Remarks

This study confirms the advantage of transformer-based representations for Twitter sentiment: most gains stem from domain-pretrained RoBERTa features, with fine-tuning providing a small but reliable boost—particularly on ambiguous tweets. Classic TF-IDF and GloVe-based neural models remain competitive as efficient baselines, yet they struggle on *neutral*.

Future work should prioritize cross-sports-domain and cross-lingual generalization, calibration-aware stacking over naive voting, systematic ablations of preprocessing/sequence length/embeddings, scaling to larger or instruction-tuned transformers and prompt-based zero/few-shot setups, and strengthening the *neutral* boundary via margin-aware or focal losses with targeted augmentation.

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6 Appendix

6.1 GitHub Repository

<https://github.com/enriquegomeztagle/MCD-NLP-SentimentAnalysisOfFIFATweets-FinalProject>