DAFT.punk

DeBERTa for Analysis of Feelings in Texts

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Academic Year:	2024/25

1 Project Summary

DAFT.punk (DeBERTa for Analysis of Feeling in Texts and Paraphrasis) project has been realized for the Natural Language Processing exam at University of Salerno.

DAFT.punk presents a **sentiment analysis system** for **Italian musical texts** using a **fine-tuned DeBERTa v3 architecture**. The project addresses the challenge of automatically classifying emotions in Italian lyrics across 7 distinct categories: **joy**, **sadness**, **rage**, **love**, **nostalgia**, **hope**, and **fear**. The system uses **state-of-the-art transformer architecture** and features an intuitive web interface developed with Gradio, and implements temperature scaling to reduce prediction overconfidence and provides comprehensive graphical visualizations of emotional probabilities.

The core technologies include PyTorch, Hugging Face Transformers for the language model, and Gradio for the user interface. The project demonstrates practical application of Natural Language Processing in the Italian musical domain, providing an accessible tool for automatic emotional analysis of texts. The web interface enables real-time sentiment analysis with detailed probability visualizations for each emotion, making the system accessible to both technical and non-technical users.

The developed model demonstrates solid performance on a **dataset of 10,000 Italian musical texts**, with a decent **64.58%** accuracy score, which appears pretty good compared to the reduced dataset size.

2 Introduction

Sentiment analysis has emerged as a crucial task in Natural Language Processing (NLP), with applications spanning from **social media monitoring** to **market research**. However, **the analysis of emotional content in poetic and artistic texts**, particularly musical lyrics, presents **unique challenges** that conventional sentiment analysis approaches often fail to address effectively.

2.1 Motivation and Objectives

The primary motivation for this work is the **lack of specialized resources and models for fine-grained emotion analysis in Italian musical texts**. While significant progress has been made in English sentiment analysis, Italian language resources is still limited, particularly for domain-specific applications like **music** and **poetry**.

The main objectives are:

- Develop a **comprehensive dataset of Italian musical lyrics** with fine-grained emotional annotations
- Create a **robust sentiment analysis model** capable of distinguishing between distinct emotional categories
- Demonstrate the **effectiveness of transformer-based architectures** for Italian emotion classification
- Provide a **practical tool** for real-time emotion analysis of Italian texts

3 Challenges of Sentiment Analysis in Italian Poetic Texts

Italian musical lyrics have several layers of linguistic complexity that represent significant challenges for automated sentiment analysis systems. Unlike social media posts or product reviews, **song lyrics employ sophisticated literary devices that can obscure or transform the apparent emotional content**.

The prevalence of metaphorical and figurative language represents perhaps the most significant challenge in Italian musical text analysis. Italian songwriters frequently employ extended **metaphors**, **allegories**, and **symbolic representations** to convey complex emotional states. Weather references such as *"la pioggia scende fredda"* typically symbolize emotional conditions rather than literal meteorological observations, while natural imagery often serves as a vehicle for expressing internal psychological states.

Cultural and historical references also complicate the emotional interpretation of Italian musical texts. Lyrics frequently contain allusions to specific cultural contexts, historical events, or literary traditions that carry profound emotional weight for Italian audiences. Political terms like "*partigiano*" in protest songs evoke complex historical memories and emotional associations, while references to specific Italian cities or regions activate cultural knowledge that influences emotional interpretation.

Italian musical texts also demonstrate remarkable **register** and **style variation**, often transitioning between colloquial expressions and highly formal literary language within the same composition. This linguistic diversity reflects the artistic tradition of Italian music, which draws from both popular culture and high literary tradition.

3.1 Limitations of Existing Approaches

Current sentiment analysis methodologies, while effective for standard text classification tasks, demonstrate significant limitations when applied to the domain of Italian musical lyrics.

- **Binary Classification Inadequacy**: Traditional positive/negative sentiment classification proves insufficient for capturing the emotional richness of musical texts. **Songs frequently express complex emotional states that cannot be reduced to simple polarity**, such as bittersweet nostalgia or hopeful melancholy.

- **Language-Specific Resource Scarcity**: While English sentiment analysis benefits from extensive annotated datasets and pre-trained models, **Italian language resources remain limited**. Existing Italian sentiment models are primarily trained on news articles, social media posts, or product reviews, which differ significantly from the artistic and poetic language of music.
- **Domain Adaptation Challenges**: **Models trained on standard text corpora often fail to generalize effectively to the musical domain**. The unique vocabulary, syntactic patterns, and emotional expressions characteristic of song lyrics require domain-specific training data and specialized model architectures.

The realized **seven-class emotion framework** captures the primary emotional categories prevalent in Italian music while maintaining sufficient granularity for practical applications.

- **Joy**: Expressions of happiness, celebration, euphoria, and positive excitement.
- **Sadness**: Sorrow, pain, grief, loss, and emotional pain. Very common in Italian music traditions, this category encompasses songs about heartbreak, separation, death, and existential sorrow.
- **Love**: Romantic affection, passion, and intimate emotional connections. Distinguished from joy by its *focus on interpersonal emotional bonds* rather than general happiness.
- **Nostalgia**: Bittersweet longing for the past, memories, and lost times. Particularly prominent in Italian musical culture, representing a complex emotion that *combines sadness with memories*.
- **Hope**: Optimism, faith in the future, and positive expectations.
- **Rage**: Fury, anger, frustration, protest, and social criticism.
- **Fear**: Anxiety, uncertainty, dread, and existential concerns.

4 Dataset Creation

The development of a comprehensive dataset for Italian musical emotion analysis required a systematic approach to **data collection, preprocessing, and annotation**. This section describes the methodology employed to create a novel dataset of 10,000 Italian song lyrics with fine-grained emotional annotations.

4.1 Data Collection and Preprocessing

The dataset collection process utilized the **Genius API** to extract Italian musical lyrics from a diverse range of artists and genres. The scraping methodology targeted **contemporary Italian music spanning multiple decades to ensure representative coverage of linguistic styles and thematic content**. The collection focused on Italian artists across **various musical genres** including pop, rock, traditional song-writing, rap, and indie music. This diversity ensures the

dataset captures different emotional expressions and linguistic registers characteristic of Italian musical culture. Raw lyrics underwent several preprocessing steps to ensure data quality. This included **removal of metadata annotations** (e.g., [Verse], [Chorus]), normalization of punctuation, and filtering of non-textual elements. **Duplicate entries and instrumental tracks were eliminated from the collection**.

4.1.1 Web Scraping Implementation

The data collection employed a systematic web scraping approach using the Genius API to access a comprehensive database of Italian musical lyrics. The scraping process implemented automated queries targeting Italian artists and songs, with rate limiting mechanisms to respect API constraints and ensure stable data extraction.

The scraper utilized the Genius search functionality to identify Italian musical content, filtering results based on language detection and artist nationality. The implementation included error handling mechanisms for network timeouts, API rate limits, and malformed responses to ensure robust data collection across the extended extraction period.

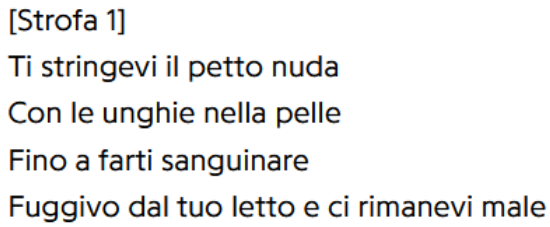


Figure 1: In this example, metadata in square brackets has to be removed

The final dataset contains about **10000** Italian lyrics excerpts.

5 LLM-Assisted Annotation and Prompt Engineering

The annotation process follows a structured pipeline designed to maintain consistency and quality throughout the labeling procedure.

GPT-4 serves as the primary annotation engine, using its advanced language understanding capabilities and cultural knowledge. The model processes each text through carefully crafted prompts designed specifically for Italian emotional analysis. The system validates each response against the predefined seven-class taxonomy, ensuring that only valid emotion labels are accepted. Invalid responses trigger automatic re-processing with modified prompts to maintain annotation quality. **The system prompt establishes GPT-4 as an expert in Italian literature and emotion analysis**, providing context for sophisticated cultural interpretation of musical texts.

The prompt explicitly defines the seven emotion categories with Italian translations and contextual examples, ensuring the model understands the specific emotional distinctions required. Instructions guide the model to consider multiple textual elements including word choice, imagery, cultural references, and overall emotional tone rather than relying on superficial keyword matching. **The prompt**

```
{
  "artist": "Baustelle",
  "title": "La Guerra È Finita",
  "url": "https://genius.com/Baustelle-la-guerra-e-finita-lyrics",
  "lyrics": "Parole nere di vita \"La guerra è finita Per sempre è finita Almeno per me\"",
  "sentiment": "hope"
},
```


Figure 2: Example of a scraped text annotated by GPT-4

requires JSON-structured responses to enable reliable parsing and integration with the annotation pipeline, reducing processing errors and ensuring consistency.

5.1 Supervised Annotation Approach

Despite using automated LLM capabilities, the annotation process still needs a **strong human supervision** to ensure accuracy and cultural appropriateness: the completed dataset underwent **final quality assessment, confirming that the emotional labels appropriately reflect the intended artistic and cultural message of each musical text**. This supervised approach ensures that while the annotation process benefits from LLM efficiency and consistency, the final labels maintain the cultural sensitivity and contextual understanding necessary for accurate Italian musical emotion analysis.

6 Methodology

This section describes the technical approach employed for developing the emotion classification model, including architecture selection, fine-tuning procedures, and specialized techniques implemented to address the challenges of Italian musical text analysis.

6.1 DeBERTa Model Architecture

The model architecture is based on **DeBERTa-v3-base** (**D**ecoding-**E**nhanced **BERT** with disentangled **A**ttention), selected for its superior performance on natural language understanding tasks and enhanced attention mechanisms. DeBERTa represents an advancement over traditional BERT architectures through its disentangled attention mechanism, which separately encodes content and position information, leading to improved contextualization of textual sequences.

The base model provides **12 transformer layers** with **768 hidden dimensions** and **12 attention heads**, totaling approximately **86 million parameters**. For the emotion classification task, a classification head consisting of a dropout layer followed by a linear transformation maps the 768-dimensional representations to the seven emotion categories. The model processes input sequences with a maximum length of 256 tokens, **balancing computational efficiency with adequate context preservation for typical lyrical content**.

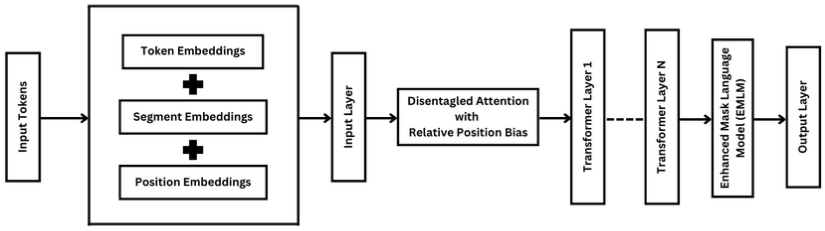


Figure 3: DeBERTa Architecture

The choice of DeBERTa-v3-base over alternative architectures is justified by its demonstrated effectiveness on multilingual tasks and its ability to capture nuanced semantic relationships crucial for emotional content analysis. The model's enhanced attention mechanisms prove particularly valuable for processing the complex metaphorical and cultural references characteristic of Italian musical texts.

6.2 Fine-tuning Procedure

The fine-tuning process employs a standard supervised learning approach with **careful optimization of hyperparameters** to achieve optimal performance on the seven-class emotion classification task. The training procedure utilizes the Adam optimizer with a learning rate of 2e-5, selected through preliminary experiments to balance convergence speed with training stability.

The model trains for **8 epochs** with a batch size of 8 per device, implementing early stopping based on validation F1-score to prevent overfitting. The training uses stratified train-test splitting with a fixed random seed to ensure reproducible results and maintains a 80/20 split ratio, providing **7,587** training samples and **1,897** test samples.

Weight decay regularization (0.01) **helps prevent overfitting** given the relatively modest dataset size compared to typical transformer training scenarios. The training process implements gradient clipping and learning rate scheduling to ensure stable optimization throughout the fine-tuning procedure. Model checkpoints are saved at each epoch with the best-performing model selected based on weighted F1-score on the validation set.

6.3 Temperature Scaling

Temperature scaling represents a post-processing calibration technique applied to the model's output logits to reduce prediction overconfidence and provide more realistic probability distributions. The technique divides the pre-softmax logits by a temperature parameter (T) **before applying the softmax activation**, where $T > 1$ produces softer probability distributions.

The implementation applies a temperature value of **2.0**, determined through validation experiments to optimize the balance between prediction confidence and

accuracy. This scaling particularly benefits the musical text domain, where emotional interpretation often involves subjective elements and multiple valid interpretations may exist for the same text. The calibrated probabilities provide more nuanced confidence estimates, **improving the interpretability of the model's emotional classifications and reducing the likelihood of overly confident incorrect predictions**.

7 Experimental Results

7.1 Overall Performance

The DAFT.punk model achieved competitive performance on the Italian musical emotion classification task, reaching a final **accuracy of 64.58%** and an **F1-score of 64.49%**. These results demonstrate the model's capability to distinguish between the seven target emotions with moderate-to-good precision across the emotion spectrum.

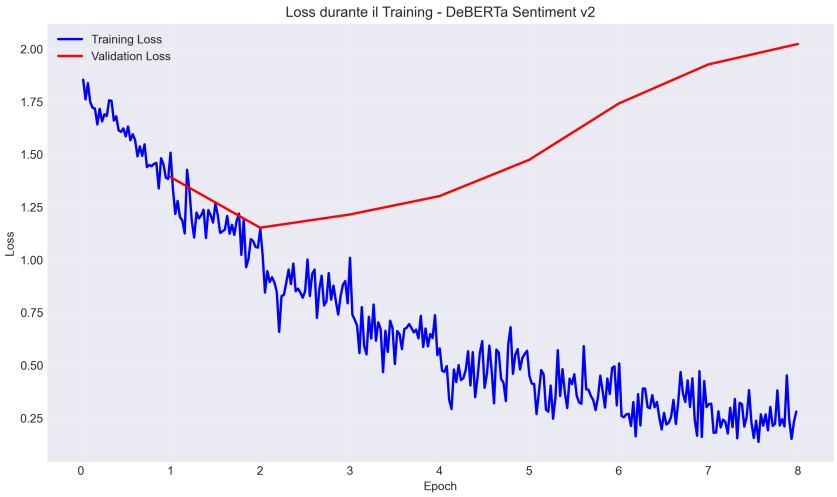
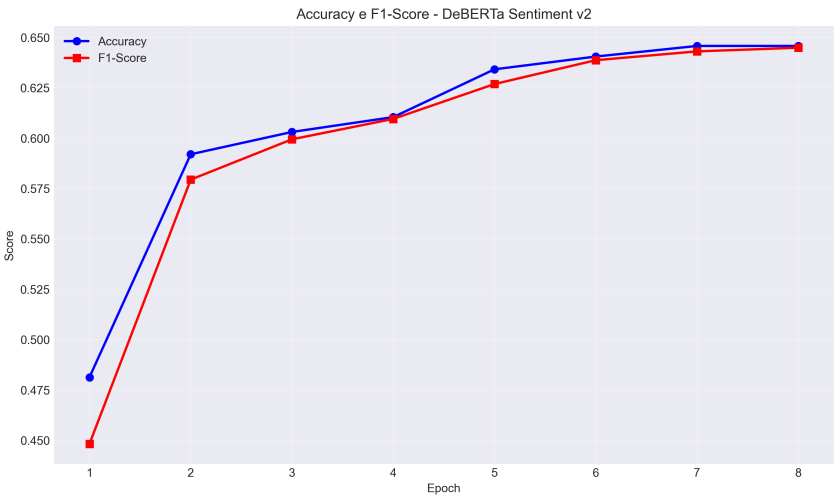
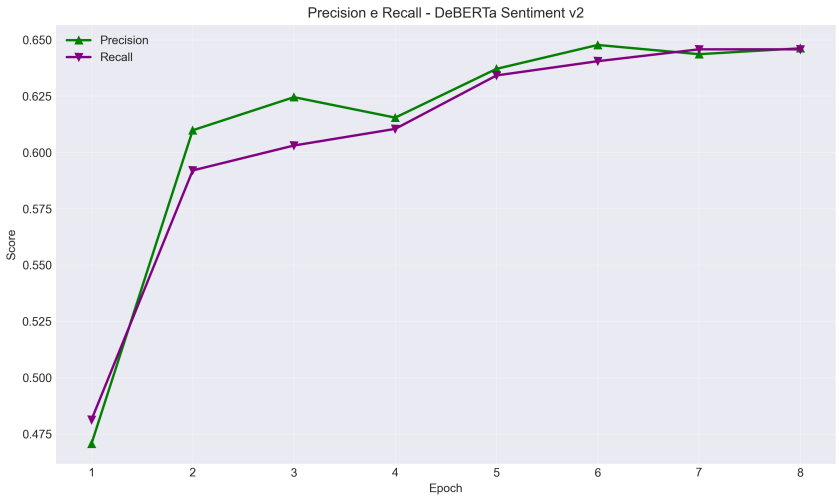


Figure 7.1 illustrates the training progression, showing a consistent decrease in loss from an initial value of 1.8540 to a final value of 0.2798, representing an 84.91% reduction. This smooth convergence pattern indicates stable optimization without significant overfitting, validating the chosen hyperparameter configuration.



The accuracy and F1-score evolution depicted in Figure 7.1 reveals steady improvement throughout the training process, with both metrics converging around the 64-65% range. The close alignment between accuracy and F1-score suggests balanced performance across emotion classes, despite the inherent class imbalance in the dataset.



Per-class performance analysis through precision-recall metrics (Figure 7.1) reveals varying classification effectiveness across emotions. Love and Sadness achieved the highest precision scores (71.6% and 69.8% respectively), while more nuanced emotions like Fear and Joy proved more challenging, achieving 42.8% and 43.6% precision respectively. This pattern aligns with linguistic intuition, as Love and Sadness typically manifest through more explicit lexical markers in musical texts.

8 Practical Application

8.1 Gradio Web Interface and Use Case

The web application utilizes the **Gradio** framework to provide an intuitive and accessible interface for emotion analysis of Italian texts. The application architecture implements real-time processing capabilities, allowing users to input Italian text and receive **immediate emotion classification results**.

The system generates comprehensive output visualizations including both textual predictions and graphical probability distributions. **Each analysis produces a bar chart displaying the probability scores across all seven emotion categories**, enabling users to understand not only the primary predicted emotion but also secondary emotional components present in the text. The visualization employs distinct colors for each emotion category, facilitating intuitive interpretation of the results.

The emotion classification system demonstrates practical applicability across multiple domains related to Italian musical and textual content analysis. The web interface serves as both a demonstration platform and a functional tool for various user communities.

For music industry applications, **the system enables automated content categorization and recommendation** algorithms based on emotional content rather than solely on genre or artist similarity. Music streaming platforms could

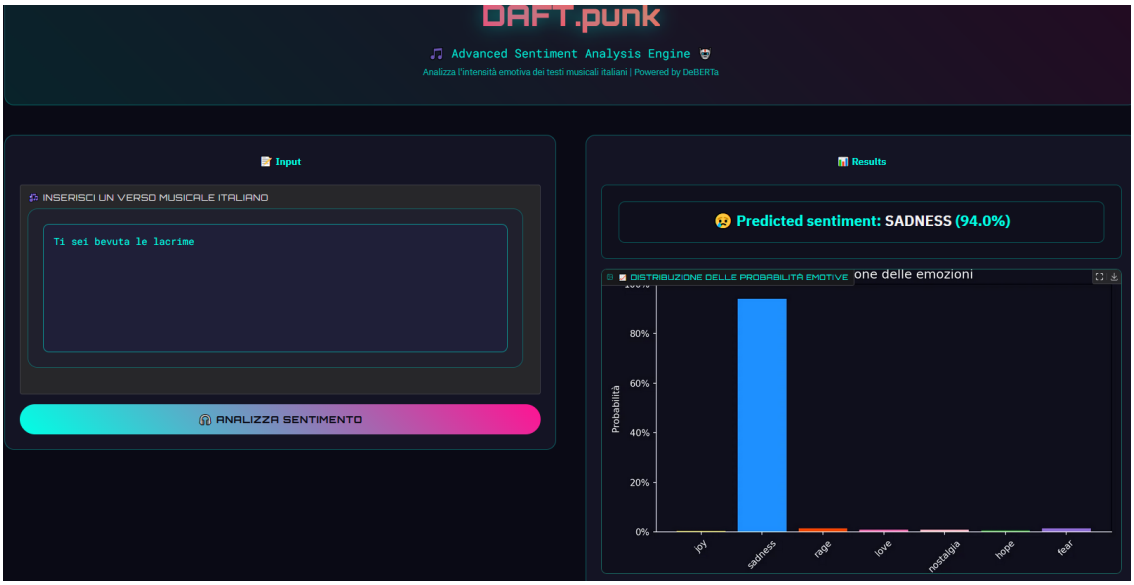


Figure 4: Demo di DAFT.punk

use the emotion classification to create mood-based playlists or to enhance search functionality with emotional queries such as "nostalgic Italian songs" or "hopeful contemporary music".

9 Conclusions

9.1 Summary of Results

This project successfully developed DAFT.punk, a specialized emotion classification system for Italian musical texts using DeBERTa-v3-base fine-tuned for seven-class emotion recognition. The system achieved **64.58% accuracy** and **64.49% F1-score** on a novel dataset of 10,000 Italian song lyrics, demonstrating competitive performance for fine-grained emotion analysis in the challenging domain of poetic and metaphorical language.

The proposed seven-class emotion taxonomy (Joy, Sadness, Rage, Love, Nostalgia, Hope, Fear) proved effective for capturing the emotional richness of Italian musical texts, moving beyond traditional binary sentiment classification to provide nuanced emotional analysis. The natural distribution of emotions in the dataset, with Nostalgia (29.6%) and Sadness (28.1%) dominating, reflects authentic patterns in Italian musical tradition and validates the cultural relevance of the chosen taxonomy.

The LLM-assisted annotation pipeline using GPT-4 enabled efficient large-scale dataset creation while maintaining cultural sensitivity through human supervision and validation.

9.2 Limitations and Future Work

Several limitations constrain the current system's performance and applicability, providing clear directions for future research and development efforts.

The dataset size of 10,000 lyrics, while substantial for the Italian musical domain, **remains modest** compared to large-scale sentiment analysis datasets available for English. This limitation particularly affects the performance on underrepresented emotions like Fear and Joy, suggesting that expanded data collection could improve classification balance. Future work should prioritize collecting additional examples of rare emotions through targeted sampling strategies or synthetic data augmentation techniques.

The seven-class emotion taxonomy, while capturing major emotional categories in Italian music, **may not encompass the full spectrum of complex emotional states** present in musical texts. Emotions like "hate", "neutral", "comedy", or "anxiety" might require separate categories or multi-label classification approaches.

Integration with audio analysis features (melody, rhythm, harmony) could provide more comprehensive emotion recognition. Multi-modal approaches combining textual and musical features represent a promising direction for improving classification accuracy and cultural authenticity.

Disclaimer

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